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Translation

DESIGN FUNDAMENTALS OF NONINDUSTRIAL AND INDUSTRIAL BUILDINGS

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DESIGN FUNDAMENTALS OF NONINDUSTRIAL AND INDUSTRIAL BUILDINGS

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CONTENTS

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Abstract

A discussion is presented of the basic principles of the standard design of nonindustrial and industrial buildings and also the procedural instructions for the development of course and diploma designs of these buildings. The problems of the modular system, standardization and unitization of the investigated buildings are discussed briefly. The classification of nonindustrial and industrial buildings, their floor plans, structural diagrams and systems, and their technical-economic indices are investigated. The general principles of planning the microdistricts and generation of master plans for industrial enterprises are presented.

The book is intended for students at the middle institutions of learning in the specialty of industrial and nonindustrial construction.

Foreword

The constant improvement of construction processes and construction engineering requires improvement of the training of qualified workers and specialists. This was pointed out at the 25th CPSU Congress. Their professional training and skills to a great extent determine the achievement of the goals set by the party and government in the construction area.

During the training process, future builders and engineers must master skills not only corresponding to the achieved level of construction, but also corresponding to a defined degree to the future requirements of construction development.

The purpose of this publication is to familiarize the students of the secondary technical schools specializing in construction with the fundamentals of the design and construction of residential, public and industrial buildings and structures. However, the book cannot claim to be an exhaustive discussion of all of the material approved by the existing program. Therefore when compiling the outline, the authors began with the future development of the scientific-theoretical principles of the course in "The Architecture of Nonindustrial and Industrial Buildings" as applied to the design of such buildings. The basic premise was that under the conditions of scientific and technical progress future builders and construction engineers must know how to find correct solutions to contemporary architectural-construction problems independently.

The theoretical principles of standard design adopted in our country as the basic area in the development of nonindustrial and industrial building design are presented in the book, the problems of modular coordination and unitization are investigated, and brief information is presented on master plans.

A great deal of attention has been given to the typology of nonindustrial and industrial buildings, their architectural planning and structural solutions, the problems of functional and production interrelations of individual zones and facilities.

One of the basic steps in reinforcing theoretical knowledge is the execution of course and diploma designs. During the process of working on such designs the students encounter difficulties in laying out the drawings on the sheets, composition, inking and pochéing procedures and also the discussion of the material in an explanatory note and the performance of heat engineering calculations. A procedure for developing designs is presented in the required detail in the book, and examples are given of the heat engineering calculations of walls and ceilings. Contemporary, advanced architectural planning and structural solutions for buildings presented in the text can serve as examples for further, more specific development of one type of building or another.

At this time a great deal of significance is attached to the problems of construction economics; therefore the basic technical-economic indices of various design solutions of buildings, master plans for housing and the territory of industrial enterprises are presented.

The indicated consolidated digital technical-economic indices must not be considered during course and diploma design as fixed inasmuch as these indices change quickly. However, they illustrate the methodology of the technical-economic calculations well for the design of various projects, and they offer the possibility of determining the relative relationship of these indices.

In conclusion, it must be noted that the study of the course in "Design Fundamentals of Nonindustrial and Industrial Buildings" is based on skills obtained in drawing, sketching, structural design and other general theoretical and specialized disciplines.

The authors express deep appreciation to the reviewers, Candidate of Architecture G. Yu. Orlov and instructor at the Donetsk Secondary Technical School of Construction Ye. N. Ratnikova for valuable comments and recommendations for improvement of the content of this edition.

Part One. General Instructions for the Course Design of Nonindustrial and Industrial Buildings

Chapter I. General Design Principles of Nonindustrial and Industrial Buildings

Section 1. Design Concepts and Basic Design Requirements

The design of any object, whether nonindustrial or industrial building, is a creative process involving architects, engineers and technicians of the design organizations based on united state norms and standards.

When developing the designed object it is necessary to determine its nature, functional interrelation of the individual parts and elements of the building, establish the optimal shape organically connected with the floor and space planning and purpose and also it is necessary to select contemporary materials and an advanced structural design.

Thus, the design process is a multifaceted, complex process including calculations and structural design work. The final purpose of the design process is to generate a design for a building which is of interest with respect to architectural concept and corresponds to modern structural, economic, fire-safety, sanitation and other requirements. The design consists of drawings, calculations, explanatory notes and estimates. The drawings contain a graphical representation of the adopted architectural and structural solution of the designed object, its elements and parts.

The explanatory note discusses the substantiation of the adopted architectural-planning, structural and engineering solutions, the basic technical-economic indices, characterizing the reasonableness of the design.

The design estimates determine the total cost of construction and serve as a basis for planning the capital investments and financing of the construction of the given project.

The development of a design of a building or structure begins with the assignment for its design which is compiled by the client with the participation of the design organization. A design development assignment contains the initial data for the design.

The design assignment for a residential or public building contains the following material: the design phasing, the area of application of the design with indication of the structural-climatic districts and calculated outside air temperatures; purpose and type of residential or public building, number of floors, extent; recommended types of apartments or rooms, areas of the facilities, requirements on engineering equipment and public amenities.

The design assignment for an industrial building includes the name of the district, the place and the construction site, the production nomenclature and capacity; the basic production processes and equipment, the basic sources of support of the operation of the enterprise (raw materials, electric power, heat, gas, and so on); the cooperation of the enterprise established as part of an industrial complex; planned expansion of the enterprise.

The basis for compiling the design assignment is a resolution by the executive committee of the Council of People's Deputies, a resolution of the union republic gosstroy or the Gosgrazhdanstroy [State Committee for Nonindustrial Construction].

The developed documents for the design of any building or structure must satisfy the requirements of the effective construction norms and regulations (SNiP) which are the state standards with all-union significance. The SNiP contain the basic principles and requirements with respect to the construction and design of cities and populated areas, all types of buildings and structures, the selection and application of structural elements and engineering equipment, and determination of the estimated cost of construction.

The construction norms and regulations consist of four parts:

1. General principles.

2. Design norms.

3. Performance and acceptance regulations.

4. Estimate norms and regulations (with unit-construction estimate norms appended).

Part I "General Principles" establishes the system of normative documents, the construction terminology, classification of buildings and structures, regulations for specification of modular dimensions and tolerances in construction.

Part II "Design Norms" contains the requirements with respect to the general design problems (construction climatology and geophysics, fire-safety standards, structural heat engineering, loads and exposures, construction in seismic areas, and so on); bases and foundations, structural elements, engineering equipment and external networks; the planning and development of cities, settlements and rural populated areas, housing and public buildings and structures; the production and auxiliary buildings and structures of industrial enterprises; farm buildings and structures; warehouses and storage structures, and so on.

Part III "Performance and Acceptance Regulations" contains the requirements with respect to the general problems of organizing the construction and acceptance of enterprises, buildings and structures as finished construction; geodetic operations; safety engineering; performance and acceptance operations when erecting earthworks, bases and foundations, structural elements, and so on.

Part IV "Estimate Norms and Regulations" contains instructions with respect to the development of elemental and consolidated estimate norms for construction operations; determination of the estimated cost of equipment; determination of the estimated cost of materials, structural elements and operation of construction machinery, definition of the limited and other expenditure norms; determination of the estimated cost of construction.

For each part of the SNiP colored vertical strips are placed on the left side of the leaves for convenience of using them: Part I--red; Part II--blue; Part III--green; Part IV--brown.

The chapters of the SNiP are published under the corresponding code approved by the USSR Gosstroy, for example, SNiP II-L.1-71 "Residential Buildings. Design Norms" means: Part II, Section L, Chapter 1, 71 is the year of approval of the given chapter. At the present time a transition is taking place to a three-number designation of the SNiP code, such as, for example, SNiP I-1-74 "General Principles. System of Normative Documents" means: Part I, Chapter 1, 74 is the year of approval.

Section 2. Design Phases and Composition of the Design Documents

The construction norms and regulations are developed when necessary in the form of technical specifications, instructions and other normative documents. These normative documents are coded with the letters SN (construction norms), TU (technical specifications); after these identification codes, the number and year of publication are indicated.

When developing designs for nonindustrial and industrial buildings it is necessary to be guided by the "Temporary Instructions for the Development of Designs and Estimates for Residential and Nonindustrial Construction" SN 401-69 and "Instructions for the Development of Designs and Estimates for Industrial Construction" SN 202-76. According to these documents, the design of nonindustrial and industrial buildings or complexes of them takes place in one or two phases. These phases are preceded by the predesign development--the technical-economic substantiation. The majority of the designs are developed in two stages--contact design and working drawings. When designing small projects it is permissible to develop the design in one phase--the contract-detail design (combination of the contract design with detailed working drawings).

After the development, coordination and approval of the design assignment, the designers begin with the development of the contract design which is the initial design phase. The basic, most efficient architectural-planning and structural solutions are discovered and established, and a decision is made with respect to engineering equipment and transportation. The total estimated cost of construction and the basic technical-economic indices of the designed project are determined.

The contract design includes the following parts: architectural-construction design, technical-economic, production process and summary cost estimate calculations.

Depending on the type of developed project the individual parts of the contract design can be altered, supplemented, combined or omitted.

The architectural-construction part includes the following:

the plans for nonrepeating floors on which all of the basic dimensions of the rooms and placement of furniture and equipment are indicated;

sections and elevations with indication of all of the basic levels (the bottom of the foundations, ground level, floors, ceilings, windows, doors, stair landings, overheads, and so on);

the structural layout of the building, subassemblies and parts, their mating, the nomenclature of products with dimensions, their weights, materials, and so on;

layouts of engineering networks and service lines, types and capacity of sanitation engineering and heating units.

The technical-economic part of the contract design contains an explanatory note with the description and substantiation of the decisions made in the design, the basic technical-economic indices and a comparison of them with analogous data of existing building designs. Data are presented on the sources of supply of the designed project (water, electric power, gas, and so on). The correspondence of the developed design data to the design assignment is indicated in the explanatory note.

The master plan which enters into the architectural-construction part is developed in the contract design.

When developing the design for a nonindustrial building, the location of this building on the construction site, the access routes and walkways in the vicinity of the building, landscaping and amenities are defined on the master plan.

The master plan is especially important when designing complexes of buildings and structures for industrial enterprises. The basic design principles of a master plan for an industrial enterprise based on the production layout are discussed in Section 7 of this publication.

The production process part of the design contains the general production route sheet, the planned specialization of the production and operating conditions of the enterprise, and the system of basic sources of support (raw materials, water supply, power supply, gas, and so on).

The summary cost estimate calculation of the design determines its total cost and is the basis for financing construction and developing the working drawings.

The contract design must be agreed on with the ispolkom [executive committee] of the local Council of People's Deputies and local agencies of the State Sanitary Inspectorate and State Fire Inspectorate.

After consultation and examination, the contract design serves as the basis for developing the working drawings. The working drawings are developed for more precise definition and detailing of the design solutions adopted in the contract design.

The composition of the working drawings for nonindustrial buildings differs somewhat from the composition of working drawings for the buildings of industrial enterprises in which the specific nature of these enterprises is taken into account.

The working drawings of a nonindustrial building must contain the following material:

the site master plan with the solution for amenities and external engineering networks, and grading;

transport routes, amenities and landscaping;

nonrepeating floor plans of the building;

foundation plans with the required detailed drawing and cross section;

plans for overheads, floors and ceilings with indication of their composition and structural solutions;

sections of the building, one of them necessarily through the stairway;

elevations of the building with details and architectural details;

drawings of individual elements used in the design (nonstandard doors, built-in closets, gates, and so on);

drawings of the erection and installation of items with indication of their types and sequence of erection, with specification of the plant-manufactured items;

drawings of the engineering and service equipment (water lines, sewage, power supply, gas supply, heating, ventilation, and so on).

The working drawings of industrial buildings and structures also include the installation drawings of power engineering equipment and the foundations under the production equipment.

After final development, the working drawings are transmitted without additional approval to the construction organization for performance of the construction and installation operations.

As has been pointed out, in addition to the two-phase design of projects, provision has also been made for the development of the designs in one phase. In this case the contract design and working drawings are combined in the contract-detail drawings. The work on the designs begins after approval of the design assignment. The approval and agreement on the contract-detail drawings are given by the same offices as the contract design.

Section 3. Standard Design, Modular System, Fundamentals of Standardization and Unitization of Buildings

The enormous volumes of construction in the Soviet Union have necessitated the creation of a large-scale production-industrial base. One of the basic conditions for the growth of industrialization of construction is mass manufacture of prefabricated construction products and parts based on standardized design work.

The basis for standardized design work is the standard design planned for mass construction and developed considering advanced architectural-planning and structural solutions and high technical-economic indices.

The goal of standardized design includes maximum reduction of the construction times, reduced cost and improved quality of construction as a result of industrialization of it, the fastest conversion to the erection of fully prefabricated buildings from large structural elements and factory-made elements.

The standard designs are developed both for defined climatic regions considering the natural climatic and local conditions (permafrost, seismics, unstable ground, and so on) and for a provisional region with calculated winter temperature of -30° C and versions of the solutions for regions with a calculated temperature of -20° and -40° C.

Standard designs intended for application in seismic regions have the index "S," for example, series 111-02S.

Standard designs are basically disseminated by the Central Institute of Standard Designs (TsITP), and some of the standard designs are disseminated by organizations developing the designs.

During the erection of buildings from industrial prefabricated products, correlation of all of the dimensions of the items used is necessary. This is possible only under the condition where the designation of the dimensions of the products will be subordinate to a defined system. The "United Modular System in Construction" (YeMS) has been developed and approved in the Soviet Union.

The YeMS is a set of regulations for the coordination of the dimensions of floor-planning and the structural elements of buildings and structures, construction products and equipment based on the ~~all-union~~state module equal to

100 mm (M). In addition to the basic YeMS module, derivative modules have been established which are divided into consolidated modules of 6,000, 3,000, 1,500, 1,200, 600 and 300, respectively, 60 M, 30 M, 15 M, 12 M, 6 M and 3 M--and fractional modules--50, 20, 10, 5, 2, 1 mm, respectively, 1/25 M, 1/5 M, 1/10 M, 1/20 M, 1/50 M, 1/100 M.

The modular grid (Figure 1a) is compiled on the basis of the modular series. It is in the form of a grid of module lines with spacing equal to the derivative modules adopted for a specific design. The module grid defines the location and the basic dimensions of the floor-planning and structural elements and parts (Figure 1b).

Three basic types of dimensions of floor-planning and structural elements and parts have been established in the YeMS: structural, nominal and natural (Figure 2a).

The nominal modular dimension is the provisional dimension of the floor-planning and structural elements including the joints and clearances between elements.

The structural dimension is the designed dimension of the floor-planning and structural elements, the construction products and equipment, which is less than the nominal dimension by the thickness of the joint and clearance.

The natural dimension is the actual dimension of the floor-planning and structural element, the construction product.

The nominal dimensions are used in the design materials and in the catalog product codes. When developing the working drawings of a design, the structural dimensions are inserted.

The basic parameters of buildings and structures characterizing their floor-planning and structural solutions are transverse span, longitudinal span and height.

The transverse span is the distance between the basic transverse bearing structures (columns, walls, and so on, Figure 2b).

The longitudinal span is the distance between longitudinal bearing structures (see Figure 2c). The story height is the distance between the floor level and ceiling of this story (Figure 2b).

As is obvious from Figure 2c, the transverse and longitudinal spans usually are designated by layout center lines.

The modular layout center lines determine the position of the basic bearing and enclosing structures and also the division of the plan of the building or structure into basic elements.

By tie-in we mean the distance from the modular layout center line (longitudinal, transverse) to the face or geometric axis of the structural element. The tie-inof the structural elements of buildings to the modular layout center lines is realized considering the possibility of using construction items of the same dimensions for the middle and edge uniform elements.

The bearing structures are tied in to modular layout center lines differently. In the middle longitudinal spans in the middle of the structural element is the so-called zero tie-in and in edge longitudinal spans with displacement of the structural element in one direction or another by the distance a considering the length of the structural elements and the conditions of their abutment and support.

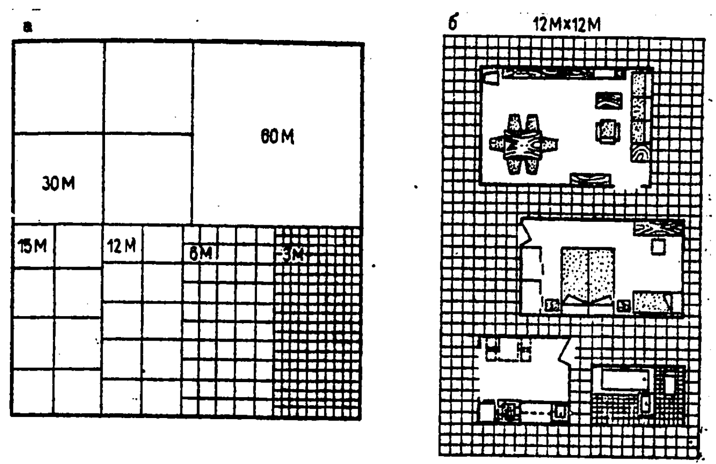


Figure 1. Modular design grid (a); floor plan solutions based on the modular grid (b).

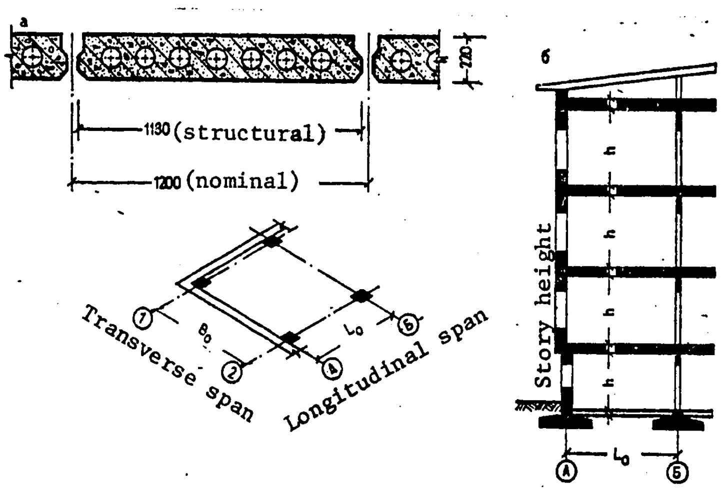


Figure 2. Basic forms of dimensions of structural products (a); space-floor plan parameters of buildings and structures (b, c).

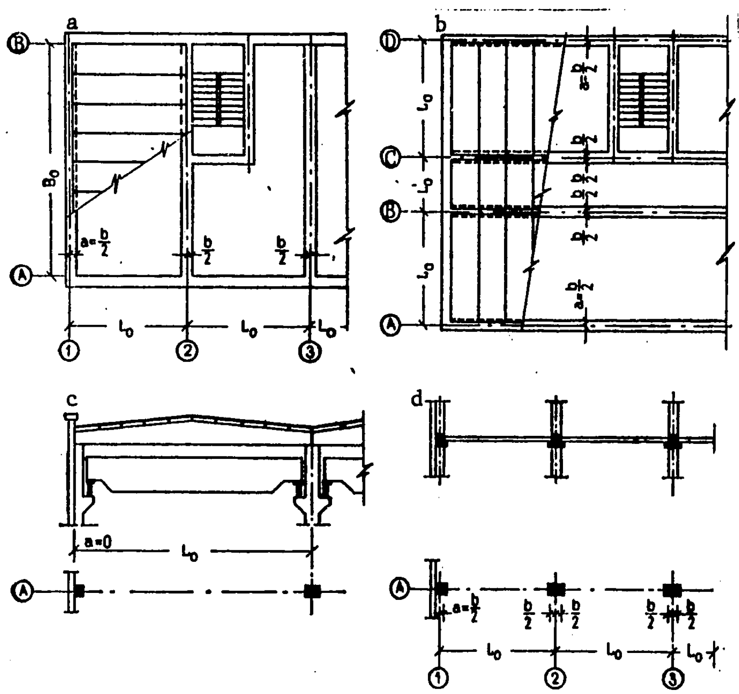


Figure 3. Examples of tie-in of bearing, self-supporting or hanging walls and columns to the modular layout center lines. In buildings with transverse bearing walls; b--in buildings with longitudinal bearing walls; c--in one-story frame buildings; d--in multistory frame buildings.

In design and construction practice, according to SNiP II-A.4-62 the tie-in of the walls to the modular layout center lines can be realized as illustrated in Figure 3a-d.

In order to ensure mutual replaceability of the structural products and elements executed from different materials, the possibility of using these products and structural elements in various types of buildings, their dimensions are designated considering standardization and unitization in construction.

By standardization we mean establishment of the optimal values of the parameters, the dimensions of the planning and structural elements and parts designed for application in mass construction.

Standardization in construction is accomplished in order to reduce the types of buildings, structures, their structural elements and parts to a technically expedient and economically advantageous uniformity.

Standardization presupposes the satisfaction of the requirements established by all-union state standards, SNiP and other normative documents imposed on the structural-planning elements and manufactured structural products and structural elements.

The end purpose of unitization, type design and standardization consists in determining the minimum number of standard sizes of products considering the variety of lay-out architectural-planning and structural solutions of buildings for different purposes.

For industrial prefabricated construction and production of structural elements and parts it is necessary to establish defined dimensions and their technical descriptions. The products are characterized by such indices as standard size and type.

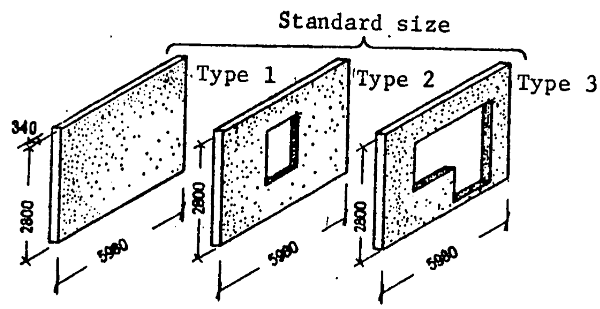


Figure 4. Types of structural elements of one standard size.

The products of certain dimensions (width, length, height) and identical structural design belong to the same standard size of structural products and elements.

The products of one standard size but having different reinforcing, embedded fittings or installation openings (Figure 4) are designated by one type indicator.

The nomenclature of the construction products is contained in the developed all-union catalogs of standardized construction products (Catalog II-04, the all-union catalog of industrial reinforced-concrete and concrete products) mandatory for application in industrial construction, and so on.

On the basis of the catalogs provision is made for production of the products for a defined period by different plants making structural elements and the application of the structural elements in one building or structure independently of the place of manufacture.

Section 4. Tying the Standard Designs to a Specific Construction Site

The construction of the majority of nonindustrial and industrial buildings in the Soviet Union, as was stated above, is by standard designs.

The choice of the standard design is made by the charts in the construction catalog (SK) published by the TsITP. In the standard design chart the initial data of the developed building are presented, the area of application (climatic district), the temperatures at which it is possible for the building to function, the basic conditions of application (seismics, unstable ground or permafrost, and so on), the technical-economic indices and the layout of the design are referenced to them.

Inasmuch as the standard design cannot fully take into account the local construction conditions (the relief, the groundwater level, aggressiveness of the groundwater, depth of freezing of the ground, and so on), and reworking it is forbidden, the local design organizations undertake "tying" of the buildings.

The tying of the standard design presupposes operations connected with ensuring its greatest correspondence to the local construction conditions.

After selecting the standard design and obtaining the documents for it, the so-called tying operations are performed consisting of the following:

Siting of the building on the master plan with determination of the basic planned elevations (the angular elevations of the building and entrance to it) and absolute elevation of the finished floor of the first story;

precise determination of the depth of the foundation and its dimensions depending on the hydrogeological data for the selected site and depth of freezing of the ground. When necessary additional structural calculations and solutions are developed for the foundation;

precise determination of the solutions for the lower story or basement in accordance with the relief of the construction site;

consideration of local climatic conditions influencing the variation in wall thickness, heat insulating layers of the enclosing structures, the number and type of heating devices;

the development of connections to the existing or planned water supply, sewage, electrical supply, heat supply and gasification networks;

replacement of certain structural elements in the standard design by others produced by local construction enterprises.

When the number of changes in the standard design is insignificant, the exact determinations are introduced directly on the corresponding sheets of the specifications.

Sometimes when tying standard designs quite complex changes come up (replacement of the prefabricated foundation by columnar or piling, and so on); in these cases additional drawings and calculations are developed.

After completion of the tying of the design all of the design materials are transmitted to the organization responsible for construction.

Section 5. Technical-Economic Indices of Design Solutions

In the case of mass construction of buildings or structures, the economicalness of the adopted layout and structural solutions has great significance. The prerequisites for reducing the cost of construction of nonindustrial and industrial buildings and structures must be established in the design stage.

Indices which are regulated by the norms exist for determining the economicalness of standard designs. These include the space and floor-planning indices, the annual operating expense indices, the labor and material consumption indices, estimate indices, the indices of the degree of unitization of the prefabricated elements, and so on.

The space and floor-planning indices include the following calculation units influencing the economicalness of the solution:

For housing--one apartment, 1 m^2 of living space and 1 m^2 of public area; for corridor apartment houses--one place, 1 m^2 of living area and 1 m^2 of public area; for hotels--one hotel space, 1 m^2 of living area and 1 m^2 of usable area; for public eating enterprises--one place in the dining room; for institutions of learning--one place for a student; for domestic services enterprises and stores--one workplace; for libraries--1,000 books; for hospitals--one place for a patient; for industrial enterprises--the unit of installed production capacity, 1 m^2 of developed production area, 1 m^2 of developed usable area.

The space and floor-planning indices are measured by the ratio of the total construction volume to the basic calculated unit:

Housing--one apartment, 1 m^2 of living space with respect to a standard floor, with respect to a section, with respect to a house; public buildings--one place and 1 m^2 of working area; industrial buildings--1 m^2 of developed usable area.

The indices of annual operating expenditures are presented only with respect to housing and corridor apartment houses, and they consist of minor repairs; communal expenditures (heating, electric lighting, sewage, water supply, gas), expenditures on maintaining stairs, elevators and areas for public use.

The estimated construction cost indices consist of the following:

estimated cost of the building: a) per unit capacity; b) per m^2 of working area; c) per m^3 of the building;

the cost of general construction operations;

the cost of equipment, furniture, inventory per calculated unit;

the cost of amenities per calculated unit.

The cost of labor and materials consumption indices characterize the degree of industrialness of construction, and they are measured by the ratio of the cost of labor and materials consumption to the basic calculated unit of the project:

1 m^2 of living space and 1 m^3 of the housing building; 1 m^2 of developed usable area and 1 m^3 of the volume of industrial buildings; 1 m^3 of the volume of public buildings.

The indices of the consumption of the basic construction materials are as follows--steel and cement in kg, lumber in m^3, insulation in m^3, brick in thousands of bricks, prefabricated reinforced-concrete and concrete elements in thousands of pieces of provisional brick--are presented in the standard designs per m^2 of living area, m^2 of working area, m^3 of building, and so on.

The consumption of the basic construction materials and mass of the building reduced to its total construction volume or to 1 m^2 of living or working area of the building, are less, the better the architectural-design and structural solution of the building.

The index characterizing the progressiveness of structural solutions is small mass of the building per m^2 of total or usable area. The mass of the building is calculated by the consolidated indices of its structural elements.

The progressiveness of the structural solution of the building characterizes two more indices: the level of prefabrication and level of unitization of the prefabricated elements. These indices include the number of installation elements per project and per m^2 of total or usable area of it; the number of standard sizes for the building, the number of types of products.

With consolidation of the installation elements, their number is reduced, which has a positive influence on the organization of the production and installation of the prefabricated elements.

The determination of the most efficient version of a design solution is made by comparing the technical-economic indices of the developed versions with a standard. The standard is a design which is progressive from the social, technical and economic points of view.

Chapter II. Course Design Phases in Examples of Nonindustrial and Industrial Buildings

Section 6. Drawing up Sketches and Preliminary Calculations of the Designed Project

During training, the student must draw up course designs of nonindustrial and industrial buildings. Drawing up a course design offers the possibility of teaching the student how to use the technical literature, standard designs, construction norms and regulations and other reference materials; how to study the basic procedures for space and floor-planning layouts of nonindustrial and industrial buildings with the development of structural solutions; to instill skills in graphical representation of the design material and also the performance of technical-economic and heat engineering calculations; to write the explanatory note to the design.

As the initial materials for drawing up the course design, the student receives the design assignment which includes the following data: the place of construction; the layout of the design; the procedure for execution of it; the layout and the dimensions of the facilities; construction materials and elements; sanitation engineering equipment; the construction site and buildings located on it; requirements with respect to graphical layout of the drawings, their scales and also the number of sheets of drawings and pages of explanation.

While studying the assignment the student must become familiar with the materials required to work on the design. By sketches from analogous designs and notes from the corresponding literature it is necessary to develop all possible versions of the architectural design and structural solutions of the building. Only then can the student clearly conceive of the functional interrelation of the facilities which will serve as the basis for the layout of the entire building with respect to functional zones, groups and floors. Carefully studying the assignment and selecting the required initial material, the student can proceed with drawing up the conceptual design of the building.

The rough drawings must reveal the general space-floor planning and structural solution of the building. The sketches are made in pencil, freehand, on a small scale (1:400). The small scale offers the possibility of encompassing the main part of the planned layout and more quickly estimating its positive and negative aspects. In every building it is necessary to isolate the main rooms auditoriums, offices, apartments, compartments, and so on) and provide for their functional interrelation with the auxiliary rooms (vestibules, corridors, entries, and so on) and also the interrelation of the auxiliary spaces to each other.

The preliminary layouts of the building must consist of sketches of the floor plans story by story, on which the architectural design layout procedure is noted, for example, whether the building will be symmetric or asymmetric, rectangular, with or without projections, and the number of stories of the building is determined.

As a result of working on the general procedures for the space and floor-planning solution of the building the student must come up with two or three versions. These versions are compared and analyzed, and after consulting with the teacher, the most efficient and economical version of the designed building is selected.

The configuration of the building and its dimensions (width, length and height) must be approximately planned in the selected version, the structural-design layout must be established considering modular coordination; the arrangement of the rooms and spaces and groups of them must be adopted considering the functional zoning, their location by floors; the general architectural-compositional concept of the building must be planned.

After approval of the design and structural layouts the student proceeds with further development of the drawings. The plans for the floors, ceilings, foundations and other elements of the building and a detailed section of the wall are drawn up, the most characteristic architectural-structural units and parts of the building are planned. When drawing up the conceptual drawings, the configuration and dimensions of the building in plan are more precisely defined, the dimensions between the layout center lines of the bearing supports are established, the distribution and placement of the rooms and spaces in plan and by stories are fixed, and the layouts of individual rooms and spaces (vestibules, stairs, and so on) are developed.

In all phases of the design work it is necessary to consider the problems of economics of the architectural-design and structural solutions. The solution which combines the requirements of expressive architecture, simple and efficient space and floor planning, expedient application of construction materials and structural elements is considered economical. Preliminary technical-economic calculations are performed in the conceptual design phase: the living or working area of individual rooms, the total or usable area of the building, the coefficients K_1, K_2 and so on are approximately calculated.

Section /. Development of the Master Plan

The design of the master plan of an industrial enterprise or complex of nonindustrial buildings is one of the most important steps in developing a course design.

The master plan is a horizontal projection of the site on which the designed building is located. The master plan gives an idea of the arrangement and the functional or production relations of the designed building to other buildings and structures, their orientation with respect to points of the compass, bringing in the service lines, and so on.

When developing the master plan it is necessary to be guided by SNiP II-M.1-71 and SNiP II-6-75. Inasmuch as the master plans of industrial enterprises and nonindustrial buildings differ from each other, let us consider their design principles separately.

General Principles of Laying Out Master Plans for Nonindustrial Buildings. In the designs for laying out and developing cities and settlements for the creation of a mutually coordinated design structure, zoning of the territory by use must be provided with isolation of the following functional zones:

development--for housing districts, microdistricts, public centers (administrative, scientific, training, and so on), and public green areas;

industrial--for locating industrial enterprises and facilities connected with them;

communal-storage--for the location of bases, warehouses, garages, streetcar yards, trolley bus and motorbus yards, and so on;

external transportation--for transport units and structures (passenger and freight stations, ports, piers, and so on).

Within the territory of a rural populated area it is necessary to isolate development and production zones.

In the course design for training purposes it is expedient to consider the placement of the designed nonindustrial building within the layout of the microdistrict or part of it. Therefore the student must become familiar with the basic principles of microdistrict design before proceeding with the development of the master plan.

The placement of the buildings within the territory of the microdistrict is based on the functional zoning diagram considering the density of coverage, the servicing radius by public buildings and structures of the population (for more details see Section 14.21). The functional zoning diagram indicates the location of public buildings, the microdistrict park, the territory occupied by housing.

When drawing up this layout it is necessary to be guided by the following principles:

it is desirable to place the microdistrict park in the central part of the microdistrict. The park must be united with respect to area or broken down into several parts;

the sites for schools and kindergartens are placed near the microdistrict park. The location of children's institutions is established considering their servicing radii. The location of sites for children's institutions near main streets is undesirable;

it is expedient to lay out stores in the form of detached cooperating buildings near main streets considering municipal transportation stops;

it is recommended that communal businesses (garages, workshops for repairing household appliances, service stations, and so on) be placed in a separate zone isolated to the maximum from the children's institutions;

the network of streets, thoroughfares and sidewalks must be designed as a united system providing for fast, safe pedestrian and transport traffic within the microdistrict.

The sanitation and fire-safety breaks between buildings play an important role in the placement of buildings. For normal insulation and ventilation of the facilities, the distances between residential buildings according to SNiP II-L.1-71 and also between residential and public buildings must be adopted in accordance with the data in Table 1.

Table 1. Minimum Sanitary Spacing Between Residential and Public Buildings

Standardized Spacing	Spacing m, When Building Buildings With Following Numbers of Stories: 2-4	5	9	16
Between the long sides of the buildings	20	30	48	80
Between the long sides and the ends of the buildings and also between the ends of the buildings with living space windows	12	15	24	45
Between the ends of buildings without living space windows	High fire-safety break norms (see Table 2)			
Between tower-type buildings with location of them on one center line	--	--	36	60

The fire-safety breaks between residential buildings, public buildings, and auxiliary buildings of industrial enterprises must be adopted according to Table 2, and between production and agricultural buildings and structures, in accordance with SNiP for the design of master plans of industrial enterprises and the design of master plans for agricultural enterprises.

Basic Principles of Master Planning Industrial Enterprises. On the basis of analyzing the master plans of modern industrial cities in the USSR it is possible to arrive at the conclusion that the industrial zones and complexes (see Sections 29, 30) are important elements of the structure of these cities and occupy 5 to 20 percent of their entire territory.

Table 2. Fire-Safety Breaks Between Residential and Auxiliary Buildings

Degree of Fireproofness of Building	Spacing, m, With Degree of Fireproofness of Building: I, II	III	IV, V
I, II	6	8	10
III	8	8	10
IV, V	10	10	15

Note: The classification of buildings by the degree of fireproofness must be assumed by the fire-safety norms for the design of buildings and structures.

The master plan, being the most important part of the complex design, organizes the designs of the structural elements of the industrial complex or enterprise and relates its internal structure to the layout of the adjacent area. Therefore, the efficient solution of a master plan comes from efficient, economical organization of the production process, transportation and normal operating conditions at a group of enterprises or the given enterprise and also the requirements of convenience of the mutual relation of industrial and developed territories.

As modern practice indicates, it is necessary to place the basic structures, roadways, service lines and amenities both of a group of enterprises and a separate enterprise (see Sections 30, 31) and also the adjacent region, observing the conditions of specialization, cooperation and combination of production, industrialization of construction, efficient and economical use of territory, the engineering networks, the power engineering and production resources of the region.

Generalizing the design experience and the operating data on the modern level, a number of specialists [18] have formulated the basic principles of master planning industrial enterprises:

the placement of the enterprises in the industrial complex is based on cooperation of them with other enterprises with respect to basic and auxiliary production, transportation, engineering networks, structures and cultural-general services for the workers;

ensurance of optimal placement of different nature and capacity of production at the plant site and also the possibility of varying the volumes and forms of production output at existing plants and creating conditions for expansion of the enterprises;

increasing the capacity of the enterprises and consolidation of the production units;

specialization of enterprises with respect to reproduction of a narrow nomenclature of products;

observation of efficient zoning of the territory of the enterprises in all phases of its development;

placement of buildings and structures with minimum separation, in blocked (see Section 32) structures insofar as possible, providing for compactness and high esthetic level of coverage, amenities for the territory, minimum length of engineering networks, roads and railroads;

complex solution of the routing and methods of laying out all forms of service lines;

application of advanced forms of industrial transportation not intersecting with basic people flows insofar as possible.

Let us consider the design of ferrous metallurgical plants as an example.

Ferrous metallurgy is among the most important branches of heavy industry. When designing metallurgical plants one of the basic goals is development of an efficient master plan. The master plan layouts for the enterprises of ferrous metallurgy are varied, and their solutions depend to a significant degree on the production volume.

The location of steel-making shops is oblique to the blast furnace and rolling-mill shops. The steel-making shops are usually arranged in parallel or series. These layouts are entirely justified for the initial design solutions. However, the appearance of new shops on the site of an enterprise increases its territory and alters the master plan significantly. An example layout of a master plan of a metallurgical combine designed in the USSR is presented in Figure 5.

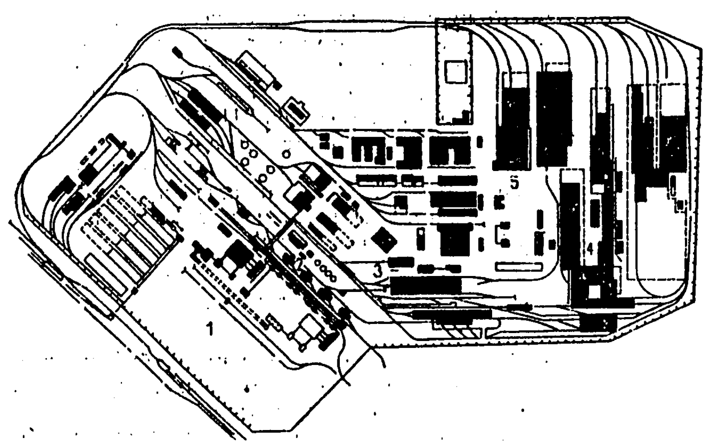


Figure 5. Version of the master plan solution for a metallurgical combine. Production: 1--by-product coke; 2--blast furnace; 3--steelmaking; 4--rolling mills; 5--repair shops.

As a rule, two master plan layouts for ferrous metallurgical enterprises have been adopted in foreign countries.

In the first layout which is most widespread in the United States, the coke-oven batteries, blast furnaces, steel-making and rolling-mill shops are arranged in a single line or in stages. The shop layout offers the possibility of expanding it without disturbing the developed flows of materials. The arrangement of the shops in a single line leads to more efficient solution of the master plan and promotes better territorial zoning. However, this solution requires a long site.

In the second layout which is widespread in western European countries and Japan, as a rule, parallel arrangement of the blast-furnace, steel-making and rolling-mill shops is used where frequently sites that are close to square or triangular are used to build the plants.

In the USSR the Gipromez [State All-Union Institute for the Planning of Metallurgical Plants] has developed design proposals for a new type of metallurgical plant based on the requirements of technical progress in ferrous metallurgy.

A theoretically new solution for the master plan of a modern metallurgical plant which takes into account the increased architectural-design requirements (Figure 6) has been created in the design proposal; problems relating to all of the shops and services providing for normal implementation of new production processes, basically continuous-action and with maximum removal of equipment to open areas, with blocking of the shops offering the possibility of construction of the entire industrial enterprise without limiting the number of blocks, have been comprehensively resolved.

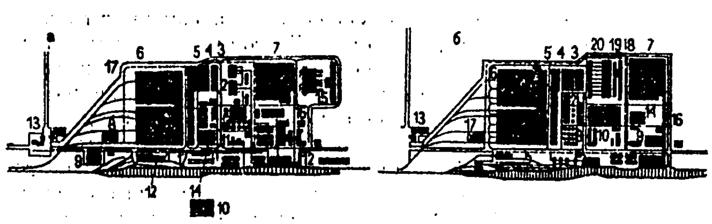


Figure 6. Versions of the master plan solution (a, b) of a metallurgical plant: 1--by-product coke plant; 2--blast furnaces; 3--converter division; 4--the same, continuous casting of steel; 5--continuous wide-sheet hot rolling mill; 6--rolling and pipe mills; 7--the same, slag processing; 8--purification works; 9--repair and installation shop; 10--main substation; 11--water management; 12--the same, storage; 13--plant administration; 14--central laboratory; 15--sintering plant; 16--conveyors; 17--tramway; 18--pelletizing plant; 19--pellet section; 20--rotary presses.

After studying the basic principles of master planning industrial enterprises or nonindustrial buildings, the student can proceed with the development and drawing up of a section of the master plan on the sheets. The drawing up of a master plan begins with plotting the contours and levels of the site which characterize its relief on the adopted scale (1:1,000, 1:2,000 and so on) and placement of the designed building on it.

The scale is the ratio of the size of the building and its elements on the drawing to the actual full-scale dimensions. Then other buildings and structures which have a functional or production relation to it are located on the site plan, the spacing between which is adopted in accordance with the sanitary and fire-safety norms. In addition, the amenities and green spaces, the dimensions of sidewalks and thoroughfares are indicated on the master plan. After drawing all the buildings and structures, a legend is compiled for the master plan. The required technical-economic indices are calculated. As a rule, the master plan drawing is pochéd in one or two shades. It is permissible to color the master plan elements.

Section 8. Development of Plan Views and Sections

When executing the course design, the student must develop various plan views of the foundations, floors, the floors and ceilings between stories and at the attic level floors, overhead or roof.

One of the most important forms of the designs of a building is the floor plans.

The floor plan is the horizontal projection of the building on the level somewhat above the base for the window openings.

The floor plans determine the dimensions and the shape of the entire building, the dimensions and shapes of individual rooms, their area and interrelation, the location of doors and windows. The plans reflect the structural layout of the building: the location of outside walls, partitions, columns, stairways and other structural elements.

The sanitary engineering equipment is indicated on the floor plans of residential buildings: baths, lavatories, toilets and other equipment and devices. In buildings with furnace heating, the dimensions and location of the furnaces and also the smoke and ventilation ducts are indicated. The dimensions of the columns, the thickness of the outside and inside walls, the dimensions of stairwells (stairways, landings), and so on are determined by the floor plan.

The dimensions and the location of the production equipment--machine tools, materials-handling equipment, tanks, boilers, and so on--are indicated on the plans of production buildings. Transport routes and crane tracks are indicated. The location and layout of the equipment are coordinated with the space-floor planning and structural solution for the building.

If the building is a one-story building and of simple shape, one plan view is drawn up. In the case of a multistory building that is complicated in plan view, several plan views are made differing from each other, for example, the plan for the first story and the plan for the standard story. In some cases (when the floor plans are identical), part of the first story, for example, a detail of the entry is indicated.

After detailed development of the sketches and performance of the heat engineering calculation for determination of the outside wall thickness (see Section 12) it is possible to proceed with drawing up the basic drawings, plan views, sections and elevations of the building.

It is recommended that TM, M, F or B pencils be used to draw the plans; the contours, center lines and dimension lines are plotted using T, 2T and H pencils in the following order:

plotting the grid of center lines constituting the layout center lines;

tie-in of bearing and enclosing structural elements of the building to the layout center lines;

layout of the rooms considering their interrelation;

placement of doors in the rooms with ensurance of the greatest convenience of use;

placement of window openings considering the lighting of the room;

placement of the sanitary engineering and process equipment;

layout of stairwells, ventilation ducts and chambers. Figure 7 shows the sequence of graphical representation of the plan view of a residential section.

After minor graphical changes, the labels are put on the layout center lines. The labels for these center lines are placed on the left side and bottom of the plan. The center lines located along the building are labeled from bottom to top using capital letters from the Russian alphabet; the horizontal center lines are labeled from left to right using Arabic numerals (see Figure 7). If the layout of the center lines from the top does not coincide with the bottom, then the layout center lines are run from the top of the plan, and in the case of an asymmetric plan the center lines are placed on all four sides. Usually three dimension lines are indicated on the drawing:

the dimensions of the window and outside door openings and partitions are indicated on the first dimension line;

the dimensions between the center lines of the bearing structure (outside walls, inside bearing walls or columns) are placed on the second line;

the overall dimensions between the edge center lines of the outside walls of the building are indicated on the third dimension line.

The first dimension line is placed at a distance of 10-15 mm from the outside outline of the walls. This line must not intersect the projecting parts of the building. It is necessary to take a distance of 6-10 mm between the dimension lines.

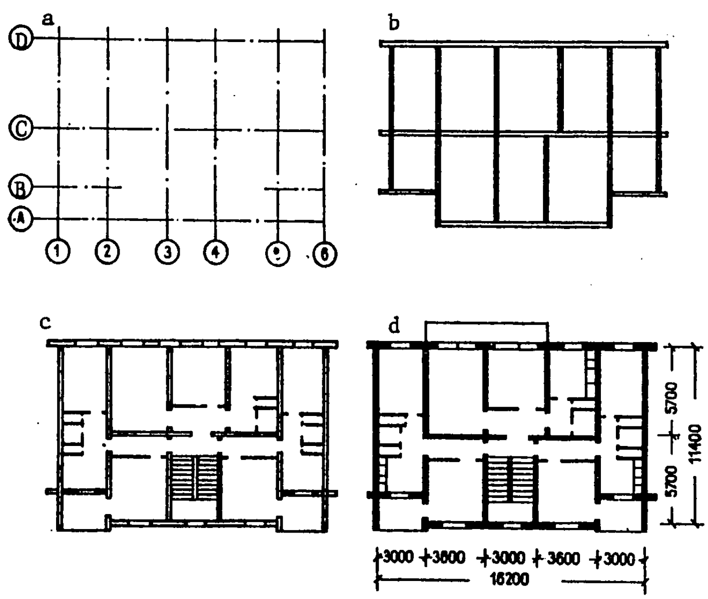


Figure 7. Sequence of graphical representation of the plan view of a residential section: a--plotting the center line grid; b--plotting the wall and partition thicknesses; c--development of the layout of the section; d--final inking of the plan.

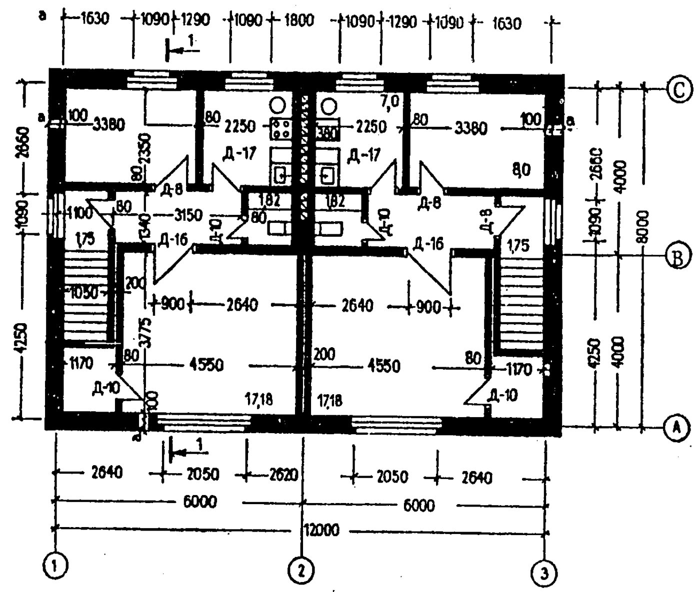
The dimensions of individual rooms are indicated inside the building with respect to depth and width with indication of different thickness of partitions, inside main walls; the dimensions of door openings in the partitions and walls are indicated. The areas of the individual rooms are indicated on the floor plans (Figure 8a).

The floor plans of residential and public buildings are usually drawn on 1:50 and 1:100 scale, and the plans for production buildings, on 1:200 or 1:400 scale. If necessary another scale can be adopted.

In the course and diploma designs, it is permissible to draw up combination plans, for example, the plan view of the foundations and the plan view of floors, the plan for the first story and the plan for the standard story, the overhead and roof plans.

The foundation, floor, overhead and roof plans are drawn on a 1:200, 1:400 scale.

The sections of the buildings (Figure 8b) are of two types: architectural to reveal the internal form of the rooms (interiors) and structural to reveal the structural design of the building. Usually structural sections are used in course designs. Depending on the position of the cutting plane the sections are longitudinal and transverse. The section is made so that the window and door openings and the structurally complex parts of the building (stairwells, elevator shafts, lifts, galleries, skylights for light and ventilation, and so on) will fall in it.



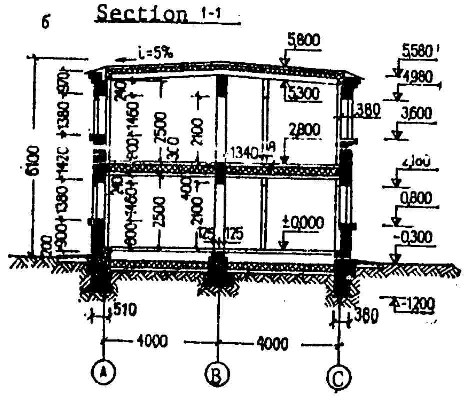


Figure 8. Graphical execution of a floor plan (a) and section of a building (b).

Before beginning to draw the sections it is necessary to select the most characteristic location for the section, establish the heights of the rooms, develop the structural design of the floors to determine their composition and thickness, find the story heights, make the heat engineering calculations of the attic floor or integrated roof, develop the structural design of the roof or overhead, determine the structural design of the foundations and the elevation of the foundation footing, precisely determine the elevations of the stair landings and draw up the section. It is recommended that the sections be drawn up according to the following procedure: plot the basic layout center lines; tie the foundations and walls to the center lines; show the floors, covering or roof; draw the window and door openings; design the stairs.

Two vertical dimension lines and one vertical numerical elevation line are shown on the sections. The numerical elevation line of the levels is plotted closest to the building: ground, first floor (taken as ±0.000), bottom and top of openings, top of cornice and hip of the roof.

The elevations of the wall openings, the pitch of the roof, and so on are placed on the next dimension line. Then comes the overall dimension line from ground level to the top of the cornice. Below ground level the elevations are indicated with a minus sign.

Two dimension lines are placed under the section. The first between the center lines of the bearing structures, and the second, between the center lines of outside walls. The labeling of the center lines on the section must correspond to the labeling on the plan view. The story height, the dimensions of the openings in the inside walls and partitions with tying to the floor and ceiling levels and the floor thickness are indicated inside the sections. In addition, the foundation dimensions, the thickness of various walls and dimensions from the center lines of these walls to their faces must be indicated on the sections. The dimensions of the stair flights and landings are indicated horizontally on the sections of the flights of stairs, and the distance between landings from floor to floor is indicated vertically.

Section 9. Development of Facades

The outside appearance of a building is closely connected with the inside layout, spatial and structural design. In addition, the city planning conditions influence its architecture (the location, natural climatic and architectural surroundings, compositional significance in the group).

When developing facades, in order to ensure harmonic relationship to all of its parts and achieve the most artistic expression, it is necessary to know a number of compositional procedures and means.

Before proceeding with the development of the facade of the building it is necessary to become familiar with the principles of architectural composition.

The basis of the architectural composition of a building is its spatial structure, that is, the harmonic relation of the inside space and outside appearance of the building. The means of architectural composition are designed to achieve the greatest artistic expression of both the individual buildings and group of buildings.

Each type of building is characterized by its spatial structure. Residential buildings consist of residential cells--different sizes of apartments. The organization of a large space, an auditorium, market or other type of large room is characteristic of public buildings. Production buildings consist of large-bay facilities (shops designed for process equipment).

The most important compositional means in building architecture is tectonics. The tectonics in the architecture of a building reveal the uniqueness of its structural system and spatial structure. The structural shapes making up the building are transformed as a result of creativity into an integrated architectural-artistic structural system. The structural and artistic features of the construction are organically combined in the tectonics of a structure. The basic structural elements of a building (walls, openings, columns and floors) dictate its outside appearance, and depending on the purpose of the building, its location in the environment and also the compositional concept, one tectonic expression of the building or another is created.

The means of architectural-artistic expression of a building include contrast--the sizes and shapes of the building elements, the nature of their arrangement, difference in the degree of illumination, color intensity, and so on. A brightly illuminated part of the building contrasts sharply with a deep shadow on it; a blank wall contrasts sharply with a wall full of openings, and vertical elements contrast with horizontal elements.

The breakdown of the surface of an architectural body into individual volumetric elements on a planned architectural scale has great significance in the composition of a building. By architectural scale we mean the degree of breakdown of the composition, the size of its from with respect to the overall building. Breakdown into small elements is not characteristic of large monumental buildings; at the same time large-scale breakdown is not characteristic of small buildings.

When designing buildings and combining them into architectural groups frequently such artistic means as rhythm are used. By rhythm in architecture we mean the law of repetition (alternation) of different elements of the building with equal intervals in the overall composition of the architectural structure. The uniform alternation of one or several elements with equal intervals is called metric (Figure 9a). The rhythmic order of repetition is characterized by regular augmentation or diminishing of elements or intervals (Figure 9b).

The proportions of a building are an important means of its artistic expression. Proportions are a defined system of relations of parts and shapes of an architectural structure. Determining the proportions of an architectural structure and its relation to the group in which it is one of the elements, it is necessary to discover the relations of the parts and the whole characteristic of it, for example, find the proportions with designation of the dimensions of the rooms and the building in plan and section.

Using certain means of architectural composition, it is necessary to remember the economic expediency of their application. An excess number of details on a facade or large blank areas lower the architectural-artistic impression of the building. The creative use of means of architectural-artistic expressive composition permits the creation of architectural structures and groups of nonrepetitive appearance.

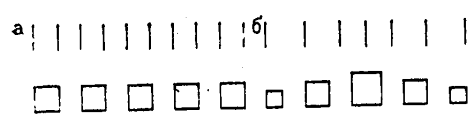


Figure 9. Diagram of the placement of the elements of buildings and structures in the architectural composition: a--metric series; b--rhythmic series.

Studying the methods of architectural composition, it is possible to develop a facade for the building. It must be remembered that facade development is the most creative process, and the solution of this problem to a great extent determines not only the external appearance of the building, but also the skill of the student in embodying the assignment in the design. The facade must be drawn up together with drawing up the plan views and sections of the building. The necessary horizontal dimensions are carried over from the plan views to the facade: the overall length of the building, the dimensions of projections and recesses, the dimensions of the window and outside door openings, the overhang and dimensions of ledges, the outlines of loggias, balconies and bay windows. The sizes of the shadows on the facade are determined by the plan view of the building.

All of the necessary vertical dimensions are determined by the section on the facade: the building height, socle and parapet dimensions, the window and door elevations, overhang, cornice and rooftop elevation, and so on. The section of a building gives a representation of the depth of shadows on the facade.

The developed facade of the building is drawn up, washed and inked. During the development of the facade, in connection with the compositional concept, the location and dimensions of the windows, doors and other architectural details of a building can be changed. These changes are introduced on the plan and section drawings.

The facades and architectural details are made with mandatory construction of shadows [10], with washing with India ink (not chemical) or single-shade water color.

Before pochéing, the entire facade is colored or coated lightly with ink; after this layer has dried, inking is completed. First of all the planes of the facade farthest from the viewer are covered with a light shade (one or two layers). Then the shadows are covered with a light shade and the window and door openings with a medium shade, after which the accenting at the required points of the shadows, openings and similar details is started. When doing this it is necessary to remember that the next layer is applied only after the preceding layer has completely dried. The shadows on the lighted part of the building from overhangs, walls, columns, projections, a row of standing buildings, and so on are called falling shadows, and the shadows on the unlighted part are called natural shadows. When pochéing the facade it is necessary to know that the falling shadows must be darker than natural shadows, and the shadows from ties, capitals and casements are deeper than the walls from projections of a wall, balconies, overhangs, and so on.

Section 10. Execution of Drawings of Architectural and Structural Details and Units of a Building

When developing a course design it is necessary to draw several units and details most characteristic of the designed building. The selection of the details and units of the building is made after developing the basic drawings. The units and details are developed on a scale ensuring clear, detailed representation of them. The basic scale for structural units is 1:20 (1:50), and for small details 1:10.

When drawing up the units and details special attention must be given to the presence of the required legends, numbers, specifications and the quality of their execution. Every unit and detail must have a designation--label and short title. When executing the drawings of units and details it is recommended that albums of standard details and structural elements be consulted.

Various architectural and structural details and units of buildings can be selected for detailed development:

the structural elements of the floors between stories, the attic and basement floors with development of the contact junctions between the floors and the outside walls and inside supports;

the elements of sloping roof and trusses in the case of attic floors or the structural design of a flat roof with details of the gutters, enclosure, and so on;

architectural-structural details of stairways with development of the basic contact junctions and handrails;

large partitions, their dimensions and details;

architectural-structural solutions for balconies, loggias and main entrance;

structural solution of suspended ceilings if they are present in the designed building.

For frame and frame-panel buildings the contact junctions of the columns with the floor beams and panels, the units for fastening the wall panels to the frame elements are indicated.

In buildings made of local building materials (brick, small blocks, tuff and wood) the units and parts of the wooden floor, the support of the wooden beams on the outside walls, the outside walls on the foundations, and so on are of interest.

The number of architectural-structural units and parts subject to development is established by instructions.

Architectural details are executed on a 1:20, 1:50 scale. The individual elements of a building (overhangs, the entry detail, window frames) and treatment of them are indicated on the drawings. For better perception, color can be introduced. The architectural details are washed with water color or nonchemical ink.

Examples of structural units and parts and architectural details are shown in Figure 10.

Section 11. Selection of the Sanitary-Engineering, Stock and Service Equipment of the Designed Project

When developing a course design it is necessary to solve the problem of sanitary-engineering, stock and service equipment of the building.

The sanitary-engineering equipment of the building includes the heating and ventilation system units, water and heat supply, sewage and gas supply. These systems can be centralized from common municipal and settlement networks servicing industrial enterprises, public buildings and multistory residential buildings or local (autonomous) servicing, as a rule, low-rise buildings (one-two-story residential buildings, corridor apartment houses, seasonally inhabited housing).

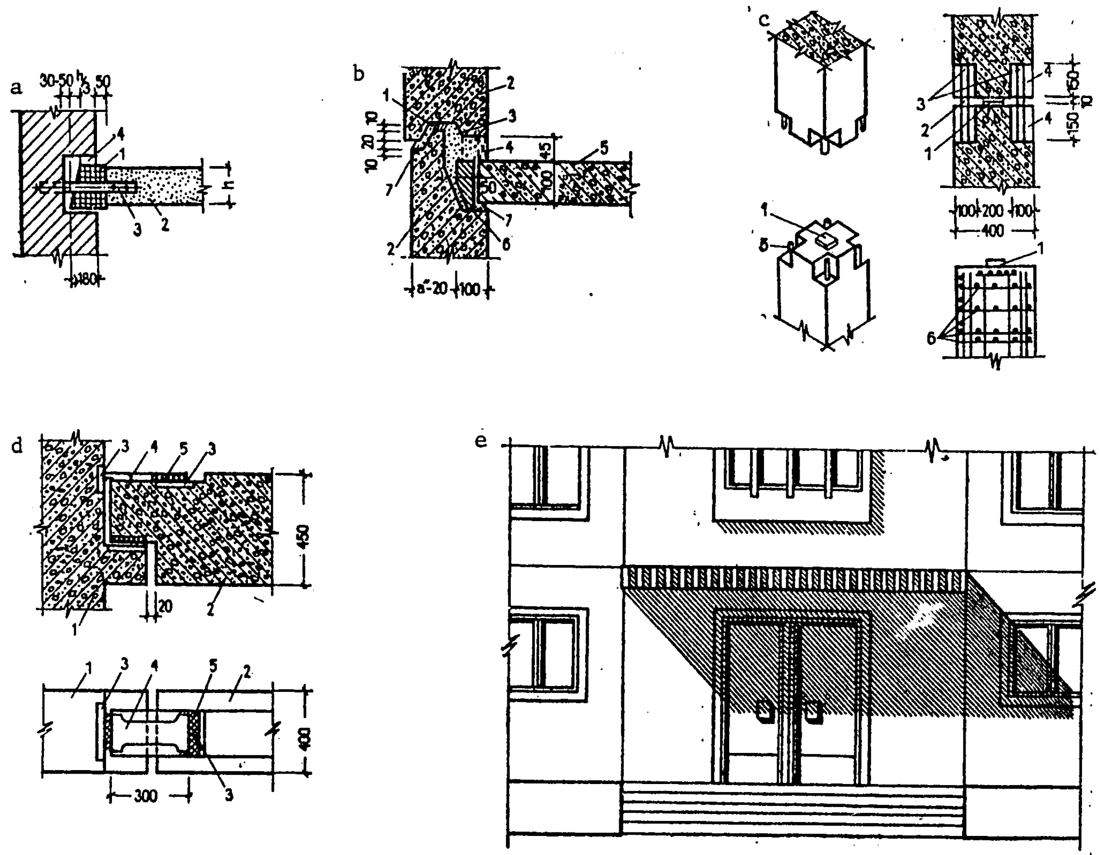


Figure 10. Examples of structural units and parts, architectural details. a--Support of the end of a wooden beam on a rock wall: 1--two layers of roofing felt on resin; 2--preservative treatment; 3--anchor 50x5 mm; 4--finish with mortar; b--structural solution of horizontal joints of outside wall panels with rain barrier: 1--insert made of porous rubber; 2--outside wall panel; 3--cement; 4--mounting gasket (2 per panel); 5--floor panel; 6--insert made of mineral tiles 50 mm thick wrapped in asphalt roofing paper; 7--caulking with mortar; c--flat metal-free column joint: 1--aligning concrete projection; 2--pool welding of reinforcing projections; 3--type-300 mortar; 4--joint recesses; 5--longitudinal reinforcing rods; 6--transverse reinforcing grids; d--structural design of the supporting unit for a truss on a column in a standardized frame: 1--column; 2--truss; 3--embedded parts; 4--top plate; 5--welded joints; 3--entry detail.

In the designed building it is necessary to place the various sanitary-engineering units (washrooms, bathrooms, showers, water closets, pissoirs, gas and electric stoves, heaters and furnaces, and so on)--see Figures 11 and 12. Depending on the room sizes, the arrangement of the various units, their types and dimensions can be different (see Section 17).

On the floor plans it is necessary to indicate the location of the ventilation ducts, modules and chambers, and the type of ventilation is indicated in an explanatory note (with natural draft, with mechanical stimulation, exhaust or intake-exhaust).

The source of heat is indicated in the assignment. The student must select the heating system corresponding most completely to the designed building, establish the point of entry of the heat line, the type or form of heating units.

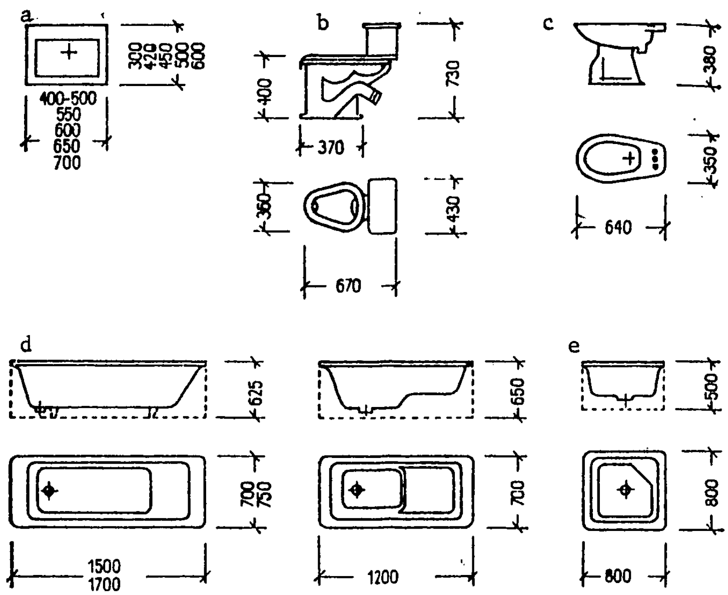


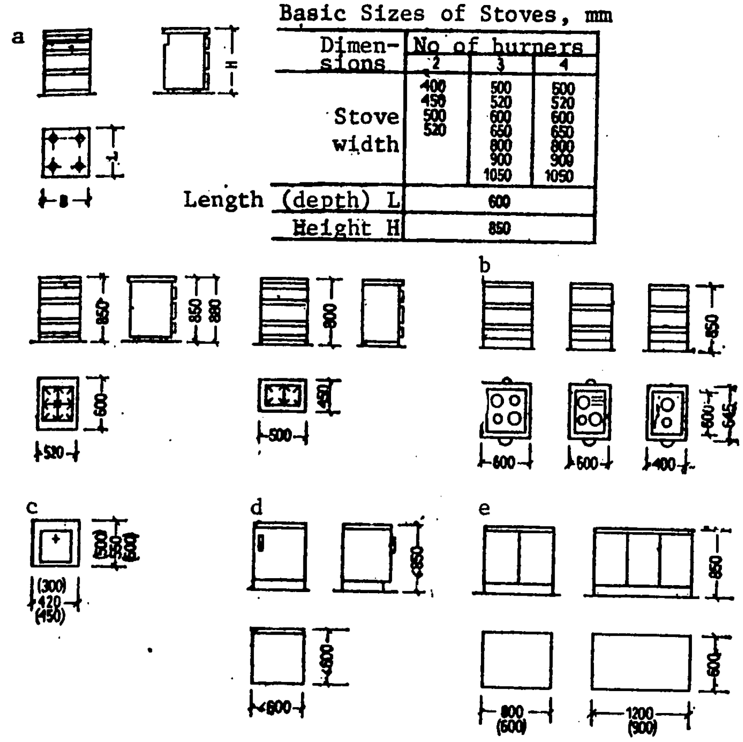
Figure 11. Overall dimensions of washroom and toilet equipment. a--Washbasin; b--water closet; c--bidet; d--bathtub; e--shower base.

When developing a building design it is necessary to determine the sewage characteristics and the locations where the units will be installed. On the plan for the first floor the location of the sewage outlet is indicated. When building a waterless toilet in a one- or two-story building it is necessary to observe a number of special requirements: the waterless toilet must be placed on an outside wall so that the cesspool hole will be as far as possible from the windows of the living quarters. The room with the toilet must be separated from the hallway by an anteroom.

When selecting the water supply system it is first necessary to establish the purpose and type, the point of entry into the building, the type and sizes of fittings and the location of fire hydrants. If provision is made for hot water, the method of heating it must be indicated in the explanatory note (water-heating columns, boilers or from a central boilerroom).

When developing the gas supply system, the point of entry into the building must be noted on the design, and the devices for using the gas must be indicated (gas stoves, furnaces, water heaters, and so on).

The service equipment of the building includes the electric networks, elevators, garbage chutes, materials-handling equipment and other machinery.



Basic Sizes of Stoves, mm

Dimensions	No of burners 2	3	4
Stove width	400 450 500 520	500 520 600 650 800 900 1050	600 520 600 650 800 909 1050
Length (depth) L	600		
Height H	850		

Figure 12. Types and sizes of kitchen equipment. a--Basic sizes of gas stoves; b--the same for electric stoves; c--the same for sinks; d--the same for refrigerators; e--the same for built-in furniture--counters and cupboards.

If an elevator is designed in the building, its location is indicated on the plan views. The explanatory note describes the type of elevator (passenger, freight-passenger, freight), its capacity, and the location of the machineroom.

An elevator is a periodic-action lifting device. The basic technical specifications of an elevator are its load capacity, speed and places. The most widespread are elevators with a load capacity of 320, 500 and 1,000 kg with a speed from 0.5 to 4 m/sec and higher. The dimensions of passenger, freight-passenger and freight elevators are illustrated in Figure 13. The number of elevators in residential buildings is taken according to Table 3; in other types of buildings the number is taken by calculation or by SNiP II-L.1-71.

Table 3. Maximum Required Number of Passenger Elevators and Their Basic Parameters According to GOST 22011-76 in Residential Buildings With Different Numbers of Floors

Number of Floors in Residential Buildings	Number of Elevators	Load Capacity in kg; Speed in m/sec	Maximum Number of People Living on Floor of Each Section of an Apartment House or on a Floor of a Corridor Apartment House
To 9	1	320; 0.71	40
10-12	2	320; 1.00 320; 1.00	40
13-16	2	320; 1.00 500; 1.00	30
13-16	3	320; 1.00 320; 1.00 500; 1.00	40
17-25	In residential buildings 17-25 floors high inclusively, the number and parameters of the elevators are determined by calculation		

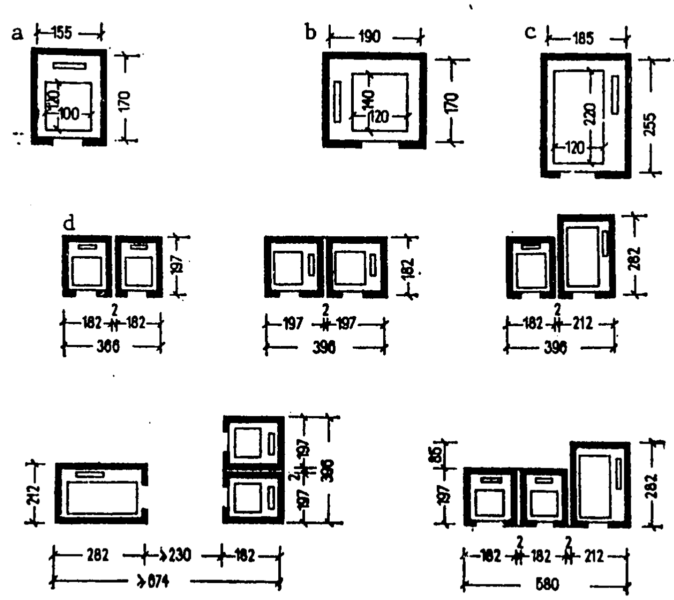


Figure 13. Types and sizes of elevators. a--320-kg passenger elevator; b--500-kg freight and passenger elevator; c--1,000-kg freight elevator; d--versions of elevator blocking.

The garbage chute is a vertical tube for the removal of garbage. The garbage dropped from the upper floors is collected in the bin installed in the garbage collection room. The garbage collection room is built on the first floor or basement and must be provided with convenient access for the garbage-hauling transportation. The garbage collecting room and the garbage chute must be provided with exhaust ventilation through the garbage chute (see Figure 14).

The selection and placement of the materials-handling equipment is discussed in Section 39.

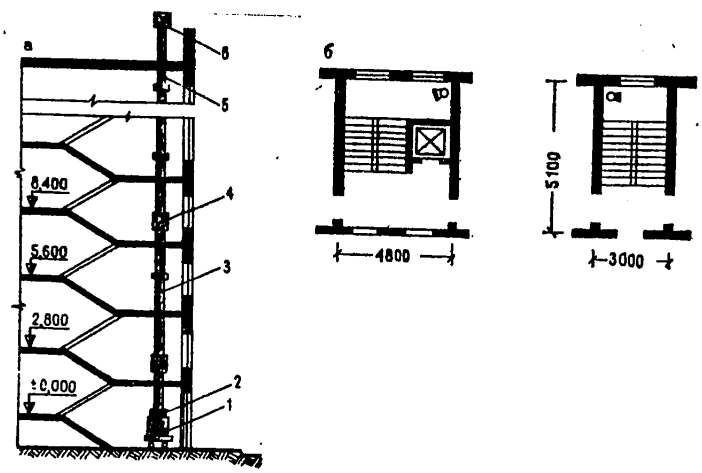


Figure 14. Diagram of the garbage chute in a residential building. a--Structure of the garbage chute: 1--garbage collecting bin; 2--supporting frame taking the load of the garbage chute; 3--garbage chute; 4--interfloor receiving station; 5--exhaust line; 6--deflector; b--versions of installation in a stairwell.

When designing public and industrial buildings, the placement of the stock equipment is indicated on the plan views of the floors: racks in the clothes closets; chairs in the auditoriums; seats in a restaurant or dining room; sales equipment in stores. Depending on the purpose of the building or room, the corresponding stock equipment is selected. The dimensions of the stock equipment are collected in various handbooks.

Before drawing up the drawings, the student, using sketches, diagrams and rough drawings plans the location of the individual design elements: plan views, sections, elevations, units, and so on on sheets considering the required places for extension lines, dimension lines and explanatory notes. The sheets must have a border, the lines of which on three sides must be 5 mm from the edges, and on the left side, 20 mm. The spaces between drawings on the sheet must be 35-45 mm. It is necessary to begin drawing with the plan views; the sketches of the sections and elevations are finished up simultaneously. The final inking of the drawings is done only after complete coordination of all of the projections with each other.

Section 12. Writing the Notes to the Designed Project

The explanatory note to a design contains its description and substantiation, and it is presented together with the graphical part (Figure 15a, b). The materials for the explanatory note must be accumulated throughout the entire time of working on the design. Simultaneously with executing the graphical portion, the student proceeds with writing the explanatory note. The explanatory note must be set up as follows: The text is written on standard writing paper sheets (210 x 297 mm); 30-40-mm margins are left on the left side of the sheet for fastening together and the instructor's comments; the pages are stitched together and numbered; the contents of the note are written in black ink. All of the decisions made are briefly and clearly substantiated in technically literate language. If necessary the explanatory note is supplemented by diagrams, drawings of the versions of the solutions, details and units. Heat engineering and, if necessary, light engineering calculations are also presented in the note, and the technical-economic indices are calculated.

The explanatory note must include the following sections:

1) a brief discussion of the assignment;

2) a brief discussion of the production or functional process;

3) master plan;

4) space and floor planning solutions;

5) structural solution;

6) calculation of the equipment of the services facilities;

7) solution of the building facade;

8) heat engineering and light engineering calculations;

9) service, sanitary-engineering and stock equipment;

10) finishing and specialized operations;

11) technical-economic indices;

12) references used.

In the section "Brief discussion of the assignment" the following are indicated: the construction location with respect to administrative division; the location of the construction site; the description of the building or structure (volume, carrying capacity, number of places, number of apartments, capacity of the enterprise, and so on); structural elements of the building.

The section on "Brief discussion of the production or functional process" includes the following information in addition to a description of these processes:

the class of structure; the adopted degrees of fireproofness and service life of the enclosing structures according to SNiP II-A.3-62; protection category with respect to degree of fire-safety according to SNiP II-M.2-72; group of sanitation characteristics of the basic processes according to SNiP II-92-76; working conditions (number of shifts and information about the number of workers).

In the "Master plan" section the following are indicated: the dimensions and shape of the site; the location of the designed building on the site; its orientation with respect to points of the compass with description of the insulation of the basic rooms; production or functional relation of the designed building to the existing buildings; spacings between them in accordance with fire-safety and sanitation norms according to SNiP II-A.5-70, SNiP II-L.1-71, SNiP II-L.2-32, SNiP II-M.1-71 and other chapters; the basic elements of the amenities and landscaping of the site; the technical-economic indices of the master plan. The following basic technical-economic indices are presented with respect to nonindustrial buildings: the density of coverage of the site with buildings which for residential blocks must be about 20-25 percent of the total area; the area for the thoroughfares, sidewalks and yards between blocks which take up about 25 percent of the total area for residential blocks; the landscaping with rest areas making up 50 to 55 percent of the total area.

The following indices are determined by the master plan of an industrial enterprise: the area of the territory, hectares; the area occupied by buildings and structures, hectares; the area occupied by open storage areas, hectares; the density of coverage (ratio of the area occupied by buildings, structures and open storage areas to the area of the territory), percentage; the area occupied by landscaping, hectares; area and extent of railroads and railless roadways, m^2 and running meters; area of paved parts of the territory, m^2; length of aboveground and underground service networks, running meters; use coefficient of the territory (ratio of the area occupied by buildings and structures, open storage areas, railroads and railless roadways, sidewalks and blind areas to the area of the territory).

In the "Space and floor planning solutions" section the following description and substantiation are presented: the configuration of the building in plan and the basic dimensions (on center lines); structural diagram of the buildings; longitudinal and transverse spacing of bearing structures (walls, columns), number of floors and their height; crane equipment and other data on intrashop transportation; the presence of basement, service corridors and levels; the presence of service equipment (elevators, escalators, garbage chutes); the evacuation problems (location of exits, stairwells, emergency stairways).

In the "Structural solution" section the substantiation and choice of structural designs are presented: determination of the depth of the foundation under the outside and inside walls according to SNiP II-15-74; description of wall material, wall thickness and waterproofing measures, details (cofferdams, cornices, parapets); for large-panel and frame-panel buildings their structural elements (columns, trusses, floor and roofing slabs) are described; measures to provide for general stability of the building; choice of types of windows, doors, partitions, stairs and gates; description of the roof design (sloping or integrated,

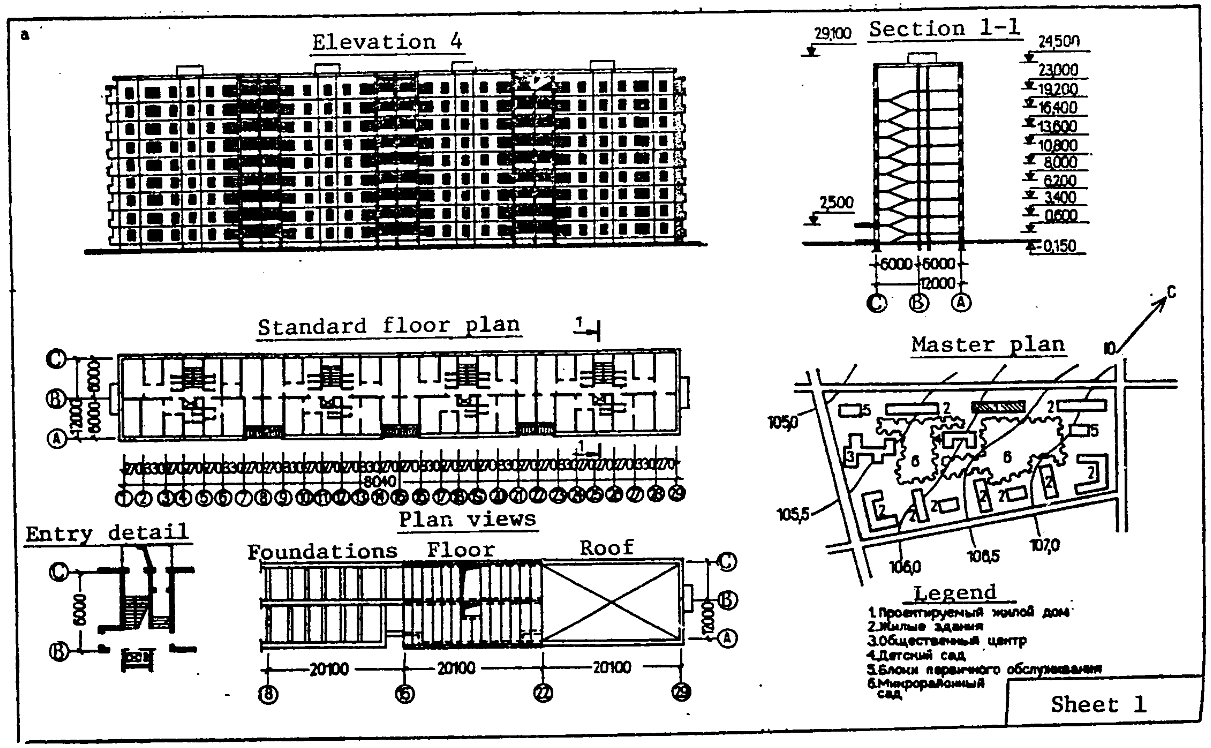


Figure 15. Examples of course design solutions. a--Nonindustrial building.

Legend key:
1. Designed residential building
2. Residential buildings
3. Public center
4. Kindergarten
5. Primary equipment blocks
6. Microdistrict garden

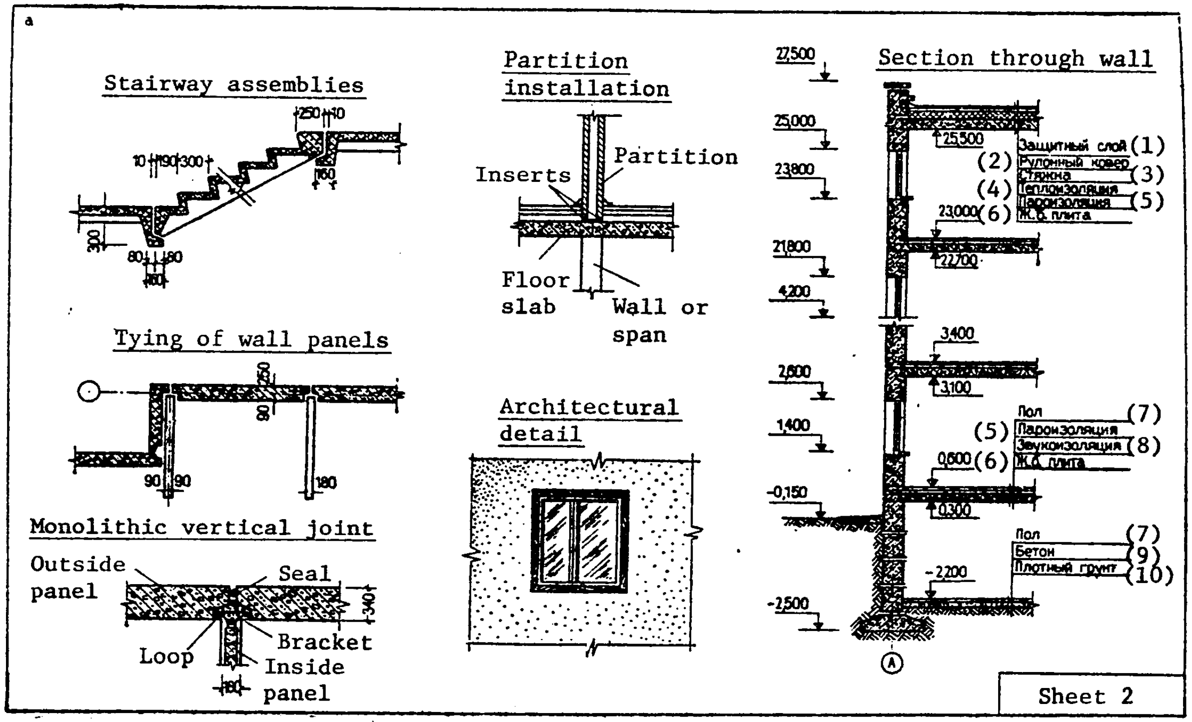


Figure 15. Examples of course design solutions. a--Nonindustrial building.

Key:
1. Protective layer
2. Roll roofing
3. Coupling
4. Thermal insulation
5. Steam insulation
6. Reinforced-concrete slab
7. Floor
8. Sound insulation
9. Concrete
10. Packed earth

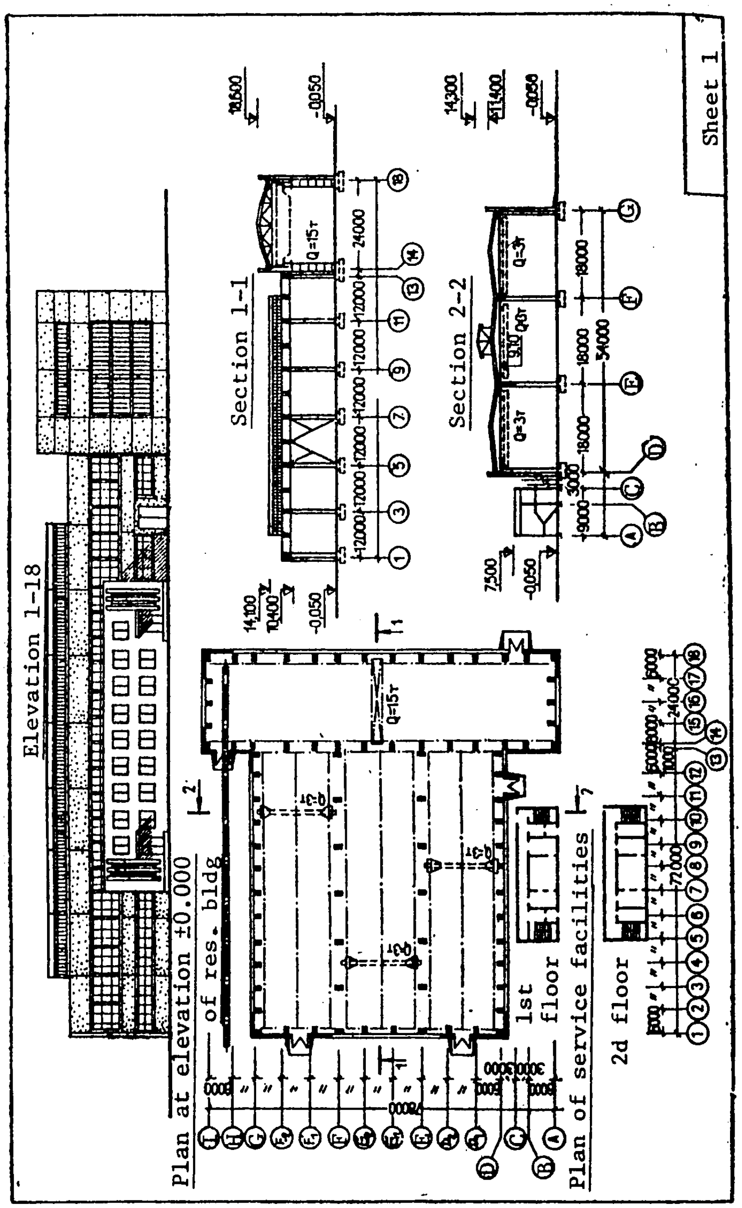


Figure 15. Examples of course design solutions. b--Industrial building.

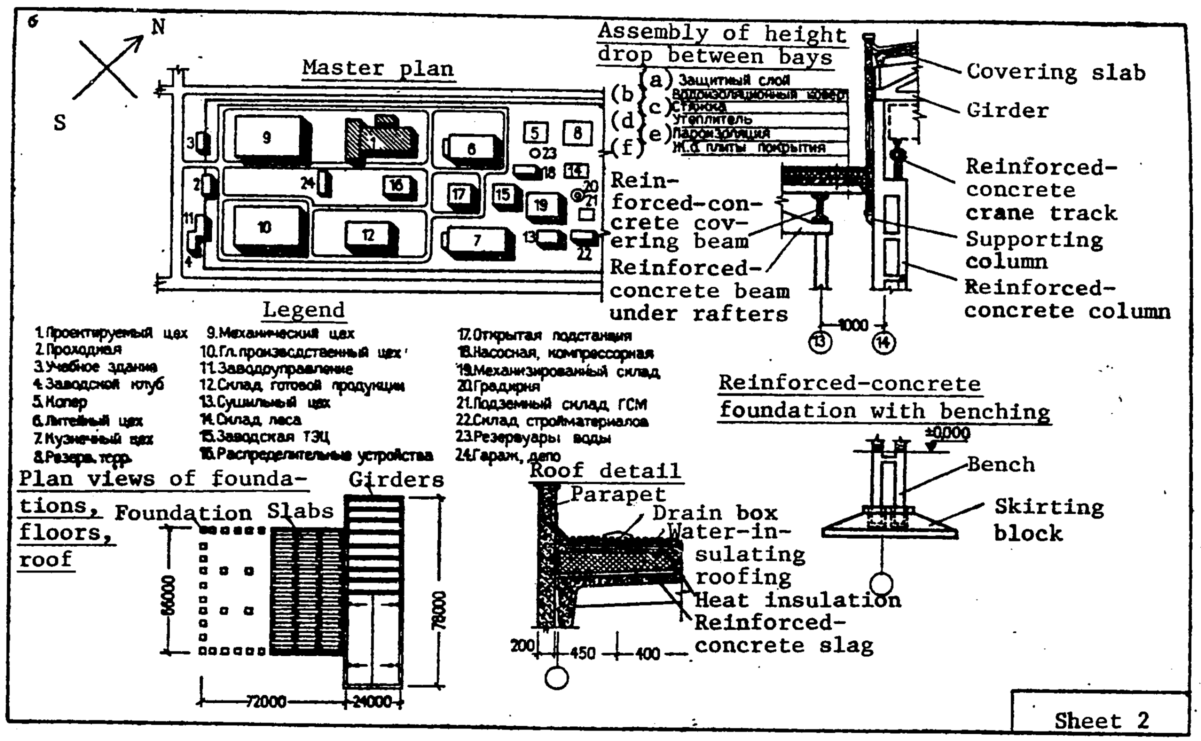


Figure 15. Examples of course design solutions. b--Industrial building.

Key:
- a. Protective layer
- b. Water-insulating roofing
- c. Coupling
- d. Thermal insulation
- e. Steam insulation
- f. Reinforced-concrete covering slabs

Legend key:
1. Designed shop
2. Passageway
3. Training building
4. Plant club
5. Pile driver
6. Foundry
7. Forging shop
8. Reserve territory
9. Mechanical shop
10. Main production shop
11. Plant administration
12. Finished product storage area
13. Drying shop
14. Lumber warehouse
15. Plant heat and electric power plant
16. Distribution stations
17. Open substation
18. Compressor and pumping station
19. Mechanized warehouse
20. Cooling tower
21. Underground storage GSM
22. Building materials storage area
23. Water tanks
24. Garage, yard

ventilated or nonventilated), roofing material and determination of pitches; determination of the location of expansion joints (when they are present in the building) in the frame, walls and in the coverings.

The equipment of the service facilities is calculated as follows: the composition of the service facilities is determined as a function of the sanitary characteristics of the production processes according to SNiP II-92-76 and SN 245-71; the required amount of coat room and sanitary-engineering equipment (lockers for clothing, water closets, pissoires and washbasins, shower networks, hand and foot baths, clothes-changing benches, and so on) is established; the required area and equipment for the coat rooms are calculated by the payroll list, the sanitary-engineering equipment, by the number of workers on the largest shift; the problem of the placement of service facilities (built-in, annexed, separately standing) is solved; the layout of the administrative-management facilities located in the general services and administrative building is determined. To facilitate the calculations, they can be made in the form of a table, the approximate form of which is presented below (see Table 4).

Table 4. Calculation of the Service Facility Equipment

Production Process Group	Number of Workers				Number of Equipment Units									
	Total Payroll		Maximum Shift		Lockers in Coat Rooms				Shower Stalls		Wash-basins		Water Closets	
					Double		Single							
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Total														

Note: Service facility equipment must be calculated with the coefficient K = 1.15 (considering variation in the number of workers--trainees, students).

The "Solution of the building facade" section must reflect the outside architectural appearance of the designed project and its space and floor plan structure. The architectural-artistic means used to design the facade must be described: tectonics, rhythm, contrast, proportions, and so on. The outside appearance of the building must reflect its purpose.

When designing industrial and nonindustrial buildings, heat engineering calculations are performed to determine the dimensions of the enclosure. These calculations are presented in the "Heat engineering and light engineering calculations" section. The thickness of the outside enclosures is determined from the condition of resistance to heat transfer which consists in the fact that the actual resistance of the outside walls to heat transfer R_0 must not be less than the required R_0^{req}. For this purpose first R_0^{req} is determined, and then the enclosing walls are designed which will have equal R_0 with respect to magnitude.

The following procedure is recommended for this calculation:

a) plot the calculation diagram;

b) assemble the initial data for the calculation according to SNiP II-A.6-72 and SNiP II-3-79;

c) determine the required heat transfer resistance (calculated winter temperature is taken considering the thermal inertia D of the enclosing structures): $D \leq 1.5$ (without inertia); $1.5 < D \leq 4$ (low inertia); $4 < D \leq 7$ (medium inertia); $D > 7$ (high inertia);

d) derive the equation for the resistance to heat transfer of the designed enclosure and equate it to the value found for R_0^{req}. Determine the thickness of the heat insulating layer from the derived equation;

e) determine the massiveness of the enclosing walls.

Example of Heat Engineering Calculation of an Outside Wall. It is required that the thickness of the outside wall of a panel-type residential building erected in Moscow be determined. The wall material is claydite concrete with a specific weight of 1,000 kg/m^3. The panels are plastered with a layer of decorative concrete 2 cm thick, and they are coated on the inside with a layer of plaster 1 cm thick made of lime-cement mortar. The calculation diagram is a schematic section through the wall containing all the layers, the numbering of the layers and their thickness (Figure 16a).

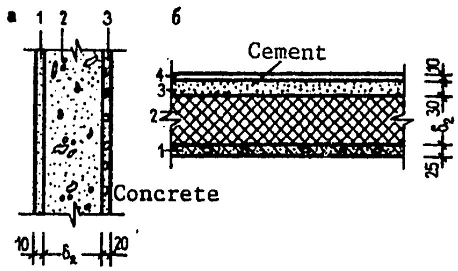


Figure 16. Calculation diagram for the enclosing structures of buildings. a--Panel-type wall: 1--lime-cement plaster 1 cm thick; 2--defined thickness of claydite concrete; 3--decorative concrete 2 cm thick; b--roofing panels: 1--reinforced-concrete slab 2.5 cm thick; 2--defined heat insulating layer made of foam concrete; 3--covering made of cement 3 cm thick; 4--three-layer ruberoid roofing.

Solution. The data required for the calculation SNiP II-3-79 are as follows: the calculated inside air temperature $t_B = 18$; calculated outside air temperature: for massive enclosures $t_H = -25°$ C, for light enclosures $t_H = -32°$ C; $n = 1$; $\Delta t^H = 6$; $\alpha_B = 8.7$ kw/(m^2-K). The climate is "normal humidity"; consequently, the value of λ is taken by column B of Appendix 3 of SNiP II-3-79.

The resistance to heat transfer of the outside enclosures must be no less than the required R_0^{req} defined by the formula:

$$R_0^{req} = n(t_B - t_H)/\Delta t^H \alpha_B \quad (m^2\text{-}K)kw,$$

where n is the coefficient depending on the position of the outside surface of the structure; t_B is the calculated inside air temperature, °C; t_H is the calculated winter outside temperature, °C, taken as a function of massiveness of the enclosure; Δt^H is the normalized temperature gradient between the inside air temperature and the temperature of the inside surface of the enclosing structure, °C; α_B is the heat transfer coefficient of the inside surface of the enclosing structure, kw/(m^2-K).

Let us first calculate an enclosure of "low inertia"

$$R_0^{req} = 1(18 + 31)/(6 \cdot 8.7) = 0.957 \ (m^2\text{-}K)/kw.$$

Let us derive a general expression for the resistance to heat transfer R_0 and equate it to the value found for R_0^{req}, then determine the thickness of the insulating layer

$$R_0 = (1/\alpha_B) + R_1 + R_2 + \ldots + R_n + (1/\alpha_H) \quad (m^2\text{-}K)/kw,$$

where α_H is the heat transfer coefficient of the outside surface of the enclosing structure. For the outside wall α_H = 23.2 kw/(m^2-K); R is the thermal resistance of the individual layers of the enclosing structure;

$$R = \delta/\lambda \quad (m^2\text{-}K)/kw,$$

where δ is the thickness of a uniform enclosing structure for an individual layer of a multilayer structure, m; λ is the coefficient of thermal conductivity of the material taken by column "A" or "B" of the function of the humidity of the climate. Then:

$$R_0 = 1/8.7 + 9.01/0.928 + \delta_2/0.348 + 0.02/1.45 + 1/23.2 = 0.957;$$

$$0.154 + 0.001 + \delta_2/0.348 + 0.013 + 0.058 = 0.957;$$

$$0.155 + \delta_2/0.348 + 0.071 = 0.957;$$

$$0.225 + \delta_2/0.348 = 0.957,$$

from which

$$\delta_2 = (0.957 - 0.225)0.348 = 0.254 \text{ m}.$$

The degree of inertia of the enclosing structure is established by the thermal inertia characteristic determined by the formula

$$D = R_1S_1 + R_2S_2 + \ldots + R_nS_n,$$

where S_1, S_2, ... S_n are the coefficients of thermal assimilation of the material of the individual layers of the enclosing structure in 24 hours.

$S = 0.51\sqrt{\lambda C_\omega \gamma_\omega}$ (kw/(m^2-K),

where C_ω is the specific heat capacity of the material in kilojoules/(kg-K);

$C_\omega = (C_0 + 0.01\omega)/(1 + 0.01\omega)$,

where C_0 is the specific heat capacity of the dry material; ω is the specific humidity, percent; γ_ω is the specific weight of the material in the dry state; ω is the specific moisture of the material ω_A or ω_B, percent.

All of the enumerated values are taken according to Appendix 3 of SNiP II-3-79.

In our calculation

$D = 0.001 \cdot 10.03 + 0.5 \cdot 4.58 + 0.013 \cdot 14.5 = 0.01 + 2.29 + 0.188 = 2.488 < 4.$

Thus, the enclosure of "low inertia" and the calculated outside air temperature for the given enclosure are taken correctly.

On the basis of the calculation results the total thickness of the wall must be:

$0.01 + 0.254 + 0.02 = 0.284$ m ≈ 28 cm.

Example of Heat Engineering Calculation of Roofing. Let us determine only the thickness of the foam concrete insulation. The enclosing part of the roofing (Sverdlovsk) consists of four layers indicated in the calculation diagram (Figure 16b).

Solution. The data required for the calculation from SNiP are as follows.

The calculated inside air temperature $t_B = 16°$ C; the calculated outside air temperature for light enclosures $t_H = -38°$ C, for massive enclosures $t_H = -31°$ C; $n = 1$; $\Delta t^H = 7°$ C, $\alpha_B = 8.7$ kw/(m^2-K); $\alpha_H = 23.2$ kw/(m^2-K).

The construction site is in a dry area; therefore the values of λ will be taken by column "A" of Appendix 3 of SNiP II-3-79. We shall first assume that the enclosure has low inertia.

The resistance to heat transfer of the roofing is:

$R_0^{req} = 1(16 + 38)/(7 \cdot 8.7) = 0.886$ (m^2-K)/kw.

Let us derive the general expression for the resistance to heat transfer R_0, equate it to the value found for R_0^{req} and determine the thickness of the thermal insulation layer δ_2:

$R_0 = 1/8.7 + 0.025/1.39 + \delta_2/0.19 + 0.03/0.75 + 0.01/0.17 + 0.058;$

$0.154 + 0.018 + \delta_2/0.19 + 0.04 + 0.05 + 0.058 = 0.886;$

$0.32 + \delta_2/0.19 = 0.886,$

from which

$\delta_2 = (0.886 - 0.32)0.19 = 0.05$ m.

After calculating the coefficient of heat assimilation of the layers of roofing materials let us determine the degree of massiveness:

$$D = 0.018 \cdot 14.5 + (0.05/0.19)2.6 + 0.04 \cdot 9.05 + 0.05 \cdot 4.7 + 0.058 = 0.26 + 0.676 + 0.362 + 0.235 = 1.53 < 4.$$

The enclosure has low inertia; therefore the calculated outside air temperature is taken correctly.

Let us sum the results of the calculations, determining the thickness of the roofing:

$0.025 + 0.05 + 0.03 + 0.01 = 0.115 \text{ m} \approx 12$ cm.

Natural lighting of the buildings is characterized by the natural lighting factor e indicating what part of the outside illumination E_H lights the inside of the buildings E_B:

$e = E_B/E_H$ 100%.

During the design process the natural illumination of the facility is calculated which consists in determining the coefficients of natural illumination of the designed facilities and comparing them with the normalized values. The grapho-analytical method of calculation by A. M. Danilyuk which is analyzed in this publication (see Section 44) is the most acceptable.

In the "Service, sanitary-engineering and stock equipment" section there is a brief description of the decisions made with respect to heating, ventilation, water lines, sewage, power supply, weak-current devices, elevators, garbage chutes, and so on.

A brief description of the finishing and specialized operations is presented in the "Finishing and specialized operations" section.

In the "Technical-economic indices" section a description of the space and floor-planning solution of the designed building and the calculation for nonindustrial buildings are presented.

1. The area of coverage, that is, the area of the horizontal cross section of the building on the first floor level within the boundaries of the outer perimeter of the building.

2. Living or working area of the spaces. The living area is calculated as the sum of the areas of the living quarters in the apartment-type houses, rooms in hotels, bedrooms in sanatoriums and rest homes, respectively. The working area

of public buildings is defined as the sum of the areas of all rooms in the building with the exception of hallways, lobbies, and passages and also rooms designed for locating the service networks and equipment (the service facilities).

3. The auxiliary or utility area for residential buildings is defined as the sum of all spaces except the living quarters, stairwells and common corridors in the corridor-type buildings. For public buildings the utility area is calculated as the sum of all spaces except the working spaces and stairwells.

4. The total area for residential buildings is calculated as the sum of the areas of all floors (ground, including service, basement) and also the areas of the mezzanines and passages to other buildings.

For industrial buildings the total area is calculated which is defined as the sum of the areas of all floors (measured within the boundaries of the inside surfaces of the outside walls), galleries, all tiers of stacks, landings, mezzanines and ramps, with the exception of areas of openings and shafts, the areas above suspended ceilings and the areas of the service corridor no more than 1.8 m high (inside) designed only for laying, inspecting and repairing service lines, lighting and other devices; areas for servicing crane tracks and platforms for the operators servicing the cranes. When performing the calculation it is necessary to take the area of the horizontal projection as the area of inclined galleries.

The volume of industrial and nonindustrial buildings, with the exception of calculating total areas, is determined in the same way. The volume of attic-type buildings is determined by multiplying the covered area measured above the socle by the height from the floor of the first story to the top of the attic floor. The volume of atticless buildings is determined by multiplying the area of the transverse vertical section measured by the outside contour (including skylights and other superstructures) times the length of the building.

The basic calculation units of the different types of buildings are discussed in Section 5.

A list of the references used in course or diploma design has been compiled with indication of author, title of the book, place and year of publication.

Part Two. Nonindustrial Building Design

Chapter III. Residential Buildings

Section 13. General Design Principles of Residential Buildings

Residential buildings are the most massive form of buildings designed for housing all categories of families, with different numbers of people and sex-age groups.

With respect to the functional attribute, residential buildings can be apartments, corridor apartment houses and boarding schools;

with respect to number of stories, residential buildings can be low-rise (1-2 stories), medium-rise (3-5 stories), medium-high-rise (6-9 stories) and high-rise (10 stories and higher);

with respect to building materials used, they are reinforced concrete, concrete, rock, wood, and so on;

with respect to space and floor planning, they are single-apartment, blocked, sectional, corridor and gallery, and so on (Figure 17);

with respect to structural design, they are framed buildings, unframed and mixed, and so on;

with respect to amenities in the apartments, there are apartments with complete service equipment (elevator, garbage chute, water supply, sewage, gas, heat, and so on), and apartments with incomplete service facilities (water line, furnace heating, waterless toilet, gas).

The basic type of residential building is an apartment building with different numbers of stories. It is designed for permanent housing. Corridor apartment houses are designed for temporary housing. Seasonal housing is used for seasonal work.

Apartment houses for permanent housing are divided into two basic types:

buildings with plots next to the apartments, basically these are low-rise buildings (1-2 stories) used in farm and settlement construction;

houses without apartment plots--high-rise buildings of the city type permitting economical use of city territory, efficient solution of transport connections, service line networks, and so on.

The corridor apartment houses are usually designed for builders, students, land reclamation workers, and so on.

Seasonal housing is also classified by purpose: housing on the herding routes, houses at field camps, and so on.

One of the most important prerequisites of creating full-valued housing is consideration of the climatic conditions of the construction site. According to SNiP II-L.1-71, the territory of the Soviet Union is divided into four climatic zones by climatic attributes (Figure 18): I--cold, II--moderate, III--warm, IV--hot.

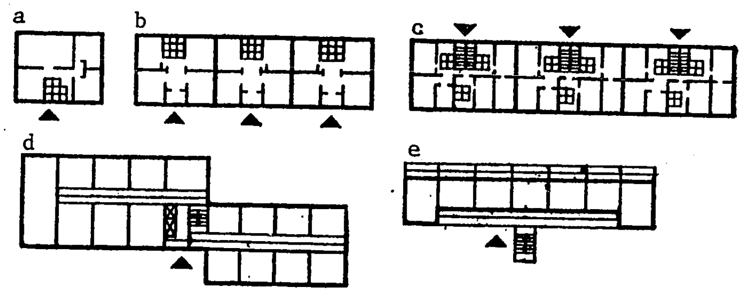


Figure 17. Diagrams of floor plans for different types of buildings. a--Single apartment; b--blocked; c--sectional; d--corridor; e--gallery.

Each of the four basic climatic zones is divided in turn into subzones. The first zone includes five subzones: IA, IB, IC, ID, IE; the second includes four: IIA, IIB, IIC, IID; the third includes three: IIIA, IIIB, IIIC; the fourth, four: IVA, IVB, IVC, IVD.

The division of the climatic zones into subzones offers the possibility of more exact consideration of the climatic characteristics of the construction area.

For creation of comfortable conditions in an apartment in hot climates, cross ventilation is necessary, that is, the rooms of the apartment must open onto opposite sides of the building. In addition, in hot climates open galleries, stairs and passages are widely used, which introduce their peculiarities into the layout of housing in the south.

The comfortableness of housing is also determined by insulation, that is, the direct irradiation of the living facilities of the apartment by the sun. Natural illumination of the rooms in an apartment depends on the construction-climatic zone, outside lighting, the amount of direct and reflected sunlight incident in the room, the building configuration, and so on. Therefore in the north, where there is little sunlight, it is expedient to construct the building in a simple rectangular shape; in the south, on the contrary, the bodies of the buildings can be more complicated, with large projections, deep loggias and the like elements which shade the main spaces.

Depending on the position of the longitudinal axis of the building, meridional and latitudinal arrangement of the buildings on the site plan are distinguished (Figure 19). The meridional arrangement is most acceptable in climatic zones I and II, for this arrangement of the buildings ensures the longest insolation of both sides of the building. In climatic zones III and IV meridional arrangement of the buildings is inadmissible, for the hottest rays of the afternoon sun will penetrate deeply into the apartments and this will create fierce overheating of them. The latitudinal orientation of the buildings is the most acceptable for these zones.

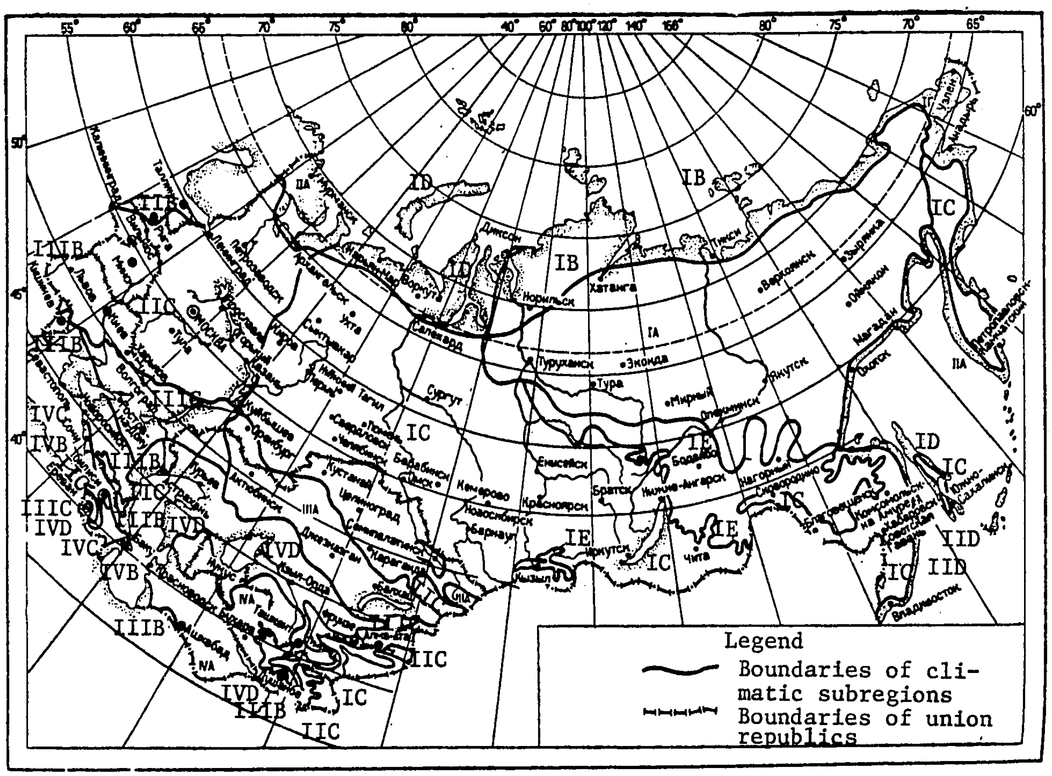


Figure 18. Schematic construction-climatic zoning of the territory of the USSR.

In order to create the most favorable conditions of insolation of an apartment by the construction norms optimal sides of their orientation with respect to points of the compass are defined (Figure 20).

The apartment is taken as the residential unit of insolation norm; therefore if the apartment rooms open to one side of the building, the apartment cannot be oriented to the north side of the horizon within the limits of 310-50° (sector A) in all climatic zones and also in the limits of the sector of the horizon 200-290° in climatic zones III and IV (sector B).

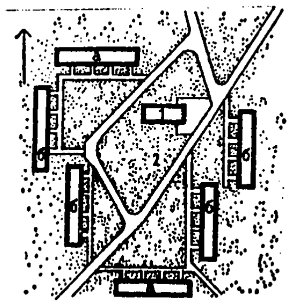


Figure 19. Arrangement of buildings on the site. a--Latitudinal; b--meridional; 1--public center; 2--microdistrict garden.

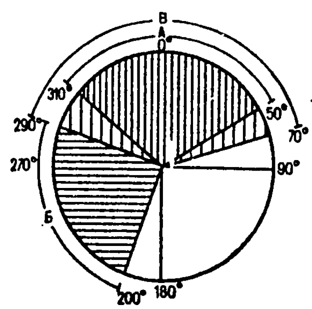


Figure 20. Diagram of the orientation of living spaces.

In corridor apartment houses it is permissible to orient the living quarters to the sector of the horizon within the limits of 310-50° (sector A) in all climatic zones and also in the sector from 200 to 290° (sector B) in climatic zones III and IV; the total area of such rooms must not exceed 40 percent of the total living area of the corridor apartment house.

The floor plan of residential buildings is often influenced by other natural climatic conditions. When constructing buildings under the conditions of climatic zone I and partially II, it is necessary to give special attention to retaining heat in the building. When laying out the plan views of the building it is necessary to strive for minimum perimeter of the outside walls and mandatory construction of a vestibule for entering the building. It is recommended that triple glazing be used. In the Far North, severe climatic conditions influence not only the floor plan of the apartment and the building, but also the coverage as a whole. In order to protect people from the severe climate, compact residential massifs are designed with closed passageways which connect the residential buildings to the public center. There are designs for settlements and cities with artificial covering and the creation of an artificial climate.

Section 14. Brief Information About Laying Out Cities and Populated Areas

Cities, settlements and rural populated areas are subdivided into groups in accordance with Table 5 by SNiP II-60-75 depending on the number of population.

Table 5. Division of Cities, Settlements and Rural Populated Areas Into Groups

Groups	Cities With a Population, thousands of people	Settlements With a Population, thousands of people	Rural Populated Areas With a Population, thousands of people
Largest	More than 1,000	--	--
	More than 500 to 1,000	--	--
Large	More than 250 to 500	More than 10	More than 5
Big	More than 100 to 250	More than 5 to 10	More than 2 to 5
Medium	More than 50 to 100	More than 3 to 5	More than 1 to 2
Small	To 50	To 3	More than 0.5
			To 1
			To 0.5

Note: Cities and populated areas are classified in one group or another in accordance with the planned number of population.

In order to create favorable living conditions in a city or settlement, the layout and coverage of the territory must be conveniently planned considering orientation of the residential buildings, the transport links between residential districts and microdistricts, commercial centers, the place of work, leisure, and so on.

The territory of a city is broken down into microdistricts which by their organization provide a complete system of cultural and general services, sports and leisure (Figure 21a). The microdistricts are separated from each other by green spaces. Several microdistricts form a residential district, and residential districts, the city.

Within a microdistrict there are residential buildings and public institutions (kindergartens, schools, stores, receiving stations for general services).

The size of the microdistrict territory depends on the number of population and it is defined by SNiP II-60-75. The placement of the institutions in the microdistrict must promote improved services to the population and must fall within the radius of pedestrian access (servicing radius). The servicing radius is the length of the pedestrian path from the most remote housing to the service installations or to a municipal transportation stop (Figure 21b).

Such facilities as mother-and-child rooms and workshops can be placed in a residential building or one of the residential buildings for a group. The schools, the produce stores and also the city transportation stops can be no more than 500 m from the residential building, and kindergartens no more than 300 m.

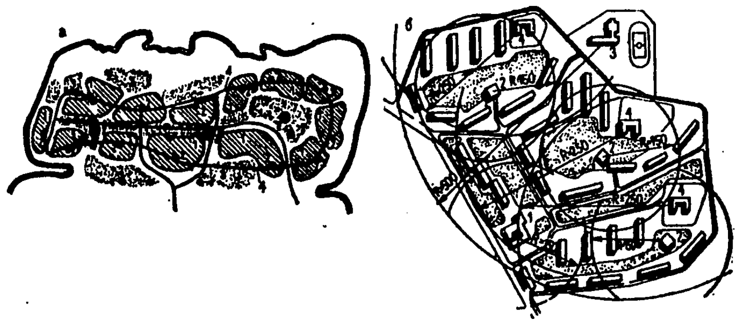


Figure 21. Organization of urban territory. a--Microdistricts: 1--residential blocks; 2--trade centers; 3--gardens and parks; 4--roads; b--placement of public institutions in the microdistrict and service radii: 1--public center of the microdistrict; 2--primary servicing blocks; 3--school; 4-kindergartens.

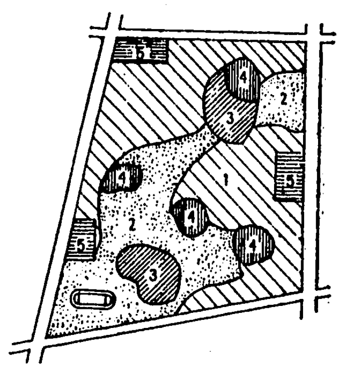


Figure 22. Housing facility density (gross) of the microdistrict. 1--Residential territory; 2--microdistrict garden and sports nucleus; 3--area for schools; 4--the same for kindergartens; 5--the same for trade and municipal institutions.

Urban transit system is excluded inside the microdistrict, which creates conditions by which the population (especially old people and children) are spared the necessary for crossing busy thoroughfares. Only trucks hauling goods to the stores, department stores, dining rooms and other service institutions are permitted within the boundaries of the microdistrict.

The basic requirement imposed on planning consists in isolation of the residential territory from harmful effects of city transportation. The landscaping of the microdistrict plays an important role in creating comfortable living conditions. Landscaping permits prevention of overheating of the soil and buildings, it protects the residential buildings from noise, wind and air pollution. The landscaping of the microdistrict is an integrated system consisting of district and microdistrict gardens and landscaping of the yards (Figure 21b). The landscaping of the microdistrict must occupy no less than 40-45 percent of the entire territory.

Economicalness of the amenities of the microdistrict depends on expedient use of the territory and it is determined by the "housing facility density" concept--the amount of living space in square meters per hectare of microdistrict territory.

The gross housing facility density was taken according to SNiP II-60-75. The gross housing territory includes the housing territory and sections of the children's institutions, schools, municipal buildings, microdistrict garden, physical culture areas and schools in the microdistrict (Figure 22). The gross density is determined by the ratio of the living space in m^2 to the territory of the microdistrict in hectares.

The sanitary-hygienic living conditions are characterized by the density of coverage expressed in percentage of the residential territory. The coverage density is the ratio of the territory covered by buildings (the built-up area) in m^2 to the habitable territory in m^2; the ratio obtained is expressed in percentages.

Section 15. Structural Diagrams of Residential Buildings

The layout of the residential building depends to a great extent on its structural diagram, the building materials used and the methods of construction. The choice of one structural diagram or another depends on the number of floors in the building, the space and floor space layout, the presence of building materials and a base for the construction industry.

When selecting the structural diagram of a residential building, its number of stories has great significance. When building low-rise buildings basically in rural areas, brick, shell rock, wood, and so on are used. In recent years two-story buildings have been built from large rocks and panels (reinforced concrete, wood), ensuring a high degree of prefabrication of the low-rise residential structures.

For the construction of one- and two-apartment and blocked houses, low-rise two- to four-story section houses, the following structural layouts are used: with transverse bearing walls (Figure 23a), longitudinal and mixed (application of longitudinal and transverse bearing walls jointly), frame, panel and frame-panel (Figure 23a-d).

In the case of transverse bearing walls, the outside longitudinal walls are only heat insulating and can be self-supporting and hanging. The self-supporting walls bear their own weight and the weight of the panels above. The lower panels transfer the load directly to the foundation. The hanging panels can be supported directly on the floor panel or hung on bearing walls or fastened to the frame columns. For the layout with an incomplete frame (without the outside row of columns) bearing panels are used which transfer loads not only from the panels above, but also from the floors.

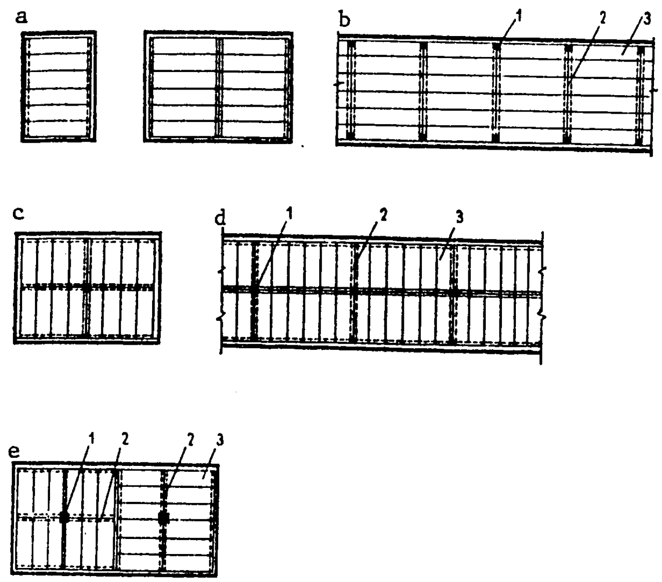


Figure 23. Basic structural diagrams of low-rise residential buildings. a--With transverse bearing walls; b--with transverse frame; c--with longitudinal bearing walls; d--with longitudinal frame; e--mixed diagram with inside supports; 1--columns; 2--slabs.

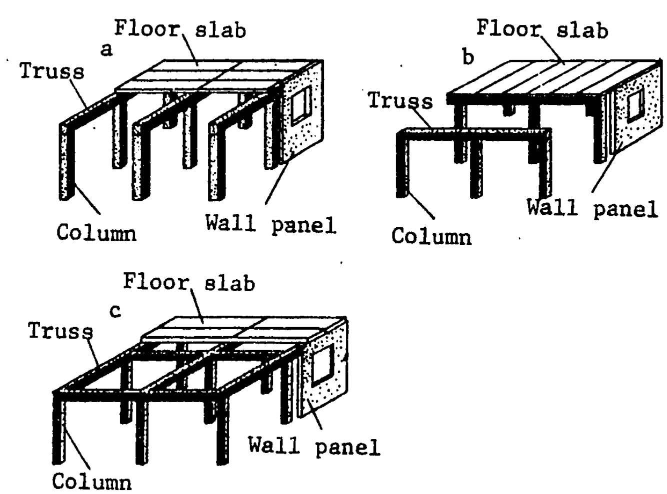


Figure 24. Frame system of low-rise residential houses. a--Layout with longitudinal frame; b--layout with transverse frame; c--layout with mixed frame.

In the case of two-row blocking of residential houses it is most expedient to use a structural layout with longitudinal arrangement of the beams (Figure 23c, d).

In houses with frame structural designs the bearing system is the system of columns and beams. In this system the beams can be arranged both along and across the building depending on the structure of the building and the dimensions of the transverse and longitudinal spans.

In building high-rise residential buildings, the following basic systems are used: with longitudinal bearing walls, with transverse bearing walls and the mixed system.

The structural diagrams of high-rise residential buildings can be resolved in various structural systems: frame, unframed and mixed.

The frame system consists of columns, beams, trusses and other framing elements taking all of the loads and ensuring spatial rigidity of the building. The wall panels in the building only perform enclosing functions.

Three schemes are distinguished in the frame system: the scheme with longitudinal pillar-collar beam frame (Figure 24a); the scheme with transverse pillar-collar beam frame (Figure 24b); the scheme with mixed frame (Figure 24c).

The unframed system is characterized by the fact that the majority of structural elements combine the functions of bearing and enclosing elements. The spatial rigidity and stability of the building are ensured by the interconnection of the walls and floor slabs. The unframed system with longitudinal layout of the bearing walls (Figure 25a) is convenient for laying out the sections and apartments, for it does not limit their dimensions with respect to the length of the building and permits free placement of both the partitions between rooms and between apartments.

In the case of transverse bearing walls (Figure 25b) the possibility appears for efficient use of various properties of building materials, for the building elements are divided into bearing and heat insulating. In this system the outside walls are made of light structures with high heat insulating properties. The thickness of the transverse bearing walls of the building is identical.

The combined structural system presupposes arrangement of bearing elements in two directions as a result of which the thickness of the bearing walls can be minimal (Figure 25c). Rigid fastening of the transverse and longitudinal bearing walls limits the layout possibilities of the given system.

The volumetric-modular housing construction is finding broader and broader application. The advanced nature of the volumetric-modular house construction consists in the following: maximum factory preparation of the modules, the application of large elements, reduction of the times required for erection of the buildings, improvement of the compositional possibilities of the housing construction.

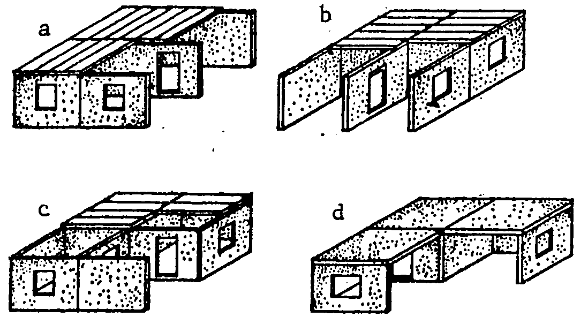


Figure 25. Unframed system of high-rise housing. a--System with longitudinal bearing walls; b--the same with transverse walls; c--mixed system; d--system with room panels.

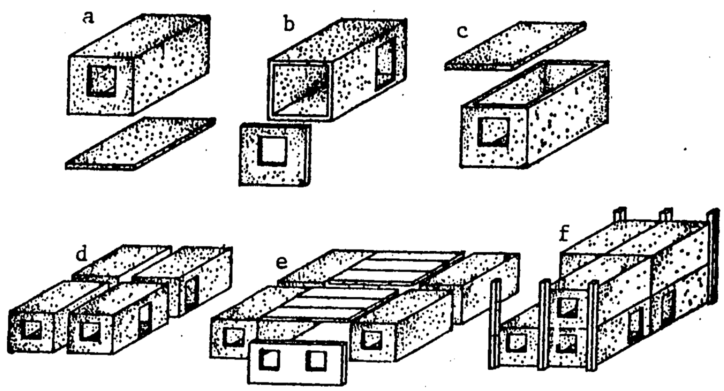


Figure 26. Types of three-dimensional monolithic modules and their structural systems. Monolithic module: a--"cap"; b--"sleeve"; c--"recumbent sleeve"; structural system: d--block; e--block-panel; f--block-frame.

The three-dimensional modules are used to build low-rise and high-rise housing, stationary and mobile seasonally inhabited housing. The three-dimensional modules are made by different structural designs: frameless and framed, compositional, monolithic, of the "cap" type, "sleeve" type, "recumbent sleeve" type (Figure 26a-c).

The basic structural systems of volumetric-modular construction are block, block-panel and block-frame (Figure 26d-f).

In the volumetric-modular construction, blocks of different shapes can be used (multiangle, oblique-angle, curvilinear, and so on) made of wood, concrete, plastic and other building materials.

Section 16. Apartment and Its Elements

The basic element of a residential building is a one-family apartment. The apartment layout must be convenient for household activities, the personal business of the residents considering their age and sex.

Each apartment consists of a set of rooms: the living spaces include the common living room, bedrooms; the auxiliary spaces are the kitchen, foyer, toilet, bathroom, built-in closets, and so on; the summer spaces include the veranda, loggia and balcony.

The common room or living room is designed for various activities of adults and children, gathering of the members of the family, leisure, and receiving guests. If the kitchen is small in area, a place for a dining table is set aside in the living room. In some cases the layout of the living room provides a sleeping place or alcove. The area of the alcove is usually 4 to 4.5 m^2. The depth of the alcove depends on the number of sleeping spaces: for one sleeping space the depth of the alcove must be no less than 1.2 m; for two places, 2.1 m (Figure 27a). The alcove isolates the sleeping space from the overall room and if necessary can be screened off by a sliding partition (see Figure 27a).

The bedrooms in the apartments are designed to have different areas depending on the number of sleeping places. The area of the primary bedroom for two people must be no less than 12 m^2; if necessary a bed for a child can be included in it. The area of the remaining bedrooms for two people is 10 m^2, and for one person, 8 m^2. All of the bedrooms are designed with one entrance. The minimum width of the bedroom must be taken as no less than 2.5 m. The depth of the bedroom must not exceed twice its width.

Often a bedroom is designed not only for sleeping, but also for activities and games; therefore space must be set aside at the window for a worktable and space for games. In large bedrooms it is necessary to provide built-in closets and a mezzanine for storing houseclothes and bed linens (Figure 27c). It is also convenient to put built-in closets in the hallways or anterooms leading to the bedrooms (Figure 27d).

The primary auxiliary facility in an apartment is the kitchen. It is designed for preparation and eating of food, washing dishes, storing and preserving fruits and vegetables, and so on. Therefore when designing the apartment it is necessary to give special attention to the kitchen layout.

Kitchens are equipped with stationary kitchen equipment and furniture. The working front of the kitchen equipment consists of a stove (gas, electric or solid fuel), sink, worktable, refrigerator and hanging cabinets. As a rule, three arrangements of kitchen equipment are used in the kitchens: single-row along one wall; double-row along two opposite walls; L-type at an angle, along two adjacent walls.

Depending on the area, set of equipment and furniture it is possible to divide the kitchens into efficiency kitchens, working kitchens and kitchen-dining rooms.

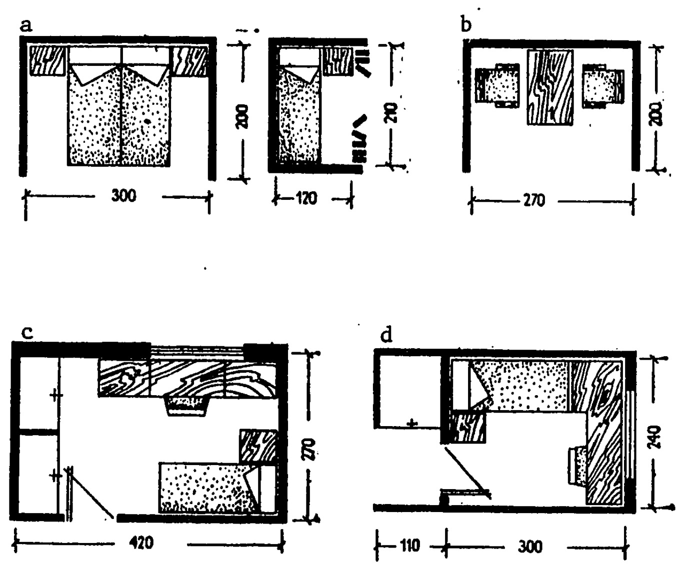


Figure 27. Overall dimensions of sleeping alcoves, recesses and built-in closets. a--Double and single alcoves; b--recess; c--built-in closets in the bedroom; d--built-in closet next to the bedroom.

An efficiency kitchen is placed in a recess in the living room or foyer (Figure 28a). The depth of the recess must be no less than 0.7 m, and the length of the kitchen front 1.4-2.7 m. Such kitchens must be equipped with electric stoves. The kitchen recesses are basically used in apartments designed for small families or singles engaged in minimum household activity.

The working kitchen in residential houses is placed in a separate, specially designed room (Figure 28c). The minimum area for such a kitchen is 7 m^2, and in farmhouses, no less than 8 m^2. In one-room apartments to 5 m^2 is permissible. The minimum width of a working kitchen is no less than 1.9 m.

The kitchen-dining room performs the functions of a working kitchen in which space is provided for a dining table (Figure 28c). The kitchen-dining room usually is designed in small apartments to relieve the living room of the eating space. The kitchen-dining room area is 8-12 m^2.

Recently there has been a trend toward separation of the eating space into a separate area between the living room and kitchen (Figure 28d).

The sanitary facilities in apartments can be combined and separated. Combined include a water closet, lavatory, bath or shower, and the separate ones have a bathroom and toilet separated. In the bathroom there is a bathtub, lavatory, towel rack and in some cases, a bidet; in the toilet is the water closet.

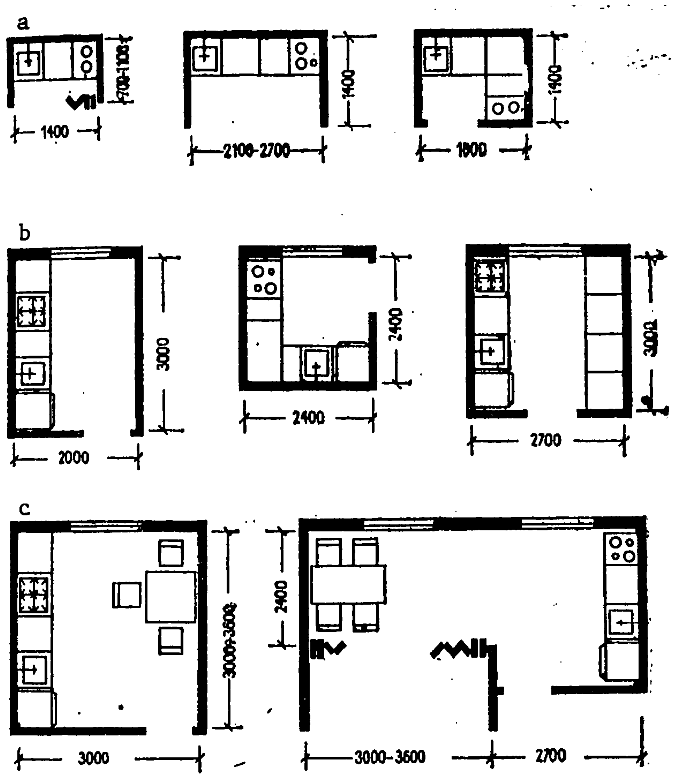


Figure 28. Basic types of kitchens and placement of the eating space in the apartment. a--Efficiency kitchens; b--working kitchens; c--kitchen-dining rooms; d--separately set aside eating space.

Combined sanitary facilities are provided in apartments for small families and singles. Separate sanitary facilities are used in three- or four-room apartments. In multiroom apartments (5-6 rooms) sometimes there are two sanitary facilities: one next to the bedrooms with a bathtub; the other with the water closet and lavatory next to the kitchen and living room. The basic types and sizes of sanitary facilities are presented in Figure 29.

The doors from the bathrooms and combined sanitary facilities must open outward.

The dimensions of the toilet rooms must be no less than 0.8 x 1.2 m with the doors opening outward and 0.8 x 1.5 m if the doors open inward.

The bathrooms and toilet rooms usually are lighted with secondary lighting, and in III and IV climatic zones natural lighting is required in them. Natural exhaust ventilation must be provided in all of the sanitary facilities.

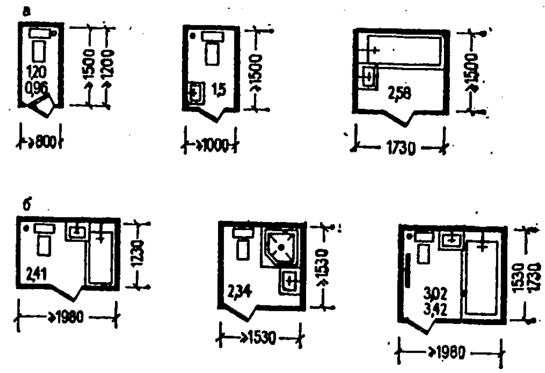


Figure 29. Basic types and dimensions of sanitary facilities. a--Separate; b--combined.

The main spaces or basic rooms of an apartment are joined by the foyer, halls and anterooms. Their dimensions are determined from the conditions of convenient use. Minimum width of a foyer is no less than 1.4 m. The widths of the corridors and anterooms leading to the living rooms must be no less than 1.1 m, and the width of the corridors and anterooms leading into the auxiliary rooms--kitchen and sanitary facilities--0.85 m. The height of the passages and anterooms can be 2.1 m. Usually mezzanines are built above them which serve to store household and domestic objects.

The basic quality of the layout of an apartment is clear-cut differentiation of the facilities with respect to purpose and convenient interrelation of the living and auxiliary spaces.

Recently apartments on two levels have become widespread. On the first level of such apartments are the entrance, the living room, kitchen sanitary facility and other auxiliary facilities; on the second floor are the bedrooms and bathroom with a laundry on the first floor. If there is no laundry, the bathroom is located on the first floor.

For apartments on two levels the location of the stairs inside the apartment has great significance (Figure 30). For high unitization of the floor slabs it is expedient to locate single-flight stairs along the slabs of these floors or along the beams (Figure 31a). When placing the stairs perpendicular to the slabs or beams the latter must be supported on an additional support (wall or collar beam) (Figure 31b, c). The most frequently used double-flight stairs complicate the structural layout, for this requires the application of additional standard sizes of slabs or beams (Figure 31d).

As a rule, the stairs inside the apartment are made of wood or other light materials. Convenience of using this stairway is determined by the ratio of the dimensions of the risers and treads (Figure 30). The sum of the dimensions of two risers (b) and treads (a) must be $2a + b = 60\text{--}64$ cm (the average stride of a man). The greatest slope of the stairs must be 1:1.25. The story height in residential buildings from floor to floor is taken as 2.8 m. If the story height is divided by 15 risers, the height of each riser will be 280 ÷ 15 = 18.7 cm. With a slope of 1:1.25, the size of the treat will be 18.7 x 1.25 = 23.4 cm. Hence, by the 2a + b = 60-64 cm rule we obtain 18.7 x 2 + 23.4 = 60.8 cm which is the average stride of a man.

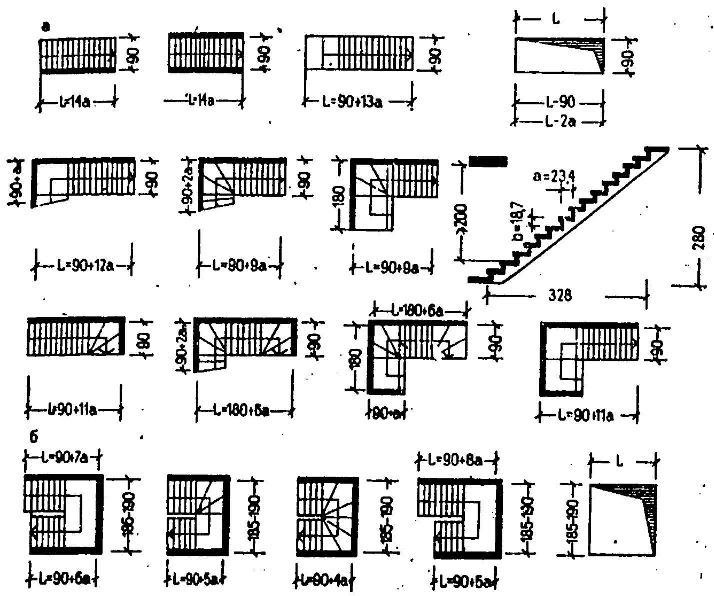


Figure 30. Types and sizes of stairs inside apartments. a--Single-flight with straight and turning steps; b--the same, two-flight; L--length of flight; a--tread width; b--riser height.

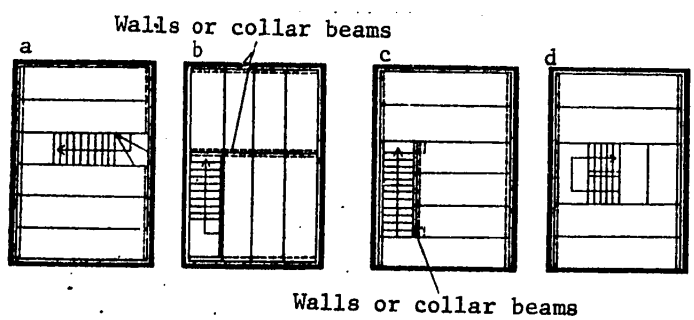


Figure 31. Diagrams of the arrangement of stairs inside apartments (a-d) as a function of the floor design.

For families of different composition (with respect to number, age, sex and relations) apartments are designed differently both with respect to number of rooms and with the same number of rooms, differently with respect to sizes of the common and living spaces (type A and B apartments, see SNiP II-L.1-71).

The basic types are one-room, two-room, three-room, four-room and five-room apartments.

The single-room apartment is designed for one person or two-person families (Figure 32a). The limited number of spaces in a single-room apartment imposes the conditions of maximum use of them. Therefore when laying out such an apartment it is necessary to provide for the largest possible closets, built-in cupboards and mezzanines. This permits relieving the living room and kitchen of part of the furniture and the use of them for their direct purpose. The kitchen in a one-room apartment must be designed with large area and the dining table placed in it, which offers the possibility of freer use of the living room area.

The living part of a two-room apartment consists of the living room and one bedroom 8-12 m^2 (Figure 32b). The living room area must be no less than 15 m^2. When a family of three occupies the apartment, a sleeping space is organized in the living room. In small two-room apartments type 2A, a combined sanitary facility is possible. In the type 2B apartment the sanitary facilities are separate.

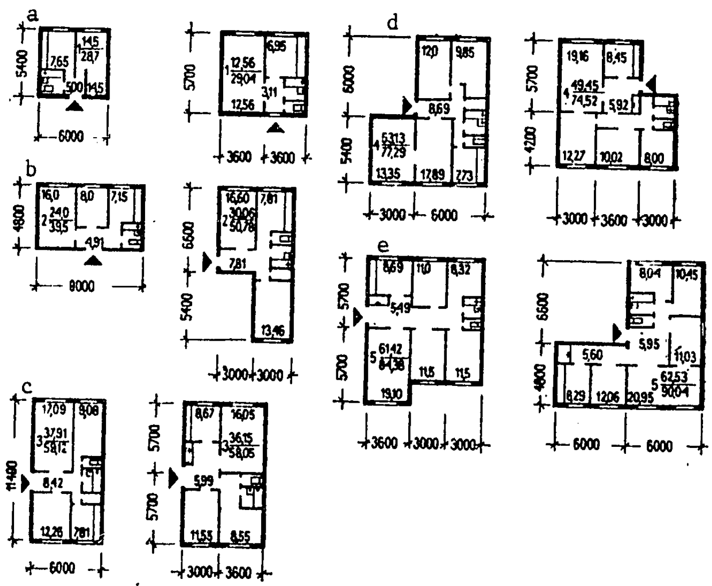


Figure 32. Apartment layouts. a--One-room; b--two-room; c--three-room; d--four-room; e--five-room.

Beginning with the three-room apartment, clear-cut division of the apartment into two basic zones is possible: daytime use and leisure. The noisiest parts of the apartment--the living room and kitchen--are placed next to the exit. The bedrooms are located in the depths of the apartment (Figure 32c). Separate sanitary facilities--bathroom and toilet--are located so that they will be convenient to use from any part of the apartment. In the majority of cases the living room in a three-room apartment is relieved of sleeping space and is basically used for activities, games, receiving guests, and so on.

Three-room apartments are oriented, as a rule, in two directions and have free orientation and cross ventilation.

A four-room apartment is designed for a family of five or six. The first bedroom for two people in this type of apartment is 12 m^2, the second bedroom is 10 m^2 and the third 8 m^2. The bathrooms in the four-room apartments are arranged next to the group of bedrooms (Figure 32d).

Five-room apartments are designed for families of seven or eight (Figure 32e). The bedrooms in these types of apartments are 8-12 m^2. At the present time there is a trend toward having two toilets in five-room apartments. One is next to the bedroom group and the other, next to the entrance.

The development of six-room apartments for construction in republics in which a high percentage of the families are eight or more is planned for the future.

In order to increase the living convenience, a modern apartment is equipped with movable (table, chest, and so on) and built-in furniture, sliding doors and partitions. The built-in furniture installed in recesses or built in the form of partitioning closets is placed between rooms. This type of use of the furniture promotes more expedient use of the apartment areas and spaces. The depth of the built-in closets must be no less than 0.6 m. The wall closets can be completely or partially recessed; in addition, they can protrude fully beyond the wall dimensions (Figure 33a).

The partitioning closets are one of the most modern forms of furniture. The purpose of the sections and compartments in the partitioning closets can be very different depending on the purpose of the space, that is, which way the closet partition doors open. With respect to nature of servicing, the closet partitions are divided into one-sided, opening into one room (Figure 33a), two-sided, serving two rooms (Figure 33b). Sometimes three- and four-sided closet partitions are used (Figure 33c).

Sliding partitions (Figure 33d) have a significant influence on the apartment layout. Replanning of the apartment is possible with their help. The closet partitions and sliding partitions permit the creation of flexible, functionally laid-out housing.

Section 17. Low-Rise Residential Buildings

The construction of low-rise housing has become widespread in small cities, workers' and farm settlements. The possibility of using simple light structural elements, local building materials, simplified engineering equipment systems in these buildings predetermines broad construction of them in the enumerated populated areas.

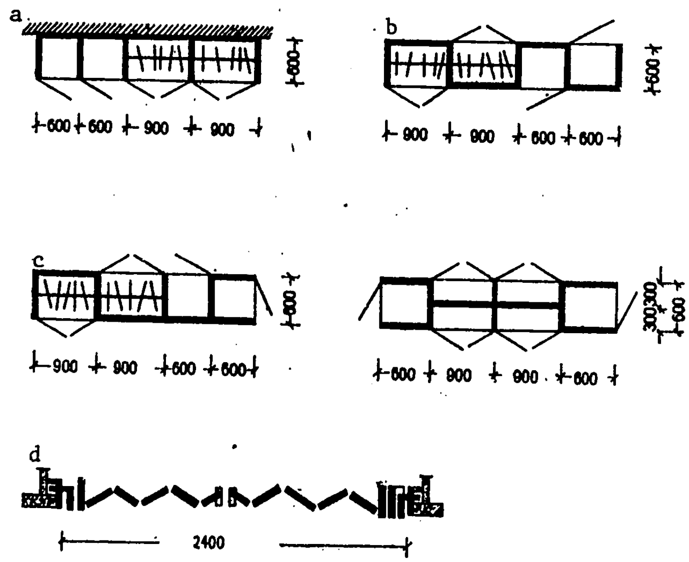


Figure 33. Closet partitions (a-c) and sliding partitions (d).

The low-rise housing is divided into several types: single-apartment, two-apartment, blocked.

As a rule, these buildings have personal plots of ground. In rural populated areas the sizes of the plots directly adjacent to the apartment must be (including the area covered by the building): in the case of one- or two-apartment buildings 1,000 m^2; in the case of blocked buildings 600 m^2.

The presence of a plot of ground next to the apartment imposes a characteristic feature on the layout of the apartment. The apartments of a low-rise building have two entrances: one on the street side and the other from the plot of ground.

With respect to space and floor planning these buildings have one- or two-level apartment (attic and two-story).

The single-apartment buildings with the apartments on one level are the most convenient in layout respects. It is possible to place all types of apartments with two to six rooms in them. A large light front along all four walls of the building permits the apartments to be laid out in various versions (Figure 34). In attic or two-story buildings it is expedient to design the four- to six-room apartments on two levels.

In attic houses separate rooms are located in the attic (Figure 35a). Here the height in the lower part of the room must be no less than 1.6 m. In such houses the area of the upper floor is less than the area of the lower floor. For more complete use of the attic space the ceiling of the upper rooms is made with clipped corners.

Figure 34. Layout of single-story, single-apartment residential houses. 1--Kitchen equipment; 2--sanitary facility; OK--living room; Cn--bedroom; K--kitchen; K-C--kitchen-dining room (the legend also applies to Figures 35-38, 40).

One type of single-apartment house is a two-story residential house with apartment on two levels.

On the first floor of such apartments there is an entry, a living room, kitchen, toilet and other auxiliary facilities. The bedrooms are located on the second floor. In apartments built on two levels the bathroom is located on the first floor, and a toilet with lavatory, on the second floor.

Two-apartment houses are in the form of a block consisting of two separate apartments joined by a single roof. This type of house has a number of advantages over the single-apartment dwelling, and it has a smaller perimeter of the outside walls, lower heating and insulating cost and cheaper cost of the apartment.

In the two-apartment houses it is necessary to provide for blocking of the service equipment of the two apartments. This permits not only a reduction in the service lines, but also insulation of the apartments against outside noise. For better insulation of the apartments the entries to the house and to the verandas are on opposite sides (Figure 35b).

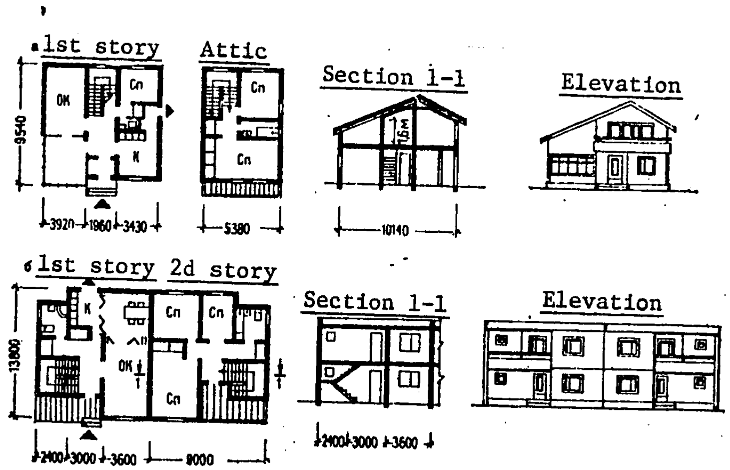


Figure 35. Attic-type residential houses (a) and two-story houses with apartments on two levels (b)

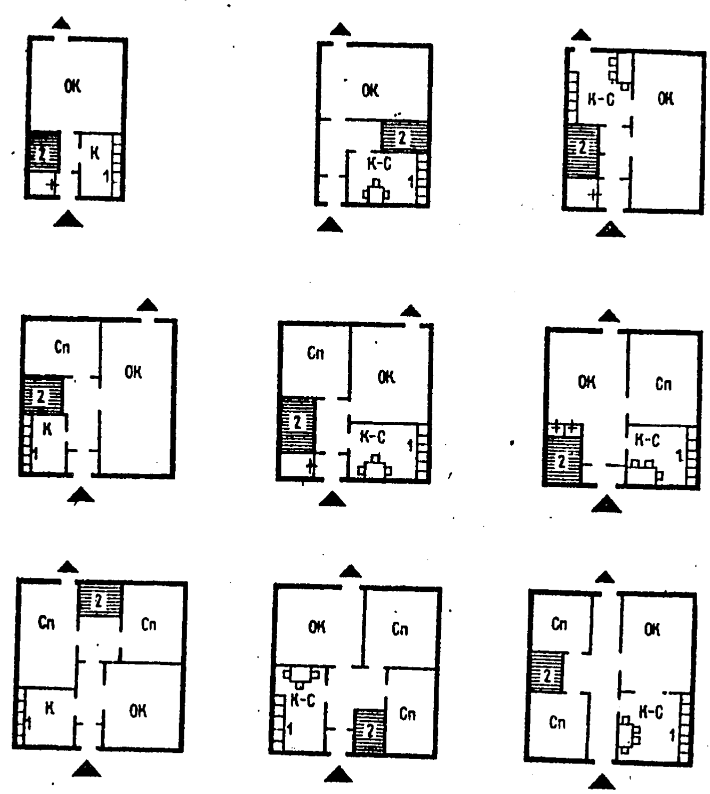


Figure 36. Block apartments in single-story blocked houses.

The blocked houses are multiapartment houses, and in them each apartment has separate entrances.

A block is an indivisible space-floor planning element consisting of various layouts of apartments. In construction and design practice in the Soviet Union, as a rule, single-apartment blocks--block apartments are used (Figure 36).

The density of coverage with blocked houses is quite high, and the separation of the apartments creates high comfort conditions for living in them. The blocked houses are made single-story, attic and two-story. In two-story houses the apartments can be both on two levels (Figure 37) and floor by floor.

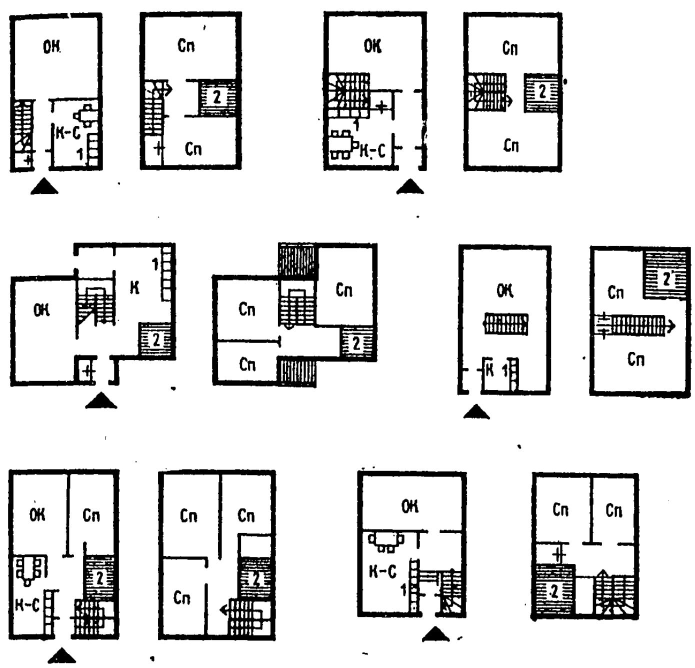


Figure 37. Block apartments in blocked houses with apartments on two levels.

Four-apartment, six-apartment and eight-apartment blocked houses are built. Four-apartment houses are most frequently encountered. The apartments in the four-apartment blocked houses are arranged in one or two rows, and they can also have cross layout (Figure 38).

The blocked houses permit the creation of the most varied combinations of blocks. The number of blocks in a house depends on different conditions: the degree of fireproofness of the structural designs, the relief, the dimensions of the construction lot, and so on.

The most widespread method of blocking is "linear," providing for contact of the rectangular block apartments with each other (Figure 39a, b). All of the apartments in a building with this type of blocking have through ventilation, and the building itself can be used without limiting orientation.

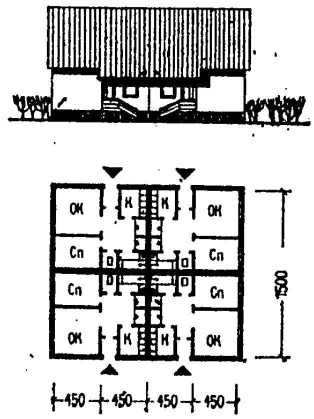


Figure 38. Cross-layout blocked residential house.

For more complete separation of one apartment from another, better insulation and city planning maneuverability, the blocks are shifted in one direction or another. This system of blocking has the form of a "saw" or "comb" (Figure 39c, d).

If it is necessary to have a large administrative room for the building, the residential block is blocked alternately with the administrative block (Figure 39e). This procedure permits the administrative facilities to be located in the block with the building which is especially frequently used in northern regions. Usually the administrative annexes serve as a lobby for entering the apartment.

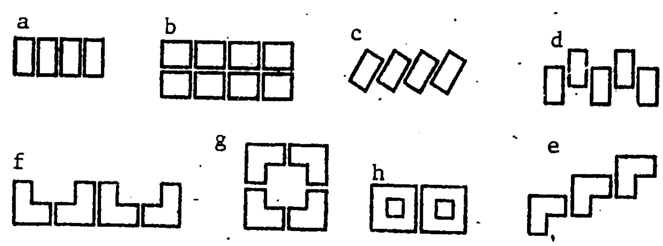


Figure 39. Apartment blocking diagrams. a--Single-row; b--two-row; c--saw-tooth; d--shifted in two directions; e--blocking by the administrative annexes; f--blocking with L-shaped apartment blocks forming courtyards; g--the same with the formation of an inside courtyard for several apartments; h--the same for one apartment.

In regions with a hot climate blocking is realized using blocks of auxiliary rooms of the apartment (kitchen, sanitary facility, closets). This form of blocking permits the kitchen to be a separate room. Shifting of the blocks makes it possible to obtain an isolated site for each apartment (Figure 39f) or isolated internal courtyard for two families.

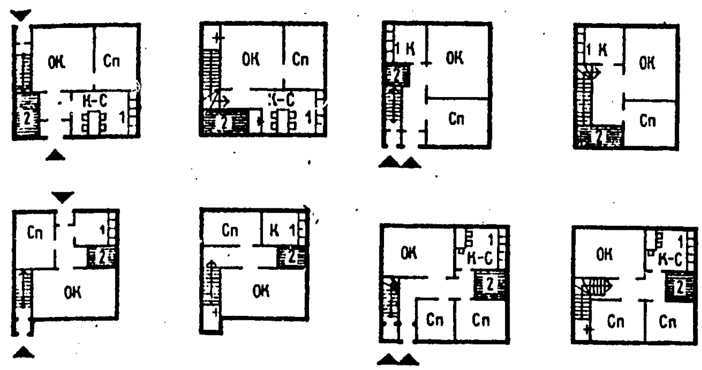


Figure 40. Layouts of blocked houses with floor-by-floor arrangement of the apartments.

In regions with warm and hot climates, blocked buildings with internal courtyards are used. Two types of such blocking are distinguished: the first--the inside yard services several apartments (Figure 39g)--and the second--a closed yard inside one apartment (Figure 39h).

For connection to a plot, in the majority cases a second entrance to the apartment is required on the plot side, for the site is split in half by the building, and it is possible to get into the plot of ground behind the building only from the apartment.

The two-story blocked houses with story-by-story arrangement of the apartments designed in cases where it is necessary to obtain one-room, two-room and three-room apartments. The apartments with story-by-story arrangement in blocked buildings have separate entrances (Figure 40).

These apartments permit small and medium-sized families (from two to five people) to live in two-story blocked buildings. Each apartment has a plot of ground next to the apartment which for the first floor is located on one side of the building and for the second floor on the other. As was pointed earlier, the apartments on the first floor usually have entrances: one from the street and one from the yard.

The negative aspect of these buildings is insufficient isolation of the dwelling--the windows of one apartment look out on the yard of the other apartment; the necessity for building additional passageways and accesses to the yards for the second-floor apartments.

The cost of blocked buildings is 25 percent less than the cost of single-apartment houses and 10 percent less than the cost of two-apartment houses.

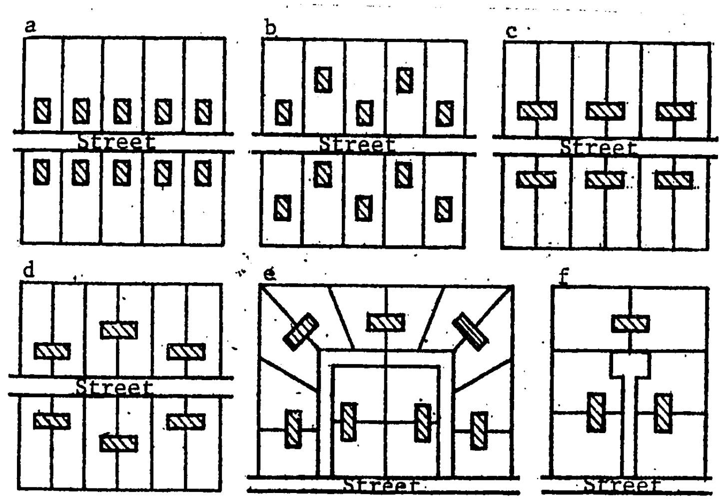


Figure 41. Basic methods of coverage with low-rise buildings with plots next to the apartment. a--Single-apartment along the street; b--the same in checkerboard arrangement; c, d--the same, two-apartment; e--cul-de-sac arrangement of the buildings; f--the same, along an internal loop access.

In the majority of cases the living conditions in such apartments are good. They have cross ventilation and free orientation; in addition, the simplicity of the structural designs permit the blocked building to be considered the most prospective for low-rise housing.

A characteristic feature of low-rise housing is the presence of the plots of ground next to the apartments. The schemes for organizing these yards and the arrangement of the buildings on them are illustrated in Figure 41.

Section 18. High-Rise Residential Buildings (Sectional, Corridor, Gallery-Type)

The high-rise residential building is the basic type of building in the cities and large settlements of the Soviet Union.

High-rise residential buildings, depending on the layout, are divided into multisectional, single-sectional (point), corridor and gallery. In addition to these three basic types, high-rise buildings of mixed structure are used: corridor-sectional, gallery-sectional. A distinguishing feature of the sectional building is the floor-by-floor grouping of apartments around vertical services (stairways, elevators). The stairways and elevators service several apartments, entrance to which is gained from the landings. It is possible to isolate the single-sectional buildings from the group of sectional buildings. This type of building is convenient in that the majority of apartments have corner ventilation and good isolation. In such buildings it is easy to use various layouts of apartments, for the buildings have light from all four sides.

In the corridor and gallery buildings the entrances to the apartments are arranged from floor-by-floor corridors and galleries. The apartments in such buildings are located on one side of the gallery, one side of the corridor or both sides of the corridor. The one-sided location of the apartments ensures cross ventilation.

Depending on the number of stories, the architectural planning solution of the apartments and structural design of the buildings differ. Two- to four-story buildings do not have an elevator or garbage chute; the stairs serve as the vertical communications joining floors. In 6-9-story buildings inclusively a garbage chute and one elevator per section are mandatory. In buildings taller than 10 stories, it is mandatory to install two elevators, and in residential buildings higher than 16 floors the number of elevators is calculated.

The choice of the number of floors depends on many factors: the size of the city or settlement; the material-technical base; the construction district, and so on. With an increase in the number of stories, the density of the housing facilities increases, the area of coverage decreases, the expenditures on service networks and amenities for the territory are reduced. On the other hand, for buildings higher than six stories it is necessary to build elevators and a garbage chute, which increases the construction cost and the operating expenditures on the building. Therefore when selecting the number of floors it is necessary to compare the data obtained from increasing the density of coverage and increasing the cost of construction of individual buildings.

Two- to four-story buildings are used primarily in farm and workers' settlements and small cities. As a result of their simple structural solutions, quite high level of amenities and good economic indices these buildings permit efficient use of the built-up territory.

Medium-rise and medium-high-rise buildings are used in large and largest cities with intensive coverage. They permit economical use of the urban development territory, they lower the cost of public transportation and amenities.

As has been pointed out, the basic element of all types of buildings is the apartment. In addition, high-rise buildings include vertical (stairs and elevators) and horizontal (corridors, galleries) communication. In order to increase the living comfort in high-rise buildings service and auxiliary facilities are provided. The layout of these facilities depends on the type of building, the amenities of the apartments and building as a whole, and the location in the built-up part of the microdistrict, and so on. Usually these facilities are located in the basement of the building or in a service corridor. For engineering servicing of a building provision is made for the following facilities: a heating station, electric panel, garbage collecting room. All of these facilities are also located in the basement.

In the majority of high-rise residential buildings the distribution station is the stairwell. This solution is economical and quite convenient. Usually the entry is located under the intermediate stair landing (Figure 42a). The height of the entry must be no less than 2 m. The entry serves to maintain a comfortable temperature in the stairwell and lobby.

When it is necessary to place the entry under the stairwell an entrance is built which not only is the distribution station, but it also is used for post office boxes, stowing bicycles, perambulators, and sometimes for leisure (Figure 42b).

One of the principal elements of a high-rise building is the stairway which provides vertical communications in the building. The basic dimensions of the stairs, their location and number depend on the architectural layout and structural solution of the building and the number of floors. In modern residential buildings basically three types of stairs are used: single-flight, two-flight and three-flight (Figure 43a, b). As a rule, the stairs have natural lighting. The slope of the flights of stairs is taken at a 1:2 ratio which corresponds to a step width of 30 cm and height of 15 cm. The number of steps in the flight must be no less than 3 and no more than 18. The width of the stair landings is taken no less than the width of the flight and no less than 1.2 m.

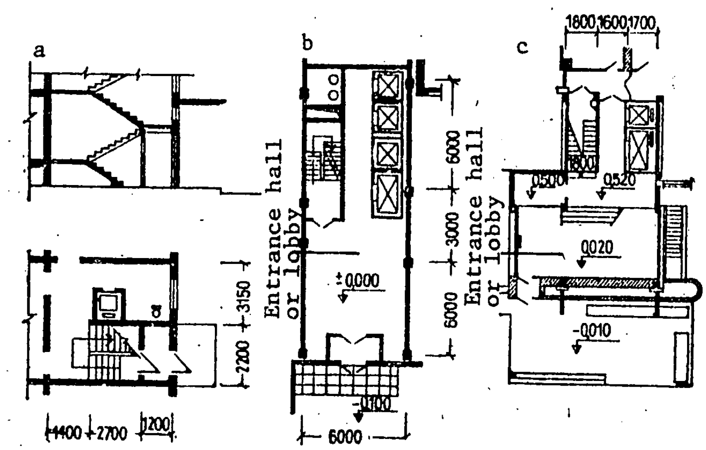


Figure 42. Versions of the solution of entrances to high-rise buildings. a--Directly through the stairwell; b--through an entry located alongside the stairs; c--the same having a cross passageway.

When designing stairs the data indicated in Table 6 must be used as a guideline.

Table 6. Least Permissible Width of Flights of Stairs and Their Greatest Slopes

Purpose of Flights	Least Width of Flights, m	Greatest Inclination of Flights
Evacuation stairs, including single-flight stairs, leading to the residential floors of the buildings:		
a) two-story	1.05	1:1.50
b) three-story or more	1.05	1:1.75

Table 6 (continued)

Purpose of Flights	Least Width of Flights, m	Greatest Inclination of Flights
Flights of stairs leading to basements, service corridors and attics and also flights of stairs within the apartments	0.90	1:1.25

Notes: 1. The width of a flight of stairs is determined by the distance from the wall to the railing. 2. In the stairways inside the apartment the tread width of turning steps midway their length must be no less than the tread width of nonturning steps in the flight, and on the narrow end of the step, no less than 0.08 m. 3. There must be a free clearance no less than 0.1 m wide between the flights of stairs. 4. The width of the flights of stairs in corridor apartment houses must be no less than 1.2 m.

Table 7. Maximum Permissible Distances From the Apartment or Room Entrance in a Corridor Apartment House From an Outside Exit or Stairwell

Degree of Fireproofness of Building	Greatest Distance From Apartment or Room Entrance in Corridor Apartment House: To Stairwell or Outside Exit, m	To Exits to Blind Corridor or Gallery, m
I	40	25
II	40	25
III	30	20
IV	25	15
V	20	10

The elevators belong to the vertical communications in high-rise residential buildings. The elevators are installed in buildings higher than five stories, and also when the top story is 14 m above the sidewalk level, independently of the number of stories. Usually the elevators are located near the stairs, and in this way a stair-elevator unit is created. In high-rise residential buildings, as a rule, 320- and 500-kg elevators are used.

The garbage chute (see Section 11) is installed to remove garbage from apartments in five-story buildings and higher.

The sectional buildings have become the most widespread in residential construction. They consist of a number of section modules and differ from each other with respect to number of stories, extent, the layout of the apartments, orientation, and so on.

The basic types of section modules are as follows: row, end, corner and rotational (Figure 45a-d).

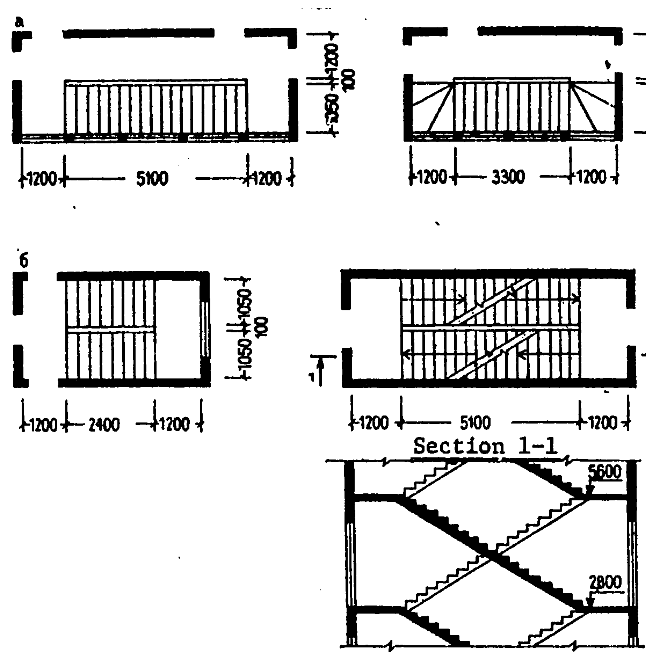


Figure 43. Types of stairs. a--Single-flight; b--double-flight.

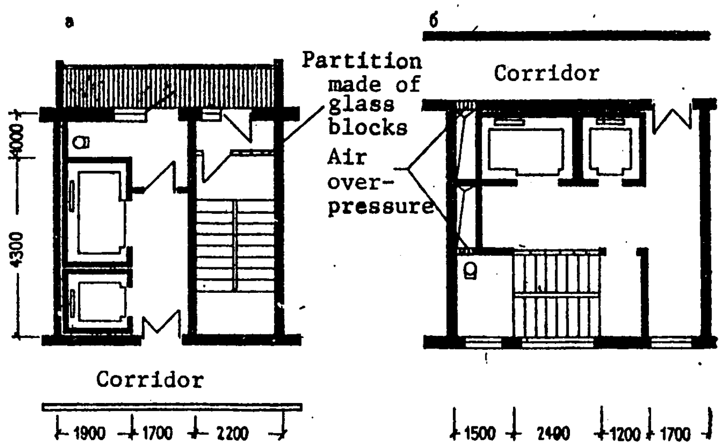


Figure 44. Diagrams of smoke-free stairwells. a--With passage through the vestibule and through an open space; b--with artificial air over-pressure and self-closing doors.

The row section models, as a rule, have simple, rectangular shape. Their layouts can be the most varied.

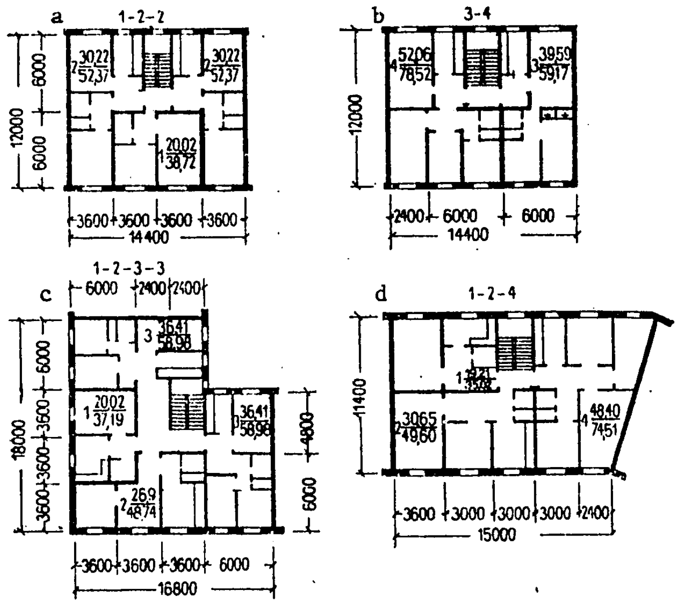


Figure 45. Layouts of basic types of section modules. a--Row; b--end; c--corner; d--rotating.

The rotating section modules, just as the row modules (Figure 45a) have two outside walls. The rotating sections (Figure 45b) differ from the row sections by configuration. In the rotating section one of the walls of the end apartment is set at an angle. The insert from the rotating section permits the orientation of the building to be changed. These sections serve to improve the city planning maneuverability of the sectional residential houses and the architectural-artistic impression of the facades. The apartments of the rotating section modules are oriented just as in the row section modules.

The end and corner section modules, in contrast to row, have three outside walls (Figure 45c, d). The layout of the apartments in the end and corner section modules can be the same as in row sections. Sometimes in the apartments located on the end walls the number of rooms can be increased as a result of the perimeter of the outside walls. The corner sections are used in buildings of complex configuration (U- and L-shapes, and so on). The corner sections are resolved by the same parameters as row and end section modules.

The layout of the sections differs and depends on the number of apartments in a section, the number of floors, the technical equipment, and so on. Most frequently two-, three- and four-apartment sections are used in residential construction. Six- and eight-apartment sections are used in medium-high-rise buildings.

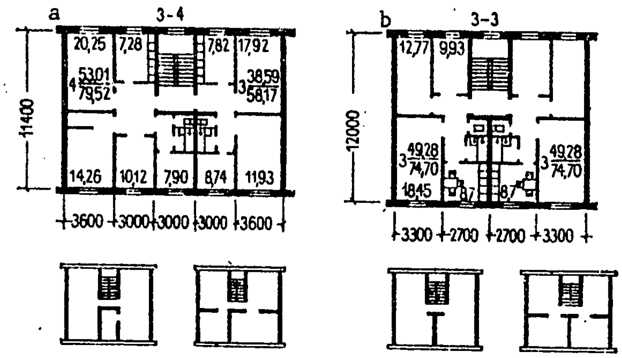


Figure 46. Layouts of two-apartment sections. a--Asymmetric (with partially limited orientation); b--symmetric (with unlimited orientation).

The standard sections are designated by type and number of apartments: the two-apartment section 3-4, the three-apartment section 2-3-3 and the four-apartment section 1-2-3-3 (see Figures 45, 46). The number of numbers indicates the number of apartments in the section, and the numbers themselves indicate the number of rooms in the apartment.

Depending on the layout the sections can have meridional or latitudinal orientation with respect to points of the compass. Meridional sections have limited orientation, and latitudinal sections are designed with partially limited and free orientations.

The two-apartment sections are designed with free orientation (Figure 46a), cross ventilation and good isolation of the apartments. The enumerated positive aspects permit application of two-apartment sections in areas of a hot climate where cross ventilation of the apartments is mandatory. In cold and warm climates application of these sections is economically disadvantageous, for a staircase on the floor serves a total of two apartments, and the cross ventilation of the apartments in these zones is unnecessary. The location of the living spaces uniformly on both sides of a section provides latitudinal free orientation of the building (Figure 46b). In cases where the greater part or all of the living spaces are located on one side of a section, the building changes the partially limited orientation (see Figure 46a).

The layout of the apartments is greatly influenced by the location of the kitchens and the sanitary facilities. Possible versions of their arrangement are shown in Figure 47. Separate placement of the kitchens and sanitary facilities leads to an increase in the number and length of supports in the building.

In the two-apartment sections it is expedient to design apartments of large area, inasmuch as with small apartments the width of the building is diminished which leads to increased cost of the living space.

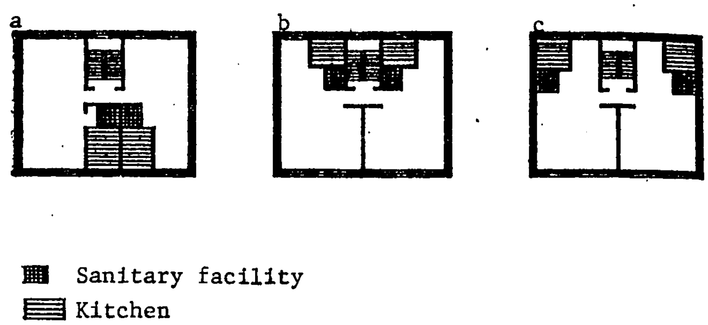


Figure 47. Arrangement of kitchens and sanitary facilities in two-apartment sections. a--Adjacent on the outside wall; b--separately on the stairwell walls; c--on the walls separating sections.

The three-apartment sections are more economical than two-apartment sections inasmuch as the cost of the stairs is distributed over a larger number of apartments. The majority of three-apartment sections has partially limited orientation; two apartments have two-sided orientation and one, of smaller area, one-way orientation. The layout of the apartments can be symmetric with partially limited orientation (Figure 48a), asymmetric with partially limited orientation (Figure 48b), and asymmetric with limited orientation (Figure 48c). The three-apartment sections with partially limited orientation have become most widespread in construction practice. The basic ways of arranging the kitchens and sanitary facilities in the three-apartment sections are illustrated in Figure 49.

By orientation conditions the four-apartment sections can be subdivided into sections of partially limited orientation (Figure 50a) and sections of limited orientation (Figure 50b). The compactness and economicalness of the apartments in the four-apartment sections have given rise to broad application of them in mass housing construction. The kitchens and sanitary facilities in the sections can be placed together (Figure 51a) or separately (Figure 51b). The deficiencies of the four-apartment sections can include absence of cross ventilation and low city planning versatility.

In addition to the above-enumerated sections six- and eight-apartment sections are used in high-rise buildings. These sections permit more efficient loading of the stairs and elevators and lower their cost. The multiapartment sections are primarily used in 16-story and higher buildings.

In addition to the sections of rectangular configuration sections with complex plan are used in housing construction (three-ray, cross, and so on, Figure 52). The three-ray sections (Figure 52a), the so-called three-leaves, permit ensurance of good isolation, cross and corner ventilation of all apartments in the three- and four-apartment sections and four apartments in the six-apartment sections.

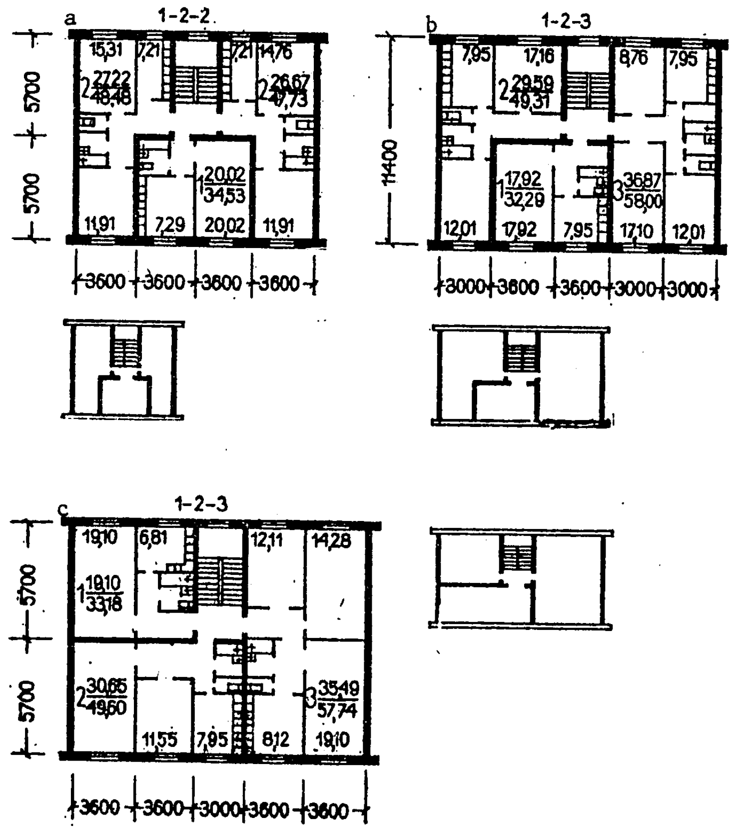


Figure 48. Layouts of three-apartment sections. a--Symmetric (with partially limited orientation); b--asymmetric (with partially limited orientation); c--the same (with limited orientation).

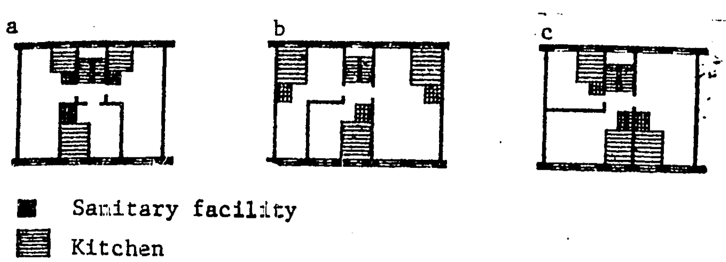


Figure 49. Location of kitchens and sanitary facilities in three-apartment sections. a--With entrance to the apartment on the stairwell walls; b--with entrance to the apartment and in depth on the walls separating the sections; c--adjacent on inside wall and stairwell walls.

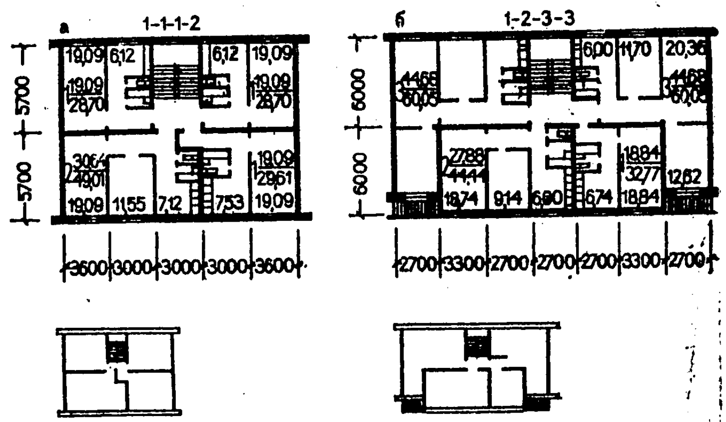
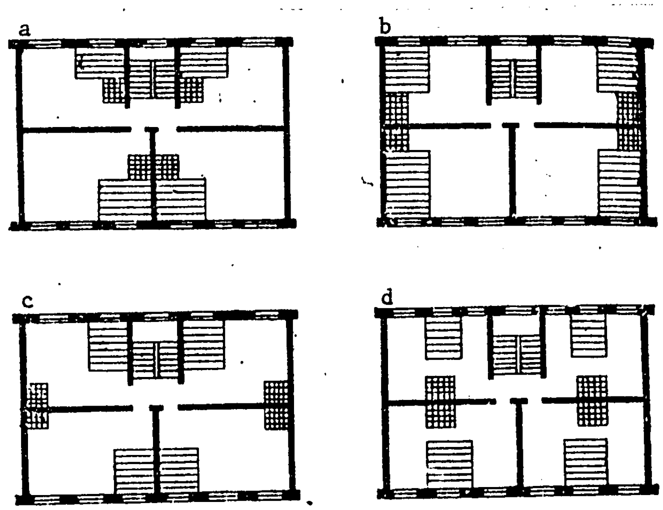


Figure 50. Layouts of four-apartment sections. a--Symmetric (with limited orientation); b--the same (with partially limited orientation).



Sanitary facility

Kitchen

Figure 51. Arrangement of the kitchen and sanitary facilities in a four-apartment section. a--Adjacent at the entrance to the apartment; b--the same in depth of the apartment; c--separate at the entrance to the apartment, sanitary facilities in depth of the apartment; d--the same in the center of the apartment.

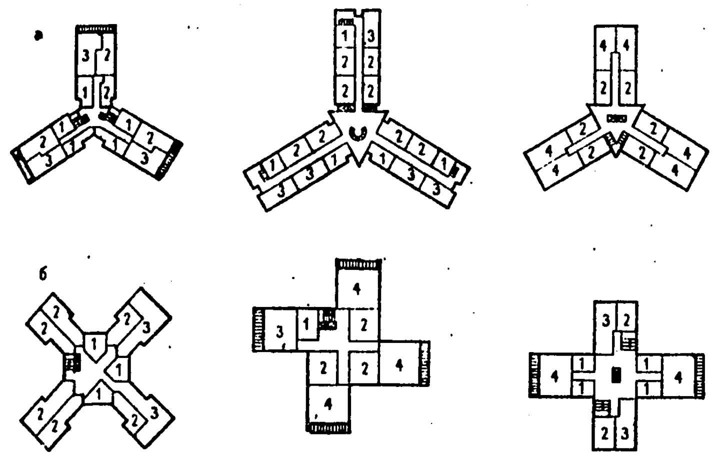


Figure 52. Diagrams of sections with complex layout and different number of apartments. a--Three-leaved; b--crisscross.

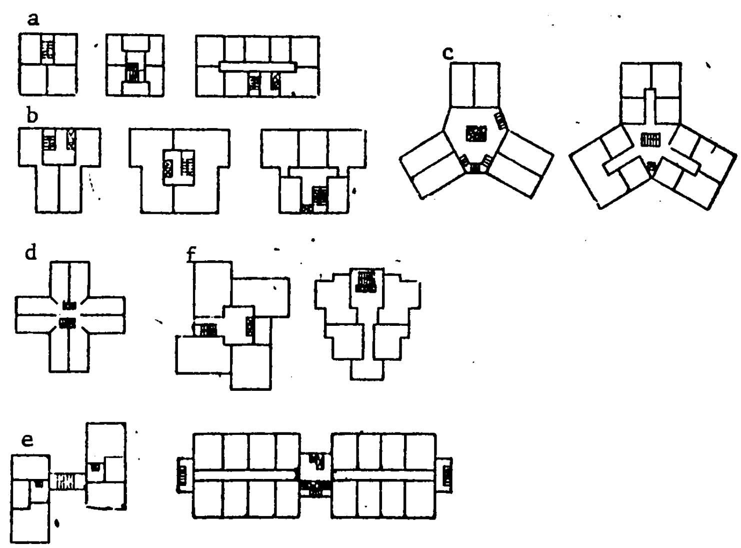


Figure 53. Configuration of single-section buildings. a--Rectangular; b--T-type; c--three-leaved; d--crisscross; e--block-pair; f--complex.

The crisscross sections (Figure 52b) permit cross and corner ventilation of all apartments in a four-apartment section, four apartments in a six-apartment section and six apartments in an eight-apartment section. A deficiency of the crisscross sections is reduced isolation of the corner apartment.

Along with multisectional buildings in construction practice single-section (point) buildings are used. The advantage of single-section buildings include optimal isolation and ventilation conditions, comparatively small sizes in plan view, one vertical communication assembly, and city planning versatility. The configuration of single-section buildings can be rectangular, T-shaped, three-leaved, crisscross, stepped, block-pair, complex, and so on (Figure 53a-f). The economicalness of the layout of a single-section building depends to a great extent on the specific cost of the vertical communications (elevators, stairs) and operating expenditures. The most economical are buildings with a compact layout in the form of a square or circle. Such layouts give the most advantageous relation between the perimeter of the outside walls and the floor area. The single-section buildings are constructed on small lots which are cleared during urban renewal. The groups of point buildings are constructed in the public center of a microdistrict or a city, creating a compositional contrast with the low-rise buildings of the public center.

Corridor buildings are designed for small families and singles. The basic communication unit in buildings of this type is the corridor. As a rule, the apartments are located on both sides of the corridor, and more rarely, on one side. The cost of construction and operating expenditures in the corridor buildings is appreciably lower than in section buildings. This is achieved as the result of the fact that one corridor is used for a large number of apartments, reduction of the number of stairs, elevators, garbage chutes, increase in the width of the building as the result of locating the apartments on both sides of the corridor, simplicity of structural designs, and so on. In the case of central arrangement the corridors are lighted on one or both ends. The length of the corridor when lighting on one end must not exceed 20 m, and when lighting on two ends, 40 m. For more significant length of the corridors, light breaks must be constructed in them, the distance between which must not be more than 20 m, and there must be no more than 30 m between the light break and the lighting of the end.

The common corridor between two stairs or between the end and the stairway must have a width of 1.4 m with a length to 40 m and 1.6 m with a length of more than 40 m. The width of the exits from the common corridors to the stairwells must be no less than the width of the flight stairs leading to these exits.

The doors to the outside exits from the stairwells and also the doors of the exits from common corridors must open in the direction of the exit from the building. The apartments in corridor buildings, as a rule, are small--one- and two-room apartments. The versions of the layouts for corridor buildings and their apartments are illustrated in Figure 54.

Gallery buildings are primarily used in areas with hot climate. In areas with cold climate closed galleries are provided. Galleries are constructed on one side of the building; they service one or several stairways and elevators (Figure 55).

Just as corridor buildings, gallery buildings are distinguished by high economicalness, good sanitary-hygienic qualities of the apartments, cross ventilation and optimal orientation of the apartments.

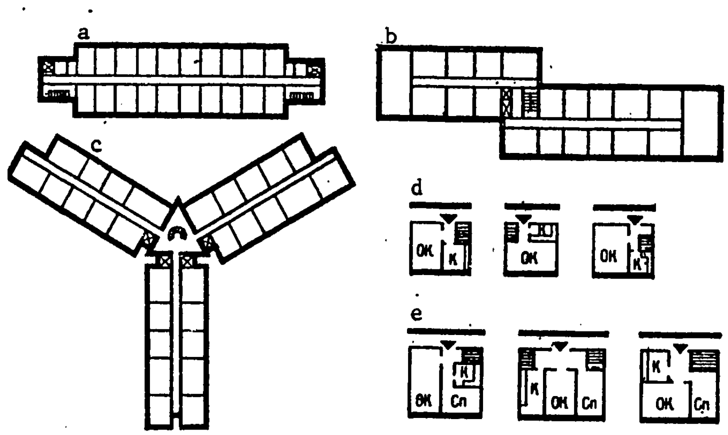


Figure 54. Layouts of corridor buildings and apartment plans for them. Configuration of the buildings: a--rectangular; b--with shift to increase lighting and ventilation of the corridors; c--three-leaved. Types of apartments: d--one-room; e--two-room; OK--living room; Cn--bedroom; K--kitchen.

For insulation of the apartments from outside noise on the gallery side they have an entry, kitchen, sanitary facility, bath and closets. The living spaces are on the opposite side. Stairs and galleries can be taken outside the building or built into it.

Section 19. Corridor Apartment Houses and Dormitories

Corridor apartment houses are designed for temporary living of singles and childless families. They are designed for students, builders, geodetic experts, land reclamation people, and so on. The corridor apartment houses include living quarters, auxiliary facilities and cultural-general services and medical facilities. The living quarters of corridor apartment houses are designed for two or three people.

The corridor apartment houses are divided into specialized corridor apartment houses and homes. The specialized corridor apartment houses include dormitories for students in the general-education schools, professional-engineering schools, pupils at the children's homes, for the aged and invalids.

The homes are designed for builders, students, postgraduates, and so on.

The homes are divided into two groups with respect to degree of cultural and general services:

a) corridor apartment houses with minimum service facilities (for industrial and office workers) and minimum sanitary-engineering equipment in the rooms;

b) improved-comfort corridor apartment houses (for students and postgraduates) with expanded service facilities and expansion of the equipment in the rooms.

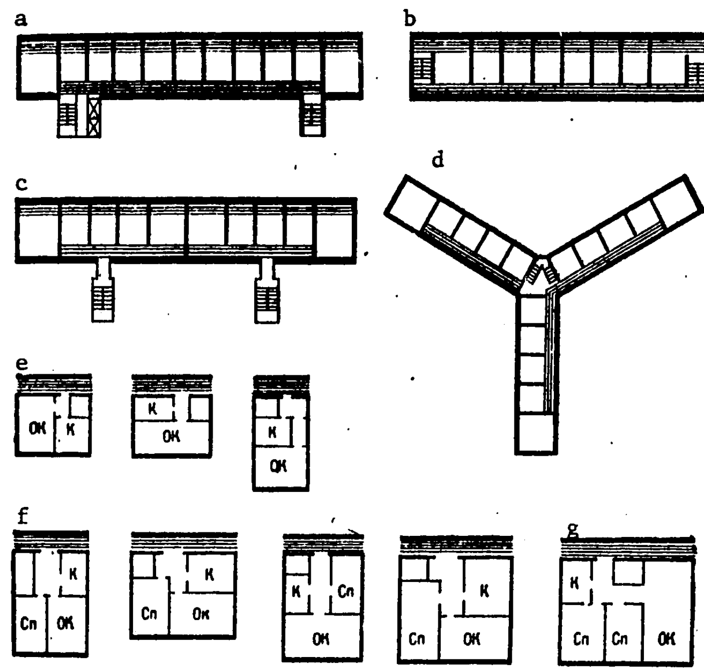


Figure 55. Layouts of gallery and gallery-sectional buildings. a--Gallery buildings with stairs outside the dimensions of the building; b--the same with stairs included in the dimensions of the building; c--gallery-sectional with stairs outside the dimensions of the building; d--three-leaved with stairs included in the building dimensions. Types of apartments: e--one-room; f--two-room; g--three-room (OK, Cn, K, see Figure 54).

The corridor apartment houses can have different capacities: The capacity of stationary corridor apartment houses is from 50 to 100 people; in rural areas the stationary corridor apartment houses can be smaller.

The basic space and floor planning unit in a corridor apartment house is the living unit which is designed for 10 to 12 people. The living unit includes one or two rooms for two, three or four people, sanitary facilities, built-in cupboards for linens and clothing, bath or shower, kitchen (Figure 56). The composition of the auxiliary facilities is determined by the degree of comfort of the corridor apartment house.

The area of the rooms is determined calculating 6 m^2 per person. The rooms in a corridor apartment house must be without passages and no less than 2.2 m wide. It is necessary to provide an exit from each room into the corridor directly or through an anteroom. The doors of the rooms in a corridor apartment house must open inward and have seals in the frames. The rooms of corridor apartment houses are equipped with built-in cupboards each 0.6 x 0.6 m for storing houseclothing and footwear. The number of compartments in the built-in closets must be equal to the number of people living in the room.

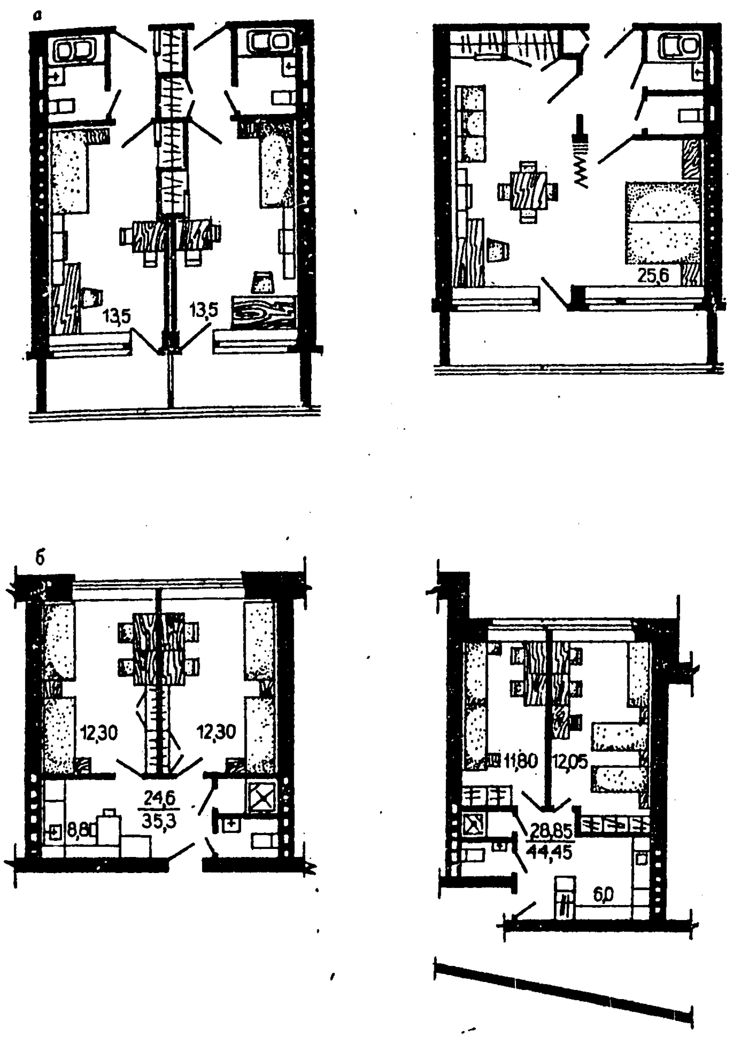


Figure 56. Layouts of living quarters (a); rooms for 2-3 people (b) in corridor apartment houses.

The living quarters, the cultural-general service facilities and corridors must have direct natural lighting. The closets, the rooms for drying clothes and footwear, showers, sewered toilets with one or two water closets can have artificial lighting. Secondary light is permissible for the room for cleaning and ironing clothes, and other auxiliary facilities.

The kitchens in the corridor apartment houses are equipped with kitchen stoves, sinks, cupboard-tables and hanging shelves. The kitchen equipment is installed calculating one burner of a gas stove or solid-fuel stove per five people, one burner of an electric stove per three people, one sink per cupboard-table per eight people, one compartment of a wall or free-standing cupboard 0.3 x 0.3 m per person. In the corridor apartment houses for students at the professional-technical schools there must be one burner, one sink and one cupboard-table per 10 people.

The rooms for cleaning and ironing clothes must be equipped with sinks, ironing boards and built-in cupboards for the laundry accessories.

The service facilities in the corridor apartment houses are located on every floor. Their layout on the different floors depends on the specialization of the corridor apartment houses. The mandatory facilities include entrance halls or lobbies, kitchens, activities room, a leisure room, laundry, various closets, a room for cleaning and ironing clothes, a facility for drying clothing and footwear, and an isolation room. In large corridor apartment houses the auxiliary facilities can include a snack bar, general services reception areas, a library with reading room, and so on.

Section 20. Design Examples and Their Technical-Economic Indices

One of the main problems solved when designing residential buildings is improvement of the living comfort. Therefore future construction of residential buildings will develop in the direction of bringing certain forms of public services as close as possible to the user. One such example is the "Lebed'" Microdistrict (Moscow) in which four 16-story buildings are joined by a stylobate (a one-story part of the building extending beyond the main body of the building), where the garages are located in the underground section, and public and service facilities in the above-ground part. It has a central lobby with coatroom, vending machines, order office, a facility for storing seasonal clothing, and a room for storing perambulators (Figure 57a, b). Landscaped areas for leisure are located on the stylobate.

In the Severnoye Chertanovo Residential District in Moscow provision is also made for finding the optimal service system and improving living comfort. For this district a social service system has been developed for the population, the basic component of which is concentrated in the large service enterprises within the district. At the same time, the lobbies of the residential buildings have domestic services reception areas, order desks, a loan and leasing office, automatic vending machines for primary necessities. In each building there are general domestic facilities: self-service laundries, perambulator storage, closets for storing seasonal clothing and sports equipment.

This system makes it possible to consolidate the public service networks and bring them close to the residents.

In addition to expansion and bringing the service system closer, in the future designs of residential buildings provision will be made for improving the operational characteristics of the apartment. One of the solutions improving the comfort of an apartment is flexible layout. The principle of such layout consists in creating a free plan in the apartment which permits the creation of various layout solutions within the same dimensions.

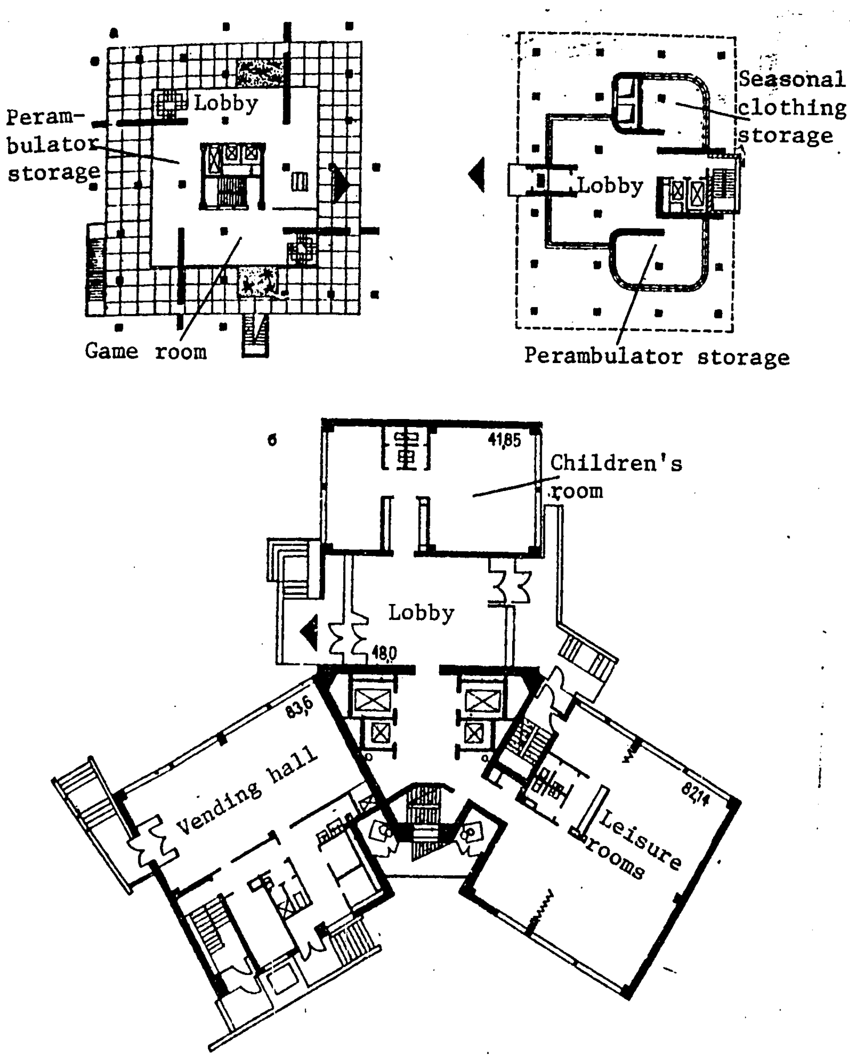


Figure 57. Designs of residential buildings. a--With reduced number of service facilities; b--with expanded number of service facilities.

In the future the majority of families will live in apartments with the number of rooms equal to the number of members of the family, and the norm for living space and common area in the apartment will be increased. This will free the living room of the sleeping space function and join it to the kitchen and entry, which, in turn, will offer the possibility of obtaining a large room, and ordinarily using the living room, kitchen and entry for their direct purposes separately (Figure 58a, b).

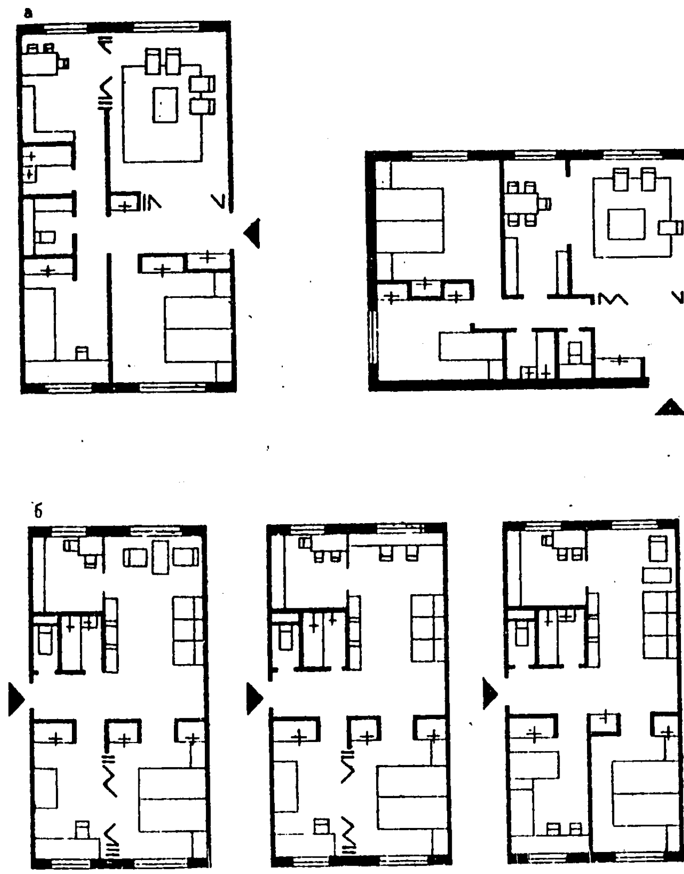


Figure 58. Floor plans for apartments with room conversion. a--Combination of adjacent rooms; b--varying the floor plan of the apartment as a function of the family composition.

The modern structural designs of residential houses create prerequisites for the development and introduction of flexible apartment floor planning into the housing construction. In such apartments, sliding partitions or the installation of closet partitions will allow the number of rooms to be varied depending on the composition of the family (Figure 58b).

For determination of the economicalness and efficiency of the architectural design and structural solutions of the buildings various coefficients are used.

The space-floor planning coefficients K_1 and K_2 which have been used in our country since 1927 are used in design practice. At the present time these coefficients are insufficient for developing the solution to all of the problems arising during technical-economic evaluation of a design. Therefore other planning indices characterizing the effectiveness of the design solutions are finding application in design practice. The coefficient of compactness of the plan K_3 is the ratio of the perimeter of the outside walls to the common area. The smaller K_3, that is, the specific perimeter of the outside walls, the lower the expenditures on erecting them. Families with square or rectangular shape of plan have the smallest coefficient K_3. Here, the wider the building, the smaller the perimeter of the outside walls obtained for equal area of coverage. In the existing standard designs for housing K_3 fluctuates within the limits of of 0.16 to 0.25.

The structural factor K_4 characterizes the degree of saturation of the building plan with vertical structures (outside and inside walls, partitions and columns), and it is defined as the ratio of the structural area occupied by the vertical structures in plan view to the area of coverage of the building. The value of the structural factor depends on the floor plan solution, the structural design and the material of the vertical structures. The coefficient K_4 fluctuates within the limits of 0.1 to 0.2. The smaller the value of this coefficient, the more economical the design solution.

Chapter IV. Public Buildings

Section 21. General Principles of the Design of Public Buildings

Public buildings and structures are designed for social, general services, cultural and communal services to the population.

The architecture of public buildings, their location and relation to the overall built-up area play an important role in the creation of the architectural layout of a city. The most significant public buildings (administrative, cultural-educational and commerce) are located in the general municipal center, on the central squares and thoroughfares. The city planning significance of large public buildings is intensified when combining them into complexes. In order to isolate public buildings from the overall development it is necessary to approach the architectural expression of these buildings.

The basis for classifying public buildings is the division of them into classes. With respect to the set of certain attributes, buildings and structures of each type are divided into four classes. The class I public buildings include buildings and structures on which increased requirements are imposed, and class IV buildings include those on which minimum requirements are imposed (sanitary-hygienic, service life, fireproofness, and other requirements). Depending on the significance, public buildings are basically classified as class II, III and IV. Class I includes the unique public buildings.

With respect to degree of fireproofness public buildings are divided into five degrees. The degree of fireproofness is characterized by the combustibility group and fireproofness limit of the basic structural elements. The degree of fireproofness of public buildings is taken as follows:

For class I buildings	no less than degree II
For class II buildings	no less than degree III
For classes III and IV buildings	degree of fireproofness not standardized

For the case of the occurrence of a fire in the building, provisibn must be made for the possibility of safe evacuation of people through the emergency exits. No less than two evacuation exits are provided for each building.

The distance from the doors of the most remote rooms in public buildings to the outside exit or stairwell is taken according to SNiP II-L.2-72 by the data presented in Table 8.

Table 8. Distance From the Doors of the Most Remote Rooms to the Outside Exit or Stairwell, m

	Degree of Fireproofness of the Building			
	I, II	III	IV	V
Exit from rooms located between stairwells or outside exits:				
In kindergartens	20	15	12	10
In hospitals	30	25	20	15
In other public buildings	40	30	25	20
Exit from rooms to a blind corridor:				
In kindergartens	20	15	12	10
In other public buildings	25	15	12	10

The service life of the basic structural elements must be no less than degree I for class I buildings, degree II for class II and degree IV for class III buildings. The service life of the basic structural elements for class IV buildings is not standardized.

The functional interrelation of the rooms and the functional process taking place in the buildings must be used as the basis for the design solutions of public buildings.

The variety and complexity of functional processes occurring in public buildings are reflected in the interrelation and sequence of the arrangement of the rooms. In accordance with this scheme, certain rooms must be connected directly, others through corridors, stairs, escalators and elevators.

When developing the plan for a building it is necessary to establish the layout of the rooms, their shape and size as a function of their purpose. The rooms and public buildings are divided into the following groups with respect to purpose:

basic rooms in which basic functional processes are realized (the auditoriums of movies and theaters; classrooms in schools and technical high schools; vending rooms of stores and department stores, and so on);

auxiliary facilities (kitchens, sanitary facilities, lobbies, coatrooms, and so on);

communication links and facilities--stairways, elevators, escalators, ramps, corridors and galleries.

The layout of the rooms is established considering the sequence of functional processes occurring in the building and giving rise to one people flow or another in it.

During the process of creating the layout of the inside space of a building it is necessary to ensure correspondence of all of the areas and heights of the rooms to the design norms and also to provide for satisfaction of the sanitary-hygienic and fire-safety requirements. These requirements include proper orientation of the rooms with respect to points of the compass, insulation, natural illumination, a defined degree of fireproofness of both individual structural elements and the building as a whole.

The quality of the architectural layout depends to a significant degree on how clearly the main element is distinguished in the spatial structure of the building and to what degree all of the remaining elements of the layout are tied to the main one as a united whole. Beginning with these conditions, the spatial structure of public buildings is divided into three basic systems: cellular, large hall systems and the combined system.

The cellular system is used in buildings in which comparatively small rooms of identical area are necessary. This system can be solved by the corridor, corridor-free and suite scheme (Figure 59a-c).

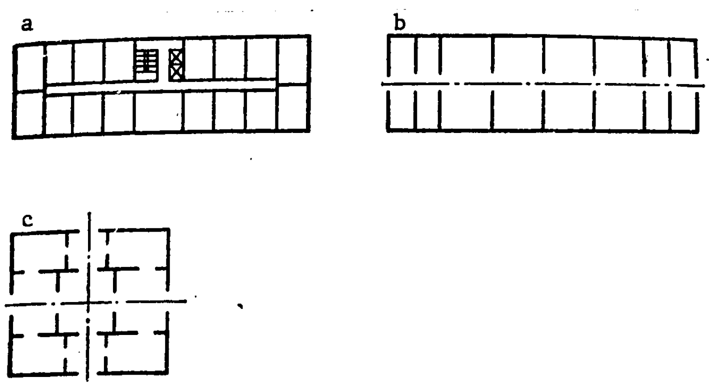


Figure 59. Layouts of public buildings. a--Corridor; b--suite; c--corridor-free.

In the case of application of the corridor scheme the rooms are arranged along one or both sides of a corridor connected to stairwells (see Figure 59a). The corridor layout is used in schools and administrative buildings and polyclinics.

In the suite layout the rooms are arranged one after the other and are connected by doorways. The suite system is used in museums, palaces and other buildings (Figure 59b).

The corridor-free layout is constructed in the form of a compact layout with entrance to all the rooms from a common small hall (Figure 59c).

The large hall system is used in buildings where rooms with large areas are required. Several large rooms are grouped together (theaters, sports arenas, exhibition pavilions, and so on). This system is used for the design of buildings with large halls in which there are internal supports (department stores, restaurants and other auxiliary institutions and enterprises in planning respects).

The combined system is based on combining the cellular and the large hall systems (such rooms as large halls are grouped with smaller rooms).

All three systems promote the creation of a regular grouping of the internal spaces of the building.

The space and floor-planning solution of buildings depends to a great extent on the adopted structural diagram.

When constructing low-rise and medium-rise public buildings, large panels, modules and bricks are used. The structural systems are the same as in residential buildings. In public buildings the frame system has become most widespread. It ensures stability of the building, free planning of the inside space, reduction of structural elements, and so on.

Frame buildings are resolved with respect to the frame-connector and connector systems using standardized structural elements (columns, collar beams, floor panels, stiffening cores) (Figure 60a, b).

In addition to the general requirements which must be satisfied by any public building, the requirements of economicalness are imposed on it. The space-floor planning and operational technical-economic indices exist for this purpose.

The space-floor planning indices include the following indices: the total structural volume, working area, usable area and coefficients K_1 and K_2.

The total structural volume of a building in m^3 consists of the basic heated volume of the building and the unheated volume--basement, attic, and so on.

The working area of public buildings is defined as the sum of the areas for the basic purpose, service and auxiliary purposes, with the exception of stairwells, corridors, vestibules, passages and also the engineering facilities in which the power and sanitary-engineering equipment is located (boilerrooms with auxiliary facilities, boilers, ventilation chambers, the elevator machinerooms, and so on). The corridor areas used as recreation or waiting rooms and also as lounges in movies, hospitals, sanatoriums, and so on must be included in the working area. The engineering facility areas, the composition of which depends on the purpose of the building, the capacity and the volume (broadcast centers, panel and auxiliary facilities for sets and scenes, movie equipment, and so on) are included in the working area.

The total area of public buildings is defined as the sum of the working area of the buildings, the area of the corridors, the vestibules, passages and also the areas designated for engineering purposes.

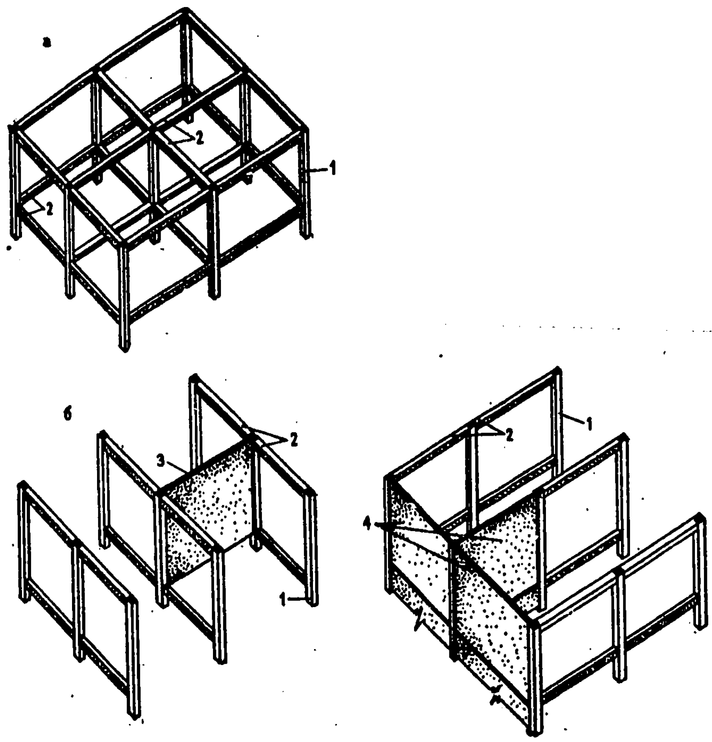


Figure 60. Basic structural diagrams of public buildings. a--Frame with cross-frames; b--frame-connector; 1--columns; 2--collar beams; 3--flat connecting element; 4--three-dimensional connecting element.

The efficiency of the space-floor plan solution to the building is revealed by the coefficients K_1 and K_2. The coefficient K_1 indicates the ratio of the working area to the usable area. The coefficient K_2 reveals the ratio of the volume of the buildings to the total area.

Section 22. Classification of Public Buildings

With respect to functional purpose public buildings and structures are classified as the following types:

training-educational institutions--kindergartens, general education schools, professional-technical schools, technical secondary schools, institutes, and so on;

trade and public eating facilities--trade centers, department stores, stores, markets, drugstores, restaurants, dining rooms, coffee shops;

general services enterprises--workshops, chemical cleaning, studios for various purposes, barbershops, baths, laundries, and so on;

cultural-education institutions--libraries, museums, movie theaters, circuses, palaces and Pioneer Houses, and so on;

public health installations, physical culture and social security--hospitals, dispensaries, polyclinics, sanatoriums, health resorts, sports facilities, Pioneer camps, and homes for the elderly and invalid;

communications enterprises and installations--post offices, telegraph offices, telephone offices and radiobroadcast centers;

administrative and public organizational installations--ministries and departments, councils of people's deputies, public procurator offices, courts, archives, registry offices, and agencies charged with keeping order;

transportation enterprises--railroad, highway, river, marine ports and airports, motor transport offices, steamship directorates, Aeroflot agencies, and so on.

All of the public installations and organizations in the city planning structure are divided into four groups with respect to degree of service to the population:

first group--primary service installations (self-service laundries, repair shops and children's rooms);

second group--daily-use installations (institutes, technical high schools, schools, kindergartens, produce stores, order desks, reception stations, dining rooms, libraries);

third group--periodic-use installations (restaurants, stadiums, trade centers, post office, telegraph office, palaces and Pioneer Houses);

fourth group--sporadic-use installations (administrative installations and organizations, theaters, museums, health resorts, sanatoriums, registry offices and archives).

The composition and the system of cultural-general services buildings are influenced by the size of the microdistrict. Depending on its size there can be various combinations of public service groups. Some functions of certain groups can be combined.

Depending on the normative radii of accessibility of an installation (the length of the pedestrian walk to it) the cultural-general services are administered in a municipal system by a three-stage system (the primary housing group, microdistrict, district). It offers the possibility of creating large housing complexes.

The first service stage is the primary servicing with a radii of 150-200 m, the normative number of people in the service area is 1,500 to 2,500. This block will include primary necessity installations and enterprises: the receiving stations of laundries and workshops for repair and sewing of footwear, snack vending machines, and so on.

The second service phase with a radius of no more than 300 to 500 m includes the cultural and general services installations joined at the trade center of the microdistrict designed for daily servicing of 9,000 to 25,000 people (produce stores, schools, kindergartens, dining rooms, and so on).

The third service phase is the service center of the district or large microdistrict including installations and enterprises of periodic and sporadic use (theaters, museums, post office, telegraph office, and so on).

The enterprises and installations for servicing the population are designed in accordance with SNiP II-60-75 depending on the specific conditions. The consolidation of the service enterprises and cooperation of them lead to economic and operating advantages--a reduction in construction cost, reduction in service personnel staffs. For this purpose the trade enterprises and installations are combined into trade centers.

Section 23. Basic Floor Plans of Public Buildings

For each type of public building, depending on its purpose, capacity and service life, a particular floor plan is adopted.

The primary element in the public education system is the kindergartens. Kindergartens are divided up as follows with respect to nature and time of operation:

day-care, designed for the children to be present from 0900 to 1400 hours;

round-the-clock, in which the children are present 6 days out of the week;

mixed, where some groups are present only in the daytime and others, round the clock.

The kindergarten buildings must be designed universal for day-care and round-the-clock presence of children. The capacity of the kindergartens must be no less than as follows: 140 places for cities, 90 places for urban-type settlements, 25 places for rural populated areas.

The service radius for these institutions is as follows: 400-500 m for kindergartens, 300-400 m for day nurseries, and 300-500 m for day nursery and kindergarten combined.

The buildings for preschools consist of three basic groups of facilities: children, common for all groups, administrative-management.

The children's facilities include cloakrooms and reception rooms, game rooms and dining rooms, sleeping porches, toilets, snack bars and bedrooms.

The facilities common to all children's groups include the music and physical culture activities hall and game room, the isolation room for sick children and medical office.

The administrative-management facilities include the feeding unit, cleaning facilities, the director's office, personnel office and other management facilities.

The basis for the space and floor plan layout of the buildings for kindergartens and day nurseries is the interrelation between the enumerated groups of facilities (Figure 61). With respect to the planning attribute the buildings are subdivided into the centralized buildings with internal communications between individual groups of facilities (Figure 62a); blocked with communications between individual groups of facilities through a heated passage (Figure 62b); pavilion with communications between the groups of facilities through a yard or unheated passages (Figure 62c).

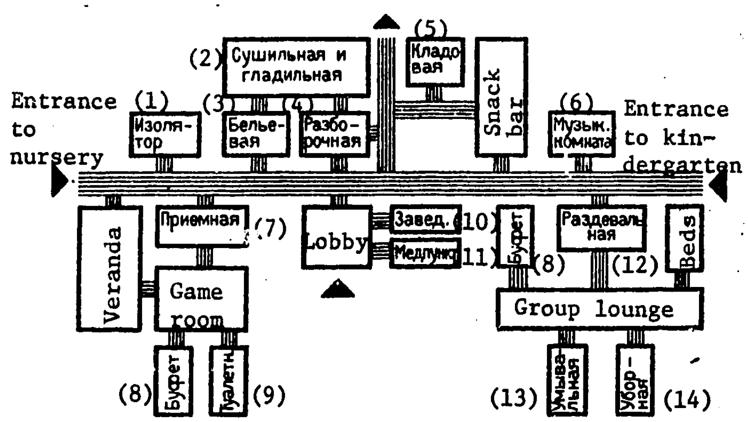


Figure 61. Diagram of the functional communications of facilities for day nurseries and kindergartens.

Key:
1. Isolation room
2. Drying and ironing room
3. Linen room
4. Distribution room
5. Storeroom
6. Music room
7. Reception room
8. Snack bar
9. Toilet
10. Director's office
11. Medical aid station
12. Coatroom
13. Washroom
14. Toilet

The space and floor planning solutions of kindergartens and day nurseries must be taken considering the climatic conditions, the structural and other possible conditions and also considering the peculiarities of the functional purpose of the buildings. When locating kindergartens and day nurseries in a two-story building, facilities are placed on the first floor for nursery-age children, the medical office, isolation room, director's office and management facilities.

The administrative and other auxiliary facilities can be placed in the basement under the condition of provision of a separate entrance from the outside.

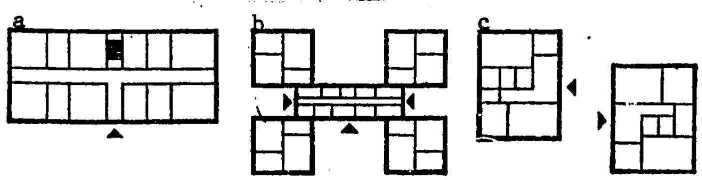


Figure 62. Layout of buildings for kindergartens and day nurseries. a--Centralized; b--blocked; c--pavilion.

The set of facilities for one group of children makes up a cell. The facilities for each group cell must be isolated from the facilities of other group cells; internal communications between each cell and the medical facilities, the music room and gymnastics exercise room and also the administrative-management facilities must be provided. The following direct communications must be provided in the nursery-age group cells--game and dining room with the reception room, sleeping porch or bedroom, toilet and snack bar; in the preschool-age group cells, group lounge with cloakroom, sleeping porch or bedroom, toilet and snack bar.

The entrances to each group cell and exits from it to the yard must be the shortest possible. This arises from the necessity for providing fast evacuation of the children from the building in case of fire.

In the case of kindergartens and day nurseries it is necessary to organize sections which are divided into zones: general children's areas, green spaces, and administrative-management.

The public education system includes general education schools and boarding schools. An example nomenclature of the universal buildings for general education schools (Table 9) has been compiled for designing schoolbuildings in SNiP II-L.2-71.

The composition of the general education schools and boarding schools depends on the purpose and capacity of the buildings while observing the basic requirements:

for classes in the incomplete middle school, classrooms must be attached for each class;

for training in the middle school, specialized training offices must be organized;

the quality of the study rooms and laboratories must be determined by their carrying capacity (when operating the school in two shifts).

The schoolbuildings are designed considering the combination of rooms into sections and groups:

the training sections (separately for the classes of the incomplete middle school and the middle school classes) made up of four (but no more than six) classes of study halls with recreational facilities and sanitary facilities;

the groups of sports training facilities for mass cultural and sports work;

the groups of general school training and training-educational facilities;

the facilities for general school purposes (dining rooms, snack bars, administrative-management and medical services, and so on).

Table 9. Arrangement, Number of Places and Sizes of Yards for General Education Schools and Boarding Schools

Arrangement	Institution	Number of Places	Capacity of Schools	Sizes of Yards, ha
Microdistrict (settlement, rural populated area)	Primary, incomplete middle and middle schools	Calculating 100% coverage of children by incomplete middle education and 75% by middle education	Primary for 4 classes:	
			40 students	0.3
			80 students	0.5
			Incomplete middle for 8 classes:	
			192 students	1.2
			320 students	1.7
			Middle:	
			For 10 classes, 392 students	2.0
			For 12 classes, 464 students	2.0
			For 16 classes, 624 students	2.0
			For 20 classes, 784 students	2.2
			For 30 classes, 1,176 students	2.8
			For 40 classes, 1,568 students	3.0
			For 50 classes, 1,960 students	4.0
	Boarding schools	By design assignment (considering the norms for a middle school)	For 280 students	2.0
			For 340 students	2.2
			For 560 students	2.5

Notes: 1. For reconstruction conditions the dimensions of the yard can be decreased, but by no more than 20 percent. 2. In climatic subdistricts IA, IB, ID the dimensions of the yards can be decreased, but by no more than 40 percent. 3. The sanatorium-forestry schools and specialized schools are designed according to the design assignment.

The arrangement of the groups and sections must be subordinate to the functional communications of the facilities (Figure 63). Here it is necessary to provide for isolation of groups of facilities from each other, for example, the study rooms should be isolated from sports and activities halls, dining rooms and workshops.

The basic floor plan unit in a school is the classroom. The classroom area (50 m^2) is designed for 40 students (1.25 m^2 per student). The classrooms are divided into longitudinal 6 x 9 m with one-sided illumination (Figure 64a), transverse 6 x 9.6 m (Figure 64b) and square 7.2 x 7.2 m (Figure 64c) with one-sided illumination and additional illumination through the recreation area (facilities for leisure, extracurricular activities, and so on).

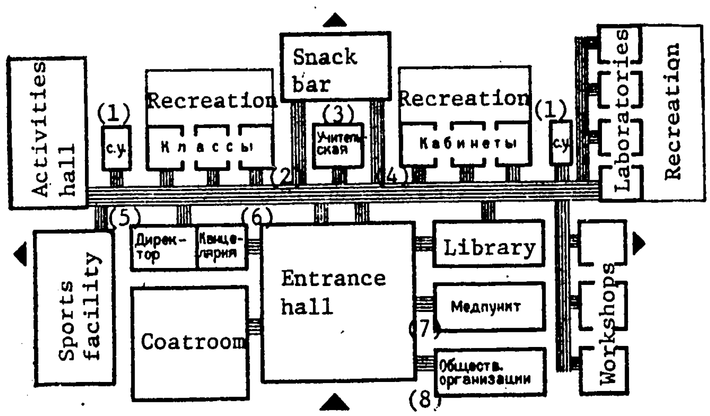


Figure 63. Diagram of the functional communications of the schoolbuilding rooms.

Key:
1. Sanitary facilities
2. Classrooms
3. Teachers' room
4. Offices
5. Director
6. Office
7. Medical aid station
8. Public organizations

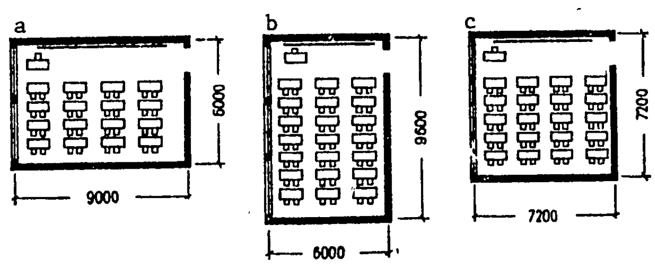


Figure 64. Type of classrooms. a--Longitudinal; b--transverse; c--square.

The space and floor plan layout of modern schoolbuildings can be centralized, blocked and pavilion.

The centralized composition is characterized by compactness, integralness of the space and the floor-planning solution (Figure 65a). The buildings designed by this layout can be freely located on the shaded sites. It is expedient to use such solutions for schools of medium capacity (to 960 students).

For blocked layout the schoolbuilding consists of individual buildings connected to each other by heated passages (Figure 65b). It is usually used for large-capacity schools and permits separation of the students into flows.

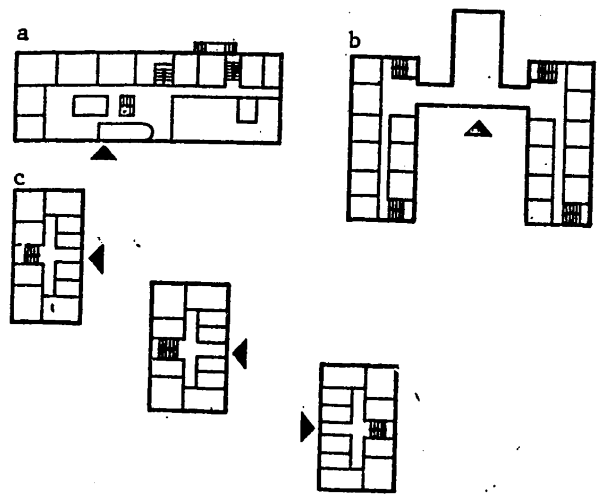


Figure 65. Space and floor-planning layout of schoolbuildings. a--Centralized; b--blocked; c--pavilion.

The pavilion layout is resolved in the form of separate buildings (teaching, activities, sleeping in the case of boarding schools) (Figure 65c). This layout permits construction of the schoolbuilding in areas with complex relief and seismics.

A yard in front of the school must be organized for every schoolbuilding. The planning and organization of the yard play an important role in the training process. Part of the training exercises are conducted in the yard (botany, geography, work, and so on). The yard usually is divided into zones: training-experimental (vegetable garden, meteorological area, and so on); sports (sports center, gymnastics camp); management, game and recreation area (sandbox, benches, cooling pond, and so on). The number of zones and their areas depend on the capacity of the schoolbuilding, available territory and other conditions.

Proper organization of the network of commercial enterprises improves the daily living conditions of the workers. Stores make up the basic type of retail enterprise. With respect to purpose, number of workplaces and turnover of goods, stores are divided into large, medium and small. They are also distinguished as follows:

with respect to trade profile--nonspecialized (produce, industrial, mixed); specialized (clothing, footwear, and so on); narrowly specialized (bread, children's clothing, knitted fabrics); combined (groceries and provisions, fruit and vegetables); combined and universal (a wide assortment of industrial and produce goods);

with respect to forms of trade--selling with the help of sales clerks, self-service method, orders;

with respect to space and floor planning, separately standing and built-in or annexed.

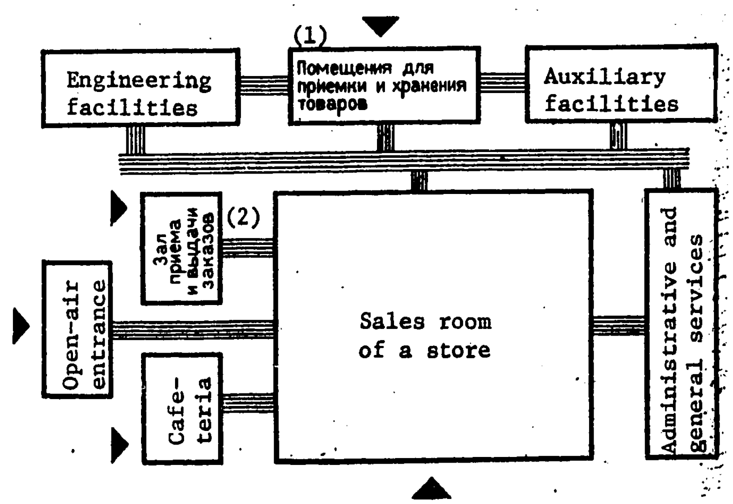


Figure 66. Functional relations of commercial enterprise facilities.

Key: 1. Facilities for receiving and storing goods
2. Order receiving and delivery

The space and floor-planning solutions of buildings for stores must ensure convenience for the buyers, the possibility of organizing commerce by advanced methods, the application of all-around mechanization means for handling goods and materials (Figure 66).

With respect to functional purpose the facilities making up stores and department stores are divided into four groups:

trade facilities--the sales rooms, receiving and delivering orders, intermediate products, and so on;

facilities for receiving, storing and preparing goods for sale--receiving, unloading, storage, and so on;

administrative and general services facilities--the director's office, public organizations offices, toilets, showers, and so on;

auxiliary facilities--storage of packaging, stockroom, washrooms, garbage rooms;

engineering facilities--ventilation chambers, electric panel, heating unit.

The space and floor plan structure of the buildings of trade enterprises must be developed considering the functional interrelation of the facilities of these enterprises:

the sales rooms must be connected with the facilities for preparing the goods for sale and storage facilities. The sales rooms must be located so that if necessary they can be isolated from the other groups of facilities;

the entrance to the administrative and general services, auxiliary and engineering facilities must be designed separately, without passage through the sales rooms and facilities for storage and preparation of goods for sale;

the receiving rooms must be located on the administrative court side and as close as possible to the facilities for storing goods.

It is possible to distinguish four floor plan schemes for the commercial and auxiliary facilities in a store building: end, deep, frontal and combined (Figure 67a-d). The advanced procedure in design and production practice is cooperation of various commercial enterprises with separately standing buildings.

The stores are located on streets, thoroughfares and squares, near public transportation stops, on the traffic patterns of the basic flows of the population. The placement of the stores must exclude intersection of the flows of customers with intense motor vehicle traffic.

The territories of commercial enterprises consist of the following zones: for customers, unloading goods, garbage collection.

The public feeding enterprises must be efficiently located within the structure of the city, the housing district or microdistrict. With respect to purpose they are divided into microdistrict (small cafes, dining rooms and kitchens); district--a broad network of snack bars, cafes, dining rooms and restaurants; municipal--large cafes and restaurants.

With respect to nature of the product, the public feeding enterprises are divided into procurement, production of intermediate products designed for dining rooms, restaurants and public sale in specialized stores handling intermediate products and cookeries; preprepared food products and stores selling products in the form of ready-to-eat dishes.

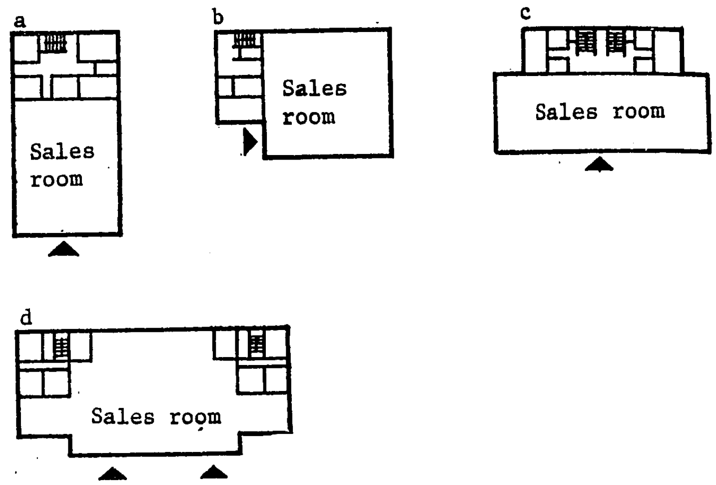


Figure 67. Space-floor plan layouts of store buildings. a--End; b--in depth; c--frontal; d--combined.

In accordance with the production process all of the facilities of the public eating enterprises are divided into facilities for guests, production, storage, administrative-general services and engineering.

The space and floor-planning structure of the buildings of the public eating enterprises depends on the specific nature of the enterprise, the nature of the production process and its capacity. The basic layout is mutual arrangement of different groups of facilities and numbers of stories of the buildings (Figure 68).

With respect to layout the indicated buildings can have three basic arrangements:

a) centric; its essence lies in the fact that the production facilities are located in the center of the room, and the facilities for guests with distribution around them. This layout offers the possibility of increasing the sales front and separating the facilities for guests into a number of rooms (Figure 69a);

b) in depth; this layout is characterized by division of zones along the short side of the plan; just as in the frontal system the production process is efficien (Figure 69b);

c) corner; in which all of the production facilities are grouped in one corner of the building, and the facilities for guests are adjacent to it on two sides. This layout is efficient when locating buildings at an angle (Figure 69c).

The site for public feeding enterprises is divided into the following zones: for guests and administrative for bringing raw materials into the enterprise.

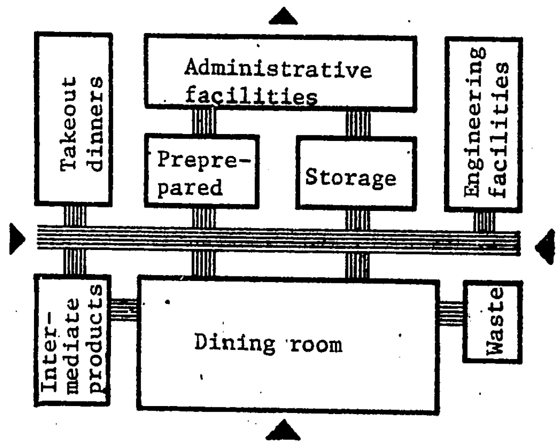


Figure 68. Functional communications diagram of the facilities of public feeding enterprises.

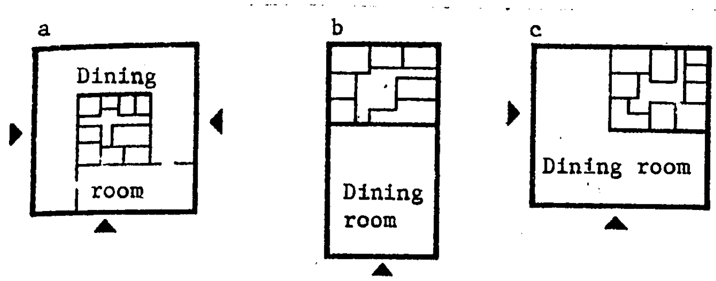


Figure 69. Space and floor-planning layout of the buildings of a public feeding enterprise. a--Centric; b--in depth; c--corner.

The most widespread form of auditorium buildings is the movie theaters which are classified by the following attributes: with respect to nature of operation--year-round and seasonal; with respect to number of auditoriums--single auditorium, double auditorium, three or more; with respect to capacity--200, 400, 600, 800, 1,000, 1,200 and 1,600 places; with respect to equipment for showing films--with ordinary screen, wide screen, wide format, panoramic.

In a movie theater it is possible to isolate the following groups: viewing (the entrance hall with ticket offices, foyer, toilets, auditoriums); movie equipment (movie equipment room, rewind room, sanitary facilities, storage battery room, acid room and electric panel); administrative-management (ticket offices, manager's office, billboards, carpenter's shop); auxiliary-engineering (ventilation, electric panel).

The layout and area of each group of facilities are developed in accordance with the capacity of the auditoriums of the theater. The interrelation and location of the individual groups of rooms in movie theaters are illustrated in Figure 70.

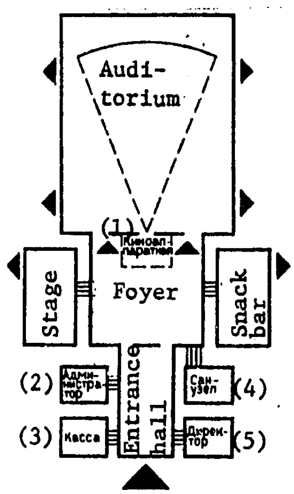


Figure 70. Functional communications layout of movie theaters.

Key: 1. Movie equipment room
2. Administrator
3. Ticket office
4. Sanitary facilities
5. Manager

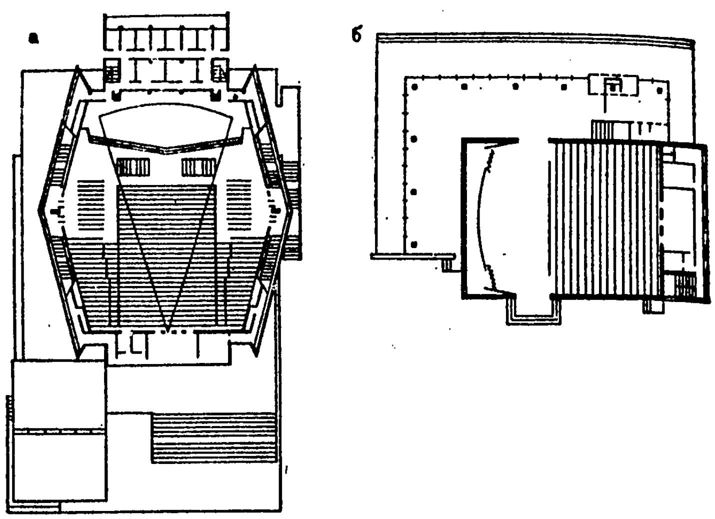


Figure 71. Diagrams of the space and floor-planning layout of movie theaters. a--End; b--frontal.

Movie theater buildings can be designed with respect to two layouts: end and frontal. In the end layout the lobby, the distribution rooms and auditorium are placed along one axis in series corresponding to the movement of the viewers

(Figure 71a). In the frontal system the distribution rooms or foyer is located along the principal facade (Figure 71b).

There must be free access around the movie theater building, and in the case of large movie theaters it is necessary to provide parking for automobiles.

Section 24. Design of Entrances and Evacuation Problems

All public buildings, independently of their purpose, have general layout elements. These include the entrance halls, coatrooms, vertical and horizontal communications (corridors, anterooms, stairs, elevators, escalators, and so on), the location and the dimensions of which are different depending on the type of public building, capacity, and the space-floor plan design.

The lobby is the part of the entrance including the vestibule, coatrooms and auxiliary facilities.

The entrance hall is designed for keeping heat in the lobby. With respect to floor plan it can be built in, that is, be part of the building space or annexed. The depth of the vestibule depends on the width of the doors used and must be no less than 1.5 times the door width. In public buildings with a continuous flow of customers (department stores, large stores, and so on) a heat curtain is created in the entry by using heating elements. The direction of the people flow in the entries must be as straight line as possible without sharp or steep turns (Figure 72a).

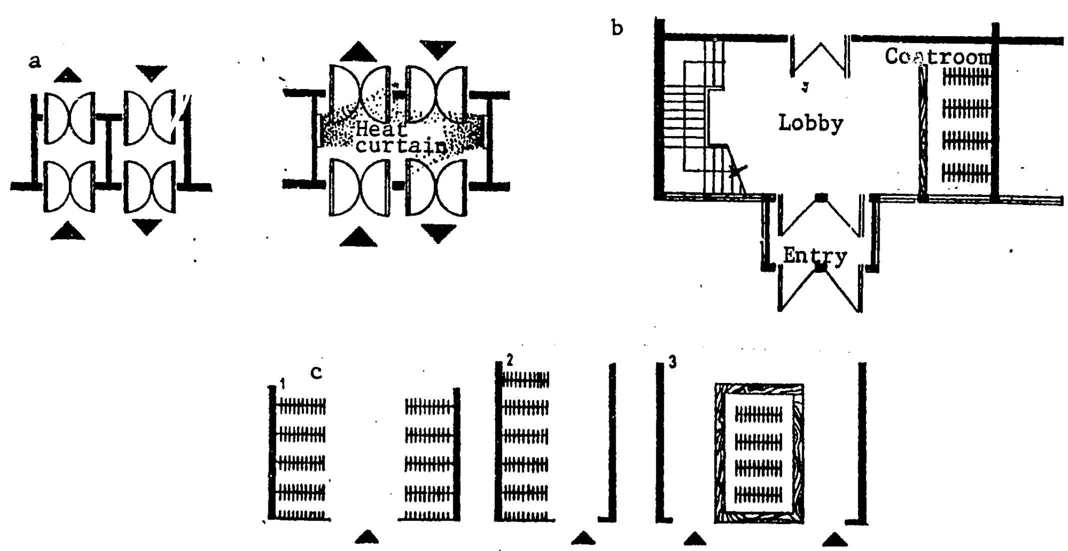


Figure 72. Examples of entries, lobbies and coatrooms. a--Double entries; b--lobby; c--coatrooms: 1--single-rack; 2--two-rack; 3--island.

The lobby is the principal distribution area in a public building, from which the vertical and horizontal communications radiate leading to the basic and auxiliary facilities (Figure 72b). The space and floor-planning solution of the lobby is determined by the functional purpose of the building, its capacity, and so on. There can be several lobbies in the largest public buildings: the main lobby and auxiliary lobbies, for example, in a theater, the main one for the spectators and auxiliary for artists and administration. As a rule, the lobby is lighted with natural light.

The coatrooms are usually placed in the lobby or alongside it, in a special room somewhat to the side of the basic flows of customers. Depending on the location, the coatroom can be one-sided, two-sided and island type (Figure 72c). The area of the coatroom behind the barrier is taken reckoning 0.07 to 0.1 m^2 per place. The depth of the coatroom must not exceed 6 m.

The basic horizontal communications in public buildings are corridors which join the rooms of one floor and have exits to vertical communications.

The width of the corridors and other horizontal communications, depending on the type of building, can be different. Minimum corridor width for mass movement in public buildings is taken as 1.5 m. In medical treatment and preventive facilities the corridor width is taken no less than 2.2 m, and in institutions of learning, no less than 1.8 m.

The vertical communications in public buildings and structures include stairs, ramps, escalators and elevators.

Depending on the purpose stairs can be the main stairs designed for basic flows and secondary, in case of emergency evacuation. The main stairs usually are connected with the lobby and lead to the basic facilities of the building. The flight width of the main stairs is no less than 1.35 m on a floor with more than 200 people and also in movies, clubs and hospitals. In the rest of the buildings, independently of the type of building or number of people on the floor, 1.2 m. The width of the stair landings must be no less than the flight width and no less than 1.2 m, and in hospitals, no less than 1.5 m.

In some cases the stairs are replaced by ramps which are in the form of an inclined plane without steps. The slope of the ramps must not exceed 1:6. As a result of the low slope ramps take up more space than stairs, and therefore they are less economical.

With respect to purpose in public buildings elevators are used for lifting people and freight. The basic types of elevators in public buildings are freight-passenger elevators and freight elevators.

When it is necessary to move significant flows from one floor to the next (in large department stores, auditoriums) escalators are used. Escalators are a moving stairway and are classified as a continuous-moving lift. One escalator 1 m wide can move up to 150 passengers per minute independently of the height of rise.

Section 25. Examples of Design Solutions and Their Technical-Economic Indices

The economicalness of design solutions of public buildings is determined by the following indices: the capacity or carrying capacity of the building, the space-floor planning and structural solution, the organization of the production or functional process, level of engineering equipment, and so on.

One of the most effective methods of decreasing capital and operating expenses is consolidation and cooperation of public buildings. Thus, increasing the capacity of a movie from 400 to 1,200 lowers the operating expenditures by 36 percent; for cooperation of commercial enterprises and institutions in public centers the estimated cost of construction is reduced by 10-25 percent by comparison with the cost of separately standing buildings. Kindergartens and day nurseries are the most widespread in the cooperation of buildings. This is explained by the fact that for approximately the same expenditures per place, the usable area of the building increases, the operating expenses and the maintenance of service personnel reduced. Increasing the capacity of day nurseries and kindergartens from 140 to 180 places permits the construction cost per place to be reduced by 15 percent. More economical solutions to the day nurseries and kindergartens can be achieved by using portable partitions, built-in, combined and folding furniture.

A large cost effectiveness is derived from the application of large multipurpose rooms (Figure 73a) (a large hall-type room can be used as an auditorium, for sports, showing movies, and so on) and also the design of these rooms with flexible floor plan, that is, the possibility of changing the layout of the facilities by using sliding partitions.

Certain trends in the development of entertainment buildings and structures are reflected by the movie theaters. These trends consist in finding solutions which will more completely correspond to the modern requirements for service comfort. In the movies provision is made for the expansion of the foyer with snack bar, air conditioning, the installation of modern movie equipment, and so on. A new type of cooperative building has been developed for a movie theater with restaurant and club facilities which permits operation of the building not only when showing films or having concerts, but also for other activities. Series of standard two-auditorium movie theaters with different sizes of halls have been developed, which permit selection of the hall for showing various films (Figure 73b). In such theaters the capacity of the auditorium has been increased by 15 to 20 percent.

Increasing the capacity of stores and dining rooms is possible by improving the organization of the production process, namely, introduction of the self-service system. The conversion to self-service in commercial enterprises reduces the total space requirements by 20 to 30 percent. The introduction of the self-service system permits the expenditures on maintaining the commercial enterprises and public eating facilities to be reduced, the service system to be improved and the expenditures of time by the population on the general services to be reduced significantly.

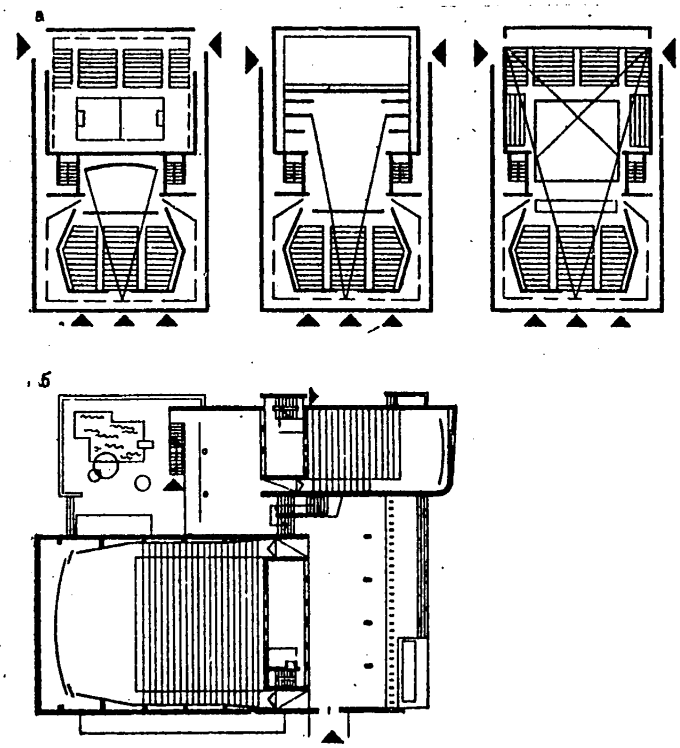


Figure 73. Examples of advanced solutions for the public buildings. a--Multi-purpose; b--single-purpose.

On consolidation or cooperation in public buildings it is necessary to remember that these measures are connected with the service system for the population, and increasing the service radii above the recommended radii is undesirable.

The choice of the optimal space and floor plan designs considering all of the technical-economic indices is made on the basis of a comparison of versions of the design solutions with respect to buildings with identical functional purpose and approximately equal capacity. For more complete consideration of the economics of the design solutions for public buildings the coefficient K_3 and K_4 calculated just as in the designs for residential buildings are introduced.

Section 26. Elements of Construction Heat Engineering and Construction Acoustics

The enclosing structures (outside walls, roofs, floors, and so on) of buildings and structures must reliably protect the facilities from the cold, heat, solar radiation, atmospheric precipitation, wind, noise and other unfavorable effects. The study of the effect of physical processes on the enclosing structures is the subject of a science--construction physics--which consists of three divisions: heat engineering, light engineering and acoustics.

The science that studies the conditions of formation of climate and the climatic conditions of various parts of the country is called climatology. The branch of climatology that studies climatic factors considered when designing buildings and developing the plans for populated areas is called construction climatology (SNiP II-A.6-72).

The outside enclosing structures of buildings must satisfy the following heat engineering requirements:

have good heat-shielding properties for protecting the facilities from low and high temperatures and other atmospheric effects;

the temperature on the inside surface should not be too low in order to avoid the formation of condensate on it;

during operation and maintenance it is necessary to maintain normal humidity inasmuch as wet enclosures lower the heat-shielding properties and service life;

air permeability must be above the admissible limit for which air exchange will cool the facility.

All of these problems are considered in construction heat engineering. Inasmuch as in a course project it is necessary to perform heat engineering calculations, the principles for these calculations are presented in Section 12.

One of the important hygienic problems in buildings is the problem of sound insulation. When developing the problems of sound engineering of buildings, any sound penetrating the facility from the outside is called noise. From the hygienic point of view, by noise we mean the sound which has an unfavorable effect on the life and activity of man and irritates his nervous system.

With respect to the conditions of the occurrence and propagation, noise is distinguished as air and impact noise.

Air noise occurs and is transmitted through the air environment. Impact noise arises and is propagated through the structural elements of the building. As a result of vibrations the structural elements can emit air noise, the cause of the occurrence of which is impact noise.

The struggle with noise is one of the necessary problems when designing and constructing buildings. It is possible to propose the following measures: with respect to restriction of internal noise: the application of low-noise and noiseless equipment, improvement of existing machines and machinery; maximum localization of the noise directly at the sources; absorption of the noise that does occur by sound-absorbing finishes or baffles and partitions; grouping of the facilities with respect to the amount of noise incurred.

The external noise can be limited by floor planning, holding up its propagation throughout the territory; consideration of prevailing winds and control of the formation of the noise field in the built-up territory; construction of noise-shielding screens by using green strips, relief, engineering structures (fills, cuts); the application of improved paving for roads and the removal of main thoroughfares to noise-safe zones; control of the reduction of intensity of external noise sources.

The reduction of noise in a building can be achieved by improving the structural designs. In order to improve the noise-insulating capacity of the walls, partitions and floors without increasing their weights, it is expedient to use various structural elements with continuous air interlayering without rigid coupling. Improvement of the noise-insulating qualities in the presence of a continuous air interlayer takes place as a result of the fact that air, similarly to a shock absorber which elastically receives the vibrations of one wall, transmits them to the second wall in an attenuated state. The values of the average noise-insulating capacity of air interlayers of different thickness are presented in Table 10.

In order to save space in the facilities, the air gap usually is no more than 60 cm.

Table 10. Sound-Insulating Capacity of Air Interlayers

Thickness of the air interlayer, cm	3	4.0	5.0	6.0	7	8.0	9	10
Noise-insulating capacity, db	1	3.5	4.5	5.5	6	6.5	7	7

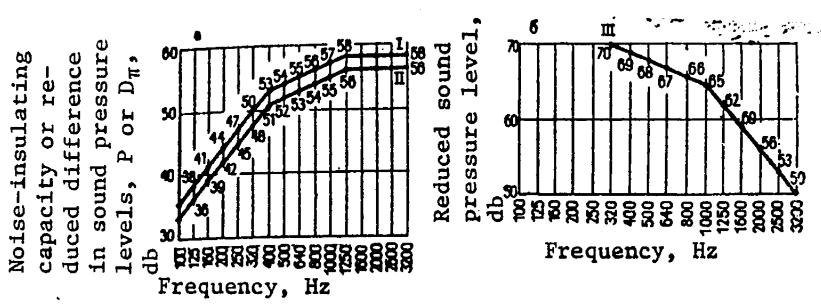


Figure 74. Determination of the sound-insulation indices of enclosing structures. a--Normative curves for the sound-insulating capacity against air noise or the reduced difference in sound pressure levels: I--obtained under laboratory conditions; II--obtained under natural conditions; III--normative curve III of the reduced impact noise level under the floor.

In order to ensure good sound insulation without increasing the weight of the wall or partition, it is expedient to use layered structures consisting of several layers of materials differing sharply from each other with respect to their density and rigidity (gypsum concrete, gypsum, mineral felt, and so on). The sound-insulating indices of the enclosing structures are determined by comparing the obtained curves with the normative curves I and II (Figure 74a).

The floors between stories must be soundproofed not only against air noise, but also impact noise. The elastic foundation of the floor absorbs noise vibrations that arise during walking and impacts. The vibration energy is expended on compressing the elastic foundation and, consequently, is transmitted to the bearing part of the floor in a significantly attenuated state. Therefore it is necessary to provide floors over a continuous elastic foundation or fill, with strip or individual interlayers.

The sound-insulating index of the floors with respect to impact noise is determined by comparing the curves of the reduced impact noise with the normative curve III (Figure 74b).

When performing the operations it is necessary to provide for strict quality control of the performance of all sound-insulating measures. It is possible to achieve more efficient shielding of buildings and apartments against noise only as a result of all-around implementation of sound-insulating measures.

Part Three. Industrial Building Design

Chapter V. Distribution of Industry and the Organization of Industrial Territory

Section 27. General Principles of Industrial Building Design

It is expedient to consider the problems of the distribution of industry after familiarization with the general information and principles of production building design.

Production buildings of the industrial enterprises frequently called industrial buildings are designed for organization of the process of the manufacture of one type of industrial product or another using the corresponding production equipment and adopted technology. When developing the production building design, the solutions to its space and floor plan composition and the selection of the structural design, it is necessary to consider the technological, technical, economic and architectural-artistic requirements and also to ensure the possibility of erecting the designed building by advanced industrial methods.

The economicalness of the design of a production building depends not only on the one-time capital expenditures on construction, but also the expenses connected with operation and maintenance of the building, which is taken into account in all design stages. Therefore when developing the design solutions of production buildings it is necessary to be concerned with the creation of normal conditions for realizing the advanced technological process and also the greatest conveniences and best internal conditions for the workers.

The creation of a modern architectural-artistic appearance of an industrial building is a responsible creative process, during the course of which the architectural-artistic problems must be organically tied to the engineering-design problems.

The interior design of production facilities (in particular, the color finish of the surfaces, and so on), the materials-handling and process equipment and also solutions connected with the scientific organization of labor and sanitary-hygienic conditions of the shops and enterprises as a whole have very important significance. These include timely and complete removal of production hazards, the creation of an optimal temperature-humidity regime, ensurance of the required illumination levels in the working zones, the presence of specially equipped general services facilities, the composition of which is defined by SNiP II-92-76 ("Auxiliary Buildings and Facilities of Industrial Enterprises"), the control of production noise, measures to improve the healthfulness of the production environment and amenities of industrial territories and also measures for the building of sports areas and the required components of the all-around cultural and general services system for the workers.

The production buildings of industrial enterprises differ significantly from residential and public buildings both with respect to external appearance and with respect to structural design, which arises from the production-technological requirements. Relatively large rooms with respect to area, the presence of devices and structural elements for fastening and moving overhead or supported cranes, superstructures on the roofs in the form of skylights and ventilation openings and a number of other peculiarities (for example, increased humidity, significant heat generation, high noise level, and so on) are characteristic of these buildings.

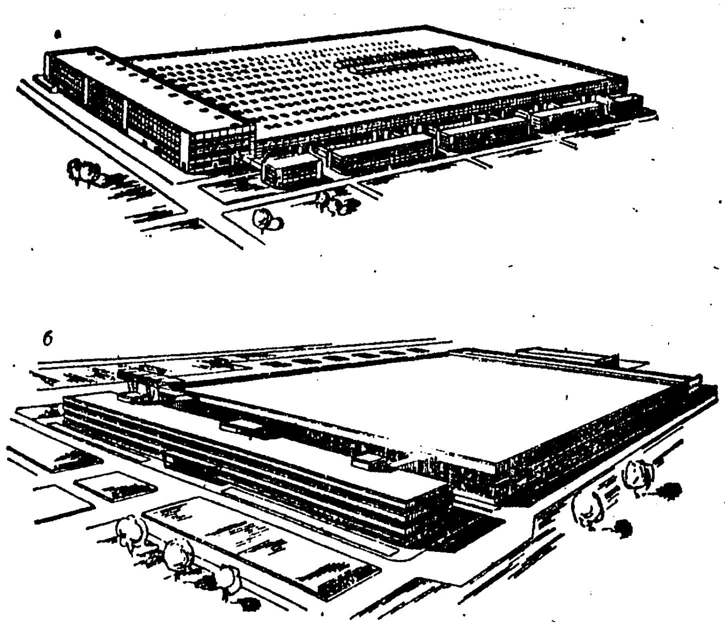


Figure 75. One-story, multibay industrial buildings. a--With skylights and ventilation openings; b--without skylights.

The number of floors has a highly significant influence on the architectural-design solution of production buildings. Two basic types of production buildings are distinguished: one-story and multistory. The one-story buildings predominate in industrial construction. It is expedient to build one-story buildings if heavy production equipment is used which requires significant bays and causes the corresponding dynamic loads in the presence of large dimensions and heavy weight of the production output in the production facilities, the basic production process of which takes place horizontally.

One-story production buildings are designed both with skylights (Figure 75a) and without skylights (Figure 75b). They can be single-bay and multibay. The latter are used significantly more frequently.

The one-story production buildings are usually frame buildings. The frame elements are made of prefabricated reinforced concrete or steel depending on the magnitude and nature of the crane load, the basic space and floor plan parameters and the internal conditions of the shop facilities, being guided by the requirements of the "Technical Regulations for Economical Consumption of Building Materials" (TP 101-76).

The problem of the expediency of using reinforced concrete, metal or other structural elements must be solved considering the efficiency of their use and the corresponding production bases and material resources in the construction area.

At the present time a prefabricated reinforced-concrete frame is more frequently used. Transverse frames of this type are a system of columns (posts) secured in the foundations and collars in the form of beams or trusses (Figure 76a, b). The spatial rigidity of the buildings in the transverse direction is created by the transverse framing, and in the longitudinal direction, by the columns, the supporting structures of the roof and the crane beams (in buildings with supported cranes) and also vertical and horizontal couplings.

The columns of the building frame are located in plan at the points of intersection of mutually perpendicular longitudinal and transverse center lines forming the column grid. In single-story production buildings most frequently an 18 x 12 or 24 x 12 m column grid is used. On the drawings the layout center lines are labeled on the long side of the building with numbers (from left to right) and on the short side (the end of the building) by Russian capital letters (Figure 77).

The basic space and floor plan parameters of a building are the transverse span, longitudinal span and height. The transverse span is the distance between center lines determining the breakdown of the buildings into floor-planning elements or the location of the vertical supporting structures of the buildings (walls and individual supports) (Figure 76). The span is usually taken as 6 or 12 m; if necessary it can be larger, but it must necessarily be a multiple of 6 m.

The longitudinal span is the distance between the center lines of the bearing walls or individual supports in the direction corresponding to the span of the basic bearing structures of the roof (beams, trusses) or floor (in multistory buildings) (Figure 76). The spans of one-story production buildings are usually taken within the limits from 12 to 36 m, but in long-span buildings, longer spans can be used. The size of the longitudinal spans must be a multiple of 6 m; in some cases it is permissible to use spans that are a multiple of 3 m.

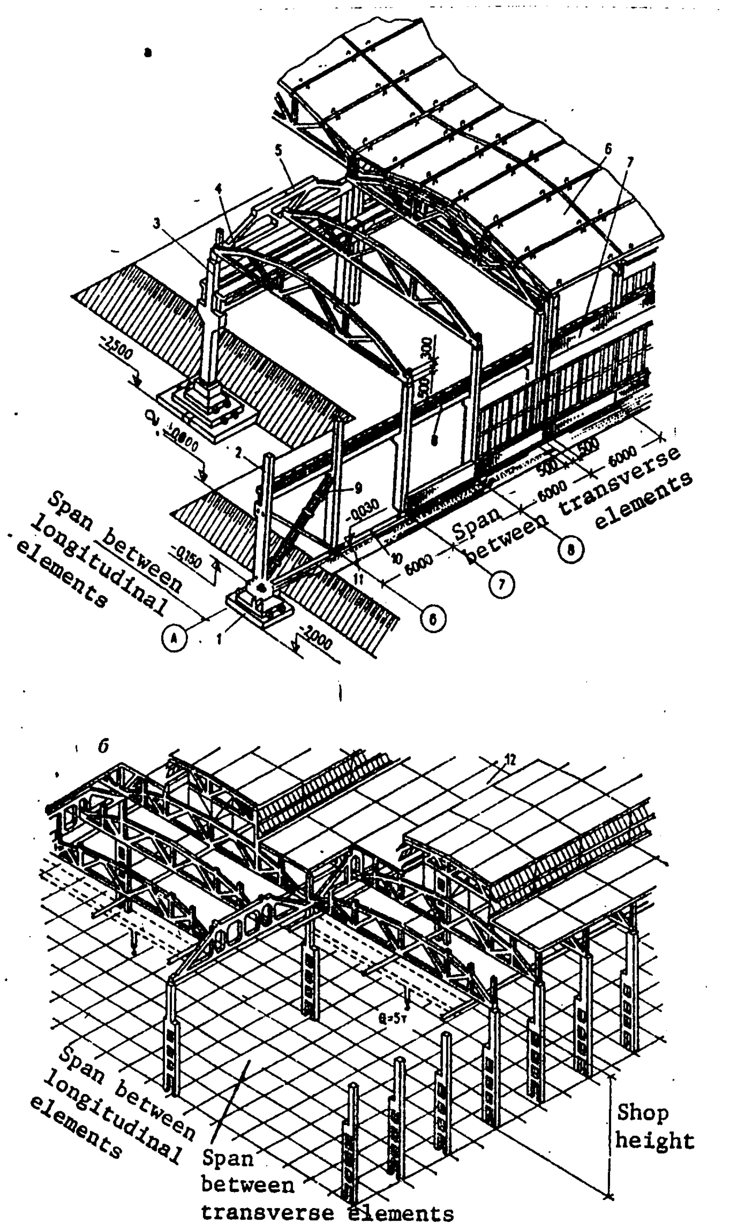


Figure 76. One-story, multibay frame industrial building built from prefabricated reinforced concrete. a--With supported cranes; b--with overhead-track hoists; 1--column foundations; 2--wall column; 3--middle column; 4--roof girder; 5--rafter truss; 6-12--roofing slabs; 7--wall panel; 8--crane girder; 9--vertical couplings; 10--foundation girder; 11--blind area.

The height is the distance from the floor level (from the ±0.000 mark) to the bottom of the bearing structure of the roof on the support (Figure 76). The height of the facilities fluctuates within significant limits (but no less than 3 m), and it must be a multiple of 0.6 m.

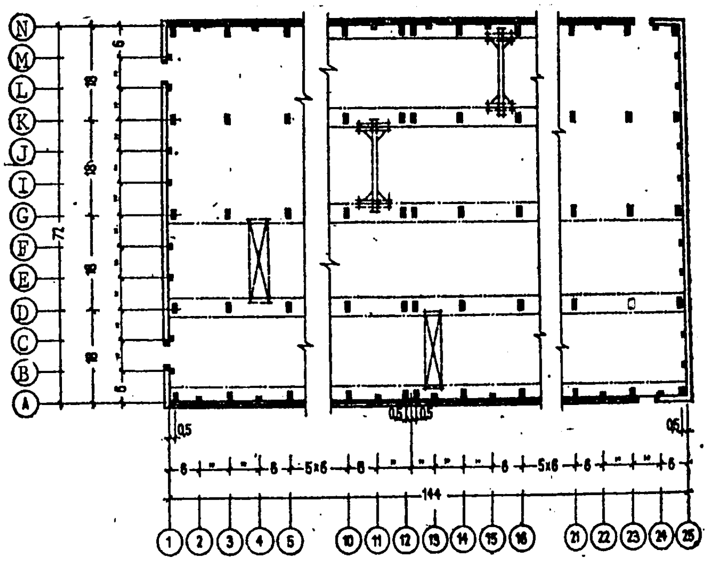


Figure 77. One-story industrial building with center lines and their labels.

The requirements of modern production processes has given rise to consolidation of the overall dimensions of one-story production buildings and their basic space and floor plan parameters, which, in turn, has required alterations and improvement of the structural diagrams and structural designs of the buildings and conversion in a number of cases from two-dimensional systems to three-dimensional systems.

The multistory production buildings (Figure 78a, b) are built more rarely, primarily for housing enterprises that produce comparatively lightweight products. They are the most widespread in the chemical, electronic, electrotechnical, radio-technical, light and food branches of industry and in other production facilities, the process in which takes place vertically. It is expedient to erect them also under conditions of dense city coverage and when rebuilding industrial enterprises.

Multistory production buildings, just as one-story buildings, are designed and constructed primarily of prefabricated frames. In multistory buildings the dimensions must be multiples of the following numbers: for the longitudinal spans, 3 m; the transverse spans between columns, 6 m; the height of the buildings, 0.6 m, but no less than 3 m. The column grid is usually taken as 6 x 6 or 6 x 9 m; in the buildings recently developed they are 6 x 12 and 6 x 18, and sometimes 6 x 24 m.

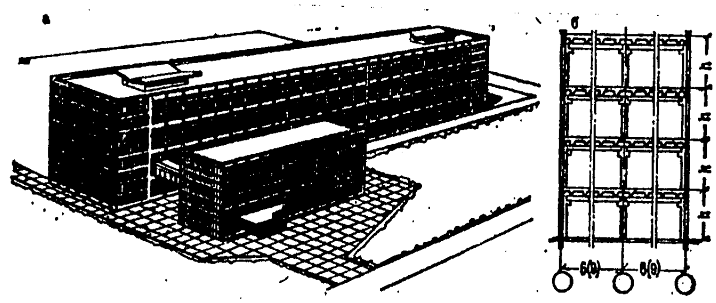


Figure 78. Multistory industrial building. a--General view; b--schematic section.

Before proceeding with the study of the basic principles of the architectural design of industrial buildings, including their architectural-spatial and floor plan solutions (discussed in Chapter IX), it is necessary to consider the problems of organizing the industrial territories: the distribution of the industrial districts, complexes and enterprises, their design principles and also the development of master plans for the enterprises (see Chapters V and VI).

During the process of drawing up the master plan for an industrial enterprise it is the only time that the production-process relations can be completely revealed which dictate the position of the production buildings and structures on the site.

The interaction of the production processes occurring in an industrial enterprise is the essence of the production flow diagram dictating the requirements on the layout of the master plan for the enterprise as a whole and making up the base on which certain space-floor plan designs of the plant buildings are developed.

In our opinion, many successful solutions in the design of an industrial enterprise can be found only with the active participation of an architect.

Section 28. District Planning Concepts

The construction of all of the projects in cities and settlements is based on the district planning layouts.

The primary goal of district planning consists in economically expedient and coordinated distribution of all of the construction projects in the planned district considering the most effective use of its natural resources and territory and in accordance with the general goals of creating a material-technical base for communism.

The district planning designs for individual industrial, agricultural, health resort and suburban districts are developed on the basis of prospective plans for the development of the national economy of the country and the prospective distribution of the productive forces of the economic districts of the union and autonomous republics, krays and oblasts.

Proposals adopted in the scheme for the distribution of production forces in one territory or another are more precisely defined and developed in the district planning designs.

Section 29. Distribution of Industrial Districts

It is expedient to place the industrial enterprises not separately, but concentrate them in large groups located on common territory and forming the industrial district (Figure 79) which occupy a part of the territory of the city or the territory adjacent to it. One or several such groups can be placed in the territory of the industrial district. In industrial cities the industrial districts with the production enterprises located in them take up as much as 50-60 percent of the territory (on the average 25-35 percent with a minimum of 15 percent), being the basic city planning nucleus.

The industrial districts have a significant influence on the sizes of the cities, their layout and the living conditions of the citizens. Their most important feature is cooperation of the basic, auxiliary and service facilities in the city. When determining the size of the municipal industrial district we begin with the most efficient and economical use of the territory of the city; therefore the district dimensions are taken as the minimum necessary considering the highest density of coverage.

Industrial districts can also be located in territories remote from the existing cities. For example, the districts where enterprises are located for the extraction of ore, coal and oil are of this type. However, the occurrence of such industrial districts gives rise to the necessity for building new settlements near them which often develop subsequently into cities.

When selecting the territory for an industrial district it is necessary to consider the natural climatic and topographic conditions (the relief and slope of the terrain, the direction, speed and repetitiveness of winds, the humidity, and so on), the engineering-geological description of the territory (type of soil, its density, the groundwater level, probability of flooding, the presence of ravines, swamps, and so on), the possibility of removing and decontaminating wastewater, the presence of water supplies and power supply networks, provision with railroad, motor or water transportation. Primary attention must be given to environmental protection problems.

The maximum slope of the territory must be considered to be 0.03 to 0.05, minimum slope, 0.003 (in order to provide for atmospheric water runoff).

For the territory of an industrial district it is preferable to have soils of uniform geological structure with normative pressure on the foundation of no less than 1.5 kg/cm^2. It is desirable that the average amount the surface of the industrial territory is above the highest groundwater level be no less than 7 m to eliminate the possibility of flooding of underground structures (basements, tunnels, and so on). In order to exclude the possibility of surface flooding of the industrial sites with floodwaters, the elevations of these sites must be no more than 0.5 m above the calculated floodwater level.

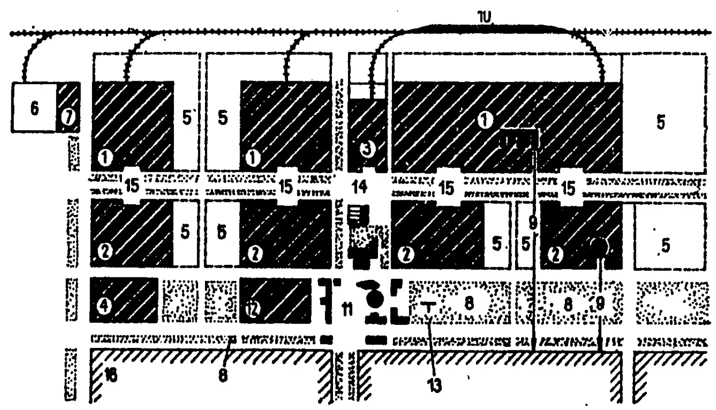


Figure 79. Example composition of a municipal industrial district. 1--Industrial enterprises with especially harmful production facilities; 2--the same with less harmful production facilities; 3--cooperative heat and electric power plant; 4--automobile and truck base; 5--reserve territories; 6, 7--section for waste piles; 8, 9--sanitary protection zone; 10--rayon [district] shunting yard, railroad approach lines; 11--public center; 12--scientific and engineering center; 13--helicopter pad; 14--fire station; 15--plant platforms; 16--developed territory.

As the calculated level, we take the highest water level with a probability of recurrence once in 100 years for enterprises of large national economic and defense significance and once in 50 years for the remaining enterprises except enterprises with short-term operation (to 10-15 years), for which the recurrence probability is taken as once in 10 years.

When choosing the industrial district territory it is necessary to consider that enterprises with significant electric power consumption, for example, aluminum production, electric steelmaking, and so on are expediently located near electric power supplies (hydroelectric power plants, state regional hydroelectric power plants) or near power transmission lines.

The industrial districts in which enterprises are planned with significant water consumption--the heat and electric power plants, artificial fiber combines and cellulose-paper combines--must be built near large bodies of water. The requirements on the water quality in accordance with the nature of production and the necessity for wastewater discharge must be considered simultaneously.

It is permissible to discharge wastewater into a body of water without preliminary decontamination of it only under the condition where the water will not lower the quality of the potable and processed water and will not have harmful effects on fishing. In the remaining cases the wastewater must be subjected to careful purification in accordance with the existing sanitary norms.

When selecting the industrial district territory, in addition, it is necessary to consider the requirements imposed by industrial transportation. Within the territory of the enterprises having railroad tracks, it is necessary to avoid long longitudinal slopes of the tracks, small turning radii and artificial structures which is possible only with the corresponding relief of the site, for example, when the direction of the contour lines approximately corresponds to the direction of the railroad tracks.

It is desirable to locate the most freight-consuming enterprises in areas having communications with water arteries. Unquestionably, for enterprises requiring a large amount of wood (woodworking combines), waterways are the most convenient for delivery of the wood.

The municipal industrial districts with enterprises that generate production hazards (gas, smoke, soot, dust, unpleasant odors and noise) must be located on the downwind side with respect to the nearest developed part of the city (the developed part of the city is considered to be the territory designated for residential and public buildings and also green areas--gardens, parks, squares, boulevards and stadiums), so that the prevailing winds will carry the harmful releases away from the developed territory.

It is expedient to locate enterprises with the longitudinal axis of the territory parallel to the direction of the prevailing winds or at an angle to them of no more than 45° in order to ensure ventilation of the intraplant thoroughfares and other accesses.

The prevailing wind direction is taken by the so-called wind rose which is a diagram of the wind distribution with respect to direction and recurrence and sometimes with respect to velocity.

For construction of a direction and recurrence wind rose (Figure 80), lines are drawn from a point in the direction of 16 points of the compass, and as many units are placed on each of these lines as the wind blows for a separate time interval in this direction; the ends of the segments are joined with straight lines. The wind roses are constructed for the annual period or for various times of the year.

When constructing the recurrence and velocity wind rose, not only the recurrence of the wind, but also its velocity is determined for each direction. Then the recurrence of each direction is multiplied times the corresponding average velocity. The values obtained are expressed in percentages of the total sum and are plotted on a defined scale along the compass directions.

In addition, industrial enterprises must be removed from developed territories some distance according to the degree of hazard of the enterprise. The strips between the source of production hazards and the boundary of the developed territory are called sanitary protection zones.

Depending on the type of production, the released hazards and the process conditions, industrial enterprises are divided into five classes: class I includes enterprises with especially harmful production; class V includes enterprises with the least harmful production (SN 245-71, Section 8 "Sanitary Norms for the Design of Industrial Enterprises").

For the enterprises in class I it is necessary to construct sanitary-protection zones 1,000 m wide; for enterprises in class II, III, IV and V, 500, 300, 100 and 50 m, respectively. In these zones it is permissible to locate industrial enterprises with less harmful production facilities and also fire stations, baths, laundries, garages, warehouses, administrative service buildings, commercial buildings, dining rooms, outpatient clinics, and so on.

In a sanitary-protection zone on the developed side it is recommended that a green area be provided no less than 50 m wide, and with a zone width of up to 100 m, no less than 20 m wide.

Depending on the nature of production, the degree of release of production hazards and the amount of freight turnover it is recommended that the industrial districts be located as follows with respect to the developed territory.

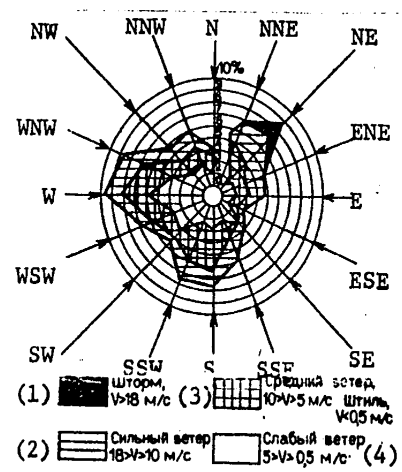


Figure 80. Wind recurrence and strength rose. 1--Storm, ... m/sec; 2--high wind, ... m/sec; 3--medium wind, ... m/sec, calm, ... m/sec; 4--light wind, ... m/sec.

The districts designed for enterprises which are assigned to class I or II with respect to the release of production hazards (independently of the freight turnover) are located outside the city limits, at a distance from the developed territory.

Industrial districts for enterprises belonging to classes III and IV with respect to industrial hazards and also to class V but with freight turnover requiring the construction of railroad approach lines and, in addition, enterprises not generating production hazards are located on the edge of the developed territory.

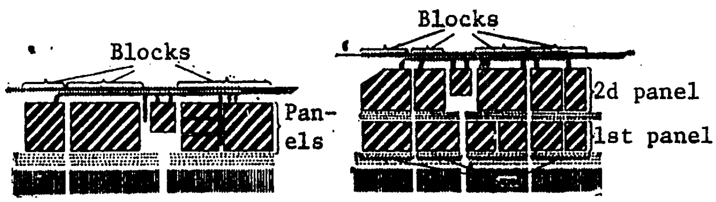


Figure 81. Single-panel (a) and double-panel (b) strip arrangement of enterprises.

Within the developed territory are enterprises which do not release production hazards, enterprises belonging to class V and also enterprises with small freight turnover and not requiring railroad transportation.

The planning of a municipal industrial district must be tied to the planning of adjacent parts of the city, the city street and service network system.

It is recommended that enterprises be located in the territory of an industrial district by the so-called strip-panel system parallel to the developed territory.

With the strip system of planning of the industrial district the strips are called panels. The accesses or streets are separated by the panels into blocks.

For enterprises belonging to one class or similar classes with respect to production hazards, the single-panel arrangement of the buildings is used. The double-panel or multipanel arrangement of the buildings is expedient for series arrangement of the enterprises which belong to the different classes with respect to production hazards (Figure 81).

Section 30. Principles of the Formation of Industrial Complexes

The resolutions of the 25th CPSU Congress propose the expansion of the practice of constructing industrial enterprises with common auxiliary production facilities for the group of enterprises, with service structures and lines.

In accordance with these resolutions the enterprises located in the industrial districts, independently of their departmental ownership, must be combined into industrial complexes with common auxiliary production facilities, engineering structures and networks, and under the corresponding conditions, with cooperation of the basic production.

This combination permits the most efficient use of social labor, material and money resources both in construction and for the operation and maintenance of the enterprise.

According to the SNiP II-M.1-71, the enterprises combined into industrial complexes must be located at distances as close as possible permissible by the norms, with the least extent of the lines common to the group of enterprises. The formation of plots of ground between the enterprises not used for building, roads, transport and not provided for future expansion of the enterprises or projects common to the industrial complex is not permissible.

The placement of the enterprises must consider and provide for the organization of external production, transport and other communications with the surrounding enterprises and the service networks and also the worker's settlements.

In the residential districts it is not permissible to have enterprises requiring the construction of railroad approach lines or laying of these lines through the residential districts or enterprises having freight turnover with traffic intensity of more than 40 vehicles per day in one direction.

In order to keep suitable land for agriculture it is necessary to select the construction sites in nonagricultural lands.

The placement of the groups or individual enterprises must take into account the most efficient use of state lands.

The industrial complex is designed for the territory provided by the district planning design, the master plan of the city, the plan for layout and coverage of the industrial district, and if these are unavailable, the territory planned beginning with the technical-economic substantiations of the construction of the enterprises included in the industrial complex.

The planning of the territory for industrial complexes and the enterprise sites, the mutual arrangement of buildings, structures and transport lines must create the most favorable conditions for the production process and labor at the enterprises, efficient and economical use of the sites and the greatest effectiveness of capital investments.

When solving the master plans of the industrial complexes and individual enterprises, the principles of the organization of the industrial territories are developed for which the following are provided: functional zoning of the territory considering the process relations, sanitary-hygienic and fire-safety requirements, freight turnover, types of transportation and construction priorities; ensurance of efficient production, transport and service communications at the enterprises, between them and with the populated areas; the creation of passenger and pedestrian walkways providing safe movement of the workers with the least expenditures of time; the possibility of the expansion and rebuilding of the enterprises as a result of using free sections in the industrial site, increasing the number of floors, minimum use of reserve sections outside the boundaries of the enterprise considering possible development of the adjacent developed territory and ensurance of access to the green areas and bodies of water; the organization of a united system of cultural-service and other forms of servicing of the workers; the creation of a united architectural ensemble tied to the architecture of adjacent enterprises and populated area.

The territory of the industrial complexes must be divided into the following zones with respect to functional use: the enterprise sites, public centers, general objects of auxiliary production, and warehouses (see Item 3.4 of SNiP II-M.1-71).

As a rule, during the design process it is necessary to include in the industrial complex the entire group of nearby enterprises, independently of the nature of their production and departmental ownership.

Here the industrial complex with respect to the national economic development plan can be formed from newly built, expanded and rebuilt enterprises.

By analogy with the industrial districts, the industrial complexes consist of rectangular and parallel strips of panels which are divided into blocks by the accesses or streets.

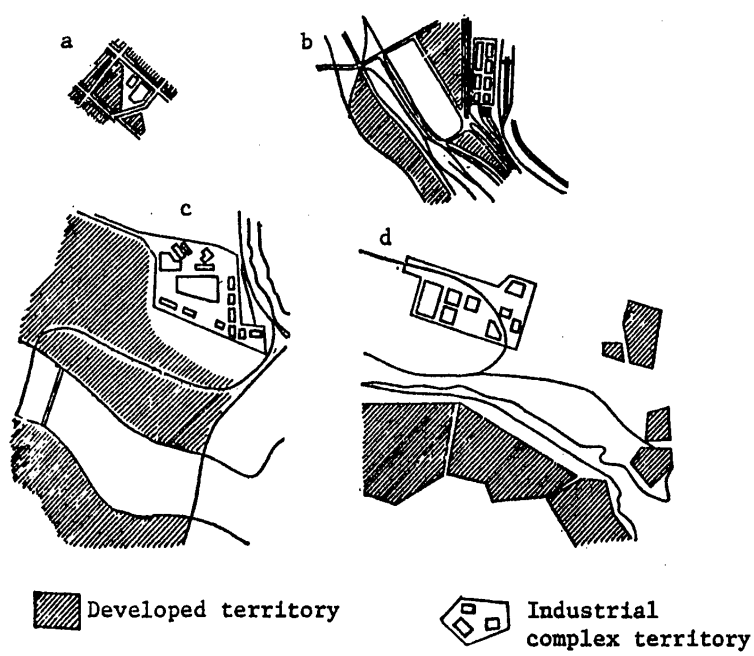


Figure 82. Solution of industrial complexes with respect to the developed territory. a--Within the developed territory; b, c--at its boundary; d--remote from it.

At this time a great deal of experience has been accumulated in the design of industrial complexes within the USSR (versions of the arrangement of industrial complexes are presented in Figure 82).

On the order of preliminary familiarization with the technical-economic effectiveness of the design of industrial complexes, let us consider an example of the combination of several plans into an industrial complex.

In one area before combining into a united complex the plants were designed as isolated enterprises with numerous small, detached buildings and structures with duplicating auxiliary shops and warehouses (Figure 83a). The coverage density of such enterprises by the terminology adopted in SNiP II-M.1-71 was 0.33-0.5. The design of the isolated plants led to long service lines and roads, a significant number of buildings and standard sizes of structural elements.

By the adopted version of the industrial complex several production facilities were placed on one site and in one building, that is, an efficient solution was obtained providing for location of all of the enterprises within the premises of the process equipment plant which was closest to the designed railroad, shunting yard and petroleum base and at the same time sufficiently remote from housing. This solution corresponds to the previously developed production diagrams and takes into account the characteristics of each plant. More advanced technology has made it possible to lower the cost of the process equipment by 4-5 percent.

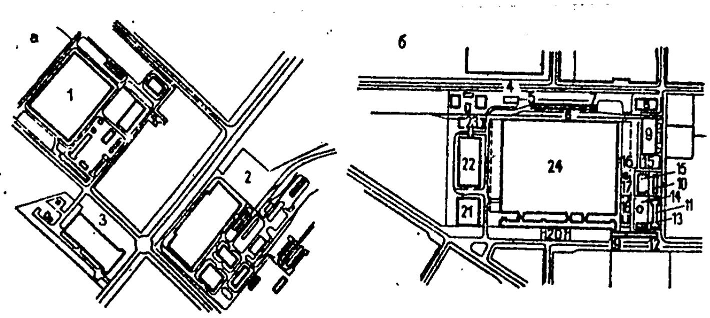


Figure 83. Master plans. a--Plants before combining into an industrial complex; b--industrial complexes; 1--process equipment plant; 2--light engineering plant; 3--pneumatic machinery plant; 4--boilerroom; 5--building materials and waste warehouse; 6--low loading and unloading platform; 7--fuel and lubricants, chemicals and tank storage; 8--oxygen compressor station; 9--cast housing; 10--wood finishing shop; 11--special design office; 12--engineering building; 13--dining room (existing); 14--fire-safety reservoir; 15--sanitary-engineering and forging divisions; 16--boilerroom (existing); 17--electrical goods storage; 18--experimental shop; 19--dining room; 20--general services facilities; 21--training building; 22--glass building; 23--composite building; 24--main building.

Many shops and material warehouses have become common to all three plants; shops with harmful releases are placed at the outside walls and are separated from the others by blind partitions.

The master plan of an industrial complex is designed as applied to the production processes of the associated plants (Figure 83b). Along the north side of the building there are three railroad tracks. The foundry building is located on the east side of the main building closer to the main casting users. The common boilerroom is placed on the north side of the building.

The technical-economic indices reached as a result of combination of enterprises into industrial complexes are presented in Table 11.

Table 11. Technical-Economic Indices Reached as a Result of the Combination of Enterprises

Indices	Technical-Economic Indices: For Isolated Enterprises	Technical-Economic Indices: For Industrial Complex	Percentage Obtained From Comparison of Versions
Total area of the territory, ha	42.30	22.00	48.9(-)
Coverage area, ha	17.10	13.80	19.3(-)
Coverage density, %	0.40	0.63	57.5(+)
Use factor of the territory	0.61	0.89	45.9(+)
Extent of intraplant roads, km	5.69	2.30	59.6(-)
Extent of railroad approaches, km	1.45	0.70	51.7(-)
Extent of enclosure, km	3.40	1.54	58.4(-)

Note: The "+" and "-" signs denote the increase or decrease in the values of the indices, respectively.

This solution has made it possible to reduce the number of standard sizes of the structural elements from 460 to 120. The savings with respect to construction and installation operations amounted to 16 percent of their total cost. In order to achieve a comprehensively substantiated arrangement of enterprises in the industrial complex and clear placement of the general complex objects and also determination of the cost effectiveness of building the enterprises within the industrial complex and the creation of general complex projects, a master plan of the complex is laid out.

When developing the master plans of industrial complexes, the all-around architectural-layout and planning concept must be realized providing for expedient placement of the industrial enterprises on one or several adjacent sites; efficient layout and organization of the territory with corresponding zoning; production cooperation with respect to the storage and preparation of raw materials, the repair of equipment and warehouses; the solution of the integrated transport and service line systems; reexamination of the master plans of the enterprise and the creation of general complex projects; blocking of shops within the boundaries of the enterprises; and standardization of construction solutions. In addition, when developing the master plans of the industrial complexes it is necessary to solve service problems (cultural-general services, medical, and so on) and amenities tied to the detailed planning of the city and also the distribution of the proportional participation of the enterprises in the construction of general complex projects. It is obvious that the greatest effectiveness in solving the master plan of the industrial complex can be reached on formation of it from the newly designed enterprises (Figure 84a, b). However, in architectural-construction practice more difficult problems are quite efficiently solved, in particular, with respect to the creation of the master plans of industrial complexes from the existing, expanded and rebuilt enterprises. In such cases provision can be made for improvement of the location of the designed enterprises considering the existing coverage, the arrangement of coverage considering the construction started, the improvement of the master plans for individual designed enterprises, and cooperation between the auxiliary services and networks.

The problem of improving industrial complexes with existing coverage is difficult and less rewarding, but it is extremely important, for the necessity has arisen long ago for reordering the existing built-up areas, especially in large industrial centers.

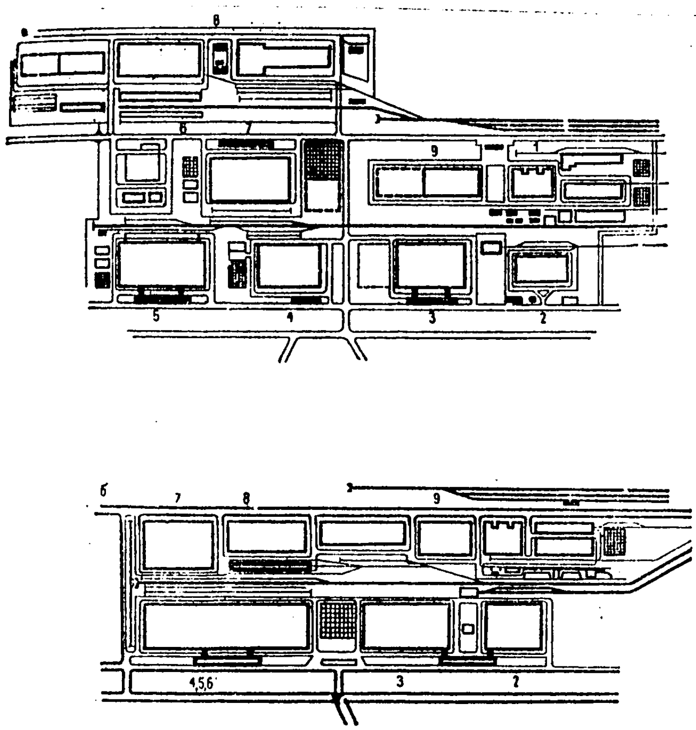
Design experience shows that industrial complexes encountered in practice are appropriately divided into two groups: 1) enterprises of different branches of industry--multibranch industrial complexes; 2) plants or factories for primarily one or several related branches of industry (for example, the enterprises of the chemical and petrochemical industry, machinebuilding and instrumentmaking, the foods industry, and so on). The industrial complexes of the second group are called specialized.

Here it must be emphasized that the basis for the classification of industrial complexes is the different degree of cooperation of the enterprises in them.

An analysis of numerous designs of industrial complexes made at the Promstroyproyekt institute makes it possible to present approximate indices. For example, it has been established that for separate placement of the enterprises the territories making up the industrial complex are diminished as a result of the reduction in networks, cooperating projects and other measures by 10 percent or more on the average.

On the modern level of design where the association of enterprises into industrial complexes is becoming the most important direction in industrial construction, it is necessary to make full use of the advantages of industrial complexes and solve not only the problems of cooperation during construction, but creation of common production facilities of an interbranch nature for groups of enterprises under the condition that this will permit timely introduction of the production capacity into operation and greatly increase the effectiveness of capital investments.

In a number of cases it is necessary to reexamine the approved master plans in connection with altering the composition and capacity of the enterprises included in the complex or in connection with altering the previously adopted construction times for individual enterprises. Here it is necessary to use the architectural planning solution procedures for the development of master plans of industrial complexes which permit alteration of their composition without significant negative influences on the technical-economic indices. This can be achieved, for example, by using the well-known method of zoning the territory of the industrial complex: zoning the complex premises in accordance with the degree of probability of construction of individual enterprises in the given times--enterprises with lower probability of construction are placed at the boundary of the covered territory.



Designed coverage
Open areas
Future expansion

Figure 84. Master plan of an industrial complex consisting of machinebuilding and chemical industry enterprises. a--Previously designed built-up area; b--design proposals; 1--glass plant; 2--household refrigerator plant; 3--electric motor-building plant; 4-6--associated plants; 7--plastics plant; 8--foundry; 9--cardboard packaging plant.

On altering the composition of the industrial complex, its layout is taken into account which must correspond completely to the city planning conditions, the peculiarities of the relief and landscape, the proposed development of the industrial district in the distant future and ensurance of invariability of the routing of basic service and transport lines and also the entire layout concept for possible partial alterations in the composition of the industrial complex or changes in the construction conditions.

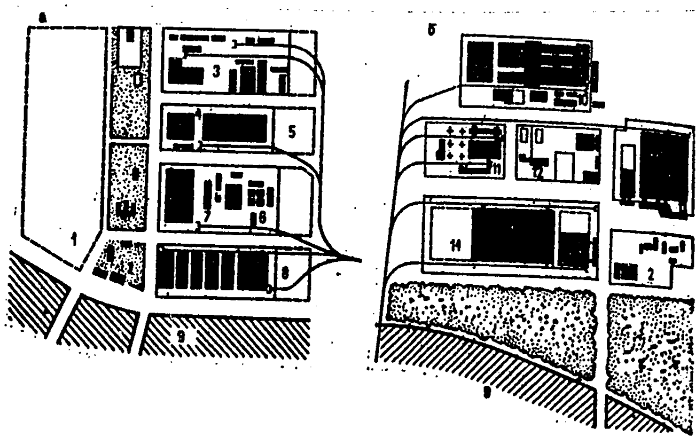


Figure 85. Example of planning industrial complexes consisting of the following enterprises: a--machinebuilding and construction industry; b--electric motor-building, metalworking, ferrous metallurgy; 1--reserve for developing the industrial complex; 2--administrative-public center; 3--construction industry enterprises; 4--reducer plant; 5--gear plant; 6--general complex projects; 7--shaft plant; 8--foundry; 9--developed residential and public territory; 10--rolled products plant; 11--reinforced-concrete structural elements plant; 12--general complex engineering support projects; 13--spare parts plant; 14--welded structural element plant.

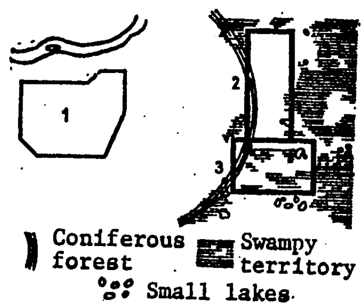


Figure 86. Version of the arrangement of an industrial complex with given position of the city. 1--City; 2--northern site; 3--southern site.

Figure 85 shows versions of layouts of industrial complexes of different production profiles. It is very important to achieve optimal mutual arrangement of the industrial complex and the city. In the industrial complex depicted in Fig-85b, the enterprises are arranged in groups by the branch attribute; each group has its architectural appearance.

The use of computers can be of great assistance when selecting the optimal solutions for the master plans of industrial complexes. In recent years procedures have been developed and experimentally checked out for their use which permit the following:

with respect to economic indices, the discovery of the most appropriate territories for construction in the given district;

selection of the most economical version of the location of the pilot structures of the industrial complex and the point of adjacency of the networks and roads to the corresponding headers and mains considering one-time expenditures and annual operating costs.

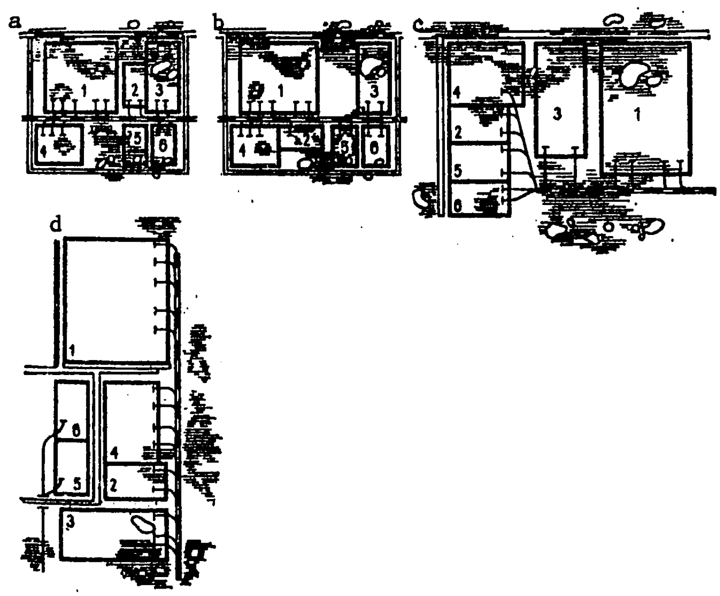


Figure 87. Versions of the layout of an industrial complex for southern (a-c) and northern (d) parts of the premises. a--First preliminary; b--second preliminary; c, d--improved; 1--oil refinery; 2--heat and electric power plant; 3--cement plant; 4--construction industry base; 5--electrocorundum plant; 6--cellulose and paper plant.

As an example let us consider one of the versions of the search for a complex site within the limits of a designed city, using the presented procedure (Figure 86).

Initially the southern part of the territory was planned for building in the vicinity of the large swampy forest, which was dictated by the size of the sanitary break. As a result of an analytical search it was established that it is more expedient to use the northern part of the territory for coverage. The site selected by computer turned out to 6.5 million rubles more economical.

The computer was also used to estimate the preliminary versions of the location of the enterprises and for automatic layout of the master plan drawings for the southern and northern parts of the territory.

As a result of more precise specification of versions of the layouts using a computer it was established that they are more economical than the previously planned ones (Figure 87a-c) and that the layout in the northern part of the territory (Figure 87d) is much more economical than the preceding ones.

The procedures making use of computers give good results and are intended for designers.

Chapter VI. Master Plans of Industrial Enterprises

Section 31. Layout and Coverage of the Industrial Site

The enterprise site, as a rule, is broken down with respect to functional use into preplant, production, auxiliary and storage zones.

When drawing up the layout of the plant territory it is useful to develop several versions, analyzing for each of them the degree of compactness and the esthetic appearance of the buildings, the length of the railroads and roads, length of service networks, relative green area, layout indices, and so on.

When designing the master plans for enterprises, the designers are obligated to consider that the construction and introduction of the enterprises into operation must be realized by start-up complexes or phases.

The industrial enterprise, independently of the type of production or its structure, consists of a group of basic facilities for production, servicing production and servicing the workers.

The basic production facilities include the billeting, processing and assembly shops.

The production servicing facilities consist of a group of buildings entering into the production technical service system (support with transportation, storage areas, equipment repair, power supply) and production control (technical training, development, and so on) realized in the administrative, engineering and other buildings.

The workers' services facilities include a group of buildings for sanitary-hygienic and communal, training-education and cultural-general services purposes.

The basic production buildings designed in accordance with the production process, that is, by production phases (for example, the shops of machinebuilding enterprises), usually include the billeting shops--casting (cast iron, steel and nonferrous casting); forging and forging-pressing; processing--machining, cold stamping, heat treatment; assembly--assembly-installation, welding, metal structural elements shop; finishing--painting, coating, and so on.

In the industrial enterprises in practice, both for new and relatively recently built enterprises, usually the shops in the enterprise site are combined into groups related with respect to purpose, for example, the basic production shops: billeting, processing, assembly; the auxiliary production shops: tools, patterns, repairs, and so on; the service production shops: power, transportation, storage, and so on.

During the process of the design, construction, operation and maintenance and also the rebuilding of industrial enterprises a system has developed which has checked out over many years by which the buildings of shops which belong in one group or another with respect to process conditions are expediently arranged compactly in one zone with minimum admissible sanitary and fire-safety breaks between them with the shortest roads and service networks.

The sanitary break between buildings lighted by windows must be no less than the greatest height to the top of the cornice of the opposite buildings. The fire-safety breaks between the production buildings and structures are established as a function of the degree of fireproofness of opposite buildings according to Table 4 of SNiP II-M.1-71. The least break is 9 m.

The proper mutual arrangement of the zones and grouping of the buildings provide a basis for expedient construction of the master plan of the enterprise.

The territorial zoning permits achievement of the most efficient solution of the planning of the industrial enterprise both by conditions of efficient organization of the production process and by the sanitary-hygienic and fire-safety requirements.

Buildings with production facilities of increased fireproofness must be located on the downwind side of the plant premises; it is preferable to locate storage structures near its outer boundaries considering the efficient use of the railroad track frontage.

The machine shops of machinebuilding plants, as a rule, are grouped with the billeting buildings of the shops (casting, forging shops).

The group of billeting shops of the machinebuilding plants, including steel and cast-iron casting shops, forging shops, is expediently located on the downwind side with respect to the machine shops. Shops of this group require a large amount of metal, molding materials, and fuel, and therefore they usually have a developed network of railroad tracks and transport lines; consequently, the group of billeting shops of the machinebuilding plants is expediently located closer to the entrances of the railroad tracks to the site. In addition, these shops consume more power and therefore must be closer to the power structures (the heat and electric power plant, and so on) of the plant (industrial complex).

The group of auxiliary shops (tools and repairs--mechanical repair, casting repair, construction repair, and so on) must be placed approximately at the juncture of the zones of the processing and billeting shops or blocked with the corresponding basic production shops.

It is also possible to put the group of woodworking shops having increased fire hazard in a separate zone. Therefore they must be located insofar as possible on the windward side of the group of hot shops.

The group of power engineering structures includes the thermal power plant, the fuel storage, distribution stations, outdoor step-down substation, and so on which are usually located adjacent to the group of billeting shops near the railroad track entrance.

The thermal power plant which generates dust, soot and gases is expediently placed outside the plant boundaries, in the common-plant or complex service zone.

The group of workers' service buildings includes such buildings as the dining room, the plant polyclinic, school, passageway, GPTU and other administrative buildings. These buildings are located, as a rule, along the way to the workplace, next to the main entrance to the plant, in the main preplant area, where part of these buildings are located outside the enterprise premises.

The main entrance to the enterprise must be on the main access or workers' approach side.

If several access points are planned, they are usually placed at a distance of no more than 1.5 km from each other and no more than 800 m from the entrance to the general services facilities. In front of the entrances there must be areas for those using passages, general services and administrative buildings calculating no more than 0.15 m^2 per person for the largest shift. At the points of intersection of walkways with the railroads or roads with pedestrian traffic of more than 300 people per hour it is necessary to provide overhead crosswalks, tunnels or galleries.

It is not recommended that the entrances to the general services facilities be located on the railroad side near the industrial building.

It is desirable to locate the cultural and general services facilities for the workers and also the scientific-technical service facilities of the enterprises within the public center of the industrial complex.

The fire station which services a group of enterprises is expediently located at isolated sites with exits to the public roads.

Primary attention must be given to the density of coverage of the enterprise site which must correspond to the indices established in the appendix to SNiP II-M.1-71.

Examples are presented below for the least coverage density of the following enterprise sites, in percentage:

Ministry of Ferrous Metallurgy:	
Iron ore concentration enterprises and enterprises for the production of pellets with a capacity in millions of tons per year	
5-20	22
Greater than 20	27
Crushing and sorting capacity in millions of tons per year	
2-3	22
More than 3	27
Coke and by-products process	30
Ministry of Nonferrous Metallurgy:	
Coppermaking	38
With a capacity to 7 million tons a year with respect to copper ore extraction	33
Ministry of Heavy Machinebuilding:	
Rolled products, blast furnace, steelmaking, sintering and coking equipment, equipment for nonferrous metallurgy	50
Electric bridge and gantry cranes	50
Locomotives and railroad rolling stock	50
Ministry of Machine Tool Building Industry:	
Forging and pressing equipment	52
Casting	45
Forgings and stampings	47
Ministry of Instrumentmaking:	
Instrumentmaking, automation means and control systems	50

Notes: 1. Coverage density of the industrial enterprise site is defined in percentages of the ratio of the built-up area to the enterprise area within the fence (or in the absence of a fence within its corresponding provisional boundaries) with inclusion of the area occupied by the railroad track fan. 2. The covered area or built-up area is defined as the sum of the areas occupied by buildings and structures of all types, including sheds, open process, sanitary-engineering, power engineering and other installations, trestles and galleries, the loading and unloading platforms, underground structures (reservoirs, burial sites, tunnels, utility corridors for service lines over which buildings and structures cannot be placed) and also uncovered parking lots for motor vehicles, machines, machinery and uncovered storage areas for various purposes under the condition that the dimensions and the equipment of the parking

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lots and storage areas are taken in accordance with the norms for the production design of the enterprises.

The built-up area must include reserve sections on the enterprise site planned in accordance with the design assignment for the placement of buildings and other structures.

The built-up area does not includes areas occupied by the blind areas around buildings and structures, sidewalks, motor vehicle roads and railroad tracks, railroad stations, temporary buildings and structures, uncovered sports areas, and so on.

The procedures for laying out and covering the territory of industrial enterprises can be highly varied, for they depend on the requirements of the production process, the number of stories of the basic buildings and their dimensions. As has already been stated, the most widespread is the so-called panel coverage by which the production buildings are located over the entire territory of the enterprise with respect to a rectangular grid of streets and accesses.

In the given case by a panel we mean a covered strip bounded on two (predominantly longitudinal) sides by accesses. This type of panel is constructed one or sometimes two buildings wide.

In the panel system of coverage the placement of the buildings within the panel must be efficient and organized; it is desirable that the panel width be identical and a multiple of 6 m.

At the machinebuilding plants, the mechanical shops are most frequently located in the panels closest to the entrance: mechanical assembly, tools, repair-mechanical and other shops for cold working of metals (it is very expedient to block and consolidate these shops). In the following panels (on going away from the entrance) there are usually hot billeting shops (forging, casting, steel casting, and so on).

Proper layout and coverage of the panels is the basis for compact, economical layout of the master plan for the plant as a whole.

Both with respect to conditions of the architectural solution to the built-up area and with respect to economical conditions it is necessary to pay special attention to the layout of the first panel of the production buildings.

With panel coverage the shape of the plant site has great influence on the economicalness of coverage of the territory and placement of the intraplant railroad tracks. Therefore the shape of the plant site must be especially carefully selected.

If railroad transportation is used within the plant premises, then a trapezoidal shape of the site is expedient which is formed as the result of the presence of the railroad track entrance fan; if there is no developed railroad network on the site or if it is beyond the boundaries of the plant premises, then a rectangular shape is more acceptable.

From design experience it has been established that the most efficient site is in the form of a rectangle with a side ratio of 1:2 (with entry on the long side). This site has the least length of path for movement of workers to the shops, for the main entrance and the main thoroughfare are approximately in the middle of its long side.

Of course, when locating the main entrance on the end (which is usual for the dead-end arrangement of the railroad tracks) this ratio of the sides of the rectangle is not optimal, and a shape approaching a square is more efficient. The sides of the plant site, depending on their orientation (toward the residential district, another industrial enterprise or the warehouses) have different architectural solution. The most important is the side on which the main entrance to the plant is located with the preplant area and public buildings of the plant; this side is usually turned toward the housing district. Therefore the architectural solution of the buildings forming this side of the site must be given special attention.

The lateral sides of the plant site have subordinate significance inasmuch as they are oriented for the most part toward adjacent industrial enterprises.

The rear side of the plant site oriented in the direction of the entrance of the railroad tracks or warehouses has secondary architectural significance.

However, in construction practice sometimes it is difficult clearly to delimit the sides of the premises with respect to architectural significance: for example, frequently the main side is oriented toward one populated area or district of the city and the lateral or even rear side, toward another.

Section 32. Blocked Shops

As is noted above, improvement of the coverage density of the premises of an industrial enterprise to the highest degree promotes blocking of the shops in large buildings. This procedure not only reduces the area of the enterprise territory but also greatly decreases the length of the service lines and transport facilities, the length of the outside enclosures of the buildings. Therefore the basic production and technical service facilities must be combined in larger buildings if this is economically substantiated and arises from the production, construction, sanitary-engineering and fire-safety requirements and also safety conditions.

The transformer substations and distribution stations (6-10 kv), ventilation units, pump stations for pumping incombustible liquids and gases, intermediate and flow storages must be designed not as detached buildings, but placed in the production buildings.

It is easier to block the shops in the enterprises of the textile and machine-building industry; in metallurgy and other branches of industry it is significantly more complicated.

It is necessary, however, also to note the deficiencies inherent in large-scale blocked enterprises. The analysis performed by the Promstroyproyekt institute demonstrates that with a wide building which cannot be oriented along the contour lines, the slope of the ground surface must be decreased by approximately 2.5 to 3 times by comparison with the previous solutions, that is, it must be no more than 1 percent. Hence we have one of the significant deficiencies of blocking--the undesirableness of the location of industrial buildings of significant area on a single directional slope.

The location of several production facilities on a small site leads to extraordinary concentration of workers, that is, it congests the people flows at peak hours and overloads public transportation. At such enterprises it is necessary to pay special attention to the organization of high-speed forms of transportation: buses, trolley buses, electric railways, and so on.

In the case of blocking hazardous production facilities it is necessary to consider that together with concentration of production the degree of generated hazards will increase.

As an example of blocking shops Figure 88a, b shows two versions of the master plan for a foundry before blocking and after it.

The master plan provides for blocking the basic production, auxiliary and service shops.

The foundry is designed with a gray cast iron shop, forged cast iron shop, steel casting shop, small-series (repair) casting shop, tool repair shops and scrap distribution shop with compacter.

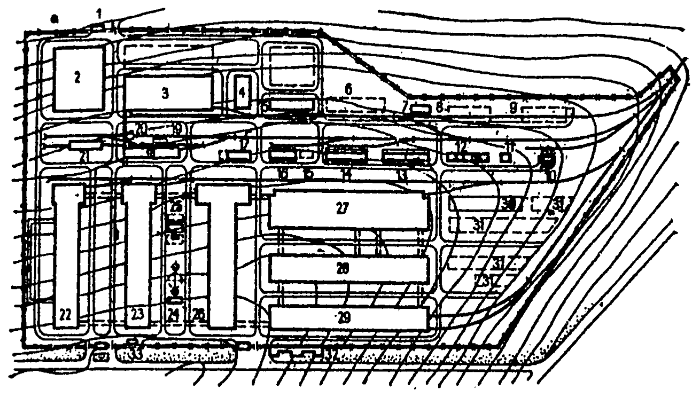
The storage areas are provided including warehouses for finished products, cast iron, molding materials, coke, refractories, cladding sand, chemicals, oils, binders, carbon dioxide, petroleum products, lumber, materials storage, and so on; the administrative-general services and office facilities are designed.

The steel casting and casting shops for gray and forged cast iron are placed in two-story buildings about 300 m long and 54 m wide in which the charging, melting and pouring divisions, molding, rod and finish divisions are blocked. On the first floor are some of the storages, the paint department, the equipment repair workshop and general services facilities, and so on.

Almost all of the production and warehousing facilities are blocked in one building where the small-series casting shops, molding materials and refractory storage, finished product and material storages and also the repair and tool shops are planned.

Only eight buildings remain on the master plan in the blocked version instead of the previously planned 19, which permitted significant improvement of the technical-economic indices of the master plan (Table 12).

The diagrams of the master plans of two specialized enterprises are presented in Figure 89a, b. During the design process, various versions of the arrangement of the industrial facilities on individual sites and in a blocked building were considered. As a result, the version providing for blocking of two production facilities in one building was adopted (Figure 90).



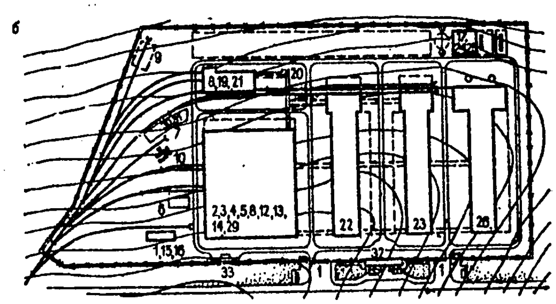


Figure 88. Master plan of a foundry. a--Before blocking; b--after blocking; 1--passageway; 2--auxiliary shop building; 3--small-series casting building; 4, 5--pattern storages; 6--lumber storage; 7--acetylene station; 8--scrap distribution base; 9--compacting shop; 10--light petroleum products storage; 11--carbon dioxide storage; 12--building materials storage; 13--refractories storage; 14--main store; 15--binder storage; 16--oil and chemical storage; 17--compressor station; 18--sand storage; 19--clay storage; 20--coke and lime gallery; 21--coke storage; 22--gray cast iron shop; 23--forged cast iron shop; 24--water pumping station with tanks; 25--transformer substation; 26--steel casting shop; 27--nonferrous casting building; 28--nonferrous casting trimming facility; 29, 30--finished casting storage; 31--uncovered areas; 32--plant administration; 33--automatic scales.

A comparison of the basic indices of the master plan of these two enterprises in the blocked version with analogous indices of the master plans of enterprises with separate location of them leads to the following conclusions:

the placement of two enterprises in one building offers the possibility of sharply reducing the area of the premises;

the placement of all basic shops and technical service facilities in one building offers the possibility of getting by without a plant yard and enclosure of the premises which improves the sanitary-hygienic conditions of the enterprise;

the existing outside service lines and access roads and also the rest areas for the workers are used simultaneously by two enterprises;

as a result of reducing the plant territory and increasing the coverage density, the volumes of operations with respect to road construction and the service line networks are reduced.

Table 12. Technical-Economic Indices by Versions of the Foundry Master Plan

Indices	Versions of Master Plan: By Production Process Design	Versions of Master Plan: Considering Blocking
Number of buildings	19	8
Area of the enterprise premises, ha	55.20	41.50
Coverage density, %	26.00	32.00
Area of paved roads, ha	3.19	2.40
Length of railroads, km	5.63	4.27
Length of water supply and sewage networks, km	19.88	14.20
Length of district heating network, km	9.27	7.00

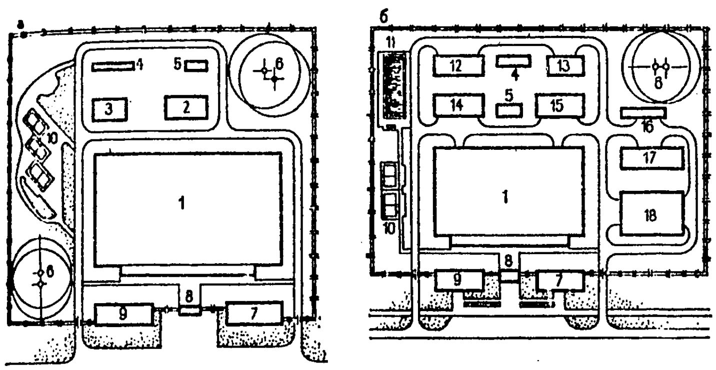


Figure 89. Master plans without considering blocking. a--Weaving mills; b--gas discharge tube shop; 1--production building; 2--auxiliary material storage; 3--storage of raw materials and finished products; 4--distribution unit; 5--boilerroom; 6--artesian wells; 7--dining room; 8--passageway; 9--administrative building; 10--sports areas; 11--cooling pond; 12--compressor and cooling stations; 13--filtration unit; 14--glass storage; 15--finished products warehouse; 16--fuels and lubricants warehouse; 17--materials storage; 18--machine building.

A comparison of the technical-economic indices by versions of the master plans of a weaving mill and special shop reveal the great advantages of the blocked version: the number of buildings was reduced from 11 to 1, the enterprise territory was decreased by 6.58 hectares or by 54 percent, the coverage density of 50.2 percent was achieved instead of 29 percent, the length of the service lines was decreased, especially the district heating networks, from 1.01 to 0.03 km. The general site expenditures reduced to the total construction cost by the blocked version was reduced by 2.4 times by comparison with the version without blocking.

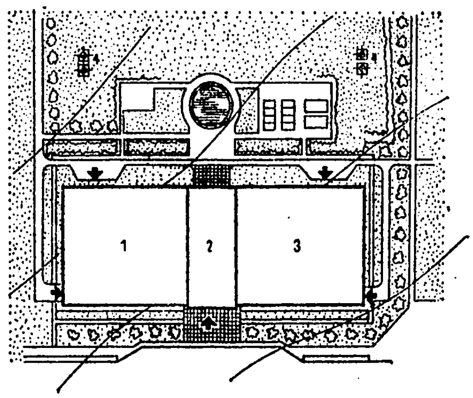


Figure 90. Master plan of a blocked weaving mill and the gas discharge tube shop. 1--Weaving mill; 2--general services facilities; 3--special shop; 4--artesian wells.

Section 33. Engineering Preparation and Amenities of the Premises

The engineering preparation of the territory provides for preparation of the territory of an industrial enterprise for building, protection of it from flooding and the provision for atmospheric water drainage.

One of the basic measures with respect to engineering preparation of the site is vertical planning in order to bring the natural relief of the territory into correspondence with the construction requirements and provide for removal of atmospheric water from the industrial site.

When designing the master plan, the graded elevations of the premises of the industrial enterprise are designated considering the following requirements: retaining the natural relief, soil cover and green areas insofar as possible; provision for the removal of surface water at a rate excluding erosion; observation of the zero balance insofar as possible in the volumes of cuts and fills within the graded site.

It is permissible to use continuous vertical grading with a coverage density of more than 25 percent and also with high saturation of the enterprise sites with roads and service lines; in the remaining cases it is necessary to use selective vertical grading with the performance of grading operations only in the sections where buildings or structures will be located. This type of grading must also be used for rocky soil in order to retain trees or green areas.

The slopes of the site surface must be no less than 0.003 and no more than 0.05 for argillaceous soils, 0.03 for sandy soil, 0.01 for loess and fine sand and 0.03 for permafrost.

The floor level of the first story of the buildings is taken above the graded elevation of the adjacent sections of the territory by no less than 150 mm.

Along the outside walls of the buildings it is necessary to build blind areas with a width exceeding the cornice projection by 200 mm but no less than 500 mm with a slope of 0.03-0.1 directed away from the walls of the building.

The amenities of industrial enterprises are some of the basic measures promoting improvement of the working conditions. The amenities operations include primarily landscaping of the plant premises, the construction of modern paved roads and sidewalks, enclosures, organization of surface water drainage, and so on.

Green areas on the plant premises protect man from gases and dust and also noise to a significant degree.

In addition, landscaping has esthetic significance, it creates favorable conditions for relaxation of the workers during breaks; therefore the green areas must be concentrated in the general services areas, in the vicinity of dining rooms, health stations, plant administration and rest areas. However, it is not necessary to landscape intensely used sections of the plant premises (for example, the railroad fan area and between the forks of the railroad tracks or also near uncovered plant storage areas) and areas formed as a result of increased breaks between buildings.

The landscaping must take up no less than 15 percent of the enterprise grounds. With a coverage density of more than 50 percent it must be no less than 10 percent.

Within the enterprise premises it is possible to use the following forms of plantings: trees of different varieties, lawns and flower beds for the organization of so-called parterre plantings, vines and bushes.

On the main plant thoroughfares, if they are sufficiently broad, it is expedient to have green areas in the form of strips; the distances from the buildings to the planted areas are taken as a function of the height of the trees and sizes of their crowns (within the limits from 5 to 10 m) in order to avoid shading of the facilities. The distances between trees in a row must be taken as 5-7 m. In addition, the trees must not prevent good visibility for motor transportation drivers. The shoulders of the thoroughfares of narrow width are better planted with bushes and lawn. In the sections where heating and gas lines are laid it is not recommended that trees and bushes be planted.

In addition to the planted areas, the microclimate of the plant premises is favorably influenced by open bodies of water and fountains which frequently are used for production and fire-safety purposes (for example, the cooling ponds).

The measures for providing the premises with amenities, as has already been mentioned, include the use of improved paved roads and sidewalks. It is especially important to have such paved areas in the vicinity of the transport entrances to the premises and main thoroughfares.

The width of the sidewalks built within the enterprise site or on the premises of a group of enterprises (an industrial complex) must be taken as a multiple of the traffic lanes 0.75 m wide. The minimum sidewalk width must be no less than 1.5 m. The number of traffic lanes on the sidewalks must be established as a function of the number of workers employed in the largest shift in the building (or group of buildings), to which the sidewalk leads, reckoning 750 people per traffic lane.

If necessary to remove water, in the absence of sidewalks along the buildings it is necessary to build gutters near the blind areas but no farther than 1 m from the edge.

The width of the bicycle paths must be no less than 1.6 m for single-lane traffic and 2.5 m for two-lane traffic.

When creating the architectural ensemble of the industrial enterprise various structures of so-called small forms are used (kiosks, various pavilions, open stairways, walls, and so on) along with sculpture. An important role is played here by the architecture of the enclosure of the plant premises (if it is considered necessary by the operating conditions).

Section 34. Examples of the Layout of Industrial Enterprise Master Plans

Let us consider individual examples from the practice of laying out master plans for the enterprises of ferrous metallurgy and machinebuilding.

Ferrous Metallurgical Plants. As is already known, the primary goal of any master plan, including the master plan for a metallurgical plant, is all-around solution of the problems connected with the location of all the buildings, structures and lines on the plant site, the creation of the best production links considering the conditions of the relief, the sanitary-hygienic and fire-safety requirements and also considering the expansion of the plant.

When developing the master plan for a metallurgical plant the basic factors are the adopted production volume of the basic conversions and the requirements of the production process expressed in the master plan which in the final analysis determine the number of shops, their mutual layout, production linkages and lines. The choice of one version or another of the master plan of metallurgical enterprises is decisively influenced by the main production links, that is, the transport links, for the metallurgical production process is distinguished by highly significant freight turnover. For example, the daily requirement of raw material, fuel and various materials of a large metallurgical plant reaches 60,000 tons with intraplant hauling of about 100,000 tons. Consequently, the freight turnover requirements have a significant influence on the location of the shops and structures which must provide for direct delivery of bulk freight to the unloading areas.

In addition to railroad transportation, other forms of transportation can also be used: various conveyors, spatial chain conveyors, cable tramways, roller conveyors and transfer tables, monorail, pneumatic and hydraulic transportation. The conveyor systems permit a significant increase in use of the enterprise territory and at the same time increase the compactness of the master plan by 20 to 30 percent.

When designing the master plan of the metallurgical plant, along with mandatory observation of the basic general conditions imposed on the master plans of all industrial enterprises it is also necessary to consider special requirements giving rise to the organization of the production process flows, the location of the shops and structures of the metallurgical plant (see Figure 91).

The blast furnace, coke and by-products process shops, sintering plants and other users of a large quantity of raw materials and fuel in the enterprise site must be located compactly near the entrance shunting yard which makes it possible to reduce the path traveled by the freight cars significantly.

The coke and by-products process shop or plant is located parallel to the blast furnace shop. Thus, a combined coke and blast furnace block is formed which permits use of conveyors of minimal length to transfer coke and coal from the coal yards and storage to the blast furnace shop (coal preparation).

The steelmaking shops are located at an angle to the center line of the blast furnace shop at a distance of up to 1 km; cast iron carrier tracks are used for connecting them.

The rolled products shops are arranged in series, along the path of the production process, that is, after the division for stripping the ingots of the steelmaking shop (at a distance of no more than 500 m), which provides for transfer of the hot ingots to the blooming or slabbing pits. The finish rolling mills are arranged in parallel groups behind the cogging mills. The repair shops are located as close as possible to the basic shops.

The power engineering and power shops are located in the vicinity of the rolling shops which use up to 50 percent of all of the electric power at the mill.

The efficient operation of all elements and units of the enterprise depends to a significant degree on the compactness of the master plan. For modern metallurgical enterprises the coverage density usually is taken as 28-35 percent. Such coverage density indices indicate economical use of the territory, minimum length of the transport lines and service networks without losses for the normal activity of the enterprise and without increasing its operating cost.

The master plan of an enterprise is selected on the basis of analyzing the technical-economic indices of several design versions considering the indices of existing plants.

At the present time the most possible versions of master plans for metallurgical plants are considered to be the series and series-parallel systems.

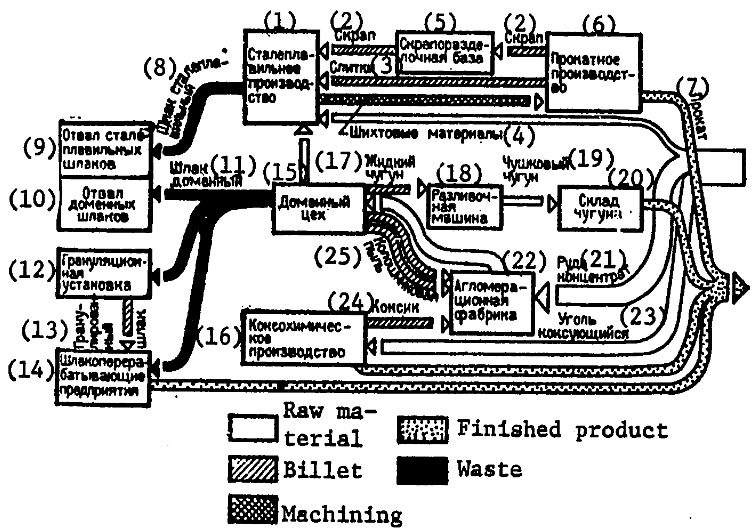


Figure 91. Example diagram of the basic process flows of a metallurgical plant.

Key:
1. Steelmaking production
2. Scrap
3. Ingots
4. Charge materials
5. Scrap distribution base
6. Rolled products production
7. Rolled products
8. Steelmaking slag
9. Steelmaking slag pile
10. Blast furnace slag pile
11. Blast furnace slag
12. Granulation unit
13. Granulated slag
14. Slag-processing enterprises
15. Blast furnace shop
16. Coke and by-products process
17. Liquid cast iron
18. Casting machine
19. Pig iron
20. Cast iron storage
21. Ore concentrate
22. Sintering plant
23. Coking coal
24. Coke breeze

The series system (Figure 92) is usually used when using elongated sites and when, as a rule, constructing small plants. According to this layout, the shops (blast furnace, steelmaking, rolling) are located along the path of the production process, that is, each successive shop is a continuation of the preceding one. With this arrangement of the shops the plant site has a very long form which leads to an increase in length of the service lines and tracks, an increase in cost and complication of construction, operation and maintenance of the enterprise and, as a rule, excludes the possibility of expanding the blast furnace and steelmaking shops. With this solution the blast furnace shop is placed at an angle to the steelmaking shop, and the rolling shop, in series after the steelmaking shop.

The series-parallel layout (Figure 93) can be used in several versions depending on the geological and topographic conditions: 1) the coke-blast furnace unit is placed with respect to the steelmaking unit in parallel, and the rolling mills, with respect to the steelmaking unit, in series; 2) the blast furnace shop is placed at an angle to the steelmaking shop, and the rolling shops, parallel to the blast furnace shop. This layout offers the possibility of achieving great compactness in the location of the basic shops.

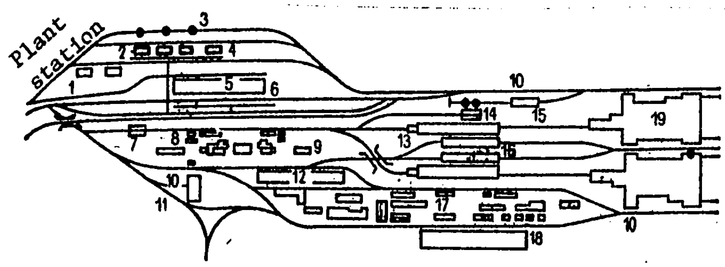


Figure 92. Series layout of the solution of the master plan of a metallurgical plant. 1--Refractory shop; 2--coke batteries; 3--chemical shop; 4--coke conveyors; 5--coal storage; 6--ore yard; 7--bucket storage; 8--blast furnace shop; 9--territory of auxiliary units for the blast furnace shop; 10--plant railroad stations; 11--plant traction unit; 12--circulating water pond for the blast furnace shop; 13--open-hearth shops; 14--casting machines; 15--cast iron storage; 16--charging yards; 17--repair shops; 18--administration center of the plant; 19--rolled products shops.

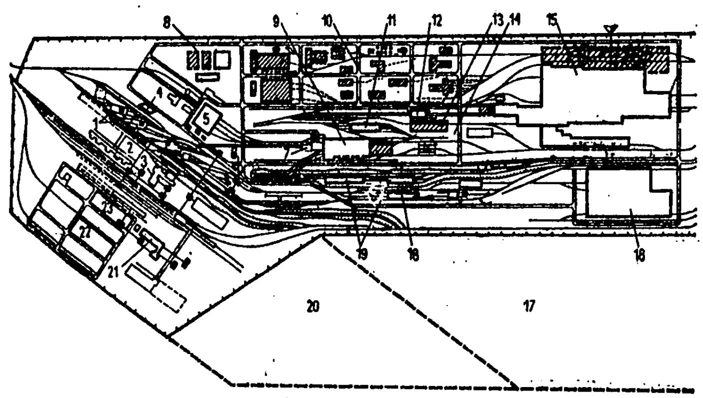


Figure 93. Series-parallel solution to the master plan of a metallurgical plant. 1--Blast furnace shops; 2--ore yard; 3--sintering shop; 4--gas purification; 5--steam-air station; 6--casting machines; 7--mixer; 8--water management; 9--open-hearth furnaces; 10--location of the repair shops; 11--slag yard; 12--ingot stripping division; 13--ingot storage; 14--ingot mold yard; 15, 16--rolling shops; 17--location for expansion of the steelmaking and rolling shops; 18--scrap distribution base; 19--stock yard; 20--location for development of the coke and by-products process and blast furnace shops; 21--coal preparation; 22--chemical shops or divisions of the coke and by-products process shops; 23--coke batteries.

Machinebuilding Plants. In the majority of cases the sites for large machinebuilding plants are selected rectangular in shape for organic tying to the analogous structure of the industrial complex constructed by the panel-block principle. When designing the automobile, tractor and certain other machinebuilding plants most frequently three- or four-panel layouts are used. The solution is preferable where such shops as the machine assembly and tool shops are located in the first panel; the casting and forging shops are located in the second panel; the storage areas and services and auxiliary shops are located in the third panel; the power engineering projects, in the fourth panel.

The solution of the master plan for a machinebuilding enterprise is presented in Figure 94. The largest modern industrial enterprise is located on a rectangular site 1,500 hectares in area. The enterprise site is separated by a main highway into northern and southern sections. The basic production, with the exception of the press building, is located in the southern part of the site where shops are grouped with the largest number of workers and less harmful production facilities. The billeting shops (more harmful production facilities) are located in the northern part of the site and are more than 2.5 km from the developed territory. In the master plan for the enterprise provision is made for production, sanitary and transport zoning.

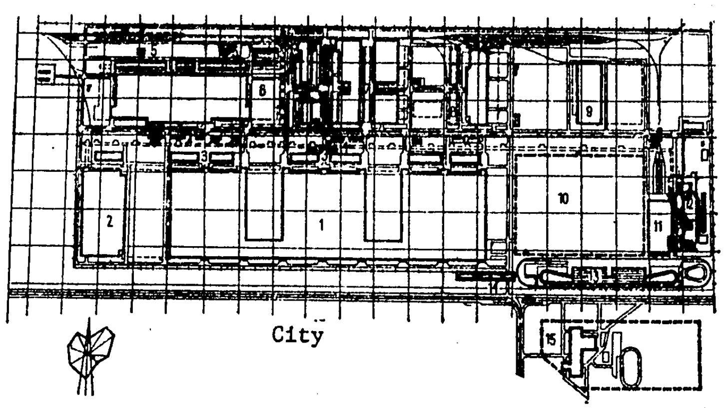


Figure 94. Master plan of a large enterprise. 1--Main building; 2--auxiliary shop module; 3--auxiliary production facilities of the main building; 4--power engineering and engineering support zone; 5--railroad stations; 6--press building; 7--group of casting shops; 8--group of forging shops; 9--spare parts production building; 10--finished product area; 11--dispatch area; 12--engineering center; 13--rolling track; 14--plant administration; 15--training center.

Section 35. Industrial Transportation

Industrial transportation is divided into two types: external and intraplant.

The external transportation (rail, railless and water) is used to link the enterprise to the raw material base, the parts production units (in the case of cooperative production), for shipping the finished product to the destinations of use and shipping the production waste out. Usually it is located beyond the boundaries of the enterprise premises. The elements of the external railroad transportation are the station, the siding and the shunting yard of the industrial district, which, as a rule, is located outside the limits of the plant premises.

The intraplant transport paths are located in the territory of the enterprise. The intraplent transportation is planned on the basis of calculating the capacity of the freight turnover and the nature of the moved freight.

Railroad transportation can be provided with a total freight turnover of the enterprises, as a rule, of no less than 10 provisional cars per day and also when shipping heavy and oversized freight. In addition to railroad and motor transportation for the intraplant movement of goods it is expedient to provide a continuous transport system (conveyor, hydraulic, pneumatic, monorail, overhead cable). If the external shipping of raw materials, fuel and products can be accomplished by railless transportation, which is economically expedient, then it is not necessary to design railroad tracks, but provide for motor and trailer shipping and also conveyors, overhead cableways and monorails and pipelines.

The following railroad transportation systems can be used on the plant premises: dead-end, through, ring and mixed.

The proper location of the plant shunting yard has great significance. In the case of small and medium plants such yards are usually located parallel to the plant tracks (Figure 95a), and more rarely in series with the plant tracks (Figure 95b) as a result of less economical use of the premises.

The most widespread are the dead-end systems which permit economical use of the plant premises and also the application of railroad transportation in territories having slopes in the direction perpendicular to the railroad tracks. One of the disadvantages of the dead-end system is the low flexibility of maneuvering the rolling stock.

The through systems (Figure 95c) are acceptable only for large plants (for example, metallurgical). In this case two plant shunting yards can be planned: for the arrival of freight and for shipping freight.

The circular layouts (Figure 95d) are used relatively rarely as a result of their disadvantages. They increase the plant territory significantly; with such schemes the intersections of people flows with the railroad tracks, and so on are unavoidable. However, these layouts have their advantages: they permit flow movement of goods, the location of the railroad tracks around the edges of the plant premises.

Mixed systems which are also used in construction practice include individual elements of the different layouts.

The railroad tracks of industrial enterprises are divided into approach lines connecting the industrial enterprises with the general network railroad tracks, docks, raw material bases and storage areas or other enterprises, and internal tracks located on the premises of the enterprises.

The approach lines of industrial enterprises are designed according to SNiP II-39-76 ("General Network 1,520-mm Gauge Railroads").

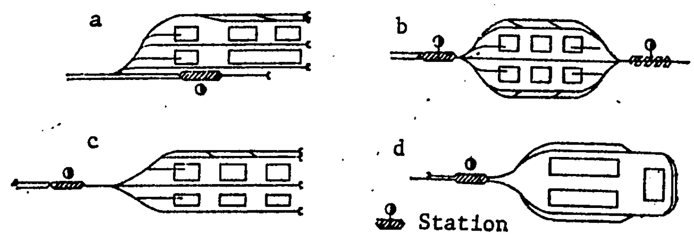


Figure 95. Layouts of intraplant railroad tracks. a, b--Dead-end with parallel (a) location of the shunting yard and series (b) location of the shunting yard; c--through; d--ring.

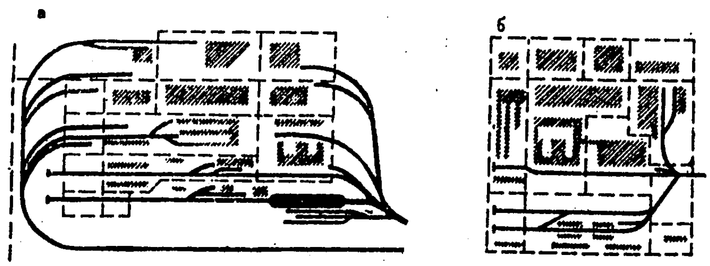


Figure 96. Master plan for an automobile plant. a--Servicing the intraplant shipping basically by railroad transportation; b--the same, rail-less forms of transportation.

With respect to purpose, the plant railroad tracks are divided into running, loading-unloading and shunting. The running tracks are designed for the basic freight to travel, at significant speeds; therefore a minimum number of switches are provided on the running tracks.

The loading-unloading tracks are designed only for loading and unloading operations.

The shunting tracks are located, as a rule, in the plant shunting yards with large freight turnover.

The railroad rolling stock of industrial enterprises includes cars, diesel locomotives and ordinary types of electric locomotives used on the main railroads and also special types which permit application of the railroad tracks with radii of curvature appreciably less than required for ordinary rolling stock.

The studies performed at the TsNIIpromzdaniy demonstrate that the application of railroad transportation at industrial enterprises greatly complicates the layout of the master plan, it requires the allotment of significant territory and the construction of complex engineering structures at their intersections (see Figure 95). Usually the intraplant railroad tracks take up as much as 10 percent of the total area of the enterprise, and when building the plant shunting yards and the railroad track fans, significantly more territory; therefore recently when possible (for example, at the enterprises of ferrous metallurgy) motor, conveyor and pipeline transportation are finding more and more application.

The conversion of the intraplant shipping to the indicated railless forms of transportation has offered the possibility of solving the master plan more compactly (Figure 96a, b): reduction of territory by 30 percent, a decrease in railroad track length by threefold, and the capital expenditures on transportation are reduced by 40 percent.

Thus, the basic form of railless transportation of many industrial enterprises is motor transportation. In this case a network of roads called accesses are planned on the enterprise premises.

When laying out the master plan the number and the dimensions of the streets and accesses and also their designation are determined after establishment of the number of panels, zones and transport links in accordance with the requirements of the production process. It is necessary to know the purpose and the required number of service networks, for this influences the width of the streets.

The streets (thoroughfares) within the territory of the industrial enterprise are divided into primary and secondary.

A main thoroughfare is usually a transport artery which begins at the main entrance of the plant and is designed for moving the bulk of the workers to the workplaces.

On the premises of average size enterprises frequently one main route is laid out which is the layout center line of the industrial site and simultaneously splits the plant premises into two approximately equal parts: other versions of laying out the plant thoroughfares are also possible.

The roads of industrial enterprises can be access, connecting the enterprises to the general network roads, and internal, located on the enterprise premises.

The basic technical indices of roads must satisfy the requirements of SNiP II-D.5-72 ("Roads. Design Standards").

The roads on the premises of the enterprises are designed as dead-end, ring and mixed.

When choosing the mixed road system, it is appropriate to consider at least one ring encompassing the main part of the built-up territory. When selecting the dead-end road system for turning the vehicles around at the end of the cul-de-sac, loop drives or areas no less than 12 x 12 m in size are provided where the size must be adopted in accordance with the technical specifications of the adopted transport means.

Section 36. Technical-Economic Indices of Master Plans

The quality of the master plan design of an industrial enterprise is characterized by its technical-economic indices which include the following data: the area of the territory, hectares; the covered area, hectares; the coverage density, percentage;* the landscaped area, hectares; the area taken up by railroad tracks and railless roads, hectares, and their length, km; the length of the underground and above-ground service networks, km; the length of the enclosure, km; types of bridges and their areas, hectares.

The presented indices characterize the solution of the master plan from the economic point of view. The economic indices of the master plan also include the dimensions of the initial and subsequent capital investments, including the operating expenditures.

When estimating the versions of the master plan the designers must consider not only the technical and economic requirements, but also the architectural-esthetic requirements, that is, solve the overall design problem.

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* For the enterprises of each branch of industry the coverage densities have different values (see Section 31).

Chapter VII. Basic Design Principles of the Buildings of Industrial Enterprises

Section 37. Classification of Production Buildings

When designing the production buildings of industrial enterprises it is necessary to consider that with respect to the production process and internal conditions connected with it, nature and effect of external loads and also by the other operating characteristics they are under specific and, as a rule, less favorable conditions than nonindustrial buildings.

There are enterprises with special production conditions: with increased humidity, highly significant heat generation (hot shops), with aggressive environment of the production facility, and so on. Thus, in the textile industry in heated buildings for normal occurrence of the production process increased humidity is required, and in such production facilities as the meat combines, the leather plants, and so on, increased humidity is the result of the production process; in many shops of the metallurgical plants (steelmaking, rolling, casting, and so on) the production process is accompanied by the release of a large quantity of heat (to 630-840 and in individual cases, to 1,260-2,100 kilojoules, and so on).

The production buildings of the industrial enterprises are classified by their specific attributes which provide for the purpose and the belonging of these buildings to one branch (subbranch) of industry or another (which is determined by the production process), the number of floors, the number of bays, the degree of fireproofness and service life, the nature of the coverage, the method of arranging internal supports, the water drainage system and form of intrashop transportation.

Depending on the purpose, the enterprise buildings are divided into production buildings in which the basic, service and certain other enterprises or shops are located and auxiliary, in which the cultural-general services, administrative-office facilities, dining rooms, laboratories, and so on are located.

The production buildings can be one-story and multistory, single-bay and multibay, with internal or external water drainage, and they can also be or not be equipped with materials-handling equipment.

The buildings and structures are divided into five groups with respect to degree of fireproofness. Their fireproofness is defined by SNiP II-A.5-70 ("Fireproofing Norms for the Design of Buildings and Structures," Table 2).

With respect to the functional attribute, considering the national economic significance, the production buildings are divided into four classes. Here the degree of fireproofness of the buildings is taken as follows: for class I buildings, no less than fireproofness II; for class II, no less than fireproofness III; for class III and IV buildings, the fireproofness has not been standarddized.

The service life of the structural elements of the production buildings must be as follows:

for class I buildings, no less than I degree (no less than 100 years);

for class II buildings, no less than II degree (no less than 50 years);

for class III buildings, no less than III degree (no less than 20 years);

for class IV buildings, the service life of the structures has not been standardized.

Depending on the nature of the coverage of the territory of an industrial enterprise, the production buildings can be with continuous and pavilion-type coverage.

The production buildings with continuous coverage are distinguished by significant dimensions. They are designed either without skylights with artificial ventilation and luminescent lighting or with light and ventilation windows and skylights (see Figure 75 and Figure 97a).

Pavilion-type coverage (Figure 97d) is usually used at enterprises of the chemical and metallurgical industry for storage and other buildings; a limited number of bays or one bay is provided here in order to ensure natural illumination and ventilation through the side openings and skylights.

With respect to the arrangement of the internal supports the production buildings are divided into bay-, cell- and hall-type buildings. In the bay-type buildings (Figure 97a) the bay size predominates over the column spacing. The cell-type buildings (Figure 97b) are buildings usually with a column network that is square or close to it. The hall-type buildings (Figure 97c) are built if it is necessary to have significant production areas without internal supports.

On the premises of an industrial site, in addition to the production buildings provision is also made for other structures, depending on the production processes. These structures, in accordance with their purpose, can be provisionally combined into groups: the first group includes the service line structures (canals, tunnels, the supports for the overhead electric power lines, and so on);

the second group includes transport structures (conveyor galleries, trestles, and so on); the third group includes tank-type structures (silos, gas-holders, cooling towers, water towers, tanks, and so on) (Figure 98a-c).

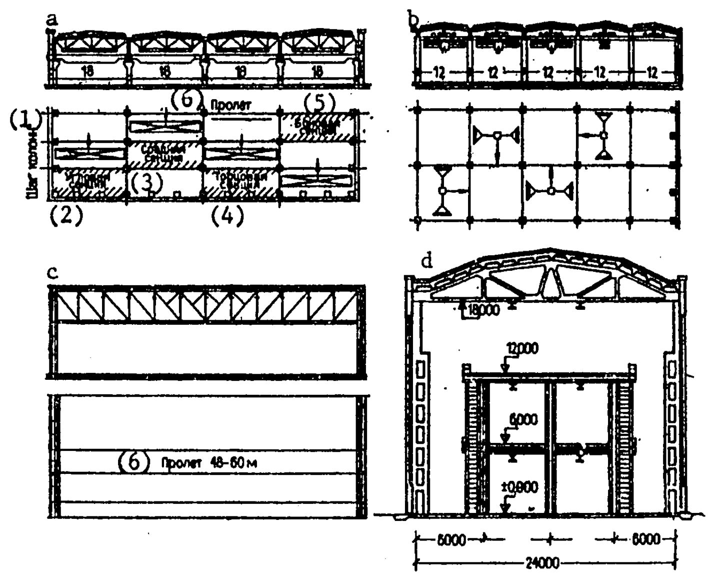


Figure 97. Diagrams of the space-floor plan and structural solutions of one-story production buildings. a-c--Continuous coverage; a--bay-type; b--cell-type; c--hall-type; d--pavilion coverage.

Key:
1. Column spacing
2. Corner section
3. Midsection
4. End section
5. Side section
6. Longitudinal span

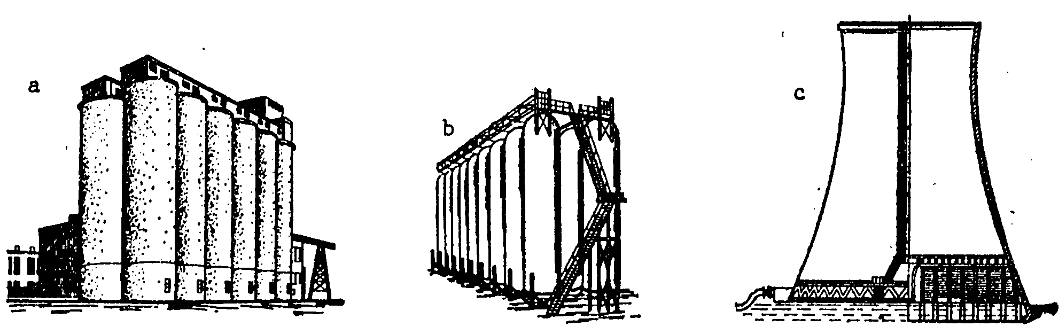


Figure 98. Tank-type structures. a--Silos; b--vertical gas-holders; c--drop cooling tower.

Section 38. Flow Diagram for the Production Process

When designing an industrial enterprise it is necessary to solve a number of the interrelated economic, organizational and technical problems:

economic problems--establishment of the production program of the enterprise, the product nomenclature, the number of products, weight, cost of one product and the total number with respect to the program, and so on;

organizational problems--the development of the administrative structure of the plant, its subdivisions (shops, sections); the distribution of functions and establishment of the mutual relations between the subdivisions and the duty personnel, and so on;

technical problems--the design of the production process for processing the raw material and intermediate products; determination of the required work time reserve and manpower; the selection and calculation of the amount of basic production and auxiliary equipment; determination of the required amount of raw material, materials and fuel and also the required amount and methods of equipping the enterprise with energy of all types, and so on.

The modern industrial enterprise and its production buildings and structures must be designed considering the requirements of the most advanced production process and the prospects for its development. The content of the production process of an industrial enterprise is closely connected with the concept of the so-called master production-process working flow diagram which is used as the basis for the solution of the master plan of the enterprise, at the same time as the partial working flow diagram is the base for each specific production building.

Developing one design or another for a production building, it is necessary first of all to study the production process flow diagram which is a graphical representation of the mutual functional relations between the production processes taking place at the industrial enterprise and in its shops.

Figure 99 shows a version of the graphical representation of the production process flow diagram of a machinebuilding plant.

Depending on the shop composition, enterprises are distinguished with complete and incomplete production cycle. The plants with complete production cycle have an entire set of basic, auxiliary and service shops--the universal plants--and plants with an incomplete cycle--these are the specialized enterprises which are distinguished with respect to type and degree of specialization.

When designing the machinebuilding plants special attention must be given to the problems of specialization of production and broad cooperation of the enterprises.

The structure of the production process and forms of its organization arise from a number of factors: for example, such as the variety of products produced at the plant, the degree of stability of their nomenclature, the volume of production output and the nature of the technology.

On the basis of the structural layouts of the production process it is possible to establish a clear-cut classification of types of machinebuilding production facilities and the enterprises themselves considering production specialization.

Depending on the level of specialization of the plant, the nomenclature of the products simultaneously in operation, unit, series and mass production are distinguished.

The production cycle of an industrial enterprise includes an entire series of transport operations connected with movement of the machined materials and production waste.

When developing the transport system for the designed industrial buildings and the entire enterprise an important factor is the load intensity of the flows.

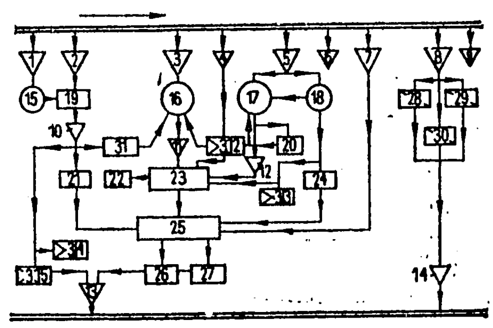


Figure 99. Procedure for graphical representation of the production process flow diagram of a machinebuilding plant. Storage area: 1--large wood materials; 2--lumber; 3--charge and molding materials; 4--tool steel; 5--metals; 6--chemical materials; 7--intermediate products and other materials; 8--fuel; 9--combustibles; 10--dry lumber; 11--castings; 12--forgings; 13--finished products and dispatch room; 14--waste pile. Billeting shops: 15--lumber; 16--castings; 17--forgings; 18--iron billeting. Processing shops: 19--lumber drying; 20--primary thermal; 21--woodworking; 22--secondary thermal; 23--mechanical; 24--boiler-welding and cold stamping; 25--assembly; 26--painting; 27--testing. Service facilities: 28--heat and electric power plant; 29--gas generator station; 30--central boilerroom. Other shops: 31--pattern; 32--tool; 33--mechanical repair; 34--construction repair; 35--packaging.

In order to ensure an economically expedient production process it is necessary to exclude the possibility of spatial intersection of the flows of materials and to provide the shortest length of these flows. During the design process it is necessary to compare the technical and the technical-economic indices of the versions of the production process flow diagrams. For each shop (just as for the entire plant) first efficient production flows are developed, and then the overall dimensions and location of the machine tools, machines and other production equipment are preliminarily determined.

Uninterrupted operation of any industrial enterprise is unthinkable without providing convenient approaches for the workers to their shops and rhythmic delivery of goods to the production sections on its premises; in particular, it is impossible to permit intersections of people and materials flows on the same level (in the case of mass movements), counter and return directions of movement of these flows.

The freight intensity of the flows is an important factor which must be considered when developing the transport system for the designed industrial buildings and the entire enterprise.

Section 39. Materials-Handling Equipment

During the development of the design for a production building, an economical solution to the entry shop transportation and expedient selection of the type of materials-handling equipment acquire important significance. This choice is conditioned by the production processes and means of mechanizing the designed enterprise, and it depends on the quantity and type of hauled goods, the nature of the performed materials-handling operations and the machinery used for loading, unloading and moving materials.

In production buildings for moving materials weighing up to 5 tons inclusively it is not necessary to use supported bridge cranes; in this case it is recommended that overhead materials-handling equipment be used in the form of various conveyors or overhead cranes (overhead beam hoists, monorails; Figure 100a); where it is expedient it is necessary to use pneumatic and hydraulic transportation. The application of bridge cranes to move materials (Figure 100b, c) is permitted only in a specific branch of industry (for example, in metallurgy or heavy machinebuilding) with the corresponding loads and operating conditions.

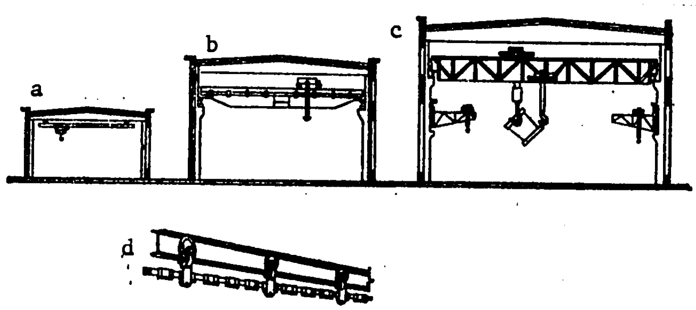


Figure 100. Materials-handling equipment of production buildings. a--Overhead beam crane; b--supported bridge crane; c--jib crane; d--suspended chain conveyor.

Electric bridge cranes are mechanisms designed for intrashop movement of goods in three mutually perpendicular directions. With respect to structural design they are divided into general-purpose cranes (used for many branches of industry) and special-purpose cranes (used primarily in metallurgy).

The general-purpose cranes include the electric supported bridge cranes which consist of a welded bridge, the crane with the displacement machinery and dollies with the mechanism for lifting and moving (see Figure 100b, c).

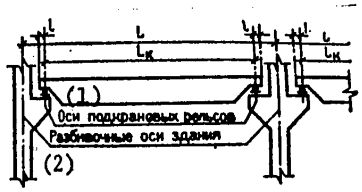


Figure 101. Interrelation between the spans of buildings L and the spans of supported cranes L_K.

Key: 1. Center lines of the crane rails
2. Center lines of the building layout

Depending on the operating conditions, they are divided into five groups: cranes with light, medium, heavy and very heavy operating conditions and continuous-action cranes with very heavy operating conditions.

The relation between the span of the bridge cranes (the distance between vertical center lines of the crane rails L_K) and the building span L. (Table 13 and Figure 101) is established according to GOST 534-69.

Table 13. Spans of Bridge Cranes

Bridge Crane Spans L_K, m	Building Spans L, m				
	12	18	24	30	36
Cranes with light operating conditions					
In the absence of passages along the crane tracks	10.5	16.5	22.5	28.5	34.5
In the presence of passages along the crane tracks	10.0	16.0	22.0	28.0	34.0
Cranes with medium operating conditions	10.0	16.0	22.0	28.0	34.0
Cranes with heavy operating conditions	10.0	15.5	21.5	27.5	33.5

The load capacity of cranes, their overall dimensions and basic parameters are determined by the state standards for cranes.

With respect to load capacity or distance ℓ (see Figure 101) the bridge cranes are divided into groups (Table 14).

It is necessary to consider that the application of bridge cranes increases the weight of the bearing structure significantly and also forces an increase in the height of the building which is undesirable.

The special-purpose cranes include charging cranes, hot-metal cranes, extractive cranes, fitting cranes, and so on. They are primarily used in metallurgy.

Depending on the type of transported material, the cranes are equipped with various types of load grappling devices: hooks, electric magnets, clamshells, and so on.

Table 14. Groups of Bridge Cranes by Load Capacity and Spacing

Indices	Group of Cranes 1	2	3
Load capacity, tons	≤50	80-125	>125
ℓ, mm, for			
General-purpose cranes	≤300	300-400	>400
Special or metallurgical cranes	≤300	300-400	>400

At the metallurgical plants for transportation of ingots, loading and unloading the metal charge, and so on, magnetic cranes with an electromagnet suspended from the load hook are used.

In the charging yards of steelmaking shops for loading ore, lime and other bulk and piece materials and also in the compacting shops for loading chips, clamshell cranes are used.

In modern one-story and on the upper story of multistory production buildings overhead cranes (overhead beam cranes) with up to 5 tons capacity are more and more frequently used. The basic parameters and the diagrams of the overhead cranes are shown in Figure 102. The distances from the ends of these cranes to the central lines of the building established considering the overall dimensions of the columns and the structures under the rafters are presented in Table 15.

Such cranes move along the lower flange of the guiding I-beams of the crane tracks attached to the bottom chord of the bearing structure of the roof (Figure 103).

The overhead cranes (overhead beam cranes) have a great advantage over the supported electric cranes as a result of their increased flexibility or universality. Here, it is possible to change the direction of motion of the overhead cranes from longitudinal to transverse, which is important when modifying the production process.

If the materials-handling machinery services only a narrow operating strip of the shop, it is expedient to use a monorail which is in the form of a I-beam attached to the bottom chord of the bearing structure of the roof (beam, truss) instead of the overhead cranes.

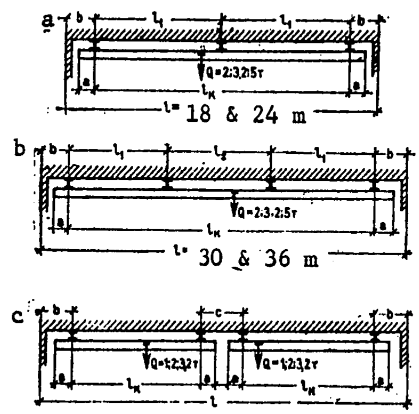


Figure 102. Basic parameters and layout diagrams for overhead cranes (a-c).

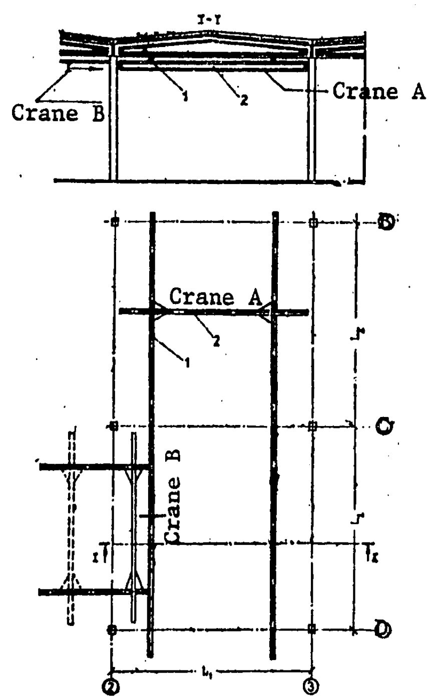


Figure 103. Operating diagram of an overhead crane A along the bay and crane B across the bay. 1--Guide beam; 2--overhead crane.

In buildings not having bridge cranes, the frame is simplified; as a result of removing the crane load the column cross section and foundation dimensions are decreased, and the nomenclature of types of bearing structures is reduced. The application of crane beams laid on the column brackets is excluded.

Table 15. Distances From the Ends of the Cranes to the Layout Center Lines of the Building (see Figure 102)

Building Span ℓ, м	Load Capacity Q, t	$l_к$, м	a, м	b, м	l_1, м	l_2, м	c, м
12	1; 2; 3,2; 5	9	1,2; 0,9; 0,6	1,5	—	—	—
18	2; 3,2; 5	15	0,9; 0,6	1,5	7,5	—	2,6
24	2; 3,2; 5	21	0,9; 0,6	1,5	10,5	—	2,6
30	2; 3,2; 5	27	0,9; 0,6	1,5	9	9	2,6
36	2; 3,2; 5	33	0,9; 0,6	1,5	10,5	12	3

Section 40. Characteristic Features of the Standardization and Unitization of Industrial Buildings

The successful implementation of the grand program for industrial construction planned by the 25th CPSU Congress can be provided for only by the introduction of new advanced space-floor plan solutions for production buildings and plant-manufactured structural elements into production, further industrialization of construction, reduction of the material consumption and also improvement of the operating characteristics of the production buildings and structures.

The solution of these problems is also promoted by further development of the standard design. The standardization of certain solutions is continuously connected with unitization. Standardized dimensioned layouts of one-story and multistory buildings were used for the first time in design practice, and then unitized standard sections (UTS) and bays (UTP) were developed.

Already in the middle of the 1960's standardized dimensioned layouts were developed for many branches of industry, which were layouts of standard space-floor plan solutions of production buildings (Figure 104a-c).

When using dimensioned layouts and UTS, the dimensions of the shops with respect to height are designated as a function of the size of the equipment and nature of the production process (Table 16), and the following notation is adopted: the height from floor level to the bottom of the bearing structures of the roof H; the height from floor level to the head of the crane rail h_K; the same to the top of the column bracket h and from the top of the bracket to the top of the column h_0.

The dimensioned layouts contain data on the planning, the column spacing, spans, height and number of stories of the buildings, crane loads, and so on.

Recently significant work has been done on the unitization of production buildings in the direction of ensuring complete unity of the structural solutions for different production processes. The coworkers of the TsNIIpromzdaniy have made a big contribution to the development of unitization. According to their concept, the main goal of unitization in industrial construction is the creation of a space-floor plan structure of buildings which will provide for the possibility and profitableness of plant production of structural elements and products for them and also the possibility of the application of industrial methods of erecting monolithic reinforced-concrete structural elements of buildings. They consider that the principal features of the unitization method in industrial construction as the most important basis for standardization are the following:

establishment of a limited number of construction parameters and their combinations in the form of dimensioned layouts for the basic types of mass-construction buildings;

the development of universal space-floor plan solutions satisfying the production requirements of individual groups of uniform production facilities and ensuring variety of architectural-layout solutions to the buildings;

the selection of efficient and economical structural layouts and solutions (types of frames, elements, and so on) permitting limitation to the least number of structural elements;

ensurance of conditions for mutual combination of space-floor planning and structural elements of buildings with the least number of standard products.

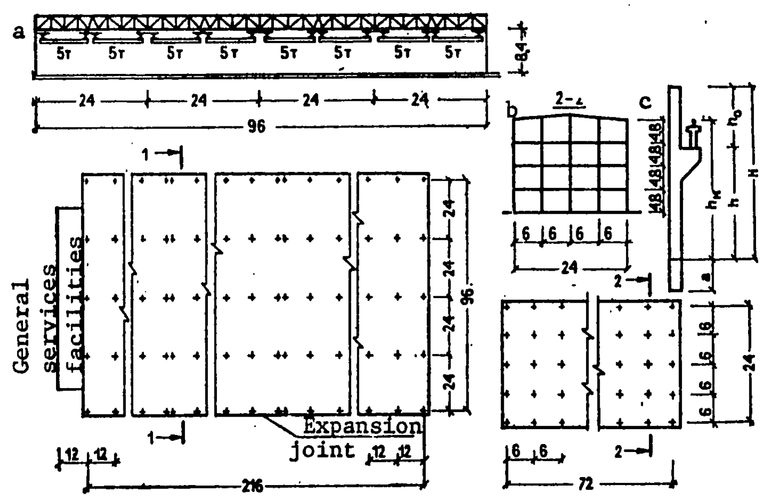


Figure 104. Dimensioned layouts of an industrial building. a--One-story; b--multistory; c--column dimensions.

As has already been stated above, unitization in industrial construction is based on the Integrated System of Modular Coordination of Dimensions in Construction (YeSMK).

A study is made below of the materials on unitization of one-story and multistory production buildings.

Table 16. Examples of Unitized Column Heights of Buildings Equipped With Bridge Cranes (see Figure 104c)

Dimensionality	Column Spacing, m	Column Height, m				
H, м		8,4	9,6	10,8	12,6	14,4
$h_к$		6,15	6,95	8,15	9,65	11,45
h, м	6	5,2	5,8	7	8,5	10,3
	12	4,6	5,4	6,6	8,1	9,9
$h_в$, м	6	3,2	3,8	3,8	4,1	4,1
	12	3,8	4,2	4,2	4,5	4,5

One-Story Industrial Buildings. In the majority of cases such buildings are laid out from parallel bays of identical width, height and identical materials-handling equipment. These spatial elements having united structural parameters and structural solution have come to be called the "unitized standard sections" (UTS) for interbranch application. They permit designs of production buildings of the required dimensions to be created (Figure 105a-c).

As experience has demonstrated, the dimensions of the sections in plan, that is, the number of transverse and longitudinal spans are established when designing the buildings based on the given capacity of the enterprise.

As a result of the analysis of specific designs of industrial buildings of a number of branches of industry the designers have defined the optimal dimensions of the sections from which it is possible to lay out production buildings of the required length and width. Thus, for the machinebuilding enterprises, in addition to the casting, pressing and forging facilities, the following types of basic sections of the buildings are recommended (see Figure 105):

dimensions in plan 144 x 72 and 72 x 72 m with column grid of 24 x 12 and 18 x 12 m;

height of craneless bays and with overhead transportation with a capacity to 5 tons, 6 and 7.2 m inclusively;

height of bays with bridge cranes with a capacity to 30 tons, 10.8 and 12.6 m inclusively.

In addition, sections are provided for the transverse spans: with a load capacity of the bridge cranes to 30 tons inclusively the dimensions of the sections in plan are 24 x 72 m and (24 + 24) x 72 m (with a height of 10.8 and 12.6 m); with a load capacity of the bridge cranes to 50 tons inclusively, the size of the sections in plan 30 x 72 m (with a height of 16.2 and 18 m).

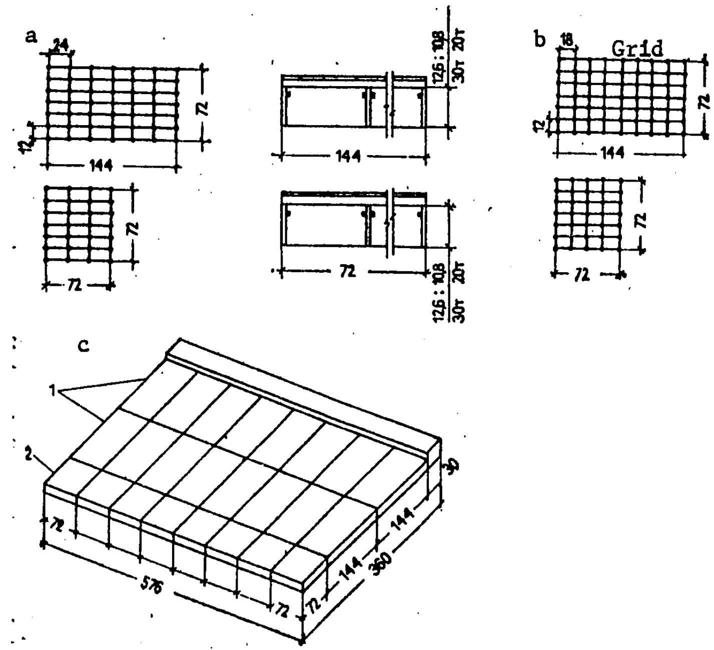


Figure 105. Examples of dimensioned layouts of unitized standard sections of one-story production buildings. a--With column grid of 24 x 12 m; b--with column grid of 18 x 12 m; c--versions of the layout of buildings from standard sections of modules: 1--basic sections; 2--auxiliary sections.

For one-story buildings of casting, pressing and forging production facilities, unitized standard sections are recommended with dimensions in plan of 144 x 72 and 72 x 72 m with column grid of 24 x 12 m.

The nomenclature of the sections for the enterprises of the chemical industry by comparison with the nomenclature of the sections for the enterprises of machine-building is significantly broader, which is caused by great variety of the production processes. The UTS nomenclature for chemical enterprises will contain 48 types of sizes of different width and height of the buildings have two lengths--60 and 72 m. This framing permits layout of the buildings with quite varied space-floor plan solutions.

The use of the UTS for laying out buildings offers the possibility of best consideration of the actual construction conditions, the use of the shop blocking procedure in a single building and also realization of the advantages of unitization when designing industrial enterprises.

The values of the basic space-floor plan parameters of the buildings, longitudinal and transverse spans and height, are designated according to the "Basic

Principles of Unitization of the Space-Floor Plan and Structural Solutions of Industrial Buildings" and on the basis of generalization of modern experience.

During the design process, the bay width (in m) of one-story buildings must in the majority of cases be designated as a multiple of the consolidated modulus 6M and, as a rule, taken equal to the following: in the absence of bridge cranes 12, 18, 24, 30 and 36; in the presence of supported electric bridge cranes 18, 24, 30 and 36.

The bay width by the process requirements can be taken as more than 36 m and be a multiple of 6 m. With manual bridge cranes the bay width is designated as equal to 9, 12, 18 m.

The column spacings are taken as multiples of 60M (6 m), and during the design process they are designated as a result of the technical-economic calculations.

The spacing of the edge columns is taken in the majority of cases equal to the spacing of the rafter elements (6 or 12 m). It is recommended that the spacing of the middle columns of multibay buildings with 12-m spans and height to 9.6 m be taken as 6 m, and for spans from 18 to 36 m, 6 or 12 m with height to 10.8 m inclusively and 12 m for height from 12 to 18 m. It is possible to use spacings of more than 12 m when this is dictated by necessity and it is technologically and economically justifiable.

In one-story frame buildings the height (from the finished floor level to the bottom of the bearing structures on the support) must be designated as a multiple of the consolidated moduli: 6M with height to 6 m; 12M with height from 6 to 18 m (Table 17). A height of more than 18 m must be a multiple of the modulus 1.2 m or the large dimension, a multiple of 0.6 m.

In Table 18 the unitized structural parameters of single-story frame production buildings are presented.

In the majority of cases buildings with manual bridge cranes are made single-bay.

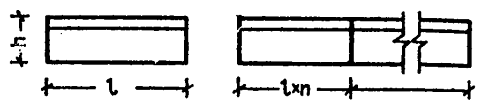
Multistory Industrial Buildings. On the basis of the unitization, the multistory industrial buildings of interbranch application with beam structural elements are divided into two groups depending on the normative loads and the column grid:

1) buildings with normative loads to 1,000 kg/m^2 and column grids of 6 x 6; 9 x 6 and (6 + 3 + 6) x 6; (9 + 3 + 9) x 6 and 12 x 6 m;

2) buildings with normative loads to 2,500 kg/m^2 and column grids of 6 x 6 and 9 x 6 m.

When designing multistory buildings the bay width must be designated as a multiple of the consolidated moduli: 30M in the range from 6 to 12 m and then every 60M; it is permissible to use a bay spacer 3 m wide.

Table 17. Recommended (+) or Unrecommended (-) Combinations of Unitized Structural Parameters of Craneless One-Bay and Multibay One-Story Frame Buildings



Height to Bottom of Overhead Structures on Support, m	Bay Width, m						
	6	9	12	18	24	30	36
3	+	+	+	-	-	-	-
3,6	+	+	+	-	-	-	-
4,2	+	+	+	-	-	-	-
4,8	+	+	+	+	+	-	-
5,4	+	+	+	-	-	-	-
6	+	+	+	+	+	+	-
7,2	-	-	+	+	+	+	+
8,4	-	-	+	+	+	+	+
9,6	-	-	+	+	+	+	+
10,8	-	-	-	+	+	+	+
12	-	-	-	+	+	+	+
13,2	-	-	-	-	+	+	+
14,4	-	-	-	-	+	+	+
15,6	-	-	-	-	-	+	+
16,8	-	-	-	-	-	+	+
18	-	-	-	-	-	+	+

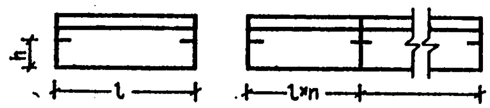
The column spacings must be designated as multiples of the consolidated moduli: 6M for height to 4.8 m and 12M for heights of more than 4.8 m. The story height of auxiliary buildings is taken as 3.3 m, but it is admissible to take at a multiple of 0.6 m with blocking of them with multistory production buildings.

The space-floor planning structure of multistory frame production buildings is analogous to the structure of one-story buildings which is achieved by blocking the unitized standard sections (UTS). The standard construction parameters of the dimensioned layouts of multistory industrial buildings presented in Table 19 give the number of adopted bays, their dimensions, the number of stories, and they characterize the adopted materials-handling equipment.

Using the UTS in the design process, it is necessary to keep in mind that they do not in all cases correspond to the requirements of the production process; therefore in practice it is permissible to develop building designs by standard sections with variation of the number of bays of the UTS and their length by an amount that is a multiple of the spacing of the middle rows of columns for multibay buildings and a spacing of 6 m for single-bay buildings. It is also permissible to vary the height of the buildings, being guided by the unitized dimensioned layouts.

At the present time when designing production buildings in certain cases use is made of the possibility of increasing the sizes of the modules (by comparison with the recommendations in the UTS) in order to decrease the number of expansion joints.

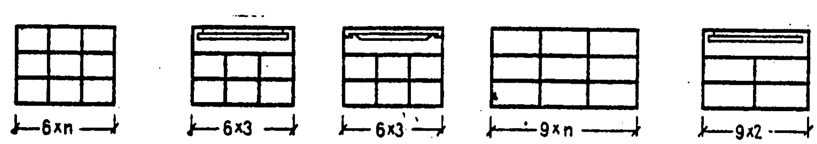
Table 18. Unitized Construction Parameters of Single-Span and Multispan One-Story Frame Buildings Equipped With Manual Bridge Cranes With a Capacity to 20 Tons and Electric Bridge Cranes With a Capacity to 50 Tons Inclusively



Height to Bottom of Overhead Structures on Support, m	Crane Equipment With Capacities, tons, in Bays of Width, m						
	9-p	12-p	18-p	18	24	30	36
6	3,2—5,8	3,2—5,8	5—8	—	—	—	—
6,6	3,2—5,8	3,2—5,8	5—8	—	—	—	—
7,2	3,2—5,8	3,2—5,8 12,5—20	5—8 12,5—20				
7,8	3,2—5,8	3,2—5,8 12,5—20	5—8 12,5—20	—	—	—	—
8,4	3,2—5,8	3,2—5,8 12,5—20	5—8 12,5—20	— 10	— 10	— —	— —
9	—	12,5—20	12,5—20	—	—	—	—
9,6	—	12,5—20	12,5—20	10—20	10—20	—	—
10,8	—	—	—	10—20	10—20	10—20	10—20
12	—	—	—	10—20 30	10—20 30—50	10—20 30—50	10—20 30—50
13,2	—	—	—	10—20 30	10—20 30—50	10—20 30—50	10—20 30—50
14,4	—	—	—	10—20 30	10—20 30—50	20 30—50	20 30—50
15,6	—	—	—	—	30—50	30—50	30—50
16,8	—	—	—	—	30—50	30—50	30—50
18	—	—	—	—	30—50	30—50	30—50

Notes: 1. When using electric bridge cranes with a capacity of 5 tons it is recommended that columns be used which are designed for 10-ton cranes.
2. 9-p, 12-p, 18-p are manual bridge cranes.

Table 19. Unitized Construction Parameters of Multistory Frame Buildings With Temporary Normative Loads on Beam Floors: 1,000-2,500 kg/m^2 for 6-m Spans; 1,000-2,000 kg/m^2 With 9-m Spans



Number of Floors	Story Height, m				
	6×n	6×3	6×3	9×n	9×2
2	3,6 — 4,8 6 6—4,8	—	—	3,6 4,8 6 6—4,8	—

Table 19 (continued)

Number of Floors	Story Height, m				
3	3,6	4,8—4,8—7,2	4,8—4,8—10,8	3,6 —	4,8—4,8—7,2 —
	4,8	6—6—7,2	6—6—10,8	4,8	6—6—7,2
	6	—	—	6	—
	6—4,5	—	—	6—4,8	—
	7,2—6	—	—	7,2—6	—
4	3,6 —	4,8—4,8—7,2	4,8—4,8—10,8	3,6 —	4,8—4,8—7,2 —
	4,8	6—6—7,2	6—6—10,8	4,8	6—6—7,2
	6	—	—	6	—
	6—4,8	—	—	6—4,8	—
	7,2—6	—	—	7,2—6	—
5	3,6	4,8—4,8—7,2	4,8—4,8—10,8	3,6	4,8—4,8—7,2
	4,8	6—6—7,2	6—6—10,8	4,8	—
	6	—	—	6	—
	6—4,8	—	—	6—4,8	—
	7,2—6*	—	—	—	—
6	3,6* 4,8* 6* 6—4,8*	—	—	—	—

* The indicated height for two-bay buildings is not provided.

Notes: 1. One number provisionally denotes the height of all stories, two numbers, the height of the first story and the upper stories, a third number, the height of the first, middle and upper stories, respectively. 2. In buildings with identical bays the number of such bays must be no less than two. 3. The load capacity of the cranes: overhead 2, 3.2 and 5 tons; bridge 5 and 8 tons for light and medium operating conditions and 12.5 tons for heavy operating conditions. 4. The height of 3.3 m is provided only for administrative and general services buildings.

§41. Basic Rules for Tie-in Columns and Walls to the Center Lines

As has been pointed out, by tie-in we mean the distance from the modular center lines (longitudinal, transverse) to the face or geometric axis of a structural element.

The tie-in of a bearing frame to the center lines of a production building has decisive significance for reducing the number of standard sizes of prefabricated bearing and enclosing structures. In order to insure unitization and mutual replaceability of the structural elements the frame is arranged relative to the center line with observation of defined tie-in rules.

When designing one-story production buildings, various tie-ins of columns, outside longitudinal and end walls (Figure 106, a), the columns at the points of construction of transverse and longitudinal expansion of joints (Figure 106, b) and at the points of the height drops between the bays of one or mutually perpendicular directions (Figure 106, c) are adopted.

As is obvious from the successively depicted schematic drawings (Figure 106, a-c), the following regulations have been adopted for tie-in to the longitudinal modular center lines:

The outer faces of the edge columns and the inner surfaces of the walls are matched with the longitudinal center line ("zero tie-in") in buildings without bridge cranes and in buildings equipped with bridge cranes with a capacity to 30 tons inclusively, with column spacing of 6 meters and height from floor to the bottom of the bearing structures of the overhead of less than 16.2 meters;

The outer faces of the edge columns and the inner surfaces of the walls are shifted from the longitudinal center lines by 250 mm in buildings equipped with bridge cranes with a capacity to 50 tons inclusively, with a column spacing of 6 meters and height from floor to the bottom of the bearing structures of the overhead of 16.2 and 18 meters and also with column spacing of 12 meters and height from 8.4 to 18 meters; with the corresponding substantiation it is permissible to shift the outer faces of the columns and the inside surfaces of the walls 500 mm from the longitudinal center lines;

The columns of the middle rows, with the exception of the columns adjacent to the longitudinal expansion joint and columns installed at the points of the height drops of the bays of one direction must be located so that the center lines of the cross sections of the part of the columns of the crane coincide with the longitudinal and transverse layout center lines.

The longitudinal expansion joints in buildings with reinforced concrete framing must be realized on two columns with a spacer; in this case the column spacing must be equal to the column spacing along the middle rows. The expansion joints and buildings with all-metal and mixed frames (reinforced concrete columns and steel girders) must, as a rule, be located on one column.

The columns adjacent to the longitudinal expansion joint and the columns installed at the point of the height drop of the bays of one direction must be tied-in to the longitudinal layout center lines, in accordance with the following regulations:

When the column spacing in the middle rows is equal to the column spacing of the edge rows (6 or 12 meters), that is, with an overhead without structural elements under the rafters, the columns are tied-in to the longitudinal layout center line in accordance with the rules established for the columns of the edge rows;

For column spacing of the middle rows of 12 meters and spacing of the edge columns of 6 meters, that is, with an overhead with structural elements under the rafters, the columns must be installed so that the spacing between the longitudinal layout center lines and the faces of the columns turned in the direction of the expansion joint will be 250 mm.

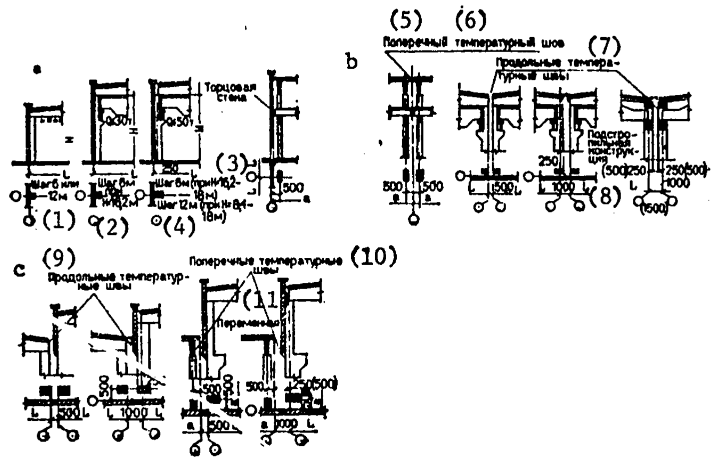


Figure 106. Tie-ins adopted in one-story frame buildings for modular longitudinal and transverse layout center lines.
a -- columns and walls; b -- columns at the locations of the expansion joints; c -- columns at the locations of the height drops

Key:

1. Spacing 6 or 12 meters
2. Spacing 6 meters for H<16.2 m
3. Spacing 6 m (for H=16.2 to 18 m)
4. Spacing 12 m (for H=8.4 to 18 m)
5. End wall
6. Transverse expansion joint
7. Longitudinal expansion joints
8. Under-rafter structural element
9. Longitudinal expansion joints
10. Transverse expansion joints
11. Variable

The tie-in of the columns and end walls to the transverse layout center lines must be made by the following rules:

The geometric axes of the column cross section, with the exception of columns at the ends of the building and adjacent to the expansion joints must be matched with the transverse layout center line;

The geometric axes of the end columns of the main frame must be shifted from the transverse layout center lines in the building 500 mm; the inside surfaces of the end walls must coincide with the transverse layout center lines ("zero tie-in," see Figure 106, a).

The transverse expansion joints must be located on the paired columns. Here the axis of the expansion joint is matched with the transverse layout center line, and the geometric axes of the paired columns are shifted from the layout center lines by amounts equal to the tie-in of the end columns of the main frame.

It is recommended that the height drop between the spans of one direction in a building with reinforced concrete framing be realized on two columns with a spacer. The size of the spacer, depending on the size of the tie-ins of the columns, is taken equal to 500, 1000 and 1500 mm (see Figure 106, c).

The height drops between spans of one direction in buildings with all-metal frame, as a rule, must be solved on one column.

The abutment structure of two mutually perpendicular spans must be realized on two columns with a spacer. Here the axis of the columns of the longitudinal spans adjacent to the transverse span is shifted 500 mm from the transverse layout center line. The size of the spacer, depending on the magnitude of the column tie-ins must be taken equal to 500 or 1000 mm (see Figure 106, c).

The tie-in of the supporting outside walls made of large blocks and also brick to the longitudinal layout center lines must be made observing the following rules (Figure 107):

When supporting the overhead slabs directly on the walls, it is necessary to move the inside surface of the wall 150 mm away from the longitudinal layout center line into the building for walls made of large blocks and 130 mm for brick walls;

In the case of resting the bearing structures of the overhead on the walls with a thickness of a large block wall of 400 mm or more and a brick wall thickness of 380 mm or more, the inside surface of the walls must be 300 and 250 mm from the longitudinal layout center line into the building, respectively.

For brick walls 380 mm thick with 130 mm pilasters, the distance from the longitudinal axis to the inside surface of the wall must be equal to 130 mm; for brick walls of any thickness with pilasters of more than 130 mm the inside surface of the walls must coincide with the longitudinal layout center line -- "zero tie-in."

The tie-in of the bearing end wall in the case of resting on the overhead slabs must be taken the same as for the bearing longitudinal wall with the overhead slabs resting on it.

The geometric axes of the inside bearing walls must coincide with the layout center lines.

The tie-in to the longitudinal layout center lines of the outer face of the columns of multistory production buildings is taken as "zero" if the collar beam covers the column or if this is expedient by the conditions of laying the slabs (Figure 108, a).

The tie-in is taken equal to half the thickness of the inside columns if the collar beams rest on the column brackets or if the floor slabs rest on the collar beam brackets (Figure 108, b).

The adopted tie-in system makes it possible to realize interchangeability of the space-floor plan and structural solutions of both the buildings as a whole and their structural assemblies and parts during the design phase.

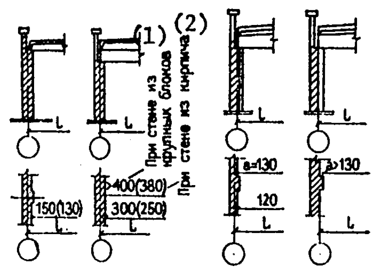


Figure 107. Tie-in of the outside bearing walls made of large blocks and brick to the longitudinal modular center lines of buildings

Key:

1. For a wall made of large blocks
2. For a wall made of brick

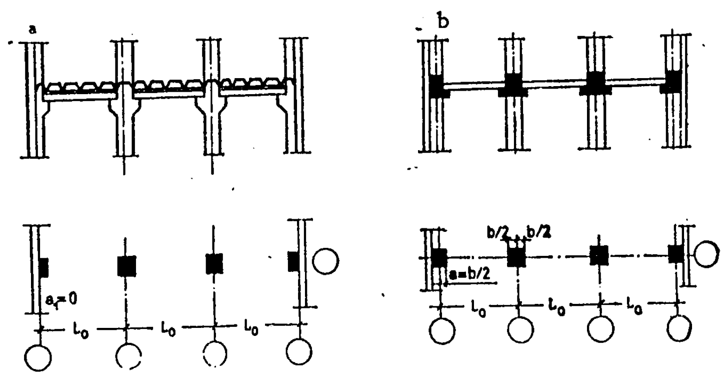


Figure 108. Examples of column and wall tie-ins of multistory buildings.
a -- zero; b -- equal to half the thickness of the inside column

§42. Economics of Industrial Building Design

The problems of the economics of designing industrial enterprises are solved in the pre-design period that is, in the phase of technical-economic substantiation of the construction of the enterprises and the development of the district planning layouts and designs.

The degree of efficiency and advanced nature of the production process has a significant influence on the economic indices, that is, how efficiently it is solved determines the construction and maintenance expenditures on the building. The optimal consolidation of shops and sections offers the possibility of lowering the specific capital investments and operating costs on the building per unit of measure of the production output. The efficient placement of equipment provided for in the production process layout permits the areas and volume of the building to be decreased which also leads to a decrease in the specific expenditures.

In addition, the economics of the design of production buildings are influenced by a number of other factors connected with the space-floor planning and structural solutions which make up the basis for the architectural-construction design of production buildings.

If in the design process the question arises of whether it is more advantageous to block the buildings or have them separately standing, it is necessary to compare the construction and maintenance costs for these versions, and only then, make the final decision. In the majority of cases blocking gives a significant cost benefit (see §32).

It is expedient to locate the block buildings on sites not having sharply expressed slope. It is desirable that the slope not exceed 1%, for with large slope and significant dimensions of the blocked building, a significant drop in the surface levels of the ground occurs. This increases the work involved in vertical grading, it requires large amount of foundation and column height which unquestionably is reflected in the cost of the building.

It is necessary to emphasize that decreasing the size of the territory allotted for construction of the enterprise also has great economic significance. Accordingly, it is necessary to strive to use types of intraplant transportation for which additional territory is not required (overhead cable tramways, pneumatic transportation, and so on).

In addition to what has been discussed above, the column network has significant influence on the cost of production buildings. Economic calculations [12] demonstrate that in one-story buildings with reinforced concrete structural elements with identical span but different column spacing the cost of 1 m^2 of covered area with column spacing of 12 meters is on the average 5-8% higher than with a column span of 6 meters.

The column grid also influences the other technical-economic indices: the concrete and steel consumption, the number of prefabricated elements, the expenditures of labor during installation, the usable area, the operating expenses with respect to heating the building, and so on.

The application of an enlarged column grid leads to an increase in cross sections and weight of the structural elements. This gives rise to the requirement for more powerful transport means and erection cranes which increases the erection cost. However, the reduction in expenditures during erection in connection with the significant decrease in the number of prefabricated elements turns out to be more significant than the increase in the cost of the operation as a result of using more powerful erection and transport machines. Thus, the application of an enlarged column grid has a positive influence on reducing the erection cost.

With enlargement of the structural grid, the usable area increases to 10% as a result of reducing the number of columns.

The space-floor plan solutions of production buildings are estimated on the basis of analyzing the technical-economic indices of the investigated solution and by comparing it with the most economical standard solutions of the given branch of industry.

The analyzed versions of the solutions must be compared with each other with respect to purpose, production capacity, product nomenclature, nature of the equipment, composition of the facilities, the effective loads, and so on.

When performing such an analysis, the nomenclature of the technical-economic, space-floor plan indices is used: number of floors, the total construction volume, m^3, and the covered area, m^2.

CHAPTER VIII. PHYSICAL-TECHNICAL PRINCIPLES OF INDUSTRIAL BUILDING DESIGN

§43. Air Exchange in Production Facilities

Different production hazards in the form of gases, dust, vapor, excessive generation of heat, and so on can be removed from the shops by intensified air exchange realized by various methods, namely:

Inleakage -- penetration of outside air into the facilities through leaks in the enclosing structures and pores of the enclosing material itself. Under ordinary conditions inleakage creates insignificant air exchange and it is considered when designing facilities with relatively small generation of powerful substances. Inleakage to a defined degree counteracts condensation of water vapor on glass surfaces;

Unorganized controlled air exchange which is realized by natural ventilation of the facilities by vents, doors and openings. In this case it does not appear possible to regulate the amount of air coming in and going out, for it depends on a number of factors (the temperature difference, direction and force of the wind, and so on);

Mechanical ventilation used primarily in shops with strictly given inside conditions in which skylights are used only for natural lighting. This method of air exchange is expedient when the source of harmful emissions is individual units or groups of units equipped with local exhausts removing these releases directly at the points of their occurrence;

Aeration -- organized, controlled and regulated air exchange of production facilities.

When comparing the expenditures on the construction and use of mechanical ventilation and aeration the advantage of the latter is noticeable, for less metal is required to set it up, and, in addition, aeration is sometimes cheaper than mechanical ventilation with respect to initial cost and requires significantly less electric power.

For aeration, sufficient inflow and exhaust openings with respect to area are constructed in the windows in the walls and skylights, the sashes of which are equipped with mechanisms for opening them (Figure 109, a-f). The theory and methods of calculating aeration, that is, finding the dimensions of these openings required for specific cases are discussed in the corresponding textbooks.

By regulating the angle of inclination when opening the sashes, it is possible to realize air exchange in previously calculated amounts in accordance with the inside and outside conditions (air temperature, wind direction and speed).

For aeration the air intake and removal takes place as a result of the pressure difference on the opposite sides of the intake and exhaust openings. The pressure difference arises as a result of the temperature difference of the inside and outside air and the effect of the wind on the building enclosure.

In order to obtain the greatest effect from aeration it is necessary to create a maximum height gradient, that is, maximum height difference of location of the inflow and exhaust openings. Depending on the time of year, the distance between centers of the inflow and exhaust openings is changed, opening the lower openings in the summer and the upper ones in the winter.

Aeration is required during the hottest months -- with minimum temperature difference of the inside and outside air -- therefore the aeration system must be designed for this least advantageous time period.

The exhaust openings are located as high as possible above the working surface, usually in the shutter elements of the skylights. Therefore shops with a high amount of heat generation must have sufficient height to organize effective aeration.

Two-level location of the intake openings excludes the effect of cold air intake on the workers in the shop. In this case the outside air coming in at a height of 4-6 meters can warm up sufficiently before it reaches the work zone (Figure 110, a).

The design of the aeration devices in multibay shops with continuous coverage more than 100 meters wide is a critical problem. The best solution to the aeration of multibay buildings of significant width is placement of the production facility in bays with different height fully coordinated with the production process requirements. In this case the skylights located above the low bays can operate as air intakes, and the skylights above the high bays, as exhaust (Figure 110, b).

During the design process it is necessary to try to locate the units -- sources of harmful or hot emissions -- in the bays of greater height so that the air intake is realized from the bays with less generation of heat. In cases where there is no necessity for bays with great height, a height gradient must also be observed (Figure 110, c).

The amount of air coming into the shop depends to a great extent on the wind direction and velocity. When the wind encounters the building, eddy currents are created, the effect of which on the surface of the buildings is characterized by the graphical pressure diagrams (see Figure 109, e, f).

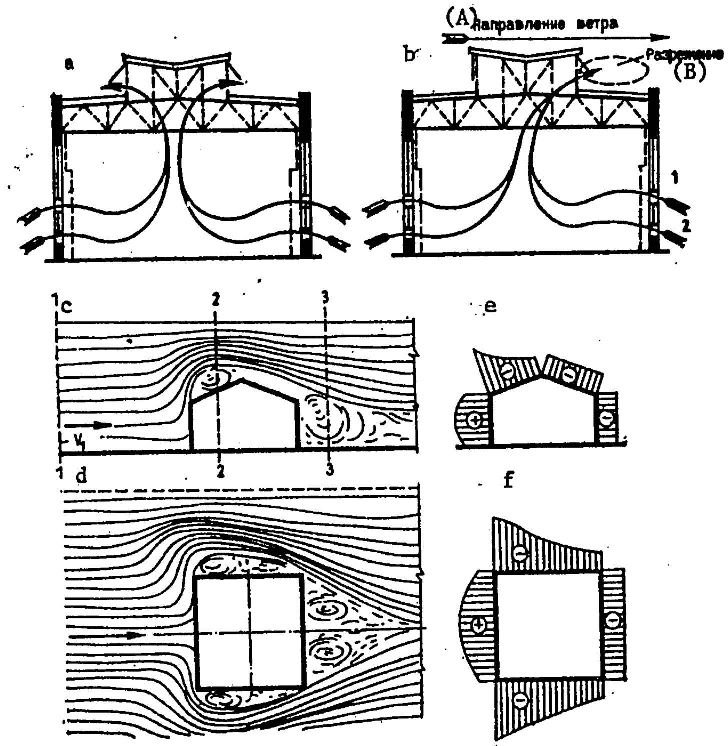


Figure 109. Aeration of production buildings. Diagram of the air currents; a -- in the absence of wind; b -- in the presence of wind; c -- air direction on flooring around the building in profile; d -- the same in plan; e -- pressure distribution on the building in profile; f -- the same in plan (the pressures greater than atmospheric are denoted by a plus sign, and those less than atmospheric, by a minus sign); the intake opening: 1 -- winter; 2 -- summer; 1-1 -- cross section in which rarefaction of the air is absent; 2-2, 3-3 -- cross sections in which rarefaction of the air occurs

Key:
A. Wind direction
B. Rarefaction

The windward side of the building experiences an increased positive effect (above atmospheric), the downwind side, a reduced negative pressure (or suction). In order to achieve more intense aeration of the facility it is necessary that the intake vents of the window sashes be located on the windward side, and the exhaust vents of the skylights, on the downwind side; in this case rarefaction corresponding to efficient exhaust will occur in the vicinity of the skylights.

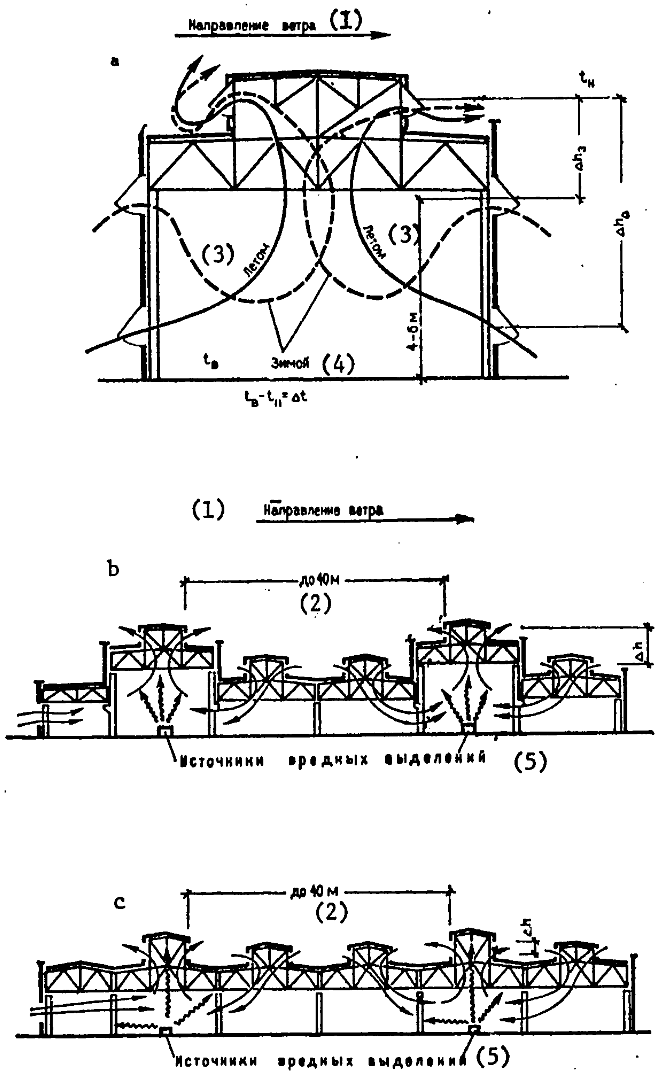


Figure 110. Aeration diagrams and layout of the intake and exhaust openings in a one-story building.
a -- single-bay; b -- multibay in the presence of bays with increased height; c -- multibay with increased height of skylights

Key:
1. Wind direction
2. to 40 meters
3. Summer
4. Winter
5. Sources of harmful emissions

In order to insure simultaneous operation of the exhaust openings on both sides of the skylight, so-called no-intake aeration skylights are used with vertical glazing.

§44. Natural Lighting

The use of natural daylight to light the rooms and work places of production buildings is one of the important factors promoting improvement of the sanitary-hygienic conditions of labor, improvement of the output capacity, improvement of production quality and also a decrease in the accident rate.

The degree and uniformity of the lighting of the facilities with natural light depend primarily on the shape, sizes and arrangement of the fenestrations. In small rooms of nonindustrial buildings the fenestration area is determined in accordance with the norms as some part of the floor area: for example, the window area in the living spaces of apartments and boarding houses and in hotel rooms, depending on the climatic conditions, must be no less than 1:8 to 1:10 of the floor area. This method of determining and rating illumination, called geometric, is not the best. It gives satisfactory results only for facilities with small areas. When designing illumination on the basis of this method, it is not the illumination itself that is standardized, but only one of the factors influencing the illumination, namely, the fenestration area.

A more efficient method of standardizing natural lighting is the light engineering method. It is usually used when designing large rooms of production and public buildings. It takes into account the factors influencing the intensity of the lighting, it permits insurance of the required levels of illumination at different points in the room. The illumination level is determined using light engineering calculations based on the laws of photometry [15, pp 246, 247].

When designing natural lighting it is necessary to use the light engineering method to find an optimal solution which most completely takes into account not only the sanitary-hygienic, but also economic requirements.

Natural illumination can be side illumination -- through windows in the outside walls -- top -- through skylights and openings in the ceilings; combined -- side illumination is added to top illumination.

The energy transmitted by radiation is called radiant energy. The power of the radiant energy estimated by the light perception produced by it on a normal human eye is called the luminous flux and is denoted by F.

The lumen (ℓm) corresponding to a power of 1/683 watts on a wave length of λ=0.55 micron and defined by special etalons is taken as the unit of luminous flux. The magnitude of the luminous flux is the characteristic of the light source.

For estimation of the lighting conditions created by a light source, the concept of intensity of illumination is used.

The illumination E of a surface is the ratio of the magnitude of the incident luminous flow F to the area of the illuminated surface:

$$E = F/S. \qquad (1)$$

A lux equal to the intensity of illumination of 1 m^2 of surface on which a luminous flux of one lumen is uniformly distributed is taken as the unit of illumination.

In practice it does not appear possible to establish minimum values of the illumination inside a facility in lux as a result of the extreme inconstancy of the natural conditions of natural lighting under a clear sky. Accordingly, the illumination of the room is expressed not in absolute units (lux), but in relative units -- in the form of the daylight factor.

The daylight factor is the ratio of the natural illumination created at some point of a given plane inside a room by the light of the sky (directly or after reflection) to the simultaneous value of the outside horizontal illumination created by the light of a completely clear sky. The daylight factor is determined by the A. M. Danilyuk method discussed in SNiP II-A.8-72 "Natural Lighting. Design Norms."

The mathematical daylight factor is expressed by the formula

$$e = E/E_0, \tag{2}$$

where E is the illumination of a point inside the room, lux; E_0 is the illumination of a point on a horizontal site under the open sky, lux.

As a result of the fact that the illumination under a clear sky is always greater than the illumination inside a building, the value of the daylight factor is always less than one. Usually the daylight factor is expressed in percentages: in this case expression (2) assumes the form

$$e = \frac{E}{E_0} 100. \tag{3}$$

The illumination under a clear sky E_0 is usually measured on the roof of a building, for E_0 is the illumination created by diffuse light of the entire hemisphere of the sky.

Natural Lighting Norms. Within the USSR the normalized value of the daylight factor (in %) considering the nature of visual work and the light climate in the area where the building is located must be determined by the formula

$$e_H = emC, \tag{4}$$

where e is the value of the daylight factor, % for diffuse light from the sky determined considering the nature of the visual work by Table 20; m is the light climate factor (without considering direct sunlight); depending on the area where the building is located in the USSR (Figure 111) for light climate zone I m=1.2; for zone II, m=1.1; for zone III m=1; for zone IV m=0.9; for zone V m=0.8; C is the sunny weather factor of the climate (considering direct sunlight) determined by Table 21 depending on the location of the building within the USSR.

Table 20. Value of the Coefficient e for Production Facilities

Description of visual work	Least size of the object of discrimination, mm	Category of visual work	Value of e for natural lighting,%: Top and combined	Side
Performed work:				
Highest precision	Less than 0.15	I	10	3.5
Very high precision	From 0.15 to 0.3	II	7	2.5
High precision	From 0.3 to 0.5	III	5	2
Medium precision	From 0.5 to 1	IV	4	1.5
Low precision	From 1 to 5	V	3	1
Rough	Greater than 5	VI	2	0.5
Work with self-luminous materials of products in hot shops	-	VII	3	1
General observation of the course of the production process:				
Constant				
Periodic	-	-	1	0.3
General observation of the		VIII	-	-
condition of the equipment		-	0.7	0.2
Work at the mechanized and unmechanized warehouses	-	IX	0.5	0.1

Simplified Method of Calculating the Fenestration Area of Facilities. Considering that the calculation of the natural lighting is quite tedious, in some cases it is expedient to determine the fenestration area by a simplified method.

The ratio of the fenestration area to the floor area of the room S_o/S_π (in %) insuring normalized values of the daylight factor is defined approximately as follows:

a) For side lighting of the facility

$$100\frac{S_o}{\underset{(2)}{S_п}} = \frac{\overset{(3)}{e_н}\,\overset{(1)}{\eta_o}}{\tau_o r_1}\underset{(4)}{K_{зд}}, \qquad (5)$$

Key: 1. fenestration; 2. floor; 3. normalized; 4. building

where e_H is the normalized value of the daylight facor with side lighting of the room defined in accordance with p.2.1 of SNiP II-A.8-72; η_o is the light characteristic of a window defined by Table 11 of SNiP II-A.8-72; τ_o is the general light transmission factor of the fenestration defined according to 3.4 of SNiP II-A.8-72; r_1 is the factor taking into account the increase in he daylight factor with side lighting as a result of the light reflected from the inside surfaces and the underlying layer adjacent to the building defined according to Table 8 of SNiP II-A.8-72; $K_{building}$ is the coefficient taking into account the shading of the windows by opposite buildings defined according to Table 12 of SNiP II-A.8-72:

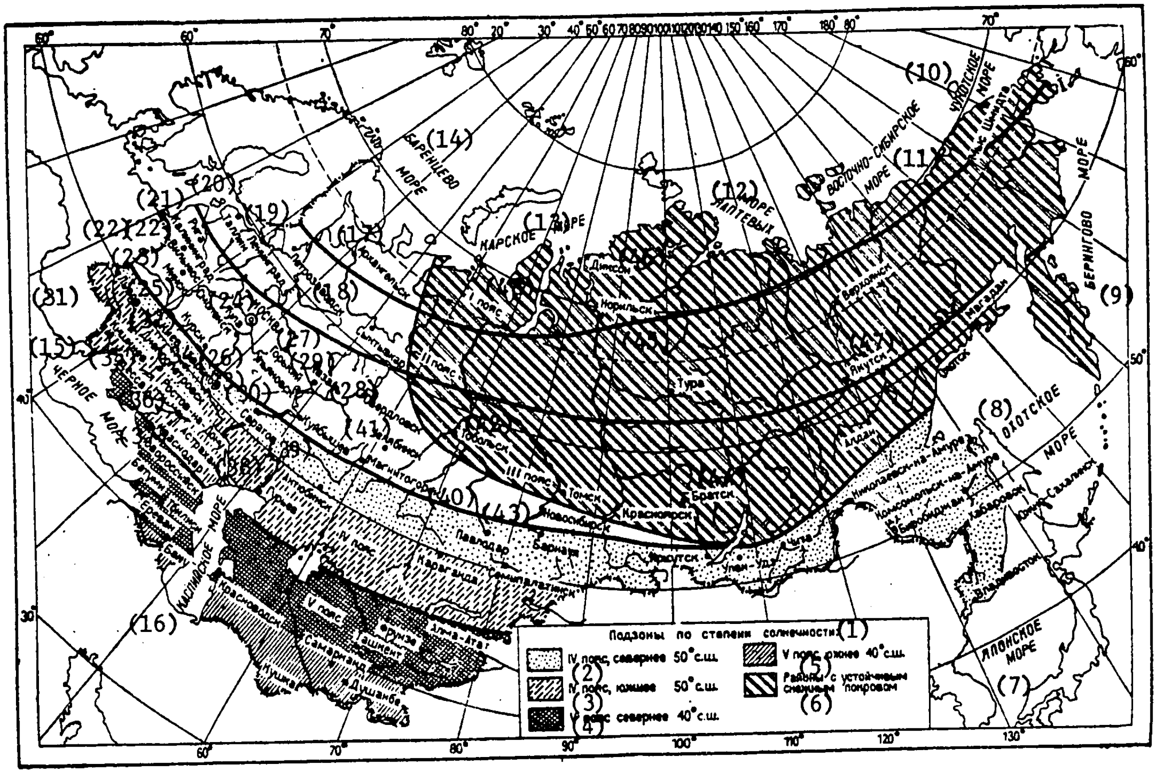


Figure 111. Schematic map of the light climate of the USSR for determining the daylight factor

Key:

1. Subzones with respect to amount of sunny weather;
2. Zone IV, north of 50° north latitude
3. Zone IV, south of 50° north lat.
4. Zone V north of 40° north latitude
5. Zone V south of 40° north latitude
6. Regions with stable snow cover
7. Sea of Japan
8. Sea of Okhotsk
9. Bering Sea
10. Chukchi Sea
11. East Siberian Sea
12. Laptev Sea
13. Kara Sea
14. Barents Sea
15. Black Sea
16. Caspian Sea
17. Arkhangel'sk
18. Petrozavodsk
19. Leningrad
20. Tallin
21. Riga
22. Kaliningrad
23. Vil'nyus
24. Smolensk
25. Minsk
26. Kursk
27. Moscow
28. Kazan'
29. Gor'kiy
30. Ul'yanovsk
31. L'vov
32. Kiev
33. Khar'kov
34. Dnepropetrovsk
35. Kishinev
36. Odessa
37. Krasnodar
38. Astrakhan'
39. Saratov
40. Magnitogorsk
41. Chelyabinsk
42. Tobol'sk
43. Novosibirsk
44. Bratsk
45. Noril'sk
46. Dikson
47. Yakutsk
48. zone ...

Table 21. Value of the Sunshine Coefficient C

Light climate zone (See Fig 111)	Coefficient C: With side lighting: Fenestrations oriented by directions of the horizon (reckoning the azimuths from the north), °: 135–225	225–315 45–135	315–45	With top lighting: Fenestration in the plane of the overhead	Rectangular and trapezoidal skylights	Sheds
I	1	1	1	1	1	1
II	1	1	1	1	1	1
III	1	1	1	1	1	1
IV:						
north of 50° north latitude	0.95	0.9	1	0.9	0.95	1
south of 50° north latitude	0.9	0.85	1	0.85	0.9	1
V:						
north of 40° north latitude	0.85	0.8	1	0.75	0.8	1
south of 40° north latitude	0.75	0.7	1	0.65	0.75	1

Notes: 1. In order to reduce the heat losses it is permissible to decrease the fenestration area to 70% of the floor area determined by the value of e_H and Appendix 2 of SNiP II-A.8-72 in buildings located in light climate zones I and II. 2. The values of e (see Table 20) must be taken for the "provisional working surface." 3. In rooms where work of different precision is performed, the values of e must be taken by the precision of the work predominating in the given facility. 4. The values of e (see Table 20) for visual work in categories II-V can be increased by one category for rooms designed for the work or production training of youths.

b) With top lighting

$$100\frac{S_{\Phi}^{(1)}}{S_{n}^{(2)}}=\frac{e_{H}^{(3)}\eta_{\Phi}}{\tau_{0}r_{2}^{(4)}}, \tag{6}$$

Key: 1. skylights; 2. floor; 3. normalized; 4. fenestration

where S_{ϕ} is the fenestration area (skylight area); e_H is the normalized value of the daylight factor for top lights in the rooms defined in accordance with p. 2.1 of SNiP II-A.8-72; η_{ϕ} is the light characteristic of the skylight or fenestration in the plane of the overhead defined by Tables 13 and 14 of SNiP II-A.8-72; r_2 is the coefficient taking into account the increase in the daylight factor with top lighting as a result of the light reflected from the surfaces of the room defined by Table 9 of SNiP II-A.8-72.

§45. Insolation and Solar Radiation

Insolation is irradiation of any surface by solar radiation.

Solar radiation is the radiant energy of the sun [in kilowatts/$m^2 \times K$)] incident on a defined surface. The radiant heat received by the outside enclosing structures of the buildings (especially in the southern parts of the country) has a significant influence on the microclimate of the facilities, being one of the reasons for extraordinary overheating of them in the summer time.

Direct solar radiation, penetrating the facility, causes sharp contrast in the illumination of the individual surfaces and the facilities as a whole and also the brightness of the objects with smooth reflecting surface. For visual work the direct sunlight incident at an angle of less than 30° to the horizontal and the reflected beams incident at an angle for 45 to 60° are considered harmful.

Among the measures to protect workers against overheating and penetration of bright sunlight into the rooms it is necessary to consider the appropriate orientation of the fenestration with respect to points of the compass, for example, one-sided sawtooth skylights (sheds) to the north, two-sided to the north and south; intense ventilation of the facilities in the summer; covering the overhead light in the summer; the presence of the corresponding overhangs, shutters, jalousies and other special devices on the windows.

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CHAPTER IX. SPACE AND FLOOR PLAN SOLUTIONS OF INDUSTRIAL BUILDINGS

§46. Basic Principles of Architectural Layout and Floor Plan Solutions of Industrial Buildings

The most important problem of industrial architecture is the organization of the environment (in part of an industrial district, the premises of an industrial complex, the interior of a separate building) in which the production process takes place.

The architectural space forming this environment is perceived in combination with the production and materials handling equipment, instruments located in it and also elements of the external space including the green plantings, small shapes and in some cases monumental pictorial art, and so on. Thus, social achievements, advanced solutions of science and engineering, and the achievements in fine arts are synthesized in architectural work.

One of the basic areas of technical progress in the design and construction of production buildings is the development of the basic principles of their layout and architectural-planning solution. A united technical policy developed in the USSR for industrial construction finds its expression in the improvement of the design solutions. The architectural-planning solutions of production buildings are based on the principles of organic connection with the solutions of the master plans of industrial enterprises and entire industrial complexes.

The primary goal of the designer -- the industrial-profile architect -- is skillful layout of the production complex or a separate building in accordance with the normative rules, production process, architectural and artistic requirements.

When solving the layout of a production building the designer begins, as a rule, with an interpretation of the city planning problem predefined by the specific architectural planning for the industrial district, complex or enterprise, which includes the designed production building as a part of the whole.

In the design process special attention must be given to expressiveness of the layouts of the spaces characteristic of the coverage of industrial territories during mass construction, using such architectural means as scaling (that is, the logical relation to man and basic modular elements), rhythm and meter, balance and dynamics, and so on for this purpose.

On the modern level of the design of enterprises and complexes it is necessary to achieve high coverage density by blocking the buildings and increasing the number of floors, if possible, establishment of the minimum attainable brakes between buildings, elimination of the construction of railroad entrances to the production building if this is not specifically called for by the production process (for example, in machine building) and also elimination of the construction of little-used railroad entrances to the enterprise premises if it is more expedient to use other forms of transportation by the technical-economic calculations, and so on.

In design practice the blocking of the shops and services of a number of enterprises is realized by combining production facilities with like production process, combining production facilities differing with respect to the production process if this does not contradict the sanitary conditions and safety engineering rules, and combining the auxiliary and service shops and services.

The blocking of the shops has become widespread in such branches of industry as, for example, machine building and so on, for which a low level of production hazards is characteristic.

When blocking, usually production facilities with the highest degree of emission of harmful materials and heat are located on the outside perimeter of the building for better use of the openings in the walls for natural ventilation. The shops requiring air conditioning and complete insulation from the external environment on the internal conditions of the facilities are placed in the central parts of the building. The part of the building turned toward the transport routes contains the storage areas for raw materials, intermediate products, finished products, and on the side turned toward the city are the general services, services, administrative and laboratory facilities. For further expansion of production facilities, as a rule, one of the lateral sides is reserved.

The buildings for blocking the enterprises must be designed insofar as possible from bays of one direction (longitudinal or transverse) which are identical with respect to width and length.

The direction of the bays is preferably designated in accordance with the course of the production process. When placing one enterprise in a building, it is expedient to direct the bays along the long dimension of the building which will permit the number of crane lines to be reduced. When selecting building sizes in plan it is desirable to call them short bays, the most used at the present time.

Soviet experience in industrial construction indicates the necessity for zoning both the entire territory and the consolidated blocked buildings of industrial enterprises. In the majority of cases the zoning is done horizontally (Figure 112, a, b).

At the present time horizontal zoning in one-story buildings is being supplemented more and more by vertical zoning. Thus, a new concept is arising -- "spatial zoning."

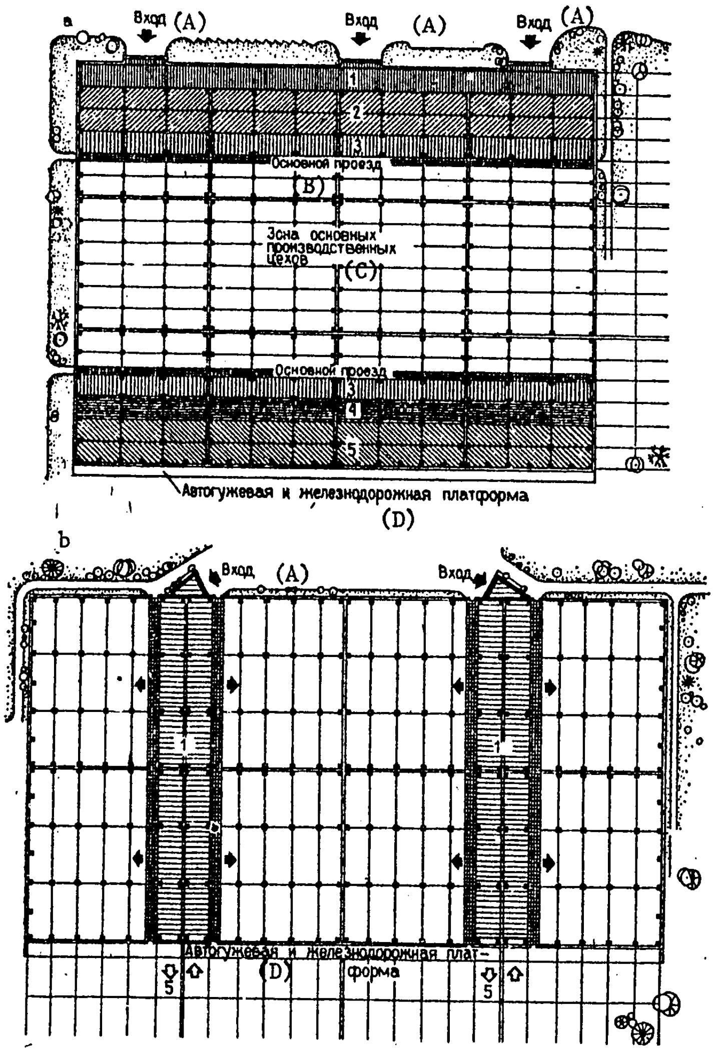

Figure 112. Zoning the area of enterprises within the boundaries of a consolidated block.
a -- longitudinal; b -- transverse. Zones: 1 -- administrative or laboratory and general services facilities; 2 -- design offices and experimental setups; 3 -- ventilation and power systems; 4 -- auxiliary production facilities; 5 -- raw materials, intermediate products and finished product warehouses

Key:

A. Entrance
B. Main access
C. Basic production shop zone
D. Truck and railroad loading platform

The improvement of the space-floor plan solutions is being realized both as a result of the application of an enlarged column grid permitting consideration of modification of the production process and as a result of blocking of the buildings and structures which offers the possibility of saving space in the production complex. The trend toward consolidation (blocking) of the buildings has found its expression in the space-floor plan solutions, for example, of the Volzhsk and Kama Automobile Plants. The covered area of the main building at the VAZ [Volzhsk Automobile Plant] was 70 hectares, the pressing building was more than 20 hectares and the auxiliary shop module, more than 11 hectares.

The application of new process, space-floor plan and structural solutions when designing blast furnace No 5 of the Novolipetsk Metallurgical Plant permitted a reduction in the capital expenditures by 13% reckoned per ton of finished cast iron and an increase in productivity of labor by 15-20% by comparison with blast furnace No 4 of the same plant.

The same advanced designs have also been adopted for the largest superpowerful blast furnace in the world with a volume of 5000 m^3 at the Krivoy Rog Metallurgical Plant.

At the present time when designing the enterprises of the chemical industry, the process equipment which does not need stability of the thermal conditions frequently is placed in unheated buildings or outside the buildings which greatly reduces the construction cost.

The blocking of the construction projects, the placement of the production equipment in open areas and stacks permit the construction area to be reduced, the number of construction projects to be reduced, the length of the service lines to be sharply reduced, and the cost of construction operations to be decreased.

It is necessary again to emphasize that the choice of the type of intrashop transportation has a large influence on the architectural-layout and planning solutions of industrial buildings.

The space-floor plan solutions of industrial buildings must satisfy the requirements of unitization of the basic modular construction parameters, loads and structural elements.

Architects and builders engaged in the design process, considering the prospects for development of industrial construction, are guided in their work by the principles, the most important of which are below:

Grouping of industrial enterprises in industrial complexes using common transportation, power engineering, water supply and sewage networks, and so on;

The maximum cooperation and maximum specialization of production;

Complex solution of the master plans for the industrial enterprises and replacement of the intraplant railroad transportation by improved, continuous-operating transport devices;

Development of enterprise master plans on the basis of standardizing their elements and the production layouts, the modular nature of the floor plan, clear-cut zoning, and so on;

When possible the enterprises are built from technologically finished starting-up complexes;

When solving the master plan for the enterprises, in a number of cases the enclosure of the territory is done away with, and the overall level of culture-general services is improved (the green areas are enlarged, sports areas are situated on the premises, and so on);

Location of enterprises with production processes that have the fewest hazards for which minimum sanitary-production zoning is required near the housing;

The achievement of high aesthetic quality of the architectural-layout and design solutions of the production buildings and structures; location of the block production facilities under a single cover in cases where the sanitary-hygienic conditions of labor are not negatively affected and also the fire and explosion danger in the buildings is not increased, and the operating expenditures do not go up. The introduction of the capacity into operation must be realized in phases;

Application of an enlarge standardized column grid;

An effort to simplify the volume, the plan and the transverse profile and insofar as possible do away with annexes and height gradients;

The use in some cases of the space between the girders as a service floor for service lines, general services, offices and other facilities;

The use of overhead materials handling equipment in the form of conveyors or overhead cranes and also pneumatic and hydraulic transportation.

§47. Architectural-Aesthetic Form of an Industrial Building

In recent years the significance of complex solution of the problems of industrial architecture connected with social conversion of society with further development of the technical process and with improvement of the significance of the architectural and city planning goals has increased. In the design process, there is greater attention to the aesthetic solution of the environment actively influencing the growth of productivity of labor. As a result of this complex understanding of the problems of Soviet industrial architecture, its quality has risen significantly. Unitization and standardization of the design processes must be accompanied by increased attention to the architectural-artistic problems of industrial construction. This problem is acquiring greater significance, for the architectural-planning and aesthetic qualities of certain production buildings and enterprises are still low even now, which is the result of extraordinary subordination of the creative problems of architecture only to the technical problems and reduction of search for new paths to achieve architectural expressiveness.

Unskilled application of unitized standard sections and spans in the design process has in a number of cases led to the association and limitation of the architectural-artistic concepts of the architects. Consequently, when designing industrial buildings it is necessary to learn how to freely and efficiently make use of the achievements of unitization and standardization. Practice shows that the most successful architectural solutions of enterprises, individual buildings and structures are those where most complete consideration is given to the artistic expressiveness of the entire complex, individual production buildings and their city planning significance in laying out the industrial complexes and master plans. Examples of such solutions are the Volzhsk and Kama Automobile Plants, the ore concentration combines in Krivoy Rog and other cities.

Designers involved with laying out the plant territory and the buildings and structures and when developing the overall layouts begin, as a rule, not only with the characteristic features of production and specific design of the ensemble, but also with the conditions of insuring the required artistic relation between the architecture of the enterprise and the surrounding cities. The architecture of industrial enterprises, being large-scale and impressive with respect to space design is capable of enriching the architecture of the city. It has often occurred that the layouts of industrial buildings were created without considering the basic aesthetic laws of formation which has led to an unimpressive architectural appearance for the production complexes and the city as a whole.

Important artistic means which can be used to achieve high architectural quality of production projects are harmonic proportional breakdown of the spaces of the main buildings, the use of interesting and varied forms of outdoor equipment and service structures and also aesthetic combination of all the space into a united whole.

In the overall layout of industrial enterprises an important role can also be played by such significant elements as smokestacks (Figure 113, a, b), cooling towers and sometimes the vent pipes and open-air equipment (see Figure 98). Such structures combined with other objects create the characteristic and industrial appearance of an industrial complex.

The buildings and structures making up the industrial enterprises complex must be arranged not only in interrelation stipulated by the production process but also so that they will create a composed structure retaining integralness and aesthetic unity in any phase of development of the production complex.

Whatever the city planning situation, the designed production complex must organically enter into the ensemble, have a characteristic aesthetic appearance, resulting from its functional-technological purpose, corresponding at the same time to the artistic-aesthetic design of the ensemble of the given city or district (or contrasting with it). Obviously the architectural-spatial solution of any specific production building must be tied to the architecture of other production buildings, but it must not repeat the architectural solution of housing or public buildings.

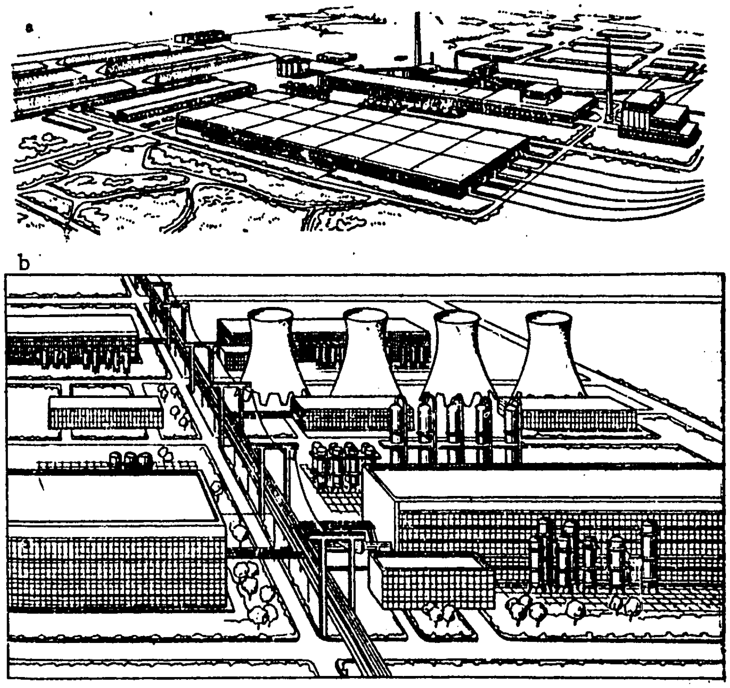

Figure 113. Architectural-spatial solution of an industrial enterprise complex.
a -- with smokestacks; b -- with cooling towers

Discussing the architecture of production buildings, it is necessary to keep in mind that not only the production process but also the nature of the structural design of a building has defining influence on the organization of the space of production buildings.

The standard features of the spatial layout of many production buildings are their integral appearance and large architectural breakdown. The modern production buildings are parallelepipeds with respect to external composition in the majority of cases, on the outside surface of which glassed openings and wall planes alternate regularly. As the basic aesthetic means of enriching the composition, it is possible to use the multiply repeating rhythm of the standard elements of the architectural treatment of the facade corresponding to the production rhythm and the metric arrangement of the spaces of general services and administrative facilities (a successful example of the use of multiply repeating rhythm is the treatment of the long facade of the main building of the Volzhsk Automobile Plant which is about 1800 meters long).

An analysis of the architectural elements of the facades of the most successful production buildings makes it possible to discover the functional causalness of these elements. Thus, the fenestrations of significant height provide normative illumination of the rooms to great depth, the large entry openings sometimes permit railroad rolling stock to enter the shop, and so on.

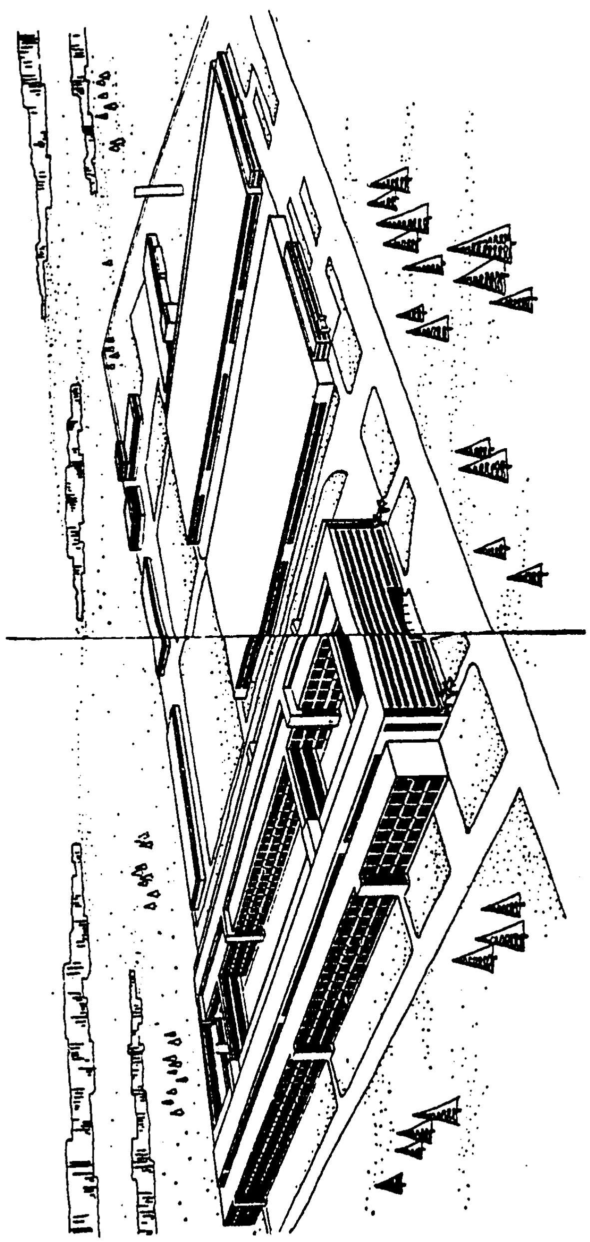

Figure 114. Overall view of a complex consisting of a detached factory, the unwoven textile materials mills and weaving mill in Shuya

For modern multistory production buildings in some cases the methods of breaking up the volume by horizontal wall elements, horizontal stripped glassing, simplicity and laconism of the outside space can be justified (Figure 114). The large inside space of one-story shops must have breakdown commensurate with the scales of the shop equipment.

At this time when the facades of the production buildings are in many cases made up of hanging panels, sheet materials or multilayer structural elements, the proper scale relations between the fenestrations and the piers between windows have great significance. As a result of this structure in modern practice sometimes horizontal construction of the facade is used corresponding to the structural design of the hanging walls. Breakup of the facades is achieved by outlining projecting or recessed elements against the breakdown of the facades -- entrances to the building, projecting vestibules, truck or railroad loading platforms, stairwells, the elements of production equipment, and so on.

For achievement of architectural expression of a long building in a number of cases contrast of the designs of the front and end elevations of the building, the blank and glassed sections, and so on is used.

In large industrial complexes which have important national economic significance, monumental-decorative pieces of art work are successfully used on the large planes of individual long buildings (for example, on the main building of the Volzhsk Automobile Plant) by including monumental pictorial art,bas relief or sculptures in the building composition.

An example of solution of a modern industrial building with simple plan and space is the industrial building designed by the Promstroyproyekt Institute in which specialized enterprises are located (Figure 115). With a laconic spatial solution of the industrial building, a great deal of attention is given to the choice of wall material, color and texture.

When developing the architectural complex of an industrial enterprise it is necessary to coordinate an entire series of contradictory requirements dictated by the production process, the specific nature of the surrounding city, the peculiarities of the plan solution of the industrial premises and nature of the landscape.

One of the possible means of providing for compositional artistic unity of the building and the surrounding structures is the use of landscaping both on the enterprise premises and outside them.

During the design process a great deal of attention is given to the architectural-aesthetic qualities of industrial enterprises and the aesthetic level of the production environment. From this point of view the examplesof the volumetric layout of a metallurgical plant are of interest where the base is made up of the buildings and structures of the blast furnace, steel making and rolling shops (Figure 116, a-c).

The spatial layout of the blast furnace complex is made up of the furnace building and the charging and erecting platforms, elevator and skip hoist rising above it and also the vertical spaces of the air heaters, dust trap and smokestack (see Figures 119-120). The blast furnaces have significant height -- 70-75 meters (see Figure 116, a) -- they are distinguished by originality of shape and include significant structural elements, for example, pipelines and so on. At the existing enterprises the basic elements of the blast furnace complex are surrounded by a network of service structures and equipment. The appearance of the furnace becomes so chopped up at times that when viewing from nearby it loses its characteristic advantages.

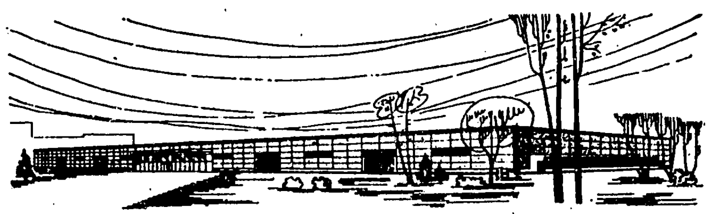

Figure 115. Perspective of a blocked building with different production facilities in Novyye Cheremushki in Moscow

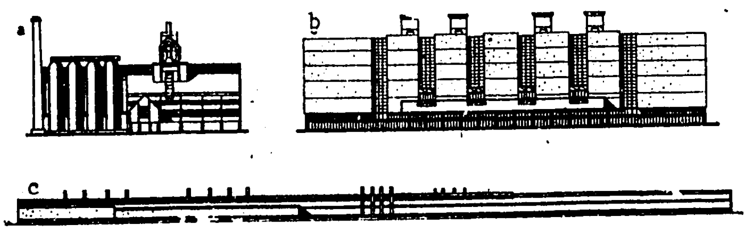

Figure 116. General view of buildings.
a -- blast furnaces; b -- converter plant; c -- rolling-mill shop

The scaling[1] of the furnace is provided by the enclosures of the work areas located at different levels, the open stairways, connecting platforms, and pipelines on supports. The discovery of the scale of a blast furnace is also promoted by the amenities, for example, green spaces, small forms, and so on. Thus, for production buildings architectural scale is created as a result of breakup of the architectural space.

The location of furnaces deep in the enterprise satisfies both sanitary-hygienic and architectural-aesthetic requirements. In this case the fractured appearance is perceived integrally and the architectural appearance of the furnace is won.

With respect to dimensions and significance, one of the main structures in the metallurgical enterprise ensemble is the converter plant and, consequently, its

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[1] Scaling is the ratio of the space or element to the size of a man or in a number of cases to a structural element, the dimensions of which are known to us.

architectural design to a significant degree determines the artistic-aesthetic impression of the plant. Let us consider the converter plants designed by the TsNIIpromzdaniy Institute (Figure 116, b) located in two buildings.

The converter section with 250 ton converters is located in the main building; the scrap and mixer division is located in the other building. The dimensions of the main building are 291×54 meters with a height of more than 60 meters. The basis for the architectural design of the facade is contrast between the horizontal breakup of the lower zone of the building wall and the vertical forms of the main body. The converter point is the compositional nucleus of the enterprise and is visible from many points of the plant site, and therefore it is correctly solved on a large scale. This large scaling is achieved by laconism of the body of this shop, refraining from small-scale breakup of the building, the interpretation of the vent pipes of the upper part of the wall in the form of powerful pylons.

The buildings and structures of the rolling mill shop, the blast furnace and steel making shops are the most important for the metallurgical enterprise. The construction spaces of the rolling mill shops take up an area of up to several tens of hectares extending about 1 km. As a rule, these shops are somewhat extended in the direction of length of the rolling mill sections connected to each other by storage areas for the finished products, the soaking pit division, blooming or slabbing mill divisions. For aeration of the shops internal yards are provided between the sections.

In the architectural-structural design of the rolling mill shops great significance is attached to the solution of the horizontal extent of the buildings having a ratio of height to length of 1:100 or more (Figure 116, c).

Under such conditions it is very complicated to eliminate the monoticity and achieve aesthetic expression of the facades and attractiveness of the buildings and, consequently, to achieve unity and integralness of the volumetric design. The reason for this is the presence of a number of annexes, transverse and longitudinal bays, a complex system of skylights which in the majority of cases chop up the body of the rolling mill shop into individual elements which are visually unrelated.

Procedures and Methods of Architectural-Compositional Solutions of Production Buildings. As has already been noted, the most important design problem of modern industrial enterprises is to connect the production buildings and structures, the natural environment surrounding them and man and the machinery located in them into an expediently organized and aesthetically justified system. Consequently, the production buildings and structures are elements of a united spatial structure in which the mutual arrangement, the volumetric solution and the design of their inside space are subordinate to the single compositional concept of the architectural organization of this spatial structure including all of the elements of the environment.

This new approach to organization of space in industrial architecture [6] creates the necessary prerequisites for joining numerous production buildings with different purposes and dimensions and engineering structures into a single architectural ensemble.

At the present time when the dimensions of industrial complexes or certain enterprises are quite large, the question of the limits of the architectural ensemble, that is, the actual limits of the spatial extent of the complex of buildings and structures making up this ensemble, beyond the limits of which the latter loses the qualities characteristic of it, that is, in practice ceases to be an architectural ensemble, is an important question.

Under the conditions of the development of modern forms of public transportation (motor vehicle, monorail and other forms of high speed transportation) possibilities are created for rapid communications over relatively extensive industrial premises with conversion of them into single architectural ensembles, with real possibilities for perception in a defined, previously thought out sequence.

Thus, large, quite extensive industrial complexes which cannot be encompassed at a glance and are perceived in space and time can under defined conditions have compositional unity of the architectural ensemble. As an example of such an architectural ensemble designed for perception of it in motion, let us present the complex of the Volgo-Don Shipping Canal imeni V. I. Lenin.

It is necessary to consider industrial complexes or parts of them which can be viewed as a whole and are perceived simultaneously as special cases of an architectural ensemble.

The spatial composition of industrial complex, depending on the nature of the effect on the viewer, can be constructed by the principle of perception from the outside or inside the territory.

The architectural compositions for which the perception from inside is predominant encompass the closed space inside which they are located. Such compositions are almost completely isolated from perception from the outside; therefore they do not have decisive significance. This principle is usually applied for layouts of large industrial complexes with block coverage.

Frequently the layouts of such complexes having geometrically regular rectangular shape with predominant straight center lines and right angles in the master plan are constructed by the principle of regularity.

In the majority of cases examples of regular architectural compositions are large industrial complexes with more or less symmetric arrangement with respect to one (or several) planning axis of like buildings and structures, the majority of which have rectangular shape in plan. The layouts of many machine building enterprises are constructed by this principle, for example, Moscow Automobile Plant imeni I. Likhachev, Gor'kiy Automobile Plant, and so on. The layouts of these enterprises are basically perceived by the viewer located in the inside space of the thoroughfare toward which the main facades of the most important production buildings of the plants are turned.

The layouts of small and complex industrial complexes are constructed by the principle of perception from the outside.

When organizing the industrial architectural ensemble an important face in the choice of the principal compositional element -- the architectural dominant.

As the architectural dominant, depending on the general concept, buildings and structures are taken which have great functional or conceptual significance, great height, and so on (for example, the central heating plant). In a number of cases this can be a sculpture (for example, the memorial to V. I. Lenin in the layout of the Severnaya Square of the main thoroughfare of the Automobile Plant imeni I. A. Likhachev).

Among the most widespread means of subordination of secondary elements of the ensemble to its architectural dominant, it is necessary to include the active silhouette, significant architectural scale, most static architectural form, active color solution and other techniques. In the majority of cases these means are used in combination in the composition of the ensemble.

When developing architectural solutions for individual buildings and structures it is necessary to be guided by the overall compositional concept of the complex, to take into account the city planning significance and expressive function of each individual building and structure in the overall architectural ensemble.

In modern industrial architecture the bodies of the basic production and auxiliary buildings of industrial enterprises have, as a rule, the simplest rectangular shapes, for example, a parallelepiped for the majority of one-story buildings with continuous coverage or cubes for multistory buildings. These solutions have arisen as the result of unitization of the architectural-structural parameters of the buildings determining the rectangular shape of their plan constructed on multiple repetition of identical spans and spacings. In some cases more complex volumetric solution of the buildings is possible, for example, in the form of a combination of various rectangular bodies, and so on.

The basis for the design of many of the engineering structures of industrial enterprises is the simplest geometric shapes of curvilinear outlines: in the shape of a sphere (for example, nuclear power plants), an ellipsoid (tanks) or a cylinder (tanks, reservoirs, silos), and so on. However, the service and engineering structures can have a more complex shape, for example, in the form of a hyperboloid of resolution (cooling tower), and so on.

The engineering and service structures with significant height separated from the general background of the surrounding structures are perceived in silhouette: blast furnaces, Cowper stoves and coke-oven batteries of metallurgical plants, cooling towers, smokestacks and end pipes, the production units of chemical enterprises and oil refineries, and so on. They lend a specific architectural appearance to the enterprises and the industrial territories. In a number of cases in the case of low horizontal construction of the machine building and textile enterprises, such individual structures are capable of enhancing the silhouette of the builtup area. At the metallurgical and chemical enterprises and other similar enterprises, as a rule, there are many high structures, and these vertical dominants must be designed so that there will be regularity and metric structure in their arrangement.

The structures with horizontal development of the architectural volume, as a rule, are perceived as a mass, for example, the dams at modern hydroengineering complexes. Production buildings located on intraplant sites, thoroughfares and accesses are perceived flat.

In modern industrial construction, in accordance with the functional or structural requirements the architectural volumes of the structures almost always have internal breakup. Using the breakup in the design process, the architect, independently of the absolute dimensions of the structure, can give it a large or small architectural scale.

The architectural volume can have horizontal and vertical breakup.

The compositional design of the facade of a production building which must correspond to the overall architectural concept of the industrial complex ensemble has important significance.

In practice three compositions of industrial facades have been developed: symmetric, asymmetric and neutral (rhythmic).

The symmetric design, as a rule, is not characteristic of modern buildings. The industrial building in Novyye Cheremushki developed by the Promstroyproyekt Institute (see Figure 115) for two different production facilities has been designed by this principle.

Asymmetric solutions in modern industrial construction are quite frequently used. This arises from production requirements. For example, the facade of the pattern and tool buildings of the ZIL Plant in Moscow was developed by this scheme.

For modern industrial facades most frequently neutral layouts are used. In the majority of cases these are metric or rhythmic solutions, the basis for which is multiple repetition of one architectural motive of the facade or another, for example, the ends of the transverse bays, the fenestrations, imposts and sashes, glazing, the frame uprights, the overhead elements, and so on (see Figures 75 and 117).

It is necessary to emphasize that the fenestrations of different shape and size are the architectural basis for the solutions of production facades, developing and varying which, the architect can achieve different visual perception of the building, either as large or small.

Facades with large fenestrations or with continuous glazing are most organically tied to the significant unbroken rooms inside the production buildings. This solution logically reflects the internal structure and characteristic features of the modern production building on the facades and simultaneously reveals its large architectural scale well. Therefore in some cases building service and auxiliary (administrative and general services, and so on) facilities around the production buildings on the one hand interferes with revealing the existing unbroken spaces, and on the other hand, promotes overall scaling. Everything depends on the specific solution.

In the majority of cases the modern production building is designed as a frame system in which the functions of the supporting and enclosing structural elements organically tied to the architectural solution of the elevations are separated and revealed clearly. Thus, in the frame system the compositional solution of the architectural-spatial body of the building, as a rule, is constructed on the basis of revealing the structural essence of the building in the facade, that is, the system of uprights and frames of the bearing frame with interpretation of the elements of the external enclosure as vertical fillings. In the architectural solution such a wall of a frame building is considered as a light shell hung on the bearing frame or leaning against it.

A number of researchers of the architecture of industrial buildings note several versions of the most characteristic architectural solutions of such enclosures [6].

The first version includes the solution technique in which horizontal fenestrations on the facade alternate with blank sections of the wall made of hanging large-scale panels (multilayer with asbestos cement or metal section covering). With respect to its structure, such an enclosure insures easy replacement of the fenestrations by blank sections of the panel wall and vice versa. This technique has found application in a number of machine building, chemical and metallurgical buildings.

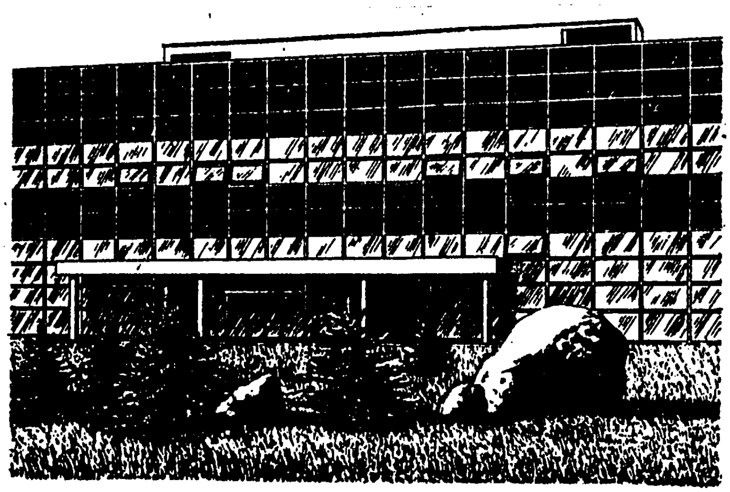

Figure 117. Compositional solution of a facade based on the architectural theme of a single light shell with fine surface structure

The second version presupposes the design of buildings from light, in the majority of cases, small panels faced with colored glass or colored hanging panels alternating with fenestrations of the same sizes glazed with ordinary glass. In this case the facade wall surface has a fine architectural structure (Figure 117) as is done in the buildings developed by the Promstroyproyekt Institute.

The third version of the solution of buildings consists in their outside enclosures being made of light hanging panels faced with steel or aluminum sheet section or fibrous asbestos cement sheets forming planes with a united structure.

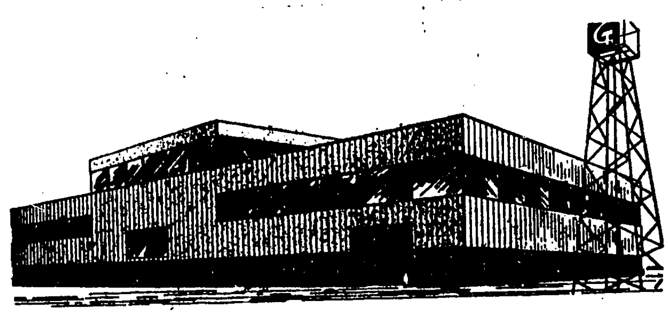

Figure 118. Compositional solution of the facade of a plant building for perlite sand production in Mytishchi

The fourth version includes the design of buildings with continuous glazing on the plane of the facade. With this design the bearing frame remains unrevealed on the facade.

A great deal of significance is attached to color in the compositional solution of production buildings and structures. It is used to reveal and emphasize the architectural body of the building (or part of it) in the environment (relationship to the landscape).

An example of a successful architectural-aesthetic solution for panel buildings in accordance with the purpose and nature of production can be considered to be the building of a plant for perlite sand production in Mytishchi (Figure 118). The architecture of the main building is strict, laconic and expressive. Contrast of the design of the front and end walls has been successfully used in a building of great extent.

Broad application of wall panels gives rise to the necessity for increasing the architectural expressiveness of the large-panel buildings. As is known, the application of panels creates a new scale which usually is clearly revealed by the joint grid. It is obvious that a 6-meter panel is less plastic than the small construction materials giving great freedom of composition. Therefore a panel wall, free of color shading, indisputably is in need of utilizing additional techniques to lend it architectural expression.

Let us consider some of the architectural techniques used in practice. For example, the decorative pointing of the joints or contrasting of them lends the wall surface a clear-cut rhythm, it emphasizes the dimensions of the panel and its scale. When combining panels of different shapes and sizes, a pattern can be obtained which permits the sameness to be overcome to a defined degree.

No fewer possibilities are provided by rhythmic alternation of panels with different surface and also color or textured bordering of the panels. In the case of using vertical panels for sun shielding, the possibility arises for obtaining light-shadow effects and also lending great plasticity to the facades.

In the case of facing the walls with various sheet materials (steel, aluminum, asbestos cement, stemalite and laminated plastic, and so on) the joints between the sheets are little noticed; therefore the walls are perceived as large surfaces with partial vertical breakup connected with the sheet profile. The shaped and corrugated sheets lend the wall surface special sharpness and harmonize well with the appearance of a production building.

Consequently, the use of the properties of materials and combinations of them in the enclosing structures is one of the basic compositional techniques of industrial architecture supplementing the volumetric-spatial solution.

Thus, the architectural expression of production buildings, variation of the designs of their facades are directly dependent on the available assortment of standard industrial products and building materials, their quality and, finally, mastery in their application.

§48. Examples of Design Solutions of Industrial Enterprises

Depending on the composition of the shops, enterprises are distinguished with complete and incomplete production cycles.

The modern metallurgical plant with a complete cycle and large annual steel output capacity usually has several blast furnaces, a converter plant, a blooming mill with continuous billeting mill (or slabbing mill) and finish rolling mills.

The most important basic production objects of the metallurgical plant include the following:

The blast furnace plant including several blast furnaces (Figure 119). The basic structures of the blast furnace plant are the casting yards with bottom houses, the air heater module, dust trap, furnace control building and top hoist building, bin trestle, casting machines, refractory repair yard for the cast iron carriers, the unit for spraying the slag carriers, and so on;

Steel making production which can include converter plants with 250, 350, 400-ton and larger furnaces. For special (low-alloy, manganese, chromium and other types) steels electric steel-making furnaces are provided with capacities of 180 to 300 tons. In steel-making production continuous casting of the steel is more and more widely used.

The auxiliary divisions include the shop for preparing the ingot mold compounds, the mixer divisions, the charge and magnetic materials divisons, the division for stripping of the ingots and a number of small structures, for example, the exhaust-heat boilers, gas cleaners, and so on.

The rolling mill shops (hot and cold rolling) at modern metallurgical plants are designed as specialized shops for the production of bar or sheet gold products. For example, the hot rolling shop of one of the large plants includes a 1250 mm slabbing mill, a continuous 2000 mm strip mill and a 4200 mm plate mill, and also the soaking pit divisions located perpendicular to the axis of the slabbing mill.

Four heating furnaces are installed in the shop. At the same plant provision is made for cold rolling shop for making cold-rolled sheets.

In metallurgy sometimes enterprises of related branches of industry are joined into combines. The combines include, in addition to the metallurgical plant, enterprises for extraction of ferrous ore, cake and by-product processes, and so on.

The production shops of the metallurgical plants, depending on their purpose and nature of production output, are divided into the following groups: basic, subsidiary and service.

The basic shops of the metallurgical plant with complete cycle, as has been pointed out, include the blast furnace, steel making, and rolling mill shops with cogging and billeting milles and finish rolling mills (beam-rail, bar rolling, sheet rolling and wheel rolling).

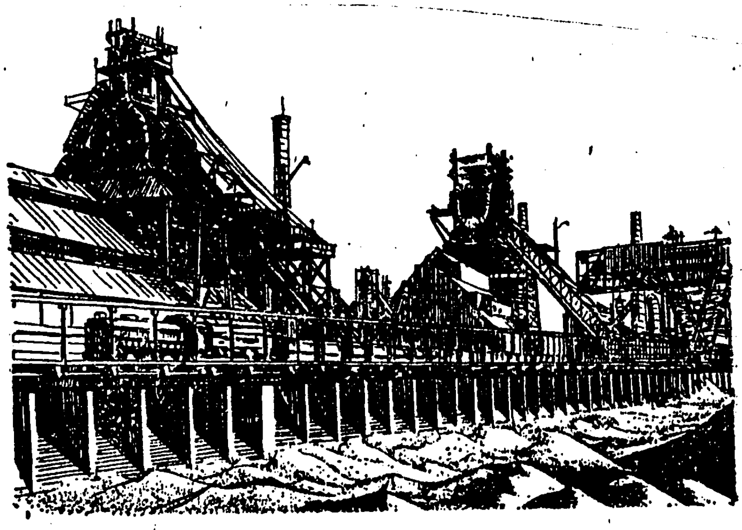

Figure 119. Blast furnace shop of the Donetsk Metallurgical Plant

At the combined enterprises the subsidiary shops include the iron ore shafts and open pits, the sintering plants, the compacting shops, refractory and coking shops, dolomite and limestone quarries and also the shops for preparation of production, for example, the cake and by-products process shop (coke battery) is designed to obtain coke and gas; the sintering plant is designed for the formation of larger pieces from fine ore or powder materials by sintering.

The cake and by-products process shop includes the coke-oven batteries, the char towers, the batching division, the coke screen, and the coal storage.

The sintering plant consists of the sintering building, the charging bins, the building for grinding, primer mixing and crushing limestone, screening the limestone and the sinter, and a large number of underground and above-ground galleries.

The service shops have a significant influence on the normal operation of all the shops and administrations of the plant. They include the following:

Repair shops (mechanical repair, steel casting facing, cast iron casting, construction repair shop, the metallurgical furnace repair shop, roll-turning and electrical repair shops);

Power engineering (electric power plants, the network and substation shops, the heat and electric power plants, the steam boilers, air blowers, oxygen, and so on);

Transport shops (the railroad track network, traction devices, depots, the overhead and stationary mechanical transportation structures), central plant laboratories, and so on.

The complex of the modern metallurgical plant includes on the average 250 to 300 different buildings and structures taking up an area of 1.2 to 1.5 million m^2. The basic shops of such a plant were designed until recently in individual buildings, the connections between which were made primarily by railroad tracks.

Along with blocking the shops to improve the space and floor plan solutions, simple volumes, plans and profiles of the buildings are used (excluding height drops), the types of space and floor plan parameters of the buildings are reduced (spacing, span and height). New effective structural designs have been introduced (for example, long-span overheads), new improved building materials were used; the bridge cranes are replaced by floor or other forms of more efficient transportation.

Architectural-Structural Solutions of the Blast Furnace Complex. The modern blast furnace is a powerful heating unit for producing liquid cast iron, and it is a very complicated, complex engineering structure.

The basic elements of the blast furnace complex include the blast furnace building (the casting yards and bottom house), the top hoist building,the loading system panel room, the air heaters, dust trap, furnace and air heater control building, elevator (Figure 120).

The blast furnace is a shaft type furnace. It is covered at the top by two cones with funnels above them.

In order to protect the furnace lining from damage, cast coolers are installed with circulating water in them. The sealed steel vessel of the furnace takes the forces from excess pressure of the gas medium, the back pressure of the charge, the hydrostatic pressure of the cast iron and other effects. In order to decrease the pressure on the jacket a clearance filled with elastic filler is constructed between the jacket and the lining or coolers.

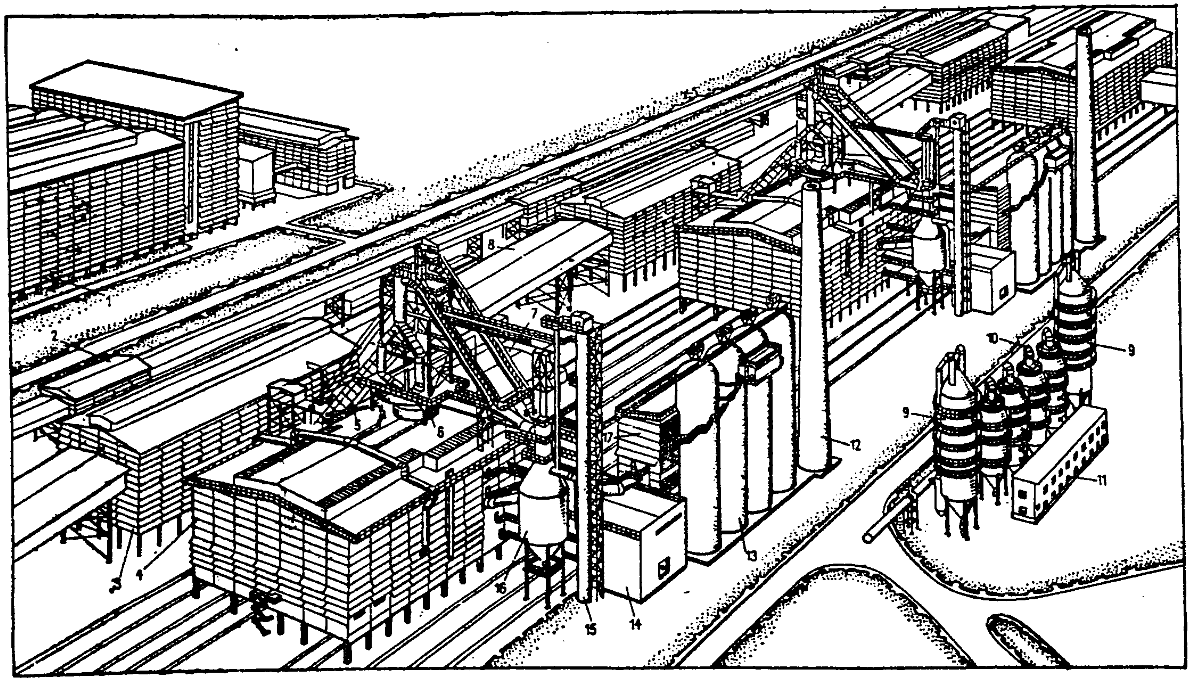

Figure 120. Perspective of a blast furnace complex
1 -- sintering plant; 2 -- coke feed; 3 -- bin trestle; 4,7 -- casting yards; 5 -- inclined bridge; 6 -- blast furnace; 8 -- gallery; 9 -- scrubber; 10 -- electric filters; 11 -- gas cleaning building; 12 -- smokestack; 13 -- air heater; 14 -- furnace and air heater control building; 15 -- elevator; 16 -- dust trap; 17 -- air heater building

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The blast furnace building (the bottom house and casting yards) is the basic building of the complex. The bottom house directly adjacent to the furnace protects the equipment and workers from atmospheric effect. The cast iron and slag are poured into the cast iron and slag carriers in the work area of the casting yard (Figure 121).

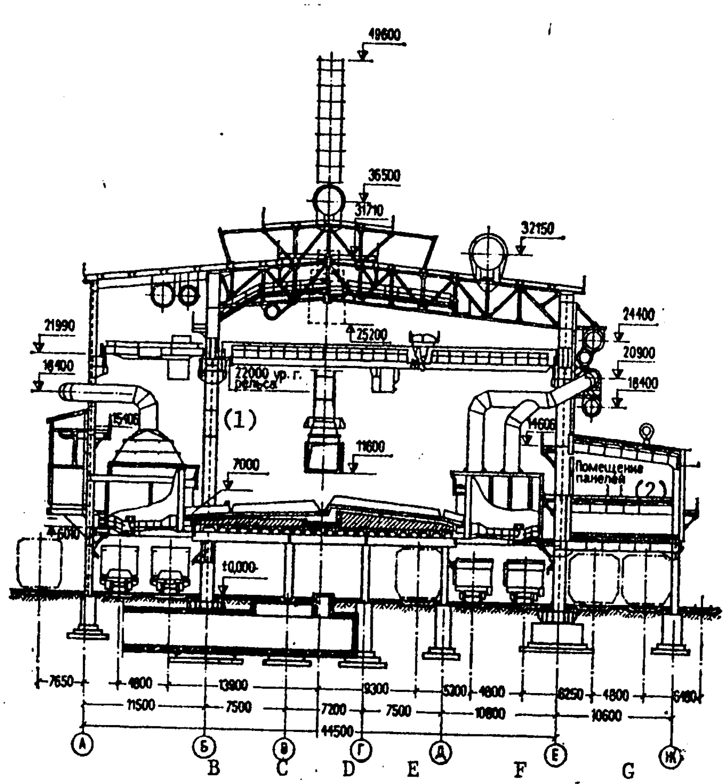

Figure 121. Section of the casting yard of a blast furnace shop along the air heater center line

Key:
1. rails
2. Panel room

The design of the blast furnace shop is based on the following principles:

Compactness of the floor plan, minimum area, minimum length of service lines (pipe lines, tracks, and so on);

Possibilities for further expansion and increasing the furnace volume;

Application of efficient structural layout of the equipment, its elements and assemblies considering the material of the structural elements;

Broad unitization of the space and floor plan parameters, the elements of the buildings and structures as a whole.

In 1966-1970, blast furnace shops were designed and built with a volume of approximately 2700 m^3, and individual furnaces with a volume of 3000 and 3200 m^3. The capacity of the blast furnaces has increased constantly, and at the present time their volume reaches 5000 m^3 or more (Figure 122, a, b).

Architectural-Structural Designs of the Main Buildings of Steel-Making Shops. Steel-making shops of modern metallurgical plants provide the rolling mill shops with hot ingots.

In recent years basic changes have taken place in modern steel-making production. The open-hearth method which predominated in metallurgy for a long time has been replaced by more advanced and efficient converter methods of production.

Converter Shops. The characteristic features of the converter shops are the presence of high-capacity bridge cranes (400-100/16 tons), the heavy operating conditions of the crane, the aggressive environment, high temperatures, the requirement of great height by comparison with the normative height, and so on.

Therefore it is possible to organize converter production only in a multibay building with converter, loading, ladle, and charging bays and a power engineering bay for the gas line of the exhaust heat boiler.

In the majority of cases the oxygen converter shop complex includes the main building, mixer division, slag and charge yards, oxygen shop, ingot mold yard, and so on (Figure 123, a, b). The converter bay is a tiered frame stack, on the platforms of which the process equipment is located. In the loading bay the railroad tracks are located on the working platform to feed cast iron from the mixer division, and so on.

The production divisions of the converter shop (for example, of the Karaganda Metallurgical Combine) include the main building which has three converters of 250-ton capacity each and a mixer division consisting of two mixers with a 2500-ton capacity each.

The subsidiary and service divisions of this shop include the unit for cooling and trapping gases, gas cleaning, the proximate analysis laboratory, electric substation, the pumping and lifting station, the pump for evacuation of the steel, general service facilities and shop office.

The liquid cast iron feed from the blast furnace shop to the mixer division takes place in 140-ton ladles; the cast iron is ladled out by the 180-50-ton mixer-ladle cranes.

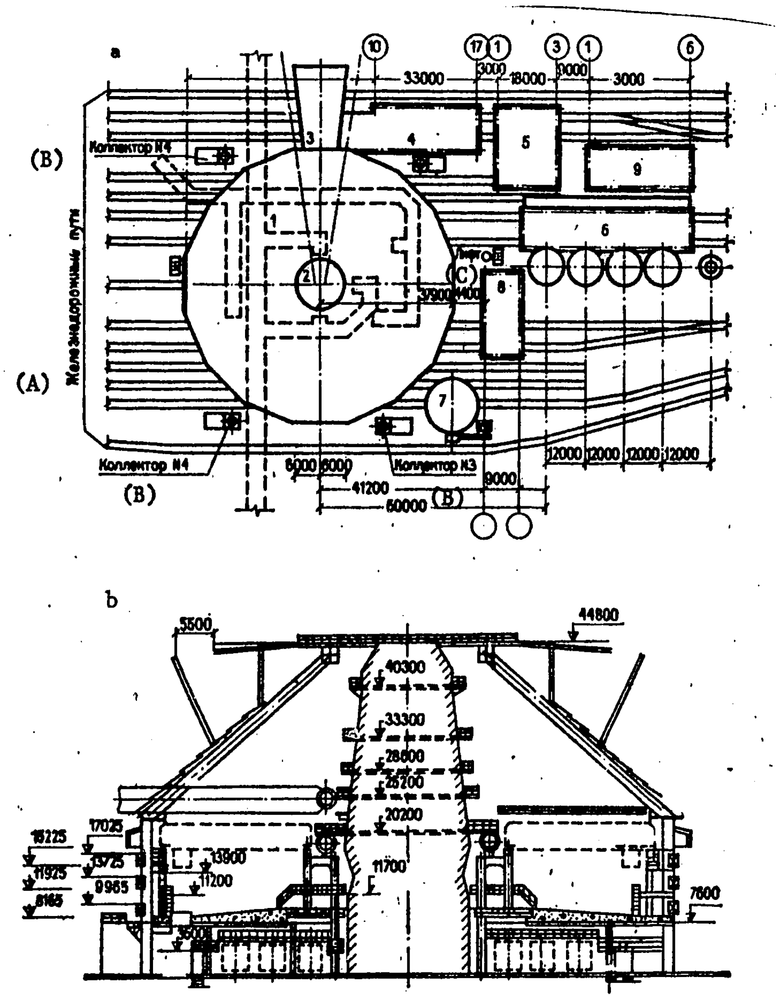

Figure 122. Schematic solution of a polygonal casting yard for a 5000 m^3 blast furnace.
a -- plan: 1 -- casting yard; 2 -- blast furnace; 3 -- top hoist building; 4 -- loading system panel facility; 5 -- furnace and air heater control station building; 6 -- air heater building; 7 -- dust trap; 8 -- filter and dust trap winch building; 9 -- centralized air feed fan building; b -- section

Key:

A. Railroad tracks
B. Header ...
C. Elevator

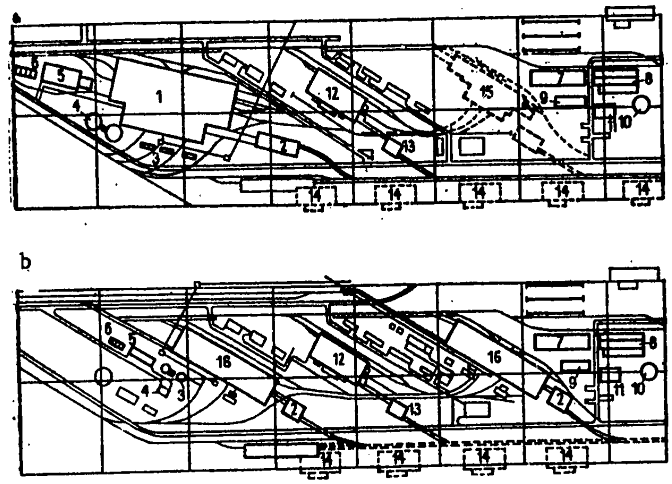

Figure 123. Examples of the location of the converter shop
a -- linear arrangement of the converter shop with three converters;
b -- block arrangement in the form of two converter shops with two
converters in each; 1 -- converter shop of three converters;
2 -- mixer division; 3 -- gas cleaning; 4 -- radial settling tank;
5 -- pump; 6 -- cooling tower; 7 -- air compression station;
8 -- air separation division; 9 -- oxygen and nitrogen compression
division; 10 -- nitrogen gas holder; 11 -- filler unit; 12 -- open-
hearth furnace; 13 -- mixer division of the converter shop;
14 -- blast furnaces; 15 -- location for converter shops;
16 -- converter shop with two converters

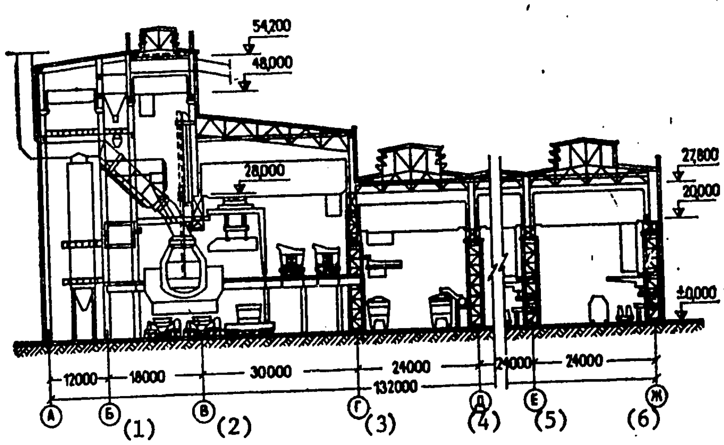

Figure 124. Section of the oxygen converter shop building with
250-ton converters for the Karaganda Metallurgical Combine
(version)

Key: 1 -- B; 2 -- C; 3 -- D; 4 -- E; 5 -- F; 6 -- G

The cast iron is poured from the mixer into the 300-ton cast iron carrier ladles installed on the cast iron carriers. When pouring the cast iron it is weighed on the 500-ton railroad scales.

Example of Architectural-Structural Solution. Thus, for the Karaganda Metallurgical Combine a linear layout has been developed for the oxygen-converter shop with one building for three convertes (Figure 124). The oxygen converters are installed on the bed, and they are equipped with rotation mechanisms by means of which they can be rotated in the vertical plane with loading of the scrap, casting the iron and pouring the steel and slag.

In the final solution for the oxygen-converter shop of the indicated combine by the version with linear layout six bays are provided: power engineering, converter, feed, ladle and two pouring bays. The column spacing in the shop along all center lines is 12 meters with the exception of the row in the vicinity of the converters where the spacing is 36 meters.

All the structural elements of the building are designed to be metal and made of reinforced concrete uninsulated panels 12 meters long, the roofing is metal rolled roofing on metal purlins with a pitch of 1:8. Natural lighting is provided through strip glazing. Fresh air comes into the shop through rotating panels and opening fixed frame windows in the walls. The draft is realized using aeration skylights or shafts. In connection with the great width of the shop and the presence of six bays water is removed from the roof through inside gutters.

Architectural-Structural Solutions of the Basic Buildings of the Rolling Mill Shops. Rolling mill production is the final phase in the metallurgical shop. Flow processing, large-scales and very heavy and awkward equipment are characteristic of it. Consequently, it is expedient to organize these processes in one story, multibay buildings with bridge electric cranes with a wide load capacity range. Passages no less than 400 mm wide must be built along the crane tracks.

The basic bearing structures of the rolling mill and pipe rolling shops usually are made of steel. However, when conditions permit, it is desirable to use prefabricated and prefabricated-monolithic reinforced concrete structural elements. The problem of using reinforced concrete in the construction of the rolling and pipe rolling shops as before retains its urgency.

The buildings of modern rolling and pipe rolling shops are the largest with respect to dimensions among the shops of the metallurgical plant and, as a rule, they determine the architectural-composition and layout solution of the enterprise as a whole. Often the length of the welding or pipe rolling shops reaches 1000 meters with an area of them up to 15,000 to 20,000 m^2. The area of shops can reach 60% of the total area of all of the shop buildings. Consequently, it is necessary to approach the design of the rolling and pipe rolling shops with a special sense of responsibility.

The following groups of rolling and pipe rolling shops are distinguished by the plan layout: bar rolling, sheet rolling and second conversion shops (cold rolling, pipe and so on).

The bar rolling shops are blocks (Figure 125, a) which include the soaking pit division, blooming mill division and billet storage area.

In construction design practice the following compositional solutions have developed which are dictated by the production requirements: the shop building is long, with several parallel mill divisions. The finished product storage area is usually located in the transverse bays closing the mill divisions where if necessary the finished product is finished off (the flaws are trimmed off, and so on).

This layout of the building has significant deficiencies; for example, closed courts are formed which are difficult to ventilate.

The sheet rolling shops (Figure 125, b) are also designed in the form of a block in which the soaking pit divisions and slabbing mills are arranged by analogy with the soaking pit divisions and blooming mill of the bar rolling shops. The sheet mill building has significant length with one direction of bays inasmuch as all of the slabbing mill production is required by one sheet rolling mill and, consequently, there is no necessity for transverse distribution storage bays (they are located in parallel bays).

Billets of shorter length are processed in the pipe shops, and it is possible to feed the products during the processing not only in the longitudinal but also in the transverse direction, which permits the construction of the shop building in a single body with rectangular or close to rectangular outline of the plan with parallel bays in the majority of cases of one height.

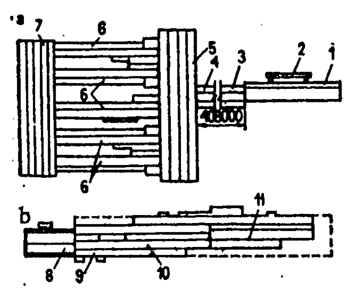

Figure 125. Schematic plans of bar rolling (a) and sheet rolling (b) shops
1 -- soaking pit division; 2 -- coke breeze and slag waste storage; 3 -- blooming mill division; 4 -- continuous billeting mill division; 5 -- billet storage; 6 -- mill division; 7 -- finished product storage; 8 -- two-row soaking pit division; 9 -- slabbing mill division; 10 -- sheet mill division; 11 -- finishing

The basic bays are 30 and 36 meters; in an number of cases 24-meter bays are possible; in new designs 42-meter bays are used.

The column spacing usually is designated as 12 meters along the edge and middle rows. When necessary large spacings of up to 36 meters are used and in individual cases, to 72 meters.

Example of the Space-Floor Plan Solution of a Soaking Pit Division at the Western Siberian Metallurgical Plant (Figure 126). The shop is a two-bay building (36+18 meters). In the basic 36-meter bay are the soaking pits with work areas for servicing the mill and three railroad tracks to feed ingots.

The 18-meter bay is designed for the tail part of the pits, and a 12-meter annex, for the bypass track for return of the transportation feeding ingots from the pits to the feed table of the blooming mill. The common spacing is 12 meters. The height to the bottom chord of the truss is more than 18 meters.

All of the bearing structures are made of steel considering high temperatures; the roof is also steel, on purlins. The walls are erected from uninsulated reinforced concrete panels. Aeration skylighting is provided in the main bay.

The floors in the work areas are brick over a layer of sand, and between the tracks at the zero elevation the floors are gravel over a packed base in case heavy hot ingots fall on them.

Example of the Space-Floor Plan Solution of a Blooming Mill Divison of the Same Plant (Figure 127, a-c). This division was designed in a three-bay building 30+30+24 meters equipped with cranes. In the middle bay is the blooming mill, the 30-meter side bay is designed for removal of trimmings and scale. The 24-meter edge bay is set aside as a machine room (the main engines and equipment), which is separated by a solid wall from the middle bays.

The 30-meter bays have aeration skylights to remove excess heat. A basement is provided under the entire machine room for blowing the engines and location of various equipment. The columns in the middle rows, the crane beams and the trusses for the overheads in the blooming mill bays and scrap bays are steel because of the thermal conditions. The floors in these bays are concrete, and in direct proximity to the blooming mill, they are made of steel plates; in the machine room they are made of ceramic tile.

At the present time important significance is attached to the development of the interior space of the rolling mill shops (Figure 128, a).

Architectural Solution of Machine Building Enterprises. The machine building plants include casting, forging, forging-pressing, mechanical, mechanical assembly and other shops.

The casting shops are distinguished by variety of architectural-structural solutions. Their structure is determined by the volume and the type of production, the nomenclature and the labor consumption of the manufactured castings, the operating conditions and degree of specialization. The casting shop includes the following:

1) The production divisions or sections (melting, molding-casting-knock-out, core, mixture preparation and finishing divisions, the trimming sections, heat treatment and priming of the castings) organized with respect to the production and subject attribute;

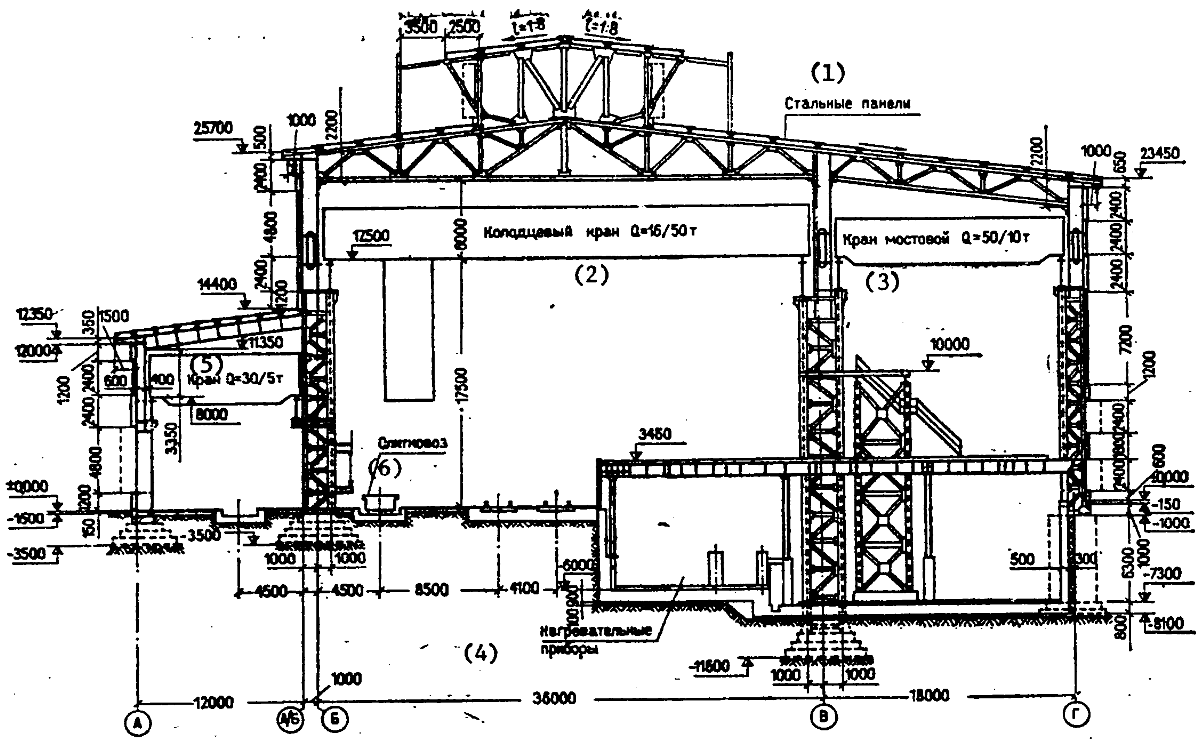

Figure 126. Transverse section of the soaking pit division

Key:
1. Steel panels
2. Soaking pit crane
3. Bridge crane
4. Cleaning elements
5. Cranes
6. Ingot carrier

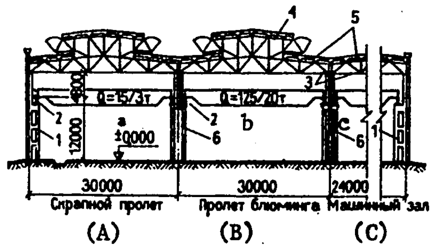

Figure 127. Transverse section of the blooming mill division
a -- scrap bay; b -- blooming mill bay; c -- machine room;
1 -- outside columns; 2 -- crane beams; 3 -- overhead trusses;
4 -- aeration skylight; 5 -- large-panel roofing slabs;
6 -- internal columns

Key:
- A. Scrap bay
- B. Blooming mill bay
- C. Machine room

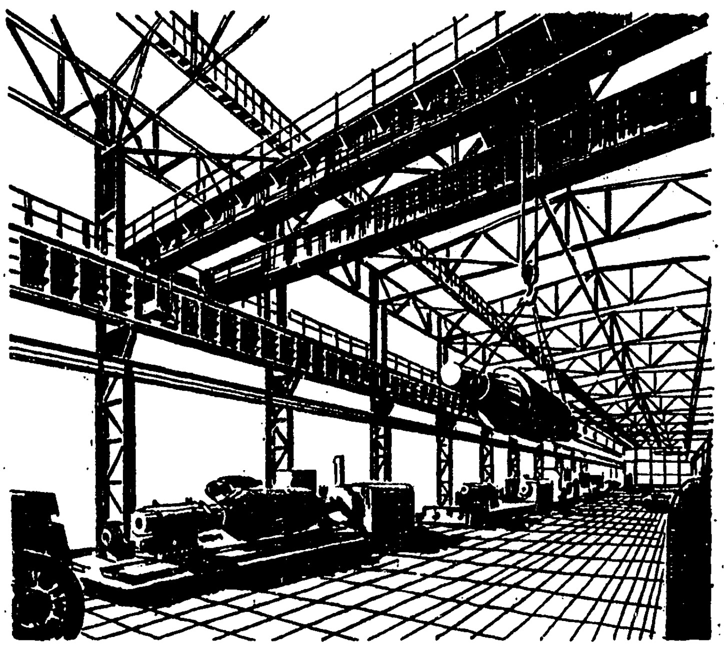

Figure 128. Interior of a hot steel (fragment) rolling shop

2) Auxiliary divisions or sections (mechanical repair and power engineering, pattern-flask, ladle, division for preparing fresh molding materials, recovery of mixtures, frame division, proximate analysis laboratory, section for obtaining carbon dioxide, substations, sections for installing sanitary engineering equipment);

3) Storage areas for charge, fresh initial molding materials, flask, pattern accessories, attachments and tools;

4) Service facilities (various administrative and general services).

Construction design practice has demonstrated that for the construction of casting shops it is possible to use unitized standard sections of industrial buildings. However, it is necessary to consider that the UTS cannot in all cases satisfy the technological requirements of production which causes departure from the adopted parameters.

When designing casting production facilities, unitized standard sections of one story and two story-multibay buildings are used. In the two-story buildings the underground shop facilities are transferred to the first floor. The two-story buildings provide more compact layout of the complex flow casting processes, and they are designed for the steel-making shops, the gray and forged cast iron shops, and so on.

The unitized standard sections of two-story casting shops are developed for buildings without height gradients. Usually the buildings of the casting shops are made rectangular without projecting elements and annexes. The dimensions of the space-floor plan and structural parameters of the buildings and also the position of the layout center lines of the buildings must correspond to the requirements on SNiP II-M.2-72 ("Production Buildings of Industrial Enterprises") and SNiP II-A.4-62 ("Integrated Modular System").

In contrast to the one-story buildings of casting shops, in the sections of which provision is made for overhead transportation and bridge cranes, in the two-story buildings only overhead transportation is provided (suspended from the overhead trusses and the floor collar beams).

The elevation of the floor on the second story is taken as 7.8 meters according to the production requirements. The column grid for the first story is established at 12×6 meters.

In the shops where the magnitude of residual heat generation is 23.2 kilowatts/(m^2-K) or more, aeration using skylights is provided.

Example of Architectural-Structural Solution of a Piston Ring Casting Shop (Figure 129). The casting shop building is designed as a three-bay skylighted building with dimensions of plan of 72×168 m with column grid of 12×24 m. Two production bays of the building are taken as two-story with a first story height of 7.8 meters and the second, 10.4 meters. The third bay, the storage bay, is designed to be one-story.

Forging and Forging-Pressing Shops. These shops are usually located in a separate free or four-bay building. According to the dimension diagrams, the size of the basic unitized standard sections of the buildings is taken equal to 72×144 meters with a column grid of 24×12 meters. However, if necessary by production requirements, other bays can be adopted dictated by the convenient placement of equipment and forgings.

Example of the Architectural-Structural Solution of a Forging Shop at the Volzhsk Automobile Plant (Figure 130). The space-floor plan solution of this shop arises from the production processes taking place in it and also the annual output program of the forging products in the shop. The bays for the metal storage and billeting division having identical room height are arranged perpendicular to the main building. The column grid is taken as 12×24 meters; the bays are equipped with overhead cranes and stacker cranes. This arrangement permits the storage of a 15-bay supply of rolled metal and insures convenience of delivery and unloading of railroad transportation, warehousing of springs and transporting of material from the warehouse to the billet cutting sections and also offers the possibility of efficient placement of equipment of the billeting division.

Mechanical Shops. The structural elements of the mechanical shop are the basic production divisions and sections, the subsidiary divisions and the service and auxiliary facilities (the administrative-office, general services).

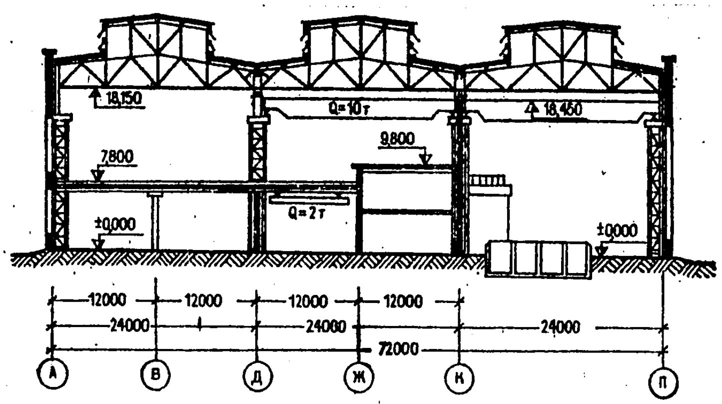

Figure 129. Piston rings casting shop (transverse cross section)

The subsidiary division and the service units include billeting, turning, inspection and repair divisions, workshops for repairing attachments and tools, the power engineering workshop, the division for preparing and distributing coolants and for processing chips, the shop storage for materials and billets, intermediate parts warehouse, inter-operation and tool-distribution storage areas, storage areas for attachments, abrasives, oils and auxiliary materials.

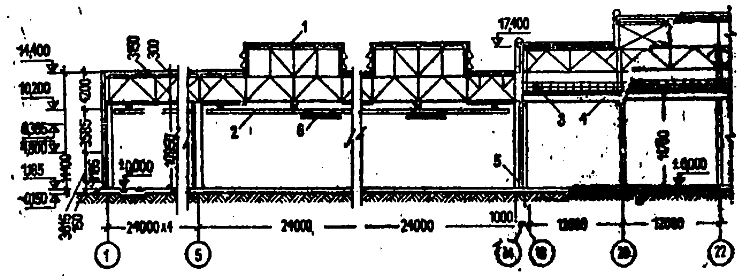

Figure 130. Volzhsk Automobile Plant Forging Shop

1--Protective gravel layer, water-proof mat, complex reinforced concrete slab; 2--overhead-track hoist, Q=8 t; 3--stop; 4--steel crane track; 5--expansion joint; 6--stacker crane, Q = 4t.

The size of the required production area can be approximately determined by the methods of consolidated or detailed design.

With the consolidated method of design the size of the production area of the mechanical section is determined by the average specific area for one machine tool.

In the detailed design the size of the production area of the mechanical shop, its section or flow line is determined on the basis of the production process layout as a result of which the location of the work places, conveyors and other devices, passages and accesses are established.

The production section or flow line is located, as a rule, in one of the shop bays. Consequently, for production process layout of the section or flow line it is necessary first of all to select the longitudinal and transverse spans, that is, determine the column grid of the mechanical shop.

For mechanical shops located in the majority of cases in one-story buildings, the most widespread are the following spans: for light machine building 18 meters; for medium 18 and 24 meters; for heavy 24, 30 and 36 meters. The column spacings are taken equal to 6 or 12 meters.

Noting the column grid, let us proceed to the process layout of the section or shop or flow line.

If the initially selected span does not offer the possibility of achieving satisfactory process layouts, it is necessary to do the layout after taking another bay size

CHAPTER X. AUXILIARY BUILDING AND FACILITY DESIGN OF INDUSTRIAL ENTERPRISES

§49. Organization of the Service Network at the Industrial Enterprises

The auxiliary buildings include the production control buildings and the buildings and facilities for cultural-general services for the workers.

In the Soviet Union the cultural and general services for the workers at the enterprises are given special attention.

The service system for workers at an enterprise can include objects of primary (multiple), daily, periodic and sporadic use.

Four phases of servicing are possible which correspond to the facilities and the structures considering the degree of their approximation to the work places.

The first phase includes the facilities and structures for primary multiple use during the work shift with a service radius of 75-100 meters; the second phase is the facilities for daily use (shop significance) with service radius of 200 m, they are used before the beginning of the shift, at breaks and after work; the third phase is the installations for periodic use which are built for several shops with a service radius of 800-1000 meters; the fourth phase is installations for sporadic use located in the public center of the enterprise. These facilities are visited off work. Their service radius is 2000 meters or more.

The local servicing (at the work places) includes general services (sanitary facilities, smoking areas, rest, warmup and semi-shower facilities); public eating (food shops and vending machines, trays, bins, carbonators, intrashop snack bars); medical services (medical stations, shop pharmacies); cultural-mass services (information and visual agitation stands, and so on).

The shop servicing is realized in buildings especially constructed for this. In them provision is made for general services in the coat rooms, showers and washrooms, including lockers and distribution points for work clothes and also facilities and structures for daily processing of work clothes (if necessary, drying or dusting off, and so on); rest areas are provided at the shops; public eating -- dining rooms (prepreparation, distribution, snack bars); medical services -- health stations and special facilities (inhalers, disinfection units, and so on); mass cultural servicing -- reading areas, training facilities, public organization rooms, and so on.

The intershop servicing is designed for periodic servicing of the workers in the shops and includes the following facilities: laundry and mending room for work clothes requiring preliminary treatment; the facilities for repairing work boots and footwear, and so on; prepreparation dining rooms with several halls, stores for intermediate food products, and so on.

General plant services are planned in the form of a center designed for the cultural and general services installations. This center is usually located on the side facing the developed territory of the city and includes the sporadic service units having general plant significance.

§50. Space-Floor Plan and Structural Solutions of the Facilities for Cultural and General Servicing of the Workers and Production Administration

The design of the auxiliary buildings and facilities of production enterprises intended for cultural and general servicing of the workers is executed in accordance with the instructions of SNiP II-92-76 ("Auxiliary Buildings and Facilities of Industrial Enterprises"), SNiP II-M.2-72 ("Production Buildings of Industrial Enterprises"), and SNiP II-A.5-70 ("Fire Safety Requirements"), and so on.

It is recommended that the auxiliary facilities be placed in annexes to the production buildings (Figure 131, a-d). If it is impossible to satisfy the aeration requirements and protect the auxiliary facilities with permanent work places from production hazards, these facilities are placed in detached buildings. It is necessary to provide heated walkways between the detached auxiliary buildings and the heated production facilities.

Sometimes it is permissible to place the auxiliary facilities inside the production buildings in spaces (Figure 132, a, b). The width of the auxiliary buildings is taken as 12 or 18 meters or more with column spacing of 6 meters. In some cases it is expedient to take a width of 15 meters, that is 6+3+6 meters. The story height of the auxiliary buildings, depending on the conditions, is taken as 3, 3.3, 3.6 and 4.2 meters; the number of stories in these buildings is up to 9.

In the public eating facilities, the health stations, cultural servicing and feeding of nursing babies, it is necessary to provide natural lighting. In the remaining facilities (showers, washrooms, toilets and so on) secondary artificial lighting is permissible.

The showers, washrooms and toilets cannot be placed above the administration facilities, design offices, public organization and eating rooms, health stations or over facilities designed for breast feeding of children or training exercises.

The distance from the door of the most remote room (except toilets, washrooms, smoking rooms, showers and so on) to the nearest outside exit or nearest stairwell must be taken as a function of the degree of fireproofness and number of stories of the building.

The least width of the flights of stairs (net between enclosures), the landings, corridors and passages (except passages between closets and coat rooms) and doors used for emergency exits must be 1.2 meters for landings and flights of stairs, 1.4 meters for corridors and 1 meter for passages.

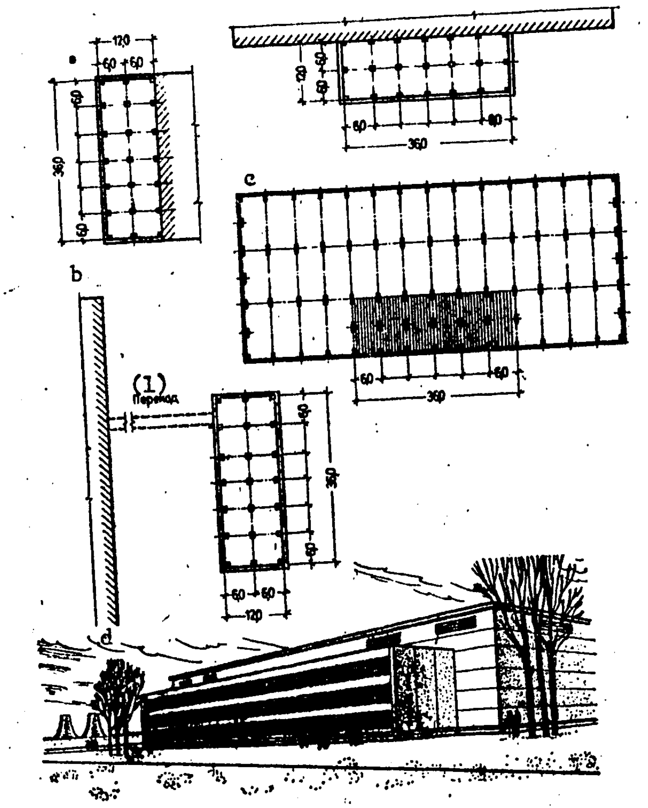

Figure 131. Arrangement of auxiliary buildings and facilities
a -- annexed; b -- detached; c -- built-in; d -- general view of an annex

Key:
1. Perekhod

Open stairs from the entrance hall to the second floor are permissible in auxiliary buildings if the walls and floors of the entrance hall are made of incombustible materials with fireproof limit of no less than 0.75 hour and if the entry hall facilities are separated from the corridors by partitions with doors.

The layout of the general service and other auxiliary facilities is established as a function of the nature of the production process taking place in them, and they are designed according to the sanitary characteristic of the production processes which are divided into four groups (see SNiP II-92-76).

Normative data are presented below on the auxiliary building rooms.

The coat rooms are designed for storing street clothes, house clothes and special clothing.

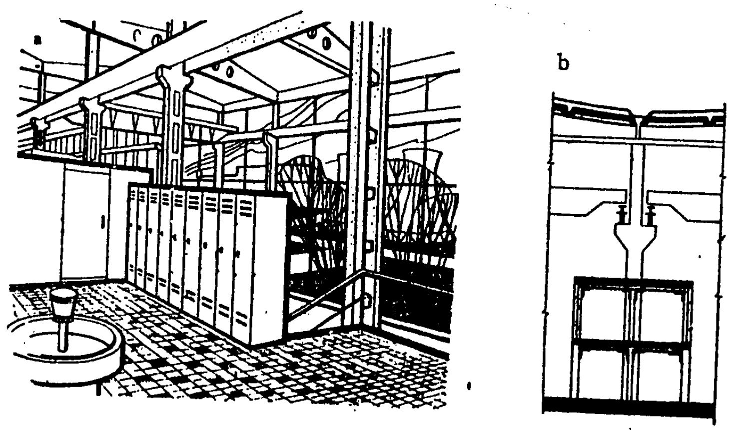

Figure 132. Built-in general services facilities
a -- with the application of sanitary engineering cubicles;
b -- the same outside the range of bridge cranes (under the crane tracks)

For group I and II production processes the coat rooms must be common for all types of clothing. Coat rooms designed only for street clothes and also coat rooms for street and house clothes can be common for all production groups.

For storage of various types of clothing provision must be made for lockers that can be locked or open, with properly equipped compartments (Figure 133, a-c). The compartments of the lockers (on center lines) must have a depth of 50 meters, a height of 165 cm, a width of 25-40 cm (according to Table 5 of SNiP II-92-76).

In the coat rooms (except the facilities with group Ia production processes) benches 25 cm wide must be provided which are located next to the lockers along the entire length of their rows. The design norms for the coat rooms are discussed in SNiP II-92-76.

Showers must be placed adjacent to the coat rooms (Figure 134, a).

Next to the showers are anterooms (Figure 134, b) for drying off and changing clothes equipped with towel hangers and benches.

The showers are equipped with open stalls enclosed on three sides (Figure 134, c), and for group III and IV the production processes, open shower rooms enclosed on two sides with through passages. The shower stalls can also be enclosed.

Shower stalls are separated from each other by partitions made of moistureproof materials with a height from the floor of 1.8 meters, starting 0.2 meters from the floor.

It is not permissible to place the showers or the anterooms to the showers on outside walls.

The dimensions (in plan) of the open shower stalls must be 0.9×0.9 meters, and the closed stalls 1.8×0.9 meters; in this case the dimensions of the changing areas must be 0.6×0.9 meters.

The shower stalls are equipped, as a rule, with individual cold and hot water mixers with control fittings located at the entrance to the stall.

The floors of the shower rooms must have gutters to drain water out of the shower stalls. The gutter width is taken no less than 200 mm, the gutter depth at the beginning of the slope must be no less than 20 mm, and the slope, no less than 1%.

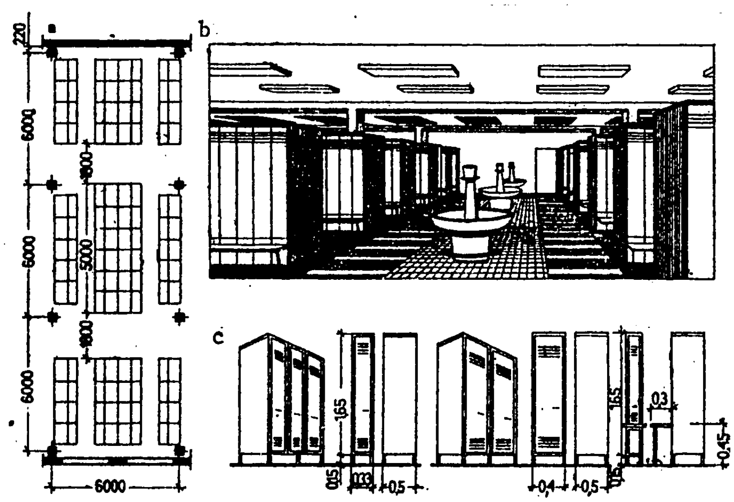

Figure 133. Example solution and equipment of a coat room
a -- layout element; b -- general view; c -- individual and double lockers for clothing

The number of shower grids is determined by the calculated number of people per shower grid working in the largest shift. The calculated number of people for a shower grid, depending on the groups of production processes is taken according to SNiP II-92-76 (Table 6).

The washrooms are placed, as a rule, adjacent to the coat rooms for specialized clothing or the general coat rooms (Figure 135, a-d).

Depending on the nature of production up to 40% of the calculated number of washrooms can be placed in the production facilities near the work places.

The washroom can be single or group. The spacing between the center lines of the wash basin faucets in a number of cases is taken as no more than 0.65 meters. The passage width between rows of wash basins must be 2 meters with five or more wash basins in a row; 1.8 meters with less than 5 in a row. The number of hydrants in the wash rooms must be taken according to the number of workers in the largest shift according to SNiP II-92-76 (Table 7).

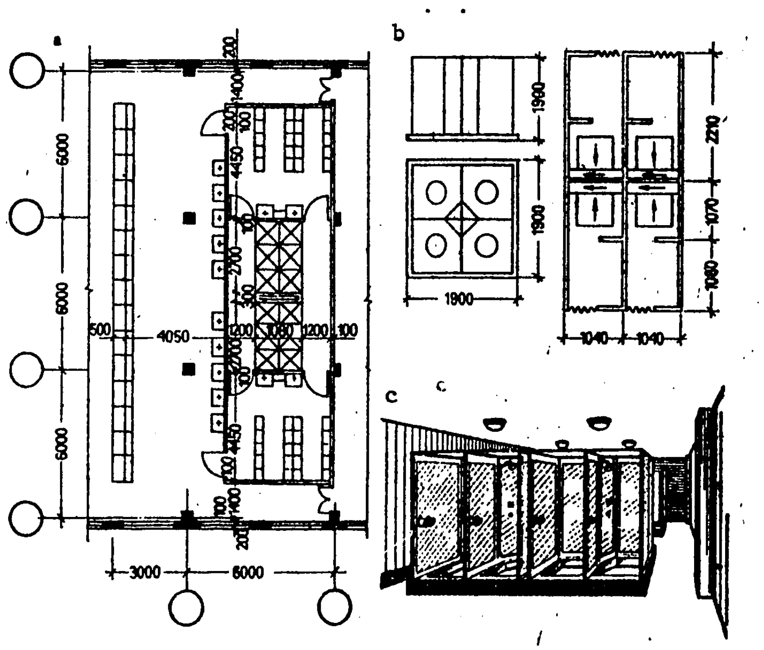

Figure 134. Example solution and equipment for a shower room
a -- located in the hall type coat room; b -- sectional shower
stalls; c -- general view of the shower

Coat Room Modules. The coat rooms, showers and wash rooms can be combined into coat room modules.

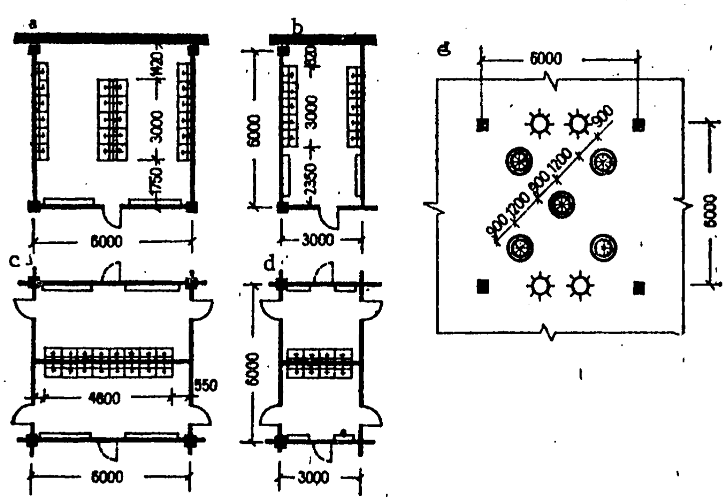

Figure 135. Layout elements of wash rooms.
a-d -- with straightsided wash basins 6×6 meters (a, c); 6×3 meters
(b, d); e -- with circular group wash basins 6×6 meters

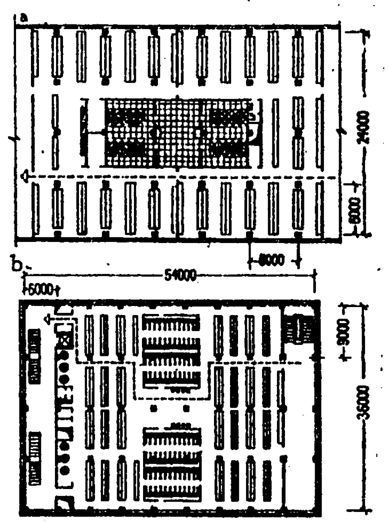

Figure 136. Hall layout of the coat room module
a -- with column grid of 6×6 meters; b -- with column grid of 6×9 meters

Beginning with consideration of the conditions of universality of the design of the coat room module for different groups of production processes and convenience of placement in the module the versions of the hall layout are the best (Fig 136,a, b).

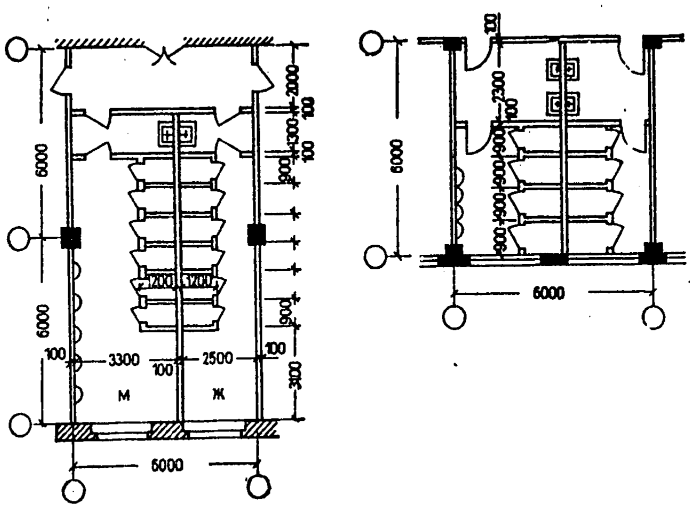

Figure 137. Layouts of toilets

The toilets in multistory production buildings must be located on each floor. Toilets can be placed on every other floor only if the number of workers on two adjacent floors does not exceed 30 people. They must be located on the floor with the larger number of workers.

The distance from the work places to the toilets in buildings must not exceed 75 meters, and to the toilets on the premises of the enterprises, 150 meters (Figure 137).

The toilet entrances should be through anterooms with self-closing doors.

The toilets are equipped, as a rule, with floor bowls or water closets without seats; in the men's toilet urinals are also provided.

The number of sanitary devices in women's and men's toilets must be taken as a function of the number of people using the toilet on the largest shift reckoning 15 people per sanitary unit.

The floor bowls and water closets are placed in individual stalls with doors that open out. The stalls are separated by partitions 1.8 meters high starting 0.2 m from the floor.

The dimensions (in plan) of a stall or toilet for one floor bowl or water closet are taken as 1.2x0.8 meters. In the case of installing heaters or other equipment in the stalls, the stall dimensions must be increased correspondingly.

The urinals are individual wall or floor mounted. The urinal troughs must be lined with glazed tile and equipped with continuous flushing units. The trough width must be no less than 300 mm, the slope toward the traps, no less than 1%, the depth of the trough at the beginning of the slope is taken at 50 mm. The distance between center lines of the wall mounted urinals must be taken as 0.7 m.

Facilities for Personal Feminine Hygiene. With 15 to 100 women working on the largest shift it is necessary to provide hygienic douche facilities 2.4x1.2 m in plan placed in the women's toilet with entrance from the toilet anteroom.

With more than 100 women this facility must be located adjacent to the women's toilets. The number of procedural stalls is taken reckoning 1 stall per 100 women. The stall size is 1.8x1.2 meters.

In the places for undressing, benches are provided above which there must be two hooks each. The number of places for undressing is determined reckoning three places per stall.

The undressing area is determined reckoning 0.7 m^2 per place.

For better organization of the interior space of the administrative and general services facilities, achievement of the best conditions of labor and rest and also corresponding interior levels, the following are recommended:

The application of flexible floor planning of standard floors with separation of the work facilities by prefabricated collapsible partitions;

Individual facilities which are closed with respect to functional purpose are combined into large facilities of so-called hall type;

An effort is made for interrelation of the interiors of individual facilities and the interior spaces of facilities with exterior space.

Smoking rooms must be provided when smoking in the production facilities or on the premises of the enterprise is not permitted because of production conditions or for fire safety and also with a volume of the production facility per worker of less than 50 m^3. These rooms must be placed acjacent to the toilets or the rest facilities. The distance from the worker to the smoking room in a building must not exceed 75 meters, and to smoking areas on the premises of the enterprise, 150 meters. The area of smoking rooms is determined reckoning one worker per shift 0.03 m^2 for men and 0.01 m^2 for women, but no less than 9 m^2 on the whole.

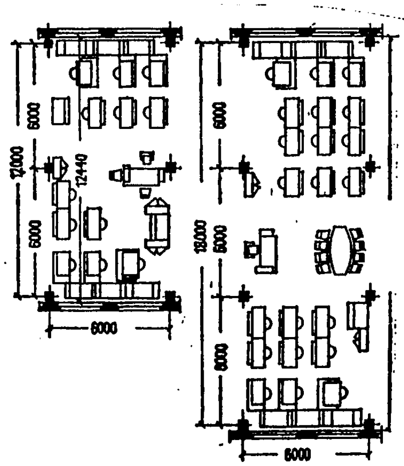

Figure 138. Example solutions of administrative-office facilities with a depth of 12 and 18 meters

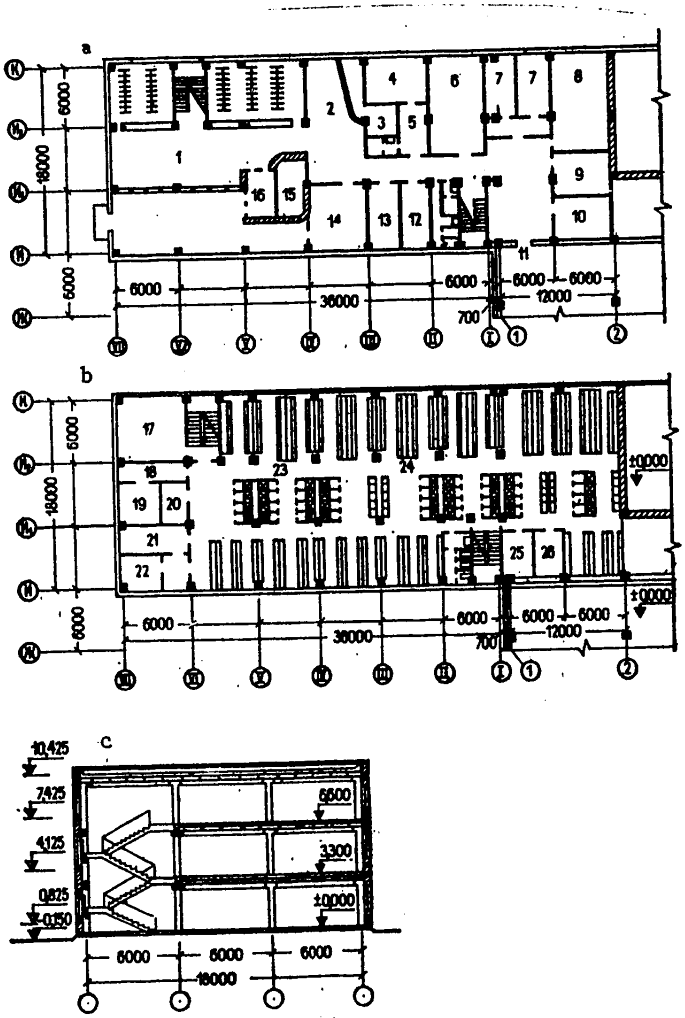

Figure 139. Example layouts of general services facilities
a -- first story; b -- second story; c -- section; 1 -- entry; 2 -- snack bar; 3 -- room for feeding children; 4 -- storage; 5 -- waiting room; 6 -- automatic telephone office; 7 -- shop committee; 8 -- boiler room; 9 -- Komsomol committee room; 10 -- partkom; 11 -- weaving mill; 12 -- rest rooms; 13 -- duty personnel; 14 -- personnel chief; 15 -- time-board; 16 -- passage; 17 -- ventilation chamber; 18 -- rooms for dusting out clothing; 19 -- dirty linen rooms; 20 -- clean linen room; 21 -- photarium; 22 -- medical aid station; 23, 24 -- women's coat room for work clothes and house clothes; 25 -- duty personnel room; 26 -- room for drying hair

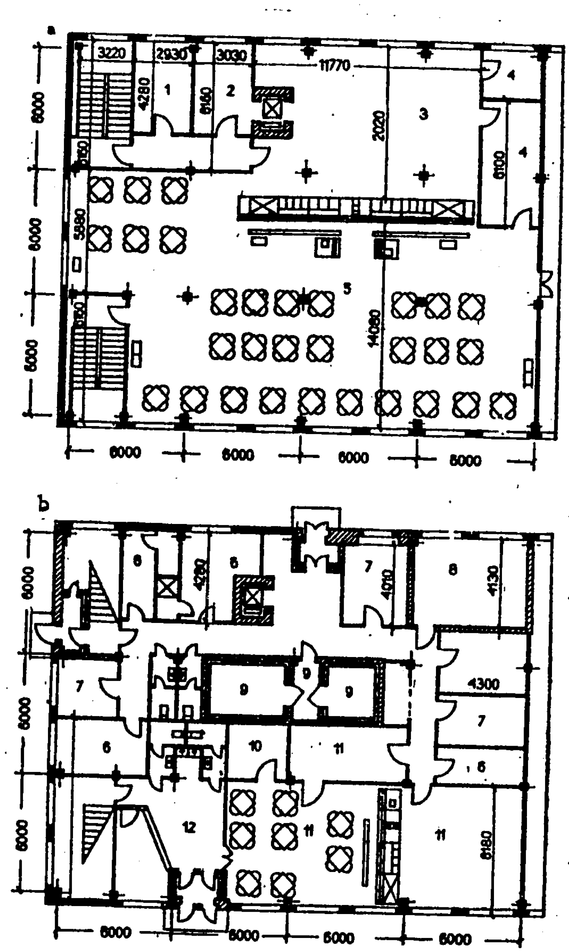

Figure 140. Example layout of a 250-person dining room
a -- plan of the second story; b -- first story plan; 1 -- chef's room; 2 -- prepreparation; 3 -- kitchen; 4 -- washing; 5 -- dining hall; 6 -- offices and personnel rooms; 7 -- storage room; 8 -- ventilation chamber; 9 -- cooling chamber; 10 -- doctor's office; 11 -- diet room; 12 -- entrance hall

Rest facilities. The area of these facilities is taken reckoning 0.2 m^2 per worker on the largest shift, but no less than 18 m^2.

The distance from the work place to the rest facilities is taken no more than 75 meters.

When developing the layout elements of administrative and office facilities and design offices one of the main requirements is the best arrangement of the work places and natural lighting of them (Figure 138).

The layout of these facilities is established in the design assignments, and the area must be taken according to SNiP II-92-76.

In Figure 139, a-c an example of the layout solution of a detached general services building is presented.

Public Eating Facilities. At enterprises with 200 or more workers on the largest shift it is necessary to provide dining rooms, as a rule, prepreparation (Figure 140, a, b).

If the number of workers in the shift is less than 200, distribution dining rooms (snack bars) are provided with hot dishes delivered from the dining room.

The distance from the work places to the dining rooms must not exceed 300 meters.

In the dining rooms and snack bars wash basins with hot and cold water and also toilets (with wash basins in the anteroom) are provided reckoning 1 floor bowl or 1 water closet per 100 places in the dining room.

The number of eating places in the dining room must be taken reckoning 1 place per 4 people working on the largest shift.

The area of the facilities for eating food must be determined reckoning 1 mm^2 per guest, but no less than 12 m^2. The auxiliary facilities are equipped with hot water heaters, wash basins and electric stoves.

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