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I. EXPERIMENTS TO DETERMINE THE STRENGTH OF BRICK LINTELS

By A. Gvotsdev, Scientific Assistant of the National Institute for All Building Matters, Moskva

[Diagrams referred to herein are not reproduced.]

Abstract: Tests on the strength of brick lintels of several types of construction are described, and from these the conclusion is drawn that with the use of cement or cement-lime mortar, the flat arch and reinforced brick lintel exhibit no advantages over lintels of simple brick masonry in horizontal layers. Considering its proportionate strength, the latter type is more economical and therefore preferable to the other.

In 1928, the National Research Institute for All Building Matters, in Moskva, prepared, among other research projects, a number of experiments for determining the strength of lintels in brick walls. These experiments, conducted by the author, are approaching termination, and already permit the formation of several interesting, practical conclusion.

The experimental objects had an inside span of 2 meters

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and a wall thickness of 2 bricks. Their total length amounted to 4 meters, and overall height, 1 meter. The [illegible] was made with either a 1:4 cement mortar or a 1.1:9 lime-cement mixture. In order to minimize the time necessary for the experiments, the test objects were finished separately, and after hardening were moved by crane onto the test site and set up on a permanent, solid foundation. Between the test object and the foundation, there were inserted a layer of mortar which bound the lintel with the foundation.

After the test object had remained on the foundation for one week, the loading of the lintel was undertaken. For this purpose, an opening was provided in the center of the span to receive a beam section which would transmit the load. A hydraulic jack served for power production and was fitted with two previously calibrated manometers for determining the force in effect. This simple apparatus proved completely adequate for the experiment with brick lintels.

All test objects in the first series of experiments had the same effective height, h; however, they differed in their construction. There were flat arches, reinforced brick lintels, and simple lintels with bricks laid in horizontal layers.

The reinforcement of the reinforced brick lintels was inserted either between the first and second brick courses, or between the individual bricks, i.e., in the vertical joints of the lower course which, in this case, was in the form of a horizontal upright course. The total cross section of the reinforcing iron in both cases amounted to 5 square centimeters. The irons were 2.5 meters in length, thus extending 25 centimeters into the supporting part of the test object on either side of the opening and were furnished with straight hooks on both ends.

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The following are results from the first series of tests:

1. The first cracks occur in the flat arches under a considerable less load than in both of the other types.

2. The breaking load in the case of all three lintel types ranges within the same limits, and thus the presence of iron inserts as well as the arrangement of the joints has no notable influence on the strength of the lintel.

These results are surprising, but easily explained. The development of the cracks is to be seen in diagrams 2, 3, and 4: the general character of the destruction process is approximately the same in all three cases. The figures printed along the cracks give the manometer reading at which the cracks appeared.

As can be seen from the diagrams, deterioration begins in all three lintel test types with the appearance of a vertical crack towards the bottom in the center of the span, caused by the tensile stresses in the masonry. The weakest spots of the masonry are never the brick or the mortar but their area of contact. In the flat arch, the occurrence of the first cracks is considerably facilitated by the numerous continuous vertical joints which extend to the under surface of the lintel. This completely clarifies the first result of the experiments. These same vertical joints in the flat arch enable rapid extension of the cracks towards the top, and in a short time the flat arch is split from top to bottom. Thereafter, the arrangement of the joints in the lower part of the lintel can have no further effect; therefore, the process of further deterioration is identical for the first and third lintel types.

After the occurrence of the vertical crack (or sometimes at the same time), horizontal cracks appear at both sides of

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the load opening: the lower part of the lintel is torn from the upper wall. With a load increase, both the horizontal cracks and the vertical crack increase, with the former falling off more or less abruptly to the abutment. Indeed, such a course of the cracks is to be expected from the direction of the main tension trajectories. The distribution of the cracks permits the presentation of a simple picture of the stress distribution for this loading phase: the lintel acts as an arch, the pressure curve runs, rising from both abutments, under the load opening. The resultant lateral shear is taken up by the abutments. In all the tests, the destruction of the lintels was caused by shearing off of the abutments. The resultant crack always runs between the test object and the foundation: examples can be seen in Diagram 3 on the left, and in Diagram 4 on the right. Thus, the weight of the breaking load is primarily determined by the strength of the abutment.

Since the course of the pressure curve is rather accurately determined by the cracks, the lateral thrust corresponding to a specific load can be easily calculated. Immediately prior to the shearing off of the abutments the lateral thrust averaged 20 tons for the tested objects with cement mortar. Measurements taken with Zeiss dial gauges indicate that the abutment shifts very little during the experiment. The stresses on the iron inserts in reinforced brick lintels thus remain relatively low up to the point of fracture, and the inserts take up only a small percentage of the lateral thrust. However, after the union between the test object and the foundation is destroyed, the inserts must play the part of a tension member and, as such, absorb the entire arch thrust. But they are not equal to it; under a thrust of 20 tons with an iron cross section of 5 square centimeter,

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not only the elastic limit, but also the tensile strength of the iron is exceeded. This indicates plainly that a light reinforcement cannot increase the strength of the lintel.

To obtain a clear picture of the iron inserts in the masonry, several reinforced brick lintels were set up on the foundation on roller bearings without the mortar binder. The breaking load in this case was 2 - 2½ times less. Calculations show that the iron tension upon fracture was far below the elastic limit. The lower breaking load is ascribed to incomplete effect of the end hooks. Diagram 6 (not reproduced herein) shows the iron inserts after the experiment. To obtain a better performance on the part of iron inserts, the iron must not only have a larger cross section but must be securely anchored in the masonry. In the tests under usual conditions, the presence of the iron inserts was evident when, at the moment of destruction, a shear crack always appeared between the first and second brick courses - attributable to the drive of the end hooks (Diagram 2).

The most significant data obtained from the first series of tests are: Although flat arches were satisfactory when lime mortar was used, they lost their usefulness with a changeover to cement or cement-lime mortar. They require more work, time and expense, and present no advantages. Therefore, the use of flat arches must be avoided in walls constructed with cement or cement-lime mortar. In all cases where the aperture in such a wall is to be bridged by a flat arch, this type can be replaced by horizontal brick courses. Use of reinforced brick lintels can be considered only in serious cases, and then, upon condition of sufficient iron cross section and satisfactory securing of the iron in the masonry. In the second series of experiments the lintels in

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simple masonry were tested more thoroughly. Test objects of various effective heights, h, were subjected to lessening tests. It was shown that lessening the effective height quickly decreases the breaking load; however, as was to be expected after the first series of experiments, the dimension, h, has almost no effect upon the maximum lateral thrust. Further experiments should clarify the effect of variations in the span, stiffness and strength of the abutment on the breaking load. The two latter factors are of importance for lintels near the corners of buildings. Lastly, the effect of repeated and dynamic loads is being examined.

The scope of this article does not allow further treatment of these questions. Upon completion of the experiments, the results with all pertinent figures will be published in the Operations of the Research Institute for All Building Matters.

II. LOADING EXPERIMENTS OF NONCOHESIVE SOILS WITH LARGE HORIZONTAL DISTANCES

Alfred Scheidig, Eng D
Moskva

Under the above title, engineer Rudolf Weir, Vienna, published in Concrete and Iron, Book 8, 1931, the results of tests involving experimental loading of building ground for a bridge-pile base in Vienna, and observation of the settling of the completed object. Since tests of that type with small and large surface loads are to be welcomed, the execution of the project as a whole and the evaluation of the results and conclusions drawn satisfy but little in this case. The author of the treatise himself does not consider these conclusions final; by presenting them explicitly for discussion purposes, several ideas and suggestions supplementary thereto may be noted.

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The first item is that the Stern ground tester, specified by the Austrian Standards, failed even in this case. Considering the report returned by official commissioner Pierhaumer to the Austrian Committee on Construction Principles which makes no mention of the cone test, but recommends slab tests, it may be concluded that the Stern ground-testing apparatus will soon no longer be the standard, and is constantly losing adherents even in Austria. Thus the question "cone or slab?" may ultimately be decided in favor on the slab.

As concerns the execution in general of the test described by Weim, its fundamental lack is primarily in the absence of all precise information on the geological profile of the building site, and on the physical properties of the soil in the supporting strata. It seems entirely out of the question to want to estimate the behavior of the completed structure in reference to the construction ground on the basis of test loads with a small surface. With the completed parts of the foundation measuring 3.0 x 3.5 meters the thickness of the supporting gravel layer is only 2.1-2.4 meters; what loam, blue clay, etc., lies beneath remains unclarified. As can be seen from Diagram 1 that the gravel layer is determinative for the bearing pressure in the case of the test object, and the clay layer is determinative for the actual structure. The gravel layer is only inserted between, as it were.

All sinking rules, as those of Boussinesq-Schleicher, Terzaghi, and Koegler, cited by Weim, concern homogeneous strata of great thickness. Therefore, they are not immediately applicable in this case. The settlement in the supporting gravel layer occurs according to different rules than the sinking of the substratified loam and clay layers.

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The relatively great settlement in the course of a half year discloses hydrodynamic tension manifestations which balance themselves only in the course of time. Had the sand stratum been thicker, the initial settlement of the finished structure would have been greater, since changes of form take place quickly in sand soils, but very slowly in cohesive soils.

The general rule for the dependence of sinking s upon the size of the load surface F with constant specific ground pressure p_0 = 0.1 is represented in Diagram 2. From a certain surface size on, the sinking remains constant because the influence of the border on the changes of form disappears.

Koegler, who includes the small surfaces in the rule, states this as follows: "The sinking increases with the diameter. For very great surfaces, the sinking approaches a limit, so that from a certain size surface on, the influence of the diameter becomes practically unnoticeable."

Terzaghi, who omits the small surfaces from the rule, says: "In completely noncohesive soils, the size of the surface plays a very small part in a settlement caused by a certain loading unit." The results of Weint's experiment do not in the least contradict "all these theorems," which he terms unsatisfactory. Rather, they actually confirm that the sinking of the large load surfaces is greater than that of the small test surfaces under constant standard pressure p_0. In addition, there are empirical theorems stated by Terzaghi and Koegler, which must receive only a sharper comprehension and limitation as soon as sufficient experimental bases are available. Herein may lie the clarification of the most outstanding differences between theory and research.

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Schleicher's formulae cannot comprehend the nature of soil since they presuppose elastic conduct of the building ground as in the case of the elastic-isotropic semispace. This general transference from solid objects to all types of building ground is naturally not permissible. It is possible for them to give approximate values only for soils which approach solid bodies both in mechanical strength and elastic behavior.

It can be seen from Diagram 2 that the numerical dependence of the sinking upon the surface with the same p_o is also dependent upon the density of the stratification (tight sand - loose sand). It is therefore necessary to determine physical numerical data for the soil layers in undisturbed stratifications and add to the test report. Data such as "gravelly sand on the right bank" and "coarse, firmly stratified gravel on the left bank", etc., are practically worthless. The great difference of the soils on both banks in their conduct relative to the test loading shows accurately the weighty influence of the type of stratification, relative density, structure, content of washable constituents, etc. Weim also states the significance of structure changes after the initial loading. However, it must be considered that the surface with p_o = 3 kg/sq cm already loads the ground at $\sigma_{crit}/3$, i.e., there is only a threefold security against sinking, while with the large foundation surface there is doubtless a considerably greater security against sudden, severe sinking-in. Therefore, the ground under the small surface is, with the same p_o, in a much more critical loading phase than under the large surface. As a result of the marginal influences, the distribution of pressure becomes more unequal and the changes in form

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in the ground become much greater. There evolves an area of energetic disturbance. Our tests in Freiberg showed this clearly. Therefore, "the size of the loaded surface does not change fundamentally" in relation to the compression process, but quantitatively changes very much; and that is decisive.

For all these reasons, the test example described here shows very clearly that it is entirely impossible to obtain through one test loading an accurate picture of all factors determinate of future settlement of the structure.

The ground water has considerable influence on the bearing potential of the sandy soil, but has little to do with its compressibility; thus it may influence the sinking but little.

It appears that too little importance has been attributed the time factor when dealing with cohesive soils. Load and unload periods of 1 - 2 hours are much too short since this leads to ignoring the influence of time.

These observations, with this example, should indicate how necessary it is to set up rules for the undertaking of that type of loading experiment, so that all data for a scientific-technical and practical-technical evaluation of this test are brought up in time. Only then will such test loadings obtain the correct value and completely accomplish their purpose. Bierbaumer's above-mentioned treatise appears to promise such rules for Austria. It may be of interest here that at this time directives are being worked out in the Soviet Union which will make obligatory throughout the Union the execution of soil examinations, test loading, and settling measurements on finished structures. On the basis of her economic organization which unites all construction agencies in one national head

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organization, Russia will be the first nation in a position to attack, [illegible] project in this difficult field.

III. FROM OBSERVATIONS IN RUSSIA

Prof. Otto Graf
Stuttgart

The new Russia is exerting great energy to effect utilization of her natural resources and to decrease her requirement of foreign bulk material. In addition, large industrial plants are springing up which are, as a rule, built according to foreign models, and not infrequently, according to German methods. Foreign sources furnish the equipment. This market is important to our country at the present time, and it will remain thus, probably becoming stronger and more profitable when the new Russian industry is in practice and economic development advances. There can be a cooperation with the Russian industry which can become particularly fruitful for both parties if the technical [illegible] which the Russian engineers expect from the Germans, and which, even, now, is being effected by numerous Germans injecting all their experience and power takes place on an economically sufficient, unrestricted plane.

The delivery of the best possible machinery is already taking its place in this plan. In Russia, I saw equipment which admittedly produced satisfactory results, and other equipment which did not satisfy requirements. Primarily, it appears that the usual prewar custom among good firms of selling only those items which are tested is being regarded here and there less scrupulously than before.

Every machine and every apparatus should be put through complete operation before shipping. If this requirement is

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not conformed with, there are occasionally expenses which, if avoided, would mean a magnificent victory for manufacturing.

My trip through Russia was devoted, among other things, to visiting Russian research and statistical laboratories for the building industry; I also inspected numerous magnificent building sites. There are many experimental plants. The institutions for material-testing often have extensive devices of the best make for statical experiments. In the newer national institutions, active efforts are being made to break into the ranks of the leading institutions. Much valuable work is in progress here.

Apparently, construction takes place under relatively high costs, because certain processes are not in evidence and because expensive precautionary measures are encountered. For example, reinforced concrete supporting frameworks are plastered throughout with a thick coat of rich cement mortar. Obviously, the building industry still requires a strong motivating force. Here, our customary cooperation with foreign industry can considerably accelerate progress.

IV. CHARACTERISTICS OF THE RUSSIAN BUILDING PROGRAM

Prof. Max Mayer, Eng D
Moskva

(Summary by paragraphs)

Paragraph:

1. Geopolitical structure of the USSR as of 1930: division into republics, autonomous oblasts, etc.

2. Division of industrial construction program into three parts, embracing (a) the entire USSR, (b) the republics, and (c) local projects.

3. Government control of materials, finance, import, export; shortages of wood, iron cement; high proces

4. Construction with iron seldom found; involved complications of reinforced concrete construction better suited to Russian characteristic of ponderous theorizing.

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5. Insulating material and roofing material shortage; roofs frequently covered with expensive sheet iron and painted reddish brown or ugly green.

6. Construction carried on in winter with project surrounded by a wooden building heated to minimum 8-degree temperature by numerous individual stoves or central heating; frequent use of connected boiler installation for supplying hot water for concrete and mortar details; cost averages 10-15 percent of total construction cost.

7. Discussion of forms: thick tree trunks set up on building ground every 5 or 6 sq meters: these run through a number of stories; working platform set up at each point where there is to be a reinforced concrete floor: floor form laid on these platforms; irregular height of trunks compensated by either cutting off or addition of scaffolding extension.

8. German consultants state that every floor form should be erected with the finished concrete of the preceding floor as support.

9. In brick work, bricks are first fitted in dry, then removed, and finally set in mortar; two different mortars are used at the same time -- both mixed by the mason himself; a soft mortar for edge fills, and a stiff mortar for the end fill.

10. Manpower shortage is prime difficulty. There is an energetic technical training program, but it is characterized as a tedious process. Russian engineering specialists know something of what takes place in the rest of the world: all foreign technical literature is avidly utilized. Russian special publications publish reports on all new developments.

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11. The Russian engineer is adapted to and greatly interested in all things theoretical.

12. The significance of the first experiment in planned economy and central economic control for the future of all mankind is impossible to predict at this time.

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