NATIONAL CONGRESS FOR STEEL DEVELOPMENT

WELDED STEEL FRAME STRUCTURES IN POLAND AND REGULATIONS CONCERNING THEM

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The development of steel framework constructions on a big scale in Poland dates from only about five years ago. Until that architectural evolution, reinforced concrete retained a prominent and, indeed, almost exclusive place in the field of constructional engineering, tall buildings not being constructed. The tendency, however, towards erecting these, and towards exploiting all possibilities presented by steel as a constructional material, brought about a distinct change in building technique, which has been responsible for the erection of a series of buildings in Poland that have occasioned much interest in European engineering circles. The great development of welding in steel construction in Poland contributed to a vast extent, but quite unexpectedly, to this change and was a most important factor.

The development of steel-framed structures in Poland has been along two distinct lines: the construction of tall and medium-sized buildings, and of small standardized ones. Various causes contributed to this.

While tall buildings are built as individual constructions, the principal use of the second class is in small dwellings where steel lends itself to quick construction and standardization in the form of repeated units. In the former the use of steel as a building material presents the advantages of high endurance and the possibility of speedy erection at any season of the year, qualities which give a considerable advantage over reinforced concrete. In the case of structures of the second type, however, despite the possibility of speedy erection, further aided by new building materials, conditions in Poland are not favourable as yet to the development on a big scale of steel small-house construction. The putting up of the few workmen's settlements, as in Sieminanowice, was made possible because the area is an industrial and iron-producing one.

Steel framing is, therefore, used chiefly in the construction of tall buildings where it competes most favourably with the reinforced concrete, which is so much used and which has been favoured by a big reduction in the price of cement on the breaking up of the syndicates in control. Building regulations allow also a high working stress for concrete in reinforced concrete constructions, while the working stresses for stee are comparatively low. In pre-war times, a 10-storied reinforced concrete building was constructed in Warsaw, and after the war the 10-storied Academicians' House built, as well as the equally high General Mutual Insurance Institution Building.

Nevertheless, from a national standpoint it pays to use steel as a building material, especially since the introduction of welded construction, and this took place in Poland at a much quicker rate than in other European countries.

In the first tall steel-framed Polish building, the Treasury House at Katowice begun in 1930, the construction of the 14-storied section was still done mainly by riveting, although welding also was applied, and the 6-storied section was constructed entirely by welding. A later structure, the 16-storied Prudential Assurance Company Building in Warsaw, begun in 1932, was constructed by welding in the workshop and by riveting on the site. The Post Office Savings Bank was built as an entirely welded structure and the recent structures for the Military Fund Quarters, and for the Navy at Warsaw similarly. The construction of these buildings has proved that costs of welded structures are less than those of riveted ones.

I should like to give here some brief details of three of these most interesting recent Polish steel-framed buildings, namely, the Treasury House in Katowice; the Post Office Savings Bank Building in Warsaw; and the Prudential Assurance Company's Building in Warsaw. I have chosen these buildings not only because, as constructor or technical adviser, I participated directly in their erections, but because their structures are most interesting as regards methods of execution.

The Treasury House Building in Katowice, with officials' quarters, is 14 storeys high, not counting the ground floor and two basement floors (Fig. 1). The building is composed of two parts, the taller of which, 14 storeys high, was executed by riveting and the second part six storeys high, by welding. The steel framework of the two sections is erected on reinforced concrete foundations. The placing of the columns in the 14-storied part within the comparatively thin walls occasioned great difficulty as riveted construction necessitated the use of angle irons. With welding, such difficulties would have been avoided. Stiffeners, vertical and horizontal, were used here. Although the main construction was done by riveting, the use of welding in many places was found to pay, as it simplified the work, especially in regard to the rigid frame connections and the base of the pillars

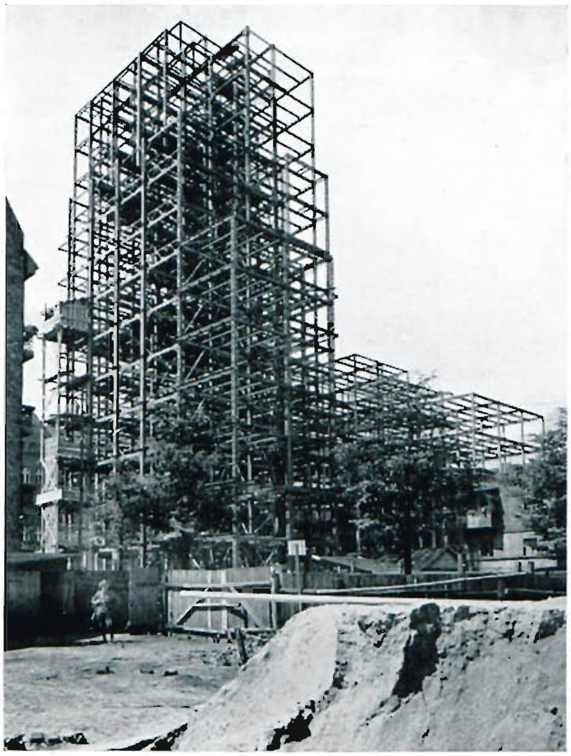

Fig. 1.

which were made of slabs, attaining 60 $^{m}/_{m}$ in thickness (Fig. 2).

The 6-storied part was executed entirely by welding, in the workshop as well as in construction. The columns here are composed of steel channels arranged face to face with plate connections, thus greatly facilitating the joining up with the floor-beams which were welded to the columns.

In the upper part of the columns, plates were used, welded on all sides, including the inside of the channels. Short angle irons were welded to them to support the beams. The columns were joined axially every second storey by splice plates 30 $^{m}/_{m}$ thick. The bracings made of round bars were necessary only for purposes of assembly.

The extensions to the Postal Savings Building in Warsaw was executed by welding, not only because this method offered a saving in cost and increased facility of execution, but especially on account of the narrowness of the site where the adoption of welding offered incomparably more freedom, with every opportunity for carrying out without delay such changes in the structural

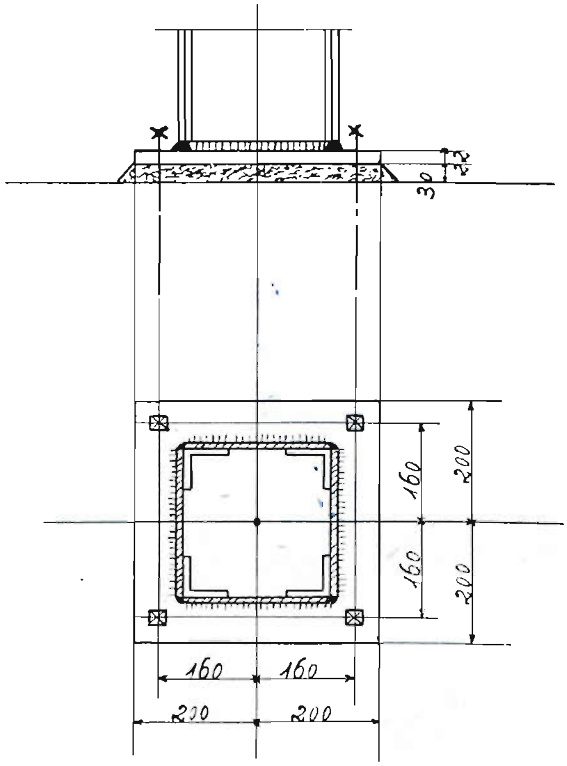

Fig. 2.

scheme as became necessary during the period of construction. Again, the comparative quietness with which welding is done was a most important factor (Fig. 3).

The enlarging of the Post Office Savings Building comprised the widening of the main front, erection of two outbuildings and the banking hall and the adding of two more storeys on to the old building. The columns were built up from steel channels and I beams. Their bases consisted of plates stiffened by means of triangular and trapezoidal plates (Fig. 4).

As this building was erected in a place completely sheltered from all winds, and the masonry-work on the walls progressed on the whole quickly, the use of wind bracing was really superfluous.

The roof of the banking hall was constructed with parabolic trusses, the diagonals of which were

Fig. 3.

made of tubes to allow of better lighting conditions. The cupola at the corner was also made of tubes, acetylene-welded (Fig. 5).

The Prudential Assurance Company Building in Warsaw is rectangular in plan, with a tower 65 m.

Fig. 4.
Column Base in the Postal Savings Bank.

high at the front. Measuring 22·33m. × 16·5 m., the tower is 16 storeys high, or, including the ground floor and upper and lower basements, 19 storeys altogether. The remaining sections of the building are each six storeys high, or, eight to nine storeys including the lower floors.

The foundations and the floors below ground level are of reinforced concrete, as in the Katowice building, while the building and tower were executed as steel-framed construction, welded in the workshop and riveted on the site. The welded construction proved far more economical but the contractors preferred to execute the main assembly by riveting. This partly welded and partly riveted construction, however, saved nearly 10 per cent. in steelwork costs as compared with an entirely riveted one.

The tower sections of the Prudential Assurance Company Building is the tallest residential building in Poland (Figs. 6 and 7). It was calculated on the basis that the east wind passes entirely over the tower's two exterior walls. Cleats were therefore applied in all spaces between columns, diagonal bracings being considered impracticable. The pressure of the north wind was more simple

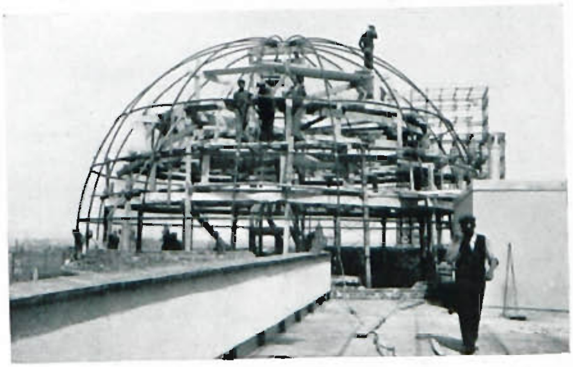

Fig. 5.

to calculate because the proportion of the height to the base of the tower was less in that direction, amounting to about one-third. It was assumed that the pressure from that direction acted upon three rows of pillars (*i.e.*, two outside and one internal), which implied additional strengths amounting to about 15 per cent. in the case of the central columns because of their vertical weight, and to a 100 per cent. increase in the case of the external corner columns.

The columns of the tower were formed as a double section composed of steel channels joined by plates. Their bases consist of plates 100 m/m in thickness. Behind the tower is a steel roof (Fig. 8).

This brief outline description of three steel-framed structures executed in Poland during the last two years, allows us to look into the differences of their construction as well as the different methods of their execution.

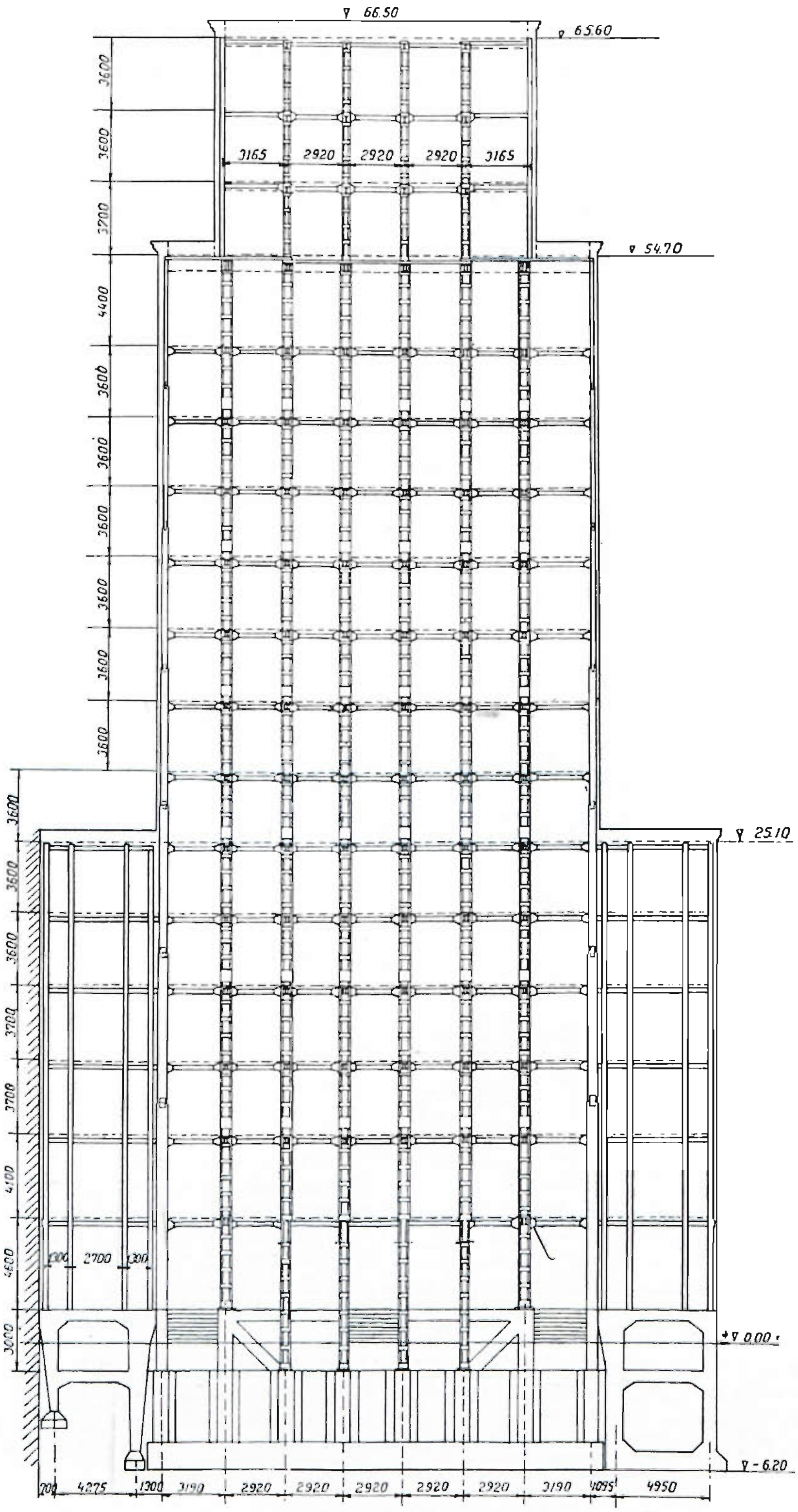
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Fig. 6.

The higher part of the Katowice Building was executed as a riveted structure, the lower part and the Post Office Savings Bank as welded structures, while the Prudential Assurance Building incorporates both methods. The bracings were planned in different ways, based on the structural requirements. It will be observed that there are permanent bracings in the taller parts of both buildings, their variations in character being due to the different architectural conditions prevailing in the two. The 6-storied building in Katowice had bracings used only during assembly, and the 6-storied part of the Prudential Assurance Building had temporary wooden ones. In the Post Office Savings Bank, bracings were not used at all. Whilst on the subject of details, it may be mentioned that the column bases were fabricated of trapezoidal plates in the Post Office Savings Bank Building only, in the others slab-bases were used, which is a far better and easier, though heavier, construction. As for the column joints, experience proved that longitudinal ones are more practical than the transverse ones, while the best are the combined longitudinal transverse joints, notwithstanding opinions to the contrary.

These rules have been already described in many foreign publications. They differ in many instances from Polish regulations of 1928, as well as from similar ones in other countries. Polish regulations are first characterised by very rigid requirements and by the insistence on a severe degree of control and secondly by their liberality in allowing even small firms to experiment towards further welding development. These regulations being severe, yet at the same time, elastic and liberal within defined limits, constitute a strong factor making for progress, as they are framed to take advantage of further improvements in material and construction. They also greatly increase the scope for welding constructions, while securing strength and safety. We may note, for instance, the high stresses permissible in welds for compression, breaking and bending, and for shearing also, in welds under 12×12 m/m, the latter sizes being mostly applied in construction. Notice should be also taken of the fact that permissible stresses for shear are differentiated according to the thickness of the weld, and, in case of small thicknesses, they are much higher than those allowed by German, or even American and Belgian

LIST OF TALL WELDED STEEL-FRAME STRUCTURES IN POLAND

(Bridges not included)

Year	Building	Height Storeys	Weight Tons	Economy (Per cent. over Riveted Structures)	
1929	Treasury Chamber, Katowice	6	180	20	All welded
1929	Treasury Chamber, Katowice ..	14	500	—	Riveted with applications of welding
1930/2	Post Office Savings Bank, Warsaw	7	800	15	All welded
1930/1	Several mansions in Warsaw and Katowice	—	—	15–25	All welded
1931	Building in Warsaw (superstructure)	2	78	10	Shop welded ; field riveted
1932	Prudential House in Warsaw ..	16	1,200	10	Shop welded ; field riveted
1932	Two mill buildings in Ostrowice ..	—	{ 84 / 120 }	15	All welded
1933	Military Fund's Quarters, Warsaw	6	700	15	All welded
1934	Military/Navy Building, Warsaw ..	5	200	15	All welded
1934	Jagellonian Library, Cracow .. (under construction)	8	550	—	All welded

The constructors of welded structures were greatly helped by legislation. The Polish Ministry of Public Works had approved by 1928 the regulations for welded structures, worked out by the author. These regulations were thus the first official document concerning welded structures in the world and to a certain extent have served as model for similar regulations in other countries.* As recently as last year, the Ministry of the Interior issued new regulations for welded structures.

regulations. Such differentiation, although resulting in certain small difficulties of calculation, allows the engineer to take full advantage of the weld, granting the same security throughout the entire construction.

Small welds consist of one layer of weld metal, whereas large ones are composed of several layers,

*This is certified by Mr Rosenberg in 'Zeitschrift des Vereines Deutscher Ingenier,' 1930, No. 38, and by 'Journal of the American Welding Society,' 1933.

according to the thickness of the weld and its diameter. Although each layer must always be well cleaned before applying the next, this connection is not an ideal one. The internal tensions increase with the thickness of the weld. The moment due to eccentricity of the force from the centre of gravity of the weld is higher for thicker welds. It is also very important that the depth of penetration of a weld should not amount to less than 1–2 m/m, whatever the thickness of the weld. The relation between the depth of the penetration from the electrode and the theoretical shearing

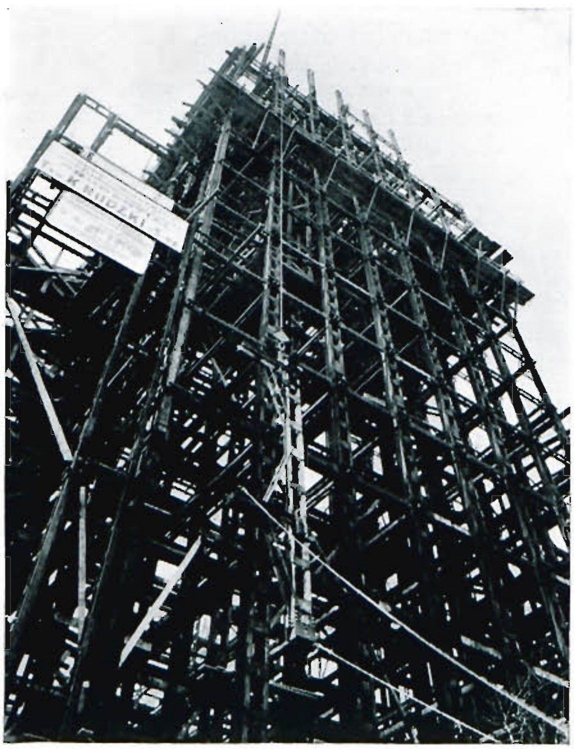

Fig. 7.

section is higher for small welds than for thick ones.

The Polish regulations of 1928 have taken this point into consideration by introducing an increase of permissible stresses (on a sheared unit of surface) according to a straight line relationship. Other countries differ in this respect by introducing a constant permissible stress (on a unit of surface), independently of the thickness of the weld —a regulation very convenient for purposes of calculation but not very economical or practical.

In Polish regulations, the permissible stress for each particular weld has been calculated on the basis of a series of tests executed by the author, admitting 1,200 kg./c.m.^{2} as the permissible basic stress for structural material. These figures should be multiplied, for other stresses, by the coefficient $\frac{k.}{1,200}$

The permissible stresses for welds have been thus expressed by one short formula.

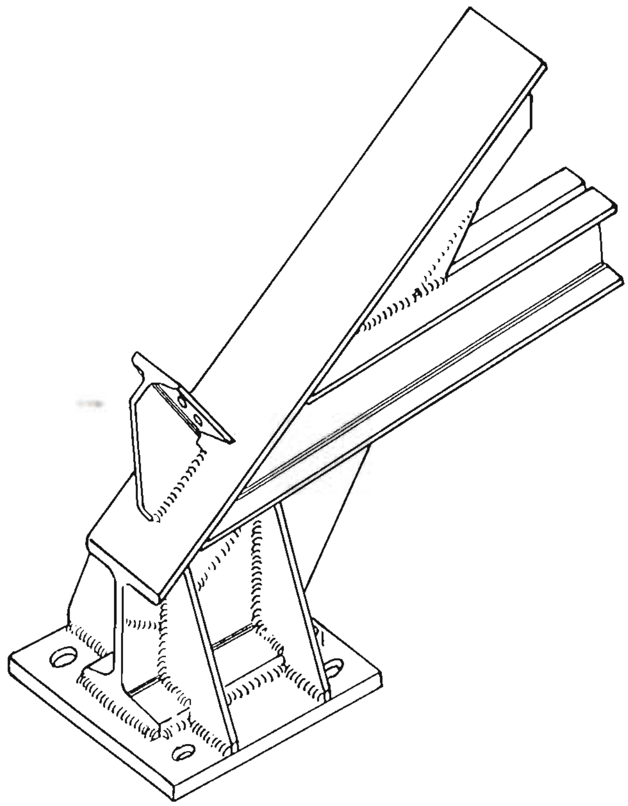

Fig. 8.

These figures are very important because they envisage a more extensive use of small welds, which are more economical as compared with large ones, firstly, because small welds require less electrode and less current, secondly, because the permissible stresses are higher on a unit of surface in thin welds than in thick ones.

Permissible stresses can be increased subject to good results from tests ; thus a premium is placed on good welding rods and on good welders as well. Another evidence of the liberality of the Polish regulations is the paragraph which permits the completion of a construction even where the results of tests are 15 per cent. lower than those required.

In order to avoid uneven work and to assure sufficient control, the regulations call for a weld log-book in which all data concerning the execution of each particular weld in shop or on site, should be entered. The regulations, for the same purpose, introduce a periodical test of the welder's skill. Tests to be executed by the welder are based on the same principle as the previous tests, but their form is simpler. Tests for shearing of fillets in normal shear instead of fillets in parallel shear are decisive, permitting the use of breaking stresses twice as small.

The Welding Diary is in two sections ; the welding shop diary and the site diary. The welding shop diary may be kept either for one particular building or for the whole welding work executed by the corresponding shop. The second method is adopted as a rule, especially in the case of small work, but for a larger job it is wiser to keep a special diary, in order to be able to present it to the building authorities upon request, without having to make special copies.

The field diary has a similar aim as regards the work executed on the building site. Although control of welding in the shop existed before the issuing of these regulations, control of the building site was quite neglected then, as often everybody was ' too busy ' to register all necessary data with the result that the execution of the work on the site was not, of course, as good as in the shop.

These regulations relating to welded structures are the basis of all future development of such structures in Poland. In the natural course of events they have necessarily been adapted to the slightly out-of-date regulations governing steel-framed constructions in Poland, but, as may easily be seen, there is the possibility of applying them unchanged as soon as the regulations are modernized, a step we expect to take place in the near future.

Until now, Polish regulations have not been favourable to steel frames, but rather to reinforced concrete. They allow only a 1,200 kg. stress in principle for building constructions, and 1,400 kg. stress when most unfavourable influences are taken into consideration, while steel, without any damage can bear much higher stresses. Polish regulations are in need of some changes in regard to this.

We may conclude that welded steel construction in Poland is developing very well. A change of regulations governing steel constructions, from the above-mentioned point of view will no doubt greatly contribute to further development, while international collaboration, becoming closer in every way has also its effect on the technical field. Uniformity of regulations for steel structures extended to every individual country, is very desirable and would make for great progress. During the Bridge and Structural Engineering Congress in Paris in 1932, I suggested the introduction of uniform welded-structure regulations, and though my proposition did not come into being, it was, nevertheless, discussed with great sympathy.

The development of steel-frame construction lies in our own hands ; the uniformity of regulations in general, and a possibly intensive exploitation of material within the limits of safety will help very much towards this end.

Note. For detailed descriptions.

[1] for Treasury Building in Katowice—" Czasopismo Techniczne."

[2] for Prudential Building—" Der Bauingenieur."

[3] for Post Office Building—" Przeglad Techniczne."