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New Polish Regulations Concerning Welded Steel Construction

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The first Polish regulations concerning steel welded construction were issued in 1928. Thus Poland claims to be the first country in which official regulations were issued, since the German regulations were not issued until 1930. (See Journal of the American Welding Society, 1933, No. 1.) Dr. Rosenberg states in the "Zeitschrift des Vereins Deutscher Ingenicure," 1930, that till 1930 even Germany was obliged to use either the regulations of the American Welding Society or the Polish regulations.

In 1930 regulations were issued governing welded steel buildings. New regulations have been actually approved; and their chief features are given below.

The new Polish regulations differ considerably from the 1928 regulations and from regulations issued in other countries. They are more severe as regards requirements from contractors, but at the same time are more liberal towards the constructors. They offer big possibilities for welded construction, with a full guarantee of stability and high quality.

Among the features we find high allowable working stresses for tension, compression and bending, as well as for shearing in welds smaller than 12 x 12 mm. (.472 in. x .472 in.). Welds of such dimensions are the most common in welded constructions.

Another characteristic feature is the variation of allowable working stresses according to the thickness of welds, stresses for thick welds being much higher not only than in the German, but also than in the American and Belgian codes. This variation results in slightly greater difficulty in calculation, but on the other hand enables better utilisation of welds, with the same security in each particular weld.

The new Polish regulations are much more elastic than the German regulations, because they allow the use of welding rods and the employment of welders even in cases where the breaking stresses obtained are lower—up to 15 per cent.—than those required by the regulations, which, as mentioned already, are relatively high. In such cases the allowable working stresses are of course accordingly reduced.

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The elasticity of the regulations upwards is even more important. If higher strength is obtained, the allowable working stress may be also increased. This is an evident premium for good welders and good welding rods.

This will serve to illustrate the liberality of the new regulations. New firms are thereby enabled to enter the field, but at the same time there is every incentive to improvement in technique and the reliable firm is favoured.

In order to avoid uneven work and to assure a sufficient control of same, the regulations require a Welding Diary, in which all data concerning the execution of each particular weld in the shop as well as in the building should be entered. For the same purpose the regulations introduce a periodical test of the welder's skill. Tests which have to be executed by the welder are based on the same principle as the tests for weld metal, but their form is more simple. Tests for shearing of fillets in normal shear (end weld) instead of fillets in parallel shear (side weld) are used, the test pieces thus requiring only half the breaking load.

Allowable Working Stresses.

The allowable working stresses for compression, tension and bending are all equal, viz., 1,000 kg/cm. (14,223 lb./sq. in.)2, whereas in Germany where the same basic stress of 1,200 kg/cm (17,090 lb./sq. in.) 2 is permitted, the tensile stress is 720 kg/cm (10,240 lb./sq. in.) 2, and the compressive stress is 900 kg/cm (12,810 lb./sq. in.) 2. Especially in bent butts the German method is very complicated and results often in big difficulties in computation.

We will consider now the shearing stress.—Small welds subject to shearing are undoubtedly relatively stronger than large welds, and this for the following reasons: Small welds consist of one layer of weld metal, whereas large welds consist of several layers, the number depending upon the thickness of the weld and the diameter of the welding rod.

Although the preceding layer has always to be well cleaned before applying the next layer, the connection is not the ideal one. Also the inner

tension at the inner face increases with increase in weld thickness. Finally the eccentric moment on the weld increases with size of weld. Another important point is that the depth of penetration of a weld amounts to 1-2 mm. (04in.-.08in.), for all thicknesses of the weld. The theoretical shearing surface of the weld is thus increased by 1-2 mm. (.04in.-.08in.), and the weld strength increased thereby. This extra depth is proportionally higher for small welds than for thick welds, e.g., with a penetration of 2 mm. (.08in.) the section of a 4 x 4 mm. (.16in. x .16in.) weld is increased by 70 per cent., whereas the section of a 20 x 20 mm. weld is increased only by 14 per cent.

The Polish regulations of 1928 had already taken this point into consideration by allowing an increase of working stresses—on the unit of sheared surface—according to a straight line. The German and American regulations, on the other hand, allowed only a constant stress—on a unit of surface—independent from the weld's thickness. This regulation, while very convenient for calculation purposes, is not very practical.

In Polish regulations the allowable stress for each particular weld has been calculated on the basis of a series of tests executed by the author, 1,200 kg/cm. (17,090 lb./sq. in.) 2 being the basic stress of structural material. For other stresses these figures should be multiplied by the coefficient $\frac{k}{1,200}$. Thus the working stresses for welds in different constructions have been expressed by one short formula. As regards welded structures the above rule concerns the basic stresses of 1,400 or 1,500 kg/cm (19,930 lb./sq. in.) (22,750 lb./sq. in.) 2. These rules can also be easily adapted to bridge constructions.

The differences between allowable shearing stresses in Polish and German regulations are therefore considerable. For the 12 x 12 mm. weld the figures in both regulations are nearly equal. For smaller welds the allowable stresses are more than 40 per cent. higher in Poland than in Germany—for a 5 x 5 mm. weld; for thicker welds a decrease reaching 17.5 per cent. can be noted in Polish regulations. These figures are very important because they render possible the use of small welds being more economical than large welds.

This provision for a further increase of allowable shearing stresses is very important. Such an increase may be used only when tests executed according to this paragraph give adequate results.

Tests of Welding Rods.

The regulations introduce tests for tension, bending and shearing of welds with two purposes; (a) to test welding rods and to allow the use of successfully tested welding rods in welded constructions, (b) to test and control the welder.

The tests of welding rods have been changed as compared with the previous regulations. The required breaking stress has been increased to 3,700 kg/cm. (52,600 lbs./sq. in.) 2, as compared to the old Polish regulations, 2,960 kg/cm (42,100 lbs./sq. in.) 2, and to the German regulations, 3,000 kg/cm (42,700 lbs./sq. in.) 2, which is wholly justified by the improvements in welding rods and welding methods.

Test for shearing of fillet welds introduced for the first time by the Polish regulations of 1928, and adopted with modifications by the Germans, have been now slightly altered. Tests for shearing of slot welds are left out and instead, tests of fillets in normal shear have been introduced in order to facilitate field control.

The Polish regulations have introduced an innovation, by which the Ministry of the Interior may allow the permanent use of welding rods successfully complying with the tests without submitting them every time to tests. This innovation was very desirable because it enabled the choice of welding rods during the work without submitting them to tests. In Poland coated welding rods are chiefly used.

Modern methods allow better control of weld than of any other structural element. These methods are evidently not needed for practical use and, besides are expensive and inconvenient. For this reason the regulations introduced another method, viz., a general control of welders every six months and every time when the welder changes his job, if in the meantime he dropped welding for more than a month. The welder must execute tests for shearing, bending and breaking of fillets in normal shear (end fillets).

In order to facilitate the control and to discern which welder is responsible for each weld, a special Welding Diary has been introduced. The Welding Diary is twofold—the welding Shop Diary and the Field Diary.

The Welding Shop Diary may be kept either for one particular building or for the whole of welding executed by the given shop. The second method is adopted as a rule, especially when small work is executed. In case of a larger job it is wiser to keep a special diary in order to present it upon request to the building authorities without making special copies.

Similar diaries were kept before by better shops, but without much system or success. The obligatory introduction of welding diaries will considerably facilitate the control of welding and compel the contractors to execute welding better and more precisely; this being the aim of this part of the regulations.

The Field Diary has a similar aim with regard to the work executed on the building site. Although the control of welding in the shop existed before these regulations were issued—the control on the building site was quite neglected, by reason that often everybody was "too busy" to enter all necessary data and that supervision on the building site is, of course, not so good as in the shop.

The general plan of the structure, together with statistical calculations, should be found always on the building premises. However, it is not required that detailed plans should be executed before starting work. Plans are often executed in succession. Some secondary construction is often executed direct on the building without any detailed plans. The execution of such plans would often delay the work and the time of completion of the building.

The regulations avoid unnecessary formalities as much as possible because the Welding Diary gives a sufficient guarantee of control.

New Polish regulations are severe, and at the same time elastic and liberal. They require a thorough control and set a high standard for the welding industry. They help at the same time to a great extent in the development of welding industry and to the improvement of welding methods and welded constructions.

The main provisions in the Polish regulations are as follow:—

1. General Principles.

1. The following regulations concern the joining of particular parts of steel structures by means of welding. In statistical calculation of welded constructions the allowable working loads and stresses established for structures should be used.

2. A welding method guaranteeing good results should be used, e.g., electric arc welding by means of alternating or direct current, electro-hydrogen welding, oxy-acetylene welding.

3. The welding method should be adapted to the character of joints in every construction.

4. The Ministry of the Interior can allow in particular cases deviations from the rules in the following regulations, provided adequate tests are carried out and the design is considered satisfactory.

2. The Welding Design.

1. In designing welded constructions, a special shape of sections adapted to their character and qualities should be taken into consideration.

2. The following data should be distinctly indicated on the drawings:—

(a) The welding method, p. 1, p. 2.

(b) All welds—except tack welds, the indication of which is not necessary—with indication of their situation and dimensions.

(c) The sequence of welding.

(d) The general disposition of joints to be executed in the shop and on the building site.

3. Statistical Calculation.

1. The following allowable stresses should be applied when calculating welded joints:—

For Tension, Compression and Bending—1,000 kg/cm (14,223 lbs./sq. in.) 2.

For Shearing in fillets in parallel shear and in fillet welds:

mm.	Dimensions of Joints. 5 x 5	6 x 6	8 x 8	10 x 10	12 x 12	14 x 14	16 x 16	18x18	20 x 20
				Admissible Stresses.					
	300	350	400	450	500	550	600	650	700
kg/cm2.									
	350	400	480	550	600	650	700	750	800
lbs./sq. in.									
	4,980	5,790	6,830	7,110	8,540	9,250	9,960	10,680	11,380

The above figures are valid for the original allowable stress of (17,090 lbs./sq. in.)2. For every other value of k they are to be k—1,200 kg/cm, multiplied by the coefficient $\frac{K}{1{,}200}$

For flanged edge welds the above figures should be increased by 10 per cent. The butt and fillet welds are used in a welded joint—the allowable stresses to be used are those for fillet welds.

In overhead welds the allowable stresses should be reduced by 25 per cent. if the results of tests do not allow the use of higher stresses.

In fillet welds executed in an angle smaller than 60 degrees the allowable stress should be reduced by 25 per cent.

Welds, the quality of which is questionable, should be left out of the calculation.

If the results of shearing tests executed according to p. 6, p.e., 1. c are higher than those foreseen in p.1., p.1.—the admissable stresses should be increased in the same proportion.

3. The transverse dimension of the weld shall be considered as follows:—

(a) For butt welds—the thickness of elements to be joined, in case of two elements of different thickness—the smaller one is to be chosen.

(b) For butt welds—the height of the dotted isosceles rectangular triangle.

(c) For slot welds executed according to Fig. 3—the height of the isosceles rectangular triangle s=0.7 s.

(d) For slot welds executed according to Fig. 4—the minimum thickness of the weld in either direction.

4. When calculating the length of the weld— the crater should be left out. In slot welds the length of the slot should be considered equal to the length of the weld.

5. When calculating stresses in welds subject to shearing the formula P—lw/kg should be applied, with P being the force transmitted by the welds, in kg.; l being the length of the weld after deduction of craters; w being the admissible stress in a weld, in kg/cm.

6. The weakening of a section by assembly holes should be taken into consideration when calculating the welding.

4. Principles of Welding Design.

1. The design of a steel welded construction should be strictly adapted to the requirements of welding technique. This may be obtained by the proper choice of rod and girder sections, of connecting elements and of methods of joining. A proper sequence of welding should be also indicated.

In special cases the direction in which the weld should be applied is to be indicated, as well as the simultaneous welding of symmetric profiles by two or four welders.

2. Welds should be arranged so as to avoid torsional stresses under the influence of external forces.

3. In welded joints consisting of assymetric profiles, welds should be arranged in such a way as to allow the gravity centre of the welds to correspond to the gravity centres of the joined rod. In cases when this cannot be obtained, the resulting eccentric stresses should be calculated.

4. The minimum length of a weld shall be 40 mm., after deducting the craters; as a rule the length of the crater is to be considered equal to the thickness of the welds.

Clear distances between intermittent welds should not exceed 15 times the thickness of the thinner part of the joint or four times the length of the weld.

5. Butt welds should be executed according to the following rules: —

(a) Plates and steel profiles thinner than 4 mm. generally do not require bevelling.

(b) For thicknesses exceeding 4 mm. bevelling is necessary.

It is not necessary to bevel the whole depth of the plate. One to three mm. may remain unbevelled, as shown on drawings 5 and 6 for V and X bevels. The bevelling angle should amount to 60 degrees to 80 degrees. The distance between the joined elements in the narrowest place should amount to 1/3 cm., depending upon their thickness. The distance between the edges is particularly important in acetylene welding.

Fillet welds in angles less than 45 degrees are not permitted.

In slot welds, the width of the slot should be at least equal to five times the thickness of the plate, if the edges are not bevelled or should amount to 10 mm. in bevelled slots.

The minimum clear distance in the transverse direction of the slot should be equal to three times the thickness of the weld.

Slot welds should be always applied when the ratio of width of the gusset or rod to thickness of same exceeds 25.

Care should be taken, when designing welds, to provide easy access to them, so as to enable the welder to execute the work as well as possible.

5. The Staff and the Welding Equipment.

1. The execution of steel welded constructions requires a thorough knowledge and practice in this kind of work and it should be entrusted only to reliable contractors possessing an adequate staff of trained welders under the supervision of an experienced specialist.

2. The contractor entrusted with welding work should possess an adequate and well-kept welding equipment.

6. Materials for Welding.

1. Structural steel conforming to the regulations of the Ministry of Public Works of June 18, 1929, is considered the principal material for welded constructions.

High grade structural steel may be used for welded constructions after having been proved suitable for welding.

2. The quality of welding material should be determined by means of (a) breaking tests, (b) bending tests, and (c) shearing tests.

(a) Breaking Tests—

Two plates 10-12 mm. thick, 150 mm. wide and 150 mm. long are bevelled to about 60-80 degrees and welded on V-butt joint (Fig. 7). The plates are cut then into five strips. The outer strips are left out, three inner strips, 30-35 mm. wide, are reduced in the middle so as to obtain a 8 x 25 mm. section, 50 mm. long. These three strips are tests for tension. The breaking stress should be at least 3,700 kg/cm. (52,700 lbs./sq. in.).

(b) Bending Tests—

The test pieces are prepared in the same way as for breaking tests, according to p.6, p.1, 1.a./, the difference being that they are not reduced in the middle. Their edges are rounded on the wider side of the weld, and the bottom of the weld has to be slightly evened. The test pieces are tested for bending according to one of the following methods:—

(aa) In horizontal position, in conditions shown in Fig. 8.

(bb) In vertical position, according to Fig. 9. In this case the test pieces should be previously bent in a jig or according to Fig. 10. The test pieces should be bent until the appearance of the first crack. The bending angle should be at least 60 degrees.

(c) Shearing Tests—

(aa) Shearing tests for fillets in parallel shear. The test pieces are made of gussets and plate-sections, according to column 1. The welds dimensions are given in column 2.

The shearing stress of the welds should amount at least to ks.

Dimensions of Plates mm. g x b	Dimensions of Welds s x s	The Force S T	Shearing Strength ks in kg/cm
8 x 50	6 x 6	28,o	1,400 (19,940 lbs./sq. in.)
12 x 50	10 x 10	36,o	1,800 (25,620 lbs./sq. in.)
16 x 50	16 x 16	48,o	2,400 (34,190 lbs./sq. in.)

The dimensions of plates b′ .g′ should be chosen so as to transfer easily the force S.

3 x 3—9 tests should be executed. Craters should be left out of the calculation.

(bb) Shearing tests for fillets in normal shear. (Fig. 13)

The test pieces are made from plates joined with gussets by means of welds, quoted below in column 2. The shearing stress of the welds should amount at least to ks.

Dimensions of Plates in mm. Outer Plates g x b	Inner Plates g′ x b′	Dimensions of Welds	The Force S t.	Shearing Strength
6 x 50	10 x 60	6 x 6	16,o	1,600 (22,790 lbs./sq. in.)
10 x 50	15 x 70	10 x 10	21,o	2,000 (28,450 lbs./sq. in.)
16 x 50	20 x 80	16 x 16	28,o	2,800 (39,850 lbs./sq. in.)

3 x 3—9 tests should be made.

3. The results of tests can be 15 per cent. lower than those required by the regulations, and in such case the corresponding allowable stresses should be reduced in the same proportion.

4. The average results should be used. The lowest result, however, should not amount to less than 90 per cent. of the average value, or of the value required by these regulations.

5. The welding rods should be free from rust, scale or dirt.

6. The welding rods should prove good weldability, melt smoothly and evenly without showing any undesirable qualities.

7. In electric arc welding the welding rods should be covered with a protecting and ennobling coating.

The use of uncoated welding rods is allowed if these rods have been submitted successfully to all tests quoted in p.6., p.2.

8. The Ministry of the Interior can allow the use of welding rods manufactured by reliable firms and tested already according to the above regulations, without testing them each time.

7. Preparation for Welding.

1. All structural elements should be carefully marked out and cut to the right dimensions.

2. Places where shop-welds or field-welds will be applied should be marked in the shop on every particular part of the structure.

3. In case of bevelling by means of oxygen-cutting the bevelled surface should be mechanically cleaned if it has to be electrically welded.

4. The surface of plates to be welded should be well cleaned from rust, paint and scale on a distance sufficiently large to prevent impurities to penetrate into the weld. If electric welding is applied, the surface should be cleaned till the metal is shining.

5. If a coating of pure linseed oil, without paint, has been applied on the clean metal, it is not necessary to remove such coating.

8. Welding Implements.

Vices, cramps, jigs and other similar tools can be used for fixing the edges of elements to be welded, but only in such a manner as to exclude any possibility of additional stresses in the weld.

9. Execution of Welds.

The welding shall be executed in the best possible manner and according to the position of the welds. The producing power of the welding torch and of the arc should be adapted to the thickness of elements to be welded, according to technical data. The welded edges should be melted thoroughly in the whole depth of the grove, simultaneously with the welding rod.

2. Care should be taken when elements placed at an angle to one another are welded together, that the weld penetrates into the bottom of the angle created by the welded surfaces.

3. Each weld should be even, clean, continuous without porosity and burnt portions, and generally should possess all external signs characteristic of a well executed weld.

4. The contractor is entitled to use tack welds in order to avoid displacement of elements during the welding process. Tack welds should be as short as possible. If they are put on a spot where later on a strength weld is to be applied, they should be removed before the application of the strength welds.

5. It is forbidden to use tack welds for another purpose than provided for in p. 9, p. 4. On no account can the tack welds be used as support for scaffolding.

6. As a rule a weld should be slightly convex.

7. Poorly executed welds should be removed and re-welded. Before applying a new weld the old one should be cut out carefully with a sharp chisel or a torch.

8. In case of an interruption in the welding process, when starting the welding again care should be taken to obtain a thorough melting of material on the whole surface of contact with the material applied previously.

9. In arc welding of several layers, before starting to superimpose the next layer, the previous layer should be carefully cleaned till the metal is shining and sound.

10. Painting of welds is allowed only after the acceptance of the structure by the Building Authorities. Before such an acceptance, only a coating of pure rust-preventive linseed oil is allowed. Compare p. 7, p. 6.

11. The welder's work should be well protected at a temperature lower than 0 degrees. A sufficient protection from snow, rain and wind should be also assured.

10. The Welding Diary.

A special Welding Diary, referring only to the execution of welds, should be kept during the execution of the welded structure independently of the Field Diary.

The Welding Diary should include the general plan of the welded construction, together with the statistical calculation. Subsequent alterations in the construction should be also entered, together with an adequate motivation into the Welding Diary, and be signed by the foreman and the contractor. All changes should be also entered into the plan of the welded construction.

4. If the Welding Diary does not include the general welding plan, according to p. 10, p. 3, it is not allowed to start welding.

5. All welds executed are entered into the Welding Diary in relation to the general plan and together with the date of execution and the name of the welder in charge of each particular weld.

6. The executive in charge of supervision of the construction required to enter into the Welding Diary all mistakes in the execution, all orders of removal of poorly executed welds and all inaccuracies and differences between the original plan and the executed welds.

7. The state of weather should be also put down in the Welding Diary if it has an influence on the welding process, e.g., rain, snow and wind (strong or weak), low temperature, etc.

8. All plans and working drawings executed, as well as the general plan of the welded construction, should be kept, and should be always available on the building premises.

9. A special Welding Shop Diary, with special reference to pp. 6 and 10 of this paragraph, should be kept for welding work executed in the shop.

After completion of the shop welding the Welding Shop Diary is to be added to the general welding diary.

10. If the welding shop in charge of structural welding is keeping its own Welding Shop Diary, embracing the whole of welding activities executed in the shop and kept accordingly to all requirements mentioned above, it is not necessary to keep a special Welding Shop Diary for every particular construction, according to p. 10 of this paragraph.

Upon request of the supervisor the welding shop is obliged to supply a copy of the Welding Shop Diary, signed by the welding shop owner and the welding shop runner. The copy can contain a part or the whole of welding.

11. The report of the final acceptance of the welded construction should be entered into the Welding Diary to close it.

11. The Control and Acceptance of Welding Work.

1. The control of welding includes activities before, during and after welding.

2. The control before welding includes:—

Examination of welding material and of the professional abilities of the welder, of the weldability of the metal to be welded, of the quality of material added and of the arrangement of the welds.

The results of the control should be entered into the Welding Diary. In accordance with the results of the control the supervisor allows the commencement of the welding.

3. The control during the welding process includes: Examination of welding methods, of the strength of the torch or arc, of the regularity and the process of welding, and of the sufficient melting of edges.

4. The control after the welding work includes: Examination of external signs, allowing the judgment about the quality of welding or the examination of welds by means of special apparatuses.

5. The contractor is obliged to facilitate to the supervisors appointed by the Building Authority the examination of welded joints in the shop as well as on the building premises.

6. At the final acceptance of the welded structure on the building premises the conformity of welds with the approved plan is verified, as regards position, dimensions and length of each weld.

7. The acceptance of the welded structure can take place when the construction is completely finished or part after part, depending upon the progress in work. Every partial acceptance should be entered into the Welding Diary.

8. On larger structures the supervisor is entitled to require from the contractor executing welding work to supply him with an apparatus for testing welds.

12. Welders' Tests.

1. The contractor undertaking welding work is obliged to examine constantly his welders, and only those welders who passed the tests successfully may be entrusted with welding work.

2. Welders should be tested by a skilled engineer every six months and each time when entering a new building job, upon request of the supervisory.

3. Every welder has to execute three breaking tests, three bending tests and three shearing tests for fillet welds in normal shear with good results. The methods and the welding rods used should be identical with those used in the structure.

4. If the welder has to execute overhead welding or has to work in a difficult position, he should execute similar tests. The results of these tests can be 25 per cent. lower than the normal results.

5. The report of the welder's tests should include precise data about the installation furnishing the energy, the material of elements to be joined, the welding rods, as well as all data concerning the execution and quality of the weld from the point of view of a thorough melting and penetrability of the material. The mistakes occurred, the finish of the weld and the welding method should be noted as well.

6. The welder's name, the date and place where the test has been executed, should be also entered into the Welding Diary. In the Welding Diary should be also noted the supervisor's authorisation entitling the welder to execute on this particular structure.

7. The contractor is held responsible for the skill and efficiency of the welder.

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