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(दूसरा पुनरीक्षण)

Welding of High Strength Steel Bars for Reinforced Concrete Construction — Recommendations

(Second Revision)

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Indian Standard

WELDING OF HIGH STRENGTH STEEL BARS FOR REINFORCED CONCRETE CONSTRUCTION — RECOMMENDATIONS

(Second Revision)

1 SCOPE

This standard lays down recommendations for welding high strength steel bars conforming to grades Fe 415, Fe 415D, Fe 500 and Fe 500D of IS 1786 by flash butt welding, shielded metal arc welding, gas pressure welding and gas metal arc welding (GMAW) using CO_2.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in Annex A.

3 TERMINOLOGY

For the purpose of this standard, definitions given in IS 812 shall apply.

4 PLANS AND DRAWING

Plans and drawing for welding reinforced steel bars shall be prepared in accordance with SP 46.

5 SYMBOLS

Symbols for welding used in plans and shop drawings shall conform to IS 813.

6 WELDING EQUIPMENT AND ACCESSORIES

Welding equipment and accessories used in welding of steel bars for concrete reinforcement shall conform to the requirements of the appropriate Indian Standards, where available. Where an Indian Standard is not available, equipment and accessories shall be of the best available quality. Their capacity shall be adequate for the welding procedure. A general guidance for selection of equipment and accessories is included in Annex B.

7 PARENT METAL

The parent metal shall be of guaranteed weldable quality of steel conforming to IS 1786.

8 SAFETY AND HEALTH REQUIREMENTS

Safety and health requirements as prescribed in IS 818 shall be applicable. Fire precautions shall be as given in IS 3016.

9 ELECTRODES

Electrodes used shall conform to IS 814.

10 WELDING PROCESSES AND PROCEDURES

10.1 General

10.1.1 High strength deformed steel bars shall be either butt welded or lap welded. Butt welding may be carried out either by flash butt, gas pressure or by shielded metal arc welding process. Lap welding may be carried out either by shielded metal arc welding process or by gas metal arc welding (GMAW) using CO_2.

10.1.2 Bars of unequal diameter may be welded. However, in case of butt welding, the difference in diameter of bars shall not exceed 5 mm. Where unequal diameter bars are welded, the dimension '*d*' mentioned in this standard refers to diameter of the smaller bar.

10.1.3 The surface of the ends of the bars to be welded shall be clean and free from rust, paint, grease and/or other contaminants which are likely to affect the quality of weld.

10.2 Flash Butt Welding of High Strength Deformed Steel Bars

10.2.1 Flash butt welding may be adopted if a large number of welding has to be done at the same place and when the electric supply is available of the required capacity in respect of the cross-sectional area of the maximum size of the bar to be welded.

10.2.2 *Procedure*

10.2.2.1 The ends of the bars to be welded should be placed in proper alignment in clamps so that bent or eccentric joints do not result. The clamps should be cleaned before each welding operation to avoid current loss and to eliminate harmful notches or grooves due to burning in of spots of arcing.

10.2.2.2 The bar ends shall be uniformly pushed against

each other from the moment of contact to the up-setting. The transformer regulator should be so set that the current at the contact area is between 85 and 90 A/mm^2.

10.2.2.3 If the capacity of butt welding machine or the available power is not sufficient to take the load for welding from cold, welding may be done after preheating. By making and breaking of the contact arc repeatedly, heat can be made to spread over the entire cross-section of the bar. The number of short-circuits (contacts and reversing) should be kept to the minimum possible so that the welding time and spread of heat in the longitudinal direction in the bar is minimum. Satisfactory joints with only slight reduction in original strength of the bar can be achieved with current density up to 25 A/mm^2.

10.2.2.4 In automatic machines, the flash rate should be so set that a continuous flash without interruption can be achieved. If the rate is set, too high additional short-circuits are required leading to heat spread. If the rate is too low, the flash will be interrupted and consequently air penetrating into the joints will form oxides. If the machine is hand-operated, the flash should be maintained to avoid interruption.

10.2.2.5 For bars with sheared ends, a burn-off (flash-off) length of about 5 to 7 mm is required (this length is practically independent of the bar diameter). Very short burn-off lengths lead to defective welding because all the impurities may not have been removed from the place of welding. Increase in the burn-off length will spread heat along the length of the bar thus reducing the strength of the bar.

10.2.2.6 The up-setting should result from the burning off, that is, without interruption in the rain of sparks. The electric supply should be switched off about 1/3 to 1 s after the start of the up-setting or in the case of automatic machine after 1 to 3 mm of up-set travel.

The voltage and frequency of the current should be checked before commencing the welding operation. Deviations from the nominal value or large fluctuations during the operation may lead to gross defects in welding. Wherever possible, welding should be done during day time when the total load on the network is fairly balanced.

10.3 Butt-Welding by Shielded Metal Arc Welding Process

10.3.1 *General*

Butt-welds by metal arc welding process are normally adopted to join bars of thickness more than 20 mm.

10.3.2 *Preparation for Welding*

10.3.2.1 The preparation of the edges of the rods shall be as shown in Fig. 1. The edges shall be prepared by shearing, machining, or oxy-acetylene flame cutting. Beveling may be made by machining, grinding oxy-acetylene cutting. The fusion faces and the surrounding material shall be free from scale, dirt, greases, paint, rust and contaminants.

10.3.2.2 When it is not possible to rotate the bars for carrying out all welding in flat position, the edge preparation shall be such that welding is done on both sides in the vertical position.

10.3.2.3 All the bars to be butt welded should be aligned and set up in position with their axis in one straight line. This may be done in a jig or by means of a clamp or by using guides. Rotation of the bars should be avoided until they are adequately welded so that no disturbance to the alignment is caused and no twist is

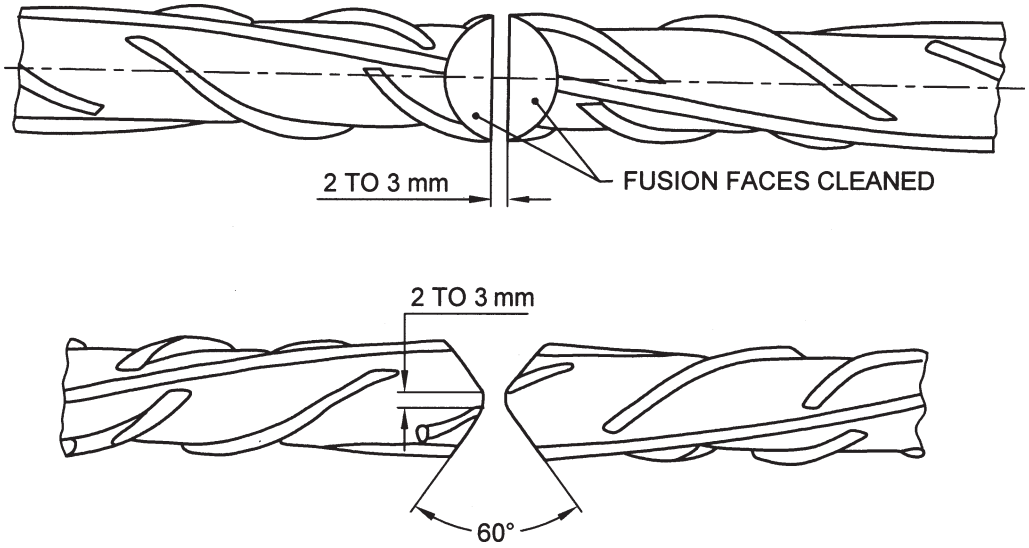


FIG. 1 EDGE PREPARATION

introduced in the bars during the process of welding. The joints may not be out of alignment by more than 25 percent of the thickness of the thinner material for material up to and including 12 mm thick, or by more than 3 mm for thicker material.

10.3.3 *Electrode*

10.3.3.1 Welding electrodes with flux covering of rutile (R) or basic (B) type as per IS 814 are recommended for better results depending on the size of the bar to be welded. Storage of the latter type and their drying immediately prior to use must be strictly in accordance with the recommendation of the electrode manufacturer.

10.3.3.2 The size of electrodes depends upon the position of the bead and thickness of the bar to be welded. The root runs should be made with electrodes of size not exceeding 2.5 mm. For successive beads, the size of the electrodes should be progressively increased so that in the top bead, the electrode size does not generally exceed 3.15 mm for 20 mm bars and 5 mm for 40 mm bars.

10.3.3.3 Concentration of heat shall be avoided by proper welding sequence and manipulation of electrodes.

10.3.4 *Procedure*

10.3.4.1 The sequence of welding beads is shown in Fig. 2. The runs 1 to 4 are made in the position of welding best suited for the quality of the weld. Besides the interruption in welding required for cleaning of each bead, a pause shall be made after every second bead and the bar is allowed to cool. The temperature of the bars at a distance of about one bar diameter from the joints shall not exceed 300 °C immediately after the bead is made. Before commencing the next bead, the temperature shall not exceed 250 °C. The temperature may be checked approximately by using temperature indicating crayons. However, in the absence of temperature indicating devices, the bar may be allowed to cool down to hand hot temperature before the next bead is deposited.

After completing bead 4, the bars are turned through 180° and the beads 5 to 7 are made in the same manner as described above. The top bead 8 is deposited as the joint is continuously rotated and the size of the reinforcement should be approximately as indicated in Fig. 2.

10.3.4.2 In the case of non-rotatable bars, the beads 1 to 4 should be made as explained in **10.3.4.1** The welder then moves to the other side and beads 5 to 7 are similarly made. It is difficult to deposit a uniform top bead for non-rotatable bars and it may be necessary to make two or more separate annular runs so that the joint is approximately axisymmetric and has sufficient reinforcement as shown in Fig. 2.

10.4 Butt Welding by Gas Pressure Welding Process

Gas pressure welding is basically a hot forging process of joining the two bars end-end. The bar ends are heated by a multi-nozzle burner using oxy-acetylene flame and fused by forcing the two bar ends against each other under pressure to effect a solid phase welded joint. Annex C gives more information on recommendations in regards to the preparation for welding procedure and equipment.

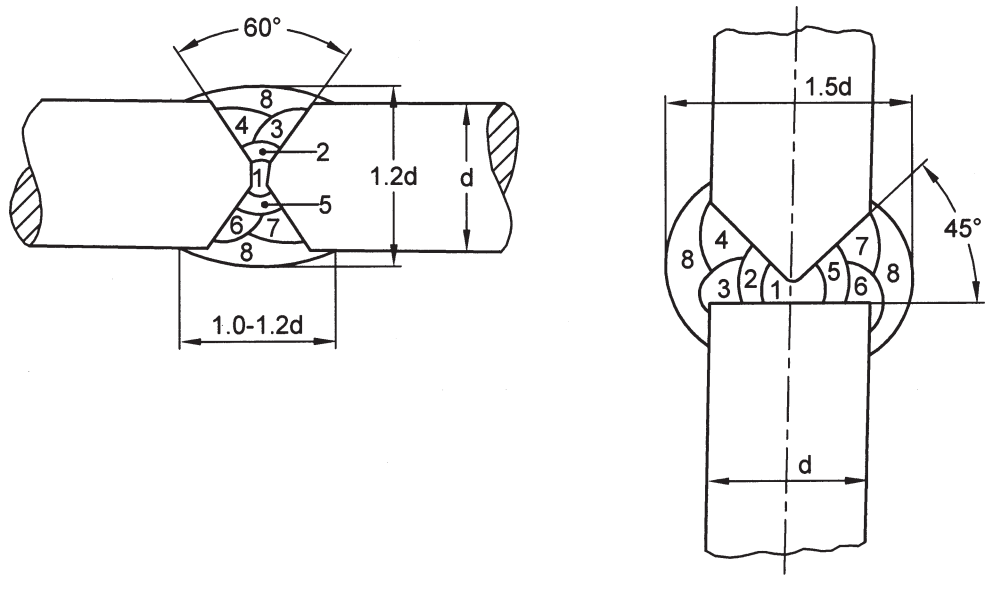


FIG. 2 SEQUENCE OF WELDING

10.5 Lap Welding of High Strength Deformed Steel Bars

10.5.1 *General*

Lap joints may be made in high strength deformed steel bars of all sizes. They are preferred when access for welding is from one side only, and while connecting prefabricated units. Use of electrodes with flux covering of Type 3 or Type 6 of IS 814 are recommended for better results depending on the size of bar being welded. Storage of the latter type and their drying immediately prior to use must be strictly in accordance with the recommendations of the electrode manufacturer.

10.5.2 *Preparation for Welding*

Edge preparation is not necessary for lap welds. The joint faces and the surrounding material shall be free from scale, dirt, grease, paint, rust and contaminants.

10.5.3 *Electrodes*

The size of electrodes according to the diameter of the bar to be welded shall be as follows:

Normal Diameter of Bar, d mm	*Size of Electrode, Max* mm
Up to and including 10	2.5
Over 10 up to and including 18	3.15
Over 18 up to and including 28	4.0
Over 28	5.0

10.5.4 *Procedure*

The arc should be struck as shown in Fig. 3. Somewhere in the middle of the joint and not at its beginning.

The movement of the electrode for welding lap joints in the horizontal and vertical position is indicated in Fig. 3.

The various lap joints used to connect high strength deformed steel bars are shown in Fig. 4 to Fig. 7.

In Fig. 4 to Fig. 6, the dimensions indicated as '5*d*' for single side welding should be halved to '2.5*d*', if the welds are deposited from the opposite side also. The single-strap arrangement shown in Fig. 7 is not recommended where access is from one side only. In the case of joints illustrated in Fig. 6 and Fig. 7, the strap material shall also conform to **7** and the strap cross-sectional area should, at least, equal that of the bar to be joined.

10.6 Gas Metal Arc Welding (GMAW) Using CO_2

10.6.1 GMAW uses a continuous and consumable wire electrode and CO_2 as the shielding gas. This welding procedure should be carried out indoors. GMAW is not recommended for butt joints.

10.6.2 Annex D gives more information about GMAW.

11 VISUAL INSPECTION

Each welded joint shall be visually inspected for the following:

a) *Shape of profile* — The profile of the welds shall be uniform, slightly convex and free from overlap at the toes of the welds.

b) *Uniformity of surface* — The weld surface shall be uniform in appearance throughout its length and shall show no pronounced hump or crater.

c) *Degree of undercut* — The welded joint shall be free from undercut but slight intermittent occurrences may be disregarded.

d) *Freedom from surface defects* — The surface of the weld shall be free from cracks, cavities, solid inclusions and other visible defects.

e) *Misalignment* — The misalignment of the bars welded shall not exceed one-fourth of bar diameter or 5 mm, whichever is less.

NOTE — Misalignment shall be evaluated on the basis of smaller diameter in case of bars of unequal diameters are used.

12 INITIAL TESTS

Prior to production welding, test welds shall be carried out under the local production conditions to establish that the proposed joints can be made satisfactorily. For the purpose, the tests shall be the same as in **13** but only 3 test pieces will be required for tensile test and 3 for bend test. Such initial tests shall be repeated, if there is any change in,

a) the welding process;
b) the grade of high strength deformed steel bars;
c) the type or size of electrode;
d) the welder; and
e) the position of welding, unless the new position is an easier one.

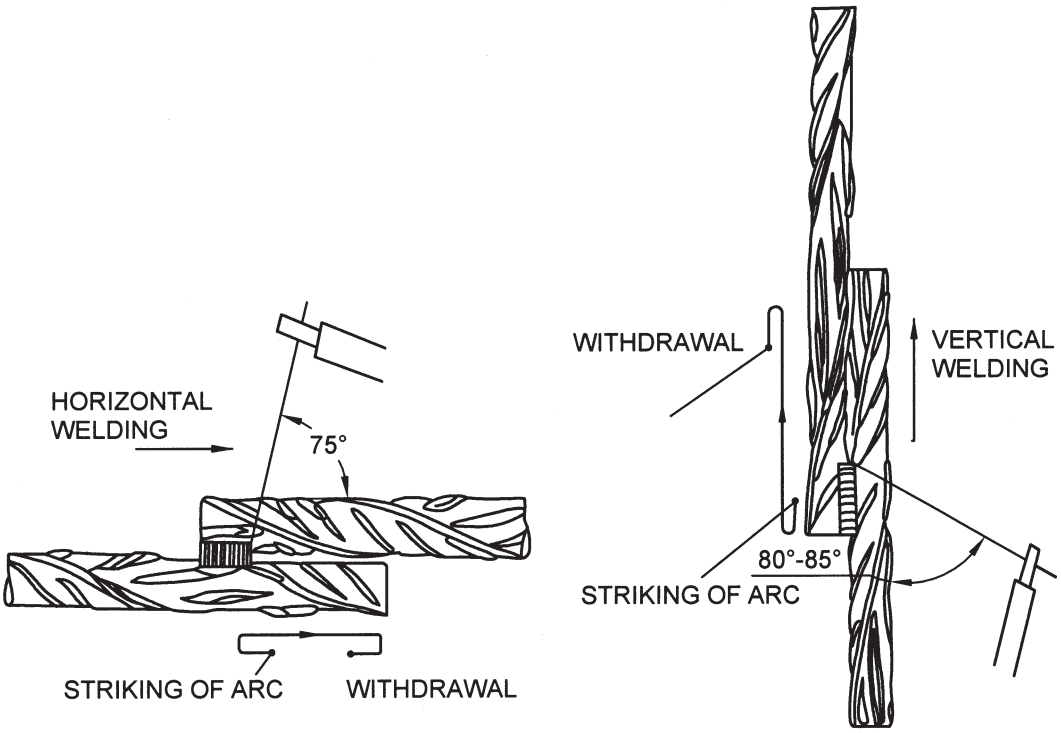
13 QUALITY CONTROL TESTS

13.1 Butt Welds

Test pieces containing butt welds at the centre in the as-welded condition shall be selected at the rate of one for tensile test and one for bend test for every 100 joints or as decided by the Engineer-in-Charge.

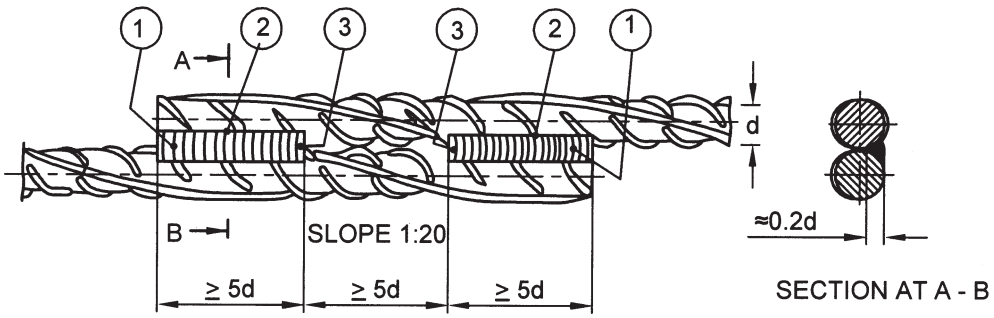
13.1.1 *Tensile Test*

Unmachined specimens with a free length between grips about 20*d* should be used. The selected pieces when subjected to a tensile test shall have tensile strength of



3A WELDING IN THE HORIZONTAL POSITION 3B WELDING IN THE VERTICAL POSITION

FIG. 3 WELDING OF LAP JOINTS



1 STRIKE THE ELECTRODE HERE: THE ARC STRIKING POINT MUST LIE IN THE GROOVE WHICH WILL BE SUBSEQUENTLY WELDED-OVER

2 WELDING DIRECTIONS FOR HORIZONTAL OR NEAR-HORIZONTAL LAP JOINTS: IN THE CASE OF VERTICAL LAP JOINTS, THE WELDING SHALL BE PERFORMED FROM BOTTOM TO TOP (RISING)

3 LIFT-OFF ELECTRODE

FIG. 4 LAP JOINT

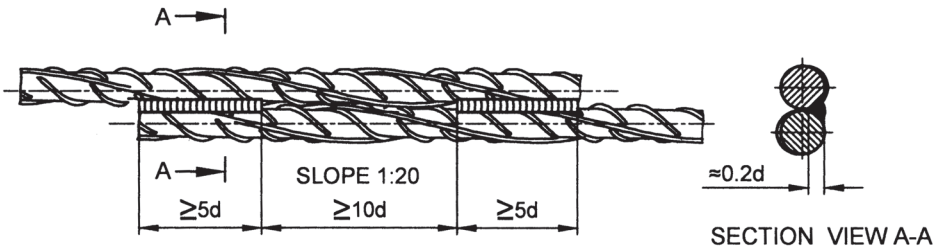
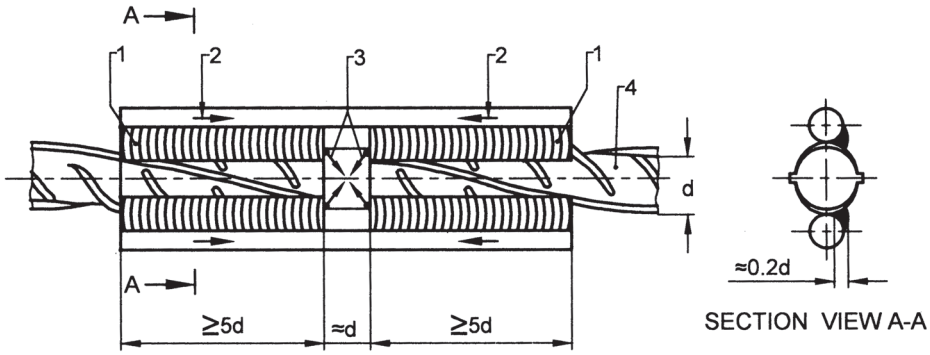


FIG. 5 LAP JOINT (VARIANT)



1 STRIKE THE ELECTRODE HERE: THE ARC STRIKING POINT MUST LIE IN THE GROOVE WHICH WILL BE SUBSEQUENTLY WELDED-OVER
2 WELDING DIRECTIONS FOR HORIZONTAL OR NEAR-HORIZONTAL STRAPPED JOINTS; IN CASE OF VERTICAL STRAPPED JOINT, THE WELDING SHALL BE PERFORMED FROM BOTTOM TO TOP (RISING)
3 LIFT-OFF ELECTRODE
4 BUTTED BAR

FIG. 6 STRAPPED JOINT (*d* = NOMINAL DIAMETER OF BUTTED BAR)

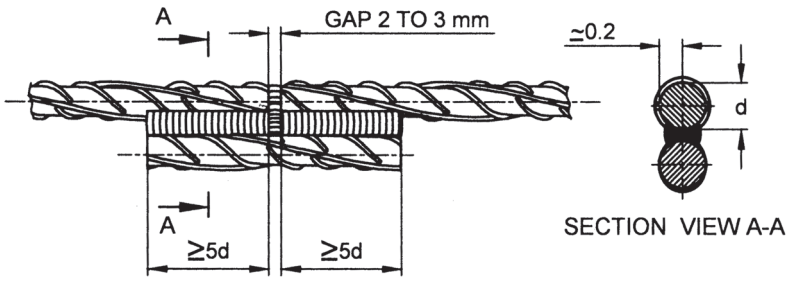


FIG. 7 STRAPPED JOINT (VARIANT)

not less than 90 percent or the actual tensile strength of the bar but in no case shall be less than 485 MPa for Grade Fe 415 and 545 MPa for Grade Fe 500 of IS 1786. The fracture shall not take place in the weld joint.

13.1.2 *Bend Test*

The welding flash or reinforcement shall be removed at the point where contact is made with the mandrel. The welded joint shall be capable of being bent to an angle of 60° around a mandrel of diameter specified below, before any crack appears:

Nominal Diameter of Bar, d mm	*Diameter of Mandrel* mm
Up to 10	5 *d*
Over 10	7 *d*

13.2 Lap Joints

Test pieces containing lap joints at their centre in the as-welded condition shall be selected at the rate of one sample for tensile test for every 100 joints or as decided by the Engineer-in-Charge.

13.2.1 *Tensile Test*

The free specimen length between grips shall be between 25 *d* and 30 *d*, where *d* is the nominal diameter of the bar. The breaking load shall not be less than the guaranteed load in accordance with IS 1786 required to fracture the bar.

14 RETESTS

If a sample selected for testing fails to meet the requirements given under **13.1** and **13.2**, the purchaser or his representative shall take two further samples from the same lot. If on testing, either of the samples fails to meet the specified requirements, the whole lot shall be rejected.