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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

GUIDELINES ON FABRICATION OF STEEL GIRDERS FOR CONSTRUCTION/FIELD ENGINEERS

BS - 110

December, 2011

ISSUED BY

B&S DIRECTORATE

**RESEARCH DESIGNS AND STANDARDS ORGANISATION
LUCKNOW-226011**

FABRICATION OF STEEL GIRDERS

The fabrication of steel girder bridges is being done by various Railway Workshops as well as through trade. The fabrication is governed by the provisions of;

- i) Indian Railway Standard specification for fabrication and erection of steel girder bridges and locomotive turn-tables. (B1-2001).
- ii) Indian Railway Standard Code of Practices for metal arc welding for structural steel bridges carrying rail cum road or pedestrian traffic (Adopted 1972 Revised 2001).

The officials associated with fabrication work should have thorough understanding of both the codes i & ii. However, these guidelines have been prepared for helping the field engineers associated with execution of the fabrication work through trade. It has been tried to cover various aspects which require close attention of the field engineers for ensuring quality of the fabrication work. These guidelines are just to facilitate and not to supersede the two codes. All engineers associated with fabrication are advised to understand the provision of IRS B1-2001 and Welded Bridge Code and take help from these guidelines. Book published by RETS IRICEN “Steel Structure Fabrication for Railways” is also a very good guide for the Engineer incharge of fabrication. The workshop engineer of contractors should also have good understanding of various provisions of above Railway codes and other related codes.

ITEM REQUIRING ATTENTION BY FIELD/WORKSHOP ENGINEERS DURING FABRICATION OF STEEL GIRDERS

A. Approved Drawing to be used for fabrication:

Field/Workshop Engineer associated with fabrication should have all the relevant drawings, Codes & Specifications with latest Correction Slips prior to the start of work. On the basis of structural drawings, fabrication drawings should be prepared by fabricator. Plate Girder Drawings to be checked for intermediate stiffeners whether riveted or welded.

B. Quality Assurance Programme (QAP) of Steel Girder Fabrication:

- To ensure the proper quality of fabrication Quality Assurance Plan (QAP) is prepared. QAP must indicate stage wise manufacturing process covering various steps, tests, checks & their frequency, sampling plan, authority for grant of clearance etc. for all activities from inspection and testing of raw material to trial assembly and erection. The QAP must cover following aspects.

- Brief Details of project
- Contract Agreement No.
- Loading Standard
- Governing Specification
- Drawing references
- Roles and responsibilities of various agencies involved in fabrication erection & inspection.

A sample QAP for 30.5m welded open web girder is given at Annexure-I.

QAP is to be scrutinized and approved by the inspection agency. In case of welded girder it is to be done by RDSO, as per prevailing orders.

Field Engineer should ensure that work is carried out strictly as per the approved QAP and no deviation takes place from QAP. All the stages should be studied in detail, prior to start of work.

C. Scrutiny & Approval of Welding Procedure Spec. Sheet (WPSS) (final approval to be done by RDSO):

WPSS is process sheet indicating plate/section used, welding process, type of joint, welding consumables quality, welding parameters, acceptance standard, tests applicable etc. Field Engineer should ensure that welding is carried out as per approved WPSS. It is to be ensured that welding consumables to be used are from approved source and a proper record of their consumption is maintained. A sample perfoma for record keeping of consumables is enclosed as Annexure – II.

D. Welding Procedure Qualification Records (WPQR) (final approval to be done by RDSO):

WPQR is the document indicating approval of various welders who are to be deployed for carrying out welding work for fabrication. It contains Name of the welder with photograph, qualification, experience, qualification tests and records for each welding process and joint, welding parameter. Tests are conducted by RDSO Official from M&C Directorate before qualifying the welders and then approval is granted through WPQR. Field engineer should ensure that welding is done only by approved welders and no deviation takes place.

E. Raw Material and Gauge Certification

Inspection of Raw Materials:- Passing of raw material is done on the basis of visual inspection and lab test for mechanical properties, chemical composition, ultrasonic examination, Charpy Impact Test, lab test report etc. Rivetes and other comsumables like paint etc. should also be got tested from NABL Lab as per relevant codes/specification.

All the required test should be got done through independent NABL Labs and compared with the mill test results given by the supplier before passing the material for use.

Material test certificate register must be maintained by fabricator as per Annexure available in IRS: B1-2001(appendix-I, Performa-7) and signed by railway representative as well as fabricator.

All angle/channel, rolled section to be used for open web girder fabrication shall be checked for rolling tolerance as stipulated in IS:1852.

In addition to above visual inspection shall be done to ensure that steel is free from surface defects like pitting, laminations, imperfect edges, twist, other harmful defects etc. and recorded in the register.

F. Item requiring attention before Fabrication of Girder.

F1. Inspection of Layout on template floor – Field engineer has to ensure that the Template floor is level. Nominal and camber layout are drawn with the calibrated steel tape. The certificate of calibration from a authorized agency should be kept in record. For squareness, diagonal measurement are also checked. It should be remembered that tape should not be changed during the various stages of measurement. Running measurement should be recorded with a long tested tape having minimum length suitable for half span/full span measurement as per the case. 4 lbs pull is to be applied for stretching the tape. Suitable device should be used for this purpose.

F2. Inspection of Jigs, Fixtures and Master Plates - Master Gussets should be checked on nominal layout and transfer of all inter section line/points to be done with great care and accuracy. If gussets are symmetrical then 1/4th or half hole marking is to be done and same will be transferred to complete the gusset marking. Dimensional Inspection of Jigs, Fixtures, Master Plates used in manufacture of girder should be done very carefully to ensure accuracy.

It should be remembered that jigs of main members of the open web girders are fabricated on the camber length with the adoption of the field holes at nominal length layout through master gussets.

F3. Layout of joints is drawn as per drawing on 1:1 scale on a level ground to check for ;

i) Any infringement of rivets, adjoining edges etc.

ii) Position of holes in master plates for jigs as per layout.

iii) The bore of bushes shall initially have tolerances of - 0mm to + 1mm. Fairing of bushes with holes of master plate shall conform to tolerances of – 0.13mm using a ‘GO’ gauge of 0.13mm less than hole diameter. Bushes of jigs during service should be maintained within

acceptable limit (D+0.4mm) which shall be checked at regular intervals.

F4. Certification of Jigs, Fixtures and Master Plates- Stamping of Master Plates by the inspection official should be ensured prior to their use.

The jigs should be checked by fabricator and field engineer from time to time for their wear and tear for maintaining accuracy during work.

G. Item requiring attention during fabrication of girder:

Field/Workshop engineer should keep a watch and maintain proper record for-

- (i) Ensuring Use of Approved Raw Material -Only raw material cleared originally to be used during fabrication.
- (ii) Ensuring use of Approved Welding Consumables- Type of consumables, source, quality, approval status, grade, suitability for fabrication as per WPSS etc. to be frequently checked and recorded.
- (iii) Ensuring use of Approved Welders- Checking of welders certificate, records, skill and procedure adopted for welding as per WPSS
- (iv) Ensuring use of Approved WPSS & Welding Parameters- Checking welding parameters and equipment used for correctness of joint preparation etc.

Important Checks for Tack Welding:

- i) Check that top & bottom flange plate are perfectly perpendicular with reference to web throughout the length of I Section.
- ii) Check the squareness i.e. 90⁰ angle between flange & web of top and bottom flange plate to avoid out of squares flanges.
- iii) Check with filler gauge throughout the length of top & bottom flange connection for uniform contact throughout the web plate.

Points requiring attention during full welding:

- i) Thorough cleaning of tack welded member should be done with appropriate tool like wire brush, before shifting for full welding. Minimum width of 75mm throughout the length shall be cleaned to ensure that the surface is free from dust, mill scale, grease, oil and paint to ensure sound quality of weld.
- ii) Full welding shall be carried out in flat position with SAW process as per sequence mentioned in WPSS/WPQR using manipulator/special welding fixture.
- iii) The sequence of welding shall be shown in WPSS/WPQR marked as 1, 2, 3 & 4 in the order of welding.
- iv) The welding should be done in proper sequence.
- v) Minor welds/ Inaccessible location welds shall be made by CO₂ welding or other type of welding as per approved WPSS.

Good Working practice for prevention of distortion in welded girders:

- i) By pre-bending of flange plate of welded girder using appropriate fixture.
- ii) By clamping the flange plate to fixture.

(Fixture developed by MMR Workshop is given at Annexure.III)

Radiographic Exam. of Butt Weld Joints- Any butt welding provided as per approved WPSS should be subjected to radiographic testing by authorized agency only. The film should be preserved for examination, sensitivity, defect interpretation and acceptance decision based on prescribed criteria.

Ensuring use of Approved set of Jigs & Fixtures- To permit the interchangeability of the components and ensure pre-stressing in open web girders and to avoid distortion, it should be ensured that only approved Jigs & fixture are used and proper clamping arrangement are provided in jigs/fixtures.

- H. Item requiring attention after fabrication of girder:** stacking of component should be proper and shipping mark is properly stenciled on component for identification.

Field/Workshop engineer should ensure that:-

While cutting the plates or other section the heat/cast mark should be transferred to all cut members while using these members for fabrication. Proper record of heat mark should be maintained/ correlating it with the components of girder.

Visual Exam of Welds- Quality of weld, uniformity of weld bead, size of the weld, weld defects e.g. under cut, blow hole, porosity, spatter, crack etc. should satisfy para 31 and Appendix C of welded bridge code.

Metallographic and NDT Exam of Fillet Welds- Macro etching on girder, run-on, run-off tabs for ensuring proper weld quality, Dye penetrant examination etc. should be arranged by fabricator, for independent inspection.

Structural and dimensional inspection- Dimensional check should be carried out by field engineer to ensure conformance to drawing dimensions including diagonal checks for squareness etc. before offering girders for final inspection.

- I. Trial Assembly:** for open web girder.

First span is always trial assembled to check whether fabrication process is proper or require any correction in jigs, workmanship or procedures to ensure regular quality output. Following important parameters are checked during trial assembly:-

(i) Camber:

Camber shall be checked while the girder is supported on the nodal points on camber jacks and after releasing jacks i.e. for residual camber with girder resting on bearing ends. The camber measurements should be done with appropriate leveling instrument:

(ii) Dimensional check:

- i) Overall length
- ii) Bearing centers
- iii) Height
- iv) Truss center
- v) Center to center distance of rail bearers
- vi) Center to center distance of panel points
- vii) Squareness
- viii) Alignment of the girder
- ix) Fairing of holes
- x) Verticality
- xi) Infringement, if any
- xii) Butting of compression flange.

(3) Component Inspection of first span- Detailed inspection of dismantled components of trial erected span is carried out to see the integrity of components. There should not be any elongation of holes, tearing of edges or other defects after dismantling of trial assembly .

(4) Component inspection of 2nd span onwards:- Once fabrication process is found satisfactory i.e all steps from A to J are proved during trial assembly and its component inspection, then only components of 2nd span and onwards should be fabricated with the approved sets of jigs and fixture, the tested WPSS and WPQR as laid out in steps earlier. Field engineer should do the components inspection and ensure all record are available before giving final inspection call inspecting authority.

Plate girder check.

- i) Overall length
- ii) Bearing centers
- iii) Height
- iv) Girder center

- v) Squareness
- vi) Fairing of holes
- vii) Verticality
- viii) Infringement, if any
- ix) Butting of compression flange.

L. Anti Corrosive Treatment- Surface preparation, metalizing and or painting as per applicable painting schedule. Should be done as per provision given in para 39 of IRS:B1-2001. It should be ensured that paint are procured only through RDSO approved sources. The list of approved vendors by M&C Directorate of RDSO is available on web site.

M. Some important DOs & DON'TS are given here for guidance:-

DOs-

- Use proper fixtures and clamps to hold the members firmly at desired location while welding. The clamps and fixtures must be strong enough to prevent any distortion of the member while cooling of the welding joint. The clamps and fixtures are only to be removed when the joint is cooled to ambient temperature.
- Do the welding work in a warm and dry place so that rain water or other atmospheric elements may not come in contact while welding is in progress.
- While welding in very cold weather pre-heat the material before welding and apply post heating to prevent the weld joint from rapid cooling and develop stress raiser due to sudden contraction.
- Cross level of bearing plates in the welded plate girders should be checked properly for proper sitting over bed plate.
- To co-relate use of steel and welders in different members proper records should be maintained.
- Drilling of holes through approved set of jig particularly long members should be ensured. No fabrication should be done with unapproved jig.
- Drain hole in the portal girders at proper locations should be ensured.
- Fairing of holes and removal of drill burrs through initial assembly should be ensured.
- Proper edge finishing with grinding/ special attention in top chord compression members butting by end milling should be carried out
- At site during the erection of girders particularly open web girders due and adequate care should be taken to achieve the required camber values.
- Camber Jacks should be provided at all the nodal points during trial assembly.

- Butting of compression members, X-levels of stringers and alignment of stringers to be checked properly in the trial erection.
- Application of paint on permanent contact surface should be ensured after proper surface preparation visual inspection is very important tool.
- The plates should be perfectly horizontal while drilling the holes to ensure horizontal verticality of holes.
- Steel with proper test certificate/ reports should be used. Commercially available steel in the market should not be used.
- Steel received from the rolling mills has generally punch heat mark numbers. These numbers should be legibly marked again with paint for easy identification. Heat mark numbers should be transferred to cut members with paints.
- Members of the open web girders should be fabricated on the camber length with the adoption of the field holes of nominal length.
- Consistency of weld quality is higher in Submerged Arc Welding Process and chances of human errors are also eliminated. Therefore, welding of the girders should be done by SAW process. Whenever not possible then only CO2 welding or MMAW may be adopted if provided in app. WPSS.
- Stage inspection during fabrication should be properly ensured to avoid rejection at later stage.
- Skilled and qualified welders, drillers, fitter should be deployed for welding drilling and marking works. The welder should be individually approved by authorized agency i.e. M&C Directorate of RDSO.
- Selection of Angles in fabrication of cross girders and stringers of open web girders requires special attention, drooping in angles either acute or obtuse should not be permitted. It will cause improper sitting of sleepers on the stringers.

DON'T'S-

- Use of pitted/ corroded material should not be done because it gives rise to concentration of stresses and results in poor fatigue strength.
- Tack welds in fabrication of riveted open web girders should be avoided.
- Do not hammer the distorted joints for rectification. It may lead to the development of cracks and failure of the joints.
- Do not do the welding in chilled weather, as due to sudden cooling of welded joints they are liable to be brittle and develop cracks. The joints may also suddenly fail under dynamic loading without any prior warning.
- Do not weld with un-controlled welding parameters, these will affect the quality of welding and make the joints weak and may yield in dynamic loading on the structure.

- Do not weld the joint haphazardly without following the proper welding sequence. This will lead to uncontrolled and irreparable distortion, of the proper geometry of the joint.
- Sharp notches in the member should be avoided.

Annexure-II

Performa for maintaining Register for consumable:

Date	Detail of Item with manufacturer name	Weather item is approved by RDSO (Yes/No)	Manufacturer test certificate detail.	Quantity received	Quantity consumed	Quantity balance	Sign of site supervisor

SAMPLE QUALITY ASSURANCE PLAN

30.5m Welded Open Web Girder (HM Loading-1995) as per RDSO's Drg. No. RDSO/B-11521

Name of project

Manufactured by

SN	Component/ Operations	Characteristic Check	Frequency & type of check	Reference Document	Fabricators Quality Control	Inspection details		Type of Record	Acceptanc e criteria	Remarks
						Inspecting Agency	Extent of inspection			
1	2	3	4	5	6	7	8	9	10	11
1.0	Raw Material									
1.1	Steel Plates, Structural Section	Identification and correlation with Mill Test Certificate from Supplier e.g., SAIL, TISCO, IISCO etc.	As per Mill T.C. and tests required by RDSO from Govt./NABL approved lab	Challan, Mill T.C.	Verification of reference document	..... Railway	100%	Fabricator's record	Plates: IS 2062-2006, Gr. E 250 B0, 12mm & above thick. Plates are fully killed & normalized or control cooled. Sections IS 2062-2006, Gr. E 250 A	
		Physical condition i.e., Pitting, rusting, straightness, rolling defect, etc.	Visual	-	Complete visual inspection Railway	100%	Fabricator's Record	IS 2062- 2006	-

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Railway Representative

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1	2	3	4	5	6	7	8	9	10	11
		Mechanical Test as per IS 2062-2006 UTS, YS, % El, Bend test,	Lab Test at appvd. Laboratory	-	Lab Test Report Railway	-	-	IS 2062-2006 Gr. E 250 B fully killed & normalized or control cooled	Raw matl. Clearance shall be by Zonal Railway
		Charpy test at 0°C for plates of thks. 12mm and above	-Do-	-	-Do-	..... Railway	Heat/Cast no. section wise as per IS 2062-2006	-	-	-
		Chemical Analysis as per IS 2062-2006	-Do-	-	-Do-	..... Railway	-Do-	-	Table 1, along with Note No. 2 of IS 2062-2006, Gr. E 250 B	
		Ultrasonic test for 12mm & above thi. Plates, as per IS 4225 or ASTM-SA 435/435M	By ASN Level II operator	-	Lab Test Report	..... Railway	100%	-	IS 4225 or ASTM SA 435/435M	
		Dimension	Measurement	Challan	Measurement of Dimension	..... Railway	100%	Fabricator's Record & Zonal Railway Records		
1.2	Reverts, Bolts & Nuts	a) Dimension	Visual/ Measurement	Challan	Verification of Reference Document	..... Railway	As per requirement	-	For Rivet IS 1148 For Bolt: IS 1367(Part ii) & property classes as per relevant Drg.	
		b) As per specn. Mechanical & Chemical	Lab test at Govt. appvd. Lab	Manufacturer's Test Certificate	-Do-	-Do-	-Do-	-Do	-Do	

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1	2	3	4	5	6	7	8	9	10	11
1.3	Paints	Verification of Manufacturer's Test Certificate, Inspection Certificate, Challan	Visual	Challan., Manufacturer's Test Certificate	Verification of Reference Document Railway	Each Batch	Manufacturer's Test Certificate	IS 102, Contract agreement	Paints to be procured from vendors approved by RDSO
		Tests as per Specification	Lab test at Govt. Appvd. Lab	Challan., Manufacturer's Test Certificate	Verification of Reference Document	..... Railway	Random	Lab. Test Report	IS 102 Contract agreement	-Do-
1.4	Welding Consumables	As per specification and as approved by RDSO	Any test as required	Challan., Manufacturer's Test Certificate	Verification of Reference Document	..... Railway	As per requirement	Fabricator's Record	-	Consumables should be of RDSO appvd. Brand
2.0	Manufacturing Process									
2.1	Lay out of Components & Joints	Dimension	Measurement with calibrated steel tape & gauges	Approved Drawing	Measurement of Dimension	RDSO	100%	Inspection Report of Inspection Official	Relevant IS/IRS Codes & Approved Drawings	Clearance by RDSO
	a) Normal									
	b) Jigs & Templates	Dimension, Intersection lines, pitch, gauge, dia. Of Holes & No. of holes	Measurement with calibrated steel tape & gauges	Approved Drawing	Measurement of Dimension	RDSO	100%	Record of Jigs & fixtures as per proforma issued by RDSO	IRS B1-2001	
	c) Cutting, Straightening, Edge preparation	Dimension, Freedom from defect	Visual/ Measurement	Inspection Report of Inspection Official & Fabricator's Record	Visula & Measurement of dimension	..... Railway	100%	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001, IS 1852-85	
3.0	Welding:									
	a) Submission of WPSS	Review of WPSS	Verification	IRS B1-2001 IS 9595-96 WBC-2001	Verification of Reference Document	RDSO	100%	Fabricator's Record	IRS B1-2001 IS 9595-96 WBC-2001	Only RDSO certified welders to be engaged in the job.

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1	2	3	4	5	6	7	8	9	10	11
	b) WPQR	Witnessing of established WPSS Witnessing of Welder Qualification test	Visual, DT & NDT at approved lab	As per code requirement	Verification of Reference Document	RDSO	100%	WPQR Sheet to be recorded in presence of RDSO Rep.	IS 7310(I)-74	
	c) Preheating	Measurement of Temperature	Visual with thermal Chalk	As per approved WPSS	Verification of Reference Document	..... Railway	Random	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001	
	d) Baking of Electrode, Flux	To have moisture free Electrode & Flux	Visual Check of Electrodes & beating	As per Manufacture's recommendations	Verification of Reference Document	..... Railway	100%	Inspection Report of Inspection Officials & Fabricator's Record	IRS B1-2001	
	e) Selection of correct Electrodes & Flux	Reference to WPSS, IRS Class, etc.	Visual	As per approved WPSS	Verification of Reference Document	..... Railway	100%	Inspection Report of inspection official & Fabricator's Record	As per list of vendors approved by RDSO	
	f) Current Condition	Measurement of Amp. & Voltage	Visual with Ammeter & Voltmeter	As per approved WPSS	Verification of Reference Document	..... Railway	Random	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001	
	g) Sequence of Welding	To control distortion	Visual	As per approved WPSS	Verification of Reference Document Railway	Random	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001	

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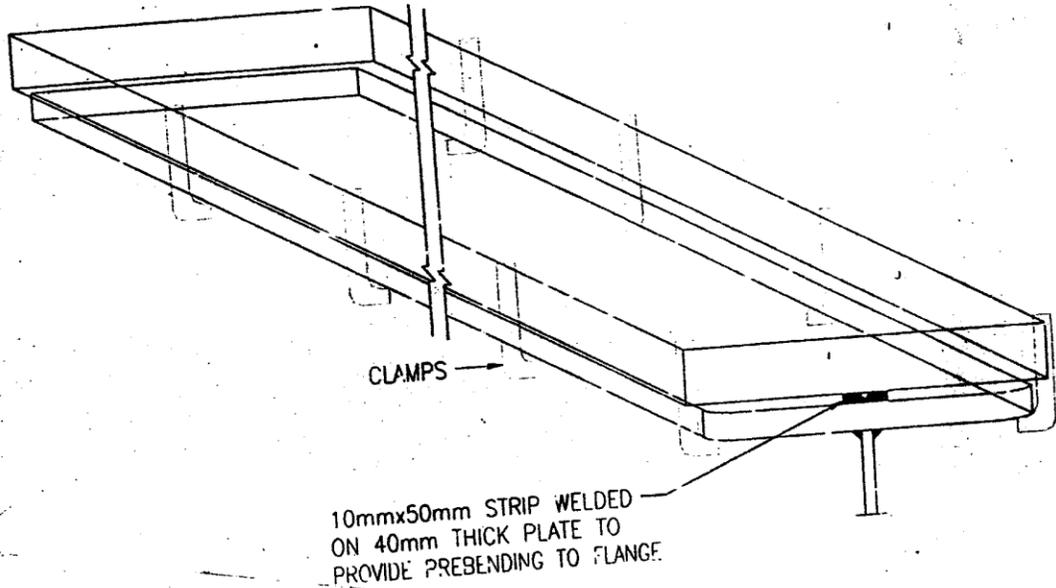
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1	2	3	4	5	6	7	8	9	10	11
	h) Provision of Run-on & Run off Plates	To avoid crater defects	Visual	As per IRS B1-2001	Verification of Reference Document Railway	100%	Inspection Report of Inspection Official & Fabricator's Record		
4.0	Inspection of Welding	a) For Fillet Welds: Visual, D.P. Test Fillet Size, Penetration, Leg Length, Throat thickness, etc.	Visual, Gauge & Macro Etching.	Approved Drg. & WPSS	Visual Inspection & Verification of dimension by gauges	RDSO	100%	Fabricator's Record	Relevant IS/IRS Code, Approved Drg. & WBC-2001	Clearance by RDSO
5.0	Trial Assembly	a) Camber on Jack b) Dead Load deflection c) Dimension d) Fairness of holes e) Temporary fasteners f) Imfringement g) Butting of compression edges	Visual & Dimensional	Approved. Drg.	Complete dimensional check of Control Assembly	RDSO	One complete span	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001	Clearance by RDSO
6.0	Final Clearance	Component completeness	Visual Dimensional & Structural	Stage clearance Record	Verification of Stage clearance Record	RDSO	Girder fabrication with approved Jigs-100%	Inspection Report of Inspection Official & Fabricator's Record	IRS B1-2001	Clearance by RDSO

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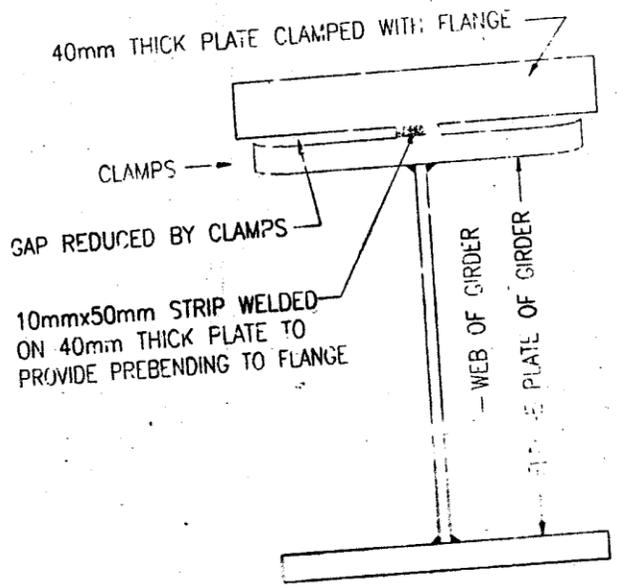
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10mmx50mm STRIP WELDED ON 40mm THICK PLATE TO PROVIDE PREBENDING TO FLANGE.

PLAN



10mmx50mm STRIP WELDED ON 40mm THICK PLATE TO PROVIDE PREBENDING TO FLANGE

SIDE VIEW

IMPROVED DESIGN OF FIXTURE