ABOUT THE AUTHOR

CORROSION PROTECTION PVT LTD.

GYANA RANJAN MOHANTY

Qualification : B. Sc. Engg (Mechanical), N.I.T. Rourkela.

Experience in Projects : Fabrication ,erection , Repairs and Restoration of Bridges & Hydro Mechanical Structures . Restoration of Monuments of Archaeological Importance. Erection and Commissioning of Coke Ovens ,Coal Handling Plants , Mineral Processing and other Industrial Plants

Experience in Manufacturing : Fabrication of Structures , Bridge Bearings, Liquified petroleum Gas cylinders, Heat exchangers & Recuperators, Mineral Processing Equipment, Steel Plant equipment ,Steel castings ,Vacuum Investment castings for Aerospace and Defence Applications and Electron Beam Welding

Membership with different technical bodies : Fellow of Institution of Engineers (India), Life Member of Indian Institute of Welding, Member of IRC-B-5 and IRC-B-6 of Indian Road Congress, Bureau of Indian Standards- CED 7:6

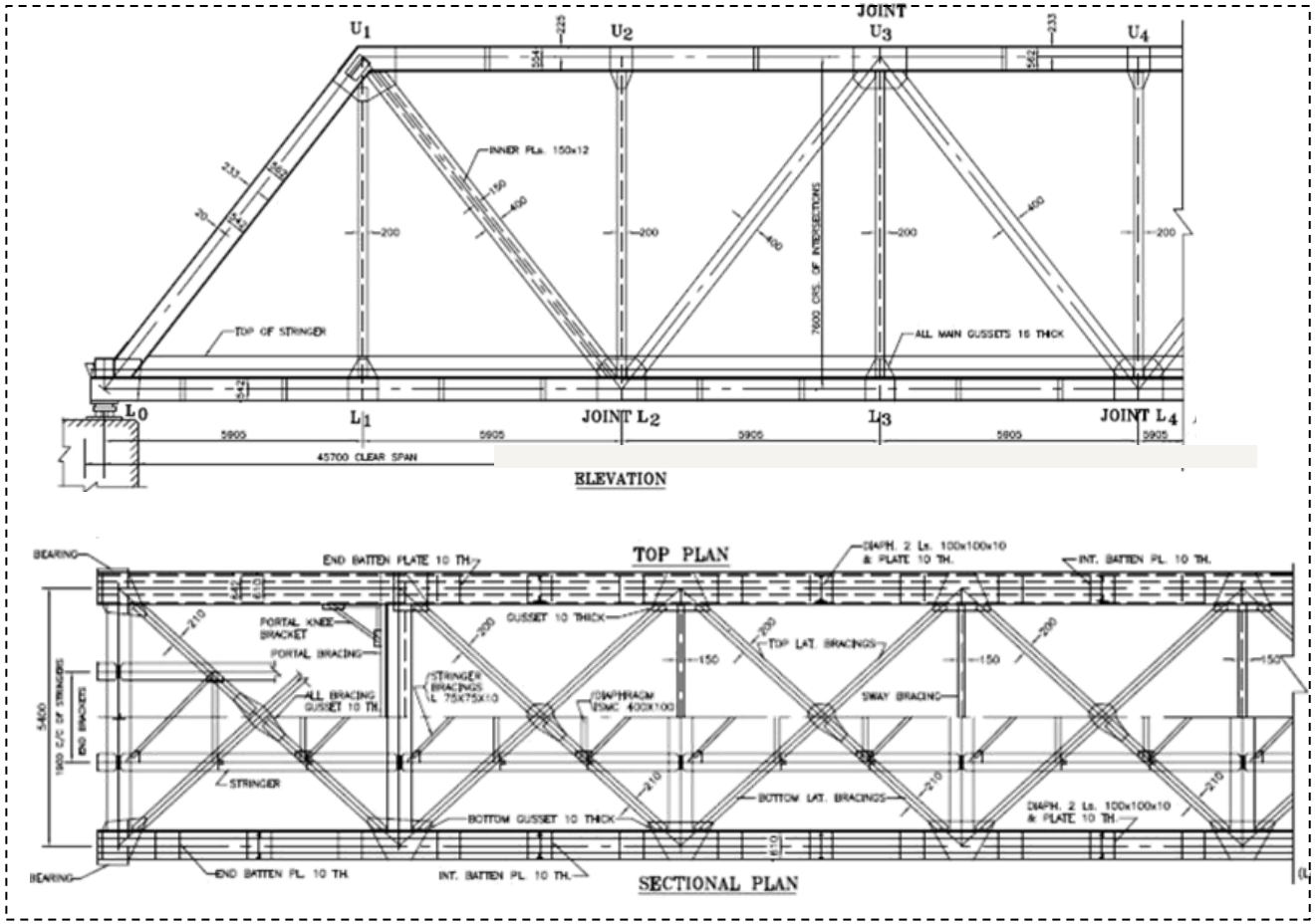
GUIDELINES FOR FABRICATION & ERECTION

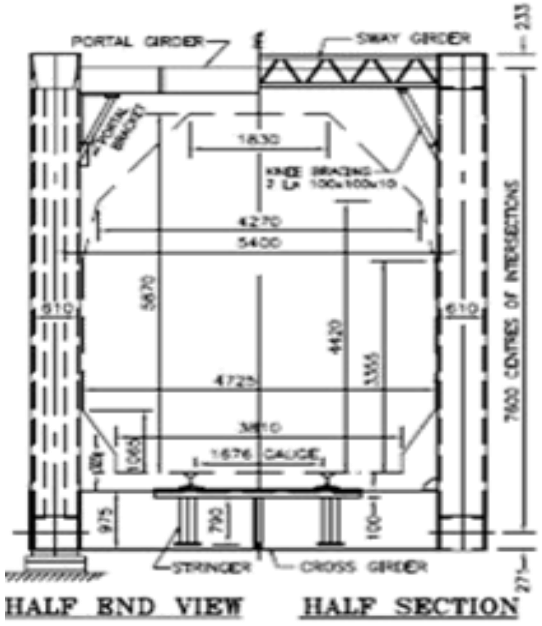
AGENDA

1. FABRICATION
2. PROTECTION AGAINST CORROSION
3. ASSEMBLY & ERECTION

FABRICATION

CASE STUDY : GIRDER DRAWING (45.7 M)





COMPONENTS OF A (45.7M) THROUGH GIRDER

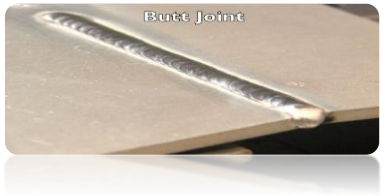
S/NO	MEMBER	TYPE	WELD DESCRIPTION
1	BOTTOM CHORD	*Built up channels*	*Fillet*
2	TOP CHORD	*Built up section*	*Fillet*
3	VERTICALS	*Built up I beams*	*Fillet*
4	DIAGONALS	*Boxed up rolled channels*	*Fillet*
5	END RAKER	*Built up channels*	*Fillet*
6	CROSS GIRDERS	*Built up I-beams*	*Fillet*
7	RAIL BEARERS	*Built up I-beams*	*Fillet*
8	SWAY GIRDERS	*Built up Truss*	*NA*
9	CROSS BRACINGS	*Rolled angle*	*NA*
10	PORTALS	*Built up I -section*	*Fillet*
11	GUSSETS	*Plates*	*NA*

There are 2 types of weld joints

1.

Fillet Weld

2.



Butt Weld

WELDING PROCESSES

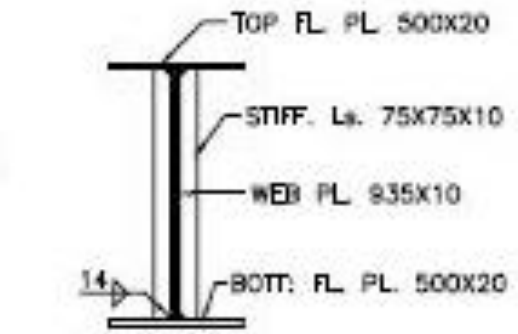
1-SMAW (SHIELDED METAL ARC WELDING)

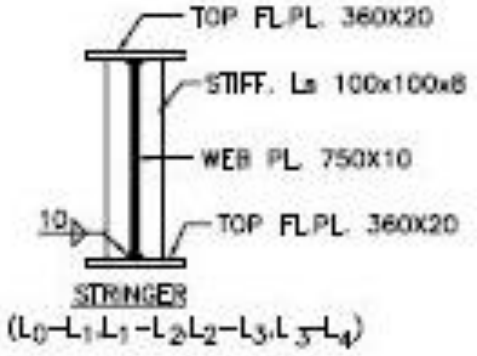
2-SAW (SUBMERGED ARC WELDING)

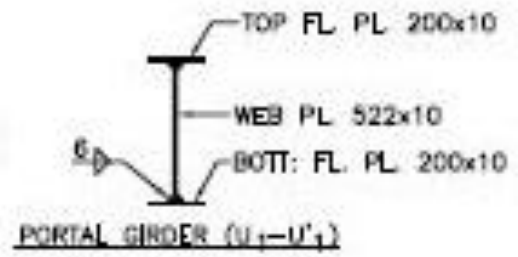
3-GMAW (GAS METAL ARC WELDING)

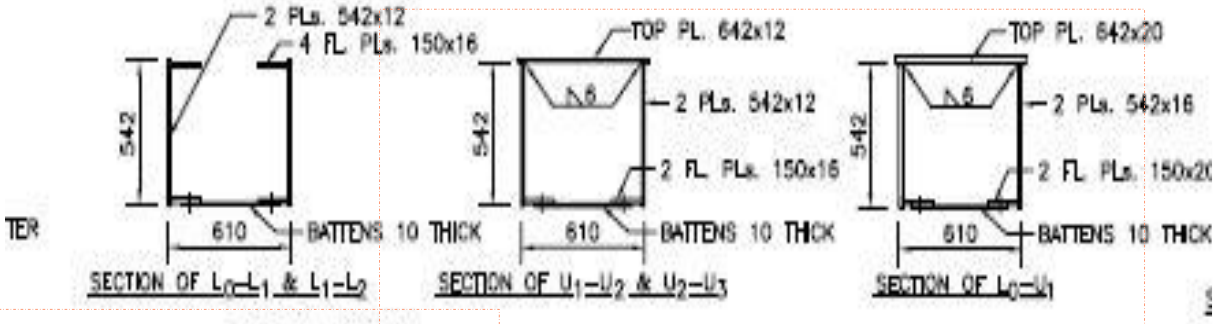
4-FCAW (FLUX CORED ARC WELDING)

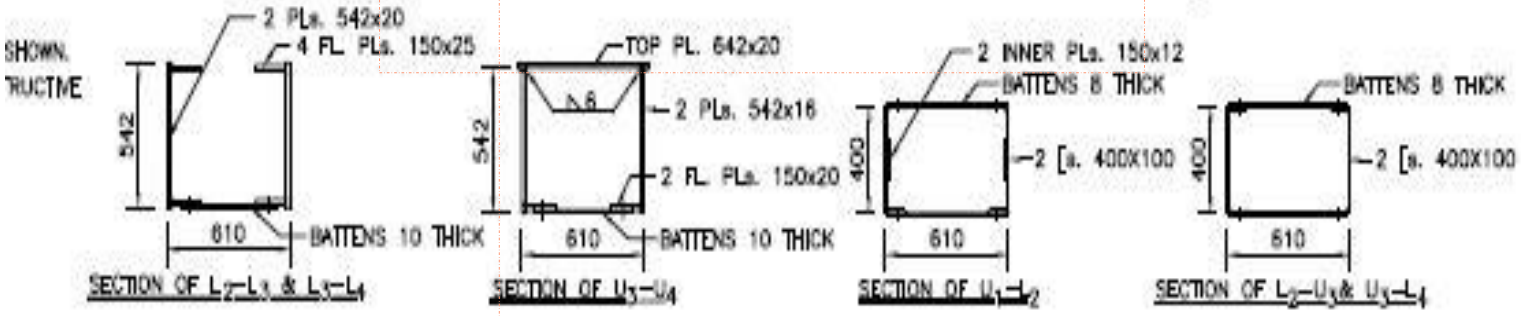
DIFFERENT BUILTUP SECTIONS

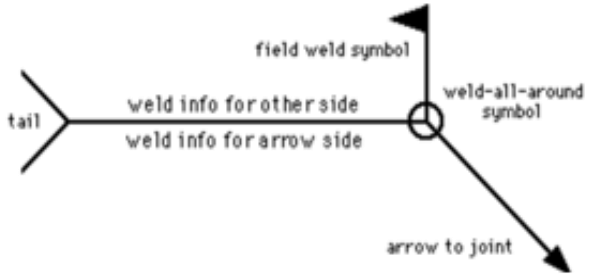


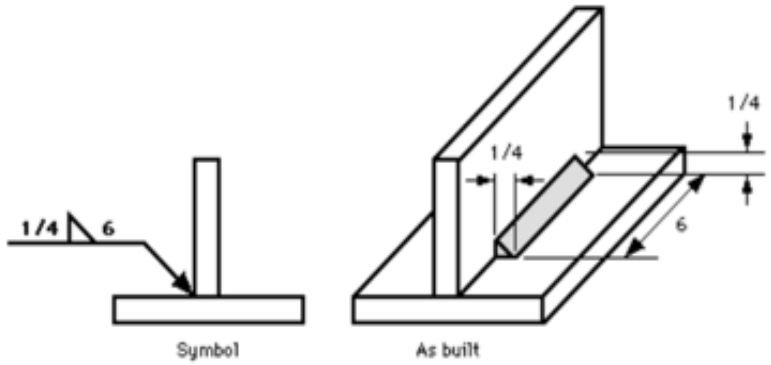


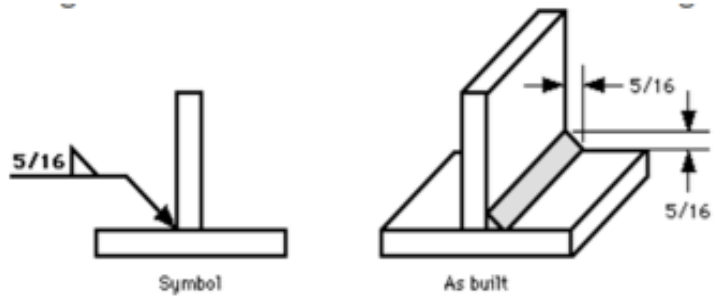


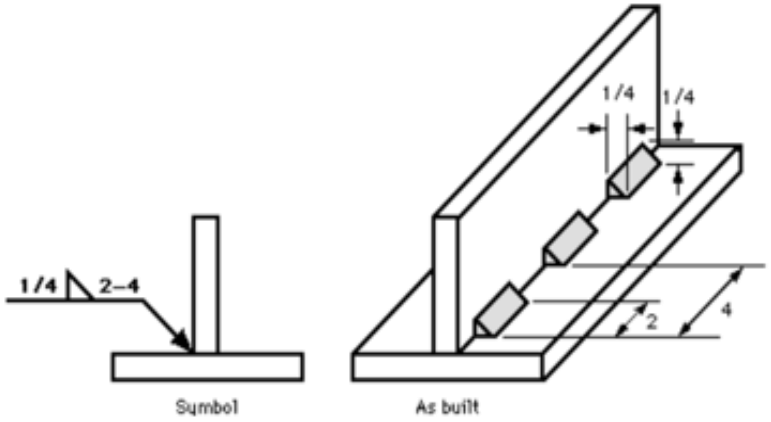


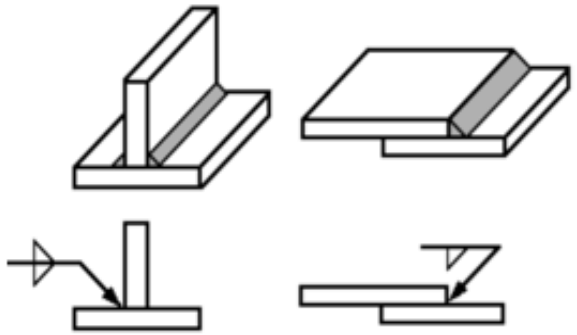


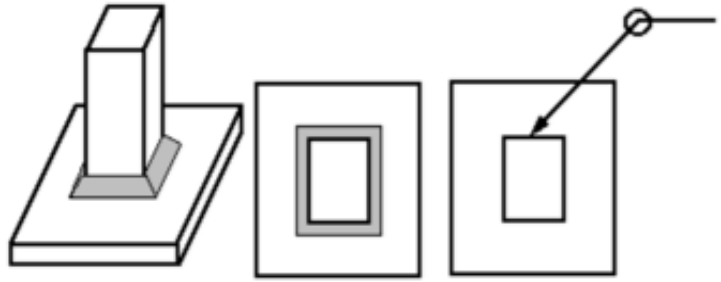

field weld symbol
tail
weld info for other side
weld info for arrow side
weld-all-around symbol
arrow to joint

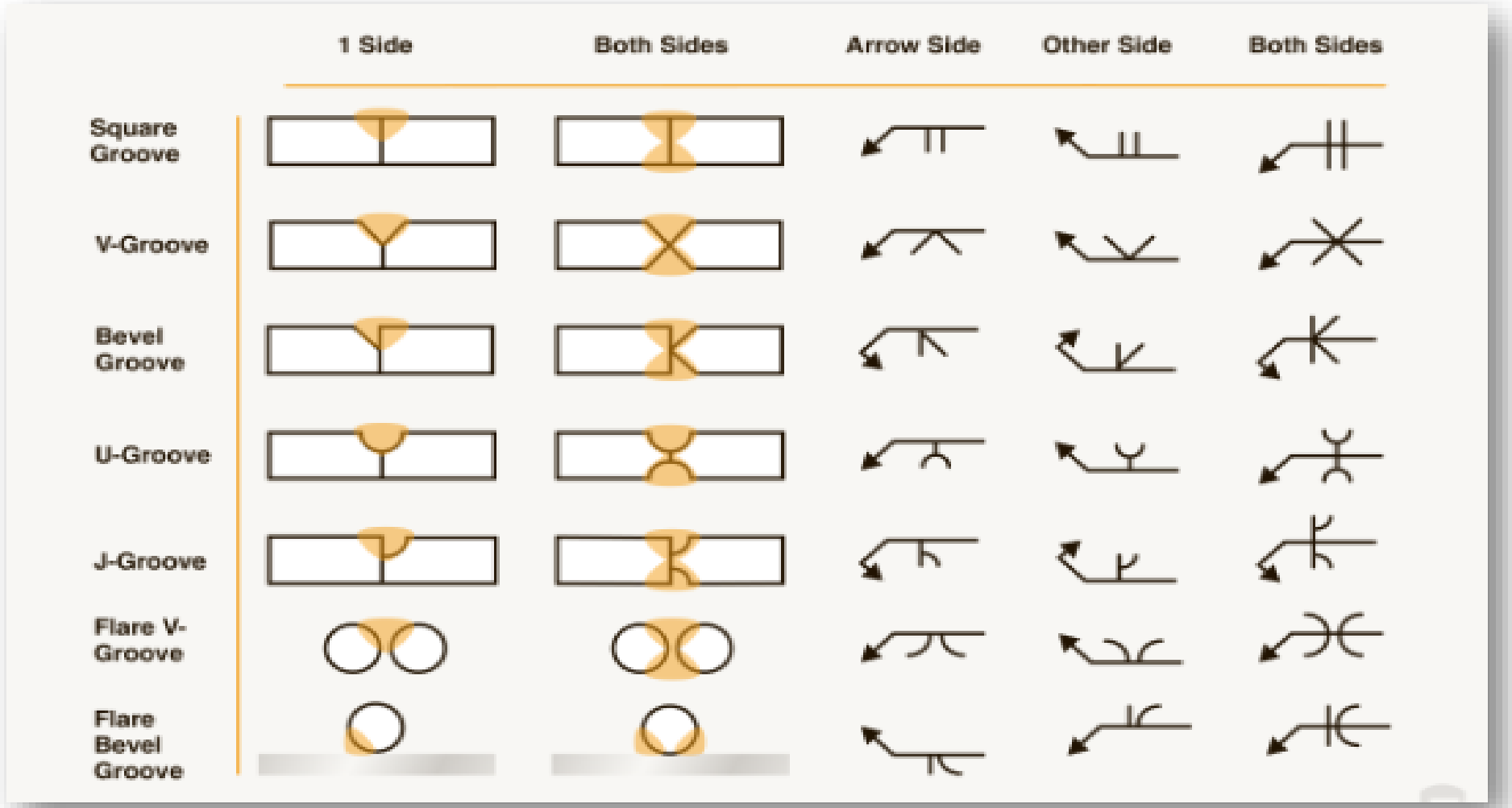

1/4
6
Symbol
1/4
1/4
6
As built


5/16
Symbol
5/16
5/16
As built


1/4
2-4
Symbol
1/4
1/4
2
4
As built






1 Side
Both Sides
Arrow Side
Other Side
Both Sides
Square Groove
V-Groove
Bevel Groove
U-Groove
J-Groove
Flare V-Groove
Flare Bevel Groove

MATERIAL PROPERTIES

Table 2 Mechanical Properties

(*Clauses* 5, 10.3, 10.3.1, 11.3.1, 12.2 *and* 12.4)

Grade Designation	Quality	Tensile Strength R_m, *Min* MPa[1] (*See* Note 1)	Yield Stress R_{eH}, *Min* MPa[1]			Percentage Elongation *A*, *Min* at Gauge Length, L_o=5.65	Internal Bend Diameter *Min* (*See* Note 2)		Charpy Impact Test (*See* Note 3)	
			<20	20-40	>40		≤ 25	>25	Temp °C	*Min* J
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E 250	A	410	250	240	230	23	2*t*	3*t*	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 275	A	430	275	265	255	22	2*t*	3*t*	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 300	A	440	300	290	280	22	2*t*	—	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 350	A	490	350	330	320	22	2*t*	—	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 410	A	540	410	390	380	20	2*t*	—	—	—
	BR								RT	25
	B0								0	25
	C								(–) 20	25
E 450	A	570	450	430	420	20	2.5*t*	—	—	—
	BR								RT	20
E 550	A	650	550	530	520	12	3*t*	—	—	—
	BR								RT	15
E 600	A	730	600	580	570	12	3.5*t*	—	—	—
	BR								RT	15
E 650	A	780	650	630	620	12	4*t*	—	—	—
	BR								RT	15

GRADES OF STEEL

IS2062 - Specifies 9 grades of steel starting with E250 to E650

For grades E 250 to E 410(5 Grades) ,there are four sub-qualities (A, BR, B0 and C)
For grades E 450 to E 650(4 Grades), there are two sub-qualities (A and BR).

A : Impact test not required, semi-killed/killed

BR : Impact test optional; if required at room temperature, semi-killed/killed

B0 : Impact test mandatory at 0°C semi-killed/ killed

C : Impact test mandatory at –20°C,

MECHANICAL PROPERTIES

Table 2 Mechanical Properties

(*Clauses* 5, 10.3, 10.3.1, 11.3.1, 12.2 *and* 12.4)

Grade Designation	Quality	Tensile Strength R_m, *Min* MPa[1] (*See* Note 1)	Yield Stress R_{eH}, *Min* MPa[1]			Percentage Elongation *A*, *Min* at Gauge Length, L_o=5.65	Internal Bend Diameter *Min* (*See* Note 2)		Charpy Impact Test (*See* Note 3)	
			<20	20-40	>40		≤ 25	>25	Temp °C	*Min* J
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E 250	A	410	250	240	230	23	2*t*	3*t*	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 275	A	430	275	265	255	22	2*t*	3*t*	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 300	A	440	300	290	280	22	2*t*	—	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 350	A	490	350	330	320	22	2*t*	—	—	—
	BR								RT	27
	B0								0	27
	C								(–) 20	27
E 410	A	540	410	390	380	20	2*t*	—	—	—
	BR								RT	25
	B0								0	25
	C								(–) 20	25
E 450	A	570	450	430	420	20	2.5*t*	—	—	—
	BR								RT	20
E 550	A	650	550	530	520	12	3*t*	—	—	—
	BR								RT	15
E 600	A	730	600	580	570	12	3.5*t*	—	—	—
	BR								RT	15
E 650	A	780	650	630	620	12	4*t*	—	—	—
	BR								RT	15

Grade Designation	Quality	Ladle Analysis, Percent, *Max*					Carbon Equivalent (CE), *Max*	Mode of Deoxidation
		C	Mn	S	P	Si		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
E 250	A	0.23	1.50	0.045	0.045	0.40	0.42	Semi-killed/killed
	BR B0	0.22	1.50	0.045	0.045	0.40	0.41	Semi-killed/killed
	C	0.20	1.50	0.040	0.040	0.40	0.39	Killed
E 275	A	0.23	1.50	0.045	0.045	0.40	0.43	Semi-killed/killed
	BR B0	0.22	1.50	0.045	0.045	0.40	0.42	Semi-killed/killed
	C	0.20	1.50	0.040	0.040	0.40	0.41	Killed
E 300	A BR B0	0.20	1.50	0.045	0.045	0.45	0.44	Semi-killed/killed
	C	0.20	1.50	0.040	0.040	0.45	0.44	Killed
E 350	A BR B0	0.20	1.55	0.045	0.045	0.45	0.47	Semi-killed/killed
	C	0.20	1.55	0.040	0.040	0.45	0.45	Killed
E 410	A BR B0	0.20	1.60	0.045	0.045	0.45	0.50	Semi-killed/killed
	C	0.20	1.60	0.040	0.040	0.45	0.50	Killed
E 450	A BR	0.22	1.65	0.045	0.045	0.45	0.52	Semi-killed/killed
E 550	A BR	0.22	1.65	0.020	0.025	0.50	0.54	Semi-killed/killed
E 600	A BR	0.22	1.70	0.020	0.025	0.50	0.54	Semi-killed/killed
E 650	A BR	0.22	1.70	0.015	0.025	0.50	0.55	Semi-killed/killed

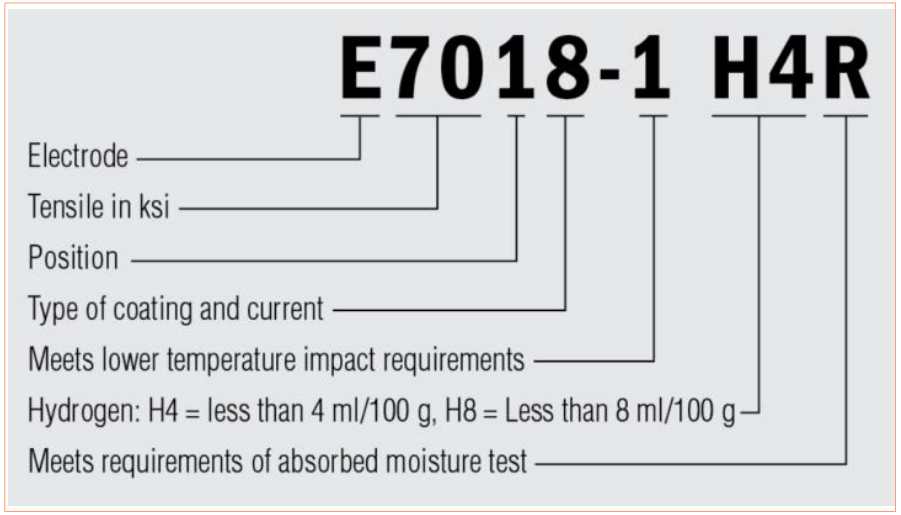
$$CE^* = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

**CE stands for CARBON EQUIVALENT*

- *The lower the value of the CE the higher the weld ability.*
- *Preheat is required to successfully weld those materials that have high values*

CARBON EQUIVALENT	WELDABILITY
Up to 0.35	*Excellent*
0.36-0.40	*Very Good*
0.41-0.45	*Good*
0.46-0.50	*Fair*
Over 0.50	*Poor*

WELDING ROD NOMENCLATURE



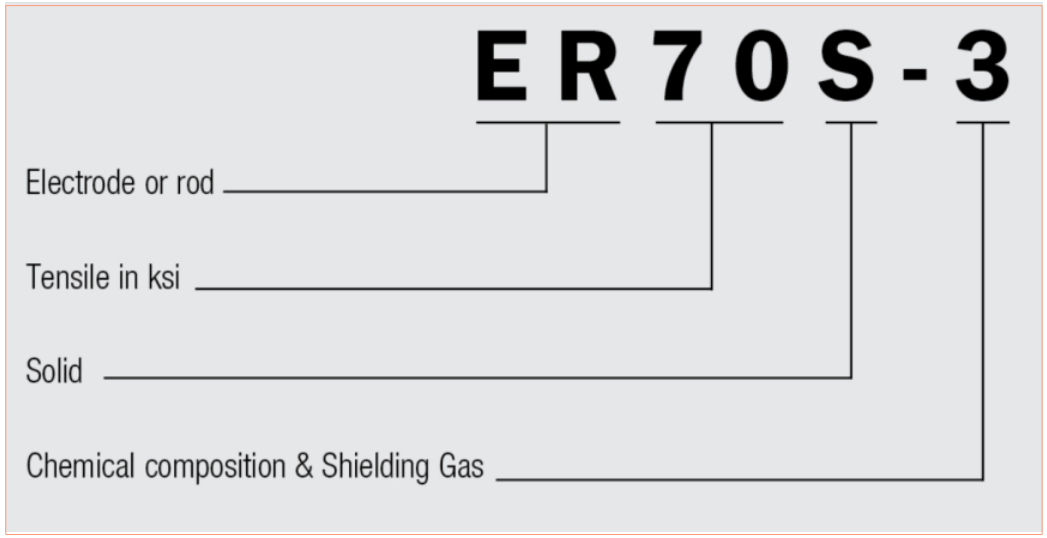
CLASSIFICATION TABLE

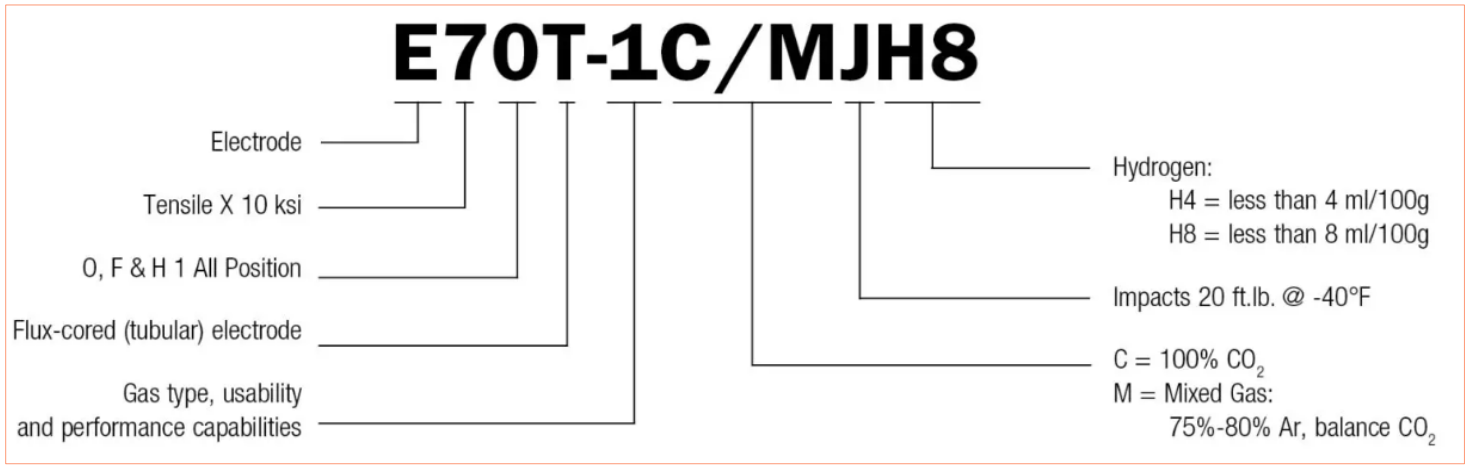
Class	Electrode Coating	Penetration	Current Type
Exxx0	Cellulose, Sodium	Deep	DCEP
Exxx1	Cellulose, Potassium	Deep	AC, DCEP
Exxx2	Rutile, Sodium	Medium	AC, DCEN
Exxx3	Rutile, Potassium	Light	AC, DCEP, DCEN
Exxx4	Rutile, Iron Powder	Medium	AC, DCEP, DCEN
Exxx5	Low Hydrogen, Sodium	Medium	DCEP
Exxx6	Low Hydrogen, Potassium	Medium	AC, DCEP
Exxx7	Iron Powder, Iron Oxide	Medium	AC, DCEN
Exxx8	Low Hydrogen, Iron Powder	Medium	AC, DCEP
Exxx9	Iron Oxide, Rutile, Potassium	Medium	AC, DCEP, DCEN

Suffix	Additional Requirement
-1	Increased toughness (impact strength) for E7018 electrodes. Also increased ductility in E7024 electrodes.
-M	Meets most military requirements - greater toughness, lower moisture content as received after exposure, diffusible hydrogen limits for weld metal.
-H4 **-H8** **-H16**	Indicates the maximum diffusible hydrogen limit measured in millimeters per 100 grams (mL/100g). The 4, 8, and 16 indicates what the limit is. Example: -H4 = 4mL per 100 grams

WELDING POSITIONS

1 Flat, Horizontal, Vertical (up), Overhead
2 Flat, Horizontal
4 Flat, Horizontal, Overhead, Vertical (down)


E R 7 0 S - 3
Electrode or rod
Tensile in ksi
Solid
Chemical composition & Shielding Gas


E70T-1C/MJH8
Electrode
Tensile X 10 ksi
0, F & H 1 All Position
Flux-cored (tubular) electrode
Gas type, usability and performance capabilities
Hydrogen:
H4 = less than 4 ml/100g
H8 = less than 8 ml/100g
Impacts 20 ft.lb. @ -40°F
C = 100% CO2
M = Mixed Gas:
75%-80% Ar, balance CO2

IMPORTANT DOCUMENTS

1. **QAP**-(QUALITY ASSURANCE PLAN)

2. **WPQR -** (WELDING PROCEDURE QUALIFICATION RECORD)

3. **WPSS-(**WELDING PROCEDURE SPECIFICATION SHEET)

QUALITY ASSURANCE PLAN FOR 45.7 M. SPAN WELDED THROUGH GIRDER.

01. Name of Work : Construction of Bridge No.449 over River Brahmani (29 x 45.7 M) in Connection with 3rd Line Between Jakhapura & Haridaspur on Howrah-Chennai Main Line in East Coast Railways, in ORISSA.

02. Purchase Order No. : LOA No.RVNL/BBS/TENDERS/JKPR-HDS/(Brahmani Bridge)/25/37/6357 dated 09.07.2008. & RVNL Letter No.RVNL/BBS/Contract/ Br No.449, Brahmani(JKPR-HDS) 3rd Line/14/51/8669 dated 24th November'2009.

03. Employer : Chief Project Manager, Rail Vikas Nigam Limited, Plot No.HIG-68, Buddha Park, Lumbini Vihar, Bhubaneswar – 751 016.

04. Contractor : M/s. BEB-DDS-RKD-JV, 72/A, Mancheswar Industrial Estate, Bhubaneswar – 751 010.

06. Reference Drawing No. : BA-11501 TO 11518.

Sl. No.	Component & Operation.	Characteristic to be Checked.	Mode of Inspection.	Extent of Checking.		Reference Document.	Acceptance Norm.	Formats & Records.	Remarks.
				Fabricator.	Inspection Authority.				
A	B	C	D	E	F	G	H	I	J
1.0	**RAW MATERIAS**								
1.1	Steel Plates, Steel Structural Sections should be from approved sources by RDSO.	a) Receipt particulars with Mill Test Certificates. b) Material conditions. c) Dimensional verification. d) Mechanical & Charpy test, V notch at 0^0C. e) Charpy test at 0^0C for plates. f) Chemical (C, Mn, Si, P, & S) composition. g)UST as in Mill TC.	a) Identification & Co-relation. b) Plates fully killed & normalized / control cooled. c) Visual Pitting, rusting etc., d) Measurement. e) UTS, YS EL% Bend. f) Charpy at 0^0C for 12 mm & above MS Plates.	100% of Items.	100% by RNVL, & verification of certificates & test reports by RDSO.	Reference documents, Manufacturers Test Certificates..	Specification: IS: 2062-Gr.-B, as per drawing. Plates below 12 mm. thick are Gr.-B fully killed. Plates 12 mm. thick & above are Gr-B fully killed & normalized/control cooled, UTS quality.	Receipt documents, Manufactures Test Certificates. IRS B1-2001 Appendix-I Table No.7. Heat wise & lot wise check of material from NABL Accredited Laboratory.	All Raw Steel Material will be supplied by SAIL/TISCO/RINL/ JINDAL & or From RDSO approved sources only.
1.2	Rivets & Bolts.	a) Visual. b) Dimensional. c) Material Quality.	a) Visual Checking. b) Measurement. c) Chemical Analysis & Physical Test.	Random per lot item a), b) & c) in col. C.	RVNL.	Manufacturers Test Certificates	Specification IS: 1148, IS: 1929 & IS: 1367 (Part-III).	Manufactures Test Certificates	Rivets & Bolts will be supplied by approved vendors.
1.3	Paints.	Name of Paints, Name of Manufactures with IS specification, Batch Nos. & Dates of Manufacture TC	Identification & Co-relation with Document Checking of T.C.	100% of Items	RVNL.	Order copies, receipts, document & manufactures Test Certificates.	Specification of Paints as per Contract. 3rd Party T.C's & IRS B1-2001.	Receipt document, Manufactures T.C's, 3rd Party Test Certificates.	All Paints will be supplied form approved Paint Manufactures

Sl. No.	Component & Operation.	Characteristic to be Checked.	Mode of Inspection.	Extent of Checking.		Reference Document.	Acceptance Norm.	Formats & Records.	Remarks.
				Fabricator.	Inspection Authority.				
A	B	C	D	E	F	G	H	I	J
0	RAW MATERIAS								
.1	Steel Plates, Steel Structural Sections should be from approved sources by RDSO.	a) Receipt particulars with Mill Test Certificates. b) Material conditions. c) Dimensional verification. d) Mechanical & Charpy test, V notch at 0°C. e) Charpy test at 0°C for plates. f) Chemical (C, Mn, Si, P, & S) composition. g)UST as in Mill TC.	a) Identification & Co-relation. b) Plates fully killed & normalized / control cooled. c) Visual Pitting, rusting etc., d) Measurement. e) UTS, YS EL% Bend. f) Charpy at 0°C for 12 mm & above MS Plates.	100% of Items.	100% by RNVL, & verification of certificates & test reports by RDSO.	Reference documents, Manufacturers Test Certificates.	Specification: IS: 2062-Gr.-B, as per drawing. Plates below 12 mm. thick are Gr.-B fully killed. Plates 12 mm. thick & above are Gr-B fully killed & normalized/control cooled, UTS quality.	Receipt documents, Manufactures Test Certificates. IRS B1-2001 Appendix-I Table No.7. Heat wise & lot wise check of material from NABL Accredited Laboratory.	All Raw Steel Material will be supplied by SAIL/TISCO/RINL/ JINDAL & or From RDSO approved sources only.

WPQR - (WELDING PROCEDURE QUALIFICATION RECORD)

Name & Address of Fabricator :
Description of weld Joint :
Welding procedure specification no. :
Name of Welder :
Date of preparation of test piece :
Dimension of test piece :
Base Metal :
Welding Process :
Welding Position :
Welding Current : Type : Polarity :
Weld joint design details :
Welding consumables :
Electrode/Wire Class : Dia : Drying method :
Flux : Type : Drying method :
Shielding gas :
Welding Parameters :

Weld Pass No.	Electrodes/ wire dia (mm	Curr ent (Amp.)	Arc Voltage (Volt)	Wire Feed Speed (m/min)	Travel Speed (m/mi	lectrical stick out (mm)	Gas flow rate (liter/ min.)
1	2	3	4	5	6	7	8

Preheating and inter pass temperature :

Results of Qualification Test :

Test.	Specification No.	Results.
1	2	3
Non-destructive Tests : i) Visual Examination. ii) Dye Penetrate test. iii) Magnetic particle test. iv) Radiographic / Ultrasonic test. Destructive Test i) Micro-examination. ii) Hardness survey : iii) Fillet weld fracture test iv) Transverse tensile test: Tensile strength Yield Stress Location of fracture. v) All-weld tensile test. Tensile strength. Yield stress Elongation % vi) Guided bend test : Root bend test : Face bend test : Side bend test : vii) Any other test :		

WELDING PARAMETERS FOR WPQR

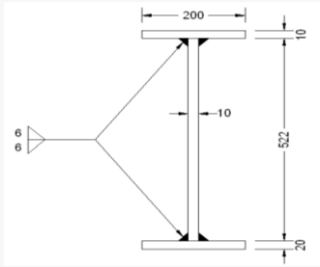
Name & Address of Fabricator :
Description of weld Joint :
Welding procedure specification no. :
Name of Welder :
Date of preparation of test piece :
Dimension of test piece :
Base Metal :
Welding Process :
Welding Position :
Welding Current : Type : Polarity :
Weld joint design details :
Welding consumables :
Electrode/Wire Class : Dia : Drying method :
Flux : Type : Drying method :
Shielding gas :
Welding Parameters

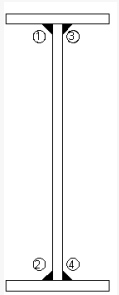
Weld Pass No.	Electrodes/ wire dia (mm	Curr ent (Amp.)	Arc Voltage (Volt)	Wire Feed Speed (m/min)	Travel Speed (m/mi	lectrical stick out (mm)	Gas flow rate (liter/ min.)
1	2	3	4	5	6	7	8

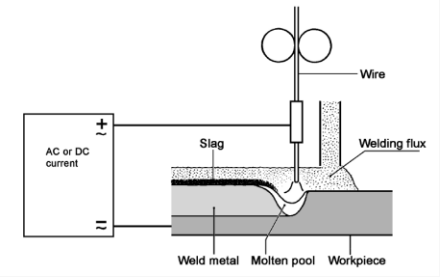
Preheating and inter pass temperature :

Non-destructive Tests :
i) Visual Examination.
ii) Dye Penetrate test.
iii) Magnetic particle test.
iv) Radiographic / Ultrasonic test.

Destructive Test
i) Micro-examination.
ii) Hardness survey :
iii) Fillet weld fracture test
iv) Transverse tensile test:
Tensile strength
Yield Stress
Location of fracture.
v) All-weld tensile test.
Tensile strength.
Yield stress
Elongation %
vi) Guided bend test :
Root bend test :
Face bend test :
Side bend test :
vii) Any other test :

Name and address of Fabricator		:	M/s. B. Engineers & Builders Ltd., 72/A, Mancheswar Industrial Estate, Bhubaneswar – 751010, Orissa
Welding Procedure Specification No.		:	BEB/WPS/088 Dated 18.07.2008
01.	RDSO Drawing No.	:	RDSO/BA – 11507
02.	Welding Joint Description	:	Fillet
03.	Base Metal	:	IS:2062 – 99, Gr. B, Fully Killed, Normalized/Control cooled
04.	Welding Process	:	SAW
05.	Welding Position	:	Flat
06.	Welding Consumable	:	
6.1	Electrode/Wire Class Type Drying Method	: : :	 W1 of IRS M 39 –2001 Copper Coated Mild Steel Wire N.A
6.2	Flux Class Type Drying method	: : :	 F1 of IRS M 39 – 2001 Agglomerated 250 ^{0}C for 1 (one) hour before use
6.3	Sheilding Gas	:	NA
07.	Base Metal Preparation	:	Fusion Faces and adjacent surfaces are cleaned and made free from Notches, Mill Scale, Grease, Paint, Rust etc., which may affect weld quality
7.1	Joint Design details		
	(Sketch showing arrangements of parts groove details, weld passes & their sequenc		
7.2	Joint Preparation	:	As per IS: 4353 – 1995, Cl.7, IRS B1 – 2001, Cl.17.3 & WBC – 2001
08.	Welding Current Type Polarity	: :	 DC Reverse
09.	Welder's Qualification	:	As per IS:7310 (Part – I) – 1974
10.	Welding Parameters & Technique	:	

10.1	Welding Parameters	:						
Weld Pass No.	Electrodes Wire dia. (mm)	Current (Amps)	Arc Voltage (Volts)	Wire Feed Speed (m/min)	Travel Speed (m/min)	Electrical Stick out (mm)	Gas Flow (l/min)	
1	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
2	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 –20	NA	
3	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
4	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
10.2	Welding Sequence & Technique	:	Welding from Center to run-off tabs at the free ends					
								
11.	Provision of run-on/run off tabs	:	Yes					
12.	Cleaning of weld bead before laying next weld bead	:	N.A					
13.	Root Preparation before welding other side of weld groove	:	N.A					
14.	Pre-heating & Inter pass temperature	:	N.A					
15.	Peening	:	N.A					
16.	Post weld treatment	:	N.A					
17.	Rectification of weld defect	:	By re-welding after complete removal of defective weld					
18.	Inspection of weld	:	Visual , D. P Test & Macro-Etching					
19.	Any other relevant details	:	Fillet weld of Portal Girder					

Name and address of Fabricator		:	M/s. B. Engineers & Builders Ltd., 72/A, Mancheswar Industrial Estate, Bhubaneswar – 751010, Orissa
Welding Procedure Specification No.		:	BEB/WPS/088 Dated 18.07.2008
01.	RDSO Drawing No.	:	RDSO/BA – 11507
02.	Welding Joint Description	:	Fillet
03.	Base Metal	:	IS:2062 – 99, Gr. B, Fully Killed, Normalized/Control cooled
04.	Welding Process	:	SAW
05.	Welding Position	:	Flat
06.	Welding Consumable	:	
6.1	Electrode/Wire		
	Class	:	W1 of IRS M 39 –2001
	Type	:	Copper Coated Mild Steel Wire
	Drying Method	:	N.A
6.2	Flux		
	Class	:	F1 of IRS M 39 – 2001
	Type	:	Agglomerated
	Drying method	:	250 ^{0}C for 1 (one) hour before use
6.3	Sheilding Gas	:	NA
07.	Base Metal Preparation	:	Fusion Faces and adjacent surfaces are cleaned and made free from Notches, Mill Scale, Grease, Paint, Rust etc., which may affect weld quality
7.1	Joint Design details		
	(Sketch showing arrangements of parts groove details, weld passes & their sequenc		
7.2	Joint Preparation	:	As per IS: 4353 – 1995, Cl.7, IRS B1 – 2001, Cl.17.3 & WBC – 2001
08.	Welding Current		
	Type	:	DC
	Polarity	:	Reverse
09.	Welder's Qualification	:	As per IS:7310 (Part – I) – 1974
10	Welding Parameters & Technique	:	

10.1	Welding Parameters	:						
Weld Pass No.	Electrodes Wire dia. (mm)	Current (Amps)	Arc Voltage (Volts)	Wire Feed Speed (m/min)	Travel Speed (m/min)	Electrical Stick out (mm)	Gas Flow (l/min)	
1	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
2	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 –20	NA	
3	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
4	4	400-500	25 - 30	0.8 – 1.2	0.5 – 0.7	15 - 20	NA	
10.2	Welding Sequence & Technique	:	Welding from Center to run-off tabs at the free ends					

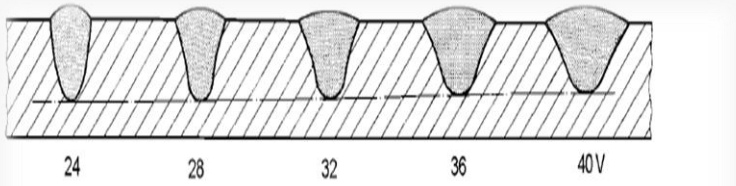


Figure 2. How a change in arc voltage affects the shape of weld. Welding current is constant.

11.	Provision of run-on/run off tabs	:	Yes
12.	Cleaning of weld bead before laying next weld bead	:	N.A
13.	Root Preparation before welding other side of weld groove	:	N.A
14.	Pre-heating & Inter pass temperature	:	N.A
15.	Peening	:	N.A
16.	Post weld treatment	:	N.A
17.	Rectification of weld defect	:	By re-welding after complete removal of defective weld
18.	Inspection of weld	:	Visual , D. P Test & Macro-Etching
19.	Any other relevant details	:	Fillet weld of Portal Girder

WELD EFFECT

MICRO ETHCHING

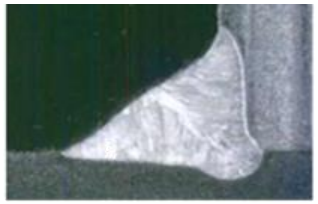


IMAGE 1 : Good Fusion

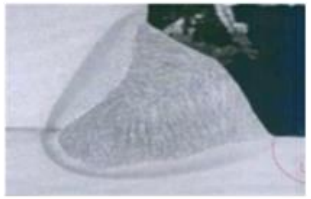
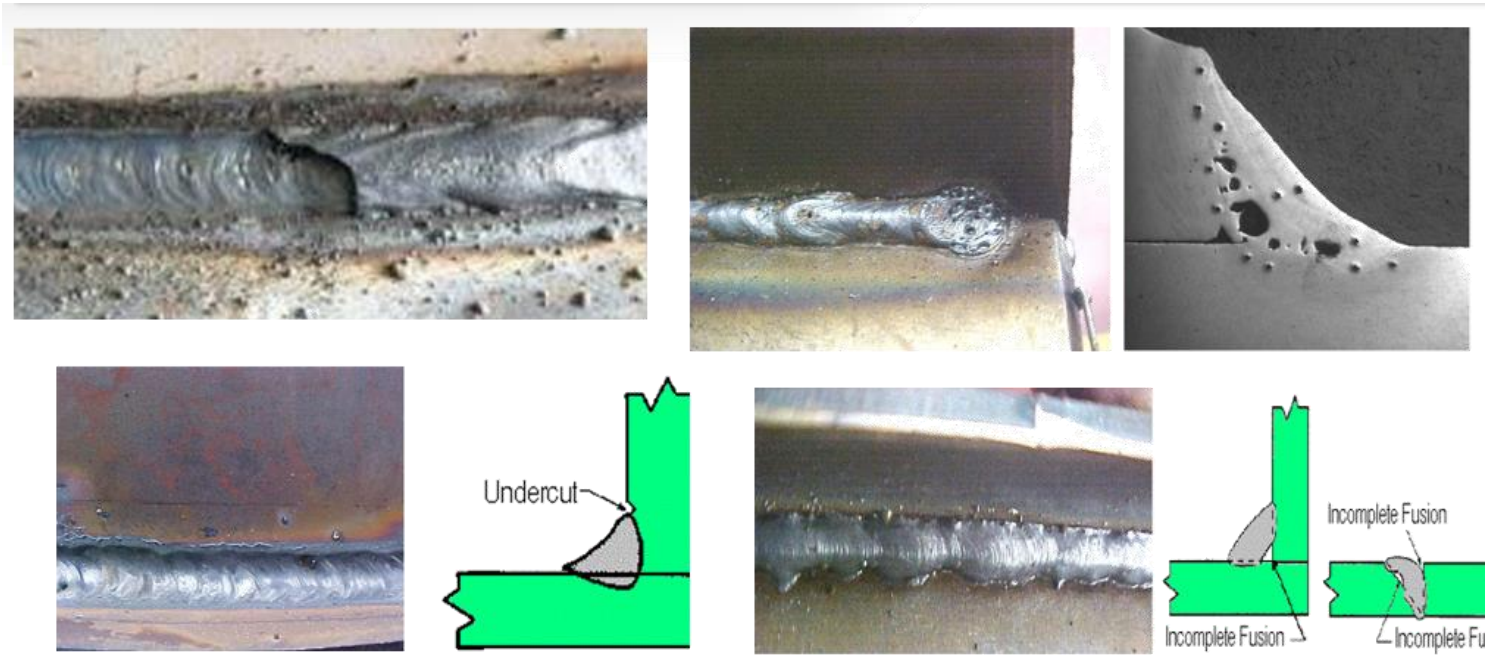


IMAGE 2 : Deeper Penetration, High Voltage

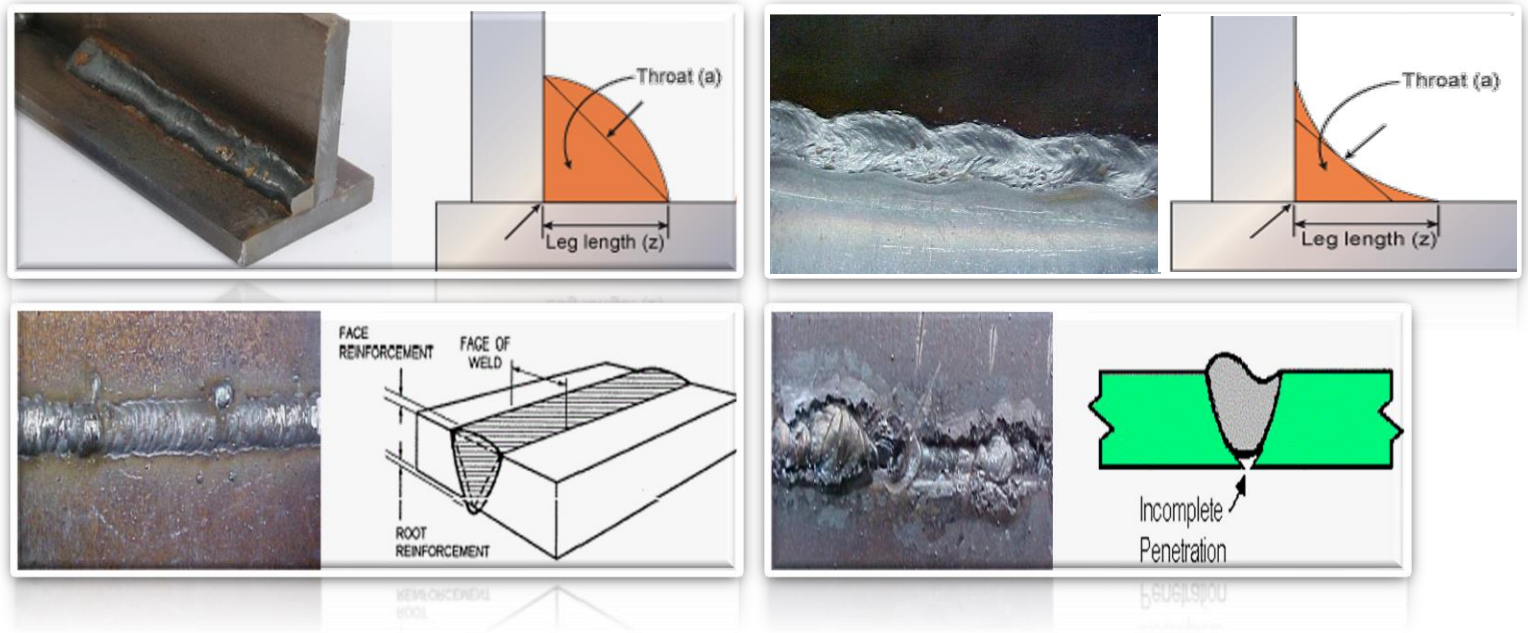
IMAGE 3 : Improper Fusion

IMAGE 4 : Improper Fusion

SLAG,PIN HOLES,UNDERCUT AND INCOMPLETE FUSION



EXCESSIVE CONVEXITY,CONCAVITY,WELD REINFORCEMENT AND INCOMPLETE FUSION

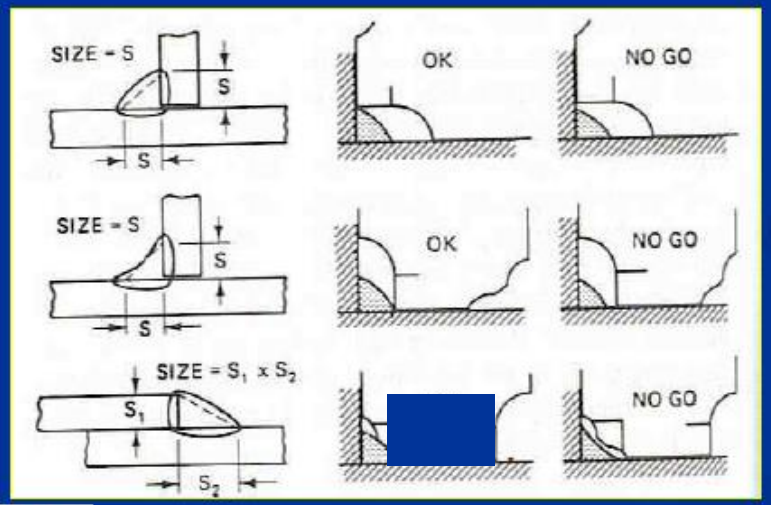


TESTING OF WELDS

1. Visual Inspection
2. Liquid Penetrant Inspection
3. Magnetic- particle Inspection
4. Radiography
5. Ultrasonic Inspection

Weld size measurements

- It is important to measure weld size.
- **Size of fillet welds** can be easily measured by using weld gauges (different standard gauges used:



Fillet weld size and method of checking

FIGURE 21-17 U.S. Navy weld gauge.

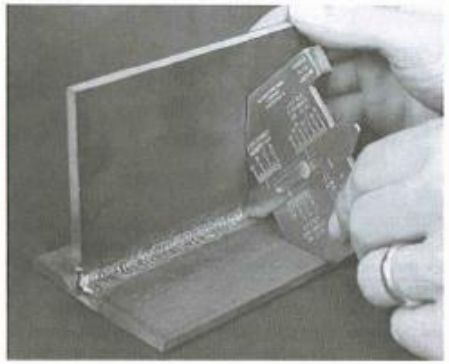
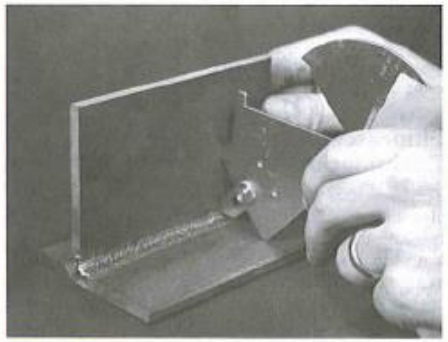
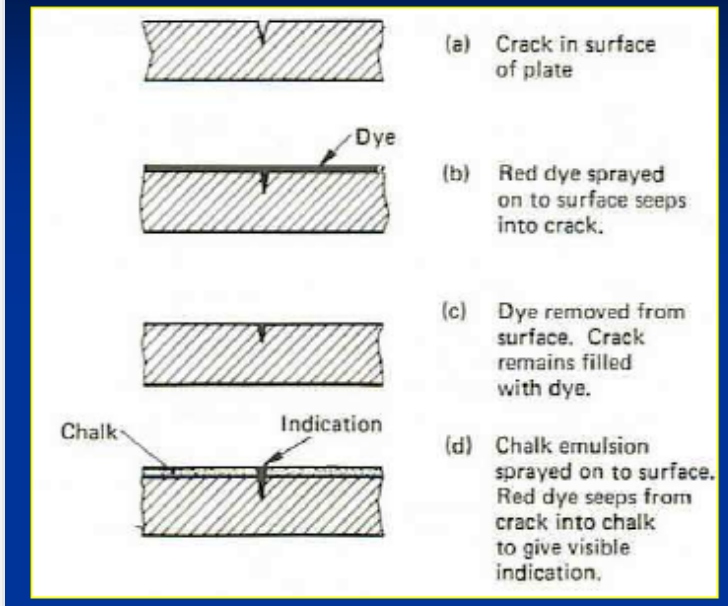


FIGURE 21-18 British welding gauge.



Method and applications



Principle of liquid-penetrate inspection

- The ***liquid penetrant*** (normally red) is applied on the surface containing cracks.
- Waiting for the liquid ***penetrates*** into the cracks.
- ***Clean off*** the excess liquid from the surface, but some liquid still remains in the cracks.
- ***Developer*** (chalk emulsion) is applied to enhance the visible indication of cracks.

Note: *Ultraviolet or black light source are used for the inspection of fluorescence liquid penetrant. Sound areas appear deep violet while the defects will glow a brilliant yellowish green.*

TOLERANCES

FABRICATION TOLERANCE IN GIRDERS

OPEN WEB GIRDER		TOLERANCE IN MM. (PLUS)	TOLERANCE IN MM. (MINUS).	NATIONAL IN THE FIGURE NO.1
a)	Overall length of Girders	1	1	K
b)	Distance between centre to centre of bearings	1	1	L
c)	Cross diagonals of assembled bays	1	1	M
d)	Centre to centre of cross girders	1	1	N
e)	Centre to centre of Rail bearer	1	1	P
f)	Panel length in lateral bracing system	1	1	Q
g)	Distance between inter section line of chords vertical & horizontal	1	1	R
h)	Butting edges of compression members i) Throughout ii) Locally	 0 0	 0.15 0.25	 s s
i)	Twist in members.	0	0	T
j)	Lateral distortion between points of lateral support	.001L	.001L	U

HOLES		TOLERANCE IN MM. (PLUS)	TOLERANCE IN MM. (MINUS).	NATIONAL IN THE FIGURE NO.3
a)	Between any two holes in group	0.5	0.5	V
b)	Between holes of one group and another	1	1	W
c)	Edge distance.	0.5	0.5	X
d)	Distance of 'GO' gauge open holes in two or more thickness.	0	0.8	Y

FABRICATION TOLERANCE IN GIRDERS (1/4)

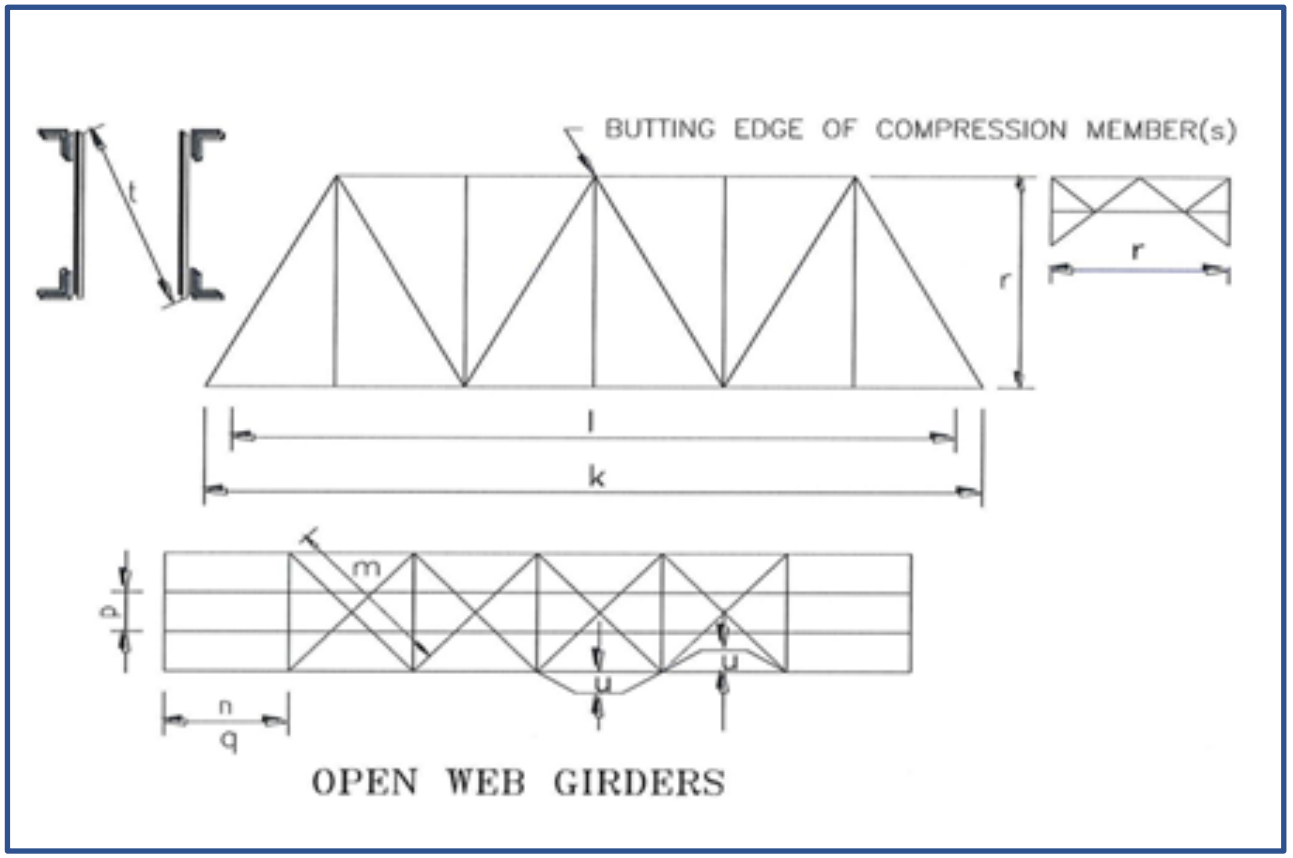


Figure 1

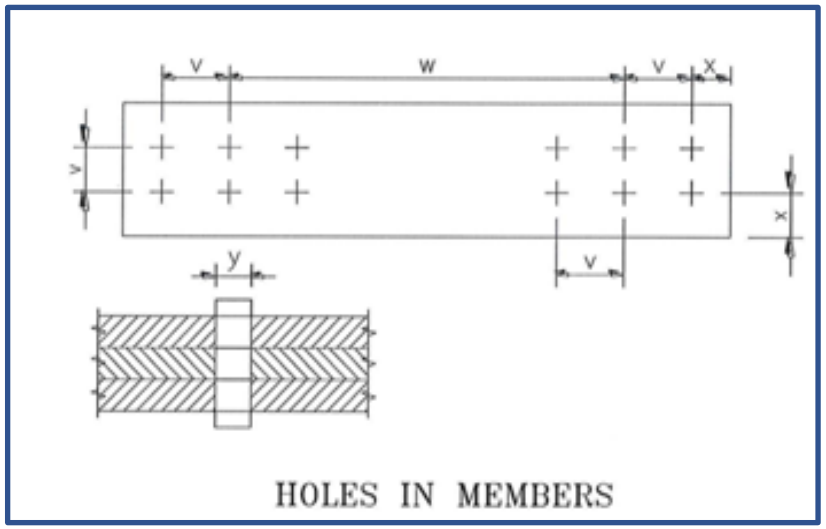


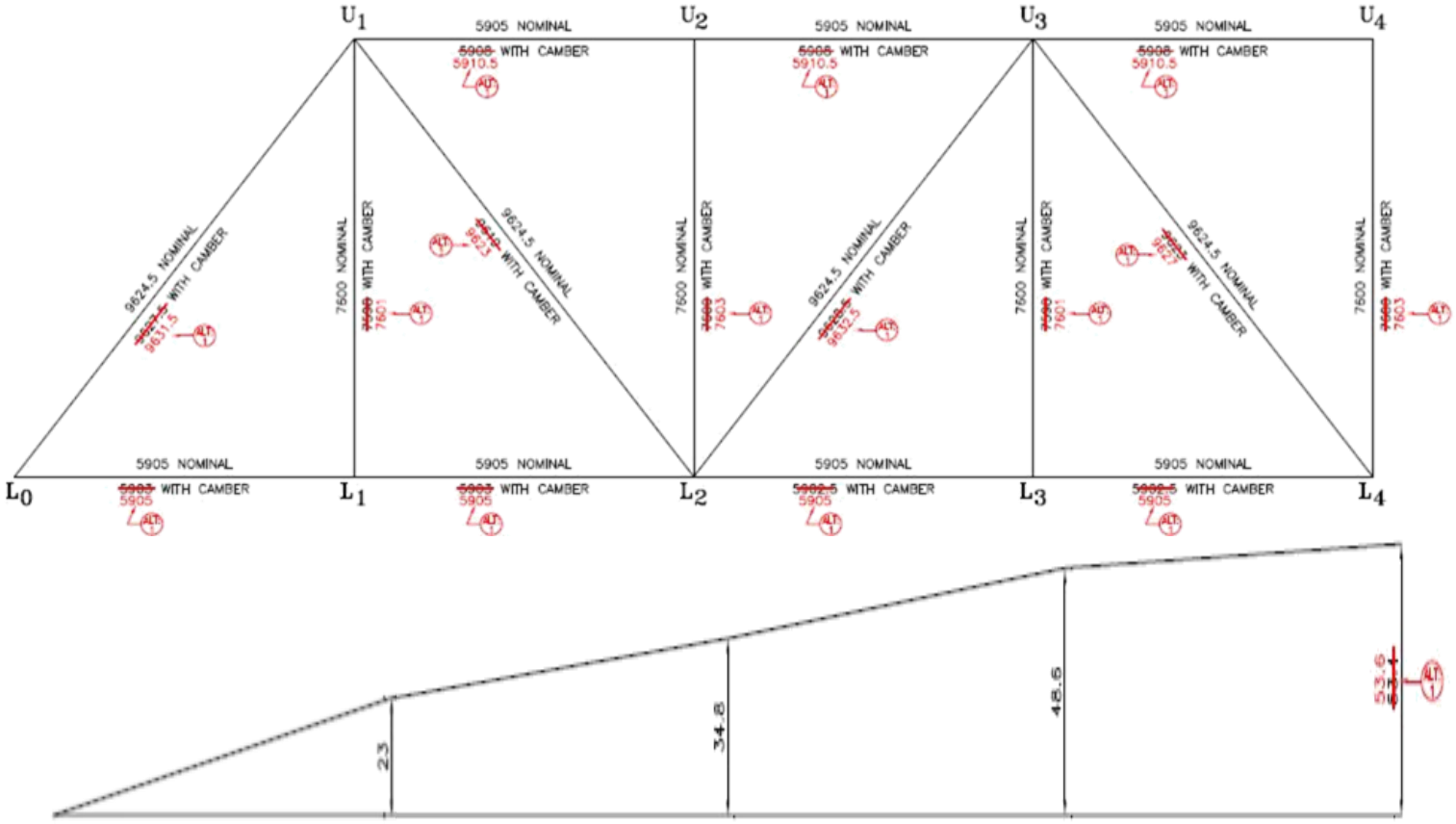
Figure 2

FABRICATION TOLERANCE IN GIRDERS

OPEN WEB GIRDER		TOLERANCE IN MM. (PLUS)	TOLERANCE IN MM. (MINUS).	NATIONAL IN THE FIGURE NO.1
a)	Overall length of Girders	1	1	K
b)	Distance between centre to centre of bearings	1	1	L
c)	Cross diagonals of assembled bays	1	1	M
d)	Centre to centre of cross girders	1	1	N
e)	Centre to centre of Rail bearer	1	1	P
f)	Panel length in lateral bracing system	1	1	Q
g)	Distance between inter section line of chords vertical & horizontal	1	1	R
h)	Butting edges of compression members i) Throughout ii) Locally	 0 0	 0.15 0.25	 s s
i)	Twist in members.	0	0	T
j)	Lateral distortion between points of lateral support	.001L	.001L	U

HOLES		TOLERANCE IN MM. (PLUS)	TOLERANCE IN MM. (MINUS).	NATIONAL IN THE FIGURE NO.3
a)	Between any two holes in group	0.5	0.5	V
b)	Between holes of one group and another	1	1	W
c)	Edge distance.	0.5	0.5	X
d)	Distance of 'GO' gauge open holes in two or more thickness.	0	0.8	Y

TRIAL ASSEMBLY


U1
U2
U3
U4
L0
L1
L2
L3
L4
5905 NOMINAL
5908 WITH CAMBER
5910.5
9624.5 NOMINAL
WITH CAMBER
9631.5
9623
9627
9632.5
7600 NOMINAL
WITH CAMBER
7601
7603
5903 WITH CAMBER
5905
5902.5 WITH CAMBER
23
34.8
48.6
53.6
54.1

TRIAL ASSEMBLY PROCEDURE (1/2)

- ✓ Camber jacks are put below each joint
- ✓ Mismatching holes in packs shall be rimmed
- ✓ Fifty percent holes should be on drifts

TRIAL ASSEMBLY PROCEDURE (2/2)

- ✓ Dimensions to be checked
- ✓ Camber at node points to be taken by levelling instruments

PROTECTION AGAINST CORROSION

BLAST SURFACE CLASSIFICATION

DESIRED LIFE OF COATING SYSTEM IN DIFFERENT ENVIRONMENT

SL. NOS.	ATMOSPHERIC CONDITIONS / ENVIRONMENTAL CLASSIFICATIONS	COATING SYSTEM					
		a	b	c	d	e	f
01	NOMINAL INLAND (RURAL AND URBAN AREAS), MILD.	12 YEARS	18 YEARS	20 YEARS	ABOUT 20 YEARS	ABOUT 20 YEARS	ABOVE 20 YEARS
02	POLLUTED INLAND (HIGH AIRBOME SULPHUR DIOXIDE), MODERATE.	10 YEARS	15 YEARS	12 YEARS	ABOUT 18 YEARS	15-20 YEARS	ABOVE 20 YEARS
03	NORMAL COATAL (AS NORMAL INLAND PLUS HIGH AIRBOME SALT LEVELS), SEVERE.	10 YEARS	12 YEARS	20 YEARS	ABOUT 20 YEARS	ABOUT 20 YEARS	ABOVE 20 YEARS
04	POLLUTED COASTAL (AS POLLUTED INLAND PLUS HIGH AIRBOME SALT LEVELS), VERY SEVERE OR EXTREME.	8 YEARS	10 YEARS	10 YEARS	ABOUT 185YEARS	15-20 YEARS	ABOVE 20 YEARS

SPECIFICATION FOR DIFFERENT COATING SYSTEM (SHOP)

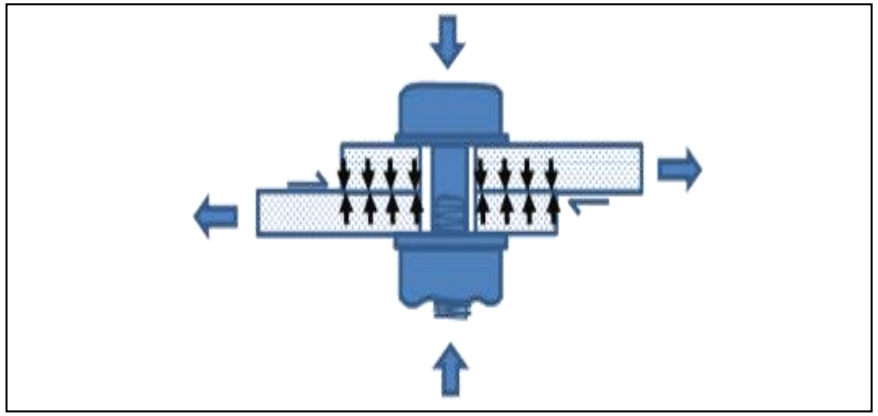
SL. NOS.	PROTECTION	COATING SYSTEM					
		a	b	c	d	e	f
01	SURFACE PREP-ARATION	BLAST CLEAN	BLAST CLEAN	BLAST CLEAN	BLAST CLEAN	GRIT BLAST	BLAST CLEAN
02	PRE-FABRICATION PRIMER	ZINC PHOS-PHATE EPOXY, 20 µm	TWO PACK ZINS RICH EPOXY, 20 µm	-	TWO PACK ZINS RICH EPOXY, 20 µm	-	ETHYLE ZINC SILICATE, 20 µm
03	POST-FABRICATION PRIMER	HIGH-BUILD ZINC PHOS-PHATE MOD-IFIED ALKYD, 60 µm	TWO PACK ZINS RICH EPOXY, 20 µm	HOT DIP GALVA-NIZED 85 µm	TWO PACK ZINS RICH EPOXY, 25 µm	SPRAYED ZINC OR SPRAYED ALUMINIUM	ETHYL ZINC SILICATE, 60 µm
04	INTERMEDIATE COAT	-	HIGH-BUILD ZINC PHOS-PHATE, 25 µm	-	TWO PACK MICACEOUS IRON OXIDE, 85 µm	SEALER	CHLORI-NATED RUBBER ALKYD, 35 µm
05	TOP COAT	-	-	-	TWO PACK MICACEOUS IRON OXIDE, 85 µm	SEALER	-

SPECIFICATION FOR DIFFERENT COATING SYSTEM (SITE)

SL. NO.	PROTECTION	COATING SYSTEM					
		a	b	c	d	e	f
01	SURFACE PREPARATION	AS NECES-SARY	AS NECES-SARY	NO SITE TREATMENT	AS NECES-SARY	NO SITE TREAT-MENT	AS NECES-SARY
02	PRIMER	TOUCH IN	TOUCH IN	-	-	-	TOUCH IN
03	INTERMEDIATE COAT	-	MODIFIED ALKYD MI-CACEOUS IRON OXIDE, 50 µm	-	TOUCH IN	-	HIGH-BUILD MICACEOUS IRON OXIDE / CHLORINATED RUBBER MI-CACEOUS, 75 µm
04	TOP COAT	HIGH-BUILD ALKYD FINISH, 60 µm.	MODIFIED ALKYD MI-CACEOUS IRON OXIDE, 50 µm.	-	HIGH-BUILD CHLORI-NATED RUB-BER	-	HIGH-BUILD IRON OXIDE CHLORINATED RUBBER, 75 µm.

3

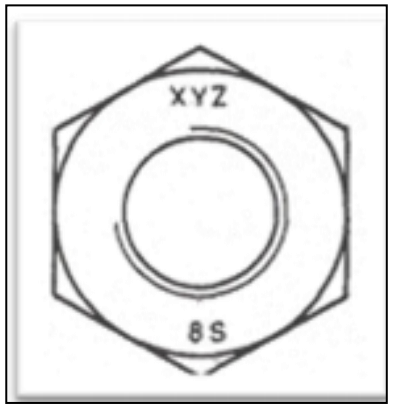
ASSEMBLY & ERECTION



Friction along interface transmits load in case of HSFG Bolt subject to shear

A bolt assembly

Typical Marking on bolt-heads

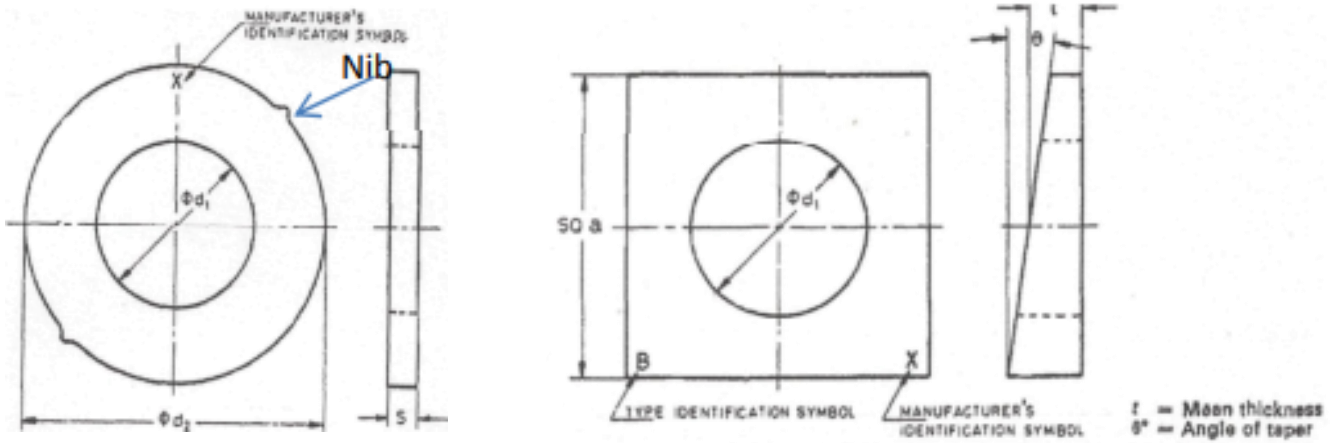


Typical Marking on Nuts

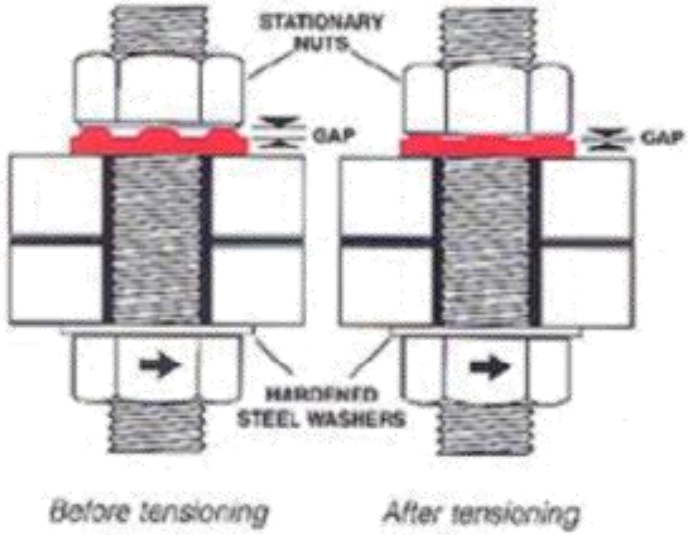
The property class of bolts 8.8 is embossed or indented as 8S

- 8 indicates-8000N/mm^(ultimate)
- 8 indicates -80%of ultimate ,640N/mm^ is the shear

Two faces of DTI



Type A: Plain hole circular washers



Type B: Square taper washers for use with channels (6deg taper)

Type C: Square taper washers for use with I-beams (8 deg taper)

PRECAUTIONS - HSFG BOLT

- All the bolts, washers and nuts should be accompanied by manufacturer test certificates
- Appropriate markings indicating that these bolts are as per relevant codes should be checked
- Metalizing the surface which is to be connected by the HSFG bolts is permitted
- Painting the interface, which has been metalized,is not permitted
- Reusing a bolt, which has been fully tightened once, is not permitted

Efficiency of the end termination or eye splice

Hand spliced eyes:

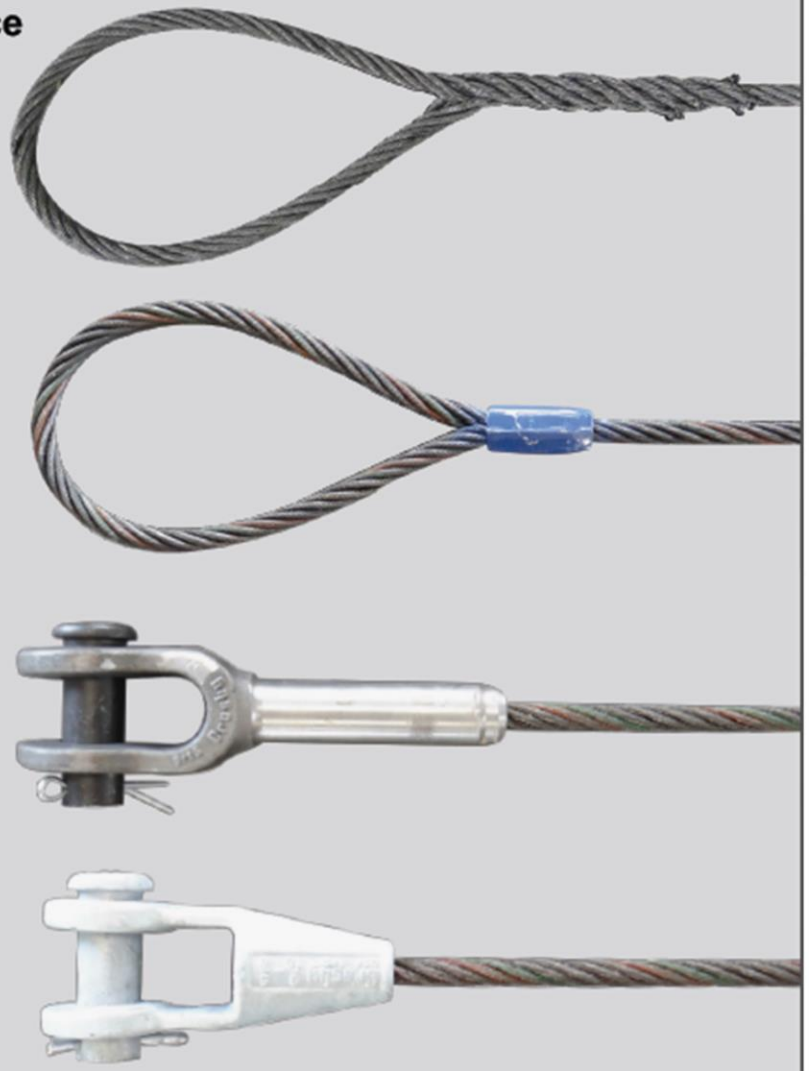
Rope Diameter	Efficiency
1/4"	90%
5/16"	89%
3/8"	88%
7/16"	87%
1/2"	86%
9/16"	85%
5/8"	84%
3/4"	82%
7/8" to 2-1/2"	80%

Mechanical spliced eyes:

Rope Diameter	Efficiency
1/4" to 1"	95%
1-1/8" to 2"	92.5%
2-1/4" to 4-1/2"	90%

Swage and spelter sockets:

Rope Diameter	Efficiency
1/4" to 4-1/2"	100%

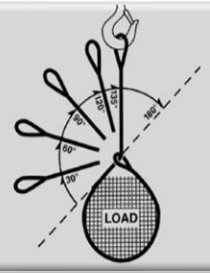


Vertical Pull:
A vertical pull is where a sling is hitched between the lifting device and load in a straight line.

Vertical Basket Hitch:
A vertical basket hitch is where the body of the sling supports the load being lifted and the two ends of the sling are attached to the lifting device.

Choker Hitch:
A choker hitch is where the eye on one end of the sling is passed through the eye on the other end of the sling and the sling is choked around the load being picked up. The chart below shows the capacity reduction of a sling used in a choker hitch.

Angle of Choke Degree	Rated Capacity %
Over 120	100
90-120	87
60-89	74
30-59	62
0-29	49



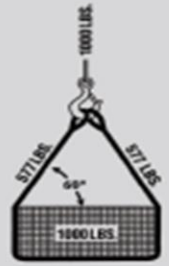
LOAD FACTOR ON SLINGS

Load Factor Guidelines

Leg Angle	Load Factor
90°	1.000
85°	1.003
80°	1.015
75°	1.035
70°	1.064
65°	1.103
60°	1.154
55°	1.220
50°	1.305
45°	1.414
40°	1.555
35°	1.743
30°	2.000

A. Vertical lift: Total load is 1,000 lbs. divided by two legs = 500 lbs. load per leg if if vertical lift

B. Horizontal sling angle is 60 degrees: Multiply 500 lbs. by 1.154 load factor (from table) = 577 lbs. actual load per leg.

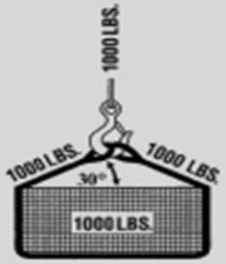


A. Vertical lift: Total load is 1,000 lbs. divided by two legs = 500 lbs. load per leg if if vertical lift

B. Horizontal sling angle is 45 degrees: Multiply 500 lbs. by 1.414 load factor (from table) = 707 lbs. actual load per leg.

A. Vertical lift: Total load is 1,000 lbs. divided by two legs = 500 lbs. load per leg if if vertical lift

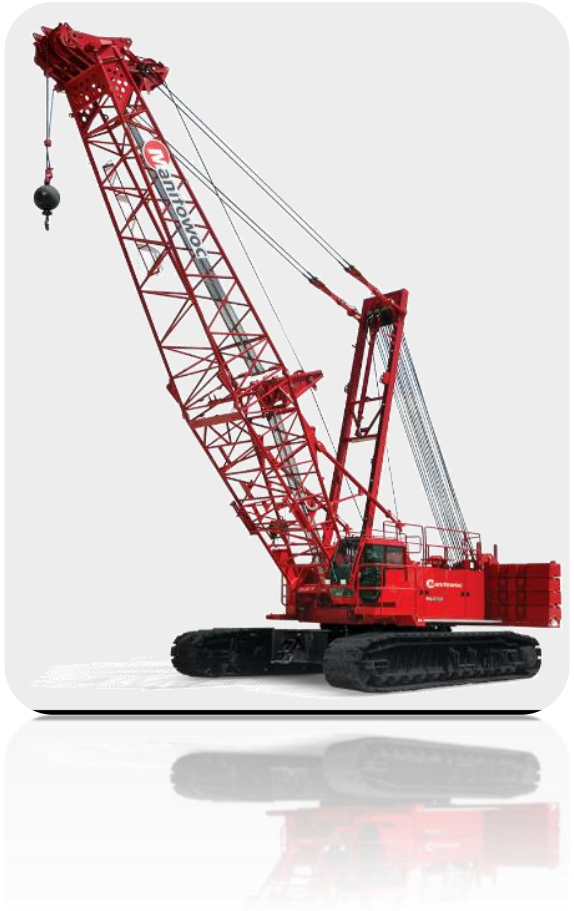
B. Horizontal sling angle is 30 degrees: Multiply 500 lbs. by 2.000 load factor (from table) = 1000 lbs. actual load per leg.



***WARNING*: Slings shall not be used with horizontal angles less than 30°.**

ALL TERRAIN CRANES

CRAWLER CRANE



- ✓ ***Details & arrangement of member*** *- show sizes, capacities, and location of centre of gravity of each pick*
- ✓ ***False work and temporary support details*** *– show sizes and capacities*
- ✓ ***Crane capacity***
  - *Crane type,*
  - *Lifting capacity at given radius and orientation*
  - *Counterweight requirements*
  - *Boom length*
- ✓ ***Pick weight chart indicating*** *– Weight of member, plus rigging and any attachments*
- ✓ ***Written procedure indicating*** *–Erection sequence for primary and secondary members , method of tie down of individual pieces, lateral bracing, and field splices.*
- ✓ ***Releasing of the hook*** *–Plan for the approach of rigger for unhooking*

CRAWLER CRANE LOAD CHART

Radius in meters	Main boom length in meters						
	12,6	15,7	18,9	22,0	28,0	34,0	40,2
2,5	120 000	—	—	—	—	—	—
3	100 000	—	—	—	—	—	—
4	84 000	69 000	66 000	52 000	—	—	—
5	75 000	69 000	61 400	52 000	37 000	30 000	—
6	70 000	67 000	54 000	48 400	37 000	29 800	21 000
7	60 000	59 000	48 300	43 300	36 200	28 500	21 000
8	52 000	50 000	43 400	38 800	33 700	27 000	20 000
9	45 000	45 000	39 300	35 200	31 000	25 200	19 400
10	40 000	39 900	36 000	32 100	28 200	23 400	18 600
12	—	30 800	30 500	27 100	24 400	20 400	16 600
14	—	—	23 900	23 200	21 100	17 900	14 800
16	—	—	19 300	19 100	18 400	15 900	13 300
18	—	—	—	15 700	16 200	14 300	12 000
20	—	—	—	—	14 000	12 900	10 800
22	—	—	—	—	12 000	11 600	9800
24	—	—	—	—	10 300	10 700	9000
26	—	—	—	—	—	9400	8200
28	—	—	—	—	—	8200	7600
30	—	—	—	—	—	7200	7000
32	—	—	—	—	—	—	6400
34	—	—	—	—	—	—	5700
36	—	—	—	—	—	—	5100
When 8 m extension is in stowed position, the rated loads must be reduced as follows:							
Reduction of load (kg)	538	436	370	321	256	214	185

PLANNING BEFORE LIFTING

- ✓ ***Details & arrangement of member*** *- show sizes, capacities, and location of centre of gravity of each pick*
- ✓ ***False work and temporary support details*** *– show sizes and capacities*
- ✓ ***Crane capacity***
  - *Crane type,*
  - *Lifting capacity at given radius and orientation*
  - *Counterweight requirements*
  - *Boom length*
- ✓ ***Pick weight chart indicating*** *– Weight of member, plus rigging and any attachments*
- ✓ ***Written procedure indicating*** *–Erection sequence for primary and secondary members , method of tie down of individual pieces, lateral bracing, and field splices.*
- ✓ ***Releasing of the hook*** *–Plan for the approach of rigger for unhooking*

- ✓ *Working area restrictions and obstacles should be mapped before lifting.*
- ✓ *Crane should be Leveled (3deg tilt can reduce lifting capacity by50%)*
- ✓ *Centrifugal force - Swinging should be slow and the job should never touch the boom when lifted*
- ✓ *Positioning of a load should not be done by side loading the boom*
- ✓ *The load should not be left suspended for a break or for the shift end stoppage*
- ✓ *Overhead power lines should be marked and the lift should be planned along with the crane operator and lift foreman*

THANK YOU