

GATES, HOISTING ARRANGEMENTS

1. GENERAL

1.1. INTRODUCTION

A Canal system comprises the channels and regulators. The channels in a large system of canals are usually termed as feeder, branch, distributary, sub-distributary, minors and sub minors. There is a parent child relation ship between these terms for different channels and the size of the channel reduces as we move down the list. While most of the distributaries take off from the branches, the sub-distributaries from distributaries, and the minors from distributaries and sub-distributaries, some of the minors take off directly from the branches and are termed as direct off take minors.

The regulators (head regulators, cross regulators, escape heads and duckbill weirs) are part of the control structures that regulate the flow and give the desired distribution of water in different channels. All these regulator structures are equipped with gates that can be opened fully or partially , or closed completely to achieve the desired distribution. The hoisting arrangement is the part of the system that provides the necessary movement to the gate and the operating platform provides access to the operating mechanism of the hoist.

While the design of flow channels in these regulators is an integral part of the design of the canal system and has been discussed in detail, earlier in this volume, the gates, hoists and operating platform are part of the mechanical system and the design methodology for these systems is presented herein.

1.2. GATE

1.2.1. Classification of gates

Gates used in a Canal system may be classified as head regulator, cross regulator, escape head or duckbill weir gates depending on the type of regulator where it is to be fitted. In all the regulators the basic function of the gate remains the same namely to permit a variation of flow between nil and the maximum that can flow through the regulator, when there is no obstruction in the flow path due to the gate. This means that there is no basic difference in the design of the gates for different types of regulators. However the size of the gate varies considerably in these regulators, being the largest for the cross regulators on the branches, somewhat smaller for the head regulators on distributaries, and escape heads on the branches, and cross regulators on distributaries, still smaller for the head regulators of sub-distributaries, and the smallest for the minors. Head regulators of some of the Direct Off-take minors require gates of considerably larger heights.

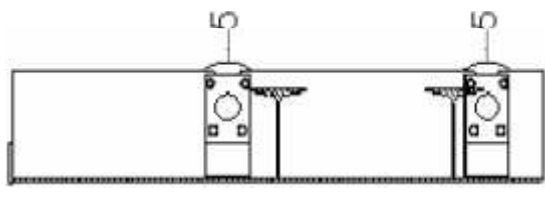
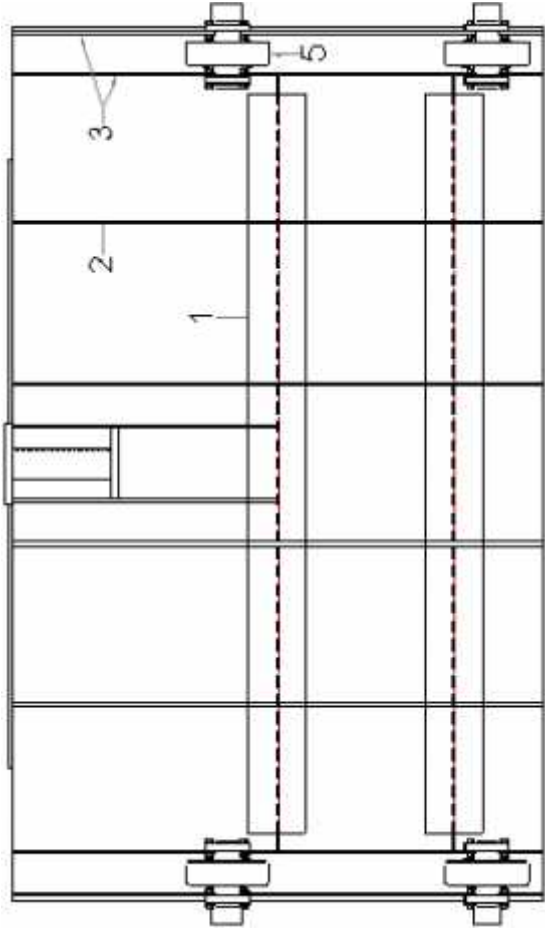
There are no set rules for classification of gates but Jain (Handbook of Hydroelectric Engineering) has suggested that they can be classified according to several criteria e.g. water head, purpose, shape, method of movement, and materials.

Based on water head the gates are generally classified as low head (upto 15 m), medium head (15 – 30 m) , and high head (above 30 m). In the canal system that we are concerned with the largest head is 3.5 m and so all gates fall in the general category of low head gates.

Based on the shape and the method of movement Jain has classified the gate in 13 different categories. A review of existing (Control structures) gates on the distributary canal systems included in this project, revealed that that all the gates were of the vertical lift type. The gate height varies between a maximum of 3.55 m (Cross regulator Dih) and a minimum of 0.5 m on many of the minors. The largest gate width is 8.10 m whereas the smallest width is only 0.5 m. Given this range the appropriate type of gate for all locations is the vertical lift type. Radial type gates become a viable option only when the heads are comparatively much higher. Other types which are suitable only in other applications are not discussed here.

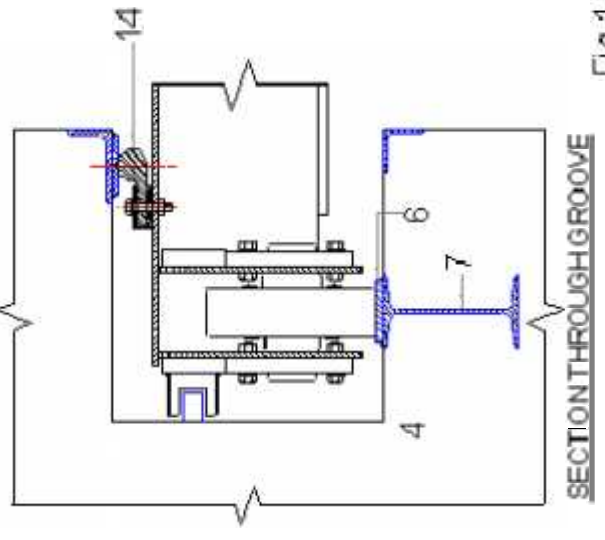
1.2.2. Basic Features of Construction

The general construction of a vertical lift gate is shown in Fig 1 (Fixed Wheel Gate) and Fig. 2 (Slide Gate). The gate has an up stream skin plate that is supported on the down stream side by a number (2 to 3) of horizontal girders 1 , vertical stiffeners 2 and end vertical girders 3, forming a panel construction. Panel Construction has been chosen in preference over the construction where skin plate is supported by either the horizontal girders or vertical stiffeners as that provides the lightest design for a given rigidity. The hydraulic load due to the water pressure is transmitted to the piers/abutment 4 of the regulator through a number of wheels 5, their track 6, and track base beam 7 in case of fixed wheel gates, (Fig1), or through the bearing pads 8, bearing plate 9 and the staunching angle 10 in case of slide gate (fig2). In order to achieve the requirement of zero flow when the gate is closed these gates are equipped wedge type bottom seals 11 pressing against a seal seat 12 fixed on to the Sill beam 13, and music note type side seal 14 in case of fixed wheel gates, and angular type side seals 15 in case of slide gates. Since the FSL is below the top edge of the gate, there is no cross beam, and no top seal.

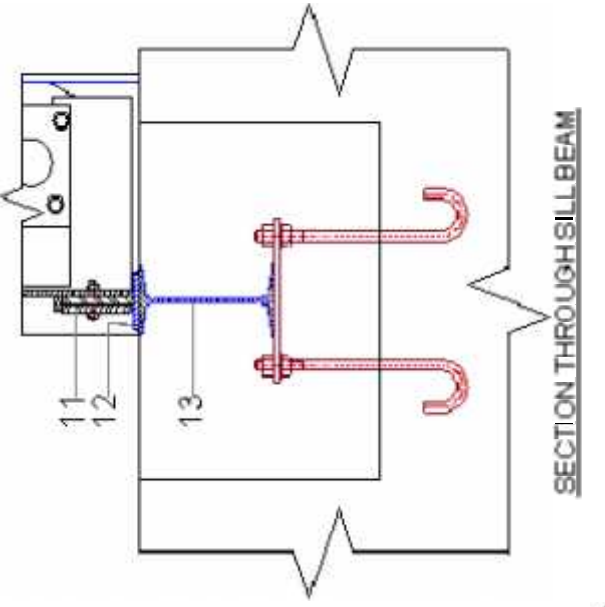


FRONT VIEW

END VIEW

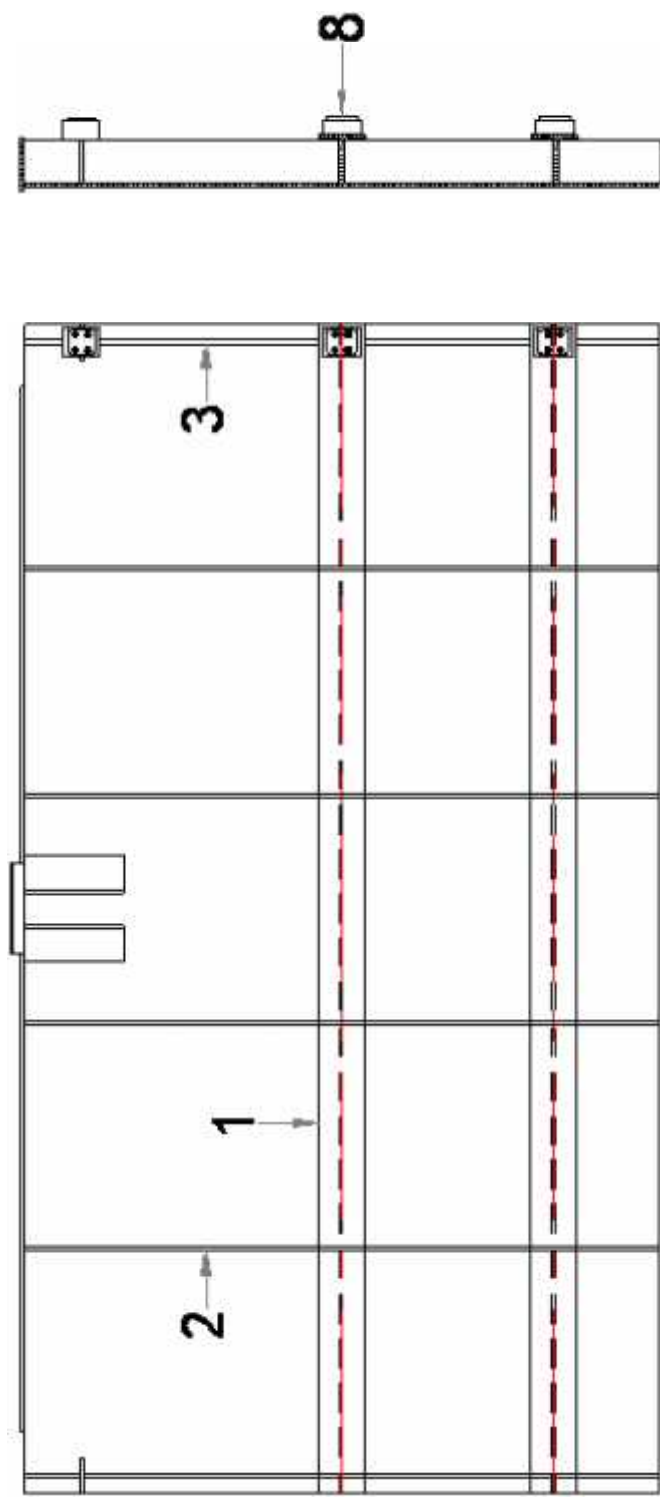


SECTION THROUGH GROOVE



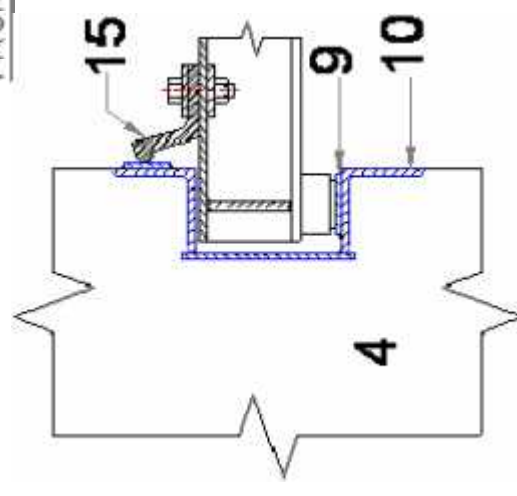
SECTION THROUGH SILL BEAM

Fig.1 Fixed wheel Gate



FRONT VIEW

END VIEW



SECTION THROUGH GROOVE

Fig.2 SLIDE GATE

1.2.3. General considerations in selection of type of construction

The hydraulic load on comparatively larger gates is large (typically about 36 tons for a 8 m x 3 m gate). With a slide gate the resistance due to friction is half this value (18000 Kg), whereas with a fixed wheel gate the value goes down to just 350 Kg . This large reduction in resistance results in considerable reduction in the required capacity of the hoist, as well as the loads on all the support structures. Fixed wheel gates are therefore the appropriate choice for the larger gates.

The design procedure follows the appropriate IS code namely IS 4622 : 2003 RECOMMENDATIONS FOR STRUCTURAL DESIGN OF FIXED WHEEL GATES.

Slide gates on the other hand offer the advantages of simplicity of construction, and ease of operation and maintenance over the fixed wheel gates. They are therefore recommended for use at all locations where the size is not large enough to require the provision of a fixed wheel gate.

The design procedure follows the appropriate IS code namely IS 5620 : 1985 (REAFFIRMED 1995) RECOMMENDATIONS FOR STRUCTURAL DESIGN CRITERIA FOR LOW HEAD SLIDE GATES.

In the size range of gates used in this system a 3 girder construction is adequate for the larger (fixed wheel) gates, whereas 2 girder construction is adequate for the smaller (slide) gates. Fixed wheel gates are provided with two wheels each on either side, and the slide gates with two bearing pads mounted directly on the two girders on either side. This is adequate for the loads in this case. Fixed wheel gates are provided with Music Note type side seals, whereas the slide gates are provided with angular type side seals.

While the design of the fixed wheel gates follows IS 4622 and that of the slide gates follow IS 5620, it is pertinent to mention that the two codes are substantially the same, in many respects. Thus most of the clauses in the design criteria presented below apply to all types of gates. Specific clauses that are applicable to fixed wheel gates only will generally have A in the number and those for slide gates only shall have B unless otherwise indicated.

1.3. HOIST

Hoists commonly used with vertical gates can broadly be divided into two types namely rope drum hoists and screw hoists.

Rope drum hoists are suitable only for gates that would close under their own weight, with sufficient force to effectively press the bottom seal to prevent leakage. This restricts their use to the fixed wheel gates only as pad friction in slide gates is rather high and the gates usually do not close under their own weight.

Such a hoist permits push button operation of the gate for control of flow in the canal. It is also possible to adapt this for remote operation, and if required for automatic operation. IS: 6938 –1989 DESIGN OF ROPE RUM AND CHAIN HOISTS FOR HYDRAULIC GATES – CODE OF PRACTICE lays down the broad requirements and has been largely followed in the design. Use of bought out components for mechanical transmission and electric control is preferred as that ensures reliability of operation. Rope drum hoists should be so designed that they can be operated manually without excessive effort.

The gates for the 4 new cross regulators at Km 44.200, 56.153, 67.00, and 97.143 of Jaunpur Branch are fixed wheel gates and are large enough to have sufficient weight to effectively seal at the bottom. These are all provided with rope drum hoist.

The sizes of gates on the cross regulator at Km 13.425 of Dih are some what smaller. These are large enough to require fixed wheel gates. However their weight is not large enough for effective pressure on the bottom seal and so a rope drum hoist is unsuitable. Screw hoists provide positive force both for upward and downward movement of the gate and can therefore be used with both fixed wheel and slide gates.

Almost all the gates except the five gates on cross regulators mentioned above, are of sizes that are not large enough to necessarily require the use of fixed wheel gates. All such gates are to be provided with screw hoist. IS: 11228-1985 (reaffirmed 1990) RECOMMENDATIONS FOR DESIGN OF SCREW HOISTS FOR HYDRAULIC GATES lays down the broad requirements and has been largely followed in the design.

1.4. OPERATING PLATFORM

Large gate (on the cross regulators) structures shall be provided with an operating platform of 1.5 m to 2.0 m width for operating the hoist mechanism for operation of gates. Generally the platform shall consist of chequered plates supported on I girders. Suitable block outs shall be provided at the top of pier and abutment for fixing the stanchions that support and fix the girders of the hoist platform.

The small gates do not require any special operating platform. The hoist is supported on a structure whose design is discussed with the design of the hoist. A reinforced concrete slab of minimum thickness (75-100mm) across the canal channel is required on either (preferably both) side of the Gate about 1.3 m to 1.5 m below the hoist operating lever level and will provide a convenient base to stand on, for the person operating the hoist.

1.5A BASIC DESIGN PARAMETERS (FOR FIXED WHEEL GATES)

(i)	Clear opening,	W	=	Width of bay
(ii)	Height of gate	H		
(a)	For discharge ≤ 2.80 Cumec	H	=	FSL – crest level + 0.15 m
(b)	For discharge > 2.80 Cumec	H	=	FSL – crest level + 0.30 m
(iii)	C/C of side seal	b	=	W+ 100 to 150 mm
(iv)	C/C of Track	a	=	W + 150 to 300 mm
(v)	Design Head	h	=	Gate height

1.5B Basic Design Parameters (for slide gates)

- (i) Clear opening, $W =$ Width of bay
(Rounded to the nearest 10 cm)
- (ii) Height of gate $H =$ FSL – crest level + 0.10 m*
(Rounded to the higher 10 cm)
- (iii) C/C of side seal $b =$ W
- (iv) C/C of Track $a =$ $W + 50$ to 100 mm
- (v) Design Head $h =$ Height of the gate

- *This provision of extra height of gate beyond the FSL is to ensure that water never spills over the gate, even in the presence of waves and surges caused by wind, earthquakes, or upstream regulation.*

2. COMMON RECOMMENDATIONS FOR DESIGN OF FIXED WHEEL AND SLIDE GATES

2.1. MATERIAL / PROPERTIES

Materials for different components of fixed wheel gates should be chosen as per recommendations given in **Table 1 of IS 4622: 2003. which is a reproduced in Table 2.1A. The materials that are recommended for use in our design and their IS CODES are indicated in Bold font**

Materials for different components of slide gates should be chosen as per recommendations given **Appendix A of IS 5620 : 1985 which is a reproduced in Table 2.1B. The materials that are recommended for use in our design and their IS CODES are indicated in Bold font**

Properties including Mechanical should be assumed as specified in the appropriate standard. Structural steel conforming to IS-2062.is selected as material for most of the members where ever this material is one of the recommended material. It has

$Y_p = 250$ MPa & $UTS = 410$ MPa For thickness less than or equal to 20 mm.

For thickness above 20 mm, $Y_p = 240$ MPa & $UTS = 410$ MPa.

2.2. ALLOWABLE STRESSES

Assumed values to be as specified in Annex “B” of IS-4622 – 1992 and Appendix B of IS-5620 – 1985 (Both are same) which is reproduced in Table- 2.2 and as applicable to wet and inaccessible conditions. While some of the gate components such as girders and stiffeners may operate under dry conditions especially in head regulators, application of the above values provide a safe design and generally do not influence the dimensions.

**Table 2.1A Materials for the Components of Fixed - Wheel Gates
(Clause 4)**

Sl.No.	Component Part	Recommended Materials	Ref to IS No.
1	Wheel	Cast Steel	1030 : 1998
		Cast Iron	210 : 1993
		Wrought Steel	
		Forged Steel	2004 :1991
2	Bearing / Bushing	Anti-friction bearing /	318 : 1981
		bronze, phosphor bronze , aluminium bronze, self lubricating bushing of high strength brass castings.	305 : 1998
3	Wheel pins or axles	Chrome nickel steel or corrosion resistance steel,	2004 : 1991
		mild steel with nickel or hard chromium plating	2062 : 1999
			1068 : 1993
			1337 :1993
4	Structural parts of gate leaf,.	structural steel	2062 : 1999
	track base etc	Carbon steel,	1875 : 1992
			8500:1991
			1337 : 1993
5	Seal	Rubber/ PVC	11855 : 1986
6	Wheel track	a) Stainless Steel	1570 (Part 5) : 1985
		corrosion resistance Steel	
7	Seal Seat	Stainless Steel plate	1570 (Part 5) : 1985
8	Seal Base , Seal seat base	Structural steel of convenient shape	2062 : 1999
	sill beam		8500 : 1991
9	Seal Clamp	Structural Steel	2062 : 1999
			8500 : 1991
			6603 : 2001
		Stainless steel	
10	Guide	Structural steel	2062 : 1999
		corrosion resistance steel	8500 : 1991
		stainless steel	6603 : 2001
11	Springs	Spring Steel,	6527 : 1995
		Stainles Steel	2062 : 1999
12	Anchor Bolts	Structural Steel	6527 : 1995
13	Guide rollers and gude shoes	Structural steel	2062 : 1999
		corrosion resistance steel	8500 : 1991
		cast iron	210 : 1993
		cast steel	1030 :1998
		forged steel	2004 : 1991

**Table 2.1B Materials for the Components of Slide Gates
(Clause 4)**

Sl.No.	Component Part	Recommended Materials	Ref to IS No.
1	Gate Leaf	Cast Iron	210 : 1970
		Structural Steel	226 : 1975
			2062 : 1977
			8500 : 1977
		Cast Steel	1030 : 1974
2	Gate Frames	Cast Iron	210 : 1970
		Structural Steel	226 : 1975
			2062 : 1977
			8500 : 1977
3	Seal Plates / Seals	Bronze	306 : 1968
			3018 1962
			1458 : 1965
		Brass	291 : 1977
		Wood (commercial Good Quality)	
		Stainless steel	1570 (Part V) : 1972
			6911 : 1972
			Appendix B of 4622 : 1978
		Rubber	11855 : 1986
4	Seal Seats / Bearings Plates	Bronze	305 : 1966
			306 : 1966
			318 : 1962
			1458 : 1965
		Brass	291 : 1975
		Steel	226 : 1975
			2062 : 1977
			8500 : 1977
		Cast Iron	210 : 1970
		Stainless Steel or	1570 (Part V) : 1972
5	Guides	Stainless Steel clad plate	6911 : 1972
		Structural steel	226 : 1975
			2062 : 1977
			8500 : 1977
		Corrosion Resisting steel	6603 : 1972

Table 2.2 Permissible Monoaxial Stress for Structural Components of Hydraulic Gates

Sl.No	Material and Type	Wet Condition		Dry Condition	
		Accessible	Inaccessible	Accessible	Inaccessible
1	Structural Steel :				
i)	Direct Compression	0.45 YP	0.40 YP	0.55 YP	0.45 YP
ii)	Compression / Tension in bending	0.45 YP	0.40 YP	0.55 YP	0.45 YP
iii)	Direct Tension	0.45 YP	0.40 YP	0.55 YP	0.45 YP
iv)	Shear Stree	0.35 YP	0.30 YP	0.40 YP	0.35 YP
v)	Combined Stress	060 YP	0.50 YP	0.75 YP	0.60 YP
vi)	Bearing stress	0.65YP	0.45 YP	0.75 YP	0.65 YP
2	Bronze or Brass				
	Bearing Stress	0.035 UTS	0.03 UTS	0.04 UTS	0.035 UTS

2.3. BASIC DESIGN CONSIDERATIONS

Design of the Gates involves design of the following components:

- a. Skin Plate
- b. Vertical stiffeners and Horizontal main girders
- c. Wheels, wheel tracks and track beam, bearing pads
- d. Seals at bottom, sides and top, with seal plates, and sill beam
- e. Guide rollers / guide shoes
- f. Anchorages

The gate shall be designed for hydrostatic forces (triangular distribution of water pressure). The effect of Hydrodynamic forces, wave effects and seismic loads have been disregarded because they are not significant. The locations of the gates do not require consideration of ice formation.

3. DESIGN OF SKIN PLATE

3.1 Panel Construction in which the skin plate is supported by Horizontal girders and Vertical Stiffeners is adopted because it gives lighter construction.

3.2 Design is based on stress calculations made in accordance with the procedure and support conditions as given in Appendix C of IS 5620 : 1985 (Clause 6.1.1.4 a)./ Annexure C of IS 4622. According to these procedures the stress **S** is given by:

$$S = K \cdot p \cdot a^2 / (100 \cdot s^2)$$

Where **K** = factor depending on the ratio of b/a for the panel and the

support conditions as given inform of tables in the procedure

P = pressure at the mid point of the panel

a = smaller dimension of the panel

b = larger dimension of the panel

s = effective skin plate thickness

All the panels fall in 3 of the 6 categories mentioned in the codes namely panels with all four edges fixed or with three edges fixed and one edge free (free edge shorter, or longer). These conditions are illustrated in **Fig. 3.2 a, b, c and the values of K are to be taken from Tables 3.2 A, 3.2 B and 9.3 C respectively.**

**Table 3.2A Values of K for Points and Support
Conditions given in Fig. 3.2A (all edges rigidly fixed)**

b/a	$\pm a2x$	$\pm a2y$	$\pm a4y$	$\pm a3x$	$\pm a4x$	$\pm a3y$
infinity	25	7.5	34.3	50	10.29	15
3	25	7.5	34.3	50	10.29	15
2.5	25	8	34.3	50	10.29	15
2	24.7	9.5	34.3	49.9	10.29	14.97
1.75	23.9	10.8	34.3	48.4	10.29	14.52
1.5	22.1	12.2	34.3	45.5	10.29	13.65
1.25	18.8	13.5	33.9	40.3	10.17	12.09
1	13.7	13.7	30.9	30.9	9.27	9.27

**Table 3.2B Values of K for Points and Support Conditions
given in Fig.3.2B (longer edge free)**

b/a	a11x	a11y	a12x	a12y	a13x	a13y	a14x	a14y	a15x
a	22	2	90	300	91	28	205	62	75
1	17.67	12.29	9.45	31.5	37.64	11.29	44.55	13.4	27.96
1.25	22.5	13	15.5	51.5	48	14.8	53	16.2	37
1.5	23.5	14.2	20.5	72.5	59.5	18.2	82	22.7	48
1.75	23	14	25.8	87	67.5	20.8	112	34.8	61
2	19.49	6.72	33.98	113.28	72.96	21.89	134.4	40.32	69.88
2.5	18.37	2.88	42.05	140.16	51.8	15.55	124.8	37.44	52.42
3	19.78	7.68	44.93	149.76	65.28	19.59	109.44	32.84	52.41

Table 3.2C Values of K for Points and Support Conditions

given in Fig.3.2C (shorter edge free)

b/a	a16x	a16y	a17x	a16y	a18x	a18y	a19x	a19y	a20x
infinity	29.0	9.0	9.0	30.0	50.0	15.0	51.0	16.0	29.0
1	17.67	12.29	9.45	31.5	37.64	11.29	44.55	13.4	27.96
1.25	20.8	11.7	8.96	29.87	28	8.4	34.5	10.35	28.53
1.5	25.51	11.1	8.48	28.28	21.04	6.31	25.5	7.66	29.11
1.75	26.48	10.6	8.49	28.3	32	9.6	36.5	10.95	28.97
2	27.46	10	8.5	28.36	45.52	13.66	50.09	15.27	28.81
2.5	28.07	9.13	8.51	28.38	46.66	14	50.8	15.24	28.78
3	28.18	8.68	8.51	28.38	46.94	14.08	50.81	15.24	28.77

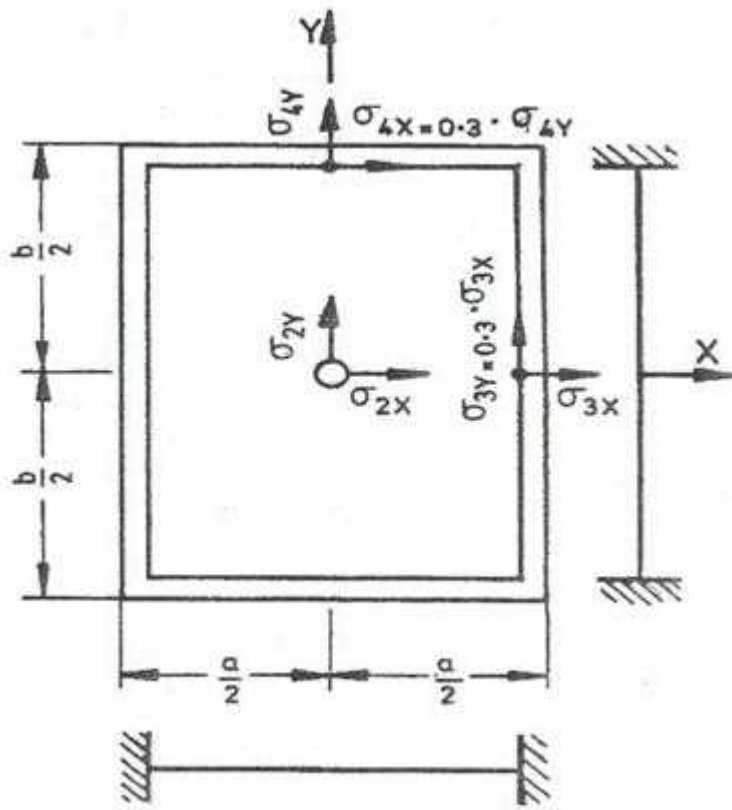


Fig 3.2 a : All Edges Rigidly Fixed

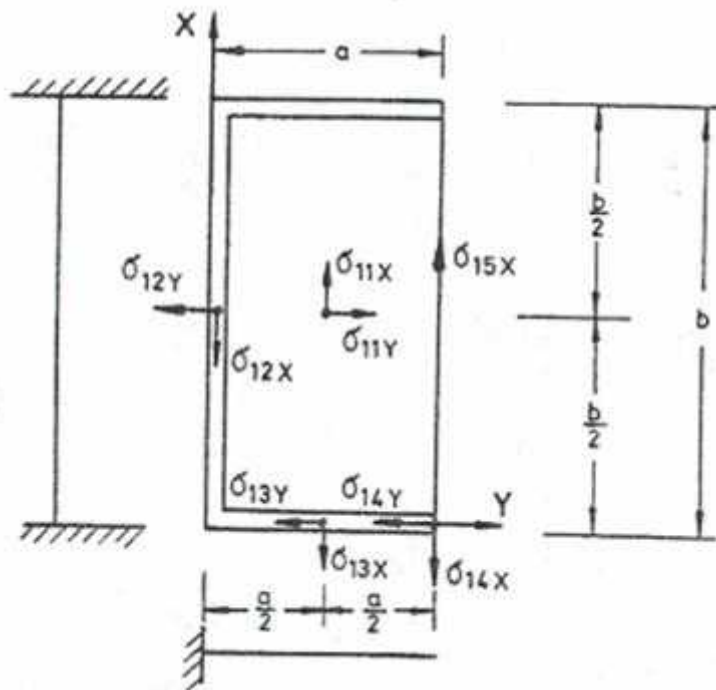


Fig 3.2 b : Three Edges Fixed & One (Longer) Edge Free

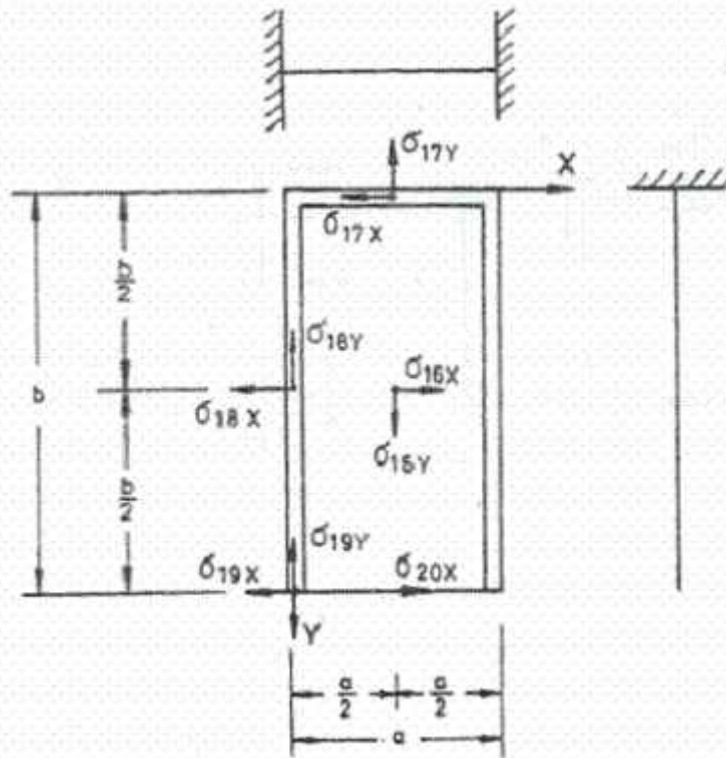


Fig 3.2 c : Three Edges Fixed & One (Shorter) Edge Free

- 3.3 The actual thickness of the skin plate shall be 1.5 mm more than the designed value to take care of the corrosion (Clause 6.1.1.2 of IS 5620).
- 3.4 The minimum thickness of skin plate shall be 8 mm inclusive of the corrosion allowance. (Clause 6.1.1.2 of IS 5620).

The recommendations in respect of 3.3 and 3.4 in IS 4622 are identical.

4. HORIZONTAL GIRDER

- 4.1** All the Fixed wheel gates of Width between 4.5 m and 6.5 m and head between 2m and 3m shall be provided with 3 horizontal girders. Smaller fixed wheel gates and slide gates shall be provided with 2 horizontal girders (Based on calculations made by the consultant).
- 4.2** The loads on girders shall be obtained from analysis as continuous beam or as simply supported beam based on the conditions of support indicated above (clause 6.1.1.4 b) IS 5620.
- 4.3** The spacing between the girders shall be so selected as to provide almost equal loading on each of the girders (Clause 6.1.2.1 IS 5620:1985).
- 4.4** The width of the skin plate co acting with the horizontal girder shall be chosen as illustrated in Annexure D of IS 5620 (clause 6.1.1.5). According to this the coacting width of the skin plate **b** is given by :

$$b = 2 \cdot V I \cdot B$$

Where **B = Half the span between two girders***

L = distance between successive stiffeners

V I = factor depending on the ratio of L/B taken from Figure 4.4

- For girders that have a free edge on one side B equals the distance to the edge
- For horizontal girders the appropriate factor is invariably V I as the girders are subject to parabolic moment over it's entire length.
- The coacting width is the least of the following values:
 - The value calculated as above
 - $40 \cdot s$
 - $0.11 \cdot \text{span}$ (length of horizontal girder)

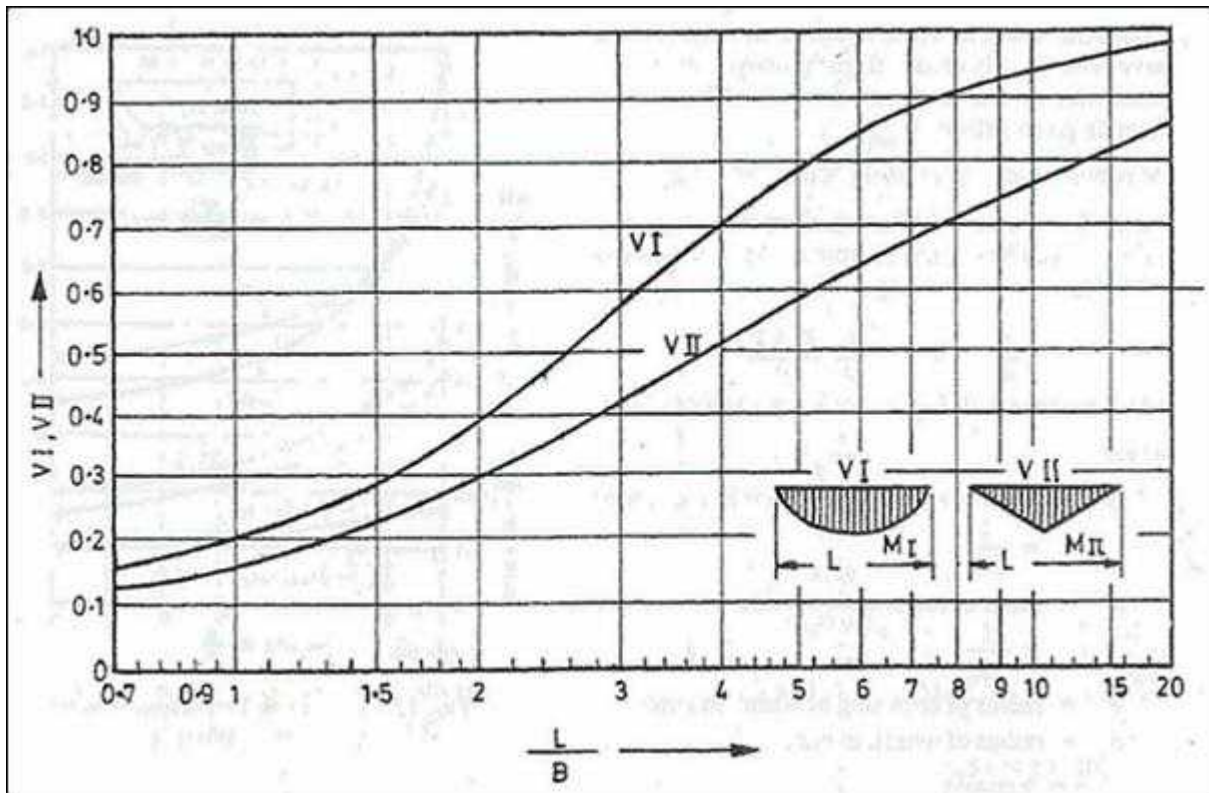


Fig 4.4 : Curves Showing Relationship Between L/B & Reduction Factors V_1 & V_2

4.5 Stresses in the members (tensile, compressive, shear, and combined) shall be within allowable limits for the materials used. (Clause 6.1.1.2 of IS 5620 and Clause 6.2.3 of IS 800) (Para 9.3 & 9.4).

4.6 Deflection shall not exceed $1/800$ of the span (Clause 6.1.3, IS 5620 :1985).

The corresponding recommendations in IS 4622 are identical though the clause numbers differ.

5. VERTICAL STIFFENER

- 5.1** The vertical stiffeners shall be in the form of plates of constant width welded on to the skin plate (the construction is simple and adequate).
- 5.2** The maximum width of the stiffener may be fixed at about 2 mm less than the width of the web of the horizontal girder.
- 5.3** The thickness shall usually equal that of the skin plate (Clause 3.8.2 IS 800 recommends a minimum thickness of 8 mm for all parts made of Structural Steel in this environment).
- 5.4** Generally the spacing should be between 300 mm and 450 mm.
- 5.5** The stiffeners in the top panel are generally collinear with those in the bottom two panels, except when there are two central half stiffeners spaced at 100-150 mm in the top panel forming part of the lifting arrangement of the gate. In such a case the number of stiffeners in the top panel equals that in the lower two panels if the later is even, and the central two stiffeners are not collinear. If the number in the bottom panels is odd, the central stiffeners in the bottom panel is placed between the two half stiffeners in the top panel. The remaining stiffeners in top and lower panels are always collinear. The number of stiffeners is chosen based on the restrictions on spacing and the construction adopted as discussed above.
- 5.6** The width of the skin plate **b** co acting with the vertical stiffener shall be chosen as illustrated in Annexure D of IS 4622 / Appendix D of IS 5620.

$$b = 2 \cdot V \cdot B$$

Where **B = Half the span between two stiffeners***

L = lengths of stiffener over which bending moment does not change sign

V = factor depending on the ratio of L/B taken from Fig 4.4

- For vertical stiffeners both V I and V II are appropriate as there are lengths with negative as well as positive bending moments. These lengths are to be determined from the BM distribution over the complete length of a stiffener.

- The coacting width is the least of the following values:
 - The values calculated as above
 - $40*s$

5.7 The loading shall be based on water pressure on the span between two successive stiffeners.

5.8 Bending moments shall be arrived at from analysis in 4.2 and 4.3.

5.9 Use of section used for the horizontal girder may be considered for the vertical stiffeners if the stresses are more than the allowable value.

6. VERTICAL GIRDERS

For Fixed wheel gates

6.1 The girder shall be designed as a simply supported or continuous beam based on the number of wheels (2 on each side or more).

6.2 The plate thickness shall be not less than that of the skin plate.

6.3 Adequate stiffening to be provided where the wheel axles fit into the girders.

In the design adopted for slide gates the bearing pads are mounted directly on the ends of the horizontal girder, as such there are no bending moments on the vertical girder. However the member also acts as a **vertical stiffener and the design criteria stated in Section 5 apply.**

7. TOP EDGE STIFFENER

The top edge of the skin plate is stiffened by welding a plate, of approximately the same section as that of the vertical stiffeners. This edge carries no load and as such there is no structural justification for providing this member. However, the provision of this member is recommended as it covers the exposed sharp edges of a number of members including the skin plate and vertical stiffeners and provides safety, against accidental injuries.

8. WHEELS (FIXED WHEEL GATES ONLY)

- 8.1** Wheels shall be designed to operate with line contact as per Clause 5.4.3 of IS 4622, which states:

$$F_c = 0.418 \cdot \sqrt{P \cdot E / (r \cdot l)}$$

Where

F_c = Contact stress

P = wheel load

E = Elastic Modulus of wheel material

r = wheel radius

l = wheel tread width

Permissible value of F_c is as specified in annexure F of IS 4622 namely 1.6* UTS of wheel material

- 8.2** They shall be fitted with self aligning bearings of adequate capacity.

- 8.3** The loads on the wheels shall be increased to 200% while designing, the wheels, as suggested in the illustrative example in Annexure E of IS 4622.

9. WHEEL PINS (FIXED WHEEL GATES ONLY)

- 9.1 Wheels shall be mounted on Fixed pins simply supported in the two plates of the Vertical Girders.
- 9.2 The pins shall be provided with ends machined eccentric (by 5 mm) to the bearing surface to enable adjustment of wheel levels.
- 9.3 The pins and the supports shall be checked for bending shear and bearing capacity.

In case of slide gates there are neither wheels nor wheel pins.

10. WHEEL TRACK AND TRACK BASE (FIXED WHEEL GATES ONLY)

- 10.1 Thickness of track plate shall be determined as per clause 5.7.3 of IS 4622. namely:

$$t > 6 \cdot 0.786 \cdot 1.55 \cdot \sqrt{P \cdot E / (r \cdot l)}$$

Where	t	=	thickness of track plate
	P	=	wheel load
	E	=	Elastic Modulus of wheel material
	r	=	wheel radius
	l	=	wheel tread width

Minimum thickness of track plate shall be 10 mm

- 10.2 Hardness of Track Plate shall be at least 50 BHN more than that of the wheel.

10.3 Track base shall be designed as per Clause 5.7.5 of IS 4622.

11. TRACK PLATE AND TRACK BASE (SLIDE GATES ONLY)

IS 5620 for slide gates makes no recommendations on track plate and Track base except indicating the method of fixing. Given the small loads structural design is not significant.

11.1 Thickness of track plate is kept at 6 mm and material stainless steel.

11.2 Track base is in the form of one leg of an Indian Standard Angle, the other leg serves as protector for the edge (Corner) of concrete.

12. BEARING PADS (SLIDE GATES ONLY)

4 Bearing pads, 1 on each end of the two horizontal girders, made of 14 mm thick bronze sheet are screwed on to steel blocks that have slots machined to accommodate the pad. In all slide gates, the steel blocks are fixed on the flange of the horizontal girder.

The size of the bronze pads is kept at a minimum of 30x40, in the case of small gates and is increased to 30x60 , and 40x 50, in case of larger sizes. Bearing pressure based on the loads coming on the girders is checked but is low for these small gates.

Two dummy pads one on either side are provided near the top edge that are identical in construction with the regular pads. These pads are kept 2 mm behind the line of the regular pads and as such serve no purpose in regular operation of the gates. However they will restrict the tilt of the gate in case of unforeseen loads on the top panel. The bronze pads fitted in these dummies can also be used as instant spares to replace regular pads in case they are worn out.

13. SEALS, SEAL PLATES, AND SILL BEAM

- 13.1** Wedge type Rubber seal pressing against the sill, with the seal projecting 5 mm below the gate leaf be provided as bottom seal (Clause 6.3.3 IS 5620).
- 13.2** Side seals fixed to the Gate with Seal Seat Plates fixed in the groove shall be provided.
- 13.3** Since the FSL level is below the top of the gate Top Seals are not required.
- 13.4** Seals shall follow recommendations in IS 11855.
- 13.5** Minimum Width of Seal Seat Plate shall be 80 mm (Clause 5.9.1 IS 4622 : 2003) In case of slide gates Minimum Width of Seal Seat Plate shall be 40 mm.
- 13.6** Minimum thickness of Stainless steel seat seal plates shall be 6 mm (Clause 5.9.2 IS 4622 : 2003).
- 13.7** Seal seat base shall be embedded in concrete.
- 13.8** The sill beam may be provided with stain less steel flats welded or screwed on to it with SS screws. (Clause 5.9.7 IS 4622 : 2003).
- 13.9** Angle (L) type II (Fig1 IS 11855: 1986) Side seals fixed to the Gate with Seal seat plate fixed to the groove protection angle shall be provided on all slide gates. Music Note type seals be provided on the fixed wheel gates. **(See Fig. 2 and Fig 1.)**
- 13.10** One leg of the upstream groove protection angle shall serve as the base for the seat of the side seals and is embedded in the civil structure.
- 13.11** The sill beam shall be provided with stain less steel flats welded on to it to serve as seat for the bottom seal. (Clause 6.4.6, IS 5620:1985).
- 13.12** Sill beam flange should be 10 to 15 mm wider than the width of the bottom seal plate.

- 13.13** It is advisable to use sections on the heavier side and symmetric (ISMB) for sill beams as this part is inaccessible for repairs during the working life of the gate.

14. GUIDES AND GUIDE ROLLERS

- 14.1** Guide in the form of a plate not below 20 mm in thickness shall be embedded in the concrete on either side of the gate.
- 14.2** Two guide shoes shall be provided on each side of the gate to resist transverse and lateral movements of the gate and to prevent jamming.

For small sizes of the gate (slide gates) no guides / guide rollers are considered necessary. The angle type side seal that has been adopted for these gates restricts the sideways motion of the gate and keeps it in proper location. The centering blocks welded on to the upstream face of the skin plate restricts movements of the gate in the flow direction.

15. ANCHORAGES

- 15.1** Suitable anchors connected to dowels embedded in first stage concrete shall be provided for all parts embedded in the second stage that would help to accurately position and hold the parts.
- 15.2** Minimum size of Anchor bolts shall be 14 mm for fixed wheel gates. However for slide gates given the small size of the gates the minimum size of anchor bolts shall be 10 mm and that of anchor plates 6 mm.
- 15.3** Additional anchors may be only in the second stage or extend to first stage depending on requirement.

16. ESTIMATION OF HOIST LOAD

16.1 Hoist Load should be estimated based on (clause 3.1. IS 11228: 1985).

- a.** The weight of the gate :
- b.** The friction at the slide (Bearing pads)/ wheels
- c.** Friction between seals and seal seat plates
- d.** Friction between guides and guide shoes
- e.** Hydrostatic and Hydrodynamic forces if any
- f.** Seating pressure (2.5 kN/m Clause 3.4 IS 11228 :1985)

16.2A The friction at the wheels and seals shall be estimated based on clauses 5.4.5.2 and 5.5.4 of IS 4622. which state:

$$F = P \cdot (f_a \cdot r + f_c) / R$$

Where
F = Total wheel frictional force
P = wheel load

f_a = coefficient of friction at wheel bearing
= 0.015 for rolling bearing starting
= 0.01 for rolling bearing running

f_c = coefficient of rolling friction at wheel = 1 mm

R = wheel radius

r = effective radius of bearing

and coefficient of friction between side seals and seal seat = 1.50 for starting and 1.20 for moving conditions

16.2A The friction at the bearing pads and seals shall be estimated based on values

of friction coefficients given in Appendix E of IS 5620. namely 0.5 Starting and 0.3 running for bearing pads and 1.5 and 1.2 for seals in the above conditions.

- 16.3** Friction at the guides should not be considered, as the force is small or the guides are not provided.
- 16.4** Hydrostatic and Hydrodynamic forces are either absent or negligible in our case and therefore shall not be considered.
- 16.5** The load so obtained shall be increased by 20% to cater for reserve capacity (clause 3.3 IS 11228).
- 16.6** The manual operation arrangement shall be so designed that the continuous effort per man does not exceed a crank force of 100 N at 400 mm crank radius at continuous rating of 24 rpm,(Clause 5.10.1 IS 11228) (Torque for manual operation is approx. 4000 Kg mm per person).

17. LIFTING ARRANGEMENT FOR THE GATE

Gates with Rope Drum Hoist

- 17.1** The gate shall be provided with two lifting pins one on either end fixed to the vertical girder.
- 17.2** The location should be so fixed that the center lines of the ropes, the center line of the attachment with the gate and the CG of the gate are as nearly coplanar as possible.

Gates with Screw Hoists

- 17.3** The gate shall be provided with a suitable connection with the screw stem.

17.4 The location should be so fixed that the distance between the line of action of the resultant of all forces on the hoist and the center lines of the screw stem is small.

17.5 The support structure for the connection be suitable to provide adequate rigidity.

18. SCREW HOIST

Screw Hoists could be of two principal types of designs namely:

1. Screw fixed to the gate leaf
2. Nut fixed to the gate leaf

The design of the first type has been selected for use in these gates as it provides easy access to the moving parts of the hoist and helps in providing adequate lubrication that is critical for trouble free operation of the hoist.

19. SCREW STEMS

19.1 Material : Structural steel conforming to IS 2062 as this is the most commonly available material among the three recommended in IS : 11228 (Clause 5.2.1).

19.2 Screw Thread : The screw thread shall be standard Metric Square of normal and appropriate pitch and form conforming to IS 4694: 1968 at the operating part, and standard metric in portions used for attachment to gate leaf. (Clause 5.2.3 IS 11228).

19.3 Stem Size : The size should be large enough such that the critical length at which it buckles is more than the maximum unsupported length (operating length when gate is fully closed). Usually the buckling load for such stem exceeds the required hoist capacity by a fair margin but it should nevertheless be checked. Torsional and bending stresses should be combined with axial stresses and checked against permissible values.

20. OPERATING MECHANISM

Operating mechanism shall have screw stem fixed to the gate leaf and the nut to be rotated to operate the hoist. The nut should have integral collar to take the thrust in both directions when the gate is being lifted or closed.

21. NUT

21.1 Material : The nut should be made of Phosphor Bronze conforming to IS 28: 1975 (Clause 4.1 (Table 1) IS 11228). It provides a lower friction in contact with the screw and the thrust pads when lubrication is not adequate.

21.2 Length : The length of the nut should be large enough to provide enough number of threads, such that the bearing and shearing load capacity of the nut is more than the hoist capacity.

22. TORQUE REQUIRED TO OPERATE THE HOIST

22.1 The torque required to operate the hoist be estimated considering the friction and the inclined plane effect between the stem and the nut on the threads, and the friction at the trust pads. This may be estimated for loads corresponding to both the starting and running conditions, and for the designed capacity of hoist (including the reserve capacity).

22.2 The thread and the thrust collars should be kept well lubricated. (Ease of lubrication is the major advantage of the design adopted) Under such conditions the coefficient of friction is between 0.03 to 0.15, according to Kingsbury and 0.10 to 0.15 according to Ham and Ryan (Marks handbook Page 3-26). The book Machine Elements by Dobrovsky etal published by Foreign Language publishing house Moscow also uses values of $\tan (6-8)$ degrees (Page 387) that works out between 0.1 and 0.14. Based on above the value of coefficient of friction shall be taken as 0.15 in estimation.

23. THRUST BEARINGS

Anti friction Thrust bearings (single row ball SKF TYPE) Thrust bearings be provided where the torque required to operate the hoist exceeds the capacity of one or two persons. The size is governed by the dimensions of the thrust collar and has more than the required capacity. However this should be checked.

24. SUPPORT STRUCTURE

24.1 The support structure should have two beams of adequate section placed side by side, that support the base plate of the Operating Mechanism. The beams are to be welded on to base plates on both ends. The inner edges of the base plate are shaped to provide an anchoring edge that is welded on to the angles of the gate guide assembly. A small cross beam of the same section is welded between the main beams on the base plates for added stiffness, and easy assembly.

24.2 The beams are checked for bending stresses and deflection that should not exceed $\text{span}/800$.

25. OPERATING HANDLE /WHEEL

25.1 A removable operating handle or a fixed wheel is provided with enough leverage to operate the hoist manually using up to two persons.

26. ADDITIONAL GEARING

26.1 Additional gearing in the form of bevel wheel and pinion with or without an additional spur gear reducer be provided to give additional mechanical advantage where the torque required to operate the hoist exceeds 10,000 Kg.mm

27. ROPE DRUM HOIST

27.1 Wire Rope

- (i) The design load on the wire rope shall be suitably increased to take into consideration the inclination of the rope.
- (ii) The breaking load of the rope shall be at least 6 times the design load on the rope (clause 4.2.3 IS 6938).
- (iii) The rope shall be of 6/36 or 6/37 construction (clause 4.2.1 IS 6938).
- (iv) The diameter of the rope shall be chosen based on load and recommendations in Table 3 of IS 2266 : 2002 or a manufacturers catalogue.

27.2 Rope Drum

- (i) Rope drum Pitch Diameter shall be at least 20 times the wire rope diameter.
- (ii) The minimum pitch of the groove shall be Rope diameter + 2.5 mm (Clause 4.3.4.2).
- (iii) The minimum number of grooves shall be 3+ the number corresponding to gate travel.
- (iv) The rope inclination in any position shall not be more than 5 degrees to the vertical.
- (v) The thickness of the drum shall be selected in accordance with Clause 4.3.3 of IS 6938.
- (vi) The drums should be manufactured as per IS 6938.

28. TRANSMISSION ELEMENTS

- 28.1** All transmission elements such as shafts, couplings, gear boxes, and gears and bearings shall be selected from standard manufacturers catalogues or shall be designed in conformance with IS 6938.
- 28.2** Manufacturing details of bought out items are not to be shown in the designs/drawings.