BUREAU OF INDIAN STANDARDS
DRAFT FOR COMMENTS ONLY

भारतीय मानक मसौदा

स्थिर - व्हील गेट के संरचनात्मक डिजाइन की सिफारिशें

(IS 4622 का पाँचवा पुनरीक्षण)

Draft Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN OF FIXED-WHEEL GATES

(*Fifth Revision of* IS 4622)

Hydraulic Gates and Valves Sectional Committee, WRD 12 Last Date for Comments: 28/08/2024

FOREWORD
(*Formal clause of the foreword will be added later*)

This Indian Standard (Fifth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Water Resources Division Council.

The gate in general, is a structural steel frame consisting of end vertical girders with properly spaced horizontal girders between them. The spacing of horizontal girders depends on design water head and gate dimensions. Various components of gate leaf are joined together by means of welding, riveting, bolting or flexible pin joints such that a single frame is produced. The disposition of skin plate is governed by factors like civil structures, downpull considerations, presence of silt/ice/debris, tailwater level, purpose of gate etc. In some cases, skin plate is provided on both downstream side and upstream sides, if the downstream water is above sill. The wheels are mounted on end vertical girders which in turn roll over embedded track. The effect of buoyancy shall be considered to determine the net vertical forces and addition of ballast may become necessary to ensure self (gravity) closure of gate where positive (downward) thrust from hoist is unavailable. The bottom lip of gate shall be shaped in a manner to present smooth hydraulics resulting in minimization of vibrations and hydrodynamic forces such that satisfactory gate operation is achieved under all conditions. A typical arrangement of various components of gate is shown in Fig. 1.

This standard was first published in 1967 and was subsequently revised in 1978, 1992 and 2003 in the light of experience gained during the course of these years. The first revision incorporated a number of modifications, the prominent among which were the revision of the permissible stresses, inclusion of tolerances and a typical solved example in Annex E. The major changes incorporated in the second

Revision were the calculation of bending stresses in flat plates, inclusion of formula for calculating the track plate thickness

(wheel track with line contact and point contact) and the criteria for determining the edge distance of the bearing flange of track base from groove face. As a result of increased use of the standard, suggestions were received for further modifying some of the provisions of the standard, therefore, third revision of the standard was brought out. In this revision, the method of design of skinplate and stiffeners has been aligned with IS 4623 'Recommendations for structural design of radial gates *(third revision)'.*

The fourth revision of the Standard incorporated Amendment No. 1, 2 and modifications in **5.11.1**.

Provision for defreezing may be made for trouble-free hoisting of gates in sub-freezing weather and shall be in accordance with IS 10021 : 2000 'Guidelines for de-icing systems for hydraulic installation (*first revision*)'.

The fifth revision of the standard has been brought out in the light of experience gained and the latest updation in design.

The criteria laid down for the design of individual component may be used for any other type of vertical lift gate under similar condition.

In the formulation of this standard, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

For design of concrete and steel structures general reference may be made to the latest version of IS 456. 'Plain and reinforced concrete — Code of practice *(third revision),* and IS 800 'Code of Practice for general construction in steel *(second revision)'* respectively.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall I be rounded off in accordance with IS 2: 2022 ‘Rules for rounding off numerical values *(second revision)*; The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1 SCOPE

1.1 This standard provides recommendations for the structural design of fixed-wheel gates for low, medium and high heads (*see* 3) commonly used for spillways, sluices and penstocks in dams and for barrage and canal regulators.

1.2 This standard also applies to such gates installed at inclined positions subject to corresponding changes.

2 REFERENCES

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

3 CLASSIFICATION OF GATES

The gates may be classified on the basis of water head above sill level as follows:

a) *High headgate* — Gate which operates under a head of 30 m and above;
b) *Medium head gate* — Gate which operates under a head of 15 m and above, but less than 30 m; and
c) *Low head gate* — Gate which operates under a head of less than 15 m.

4 MATERIALS

The materials generally used for different components arc given in Table 1. Any other material satisfying the requirements of the job may also be specified.

5 DESIGN CONSIDERATIONS

5. 1 General design of the gates involves design of the following components:

a) Skin plate and stiffeners;
b) Horizontal girders, end vertical girders and stiffeners, lifting brackets / lifting lugs;
c) Wheels and wheel pins;
d) Seals and accessories;

e) Guide rollers and guide shoes
f) Wheel track and track base, dogging beam;
g) Guides;
h) Seal seat, seal base and sill beam; and
j) Anchorages.

5.1.1 The gate in general shall satisfy the following requirements:

a) The gate shall be reasonably water tight, the maximum permissible leakage being not more than 5 litres/min/metre length of seal in case of low and medium head gates and 10 litres/ min/metre length of seal in case of high head gates. The figure of permissible leakage is the upper limit beyond which the remedial measures shall be required to rectify defects;
b) It shall be capable of being raised or lowered by the hoist at the specified speed;
c) Power-operated gates shall normally be capable of operation by alternate means in case of power supply failure;
d) If meant for regulation it shall be capable of being held in partially open position within the range of travel to pass the required discharge without cavitation and undue vibration; and
e) Wherever necessary, model studies may be carried out for high head regulating gates.

5.1.2 The gate shall be designed for the hydrostatic and hydrodynamic forces taking into consideration forces arising from wave effects, seismic loads and ice formation wherever applicable.

5.1.3 In addition to water load, the additional water head to the static head to account for the sub-atmospheric pressures, if applicable, should be added as given below, unless some definite values is available through model study:

a) No head is added for low and medium head gates;
b) 2.0 m head for gate subjected to water head of 30 m to 50 m; and
c) 2.0 m - 5.0 m head for gate subjected to water head greater than 50m.

5.1.4 The gate is normally designed to close under its own weight with or without addition of ballast but sometimes it may require a positive thrust for closing, in which case hoists shall be suitable for that purpose.

5.2 Skin Plate and Stiffeners

5.2.1 The skin plate and stiffeners shall be designed together in composite manner.

Table 1 Materials for the Components of Fixed-Wheel Gates
(*Clause* 4)

Sl No.	Component Part	Recommended Materials	Ref to, IS No.
i)	Wheel	Cast steel Grey iron casting Wrought steel Forged steel	1030 : 1998 210 : 2009 2004 : 1991
ii)	Bearing /Bushing	Anti-friction bearing /bronze, phosphor bronze, aluminium Bronze, self lubricating bushing of high strength brass castings	318 : 1981 305 : 1981
iii)	Wheel pins or axles	Chrome nickel steel or corrosion resistance steel, mild steel with nickel or hard chromium plating	2004 : 1991 2062 : 2011 1068 : 1993 1337 : 1993
iv)	Structural parts of gate leaf, track base, etc	Carbon steel, structural steel	1875 : 1992 2062 : 2011 8500 : 1991
v)	Soil	Rubber	11855 : 2017
vi)	Wheel track	a) Stainless steel b) Corrosion resistance steel	1570 (Part 5) : 1985
vii)	Seal seat	Stainless steel plate	2062 : 2011
viii)	Seal base, seal seat base, sill beam	Structural steel of convenient shape	8500 : 1991
ix)	Seal clamp	Structural steel Stainless	2062 : 2017 8500 : 1991 6603 : 2024
x)	Guide	Structural steel or corrosion resistance steel or stainless steel	2062 : 2017 8500 : 1991 6603 : 2024
xi)	Springs	Spring steel Stainless steel	6527 : 1995 2062 : 2017
xii)	Anchor bolts	Structural steel	6527 : 1995
xiii)	Guide rollers and guide shoes	Structural steel or corrosion resistance steel, cast iron, cast steel or forged steel	2062 : 2017 8500 : 1991 210 : 2009 1030 : 1998 2004 : 1991

NOTES

1 Grade of the material conforming to the specifications mentioned above shall be specified by the designer to suit to the particular requirement.

2 Cast iron shall not be used for wheels and tracks for high head gates.

3 The choice of material is governed by the type of installation, accessibility for maintenance, reservoir water properties, silt, etc.

4 Antifriction bearings used for gates shall be of pressed steel cage.

5.2.2 The skin plate shall be designed for either of the following two conditions unless more precise methods are available:

a) In bending across the stiffeners or horizontal girders as applicable; and
b) As panels in accordance with the procedure and support conditions as given in Annex C.

5.2.3 The stresses in skin plates for conditions in **5.2.2** shall be determined as follows:

a) For determining the stresses for conditions in bending across stiffeners or horizontal girders in accordance with the procedure given in **5.2.2** (a), bending moment shall be determined according to the conditions of supports; and

b) For calculating the stresses in skin plates for conditions in bending as panel in accordance with the procedure given in **5.2.2**(b), the stresses as given in Annex C shall be used.

5.2.4 In either of the cases specified in 5.2.2 while designing the stiffeners and horizontal girders the skin plate can be considered coacting with them.

a) The coacting width of the skin plate in non-panel fabrication is as per **5.2.2** (a) shall be taken by restricting to the least of the following values; and

1) *40t+B*
2) 0.11 span; and
3) Centre-to-centre of stiffeners and girders.

where,

t = thickness of skin plate, and
B = width of stiffener flange in contact with the skin plate.

b) When skin plate coacts with girders as well as stiffeners to form a panel construction, width of skin plate coacting with horizontal girder or stiffener shall be as illustrated in Annex D.

5.2.5 The stresses so computed shall be combined in accordance with the formula:

$$\sigma_v = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3^2_{\tau_{xy}}}$$

where,

σ_v = combined stress,
σ_x = sum of stresses along x-axis,
σ_y = sum of stresses along y-axis, and
τ_{xy} = sum of shear stresses in x-y plane.

NOTE — The appropriate algebraic sign should be taken for σ_x and σ_y in the above formulae.

5.2.6 The permissible values of mono-axial as well as combined stresses shall not be greater than those specified in Annex B.

5.2.6.1 Permissible values of stress in welds shall be the same as permitted for the

Parent material. For site weld the efficiency should be considered 80 percent of shop weld.

5.2.7 To take care of corrosion, the actual thickness of skin plate to be provided shall be at least 1.5 mm more than the theoretical thickness computed based on the stresses specified in Annex B. The minimum thickness of the skin plate shall not be less than 8 mm exclusive of corrosion allowance.

5.2.8 The stiffeners may if necessary be of a built-up section or of standard rolled section, that is, tees, angles, channels, etc.

5.3 Horizontal Girders, End Vertical Girders and Stiffeners, Lifting Brackets/Lifting Lugs

5.3.1 The horizontal and vertical stiffeners shall be designed as simply supported or continuous beam depending upon the framing adopted for gate. The spacing between main horizontal girders shall preferably be such that all the girders carry almost equal loads.

5.3.2 The end vertical girders shall be designed as continuous beams resting on wheel centre points with concentrated loads, coming from horizontal girders, at points where they meet the end vertical girders. Care shall be taken in carrying out the analysis of end girders to include torsional effects, if any.

5.3.3 The permissible values of stresses shall not be greater than those specified in Annex B.

5.3.4 Whenever the gate is connected to the hoisting mechanism at points other than the end vertical girders, care shall be taken to avoid stress concentration particularly on the web of the top horizontal girder. The hoisting force should preferably be dispersed through suitable stiffeners to one or more horizontal girders below the top one. The extra stresses arising due to this arrangement may be combined with other stresses to ensure that the permissible limits are not exceeded.

5.3.5 *Deflection of gates*

Maximum deflection of the gate under normal conditions of loading shall be limited to 1/800 of the span (centre-to-centre of the wheels).

However, in case of gates with upstream top seals a maximum deflection of the gate leaf at the top seal shall not be more than 80 percent of the initial interference of the seal.

5.4 Wheels and Wheel Pins

5.4.1 The gate wheels shall be suitable to withstand the stresses developed due to hydrostatic loads including any other sustained imposed loads like silt, which they will carry. Wheels may preferably be without flanges but may be flanged, where considered necessary. For high head and large spillway gates, the tread of the wheel or pin may be slightly crowned to accommodate gate deflection under heavy load. The tread of the wheel may be flat when self-aligning bearings are used between the wheel and wheel pin.

5.4.1.1 The wheels shall be machined true to size and shall operate smoothly without vibration and without undergoing undue drift.

5.4.1.2 In case of cylindrical bushings, the wheel tread face should be crowned in order to follow the pin inclination caused by deflection of the gate horizontal beams, thus avoiding stress concentration at outer edges of bush. The curvature radius of wheel tread face shall be selected as 10R, where R = radius of wheel.

5.4.2 *Design of Wheels with Point Contact*

The capacity of the wheels shall be calculated in accordance with Annex E. A typical solved example is also given in Annex E. The maximum shear stress in N/mm^2 thus computed shall not exceed 2.41 X BHN where, BHN is the Brinell Hardness Number of wheel tread or wheel path whichever is smaller, or 0.7 X· ultimate tensile strength, whichever is less. In general, the required tread hardness shall penetrate to at least twice the depth at which the maximum shear stress occurs as calculated using the above curves. The tread width/pin width shall be such that with the gate deflected under the actual design loads, the distance from the edge of the wheel tread/pin shall be at least 15 mm. The radius of crowning of the wheel or pin shall not be more than 10 times the radius of the wheel.

5.4.2.1 Permissible value of contact stress shall be taken as given against 'point contact' in Annex F.

5.4.3 *Design of Wheels with Line Contact*

5.4.3.1 The following formula shall be used for computing the wheel frictional forces for bush and roller bearing:

$$f_e = 0.418\sqrt{\frac{PE}{rl}}$$

where,

f_e = Contact stress, in N/mm^2;
P = Wheel load, in N;
E = Modulus of elasticity, in N/mm^2;
r = Radius of wheel, in mm; and
l = Tread width, in mm.

5.4.3.2 The permissible contact stress shall be as specified against 'line contact' in Annex F.

5.4.4 *Wheel Pins*

The wheels shall be mounted on fixed pins. The pin shall be harder than bronze bushing. Grease fittings shall be provided to permit greasing of the bearings at easily accessible location and suitable grease holes shall be provided in the pin for this purpose.

5.4.4.1 The wheel pin shall either be supported at both ends, on one side of the web of the vertical girder and on the other side by the stiffener plate or of cantilever box of the end vertical girder. In the latter case the rigidity of cantilever box should be ensured.

5.4.4.2 The wheel pin shall be designed for bearing, bending and shear. The load shall be taken as the wheel load acting on the width of the bearing. The pin supports shall be suitably stiffened against bearings and tearing. The permissible stresses shall be in accordance with stresses given in Annex B.

5.4.4.3 The pins may be given suitable eccentricity to permit alignment of wheels. Normal eccentricity provided is 5 mm.

5.4.5 *Wheel Bearing*

The wheel bearing may be bronze bushing, self-lubricating bushing or antifriction roller bearings of any suitable design to suit the operational requirements and installation of gates. Where bronze bushing is used, the bearing stress shall not exceed the values specified in Annex B. The permissible bearing stress in case of self-lubricating bush bearing shall not more than 10 percent of yield point of the selected material.

5.4.5.1 For antifriction roller bearings the outer diameter of the roller bearing shall not exceed 0.6 times the wheel diameter in case of point contact and 0.8 times the wheel diameter in case of line contact. The bearing shall be selected on the basis of factor of safety of 1.5 on the static capacity.

5.4.5.2 The following formula shall be used for computing the wheel frictional forces for bush and roller bearing:

$$F = \frac{P}{R}\left(f_a \times r + f_t\right)$$

where,

F = Total wheel friction, in N;
P = Total hydro-static load, in N;
R = Wheel radius, in mm;
f_a = Coefficient of axle friction (sliding);
f_r = Coefficient of rolling friction, in mm; and
r = Effective radius of bearing, in mm.

a) *Coefficient of axle friction (sliding)* — The following values shall be used:

For	*Starting*	*Starting*
Self lubricating or Bronze bushing	0.20	0.15
Roller bearing	0.015	0.01

b) *Coefficient of rolling friction* — For rolling between wheel and wheel pin, the coefficient of friction shall be taken as 1.0.

5.4.5.3 *Fits and tolerances*

When bronze bushing is provided, the bushing shall be force-fit in the wheel and the wheel pin shall be running-fit in the bushing. When roller bearing is provided, the outside diameter of bearing shall be tight-fit in the wheel and the pin shall be tight-fit in the inside diameter of bearing. For self-lubricating bushes, tolerances/fit shall be as per manufacturer's recommendations.

5.5 Seals and Accessories

5.5.1 Seals shall be fixed by means of seal clamps and G.L or stainless steel bolts/stainless steel screws so as to ensure a positive water pressure between the seal and the gate, and to bear tightly on the seal seat to prevent leakage. For reducing the seal friction fluorocarbon clad seals may be used. Edges of seal clamp adjacent to seal bulb shall be rounded.

5.5.2 Various types of seals recommended for different classes for gates are given in Annex G for information.

5.5.2.1 For regulating gates, the designer at his discretion may make the seals effective throughout the range of the travel of gates either by fixing the seals to the embedded parts or by providing a liner plate above in continuation of the top seal seats for the entire width of the gate and range of regulation.

5.5.3 *Initial Interference*

The seal interference of double stem or music note type seal shall vary from 2 mm to 5 mm depending upon shall vary from 2 mm to 5 mm depending upon the requirement and type of installation at the discretion of the designer. The projection of bottom wedge seal shall vary from 2 mm to 5 mm depending upon the requirement and type of installation at the discretion of the designer. Suitable chamfer shall be provided at the bottom of the skin plate and clamp plate to accommodate the bottom wedge seal in compressed position (*see* IS 11855).

5.5.4 *Seal Friction*

For the purpose of calculating the frictional forces to overcome, the following friction coefficients shall be used:

For	*Starting*	*Moving*
Rubber seal on stainless steel	1.50	1.20
Fluorocarbon on stainless steel	0.20	0.15

5.6 Guide Rollers and Guide Shoes

5.6.1 Gate guide roller/shoes shall be provided on the sides of the gates to limit the lateral motion of gate to not more than 6 mm in either direction. The rollers shall be flanged and travel on steel plates or rails securely attached to anchor bolts. In case of rollers it shall be provided with bronze bushing or self-lubricating bushing turning on fixed steel pins. Suitable arrangement for lubrication of these rollers shall also be provided. Where necessary, counter guide rollers shall be provided to limit the transverse movement of gates.

5.6.2 A minimum of two guide rollers or shoes should be provided on each side of the gate to resist the transverse and lateral movement of the gate and at same time to prevent the gate from jamming. A clearance of 3 mm to 6 mm between the guide rollers and guide surface is normally recommended. The guide rollers or shoes should be structurally adequate to withstand the load, they are likely to be subjected to, depending upon the type of installation, hoist and hydraulic condition. Guide rollers may also be provided with suitable springs, whenever required. Guide rollers may be preferred for high head gates and gates to be handled by lifting beams.

5.6.3 Suitable spring assembly may be provided beneath the guide shoes or guide roller assembly to restore the gate to normal position after any deflection, specially for high head gates.

5.6.4 The guide roller/shoes shall be designed to the maximum loads to which they may be subjected during operation. A minimum load of 5 percent of the total dead weight of the gate is recommended for the design of each guide roller.

5.7 Wheel Track and Track Base, Dogging Beam

5.7.1 The wheel pin shall provide a true and smooth machined surface for the wheels to roll and transmit the loads through the wheels to the pin base.

5.7.2 The hardness of wheel pin surface shall be kept minimum 50 points Brinell Hardness Number (BHN) higher than that of the wheel tread to reduce wear. For gates which may not be put to frequent use, the difference between the BHN of wheel and wheel pin may be reduced suitably at the discretion of the designer.

5.7.3 *Thickness of Pin Plate (Wheel Pin with Line Contact)*

The thickness of pin plate shall be calculated from the following formula:

$$b = 1.55\sqrt{\frac{p}{l} \times \frac{r}{E}}$$

where,

l = Tread width, in mm;
b = Half contact width, in mm;
P = Wheel load, in N;
r = Radius of wheel, in mm; and
E = Modulus of elasticity, in N/mn^2.
Z_1 = Depth to the point of maximum shearing stress, in mm 0.786 b.

5.7.3.1 The thickness of the wheel pin shall not be less than 6 times the depth to the point of maximum shearing stress (Z_1) as calculated in **5.7.3.**

5.7.4 *Thickness of Pin Plate (Wheel Pin with Point Contact)*

The thickness of pin plate shall be calculated by the following formula:

$$t = \frac{1.27\,\mathrm{P}}{2\mathrm{c} \times f_i}$$

where,

t = Pin thickness, in mm;
p = Wheel load, in N;
$2c$ = Pin width, in mm; and
f_t = Allowable pin bending stress, in N/mm*(*0.4* YP of pin material).

NOTE — The minimum thickness of pin plate shall be 10 mm.

5.7.5 The pin base shall be embedded in concrete. It shall be designed as a beam on elastic foundation. The stresses in concrete under the pin shall be found from the following formula. The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be of at least M 20 grade.

$$p = 0.2813 \times p\left(\frac{E_c}{E_s \times I \times w^2}\right)^{1/3}$$

where,

p = Bearing stress in concrete, in N/mm^2;
P = Total wheel load, in N;
E_c = Modulus of elasticity of concrete, in N/mm*;
E_s = Modulus of elasticity of steel, in N/mm*;
I = Moment of inertia of pin base, in mm^4; and
w = width of pin base in contact with concrete, in mm.

5.7.5.1 The edge distance of the bearing flange of pin base from the groove face shall be determined on the basis of the following criteria:

a) The wider flange, in case of double flanged pin base, shall be considered as bearing flange for the purpose of transferring load from the pin base to the concrete;

b) The minimum distance ‘e’ of the bearing plate flange shall not be less than 150 mm. It can be further reduced if steel plate claddings (armored plating) are installed on the concrete surface and if these are sufficiently anchored by reinforcement bars which are provided in *Y*-direction;

c) The load shall be assumed to be distributed at 45^0 dispersion as shown in Fig. 2; and

d) In case shear stress in second stage concrete is not within the permissible limit (with or without provision of shear bars), the width of loaded area at the interface of primary and secondary concrete should fully lie in the primary concrete . Clear cover of the reinforcement is to be neglected as shown in Fig. 2.

5.7.5.2 The length of influence of the parabolic distribution under the pin base may be found from the following formula:

$$L = \frac{3}{2} \times \frac{p}{w \times p}$$

where,

L = Length of influence under pin base, in mm,
p = Total wheel load, in N,

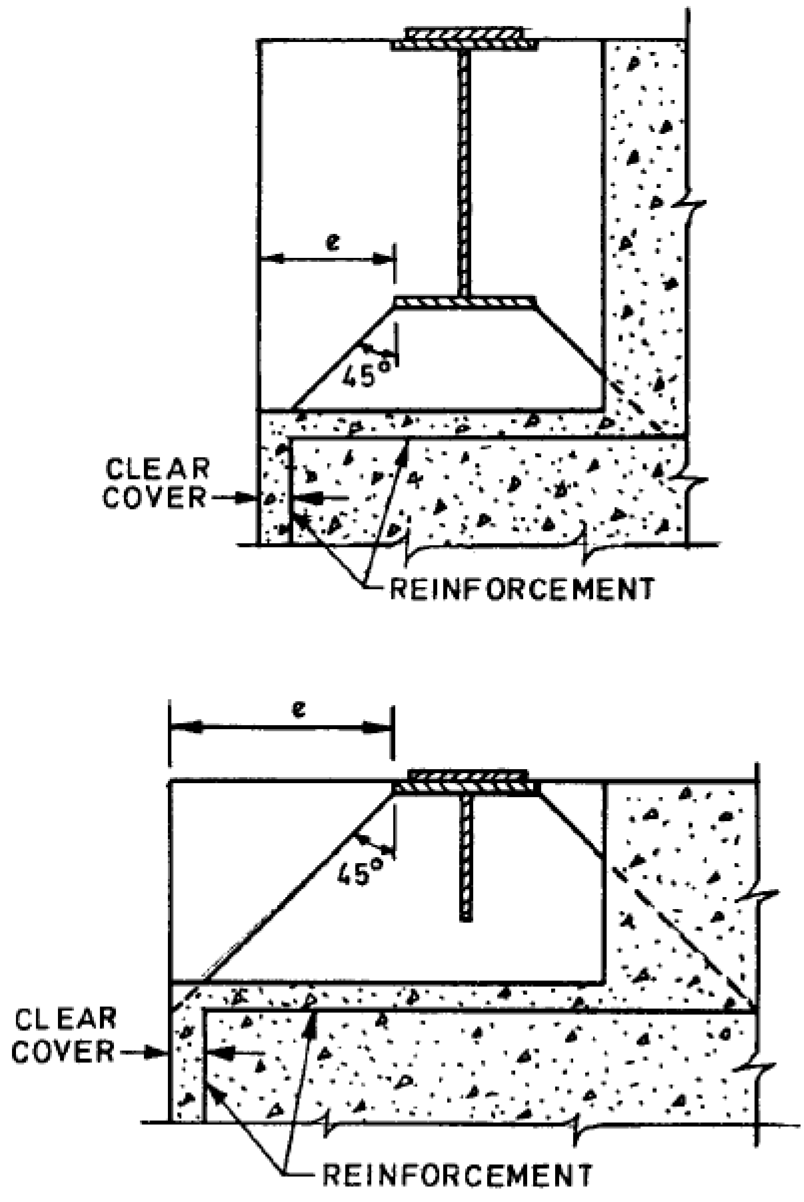


FIG. 2 EDGE DISTANCE CRITERIA FOR PIN BASE

W = Width of pin in contact with concrete, in mm, and
p = Stress in concrete in N/mm.

5.7.5.3 If pressure distribution under adjacent wheels overlaps, superposition of the pressures shall be adopted and checked for the worst condition.

5.7.5.4 The pin base shall be checked for bending and shear also. Bending stress shall be calculated from the following formula:

$$\sigma_b = 0.5\frac{p}{Z}\left(\frac{E_s}{E_c}\times\frac{I}{w}\right)^{1/3}$$

where,

σ_b = Bending stress, in N/mm^2;
p = Load on roller, in N;
Z = Modulus of section of the pin base about the neutral axis, in mm^3;
E_c = Modulus of elasticity of concrete, in N/mm^2 ;
E_s = Modulus of elasticity of steel, in N/mm^2;
I = Moment of inertia of the pin base about the neutral axis, in mm^4; and
w = Width of pin base in contact with concrete, in mm.

5.7.5.5 The flange of the pin base shall be checked for local bending. The web of the pin base shall also be checked for compression. Permissible stress in compression for web shall be taken as 85 percent of yield point for normal condition and equal to yield point for MWL/occasional load condition.

5.7.6 The permissible stresses in pin base shall be those as specified in Annex B.

5.8 Guides

5.8.1 The guides shall be fixed inside the groove in piers.

5.8.2 The guide shall be flat plate or a rail section (in case of gates fixed with guide rollers) anchored into concrete for gates fixed with guide rollers. The thickness of the plate shall not be less than as given below:

Type of Gate	*Thickness of Plate,* mm
Low head gate	20
Medium head gate	32
High head gate	40

5.8.3 The guide shall be suitable for the type of guide rollers or shoes provided on the gate.

5.8.4 The guides shall continue to the full range of travel of the gate.

5.8.5 If the gate is intended to be supported on dogging beams above the gate grooves, the guides may be extended up to the top of the gate at the discretion of the designer. Suitable supporting structure shall be provided above the deck to hold the guides. The guides and their supporting structures shall be of dismountable type and shall cover full height of the gate. The guide extensions and their supporting structure shall be checked for bending, shear and stability due to imposed wind and other applicable loads.

5.9 Seal Seat, Seal Seat Base, Seal Base and Sill Beam

5.9.1 The minimum width of seal seat shall be 80 mm excluding the required chamfer.

5.9.2 The minimum thickness of the stainless steel plates for low head gates may be adopted as 6 mm and for medium and high head gates to 8 mm.

5.9.3 The seal seat shall be welded or screwed with corrosion resisting steel screws to the seal seat base. The number of screws shall be sufficient for rigidity of the seat on base and water tightness.

5.9.4 The seal seat shall be finished smooth to present a smooth surface to the gate seal.

5.9.5 The seal seat base shall be embedded in concrete.

5.9.6 The edges of side and top seal seat shall be rounded/chamfered (*see* Fig. 3) to prevent damage to rubber seal during gate operation.

5.9.7 The sill beam, may be provided, with the corrosion resistant steel flats welded or screwed with corrosion resistant steel screws. The surface of the sill beam may be machined smooth, wherever required, and made flush with the surrounding concrete.

5.10 Ballast

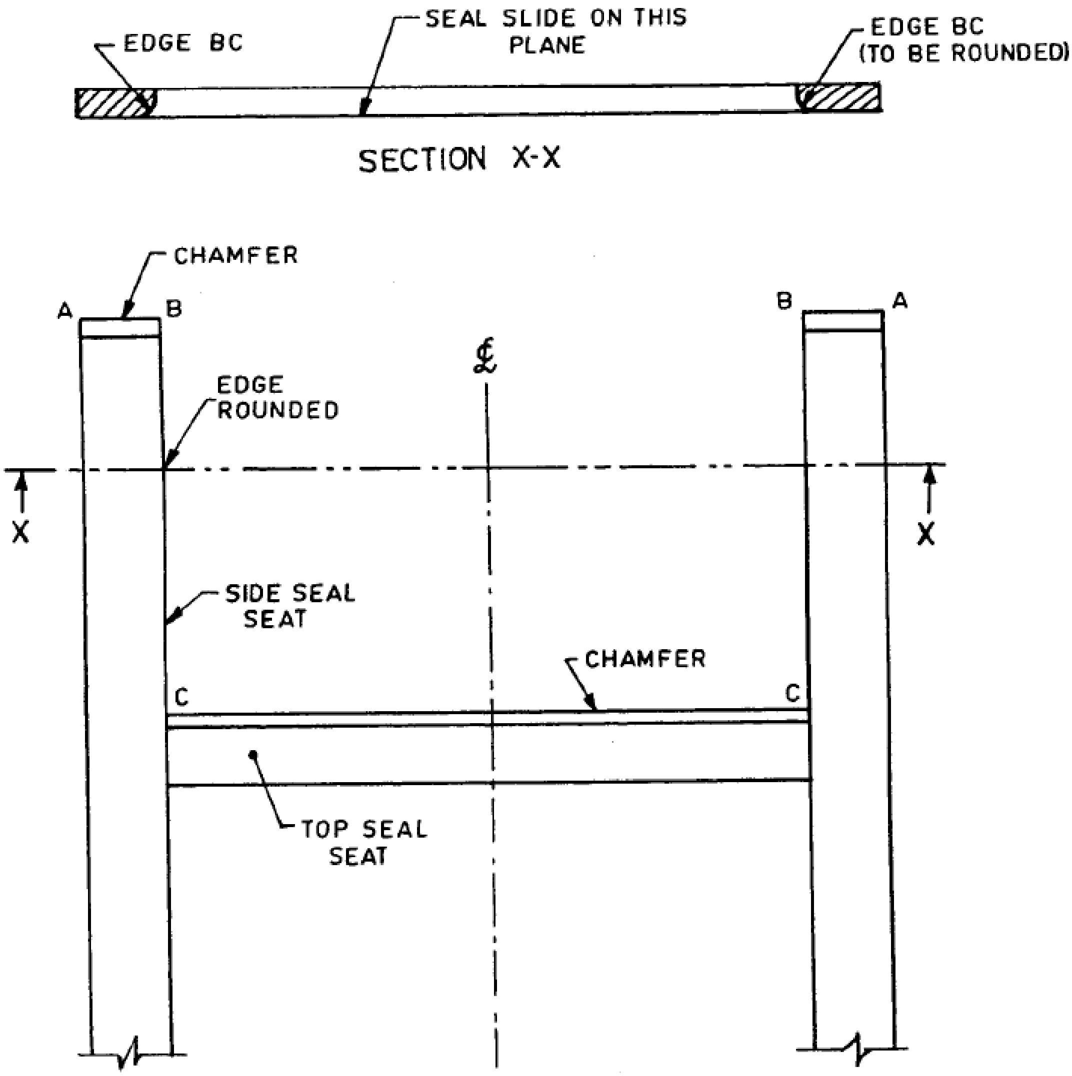
5.10.1 Suitable ballast in the form of dead weight shall be added for making the gate self-closing, when necessary. The ballast shall be in the form of cast iron/pig iron billets, concrete or any other suitable material and shall be secured firmly in between the webs of the horizontal girders. Precaution shall be taken to ensure that the ballast is not dislodged from its position during the gate operation.

5.10.2 The effect of dead weight of the ballast on the horizontal girders shall be analyzed.

5.10.3 The centre of gravity of the gate shall be determined after the consideration of the location of the ballast.

5.11 Anchorage or Anchor Plates

5.11.1 Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts of the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size of anchor bolts shall not be less than 16 mm diameter and the thickness of anchor plates shall not be less than 10 mm.



Notes:

1 Edges *AB* and *CC* to be chamfered.

2 Edges *BC* to be rounded.

FIG. 3 ROUNDING/CHAMFERING ON SEAL SEAT

5.12 Tolerances

The tolerances for embedded parts and in components of gate shall be as given in Annex H.

5.13 The surface finish of corrosion resistant steel track plate and stainless steel seal seats or sill beam shall not be less than double delta (*see* IS 3073).

6 EARTHQUAKE EFFECT

6.1 Where the project lies in a seismic zone earthquake forces shall be considered in accordance with IS 1893, and the gate designed accordingly.

6.2 The allowable stresses as given in Annex B shall be increased 33 percent in case of earthquake conditions subject to an upper limit of 85 percent of the yield point. In case of nuts and bolts increase in stress shall not be more than 25 percent of allowable stress.

6.2.1 The permissible values of stresses in welded connections shall be the same as permitted for parent material.

7 WAVE EFFECT

7.1 For very wide and big reservoirs, the effect of wave height due to storms, etc, in causing increased loading on the gate, shall also be considered.

7.2 Increased stresses in various parts of the gate, as described in **6.2** for earthquake forces, shall be allowed for the wave effect.

7.3 The earthquake forces and the wave effect shall not be considered to act together while computing the increased stresses in the gate.

8 ICE LOADS

8.1 Ice Impact and Ice Pressure

Provided local conditions do not impose other values, ice impact and ice pressure shall be taken into account in such a way that the water pressure triangle shall be replaced as given below:

a) In water with ice thickness greater than 300 mm, by an even surface pressure of 30 000 N/m^2 up to 3 m depth; and

b) In water with ice thickness up to 300 mm, by an even surface of 20 000 N/m^2 up to 2 m depth.

9 MWL CONDITION

In case the gate is to be checked for MWL condition, the allowable stress shall be increased by 33 1/3 percent of the values specified in Annex B subject to upper limit of 85 percent of yield point. No two adverse or transient conditions shall be considered simultaneously. However, if the gates are required to be designed for MWL condition, normal stresses shall be taken in accordance with Annex C.

10 POST WELD HEAT TREATMENT (PWHT)

Post weld heat treatment (PWHT) shall be carried out for all butt – welded joints with member thicknesses 36 mm and above, as per provisions of IS 2825.

ANNEX A
(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
IS 210 : 2009	Grey iron castings — Specification (*fifth revision*)
IS 305 : 1981	Aluminium bronze ingots and castings (*second revision*)
IS 318 : 1981	Leaded tin bronze ingots and castings *(second revision)*
IS 456 : 2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
IS 800 : 2007	General construction in steel — Code of practice (*third revision*)
IS 1030 : 1998	Carbon steel castings for general engineering purposes (*fifth revision*)
IS 1068 : 1993	Electroplated coatings of nickel plus chromium and copper plus nickel plus chromium (*third revision*)
IS 1337 : 1993	Electroplated coatings of hard chromium on iron and steel for engineering purposes (*third revision*)
IS 1570 (Part 5) : 1985	Schedules for wrought steels: Part 5 Stainless and heat resisting steels (*second revision*)
IS 1875 : 1992	Carbon steel billets, blooms, slabs and bars for forgings (*fifth revision*)
IS 1893 : 1984	Criteria for earthquake resistant design of structures (*forth revision*)
IS 2507 : 1975	Cold-rolled steel strips for springs (*first revision*)
IS 2004 : 1991	Carbon steel forgings for general engineering purposes *(third revision)*
IS 2062 : 2011	Hot rolled low, medium and high tensile structural steel (*seventh revision*)
IS 2644 : 1994	High strength steel castings for general engineering and structural purposes-Specification (*fourth revision*)
IS 2825 : 1969	Code for unfired pressure vessels
IS 2707 : 1996	Carbon steel castings for surface hardening - Specification (*fourth revision*)
IS 3073 : 1967	Assessment of surface roughness
IS 4454(Part 1) : 2001	Steel wire for mechanical springs — Specification: Part 1 Cold drawn unalloyed steel wire (*third revision*)
IS 4454(Part 2) : 2001	Steel wires for mechanical springs: Part 2 Oil hardened and tempered spring steel wire and valve spring wire — Unalloyed (*second revision*)
IS 4454(Part 4) : 2001	Steel wires for mechanical springs: Part 4 Stainless steel wire (second revision)
IS 6527 : 1995	Stainless steel bars and flats Specification (*first revision*)
IS 6603:2001	Design and use of rubber seals for hydraulic gates — Recommendations (*second revision*)
IS 10021 : 2000	Guidelines for de-icing system for hydraulic installations (*first revision*)
IS 11855 : 2017	Design and use of rubber seals for hydraulic gates — Recommendations (*second revision*)

ANNEX B

(*Clauses* 5.2.6, 5.2.7, 5.3.3, 5.4.4.2, 5.4.5, 5.7.6, 6.2 *and 9*)

PERMISSIBLE MONOAXIAL STRESSES FOR STRUCTURAL COMPONENTS OF HYDRAULIC GATES

Sl No.	*Material and Type*	*Wet Condition*		*Dry Condition*	
		Accessible	Inaccessible	Accessible	Inaccessible
(1)	(2)	(3)	(4)	(5)	(6)

a) *Structural Steel:*

i)	Direct compression	0.45 YP	0.40 YP	0.55 YP	0.45 YP
ii)	Compression/tension i 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 stress	0.35 YP	0.30 YP	0.40 YP	0.35 YP
v)	Combined stress	0.60 YP	0.50 YP	0.75 YP	0.60 YP
vi)	Bearing stress	0.65 YP	0.45 YP	0.75 YP	0.65 YP

b) *Bronze or Brass:*

Bearing stress	0.035 UTS	0.030 UTS	0.040 UTS	0.035 UTS

NOTES:

1 Y"stands for minimum guaranteed yield point stress. UTS stands for ultimate tensile strength. For materials which have no definite yield point, the yield point may be taken at 0.2 percent proof stress.

2 When the members are subjected to direct compression/compression in bending, the *fir* ratio of members is to be considered and the stresses correspondingly reduced in proportion given in Annex B and shall be in accordance with IS 800

3 The term 'wet condition' applies to skin plates and those components of gate which may have a sustained contact with water, for example, horizontal girder and other components located on upstream side of skin plate. The term 'dry condition' applies to all components which generally do not have a sustained contact with water, for example, girders, stiffeners of skin plate etc. on downstream side, even though there may be likelihood of their wetting due to occasional spray of water. Stop logs are stored above water level and are only occasionally used. Hence, stresses given under dry and accessible conditions should be applied to them in accordance with **5.2.7**.

4 The term 'accessible' applies to gates which are kept in easily accessible locations and can, therefore, be frequently inspected and maintained, for example, gates and stop logs which are stored above water level and are lowered only during operations. The term 'inaccessible' applies to gates which are kept below water level and/or are not easily available for frequent inspection and maintenance. For example, gates kept below water level or in the bonnet space even while in the raised position or gates which on account of their frequent use are generally in water.

ANNEX C

[*Clauses* 5.2.2(b), 5.2.3(b) and 9]

METHOD OF COMPUTATION OF BENDING STRESS IN FLAT PLATES

C-1 STRESS OF FLAT PLATES IN PANELS

Bending stress in flat plates may be computed from the following formula:

where,

σ = Bending stress in flat plate, in Nzmm^2;
K = Non-dimensional factor depending on values of *a* and *b;*
p = after pressure (relative to the plate centre), in Nzmm^2;
a.b = Bay width as in Fig. 4 to 9, in mm; and
s = Plate thickness, in mm.

The values of *K* for the points and support conditions given in Fig. 4 to 9 are given in Tables 2, 3 and 4.

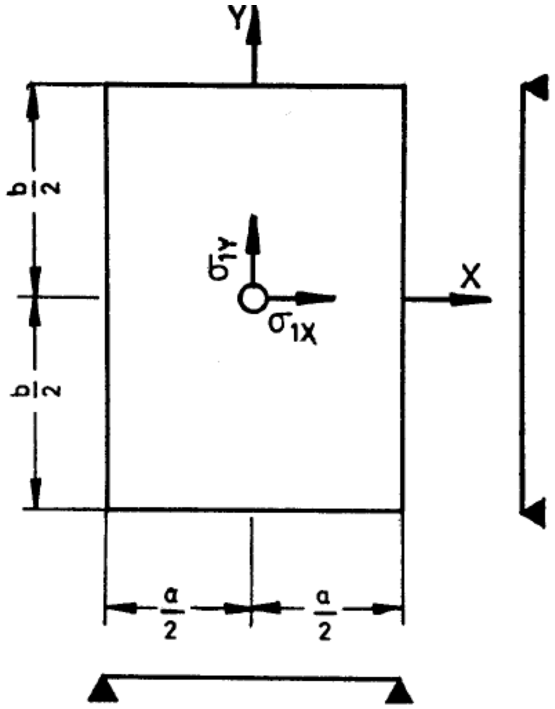


FIG. 4 ALL EDGES SIMPLY SUPPORTED

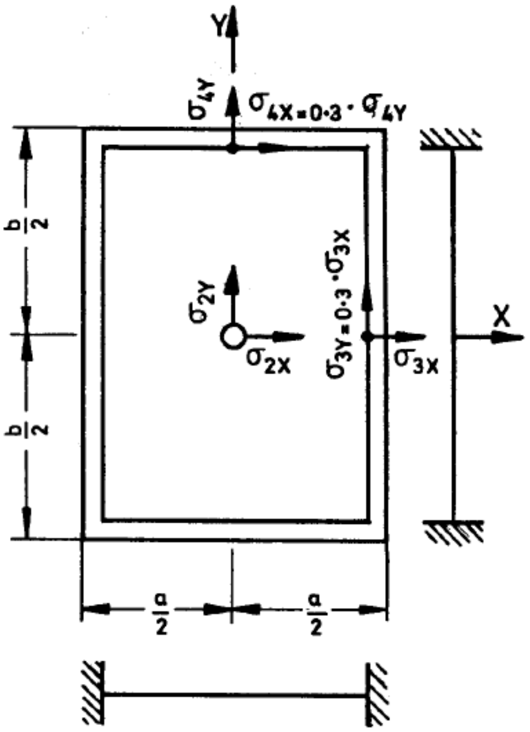


FIG.5 ALL EDGES RIGIDLY FIXED

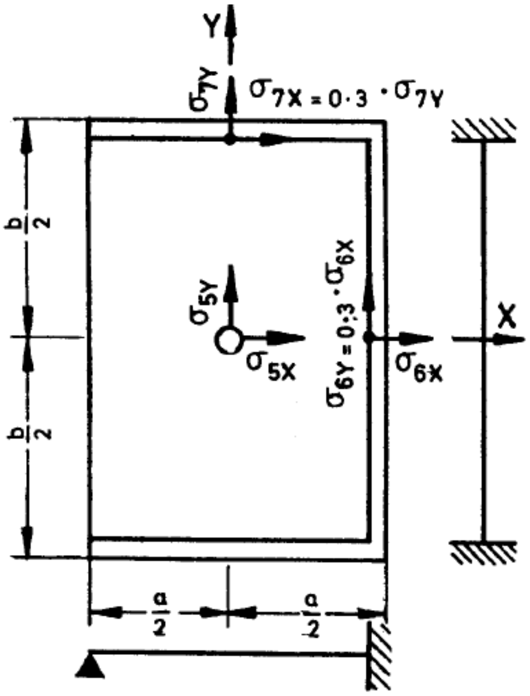


FIG.6 TWO SHORT AND ONE LONG EDGES FIXED AND ONE LONG SIMPLY SUPPORTED

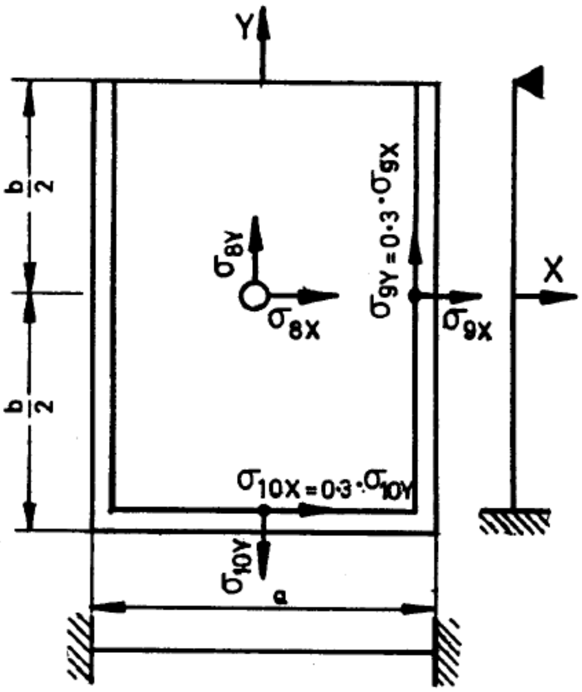


FIG.7 TWO SHORT AND ONE LONG EDGES FIXED AND ONE LONG SIMPLY SUPPORTED

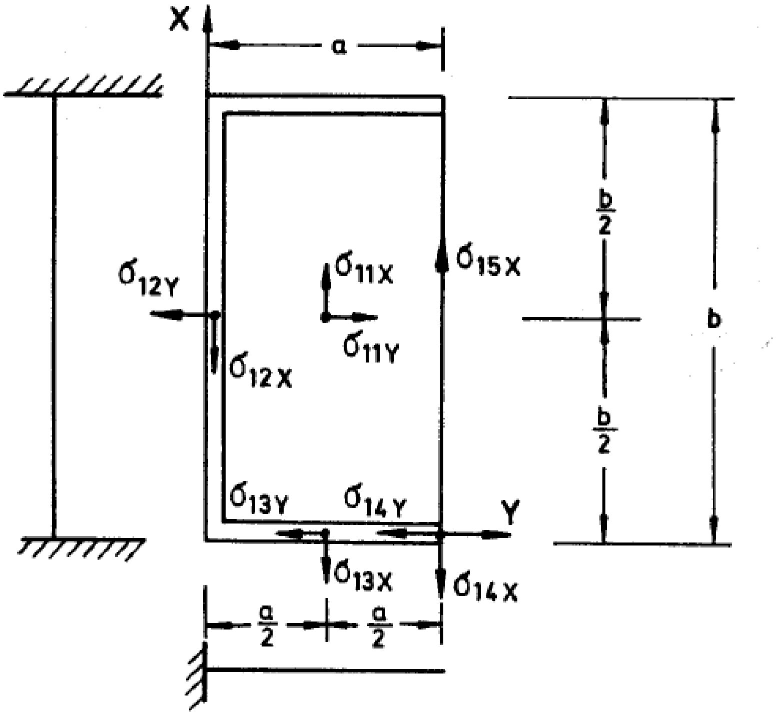


FIG. 8 THREE EDGES FIXED AND ONE (LONGER) EDGE FREE

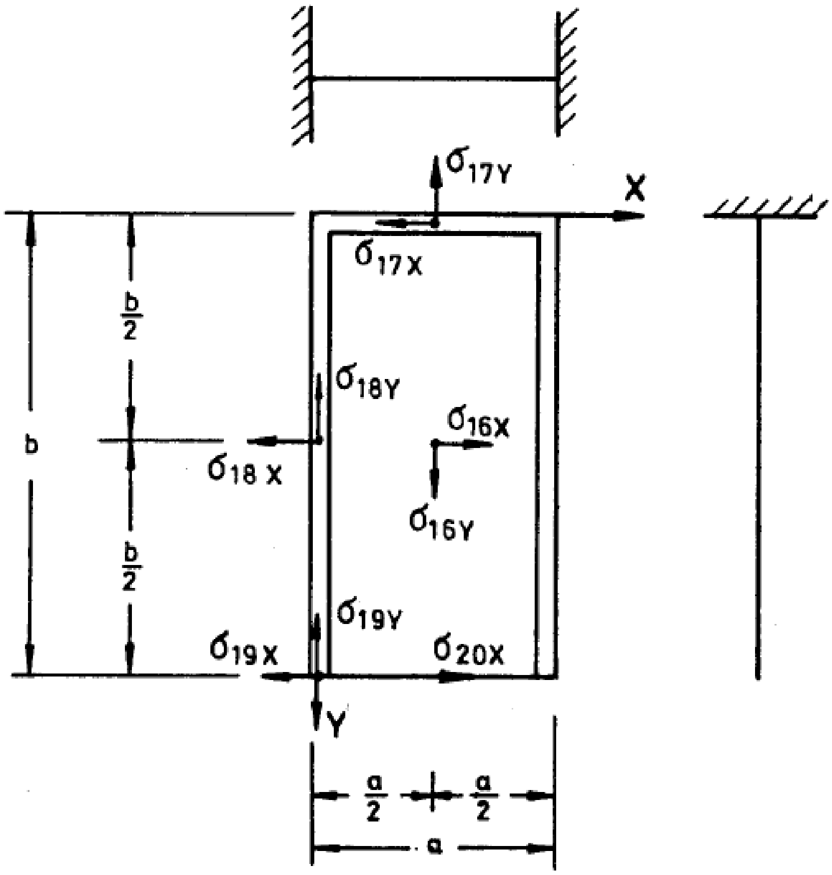


FIG. 9 THREE EDGES FIXED AND ONE (SHORTER) EDGES FREE

Table 2 Values of *K* for Points and Support Conditions given in Fig. 4 to Fig. 7

(*Clause* C-1)

Sl. No.	$\frac{b}{a}$	$\pm\sigma_{1x}$	$\pm\sigma_{1y}$	$\pm\sigma_{2x}$	$\pm\sigma_{2y}$	$\pm\sigma_{4y}$	$\pm\sigma_{3x}$	$\pm\sigma_{5x}$	$\pm\sigma_{5y}$	$\pm\sigma_{7y}$	$\pm\sigma_{6x}$	$\pm\sigma_{8x}$	$\pm\sigma_{8y}$	$\pm\sigma_{10y}$	$\pm\sigma_{9x}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	«	75	22.5	25	7.5	34.3	50	37.5	11.3	47.2	75	25	7.5	34.2	50
ii)	3	71.3	24.4	25	7.5	34.3	50	37.4	12.0	47.1	74.0	25	7.6	34.2	50
iii)	2.5	67.7	25.8	25	8.0	34.3	50	36.6	13.3	47.0	73.2	25	8.0	34.2	50
iv)	2	61.0	27.8	24.7	9.5	34.3	49.9	33.8	15.5	47.0	68.3	25	9.0	34.2	50
v)	1.75	55.8	28.9	23.9	10.8	34.3	48.4	30.8	16.5	46.5	63.2	24.6	10.1	34.1	48.9
vi)	1.5	48.7	29.9	22.1	12.2	34.3	45.5	27.1	18.1	45.5	56.5	23.2	11.4	34.1	47.3
vii)	1.25	39.6	30.1	18.8	13.5	33.9	40.3	21.4	18.4	42.5	47.2	20.8	12.9	34.1	44.8
viii)	1	28.7	28.7	13.7	13.7	30.9	30.9	14.2	16.6	36.0	32.8	16.6	14.2	32.8	36.0

NOTE — The edges over which the panels are continuous may, for all practical purposes, be treated as edges rigidly fixed. However. More exact analysis may be resorted to at the discretion of the designer.

Table 3 Values of *K* for Points and Support Conditions given in Fig. 8

(*Clause* C-1)

Sl No.	$\frac{b}{a}$	σ_{11x}	σ_{11y}	σ_{12x}	σ_{12y}	σ_{13x}	σ_{13y}	σ_{14x}	σ_{14y}	σ_{15x}	σ_{15y}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	α	22.00	75.00	90.00	300.0	91.00	28.00	205.00	62.00	2.00	0
ii)	1.0	17.67	12.29	9.45	31.5	37.64	11.29	44.55	13.4	27.96	0
iii)	1.25	22.5	13.0	15.5	51.5	48.0	14.8	53.0	16.2	37.0	0
iv)	1.50	23.5	14.2	20.5	72.5	59.5	18.2	82.0	22.7	48.0	0
v)	1.75	23.0	14.0	25.8	87.0	67.5	20.8	112.0	34.8	61.0	0
vi)	2.0	19.49	6.72	33.98	113.28	72.96	21.89	134.4	40.32	69.88	0
vii)	2.5	18.37	2.88	42.05	140.16	51.84	15.55	124.8	37.44	52.42	0
viii)	3.0	19.78	7.68	44.93	149.76	65.28	19.59	109.44	32.84	52.41	0

Table 4 Values of *K* for Points and Support Conditions given in Fig. 9

(*Clause* C-1)

Sl No.	$\frac{b}{a}$	σ_{16x}	σ_{16y}	σ_{17x}	σ_{17y}	σ_{18x}	σ_{18y}	σ_{19x}	σ_{19y}	σ_{20x}	σ_{20y}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	α	29.00	9.00	9.00	30.0	50.00	15.00	51.00	16.00	29.00	0
ii)	1.0	17.67	12.29	9.45	31.5	37.64	11.29	44.55	13.4	27.96	0
iii)	1.25	20.8	11.70	8.96	29.87	28.0	8.4	34.5	10.35	28.53	0
iv)	1.50	25.51	11.12	8.48	28.28	21.04	6.31	25.53	7.66	29.11	0
v)	1.75	26.48	10.56	8.49	28.3	32.0	9.6	36.5	10.95	28.97	0
vi)	2.0	27.46	10.0	8.5	28.36	45.52	13.66	50.09	15.27	28.81	0
vii)	2.5	28.07	9.13	8.51	28.38	46.66	14.0	50.8	15.24	28.78	0
viii)	3.0	28.18	8.68	8.51	28.38	46.94	14.08	50.81	15.24	28.77	0

ANNEX D

[*Clause* 5.2.4(b)]

METHOD OF CALCULATION OF CO-ACTING WIDTH OF SKIN PLATE WITH BEAM OR STIFFENERS

D-1 METHOD

D-1.1 Coacting width of skin plate is given by 2*VB:*

where,

V = Reduction factor (non-dimensional) depends on the ratio of the support length to the span of the plate and on the action of the moments, and is ascertainable from Fig. 10 and Fig. 11; and

B = Half the span of the plate between two girders (see Fig. 10) or overhang length of a bracket plate.

D-1.l.l The ideal support length (L1 or l,[l, *see* Fig. 10) corresponding to the length of the moment zone of equal sign shall in the case of continuous girders be basis with regard to support length L. In the case of single bay girders, the ideal support length corresponds to the actual:

V_1 = Reduction factor corresponding to the parabolic moment zone (*see* Fig. 10 and 11), and

V_{11} = Reduction factor corresponding to the moment zone composed of two concave parabolic stresses and approximately the triangular shaped moment zone (shown with dashes in Fig. 10 and 11).

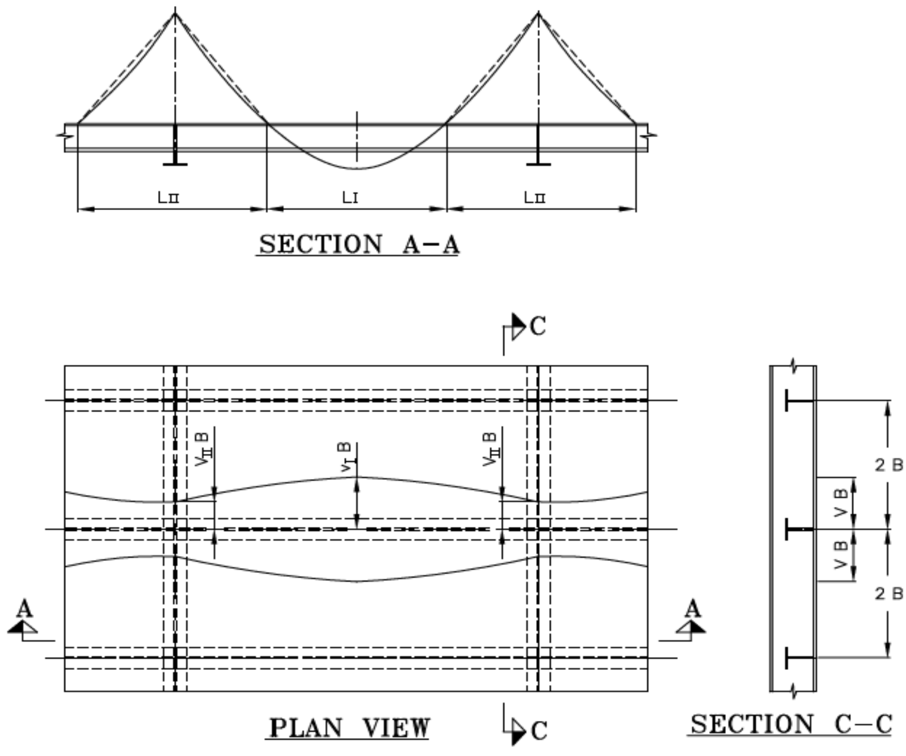


FIG.10 FIGURE SHOWING VARIATION OF CO-ACTING WIDTH FROM

SUPPORT TO SUPPORT

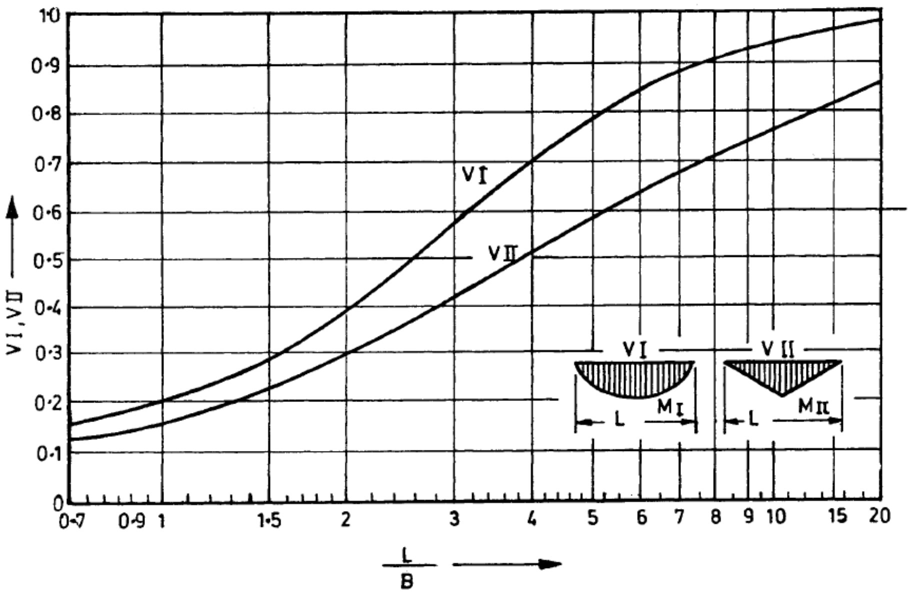


FIG. 11 CURVES SHOWING RELATIONSHIP BETWEEN $\frac{L}{B}$ AND REDUCTION FACTORS V_I AND V_{II}

ANNEX E
(*Foreword*, and *Clause* 5.4.2)

PROCEDURE FOR CALCULATION OF CAPACITY OF WHEEL FOR POINT CONTACT

E-1 PROCEDURE

E-1.1 Knowing the water load on the gate, the procedure for wheel design is as given in **E-1.2** to **E-1.5**.

E-1.2 The design of the wheels is governed primarily by the stress in the tread. The required projected area of the tread, that is, the area represented by the product of wheel diameter and net tread-width, is determined by the following formula:

Critical stress of projected area in N / mm^2
= (Brinell hardness number x 0.169) -15.174

E-1.3 Owing to the necessarily extreme stiffness of the vertical girders of the gate on which the wheels are mounted and to allow for slight misalignment of pin surfaces, it is assumed that any wheel on one side of the gate may not bear on the pin for a short distance of travel. This condition will cause an overload on some of the adjacent wheels which is taken for design, with a factor of safety of 2.0 over the critical stress on projected area while for a normal case, that is, all the wheels bearing evenly on the pins, the factor of safety shall be taken as 3.0. The contact of all the rollers with the pin can be ensured if the gate is designed as semi-flexible with a number of elements each fitted with only two wheels on either side. The vertical girder in such construction is discontinuous.

E-1.4 After diameter and net tread dimensions of wheel have been suitably chosen from the above formula, the stress may be analyzed with the help of Fig. 11 and formula given below:

Maximum shearing stress, in N/mm^2 = 0.5 (IZZ -, YY)

Value of maximum difference of stress components (,2,+ , YY)can be calculated from the known values of variables :

$$\frac{\Lambda}{A}\left({}_1 z_z - {}_1 Y_z\right), \frac{Z_1}{a}, \frac{Z_1 \Lambda P}{a^3}$$

which are read with Fig. 10 for known values of *B/A*

where,

B = Mean of reciprocals of radii in y–direction $= \dfrac{1}{2R_2}$;

A = Mean of reciprocals of radii in x-direction1$= \dfrac{1}{2R_1}$;

R_1[1)] = Radius of crowning of wheel, in mm;
R_2 = Radius of wheel, in mm;

A = $\frac{2\left(1-\mu^2\right)}{E\left(A+B\right)}E$ =Evaluation of elastic property and shape property;

μ = Poisson's ratio $=\frac{1}{4}$;

E = Modulii of elasticity, in N/mm^2;

Z_1 = Depth to point of maximum stress difference or point at which maximum shearing stress occurs in mm;

a = Semi-major axis of ellipse of contact, in mm; and

P = Wheel load, in N.

E-1.5 The horizontal compression between wheel and pin for curved contact is given by:

$$P_{\max} = \frac{1.5P}{\Pi\, ab}$$

where,

P_{Max} = Maximum horizontal compressive stress, in N/mm^2;

P = Wheel load, in N;

a = Semi-major axis of ellipse of contact, in mm; and

b = Semi-minor axis of ellipse of contact, in mm.

It may be noted that $b = K_a$ in which values of K can be read from Fig. 12.

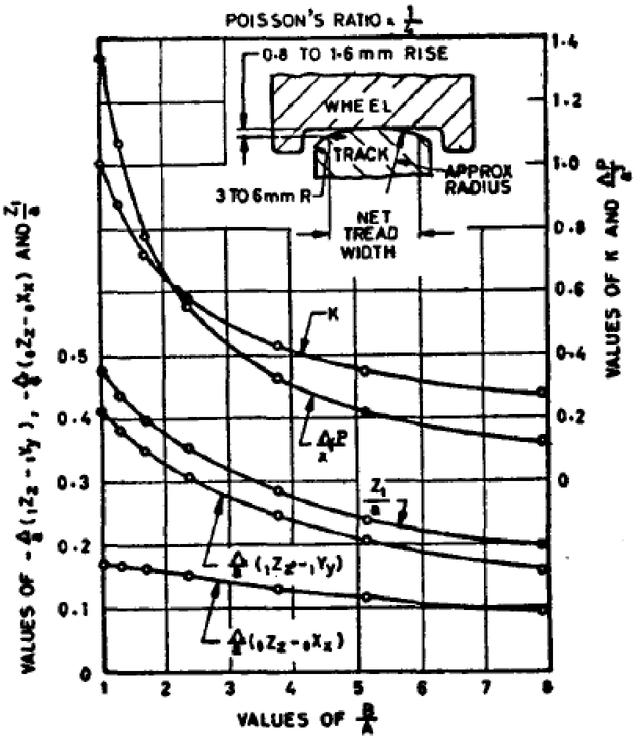


FIG. 12 CURVES FOR DETERMINATION OF STRESSES IN WHEELS

E-2 ILLUSTRATIVE EXAMPLE

E-2.1 Data

a) Wheel load:

normal = 232 105 N
maximum = 356 495 N (say with one wheel not touching)

b) Wheel diameter = 430 mm *Max* (determined from other practical considerations)

c) Wheel material:
Steel with UTS
Rim hardened to
BHN 255 = 883 N/mm^2

E-2.2 Design Procedure

a) Critical stress = (0.169 × BHN)- 15.174 (*see* **E-1.2**)
= (0.169×255) - 15.174
= 27.921 N/mm^2 of the projected area

b) Allowable stress = $\frac{27.921}{3}$
= 9.307 N/mm^2 of projected area for normal load (factor of safety = 3)
or
= $\frac{27.921}{2}$
= 13.96 N/mn^2 of projected area for maximum load (factor of safety = 2)

c) Projected area required = $\frac{232\ 105}{9.307}$

= 24939 mm^2 for normal load
or
$= \frac{356\,495}{13.96}$

= 25.537 mm^2 for maximum load

d) Net tread width required $= \frac{25\,537}{430}$
= 59.38 mm
Provide say 60 mm

e) Check for maximum shear stress

P = Wheel load = 356 495 N
R_1 = Radius of wheel (assumed) crowning = 768 mm
R_2 = Radius of wheel = 215 mm
μ = Poisson's ratio $\frac{1}{4} = 0.25$

$\frac{B}{A} = \frac{R_1}{R_2}$

$\frac{768}{215}$

= 3.57

B+*A* = $\frac{1}{2}(0.001\,30 + 0.004\,65)$

=0.002 98

From Fig. 2 for *B/A = 3.57,* we get:

1) *k = 0.44* . ..(1)

2) $\frac{\Lambda_P}{a^3}$ *= 0.35* . ..(2)

3) $\frac{Z_1}{a}$ = 0.29 ...(3)

4) $\frac{\Lambda}{a}\left({}_1Z_z - Y_y\right)$ = 0.25 …(4)

Substituting values in equation given in E-1.4, we get,

$\Lambda \quad = \frac{2(1 - 0.062\,5)}{0.206 \times 10^6 \times 0.002\,98}$ mm^3/N

$= \frac{3.05}{10^3}$ mm^3/N

From (2) we get:

$a = \sqrt[3]{\frac{AP}{0.35}}$ mm

$= \sqrt[3]{\frac{3.05 \times 356\,495}{10^3 \times 0.35}}$ mm

$= \sqrt[3]{3106.6}$ mm

= 14.59mm

From (4) we get:

$\left({}_1Z_z =_1 Y_y\right) = 0.25\frac{a}{\Lambda}$

$= \frac{0.25 \times 14.59 \times 10^3}{3.05}$

= maximum differential of stress components

$\therefore$ *Max* shear stress = $\frac{1}{2}\left({}_1Z_z -_1 Y_y\right)$

= 597.95 N/mm^2

This is greater, than the actual shear stress 597.95 N/mm^2. Hence safe.

f) Check for contact stress

Substitution in (e) (3)

$Z_1 = 0.29\,a$
$= 0.29 \times 14.59$
$= 4.231$ mm

Semi-major and semi-minor axis of ellipse of contact are:

a = 14.59 mm
b = *k.a*
= 0.44 × 14.59
= 6.42 mm

Contact stress = $\frac{3}{2} \times \frac{p}{\pi \times ab}$

$$= \frac{3 \times 356\,495}{2 \times 3.14 \times 14.59 \times 6.42}$$

E-2.3 Allowable Stress (If Used on Low Head Gate)

In accordance with Annex F, allowable stress:

= 2.4 UTS
= 2.4 × 883
= 2 119.2 N/mm^2

This is greater than actual stress 1818.1 N/mm^2. Hence safe.

E-2.4 Allowable Stress (If Used on medium or high head Gate)

In accordance with Annex F, allowable stress:

= 2.1 × 883
= 1 854.3 N/mm^2

This is greater than actual stress 1818.1 N/mm2. Hence safe.

E-2.5 Minimum Depth of Penetration of Hardness Required

$= 2.0 \times Z_1$

But $\frac{Z_1}{a} = 2.9$

Therefore, $Z_1 = 0.29\,a$

$= 0.29 \times 14.59$
$= 4.231$ mm

$\therefore$ Minimum depth of penetration of hardness

$= 2 \times 4.231 = 8.462$ mm (say 9 mm).

ANNEX F
(*Clauses* 5.4.2.1 and 5.4.3.2)

PERMISSIBLE LINE AND POINT CONTACT STRESSES

	Crest Gates and Low Head Sluice Gates	*Medium and High Head Sluice Gates*
Line contact	$1.6 \times UTS$ 1)	1.4 × UTS
Point contact	$2.4 \times UTS$ 1)	2.1× UTS

NOTE — UTS = Ultimate tensile strength in N/mm^2.

1) These values can be used for less frequently operated gates irrespective of water head

ANNEX G
(*Clause* 5.5.2)

TYPES OF RUBBER SEALS RECOMMENDED FOR DIFFERENT CLASSES OF GATES

a) *High Head* — Double stem type (preferably with cladding) for top and top comer seals, music note seal for side seal.

b) *Medium Head* — Solid bulb music note type, and

c) *Low Head* — Hollow/solid bulb music note type or flap or pre moulded *L*-type

NOTE — Wedge type seal may be used at the bottom ‘of the gate when it comes to rest on the sill. If the gate slides on the face of an opening, musical note or double stem type seals may be used.

ANNEX H

(*Clause* 5.12)

TOLERANCES FOR EMBEDDED PARTS AND IN COMPONENTS OF GATE

(1)	*Components*			Classification Low and Medium Head mm (2)	High Head mm (3)
1	***A Embedded Parts*** Pin Plates 1.1 Alignment in plane parallel to flow 1.2 Distance between centre line of opening 1.3 Coplanerness	and	pin	±1.0 ±1.5 ±1.0	±0.5 ±1.0 ±0.5
2	Guides				
	2.1 Alignment in plane parallel to flow			±1.0	±1.0
	2.2 Distance between centre line of opening	and	face of guide	±1.0	±1.0
3	Side Seal Seats				
	3.1 Alignment in plane parallel to flow 3.2 Distance between centre line of opening	and	side seal seat	±2.0 ±1.5	±;1.0 ±1.0
	3.3 Coplanemess			±1.0	±0.5
4	Top Seal Seat				
	4.1 Alignment 4.2 Height above sill 4.3 Coplanemess with side seal			±2.0 ±3.0 ±1.5	±1.0 ±2.0 ±1.0
5	5 Critical Dimensions 5.1 Centre-to-centre distance between pin plates 5.2 Centre-to-centre distance side seal seats 5.3 Face-to-face distance between guides 5.4 Face of pin to face of side seal seat 5.5 Face to pin to centre line of guide			±3.0 ±3.0 ±2.0 -1.0 +0.0 ±2.5	±2.0 ±2.0 ±2.0 -1.0 +0.0 ±2.0

6	Bottom Seat Seal 6.1 Alignment in horizontal plane +2.0mm for Low and Medium Head as well as for High Head **B** ***Gate***				
1	Wheels 1.1 Alignment of treads in zero eccentricity position			1.5	1.5
2	Side and Top Seal Base 2.1 Alignment 2.2 Coplanemess			±1.0 ±1.0	±0.5 ±0.5
3	Critical Dimensions 3.1 Centre-to-centre distance between seal bases 3.2 Centre-to-centre distance between centre line of wheel 3.3 Face-to-face distance between faces of guide shoes or guide rollers 3.4 Face-to-face distance between wheel tread to side seal base 3.5 Distance between faces of wheel tread and centre line of guide shoe/roller			±2.0 ±2.0 ±3.0 +2.0 -0.0 ±2.5	±1.0 ±1.0 ±2.0 +1.0 -0.0 ±1.5

(*Continued from second cover*)

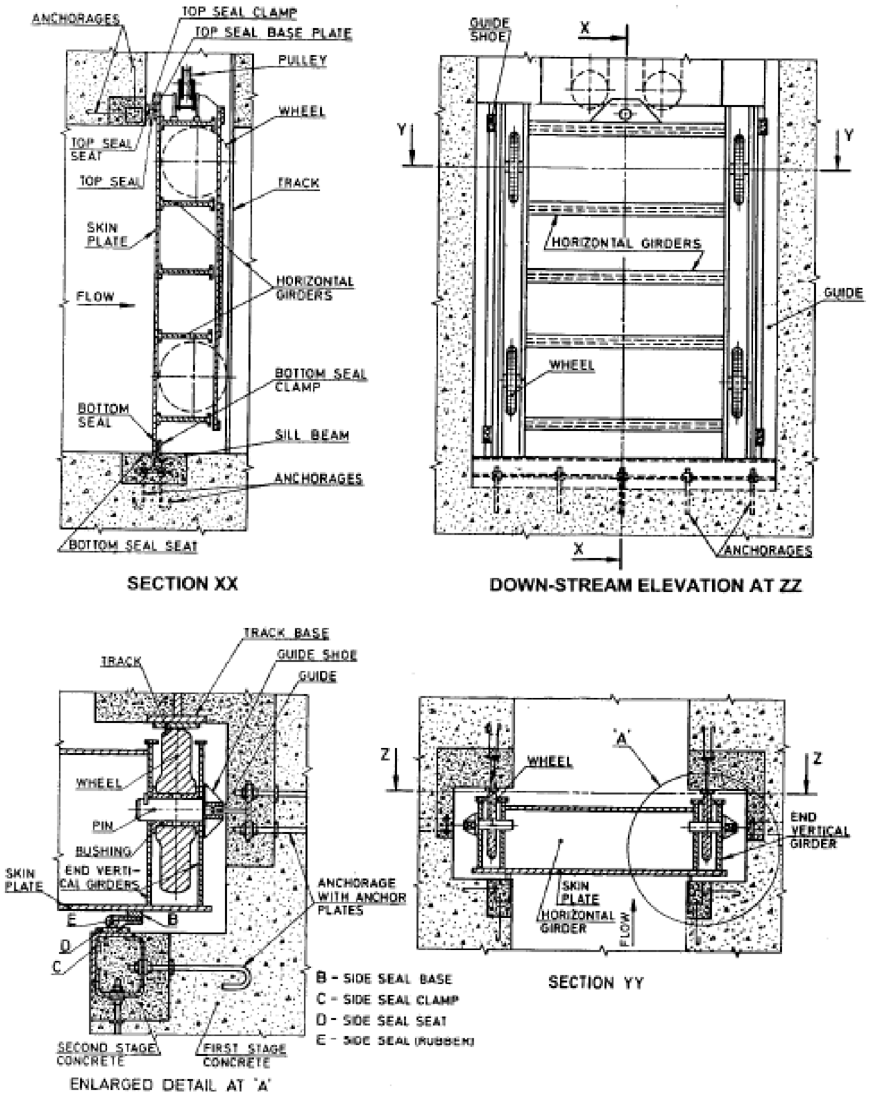


FIG.1 TYPICAL ARRANGEMENT OF VARIOUS COMPONENTS OF FIXED-WHEEL GATES