भारतीय मानक मसौदा

मध्यम और उच्च शीर्ष के स्लाइड गेट की संरचनात्मक डिजाइन के लिए अनुशंसाएँ

(IS 9349 का तीसरा पुनरीक्षण)

Draft Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN OF MEDIUM AND HIGH HEAD SLIDE GATES

(*Third Revision of* IS 9349)

Hydraulic Gates and Valves Sectional Committee, WRD 12 Last Date for Comments: 11/11/2024

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

Slide gate, as the name implies, is the gate in which the operating member (gate leaf) slides on the seating surfaces provided on the frame consisting of bodies with or without bonnets. These gates are generally installed in closed conduits and have seals all around. Jet flow gate also falls into this category. The use of slide gates as the control and guard or emergency gates in conduits and sluices for a water head of up to 100 m has gained popularity because of comparative simple construction and better hydraulic performance resulting from narrow groove width. Jet flow gates are also being used for heads up to 200 m. However, slide gates normally do not close under their own weight and under the condition of an unbalanced head when water is flowing through conduit or sluice, and therefore have to be pushed down for closing. This factor decides the location of the hoist directly above the gate and also limits the use of slide gates. It is advisable, especially for high-head gates, to get a hydraulic model of the gate tested to determine the following for various operating requirements:

a) Down pull and uplift force;
b) Air demand and its location;
c) Gate slot geometry;
d) Gate geometry – Special bottom shape;

e) Vibration; and
f) Negative pressure and cavitation.

This standard was first published in 1979. The first revision of the standard was published in 1986 in view of the experience gained during the course of years while using this standard. In that revision, two more conditions that is, three edges fixed and one (longer) edge fixed, and three edges fixed and one (shorter) edge free to cover the most commonly occurring field conditions were added.

The second revision of this standard was brought out in 2006 to incorporate changes, especially with reference to co-acting width in case of panel construction, jet flow gates, requirement of aeration, figures showing rubber seal arrangement, etc.

The third revision of this standard has been brought out to bring the standard in the latest style and format of the Indian Standards. In addition, the following major changes have been incorporated:

a) Annex B on recommended material for different components has been updated,
b) Table 1 to Table 3 have been updated; and
c) Annex C has been updated; and
d) Recommended materials for components of the gate have been updated.

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 l 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.

Draft Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN OF MEDIUM AND HIGH HEAD SLIDE GATES

(*Third Revision of* IS 9349)

Hydraulic Gates and Valves Sectional Committee, WRD 12

Last Date for Comments: 11/11/2024

1 SCOPE

This standard provides recommendations for structural design of medium and high head slide gates.

NOTE — This standard does not cover bulkhead stoplog gates and hoisting mechanism.

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 there standards.

3 TERMINOLOGIES

For the purpose of this standard the following definitions shall apply.

3.1 Medium Head Gate — A gate which is subjected to a head of water exceeding 15 m but less than 30 m, over sill.

3.2 High Head Gate — A gate which is subjected to a head of water 30 m or above, over sill.

4 TYPES OF GATES AND REQUIREMENTS

4.1 Type

Slide gate for medium and high head installations are classified into the following two types depending upon their service conditions:

a) *Emergency or guard gates* — These are designed to be closed under unbalanced head, that is, with water flowing through the conduit or sluice, but are not meant for regulation. They are generally opened under balanced head but may be designed to open under unbalanced head also. These are kept either fully open or fully closed;

b) *Regulating gates* — These are used for regulating flow of water. These are operated under unbalanced head conditions and are designed to be operated at any gate opening. Jet flow gates are used as regulating gates either at discharge end or at any intermediate point in a conduit. These can be useful for small size outlets under high head (150 m to 200 m) installation.

4.2 Requirement

The principal requirements of slide gates shall be as given below:

a) The gates shall be reasonably watertight. Leakage, if any, unless otherwise specified, shall not normally exceed 5 and 10 liter per minute per meter length of periphery of the sealing surface, for medium and high head gates, respectively;
b) The gates shall be rigid, smooth, and straight at joints and reasonably free from vibration;
c) The bottom shape of the gates shall be suitably designed to minimize down pull in the case of downstream sealing and to minimize uplift and vibrations in case of gates with upstream sealing and to provide a converging fluid way and definite spring flow discharge;
d) The slot of the gates shall be as narrow as possible, in conformity with structural safety of the gate;
e) The gates shall be capable of being raised or lowered by the hoisting mechanism provided, within the prescribed time; and
f) Downstream edges in the opening of-the slot on top and side of the gates shall not be sharp. These may be suitably set back from the upstream edge of the slot and rounded off for better hydraulic performance.

5 DESCRIPTION AND ARRANGEMENT OF GATE

5.1 General

The typical installation of a slide gate for medium or high head is shown in Fig. 1. It consists of gate leaf, which moves, in a frame. The frame consists of body and bonnet which houses the gate in closed and open position respectively. The body and bonnet are embedded in concrete. The bonnet is covered by bonnet cover with a stuffing box through which stem rod passes. The hoisting mechanism may be supported directly over the bonnet cover or over a separate set of girders at higher level

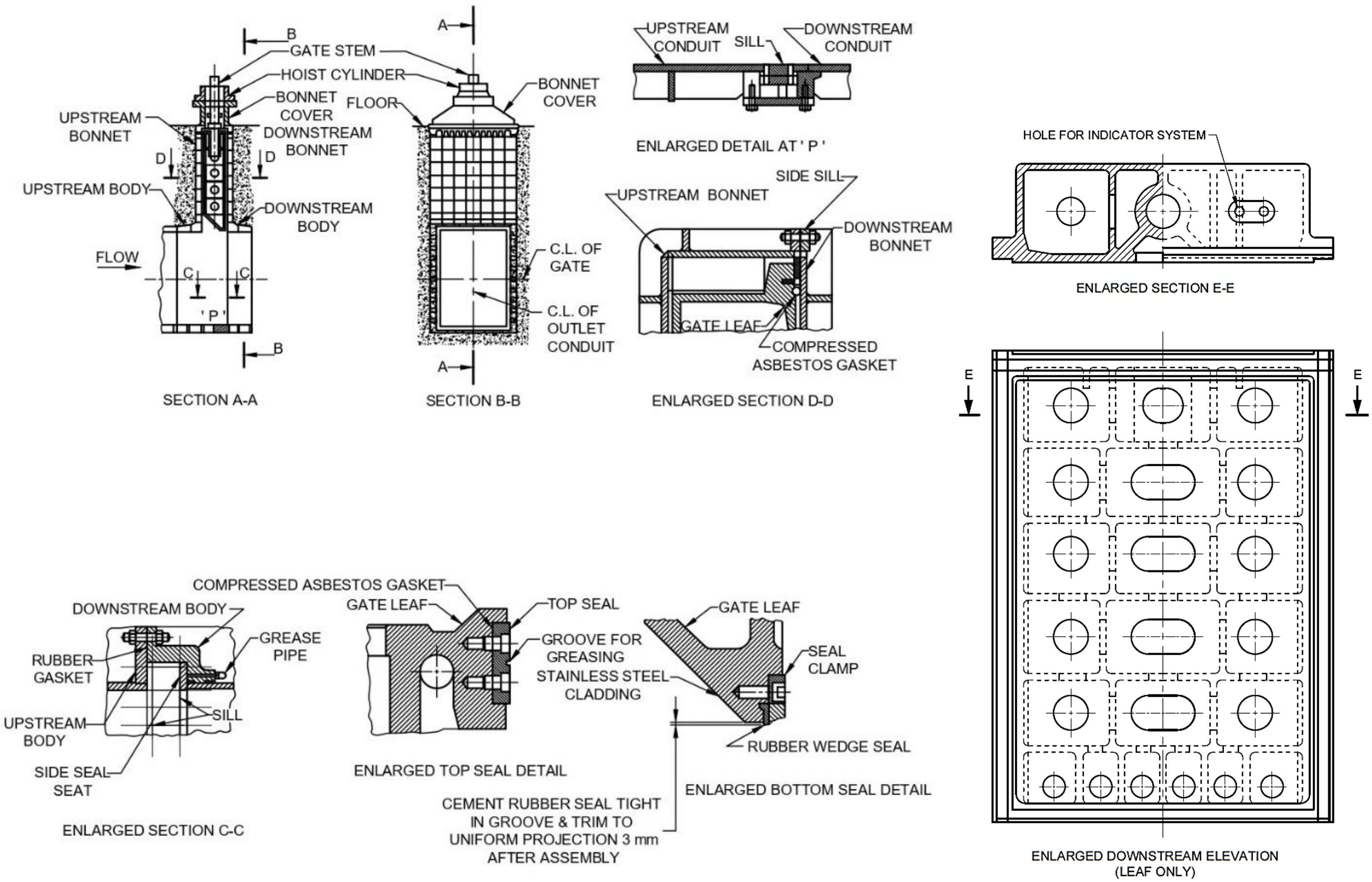

FIG. 1 DETAIL OF SLIDE GATE

5.2 Gate Leaf

5.2.1 The gate leaf is a rigid frame structure consisting of a skin plate supported on stiffener and/or girder which transmits the water load from the skin plate to the vertical end girder. The skin plate may be upstream and/or downstream, according to design requirements. The gate leaf may be of cast steel or of structural steel in welded construction. Provision shall be made for connecting the gate position indicator and connections for the hoist to the gate leaf. Connections for the hoist shall be determined so that the gate shall remain truly vertical in suspended condition.

5.2.2 The seals which are screwed on the downstream face of the gate leaf transmit the water load on the gate leaf to the concrete through seal seats and embedded downstream body. Sufficient number of screws should be provided to resist the frictional forces during raising or lowering of gate under maximum head of water. In addition, shear plug to resist about 10 percent of shear force should be provided. Alternatively, rubber seals of suitable size may be fixed on sides and top with the help of seal clamps and G.I. or stainless-steel bolts/ stainless steel screw 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 seal may be used. Edges of seal clamp adjacent to seal bulb shall be rounded. Rubber seal shall be provided at the bottom of the gate leaf. Its projection shall be uniform and should not be normally more than 3 mm. In the case of high head gates, the projection should be limited to 1.5 mm. Sealing arrangement showing rubber seals is shown in Fig. 2.

5.2.3 The gate shall have a narrow sill surface at the bottom with its upstream or downstream face sloping upwards at an approximate angle of 45° with the horizontal to reduce down pull or uplift respectively, especially when the gate is used for regulation.

5.2.4 For high head gates bottom sealing and sloping surfaces of the gate should preferably be of austenitic stainless steel for better resistance to cavitation damage. To reinforce it against cavitational pitting that may occur, the upstream edge of the gate leaf may be slightly projected and rounded off suitably for better hydraulic performance. An overlay of corrosion resistant steel of thickness of not less than 3 mm on sloping plate or complete corrosion resistant bottom plate is recommended on the sloping plate as shown in Fig. 1. Cladding shall be done by established metallurgical methods in manufacturer’s mill and not by plug welding.

5.3 Frame

The frame consists of the following components:

a) Sill girder with bottom seal seat;
b) Body;
c) Bonnet, and
d) Bonnet cover.

5.3.1 *Sill Girder with Bottom Seal Seat*

Bottom seal seat should be flush with the bottom of the opening and should be fixed on to the sill girder either with screwing or by welding to provide bottom sealing surface for the gate. All flanged joints should be provided with O-ring gasket. Silicone compound shall be applied to O-ring to mitigate leakage due to its degradation with time.

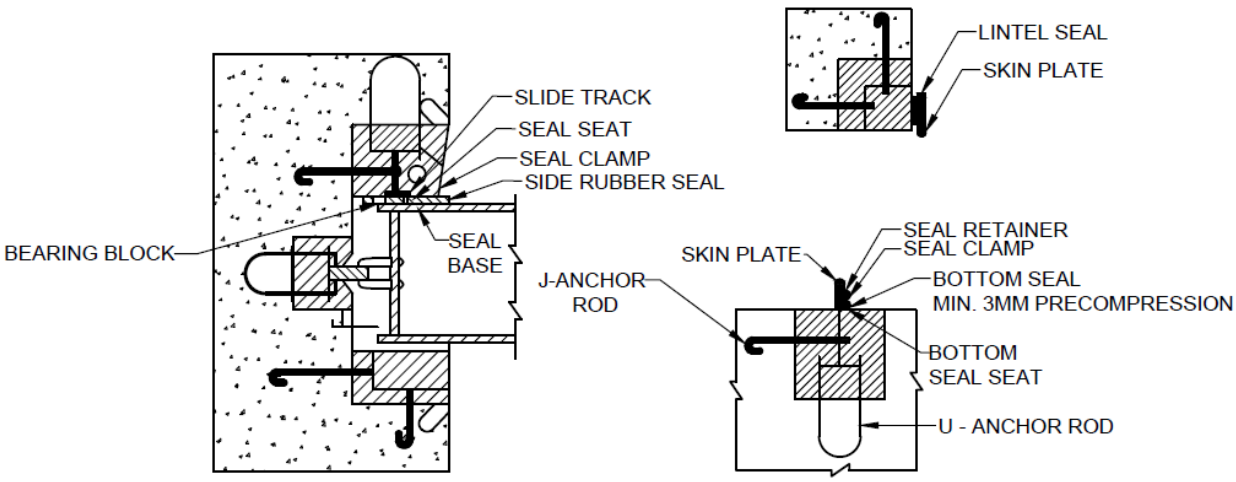

FIG. 2 RUBBER SEAL ARRANGEMENT

5.3.2 *Body*

The body which houses the gate leaf in closed position may be in sub-assemblies with joints. The body maybe of cast steel or structural steel in welded construction. In the latter case, proper care shall be taken to prevent warping during welding so that the tolerance of gaps around the gate is strictly adhered to. These should be adequately ribbed to provide proper anchorage with the surrounding concrete. The ribs so provided should have enough openings for allowing good concreting behind the groove bodies. The downstream portion of the body carries the bearing-cum-sealing plate in case of metallic seals, which may be fixed-by welding or screwing. It should be so designed that the maximum bearing pressure to which the concrete is subjected should not exceed the permissible stress specified in IS 456. The adequacy of embedded bearing plates/track sections shall be checked in bending and shear also based on theory of bending of infinite beam on elastic foundation. Guides are also fixed to the body for guiding the gate. Separate seal seats should be provided for rubber seals on upstream or downstream depending upon location of seals.

5.3.3 *Bonnet*

The bonnet houses the gate leaf in open position. It has flanges on the bottom for being bolted to the body and on the top for the bonnet cover. The bonnet may either be of cast steel or structural steel in welded construction. It should be adequately ribbed to provide

proper anchorage with surrounding concrete. The ribs so provided should have enough openings for allowing good concreting behind the groove bodies. Guides are fixed to the bonnet in continuity of the guides fixed on the body for guiding the gates.

5.3.4 *Bonnet Cover*

Bonnet cover is provided to seal the gate slot and provide a support for the hoist, in case the hoist is mounted directly over the bonnet. It should be designed for full hydrostatic pressure and also for the hoist capacity if the hoist is directly mounted over it. It should be in either one piece or more pieces according to the requirement. Provision for venting of air should be made in the bonnet cover. Provision of manhole may be provided in bonnet cover for large size gate to access for connection/ removal of connecting pin provided between gate and hydraulic cylinders.

5.4 Jet Flow Gate

Jet flow gates are used as regulating gates either at discharge end or at any intermediate point in a conduit. They consist of a flat-bottomed leaf, a body and bonnet and a bonnet cover on which the operating hoist is mounted. The fluid way upstream of gate forms a nozzle in the shape of the frustum of a 45° cone with upstream diameter at least twenty percent greater than downstream diameter or orifice diameter, causing, the discharging jet to contract and spring free of the slot in the gate body. The advantage in jet flow gates is that there is little or no pressure on the bonnet of gate. These can be useful for small size outlets under high heads (150 m to 200 m) installation. The arrangement is shown in Fig. 3.

6 MATERIALS

The recommended material used for different components are specified in Annex B.

7 UNIT STRESSES

7.1 The permissible value of stresses in the structural parts should be as specified in Annex C.

7.2 The permissible value of stresses in welded connections should be the same as permitted for the parent material.

8 LOADING

8.1 The gate shall be designed for hydrostatic and hydrodynamic forces as determined from model studies.

8.2 In case of gates located in conduits/sluices the minimum increase in head on account of sub atmospheric pressure, downstream of gate, should be 2 m for medium and 5 m for high head gates.

8.3 Earthquake forces shall be considered in accordance with IS 1893.

8.4 Silt Load, if Applicable, shall also be Considered.

9 STRUCTURAL DESIGN

9.1 Gate Leaf

9.1.1 The skin plate and stiffeners should be designed together in a composite manner.

9.1.2 The skin plate should be designed for the following two conditions, unless more precise methods are available. However, in case of gates with upstream top seals, maximum deflection of the top seal shall be not more than 80 percent of the initial interference of the seal.

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

9.1.3 The-stresses in skin plates for conditions in **9.1.2** should be determined as follows:

a) For determining the stresses for condition in bending across stiffener, or girders, as per procedure in **9.1.2** (a), bending moment should be determined according to the conditions of support; and
b) For calculating the stresses in skin plates for condition in bending as panel, in accordance

9.1.4 In either of the cases specified in **9.1.2** while designing the stiffener and girders the skin plate can be considered to be coacting with them.

a) The coacting width of the skin plate in non-panel fabrication as per **9.1.2** (a) shall be taken by restricting to the least of the following values;

1) $40t + B$,

where

t = thickness of skin plate, and

B = width of stiffener flange in contact with the skin plate;

2) 0.11 span; and
3) centre to centre of stiffeners or girders.

b) When skin plate co-acts with girder as well as stiffener to form a panel construction, width of skin plate coacting with horizontal girder or stiffener should be worked out as illustrated in Annex E.

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

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

σ_v = combined stress,

σ_x = sum of stresses along x axis,

σ_y = sum of stresses along y axis, and

τ_x = sum of shear stresses along x – y plane.

NOTE – The appropriate signs should be taken for σ_x and σ_y in the above formula.

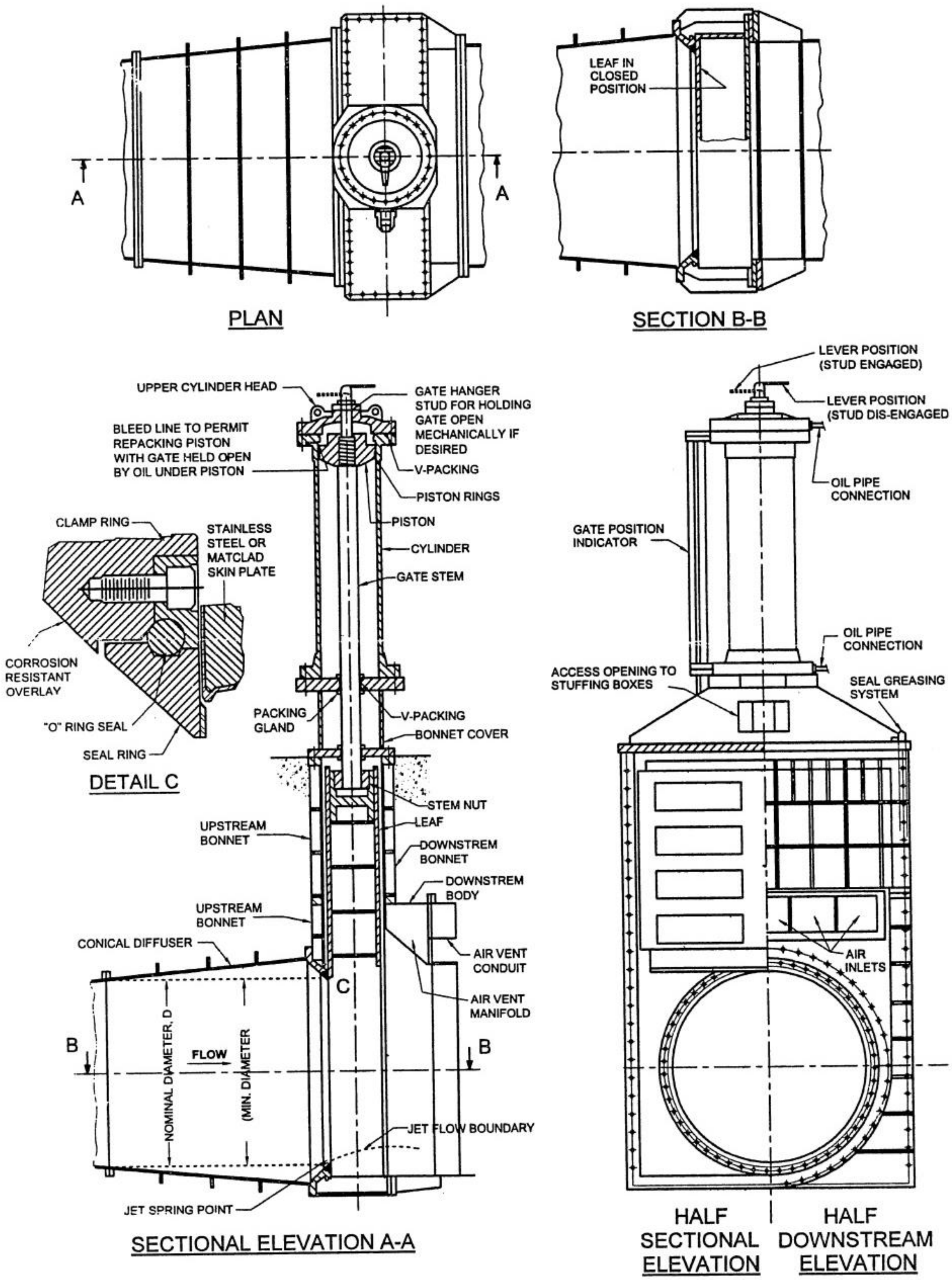

FIG. 3 JET-FLOW GATE

9.1.6 The permissible value of mono-axial and combined stresses should not be greater than those specified in Annex C.

9.1.7 Permissible value of stresses in the welds should be the same as permitted for the parent material. For site weld, efficiency should be considered 80 percent of shop weld.

9.1.8 To take care of corrosion, the actual thickness of skin plate to be provided should be at least 1.5 mm more than the theoretical thickness computed, based on the stresses given in Annex C. The thickness of the skin plate should be not less than 8 mm, exclusive of corrosion allowance when considered.

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

9.1.10 Horizontal and vertical stiffeners should be designed as simply supported or continuous beams, depending upon the framing adopted for the gate. The spacing between horizontal girders should preferably be such that all the girders carry almost equal loads.

9.1.11 The end vertical girders should be designed as continuous beams with concentrated loads, coming from horizontal girders, at points where they meet the end vertical girders.

9.1.12 *Deflection of Gate*

a) Maximum deflection of the gate under normal conditions of loading should be limited to 1/2 000 of the span;
b) In case of bulkhead gates the maximum deflection should be limited to 1/1 200 of the span, and;
c) In case of gates with upstream top seals, maximum deflection of the gate leaf at the top seal shall be limited to 80 percent of the initial interference of the top seal.

9.1.13 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 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 the other stresses to ensure that permissible limits are not exceeded.

9.1.14 *Gate Slot Geometry*

Width of slot should be kept as small as practicable. The downstream edge of the gate slot should be offset to reduce the cavitation hazard. In the absence of model studies, a downstream offset of about 0.075 to 0.10 of the slot widths and 1/12 to 1/24 gradient downstream of the gate slot and a rounded point of intersection is recommended.

9.1.15 *Aeration Requirement*

The location and sizing of air vent is critical for minimizing cavitation and vibration problems associated with regulating services of gated outlets. Such installation, should be provided

with adequate air supply downstream of the gate. For determination of air requirements and size of air vent, IS 12804 may be referred.

9.2 Seals

9.2.1 The seal should be fixed to the gate leaf by means of countersunk screws made of corrosion resisting steel. The hole in the seal should be counter bored to accommodate the conical head of the screws. When assembled, the heads of the screws should remain 1.0 mm below the surface of the seal. The screws used for fixing of seals to the gate leaf, should be designed to take up full shear likely to develop between the seal and the gate leaf due to friction force encountered between the seal and seal seat during raising or lowering of gates under maximum head of water. The screws should be adequately tightened to a constant torque and locked by punch marks. A compressed asbestos/rubber gasket should be provided between the seal and the leaf/body to prevent leakage. Shear plugs may be provided in addition, at the discretion of the designer. The bottom seal should be of wedge type and manufactured from rubber. For reducing the friction fluorocarbon cladded seals may be used. Suitable groove for grease should be provided on the top and side seals as shown in Fig. 1 for metallic sealing.

9.2.2 The surface of the gate leaf over which seals are fixed, should be machined to a finish of 12.5 μm to 25 μm (*see* IS 3073).

9.2.3 The surface finish of the sliding surface of metal seals should be within the range of 1.6 μm 6.3 μm (*see* IS 3073).

***9.*2.4** Minimum threaded length equivalent to one and a half times the diameter of the screws should be screwed with the gate leaf to ensure against their loosening under vibrations during operations.

9.2.5 Suitable chamfer should be provided at the bottom of the gate leaf/clamp plate to accommodate the bottom wedge seal in compressed position.

9.2.6 For regulating gates, the designer at his discretion, may make the seals effective throughout the range of 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.

9.3 Body

9.3.1 The body is embedded in concrete which should be reinforced sufficiently to withstand the water pressure. However, the gate body is made sufficiently rigid to prevent damage or distortion during transportation and installation by providing reinforcing ribs in longitudinal, as well as transverse direction. The ribs should be provided with enough opening for good concreting. The body shall be checked to withstand full external pressure with a permissible stress of 80 percent of yield point stress of the material and should have sufficient anchorage with the concrete to withstand the external pressure. In case sufficient

anchorage length in concrete is not available, the body should be designed to withstand full external pressure on its own.

9.3.2 The downstream portion of the body carries the bearing plate and should be so designed that maximum bearing pressure to which the concrete is subjected, shall not exceed the permissible stress specified in IS 456.

9.3.3 The following minimum plate thickness are recommended for the main plates of the body.

S. No.	**Head**	**Cast Steel** (mm)	**Mild Steel** (mm)
(1)	(2)	(3)	(4)
i)	Medium head (exceeding 15 but less 30 m)	20	16
ii)	High head (30 m to 60 m)	25	20
iii)	High head above 60 m	30	25

9.3.4 The body is either with flanged bolted joints both at the top and bottom and in welded construction without flanged joints, strictly maintaining tolerances of gaps around the gate.

9.4 Connectors

In case provision for connectors is made, where two gates are used in tandem, the design should be the same as done for a single body.

9.5 Bonnets

9.5.1 The bonnets, like bodies, are also embedded in concrete, which is sufficiently reinforced to withstand the hydrostatic pressure of water. The design and thickness of bonnet and other ribbing should be similar to those of bodies. Bonnets or parts of bonnets which are not embedded should be designed for fill internal water pressure.

9.5.2 The top flange of bonnet and flanges of bonnet cover should be designed for hydraulic hoist load, in addition to the full pressure, if the hydraulic hoist is mounted on the bonnet cover. The flange joint shall be provided with rubber O-ring gasket.

9.5.3 The bonnet parts are either with flange bolted joints both at top and bottom or in welded construction without flanged joints, maintaining strict tolerances for gaps around the gate.

9.5.4 The entire plate of the downstream bonnet in contact with the gate seal, when gate is in fully open position, should be of stainless steel plate/stainless steel cladded plate.

9.5.5 The surface finish of the top flange of bonnet and matching face of the bonnet cover should be within the range of 12.5 μm to 25 μm (*see* IS 3073).

9.6 Bonnet cover should be designed to withstand the full internal water pressure. In installations where hoist is directly mounted over the bonnet cover, it should in addition, be designed to resist the full load of maximum hoisting effort.

9.7 Gland stuffing-box should be provided on bonnet cover to prevent leakage of water around stem rod of hoist passing through the bonnet cover. The gland stuffing box should be in two pieces, namely, hoisting or box and the cover gland. It should either be of cast steel or fabricated with structural steel. It should be designed for full hydrostatic pressure. The material for sealing should be graphite impregnated asbestos rope, or chevron or equivalent, preferably of square cross-section. The housing should have bushing of nonferrous material, preferably phosphor bronze, to facilitate the supporting of sealing rope and for free passage of-stem rod. Cover of the box also should have similar arrangements. The housing box should have suitable arrangements for fixing the assembly to the bonnet cover. Stuffing box placed inside bonnet cover and hoist mounted over cover shall be split type to facilitate ease of maintenance or replacement.

9.8 Seal Seats/Bearing Plates/Sill Beam

9.8.1 The width of sealing surface should be so chosen that the bearing pressure does not exceed the permissible limit.

9.8.2 The bearing plate should be welded or fixed to the downstream body by means of counter bore screws made of corrosion resistant steel. The holes in the bearing plate should be countersunk to accommodate the conical head of screw. When assembled, the head of screws should remain 1.0 mm below the surface of the seal seat. The weld or the screws used for fixing the bearing plates should be designed to take up the full shear likely to develop between the seal and the bearing plate. These screws should be adequately tightened and locked by punch marks. Suitable means shall be provided for greasing the seal seats. It should be ensured that the grease does not leak out of the joints. A recommended method is the provision of O-ring seals around the greasing holes to seal the joint between the seal seat and the downstream part of the body.

9.8.3 The surface finish of bodies to which seal seats are fixed should be machined to a finish of 12.5 μm 25 μm (*see* IS 3073).

9.8.4 The surface finish of the bearing plate/side seal seat in sliding contact with metal seals during gate operation should be within the range of 1.6 μm 6.3 μm (*see* IS 3073).

9.8.5 The surface finish of the bottom seal seat should be within the range of 12.5 μm 25 μm (*see* IS 3073).

9.8.6 For regulating and emergency gates, where metal-to-metal seals are provided, same material should not be used for seals and seal seats. The material should not be used for seals and seal seats. The material for the seal should be softer than the material for seal

seats so that the wearing is on seals and not on seal seats and also for avoiding seizing while sliding under load.

9.8.7 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.

9.9 Anchorage or Anchor Plates

Anchorages should 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 should be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts should not be less than 16 mm and the anchor plate thickness should not be less than 10 mm. In order to limit the permissible stress in shear in concrete suitably designed shear reinforcement may be necessary. A typical arrangement is given in Annex F.

9.10 Guides and Guide Bars

Guides are fixed on the gate leaf and guide bars on-the bodies and bonnets to guide the leaf properly throughout its travel. The guides should be effective in both directions, that is, longitudinal as well as transverse. The recommended clearance between the guide and guide bar is a maximum of 3 mm in each direction on either side.

9.11 Guide Rollers and Guide Shoes

9.11.1 Gate guide rollers/shoes should 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 roller should be flanged and travel on steel plates or rails securely attached to anchor bolts. In case of rollers they should be provided with bronze -bushing or self-lubricating bushing turning on fixed steel pins. Suitable arrangement for lubrication of these rollers should also be provided. Where necessary counter guide rollers should be provided to limit the transverse movement of gates.

9.11.2 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 the same time, to prevent gate from jamming. A clearance of 3 mm to 6 mm between the guide rollers and guide surface 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, when required. Guide rollers may be preferred for high head gates to be handled by lifting beams.

9.11.3 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.

9.11.4 The guide roller/shoes should be designed for the maximum load 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.

9.12 Tolerance

The tolerance for embedded parts and in components of gate should be as given in Annex G (*see* Fig. 4 also).

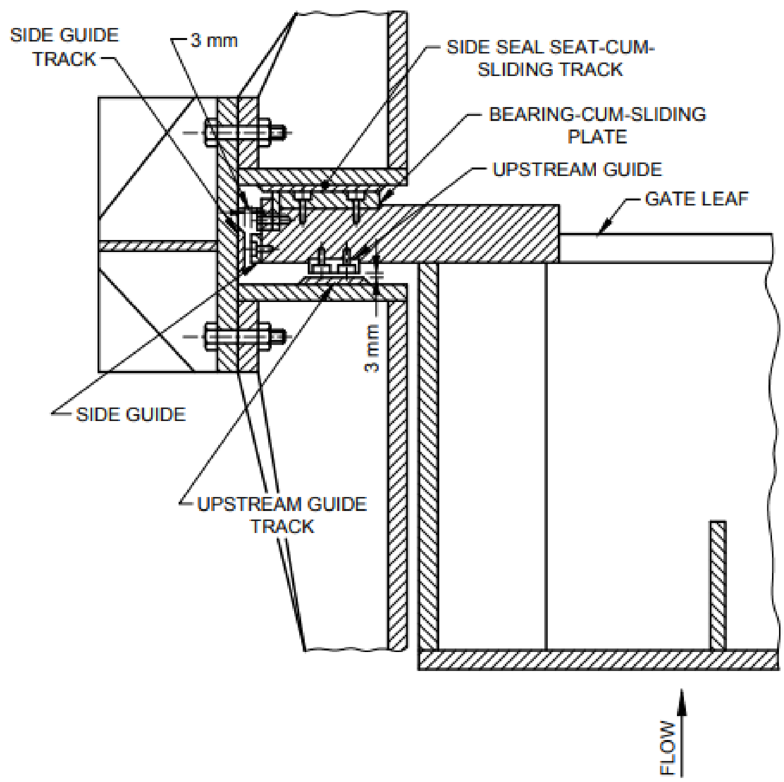

FIG. 4 SLOT SECTION FOR SLIDE GATE

10 COEFFICIENT OF SLIDING FRICTION

10.1 Values of coefficient of friction recommended for design of gates are given in Annex H.

10.2 Arrangement for lubricating the sliding surface of the gate seal and the bearing plate may be provided at the discretion of the designer.

11 EARTHQUAKE EFFECT

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

11.2 The allowable stresses as given in Annex C shall be increased by $33\frac{1}{3}$ 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.

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

12 WAVE EFFECT

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

12.2 Increased stresses in various parts of the gate, as described in **11.2** for earthquake forces, should be allowed for the wave effect.

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

13 ICE LOADS

13.1 Ice-Impact and Ice-Pressure

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

a) In waters with ice thickness greater than 300 mm, by an even surface pressure of 20 000 N/m^2 up to 2 m depth, and;
b) In waters with ice thickness up to 300 mm, by an even surface of 30 000 N/m^2 up to 3 m depth.

14 MAXIMUM WATER LEVEL (MWL) CONDITION

In case the gate is to be checked for MWL condition, the allowable stress shall be increased by 33.333 percent of the values specified in Annex C subject to 80 percent of upper limit of yield point. However, if the gates are required to be designed for MWL condition, normal stresses should be taken in accordance with Annex C.

15 STRESS RELIEVING

Stress relieving is required depending on the thickness of the plate or size of weld. For plates with thickness more than 30 mm stress relieving should be done. The stress relieving may be done according to the procedure mentioned in IS 2825.

16 GROUTING

Provision for contact grouting, that is, grouting between gate body and bonnet and surrounding concrete should be made to ensure a perfect bond between them. Provision for suitably designed grout hole arrangement should be made in the liner and bonnet to avoid voids between various stages of concreting and between gate body/bonnet and concrete. Provision should also be made for escape of air during grouting. Such grout holes should be plugged subsequently and ground flushed.

ANNEX A
(*Clause 2*)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
IS 291 : 1989	Naval brass rods and section for machining purposes - Specification (*third revision*)
IS 305 : 1981	Specification for aluminum bronze ingots and castings *(second revision)*
IS 306 : 1983	Specification for tin bronze ingots and castings *(third revision)*
IS 318 : 1981	Specification for 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 - Specification (*fifth Revision*)
IS 1367 : Part 14/Sec 1: 2023	Technical supply conditions for threaded steel fasteners part 14 mechanical properties of corrosion-resistant stainless Steel fasteners section 1 bolts screws and studs with specified grades and property classes (*fifth revision*)
IS 1893 : 1984	Criteria for earthquake resistant design of structures *(fourth revision)*
IS 2004 : 1991	Carbon steels forgings for general engineering purposes - Specification *(third revision)*
IS 2062 : 2011	Hot rolled medium and high tensile structural steel - Specification (*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 3073 : 1967	Assessment of surface roughness
IS 3757 : 1985	Specification for high strength structural bolts (*second revision*)
IS 6603 : 2024	Stainless steel semi-finished products, bars, wire rods and bright bars — Specification (*second revision*)
IS 6911 : 2017	Stainless steels plate, sheet and strip specification (*second revision)*

IS 11855 : 2017	Design and use of different types of rubber seals for hydraulic gates (*second revision)*
IS 12804 : 1989	Criteria for estimation of aeration demand for spillway and outlet structure

ANNEX B
(Clause 6)

RECOMMENDED MATERIAL FOR THE COMPONENT OF MEDIUM AND HIGH HEAD SLIDE GATE

S. No.	Component part	Material	Ref to Indian Standards
(1)	(2)	(3)	(4)
i)	Gate leaf, sill girder bodies, bonnet and bonnet cover	Forged steel Structural steel Cast steel High Strength Steel Castings	IS 2004 IS 2062 IS 1030 IS 2644
ii)	Seal seats, bearing plate and bottom seal seat	Bronze Stainless steel	IS 305, IS 306, IS 318 IS 6911
iii)	Guide bars	Bronze	1S 318
iv)	Guides	Stainless steel Structural steel	IS 6603, IS 6911 IS 2062
v)	Clamps	Stainless steel	IS 6603
vi)	Fixing Screw/bolts	Stainless steel	IS 1367 Part 14/Sec 1
vii)	Gland stuffing box		
	a) Body and stuffing collar	Structural steel	IS 2062
	b) Bushing and bushing collar	Cast steel	IS 1030
	c) Seals	Bronze Rubber[1)]	IS 318 IS 11855
		Chevron	—

NOTES:
1 The Rubber seals used may be fluorocarbon coated as given in IS 11855.
2 The grade of the material conforming to specification mentioned above shall be specified by the designer to suit the particular requirement.

ANNEX C

(*Foreword*, *Clauses* 7.1, 9.1.6, 9.1.8, 11.2 and 14.1)

PERMISSIBLE MONOAXIAL STRESSES FOR STRUCTURAL COMPONENTS OF HYDRAULIC GATES

Sl No.	**Material and Types of of Stress**		**Wet Condition**		**Dry Condition**	
			Accessible	Inaccessible	Accessible	Inaccessible
(1)	(2)		(3)	(4)	(5)	(6)
i)	Steel :					
	a)	Direct compression and compression in bending	0.45 YP	0.40 YP	0.55 YP	0.45 YP
	b)	Direct tension and tension in bending	0.45 YP	0.40 YP	0.55 YP	0.45 YP
	c)	Shear Stress	0.35 YP	0.30 YP	0.40 YP	0.35 YP
	d)	Combined stress	0.60 YP	0.50 YP	0.75 YP	0.60 YP
	e)	Bearing stress	0.65 YP	0.45 YP	0.75 YP	0.65 YP
ii)	Bronze or Brass :					
		Bearing Stress	0.035 UTS	0.030 UTS	0.040 UTS	0.035 UTS

NOTE

1. YP 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 or compression in bending, the l/r ratio of members is to be considered and the stresses to be correspondingly reduced in proportion as 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. Stoplogs are stored above water level and are only occasionally used and therefore stresses given under dry and accessible conditions should be applied to them in accordance with 9.1.8.

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 like 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 D

[*Clauses* 9.1.2 (b) *and* 9.1.3(b)]

METHOD OF COMPUTATION OF BENDING STRESSES IN FLAT PLATES

D-1 STRESSES OF FLAT PLATES IN PANELS

Bending stresses in flat plates maybe computed from the following formula:

$$\sigma = \frac{K}{100} \times \frac{p \times a^2}{s^2}$$

where

$\sigma =$ bending stress in flat plate in N/mm^2
$K =$ non-dimensional factor depending on values of a and b,
$p =$ water pressure in N/mm^2 (relative to the plate centre),
$a, b =$ panel width in mm as in Fig. 5 to Fig. 10, and
$s =$ plate thickness, in mm.

The values of K for the points and support conditions given in Fig. 5 to Fig. 10 are given in Tables 1, 2 and 3.

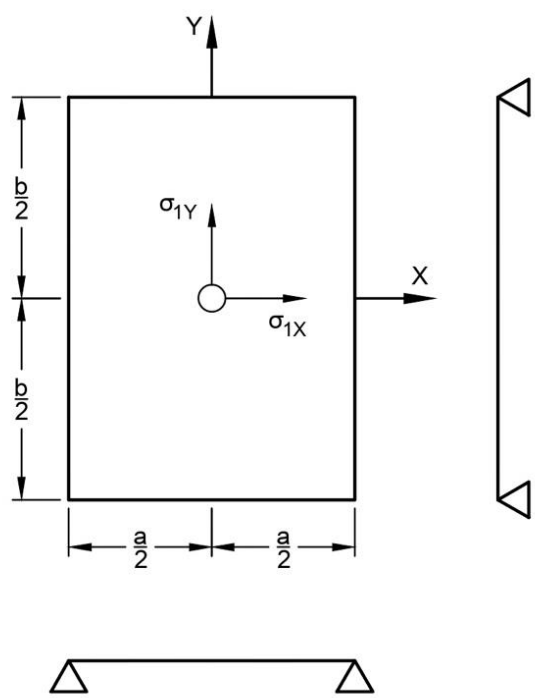

FIG. 5 ALL EDGES SIMPLY SUPPORTED

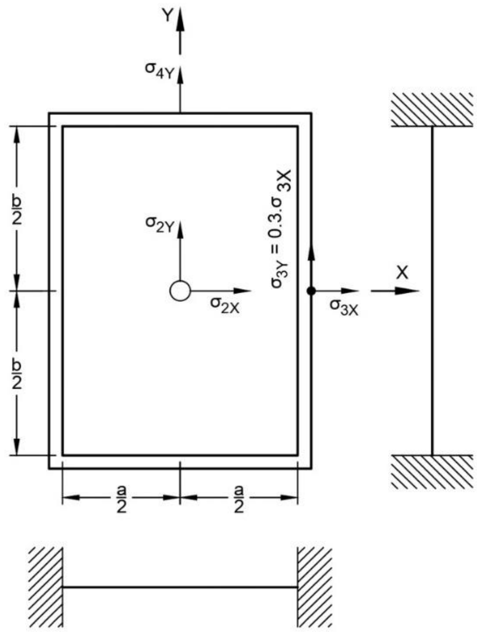

FIG. 6 ALL EDGES RIGIDLY FIXED

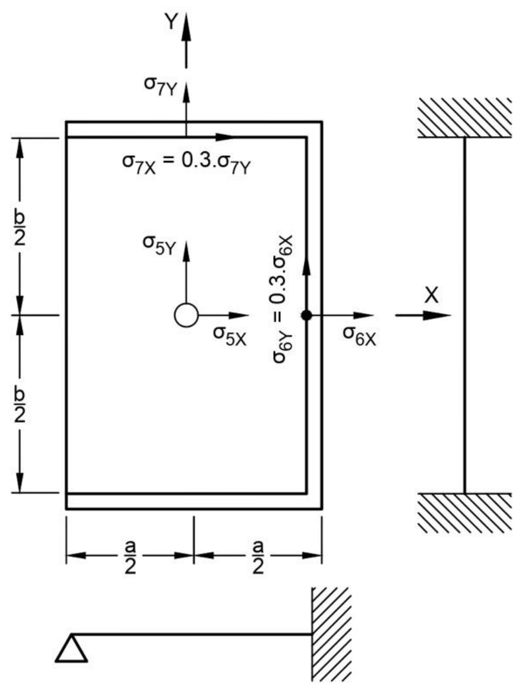

FIG. 7 TWO SHORT AND ONE LONG EDGES FIXED
AND ONE LONG EDGE SIMPLY SUPPORTED

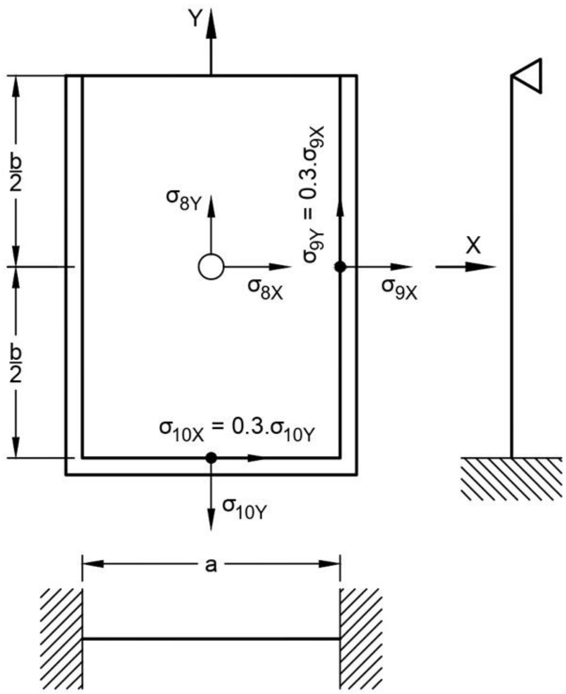

FIG. 8 TWO LONG AND ONE SHORT EDGES FIXED
AND ONE SHORT EDGE SIMPLY SUPPORTED

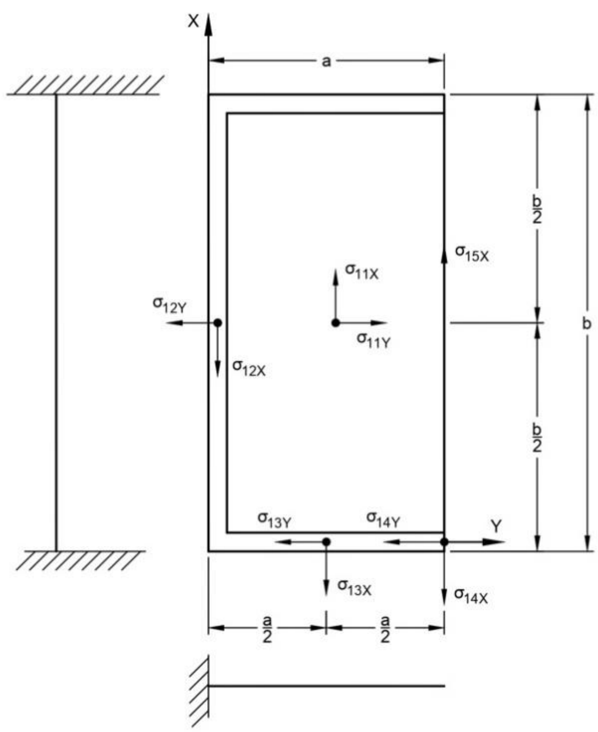

FIG. 9 THREE EDGES FIXED AND ONE (LONGER) EDGE FREE

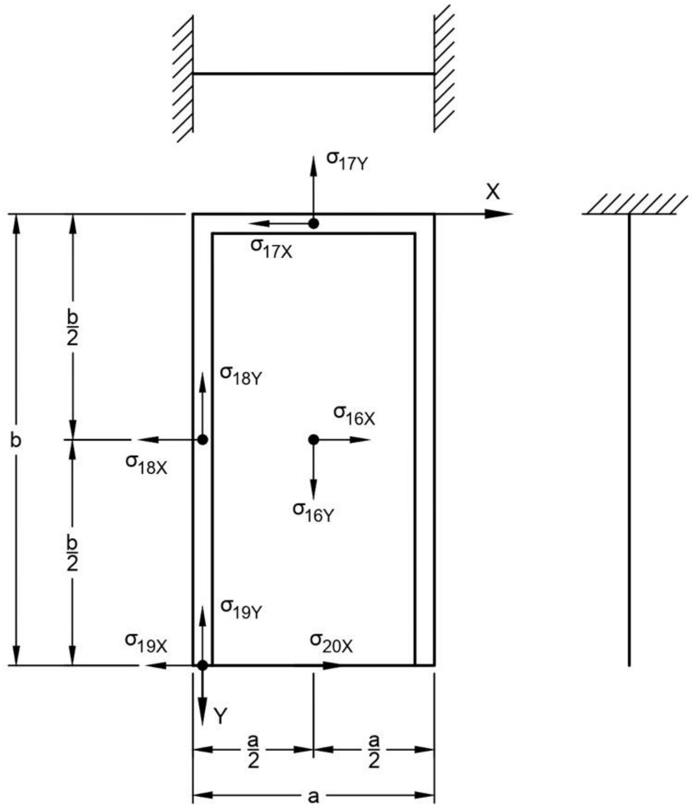

FIG. 9 THREE EDGES FIXED AND ONE (SHORTER) EDGE FREE

Table 1 Values of *K* for Points and Support Conditions given in Fig. 5 to Fig. 8
(*Clause* D-1)

Sl No.	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)	α	75.0	22.5	25.0	7.5	34.2	50.0	37.5	11.3	47.2	75.0	25.0	7.5	34.2	50.0
ii)	3	71.3	24.4	25.0	7.5	34.3	50.0	37.4	12.0	47.1	74.0	25.0	7.6	34.2	50.0
iii)	2.5	67.7	25.8	25.0	8.0	34.3	50.0	36.6	13.3	47.0	73.2	25.0	8.0	34.2	50.0
iv)	2	61.0	27.8	24.7	9.5	34.3	49.9	33.8	15.5	47.0	68.3	25.0	9.0	34.2	50.0
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 2 Values of *K* for Points and Support Conditions given in Fig. 9
(*Clause* D-1)

Sl No.	b/a	$\pm\sigma_{11x}$	$\pm\sigma_{11y}$	$\pm\sigma_{12x}$	$\pm\sigma_{12y}$	$\pm\sigma_{13x}$	$\pm\sigma_{13y}$	$\pm\sigma_{14x}$	$\pm\sigma_{14y}$	$\pm\sigma_{15x}$	$\pm\sigma_{15y}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	α	22.00	75.00	90.00	300.00	91.00	28.00	205.00	62.00	2.00	0
ii)	1.0	17.67	12.29	9.45	31.50	37.64	11.29	44.55	13.40	27.96	0
iii)	1.25	22.50	13.00	15.50	51.50	48.00	14.80	53.00	16.20	37.00	0
iv)	1.50	23.50	14.20	20.50	72.50	59.50	18.20	82.00	22.70	48.00	0
v)	1.75	23.00	14.00	25.80	87.00	67.50	20.80	112.00	34.80	61.00	0
vi)	2.0	19.49	6.72	33.98	113.28	72.96	21.89	134.40	40.32	69.88	0
vii)	2.5	18.37	2.88	42.05	140.16	51.84	15.55	124.80	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 3 Values of *K* for Points and Support Conditions given in Fig. 10

(*Clause* D-1)

Sl No.	b/a	$\pm\sigma_{16x}$	$\pm\sigma_{16y}$	$\pm\sigma_{17x}$	$\pm\sigma_{17y}$	$\pm\sigma_{18x}$	$\pm\sigma_{18y}$	$\pm\sigma_{19x}$	$\pm\sigma_{19y}$	$\pm\sigma_{20x}$	$\pm\sigma_{20y}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	α	29.00	9.00	9.00	30.00	50.00	15.00	51.00	16.00	29.00	0
ii)	1.0	17.67	12.29	9.45	31.50	37.64	11.29	44.55	13.40	27.96	0
iii)	1.25	20.80	11.70	8.96	29.87	28.00	8.40	34.50	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	28.30	32.00	9.60	36.50	10.95	28.97	0
vi)	2.0	27.46	10.00	8.50	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	14.00	50.80	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 E

[*Clause* 9.1.4(b)]

METHOD OF CALCULATION OF COACTING WIDTH OF SKIN PLATE WITH BEAM OR STIFFENERS

E-1 METHOD

E -1.1 Coacting width of skin is given by 2 $(V \times B)$.

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. 11 and Fig. 12; and

B = half the span of the plate between two girder (*see* Fig. 11) or overhang length of a bracket plate.

E-1.1.1 The ideal support length (L_I or L_{II}, *see* Fig. 11) corresponding to the length of the moment zone of equal sign, in the case of continuous girders shall be taken as a basis with regard to support length L. In the case of single bay girders, the ideal support length corresponds to the actual.

V_I = reduction factor corresponding to the parabolic moment zone (*see* Fig. 11 and 12).

V_{II}= 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. 11 and 12).

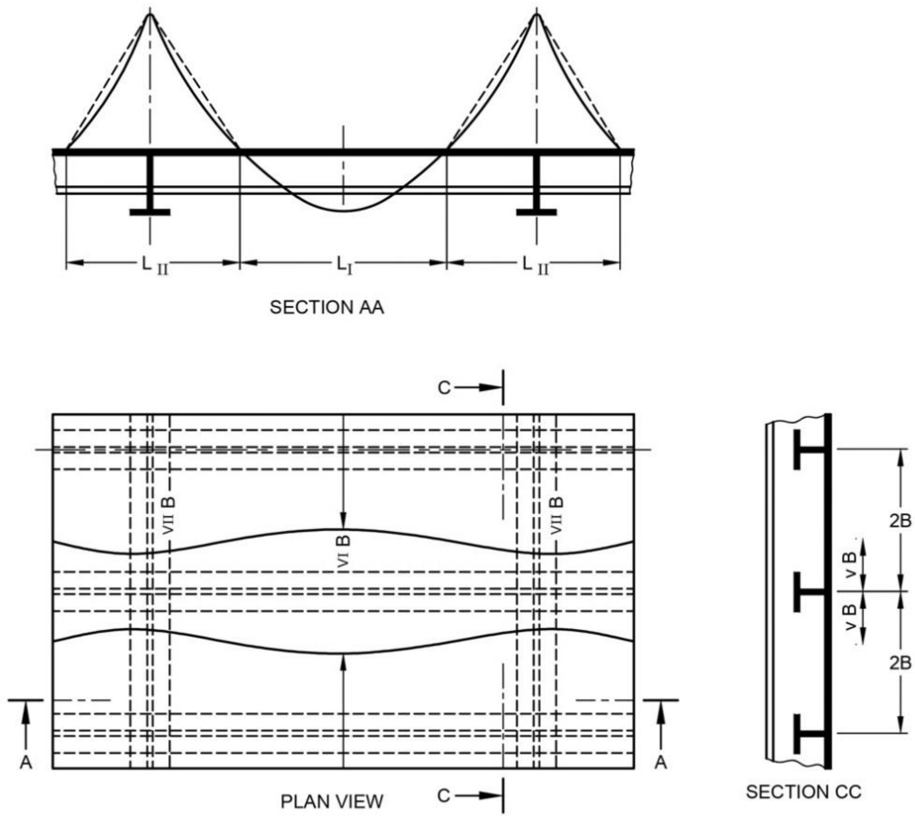

FIG. 11 FIGURE SHOWING VARIATION OF CO-ACTING WIDTH FORM SUPPORT TO SUPPORT

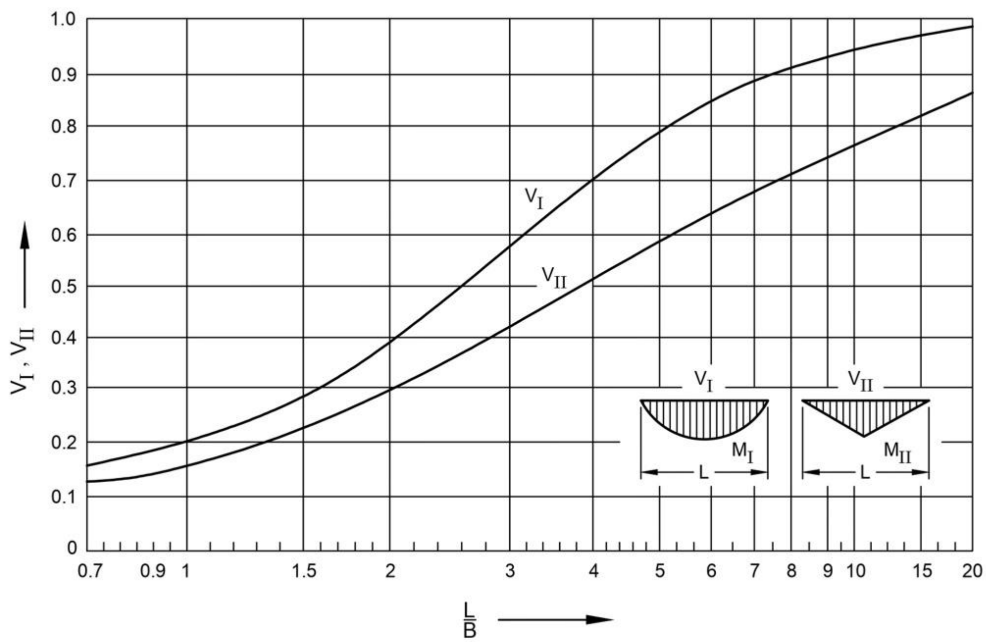

FIG. 12 CURVES SHOWING RELATIONSHIP BETWEEN L/B AND REDUCTION FACTOR V_I AND V_{II}

ANNEX F

(*Clause* 9.9)

ANCHORAGE OR ANCHOR PLATES

F-1 The depth of second stage concrete shall be such that the plane drawn at forty five degrees from the inner edge of the track base beam passes through anchors placed provided in first stage concrete. Diagonal shear stress in the concrete due to maximum load derived from bearing stress under the track base shall be within allowable limits permitted by the IS 456. Where excessive shear stress in the concrete is unavoidable, reinforcement properly designed for shear and placed in the first stage concrete can be considered. In no case shall the alignment bolts be considered as the shear reinforcement.

ANNEX G
(*Clause* 9.12)

TOLERANCE FOR EMBEDDED PARTS AND COMPONENTS OF GATES

Sl. No.	Components	Classification (mm)	
		Medium Head	High head
(1)	(2)	(3)	(4)
A	**Embedded Parts**		
i)	Side seal seat: a) Alignment in plane parallel to flow b) Distance between centerline of opening and seal seat c) Coplanerness	 ± 0.5 ± 1.5 ± 1.5	 ± 0.25 ± 1.00 ± 0.25
ii)	Top seal seat: a) Alignment parallel to flow b) Height above sill c) Coplanerness with side seal seat	 ± 0.5 ± 1.0 ± 0.5	 ± 0.25 ± 1.00 ± 0.25
iii)	Upstream guide track: a) Alignment in plane parallel to flow b) Distance between centre line of opening and guide track c) Coplanerness	 ± 0.50 ± 1.50 ± 0.50	 ± 0.25 ± 1.00 ± 0.25
iv)	Side guide track: a) Alignment in plane normal to flow b) Distance between centre line of opening and guide track c) Alignment in plane parallel to flow	 ± 1.00 ± 1.00 ± 1.00	 ± 0.5 ± 0.5 ± 0.5
v)	Bottom seal seat: Alignment in horizontal plane	 ± 0.25	 ± 0.25
vi)	Critical dimensions: a) Centre-to-centre distance between side seal seat b) Face-to-face distance between side guide tracks	 ± 3.00 ± 2.00	 ± 2.00 ± 2.00

	c) Distance between face of upstream guide track and side seal seat d) Centre-to-centre distance between upstream guide tracks	± 1.00 ± 3.00	± 0.50 ± 2.00
B Gates			
i)	Side and top seal seat: a) Alignment parallel to flow b) Coplanerness	 ± 0.50 ± 0.50	 ± 0.25 ± 0.25
ii)	Side guide: Alignment parallel to flow	 ± 1.0	 ± 0.5
iii)	Upstream guide: Alignment parallel to flow	 ± 0.50	 ± 0.25
iv)	Gate leaf bottom edge: Alignment in horizontal plane	 ± 0.25	 ± 0.25
v)	Critical dimensions: a) Centre-to centre distance between side seal plates b) Centre-to centre distance between upstream guides c) Face-to-face distance between side guides d) Face-to-face distance between side seal plate and upstream guide	 ± 1.00 ± 1.00 ± 1.5 ± 1.00	 ± 0.50 ± 0.5 ± 1.00 ± 0.50

ANNEX H

(*Clause* 10.1)

RECOMMENDED VALUES OF COEFFICIENTS OF FRICTION TO BE USED IN THE DESIGN OF GATES

Sl. No.	**Material**	**Coefficient of Friction**	
		Static	Kinetic
(1)	(2)	(3)	(4)
i)	Rubber seal on steel	1.50	1.20
ii)	Brass on bronze	0.40	0.25
iii)	Brass or bronze on steel	0.50	0.30
iv)	Steel on steel	0.60	0.40
v)	Stainless steel on steel	0.50	030
vi)	Fluoro-carbon on stainless steel	0.20	0.15