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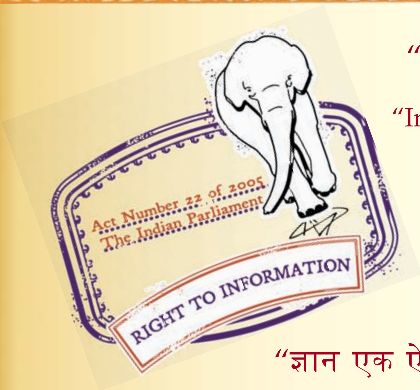
IS 5620 (1985): Recommendations for Structural Design Criteria for Low Head Slide Gates [WRD 12: Hydraulic Gates and Valves]



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IS : 5620 - 1985

(Reaffirmed 2000)

Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN CRITERIA FOR LOW HEAD SLIDE GATES

(Second Revision)

UDC 627·833·51·04

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 7

November 1985

Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN CRITERIA FOR LOW HEAD SLIDE GATES

(Second Revision)

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Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN CRITERIA FOR LOW HEAD SLIDE GATES

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Revision) was adopted by the Indian Standards Institution on 31 January 1985, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Slide gates, as the name implies, are the gates in which the operating member (that is, gate leaf) slides on the sealing surfaces provided on the frame. In most cases, the sealing surfaces are also the load-bearing surfaces. Slide gates may be with or without top seal depending whether these are used in a close conduit or as crest gate.

0.3 This standard was first published in 1970. The first revision was made in view of the experience gained during the use of this standard. Modifications made in the first revision included the revision of the permissible stresses in structural materials which have been linked with yield point or ultimate tensile strength of the material and their situation of use; thus making it not only more rational but also providing guidelines in choosing permissible stresses for materials other than those provided in the standard, if intended to be used at the discretion of the designer.

0.4 As a result of increased use of the standard, suggestions were received for modifying some of the provisions of the standard, and, therefore, second revision of the standard is being brought out. Two more conditions that is three edges fixed and one (longer) edge free and three edges fixed and one (shorter) edge free have been included for computation of bending stresses in flat plates to cover the most commonly occurring conditions in the field have been included in the revision.

0.5 Provision for defreezing may be made for trouble-free hoisting of gates in sub-freezing weather.

0.6 Provision of hood and flow breakers may be made whenever occasional over topping of gate is expected.

0.7 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 the practices in this field in the country. This has been met by deriving assistance from DIN 19704 : 1976 'Principles for computation of steel hydraulic plant' issued by Deutsches Institute für Normung.

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1. SCOPE

1.1 This standard lays down the criteria for the design of slide gates for low head installations, that is, for heads up to and including 15 metres over sill.

1.2 This standard does not cover the hoisting mechanism.

2. MATERIALS

2.1 The materials recommended to be used for different components is given in Appendix A.

3. DESCRIPTION OF GATE

3.1 General — The typical installations of a slide gate are shown in Fig. 1 to 4 and 6. These consist of a gate leaf and embedded parts. These embedded parts shall serve:

a) to transmit water load on the gate leaf to the supporting concrete (structure),

b) to guide the gate leaf during operation, and

c) to provide sealing surface.

3.1.1 The low-head slide gates are generally operated by screw/winch type mechanical hoists. For bulkheads or stoplogs, mobile cranes or gantry cranes are usually employed.

3.2 Gate Leaf

3.2.1 The gate leaf or the operating member is a rigid structure consisting of skin plate suitably ribbed or reinforced. The skin plate may be upstream or downstream. Upstream skin plate avoids accumulation of debris inside the gate leaf.

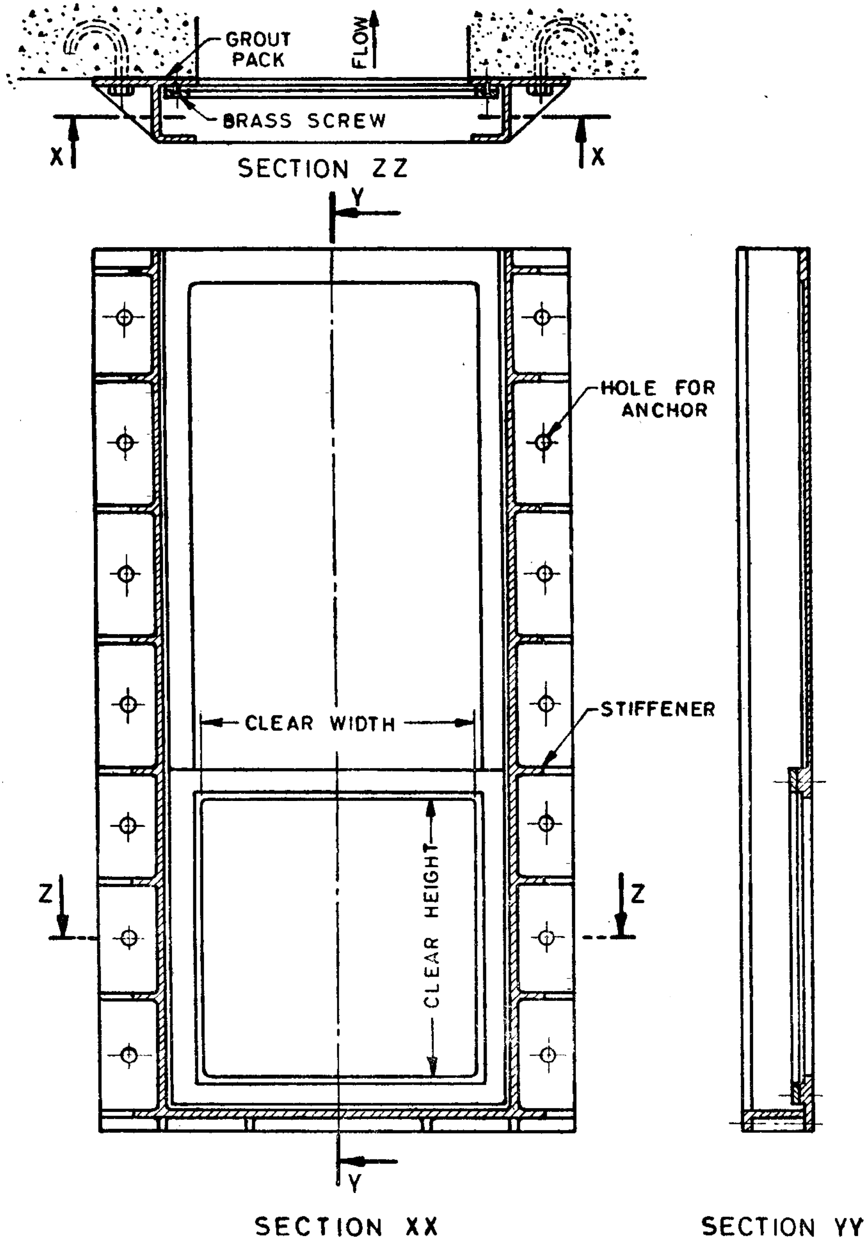


FIG. 1 TYPICAL DIAGRAM SHOWING LOW HEAD SLIDE GATE (FULL FACE GATE FRAME)

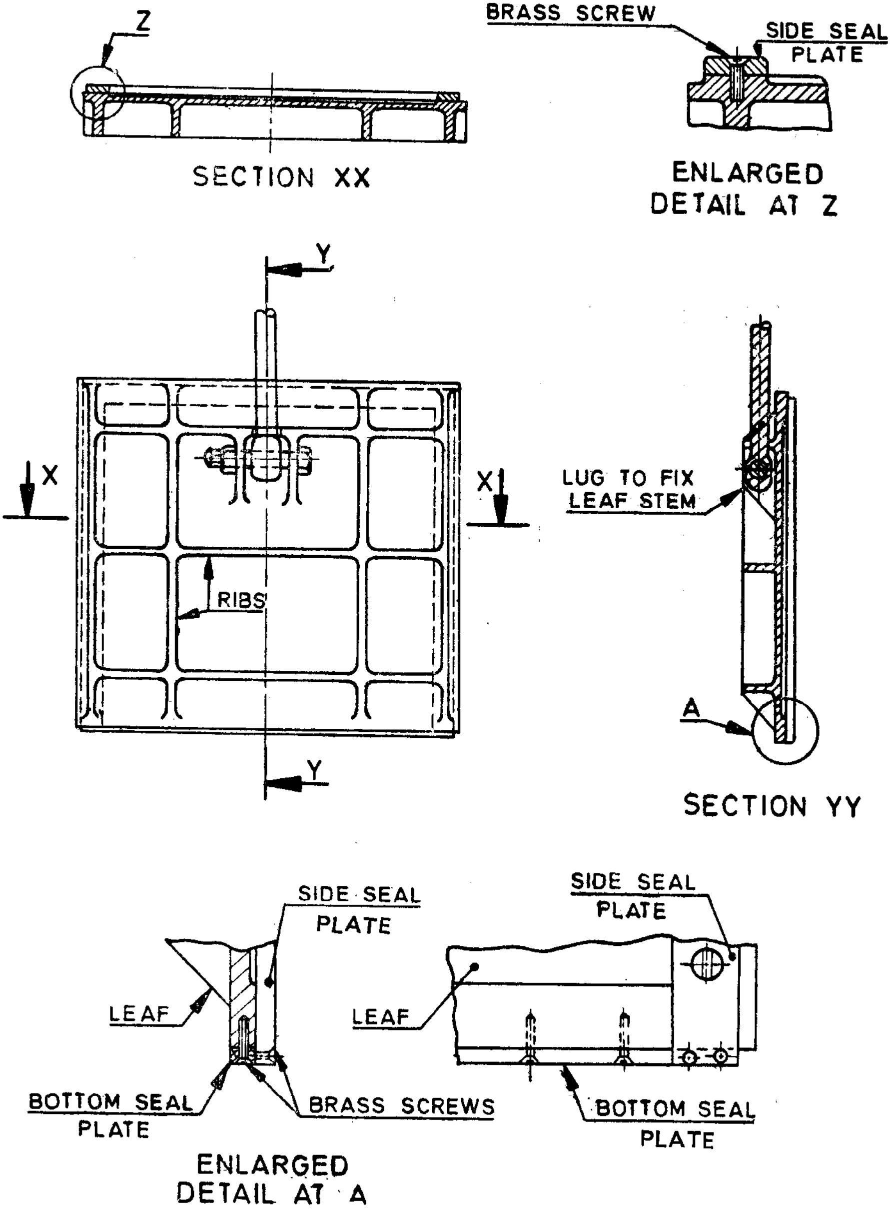


FIG. 2 TYPICAL DIAGRAM SHOWING LOW HEAD SLIDE GATE LEAF

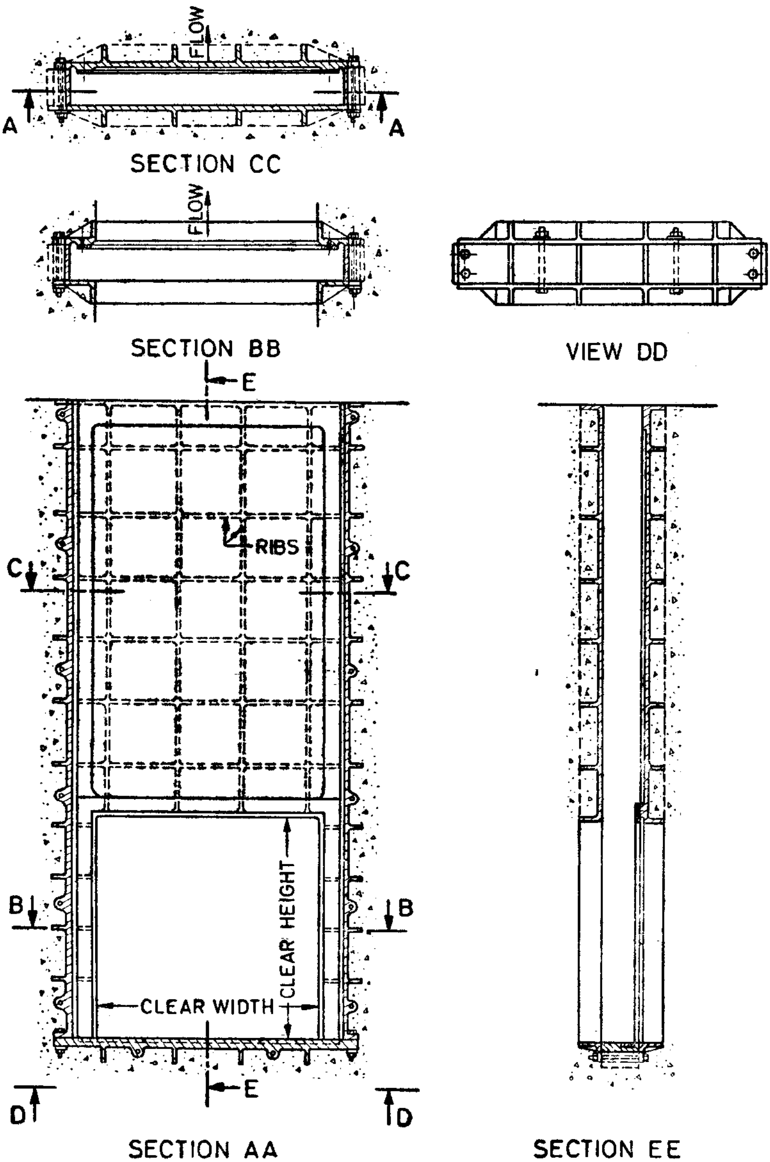
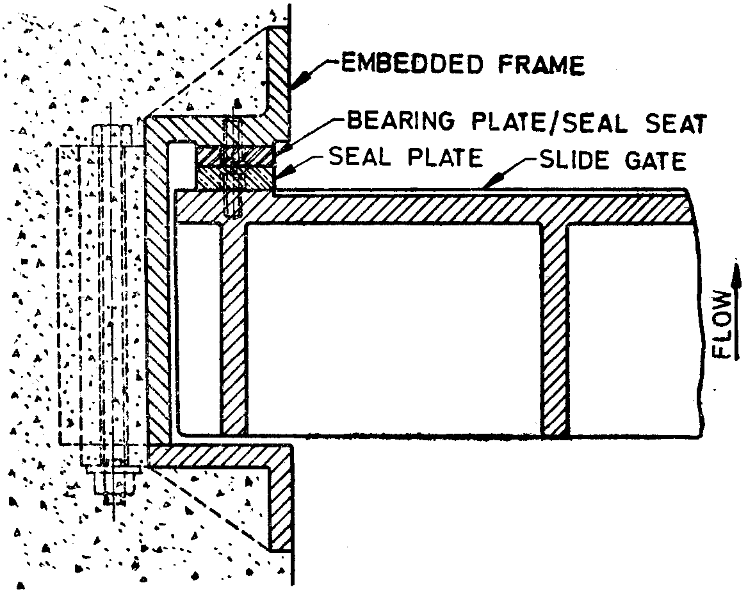
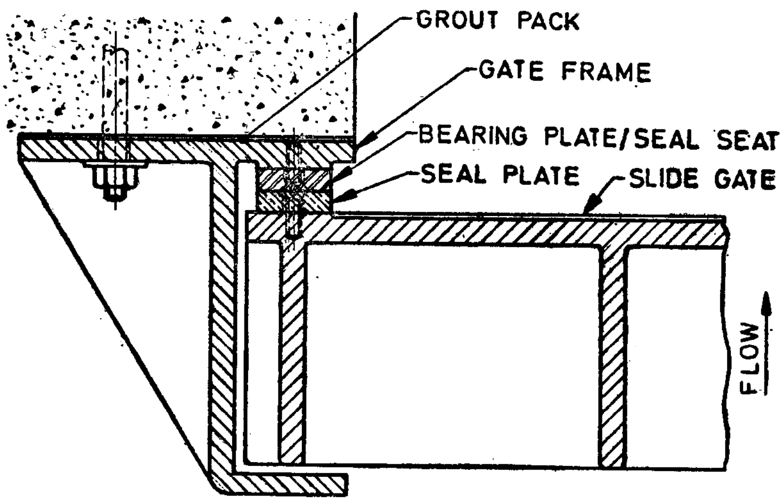


FIG. 3 TYPICAL DIAGRAM SHOWING EMBEDDED FRAME OF LOW HEAD SLIDE GATE

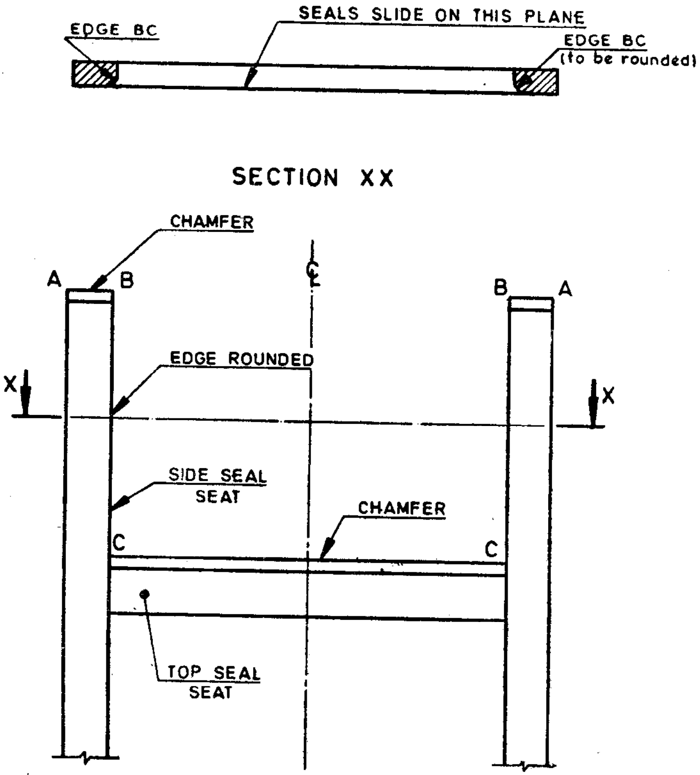


4A Typical Slot Section Detail Showing Low Head Slide Gate and Emmbedded Frame



4B Typical Slot Section Detail Showing Low Head Slide Gate and Full Face Gate Frame

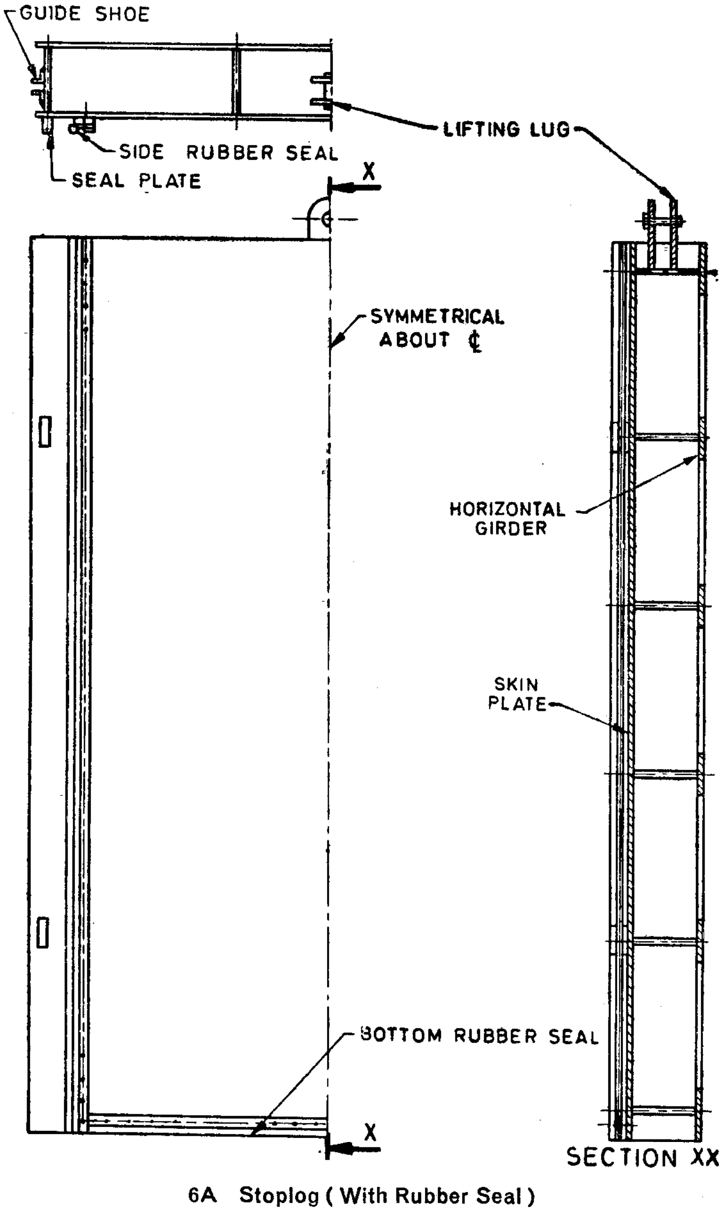
Fig. 4 Low Head Slide Gate Showing Gate and Frame



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

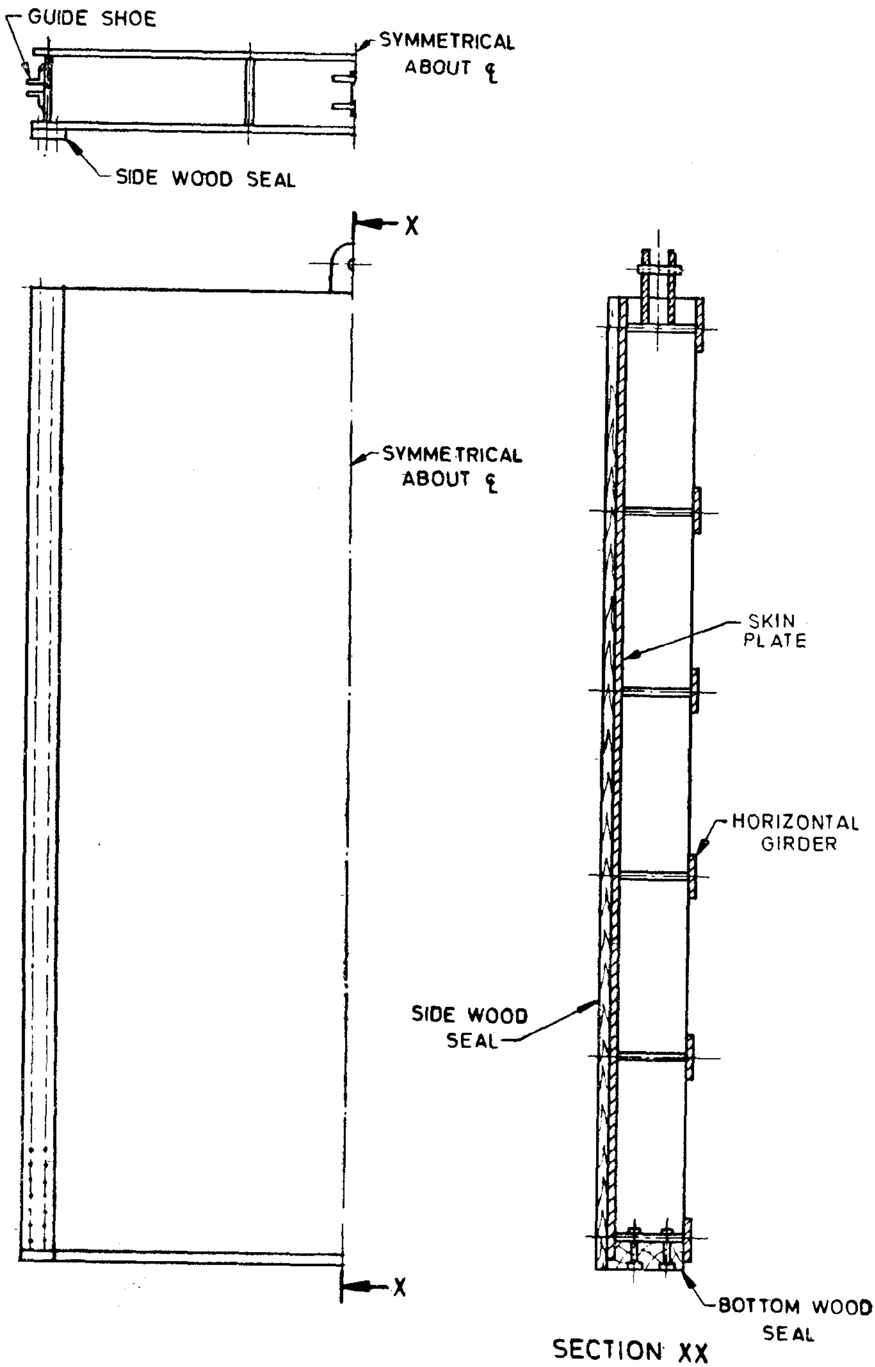
NOTE 2 — Edges *BC* to be rounded.

FIG. 5 ROUNDING/CHAMFERING OF SEAL SEAT



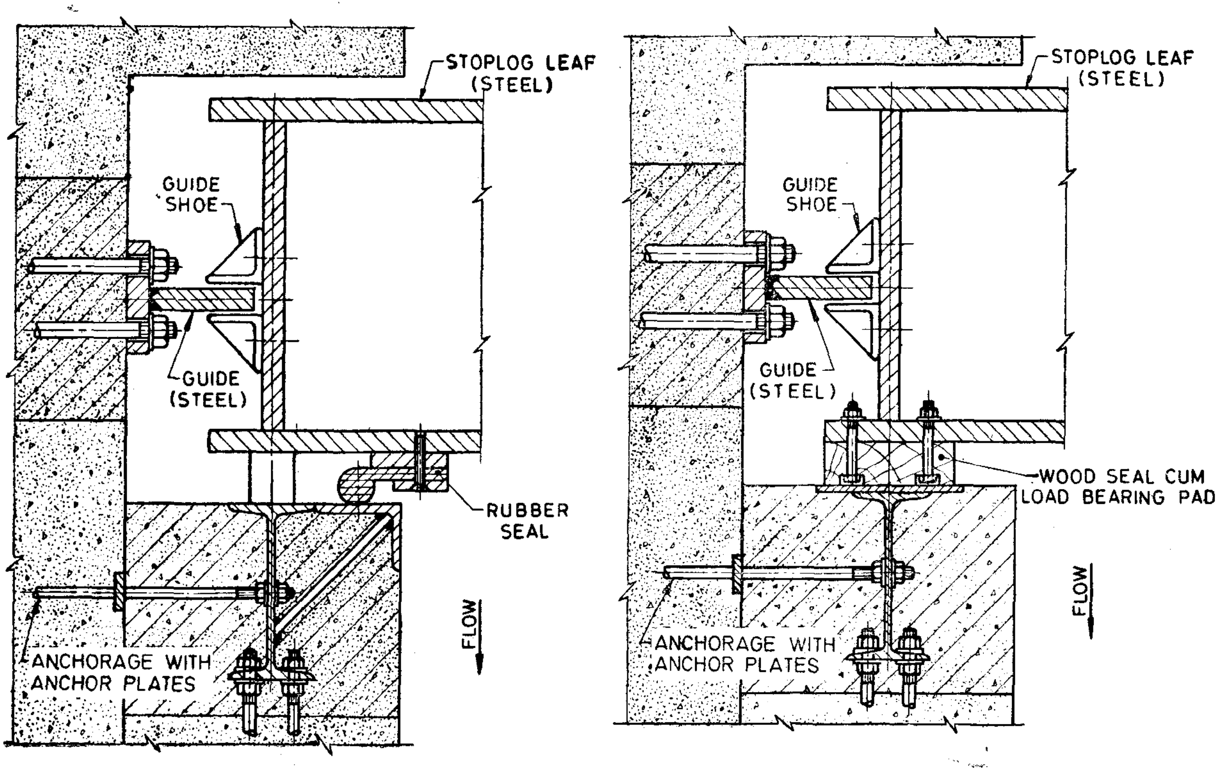
6A Stoplog (With Rubber Seal)

FIG. 6 LOW HEAD SLIDE GATE SEALING ARRANGEMENT — *Contd*



6B Stoplog (With Wood Seal)

FIG. 6 LOW HEAD SLIDE GATE SEALING ARRANGEMENT — *Contd*



6C Details of Rubber Seal

6D Details of Wood Seal

FIG. 6 LOW HEAD SLIDE GATE SEALING ARRANGEMENT

3.2.2 The gate leaf may be of cast iron, cast steel or structural steel in welded construction. For gates used for emergency or regulating purposes, the gate leaf shall be sufficiently rigid to withstand vibrations and hydrodynamic forces arising from high velocity flow under the gate leaf. The seal plates which are generally of brass, bronze or gun metal are screwed on the downstream face of the gate leaf.

3.2.3 For large size, the components may be cast-fabricated in convenient lengths and bolted or welded together.

3.3 Embedded Parts

3.3.1 The embedded parts which provide sealing surfaces, bearing surfaces and guides for the gate leaf are embedded in concrete or masonry and securely anchored. The bearing track generally extends at least one gate height above the opening or water level whichever is lower in case the gate is operated under unbalanced conditions. However, the side guide shall extend up to full travel of the gate.

3.3.2 The embedded parts are either of cast iron or of structural steel in welded construction. The sealing-bearing surface is made of brass, bronze, gun metal or stainless steel in order to have corrosion resisting surface with a low coefficient of friction. This sealing strip may be screwed-welded on to the seal base.

3.3.3 For large size, the components may be cast-fabricated in convenient lengths and bolted or welded together.

4. REQUIREMENTS

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

a) These shall be reasonably watertight,

b) These shall be capable of being raised or lowered by the hoisting mechanism provided within the prescribed time; and

c) These shall be rigid and reasonably free from vibration.

5. LOADING

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

5.2 In addition to water load, the designer may, at his discretion, add 1 to 3 m of water head to the static head to account for the sub-atmospheric pressures downstream of gates located in conduits/sluices.

6. STRUCTURAL DESIGN

6.1 Skin Plate and Horizontal and Vertical Stiffeners

6.1.1 *Skin Plates*

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

6.1.1.2 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 given under 'Dry Condition' in Appendix B. Alternatively the design stresses specified in the column 'Wet Condition' in Appendix B shall apply for which case corrosion allowance shall not be necessary. The minimum thickness of skin plate shall not be less than 8 mm inclusive of corrosion allowance, when considered.

6.1.1.3 The skin plate shall be designed for the following two conditions:

a) In bending, across the stiffeners or horizontal girders or as panels; and

b) In bending, co-acting with stiffeners and/or horizontal girders.

6.1.1.4 The stresses for conditions in **6.1.2** shall be determined as follows:

a) For determining the stresses for conditions in bending as panel, the procedure as given in Appendix C may be used.

b) For determining the stresses for conditions in bending across stiffeners or horizontal girders, the bending moment shall be determined according to conditions of support.

6.1.1.5 The width of the skin plate co-acting with beam or stiffeners continuous or simply supported shall be assumed (as illustrated in Appendix D), if more exact determination is not available and stresses due to beam action calculated. The co-acting width of the skin plate in non-panel fabrication shall, however, be restricted to the least of the following values:

a) $40\ t + B$

where

t = thickness of skin plate, and

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

b) 0·11 × span; and

c) centre-to-centre of stiffeners or griders.

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

$$\sigma v = \sqrt{\sigma x^2 + \sigma y^2 - \sigma x \sigma y, + 3\ \tau xy^2}$$

where

σv = combined stress,

σx = sum of stresses along x-axis,

σy = sum of stresses along y-axis, and

τxy = sum of shear stresses in x-y plane.

NOTE — The appropriate signs should be taken for σx, σy in the above formula.

6.1.2 *Horizontal and Vertical Stiffeners/Girders*

6.1.2.1 The horizontal and vertical stiffeners shall be designed as simply supported or continuous beams 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.

6.1.2.2 The span of the horizontal girders shall be taken between centres of end vertical girders. The end vertical girder shall be designed as continuous beam having concentrated loads from horizontal girders and uniform reaction from the bearing plate.

6.1.3 *Deflection of Gates* — Maximum deflection of the gate under normal load shall be limited to 1/800 of the span (centre-to-centre of the seat).

6.2 Embedded Parts

6.2.1 Embedded parts shall be rigid and adequately anchored in the concrete/masonry.

6.2.2 The section of the embedded parts shall be so chosen that bearing pressure on concrete/masonry shall not exceed the permissible values as specified in IS : 456-1978* and IS : 1905-1980† respectively. Second stage concrete shall be at least of M 20 grade.

*Code of practice for plain and reinforced concrete (*third revision*).

†Code of practice for structural safety of buildings: masonry walls (*second revision*).

6.2.3 The embedded parts shall be embedded in concrete/masonry as a second stage and suitable anchors shall be provided to align the embedded parts within tolerance of 3 mm.

6.3 Seals

6.3.1 The following types of seals are generally employed for low head slide gates:

a) Wood,

b) Rubber, and

c) Metal.

6.3.2 *Wood Seals* — Entire water load on the gate element is transferred to the embedded parts through the seal. The woods commonly used for seals are sal, deodar and shisham. The seals should be used in such a way that compression is parallel to the grains. The maximum permissible compressive stress to be adopted in design of seals may be taken as given below:

a) For hard woods (teak and shisham)	240 N/cm^2
b) For deodar and sal wood	140 N/cm^2

6.3.2.1 The wood seals shall be fixed by means of socket head shoulder bolts and seals shall be counter-bored to accommodate the heads of the bolts which shall remain at least 3 mm below the surface of the seal.

6.3.2.2 The bottom seal shall project at least 15 mm below the gate leaf and shall be designed to support the full load of the gate leaf.

6.3.3 *Rubber Seals* — The rubber seals for sides and top shall be of music-note type, and shall be fixed to the gate leaf by seal clamps and bolts/stainless steel screws. The edge of seal clamp adjacent to the seal bulb shall be rounded. The rubber seal for the bottom shall be of wedge type and shall project 5 mm below the gate leaf. It shall be fixed to the gate leaf by structural steel clamps and screws.

6.3.4 *Metal Seal Plates* — The metal seal plates shall be of either brass or bronze and shall be fixed to the gate leaf by countersunk screws made of stainless steel or of the same material. These shall also transmit the entire water load on the gate leaf to the embedded parts and the width of the sealing strips shall be sufficient so as to keep the maximum bearing stress within the prescribed limits. The deviation in the alignment of metal seal plate and bearing plate shall not exceed $\pm$ 1·0 mm.

6.4 Bearing Plates/Seal Seats and Sill

6.4.1 For the seal seats/bearing plates and sill of slide gates, one of the following materials may be used:

a) Cast iron,

b) Structural steel,

c) Brass,

d) Bronze, or

e) Stainless steel.

6.4.2 Where metal seal plates and bearing plates are provided, materials having the same chemical composition shall not be used for them. The material for seal plates shall be somewhat softer than material for bearing plate so that wearing is on seal plates and not on bearing plates and also tendency of seizing is avoided under load.

6.4.3 The bearing plates, when of brass, bronze or gun metal, shall be fixed to the base by means of countersunk screws/bolts made of stainless steel or of the same material as the bearing plates. The holes in the bearing plates shall be suitably counterbored and, when assembled, the heads of the screws/bolts shall remain one millimetre below the surface of the bearing plate.

6.4.4 Bearing plates of structural steel and stainless steel (corrosion resisting) may be welded to the embedded parts. Bearing plates of case iron are generally used when embedded parts are also of cast iron. In such cases these are cast integrally with the embedded parts.

6.4.5 Where the water load is transferred to the embedded parts by end diaphragms and wood or rubber seals are used, surface of the frame may itself serve as the bearing plate and no separate bearing plate may be provided.

6.4.6 The sill beam may be provided with bronze, brass or gun metal flats, if required, and fixed with screws made of stainless steel or of the material as that of seal. The seal seats of stainless steel may be welded.

6.4.7 The sealing surface of sill beam flats, bearing plates/seal seats shall be in one plane and smooth. The sealing surface of seal beam flats shall be flushed with surrounding concrete, unless otherwise specified.

6.4.8 The edges of seal seat should be rounded/chamfered as indicated in Fig. 5 to prevent damage to rubber seal during gate operation.

6.4.9 Typical details of rubber seals or wood seals used in low head slide gates are shown in Fig. 6.

6.5 Guides

6.5.1 Suitable guide shall also be provided on the embedded parts to limit its lateral and longitudinal movements within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm.

6.5.2 For stoplogs the dimensions of the groove may be proportioned so as to limit the motion of the stoplog in the groove, in both the transverse and longitudinal directions and a separate guide may not be necessary.

6.6 Tolerances — The tolerances for embedded parts and in components of gate shall be as given in Appendix E.

6.7 Clearances — Where the frame serves as a guide the clearances should be as follows:

a) Longitudinal (along the flow) clearance between the leaf and frame — 3 to 5 mm

b) Transverse (perpendicular to the flow) clearance between the leaf and frame — 5 to 8 mm

6.8 Connection for the Hoist — Provision shall be made for stem to be fixed on the gate leaf. The stem connection may be hinged as to allow for inaccuracies in stem alignment. In case of stoplog, suitable arrangement for fixing the crane hook on the top of stoplog should be provided. The location of the hook shall be such that the gate or stoplog, when hung, shall remain truly vertical.

6.9 Values of Coefficient of Friction — Values of coefficients of friction recommended for the design of gates are given in Appendix F.

7. OCCASIONAL FORCES

7.1 Earthquake Effect — Earthquake forces shall be computed in accordance with IS : 1893-1975* and the gate designed accordingly.

7.2 Wave Effect — For very wide and big reservoirs the effect of wave height due to storms in causing increased loading on the gate shall be in accordance with IS : 10635-1983†.

*Criteria for earthquake resistant design of structures (*third revision*).

†Guidelines for freebond requirements in embankment dams.

7.3 The stresses in various parts of the gate under the action of occasional forces shall not exceed 133 percent of the permissible stresses specified in Appendix B subject to the maximum of 85 percent of the yield stress stem.

7.4 The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress 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 30 cm, by an even surface pressure of 30 000 N/m² up to 3 m depth, and

b) In waters with ice thickness up to 30 cm, by an even surface pressure of 20 000 N/m² up to 2 m depth.

APPENDIX A

(*Clause* 2.1)

RECOMMENDED MATERIALS FOR VARIOUS COMPONENTS

A-1. DETAILS OF MATERIALS

A-1.1 The recommended materials for various components are given below:

a) *Gate Leaf*

Cast Iron	IS : 210-1978*
Structural steel	IS : 226-1975†
	IS : 2062-1980‡
	IS : 8500-1977§
Cast steel	IS : 1030-1974‖

*Specification for grey iron castings (*third revision*).

†Specification for structural steel (standard quality) (*fifth revision*).

‡Specification for structural steel (fusion welding quality) (*second revision*).

§Specification for weldable structural steel (medium and high strength qualities).

‖Specification for carbon steel castings for general engineering purpose (*second revision*).

b) *Gate Frames*

Cast iron	IS : 210-1978*
Structural steel	IS : 226-1975†
	IS : 2062-1980‡
	IS : 8500-1977§

c) *Seal Plates/Seals*

Bronze	IS : 306-1968‖
	IS : 318-1981¶
	IS : 1458-1965**
Brass	IS : 291-1977†† (Grade I)
Wood (commercial good quality)	
Stainless steel	IS : 6911-1972‡‡
Forged steel	IS : 2004-1978§§
Rubber	Appendix B of IS : 4622-1978‖‖

d) *Seal Seats/Bearing Plates*

Bronze	IS : 306-1968‖
	IS : 318-1981¶
	IS : 1458-1965**
Brass	IS : 291-1977†† (Grade I)
Steel	IS : 226-1975†
	IS : 2062-1980‡
	IS : 8500-1977§
Cast iron	IS : 210-1978*
Stainless steel or stainless steel clad plate	IS : 6911-1972‡‡

e) *Guides*

Structural steel	IS : 226-1975†
	IS : 2062-1980‡
	IS : 8500-1977§
Corrosion resisting steel	IS : 6603-1972¶¶

*Specification for grey iron castings (*third revision*).

†Specification for structural steel (standard quality) (*fifth revision*).

‡Specification for structural steel (fusion welding quality) (*second revision*).

§Specification for weldable structural steel (medium and high strength qualities).

‖Specification for tin bronze ingots and castings (*second revision*).

¶Specification for leaded tin bronze ingots and castings (*second revision*).

**Specification for railway bronze ingots and castings (*revised*).

††Specification for naval brass rods and sections (suitable for machining and forging) (*second revision*).

‡‡Specification for stainless steel plate, sheet and strip.

§§Specification for carbon steel forgings for general engineering purposes (*second revision*).

‖‖Recommendations for structural design of fixed-wheel gates (*first revision*).

¶¶Specification for stainless steel bars and flats.

APPENDIX B

(*Clause* 6.1.1.2)

PERMISSIBLE MONOAXIAL STRESSES FOR STRUCTURAL COMPONENTS OF HYDRAULIC GATES

Sl No.	*Material and Types of Stress*	*Wet Condition* Accessible	*Wet Condition* Inaccessible	*Dry Condition* Accessible	*Dry Condition* Inaccessible
(1)	(2)	(3)	(4)	(5)	(6)
i)	*Structural 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	0·35 UTS	0·25 UTS	0·40 UTS	0·35 UTS
ii)	*Bronze or Brass*				
	Bearing stress	0·035 UTS	0·030 UTS	0·04 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.

NOTE 2 — 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, etc, on downstream side of skin plate, 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. Hence stresses given under dry and accessible conditions should be applied to them.

NOTE 3 — 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 stoplogs 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.

NOTE 4 — In gate leaves made of cast iron, the maximum permissible tensile strength should be limited to 10 percent of ultimate tensile strength.

APPENDIX C

[*Clause* 6.1.1.4 (a)]

METHODS OF COMPUTATION OF BENDING STRESSES IN FLAT PLATES

C-1. STRESSES OF FLAT PLATES IN PANELS

C-1.1 Bending stresses in flat plates may be computed from the following formula:

$$\sigma = \frac{k}{100} \cdot \frac{pa^2}{S^2} \text{ N/cm}^2$$

where

σ = bending stress in flat plate in N/cm^2,

k = non-dimensional factor,

p = water pressure in N/cm^2 (relative to the plate centre),

a, b = bay width in cm as in Fig. 7 to 12, and

S = plate thickness in cm.

The values of k for the points and support conditions shown in Fig. 7 to 12 are given in Tables 1, 2 and 3.

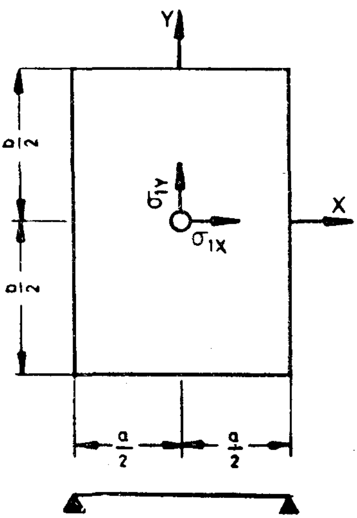


FIG. 7 ALL EDGES SIMPLY SUPPORTED

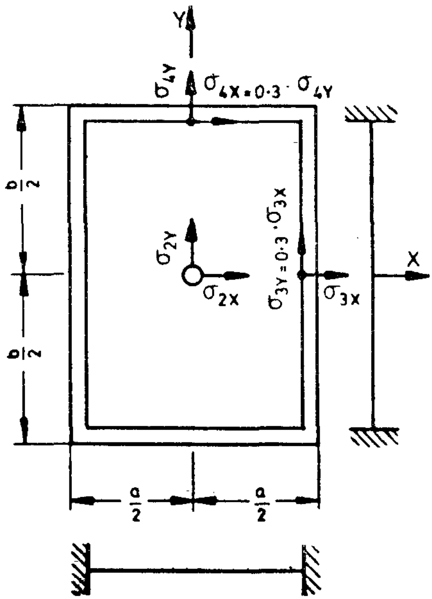


FIG. 8 ALL EDGES RIGIDLY FIXED

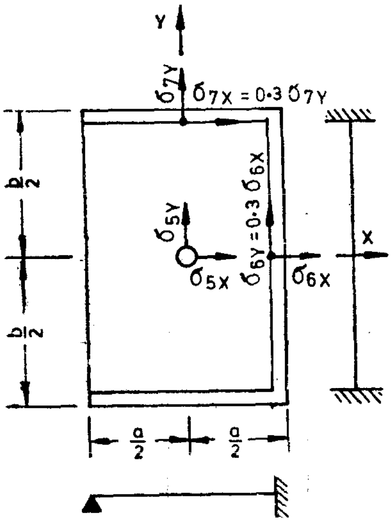


FIG. 9 TWO SHORT AND ONE LONG EDGES FIXED AND ONE LONG EDGE SIMPLY SUPPORTED

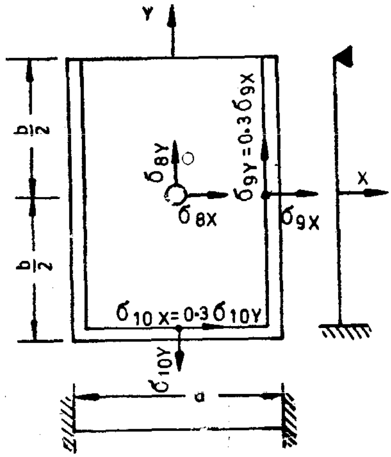


FIG. 10 TWO LONG AND ONE SHORT EDGES FIXED AND ONE SHORT EDGE SIMPLY SUPPORTED

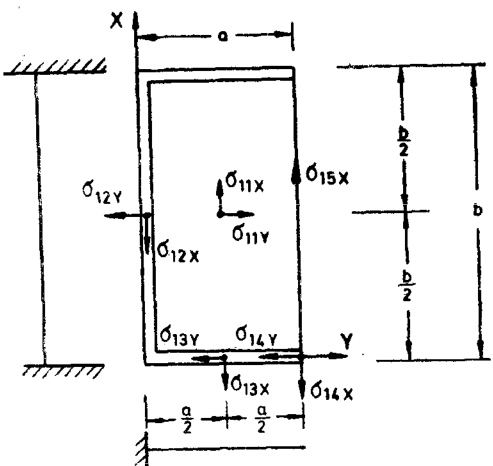


FIG. 11 THREE EDGES FIXED AND ONE (LONGER) EDGE FREE

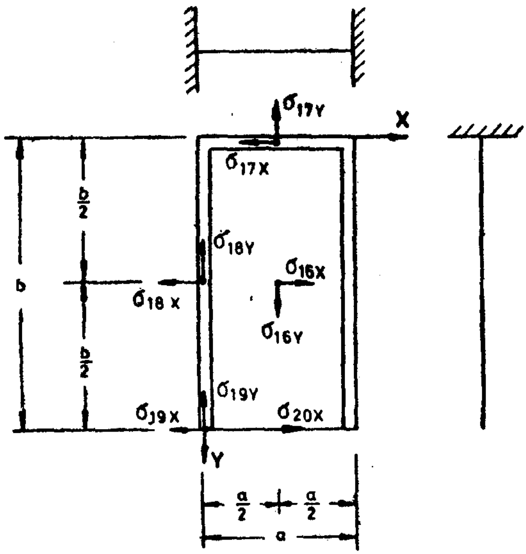


FIG. 12 THREE EDGES FIXED AND ON (SHORTER) EDGE FREE

TABLE 1 VALUES OF *k* FOR POINTS AND SUPPORT CONDITIONS SHOWN IN FIG. 7 TO 10

(*Clause* C-1.1)

b/a	$\pm\sigma_1x$	$\pm\sigma_1y$	$\pm\sigma_2x$	$\pm\sigma_2y$	$\pm\sigma_4y$	$\pm\sigma_3x$	$\pm\sigma_5x$	$\pm\sigma_5y$	$\pm\sigma_7y$	$\pm\sigma_6x$	$\pm\sigma_8x$	$\pm\sigma_8y$	$\pm\sigma_{10}y$	$\pm\sigma_9x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
α	75	22·5	25	7·5	34·2	50	37·5	11·3	47·2	75	25	7·5	34·2	50
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
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
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
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
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
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
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

TABLE 2 VALUES OF k FOR POINTS AND SUPPORT CONDITIONS GIVEN IN FIG. 11

(*Clause* C-1.1)

b/a	$\pm \sigma_{11}x$	$\pm \sigma_{11}y$	$\pm \sigma_{12}x$	$\pm \sigma_{12}y$	$\pm \sigma_{13}x$	$\pm \sigma_{13}y$	$\pm \sigma_{14}x$	$\pm \sigma_{14}y$	$\pm \sigma_{15}x$	$\pm \sigma_{15}y$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
α	22·00	75·00	90·00	200·00	91·00	28·00	205·00	62·00	2·00	0
1·0	17·67	12·29	9·45	31·5	37·64	11·29	44·55	13·4	27·96	0
1·25	22·5	13·0	15·5	51·5	48·0	14·8	53·0	16·2	37·0	0
1·50	23·5	14·2	20·5	72·5	59·5	18·2	82·0	22·7	48·0	0
1·75	23·0	14·0	25·8	87·0	67·5	20·8	112·0	34·8	61·0	0
2·0	19·49	6·72	33·98	113·28	72·96	21·89	134·4	40·32	69·88	0
2·5	18·37	2·88	42·05	140·16	51·84	15·55	124·8	37·44	52·42	0
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. 12

(*Clause* C-1.1)

b/a	$\pm \sigma_{16}x$	$\pm \sigma_{16}y$	$\pm \sigma_{17}x$	$\pm \sigma_{17}y$	$\pm \sigma_{18}x$	$\pm \sigma_{18}y$	$\pm \sigma_{19}x$	$\pm \sigma_{19}y$	$\pm \sigma_{20}x$	$\pm \sigma_{20}y$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
α	29·00	9·00	9·00	30·00	50·00	15·00	51·00	16·00	29·00	0
1·0	17·67	12·29	9·45	31·5	37·64	11·29	44·55	13·4	27·96	0
1·25	20·8	11·70	8·96	29·87	28·0	8·4	34·5	10·35	28·53	0
1·50	25·51	11·12	8·48	28·28	21·04	6·31	25·53	7·66	29·11	0
1·75	26·48	10·56	8·49	28·3	32·0	9·6	36·5	10·95	28·97	0
2·0	27·46	10·0	8·5	28·36	45·52	13·66	50·09	15·27	28·81	0
2·5	28·07	9·13	8·51	28·38	46·66	14·0	50·8	15·24	28·78	0
3·0	28·18	8·68	8·51	28·38	46·94	14·08	50·81	15·24	28·77	0

APPENDIX D

(*Clause* 6.1.1.5)

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

D-1. METHOD

D-1.1 Co-acting 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. 13 and 14; and

B = half the span of the plate between two girders (*see* Fig. 13) or overhang length of a bracket plate.

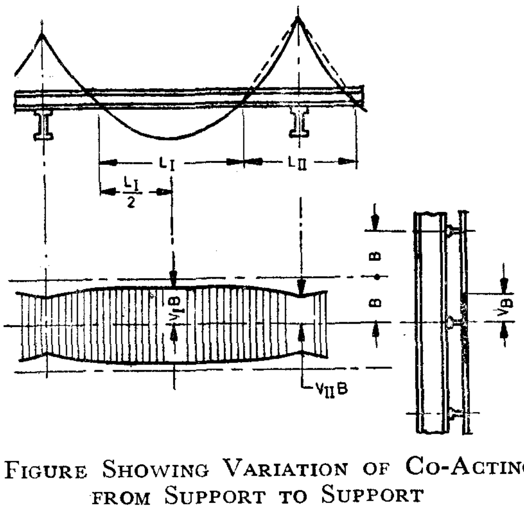


FIG. 13 FIGURE SHOWING VARIATION OF CO-ACTING WIDTH FROM SUPPORT TO SUPPORT

D-1.1.1 The ideal support length (L_I or L_{II}, *see* Fig. 13) corresponding to the length of the moment zone of equal sign shall in the case of continuous girders be basic as support length *L*.

In the case of single bay girders, the ideal support length corresponds to the actual.

V_I = reduction factor correponding to the parabolic moment zone (*see* Fig. 13 and 14), and

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. 13 and 14).

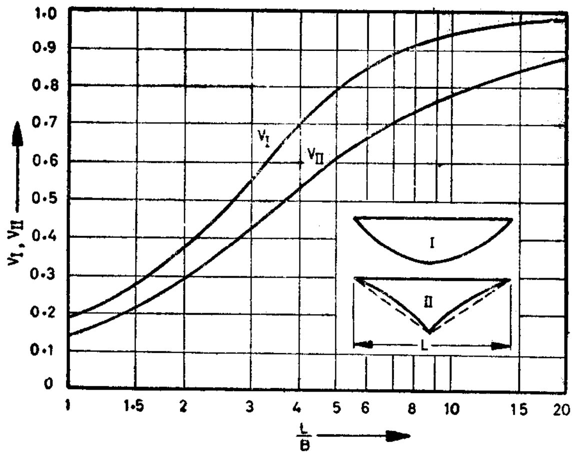


FIG. 14 CURVES SHOWING RELATIONSHIP BETWEEN $\frac{L}{B}$ AND REDUCTION FACTORS V_I AND V_{II}

APPENDIX E

(*Clause* 6.6)

TOLERANCE FOR EMBEDDED PARTS AND COMPONENTS OF GATES

Components	*Tolerances* (mm)
I. EMBEDDED PARTS	
i) *Side Seal Seat:*	
a) Alignment in plane parallel to flow	± 0·50
b) Distance between centre line of opening and seal seat	± 1·50
ii) *Top Seal Seat:*	
a) Alignment parallel to flow	± 0·50
b) Height above sill	± 1·50

iii) *Side Guide Track:*

a) Alignment in plane normal to flow	± 1·50
b) Distance between centre line of opening and guide track	± 1·00
c) Alignment in plane parallel to flow	± 1·00

iv) *Critical Dimensions:*

a) Centre-to-centre distance between side seal seat	± 3·00
b) Face-to-face distance between side guide tracks	± 2·00

II. GATE

i) *Side and Top Seal Seat:*

a) Alignment parallel to flow	± 0·50
b) Coplanerness	± 0·50

ii) *Side Guide:*

a) Alignment parallel to flow	± 1·50

iii) *Critical Dimensions:*

a) Centre-to-centre distance between side seal plates	± 1·50
b) Face-to-face distance between side guides	± 1·50

APPENDIX F

(*Clause* 6.9)

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

Sl No.	*Material*	*Coefficient of Friction*	
		Starting	Moving
i)	Rubber seal on steel	1·5	1·20
ii)	Brass on bronze	0·40	0·25
iii)	Brass or branz on steel	0·50	0·30
iv)	Steel on steel	0 60	0·40
v)	Stainless steel on steel	0·50	0·30
vi)	Wood on steel	1·00	0·70
vii)	Gun metal on gun metal	0·40	0·25
viii)	Fluorocarbon on stainless steel	0·20	0·15