PERENCANAAN PINTU AIR

Table 1.1 Inventions and Earlier Use of Gates

Year	Gate type	Project	Span x height (m)	Inventor and/ or supplier
1490	Segment			L.da Vinci (?)
1818	Bear-trap	Mauch Chunk Creek	7.6 (span)	Josiah White
1828	Miter (metallic structure)	Nivernais, France		
1853	Segment	Senne River	8.75 x 1.00	Poirée
1860	Reverse segment	Nile River Delta	6.00 x 5.10	Mougel Bey
1873	Bottom-hinged flap	Ile Brûlée, France (*)	3.52 x 1.97	Girard
1883	*Stoney*	Belleek, Ireland	8.90 x 4.40	F. Stoney
1886	Segment	(USA patent)		J. B. Tainter
1896	Drum	(USA)		H.Chittenden
1898	Roller	(Germany)		Carstanjen
1902	Double-leaf fixed-wheel	Assiout, Egypt (*)	5.0 x 5.0	
1902	Roller	Schweinfurt	18.00 x 4.14	M.A.N.
1907	Sector	Lockport Dam, USA	14.60 x 5.79	C. L. Cooley
1910	Reverse segment	(USA patent)		L. F. Harza
1911	Drum	Dam no. 1, Osage River		H.Chittenden
1911	Sector	Weser Dam (*)	54 x 4.6	
1915	Broome (caterpillar)	Turner Falls, USA (*)	3.00 x 4.88	
1920	Cylinder (*)	Kern	2.43 dia. x 6.70	
1926	Fixed-wheel with flap	Juliana canal (*)	23.00 x 4.40	T. Klönne
1930	Double-leaf hook type	Reckingen		M.A.N.
1933	Segment with flap	Münster (*)	23.30 x 7.40	M.A.N.
1936	Ring	Owyhee Dam	18.0 dia. x 3.60	BuRec
1943	Double segment	Rupperswill-Auenstein	22.00 x 8.00	C. Zschokke
1955	Inflatable	(France)		Mesnager
1958	Reverse segment with flap	Oberelchingen (*)	16.00 x 8.20	M.A.N.
1960	Visor	Hagenstein, Holland	48.00 x 6.00	
1966	Inflatable	Shiga, Japan (*)	0.45 x 3.7	Sumitomo
1991	Fusegate	Lussas Dam, France	3.5 x 2.15	Hydroplus

(*) Refers to earlier use, but not necessarily to the first application.

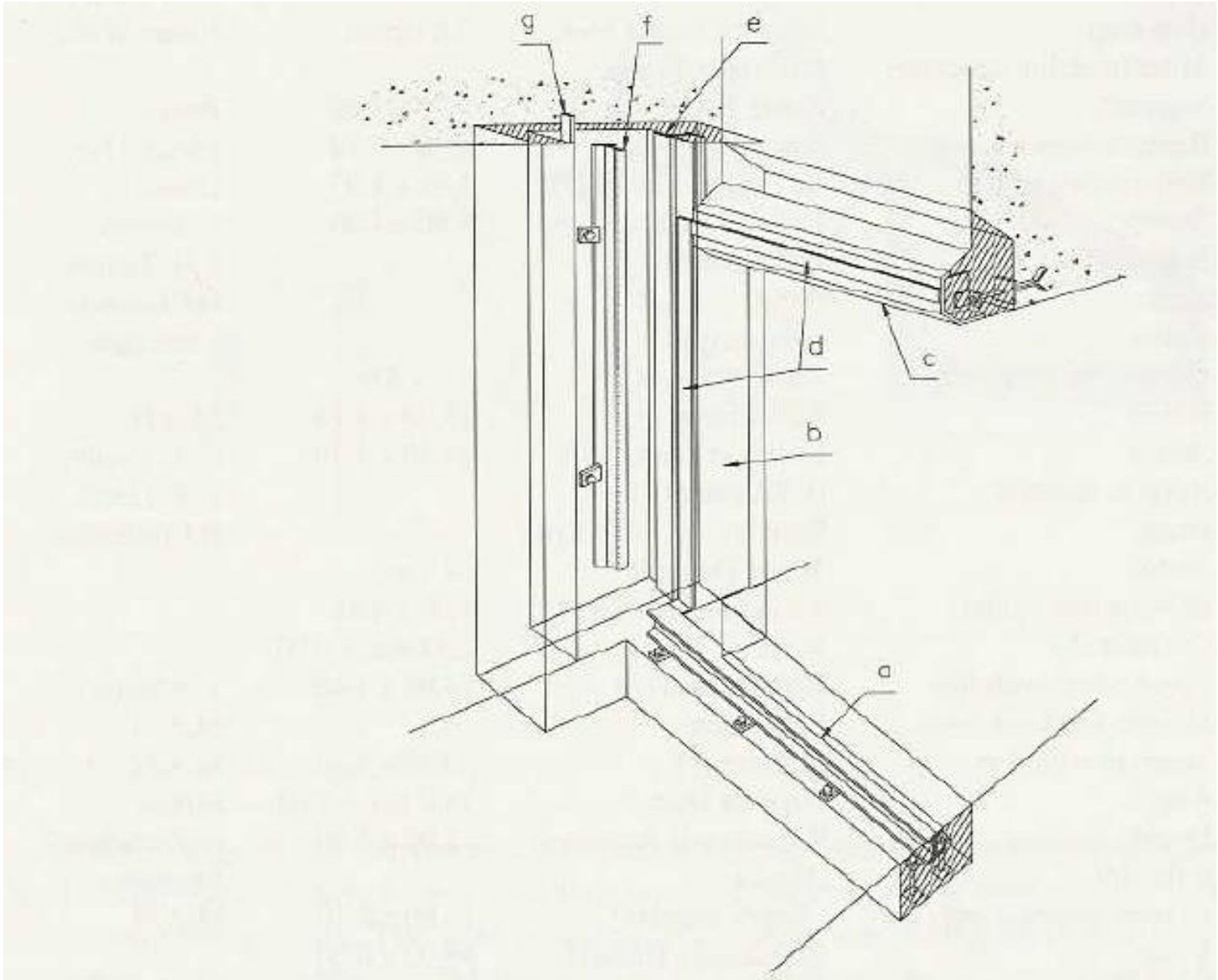


Fig. 1.9 Embedded parts components
(a) sill; (b) slot lining; (c) lintel; (d) seal seat; (e) wheel track; (f) side guide; (g) counterguide

Fixed Wheel

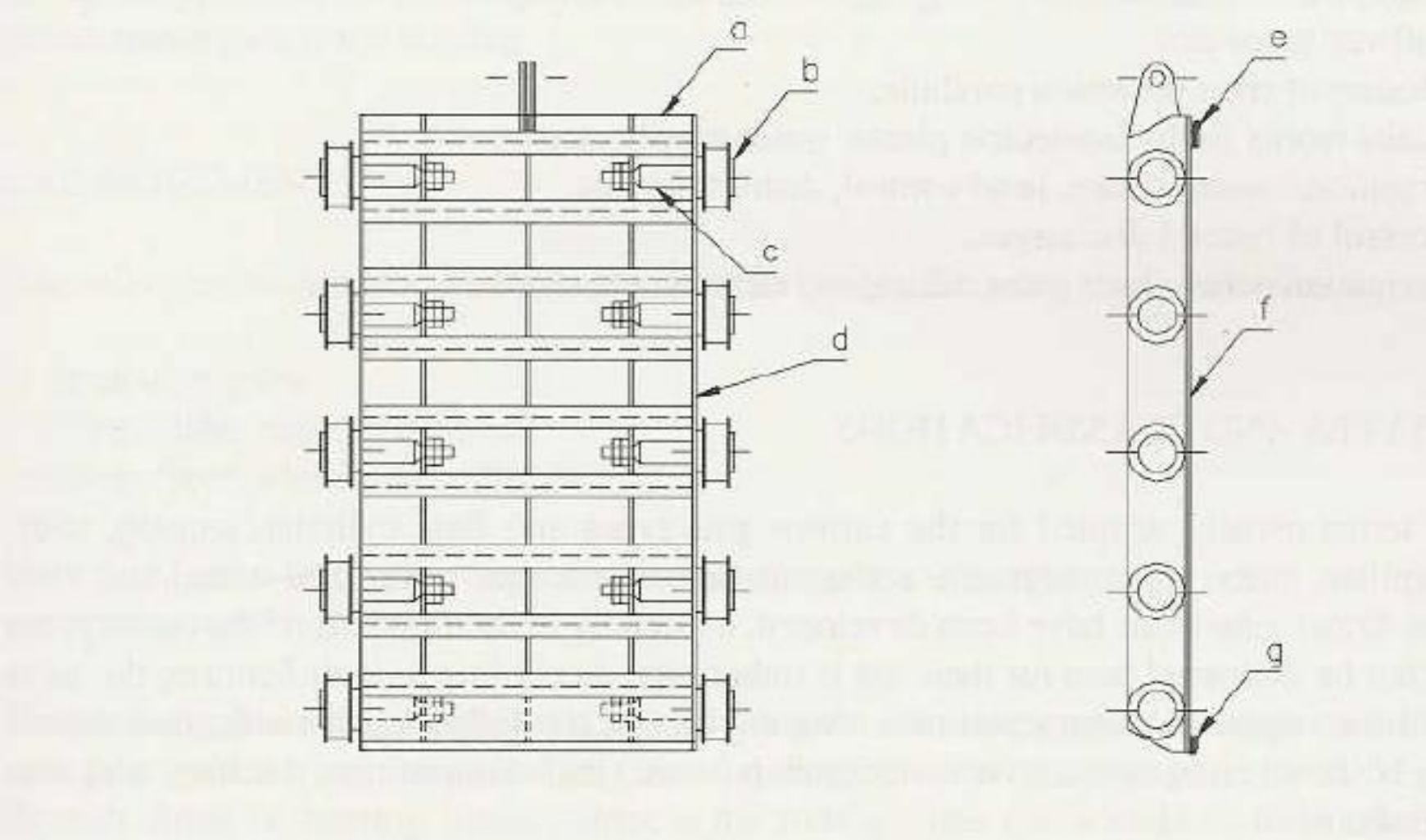


Fig. 1.10 Fixed-wheel gate nomenclature
(a) gate leaf; (b) wheel; (c) wheel pin; (d) end girder; (e) top seal; (f) skin plate; (g) bottom seal

Flap Gate

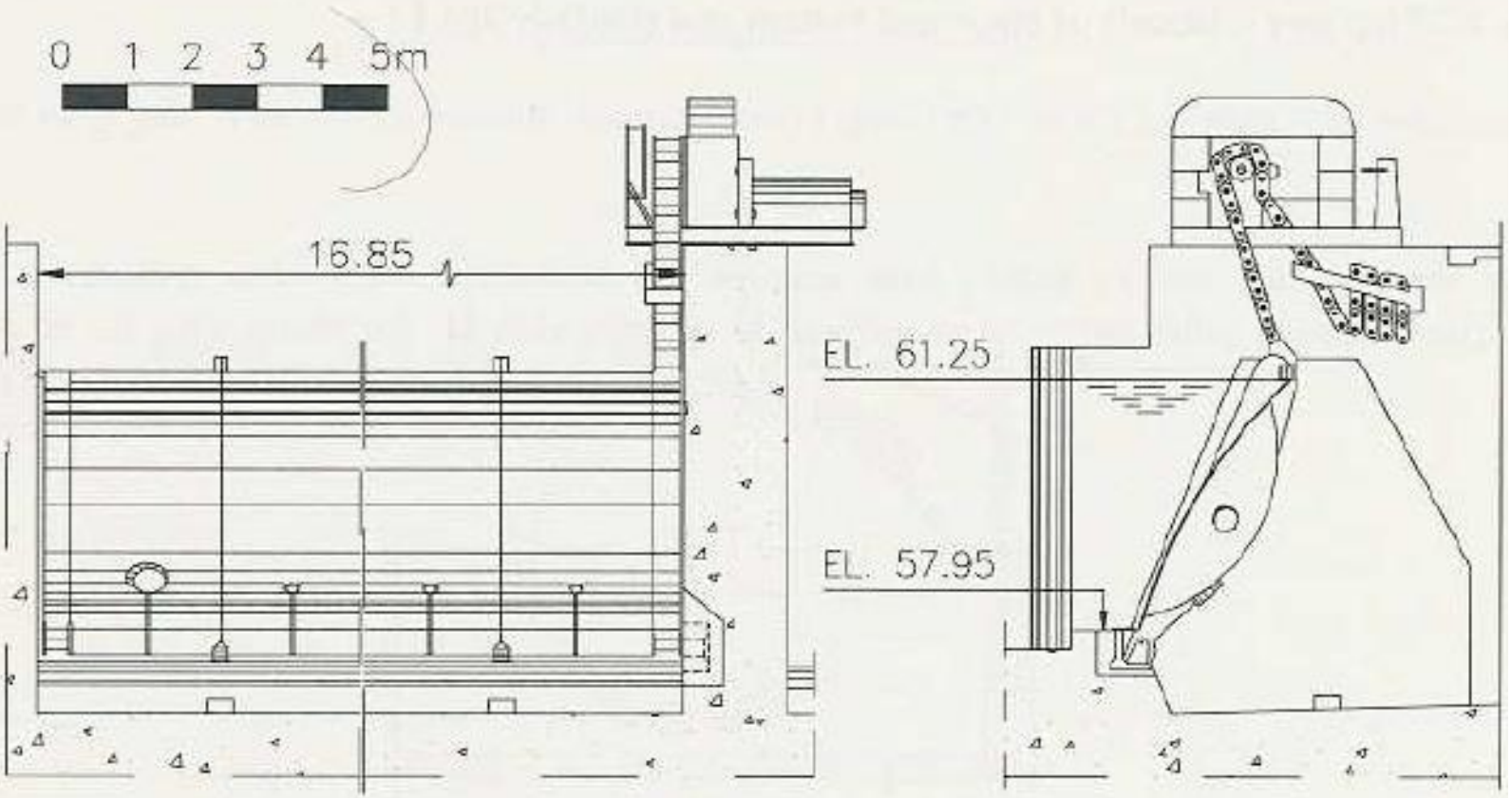


Fig. 2.1 Flap gate, Villeperrot Dam, span 16.85 m and height 3.3 m (ALSTOM)

Flape Gate

Fig. 2.7 Flap gate, Ottendorf Dam (M.A.N.), 30 m wide by 5.5 m high

Flap Gate

Fig. 2.6 Downstream view of a flap gate with nappe breakers (RODNEY HUNT)

Cylinder Gate

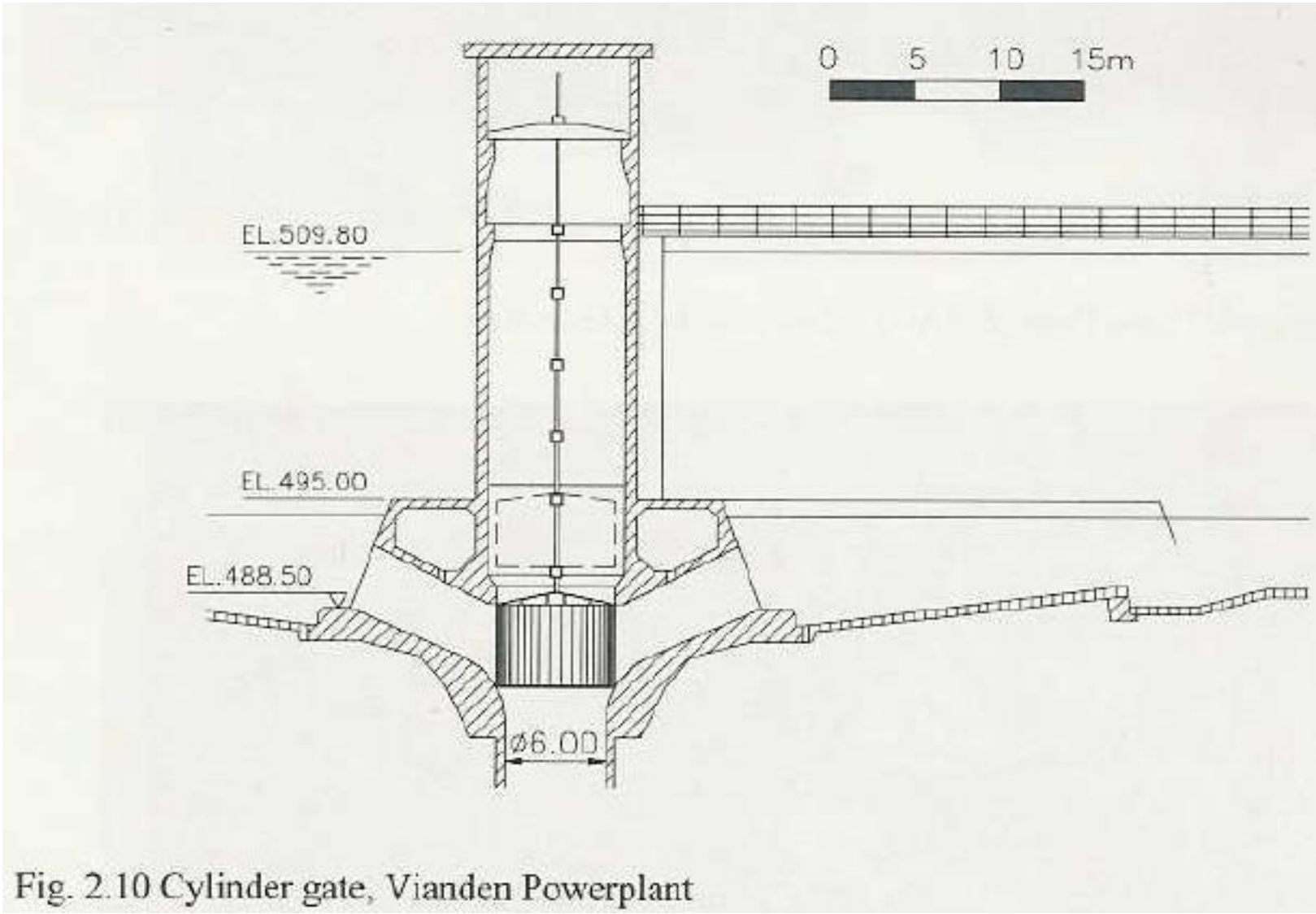


Fig. 2.10 Cylinder gate, Vianden Powerplant

Ring Gate

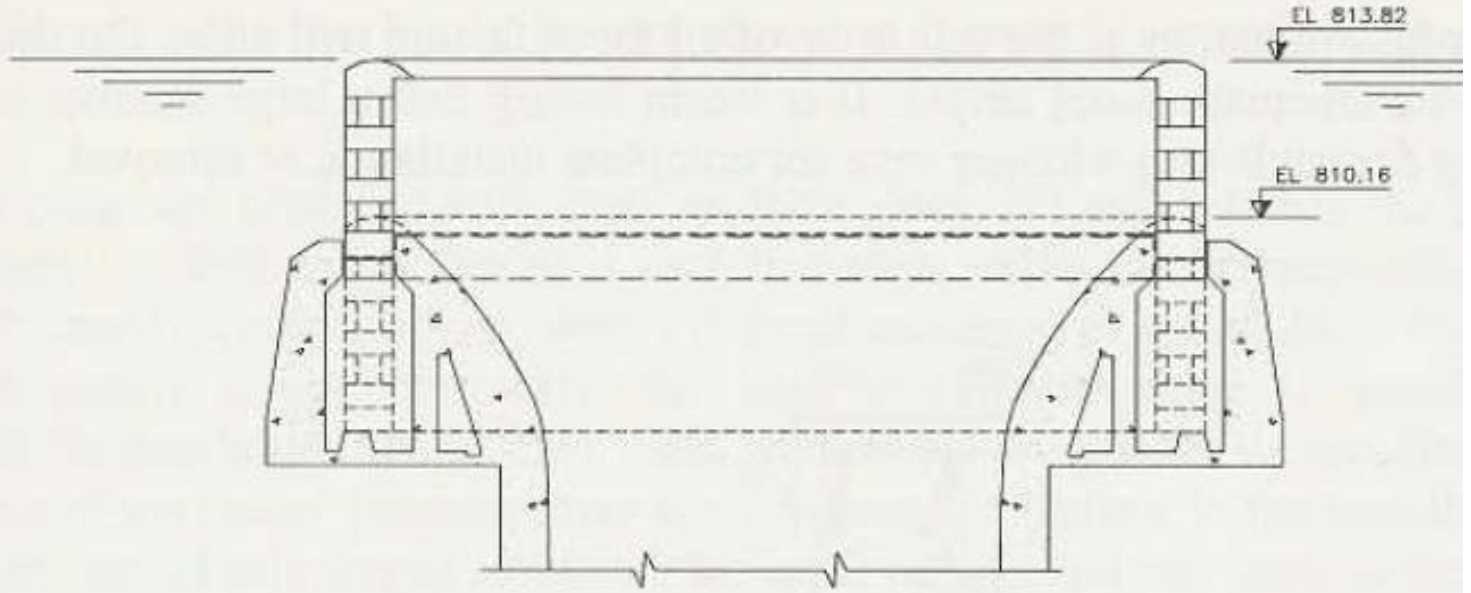


Fig. 2.11 Ring gate, Owyhee Dam, 18 m diameter and 3.6 m height

Stoplog Panel

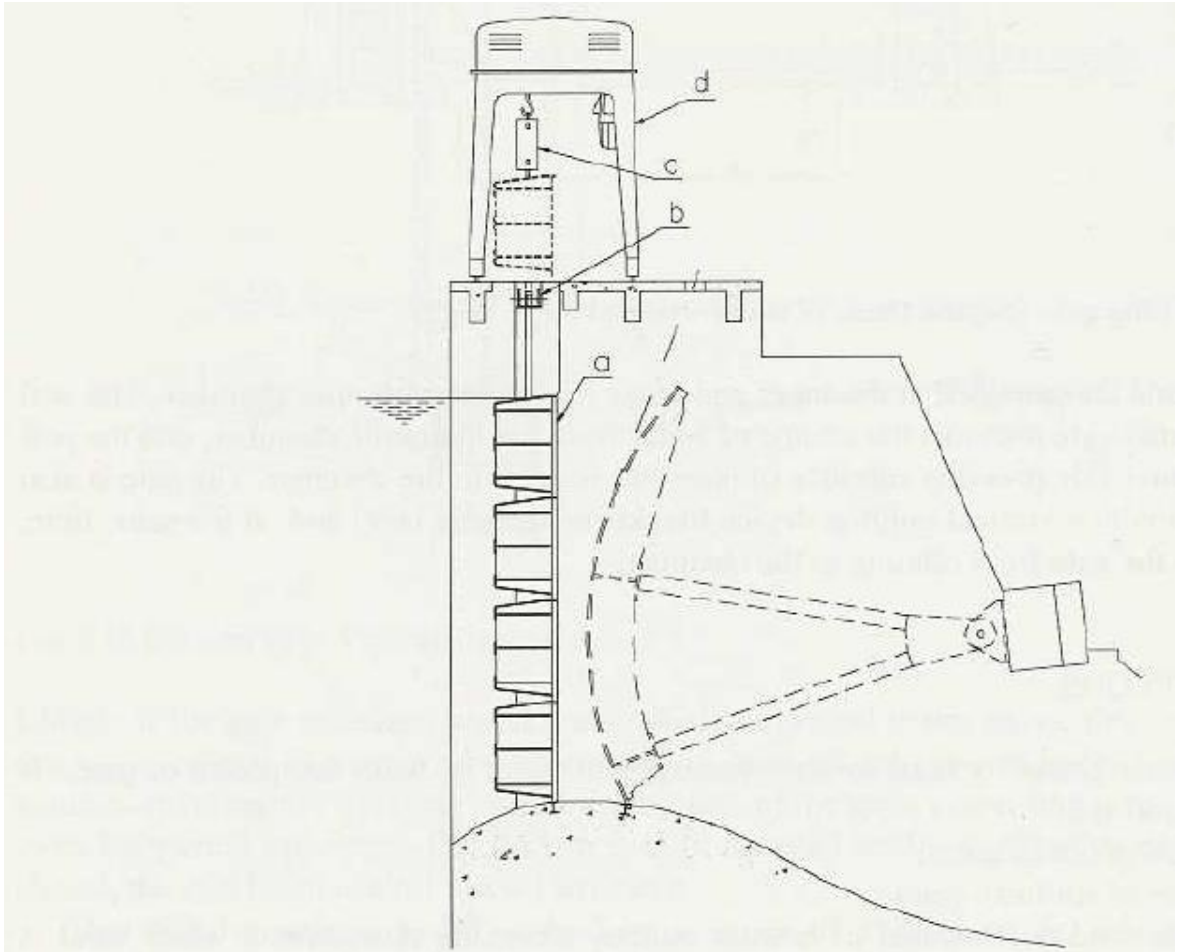


Fig. 2.12 Spillway stoplogs
(a) stoplog panel; (b) dogging device; (c) lifting beam; (d) gantry crane

Lifting Beam

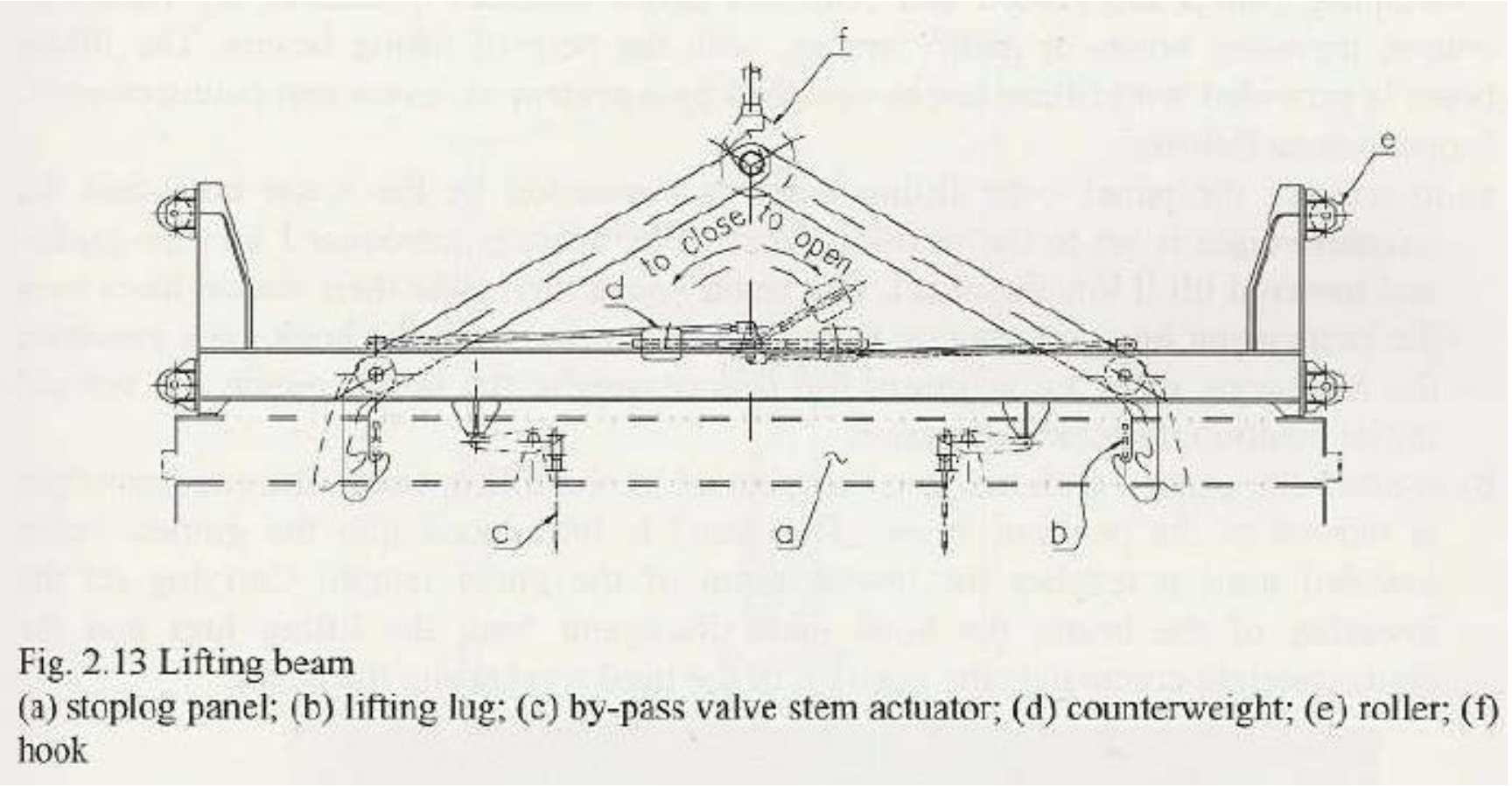


Fig. 2.13 Lifting beam
(a) stoplog panel; (b) lifting lug; (c) by-pass valve stem actuator; (d) counterweight; (e) roller; (f) hook

Lifting Beam & Stoplog

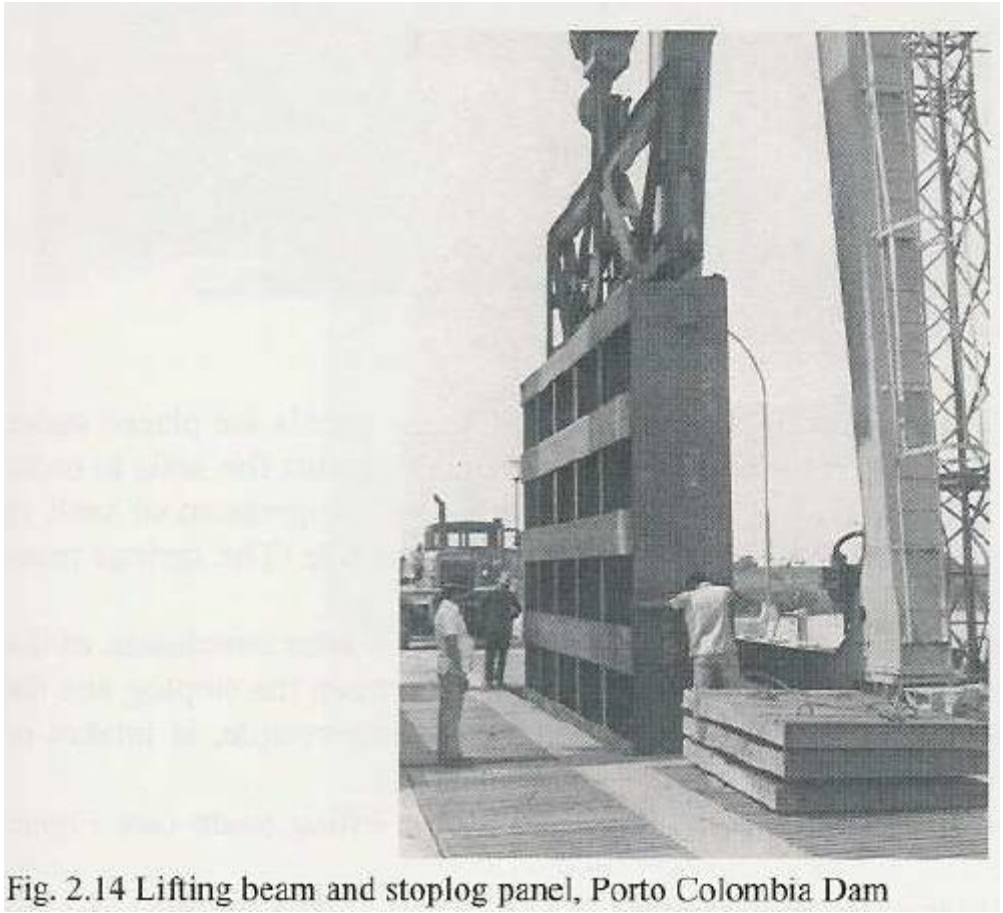


Fig. 2.14 Lifting beam and stoplog panel, Porto Colombia Dam

Slide Gate

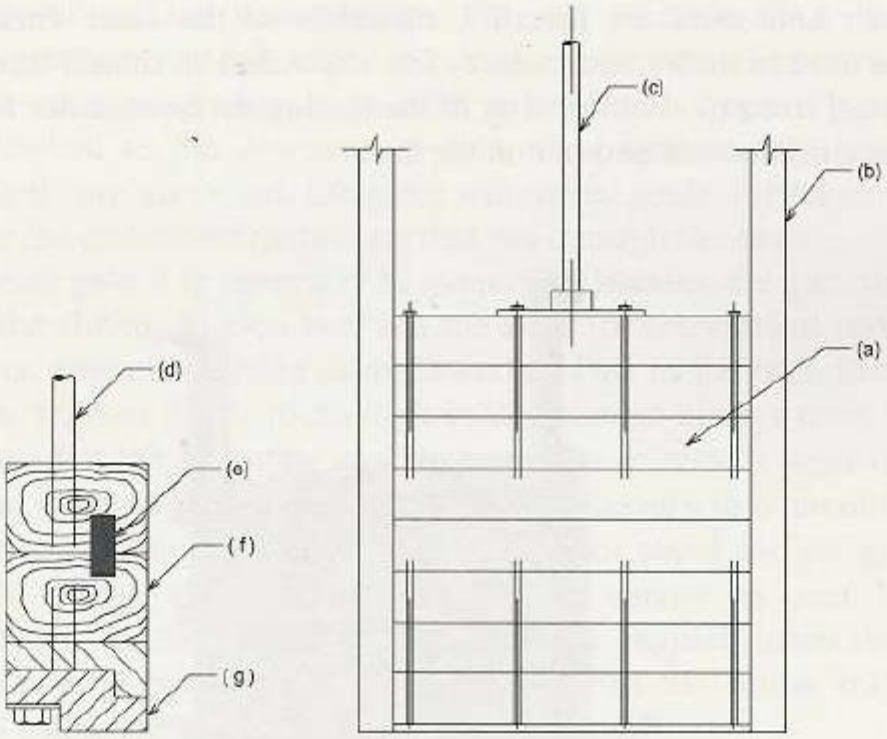


Fig. 2.19 Timber slide gate (RODNEY HUNT)
(a) gate; (b) side guide; (c) operating stem; (d) tie rod; (e) timber spline; (f) timber beam; (g) bottom seal

Seal

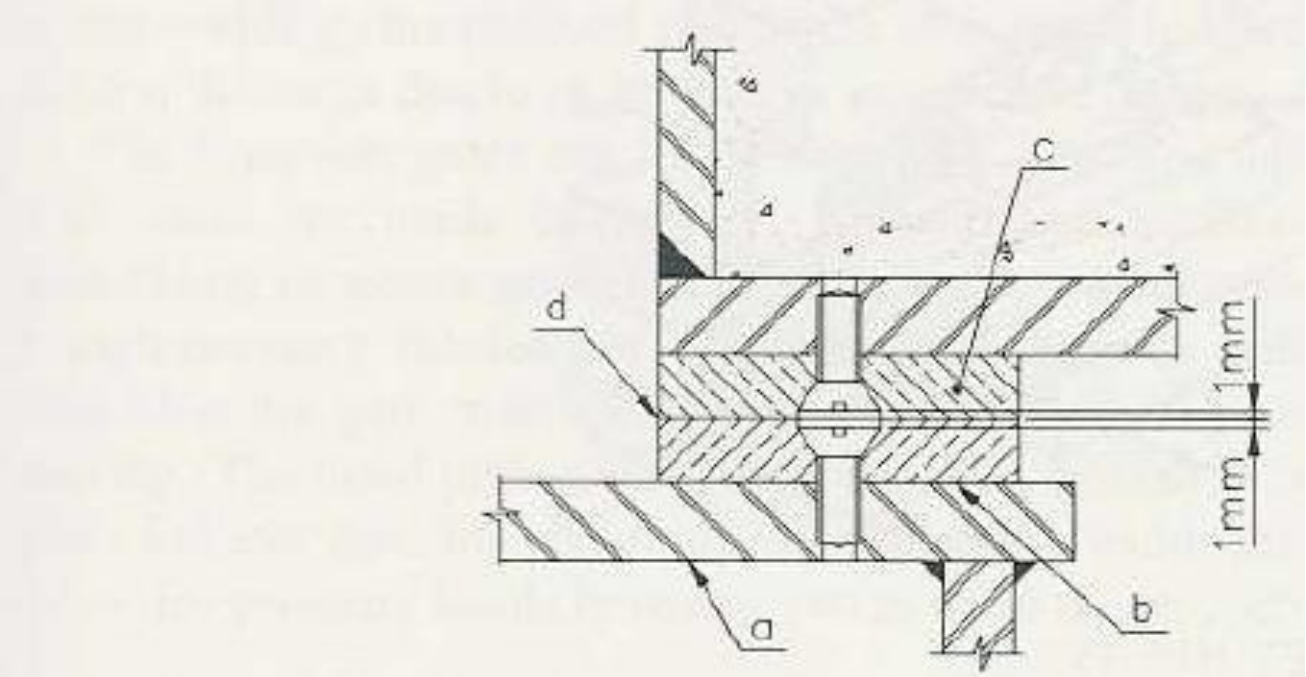


Fig. 2.20 Attaching of metallic seals
(a) skin plate; (b) seal seat; (c) metallic seal; (d) sliding surface

Slide Gate

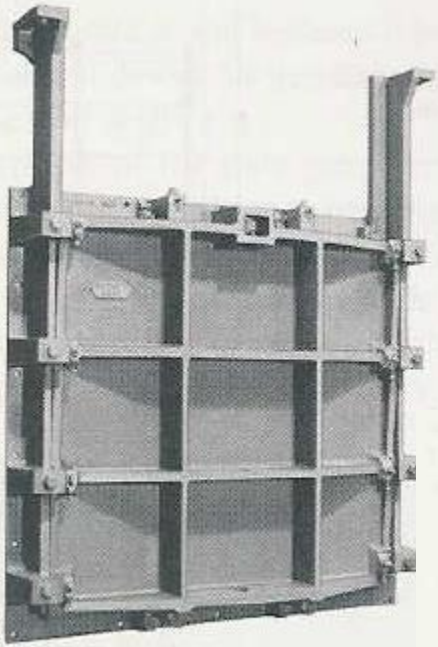


Fig. 2.21 Cast iron slide gate (RODNEY HUNT)

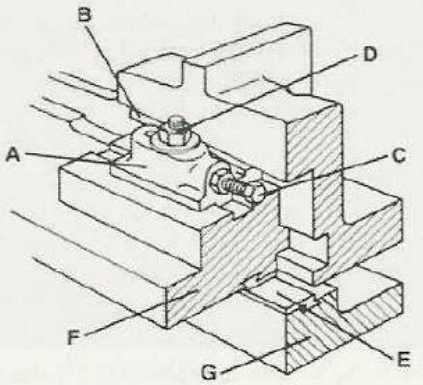


Fig. 2.22 Wedge system (RODNEY HUNT)
(a) bronze wedge; (b) bronze wedge seat; (c) bronze adjusting screw with lock nut; (d) hold down bolt; (e) bronze seat facing; (f) gate disc; (g) gate frame

Caterpillar Gate

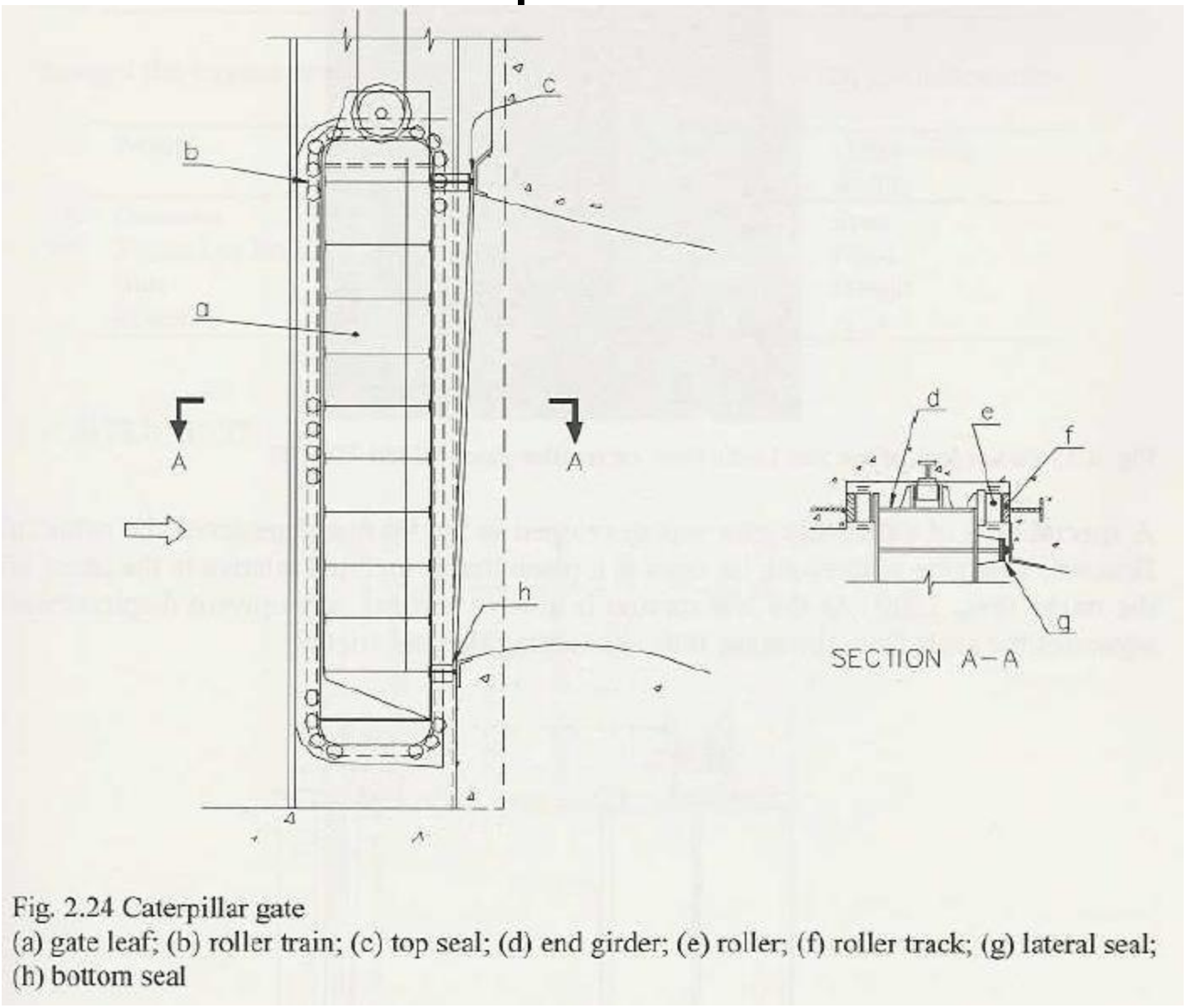


Fig. 2.24 Caterpillar gate
(a) gate leaf; (b) roller train; (c) top seal; (d) end girder; (e) roller; (f) roller track; (g) lateral seal; (h) bottom seal

Caterpillar Gate

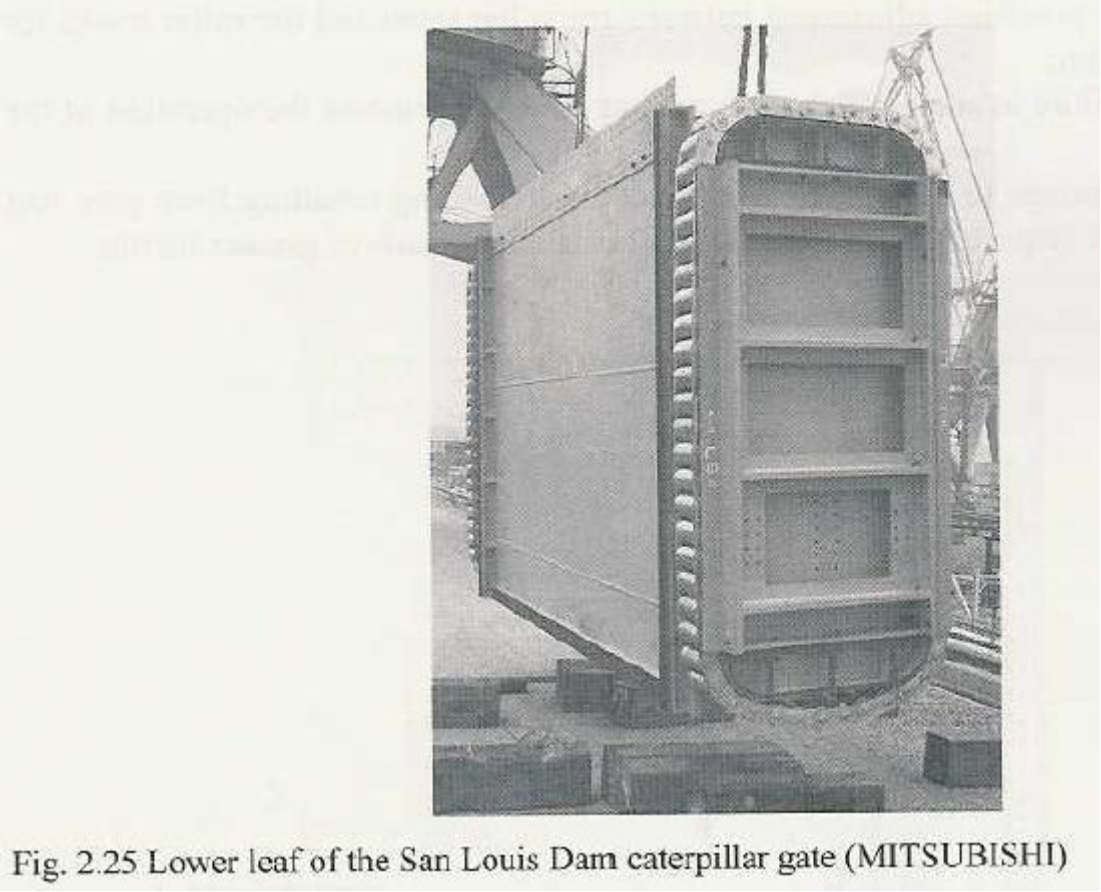


Fig. 2.25 Lower leaf of the San Louis Dam caterpillar gate (MITSUBISHI)

Caterpillar Gate

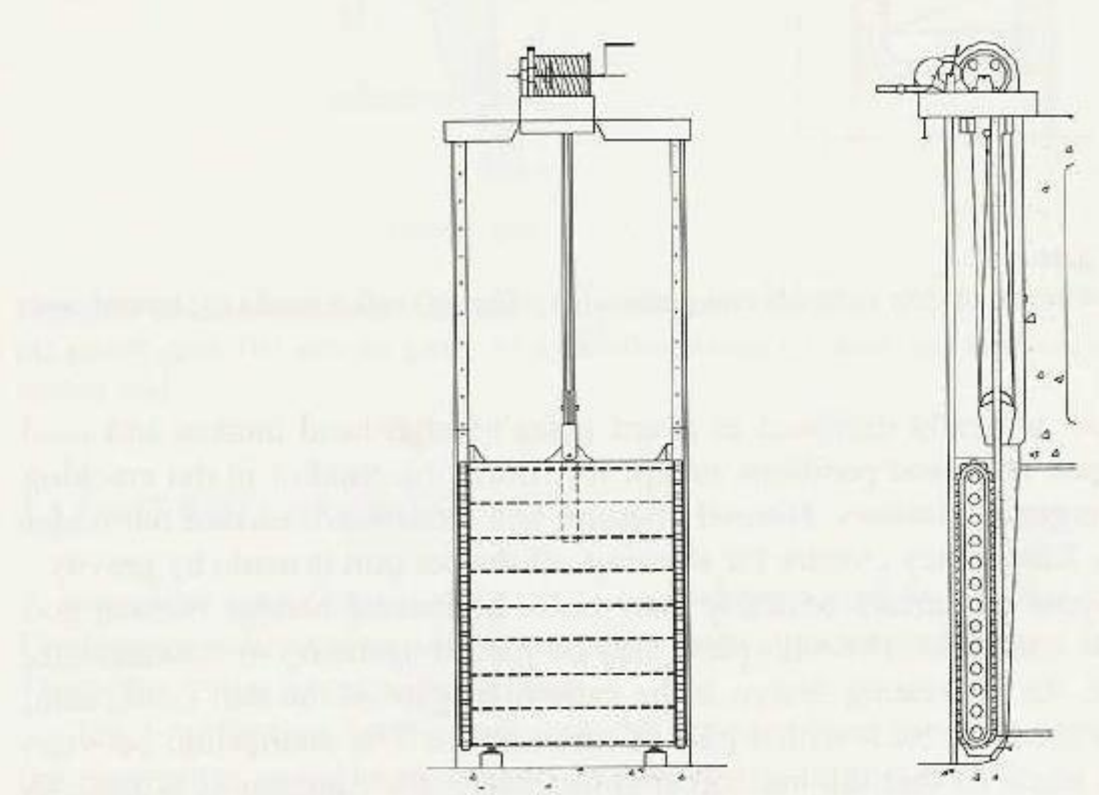


Fig. 2.26 Broome-type caterpillar gate

Miter Gate

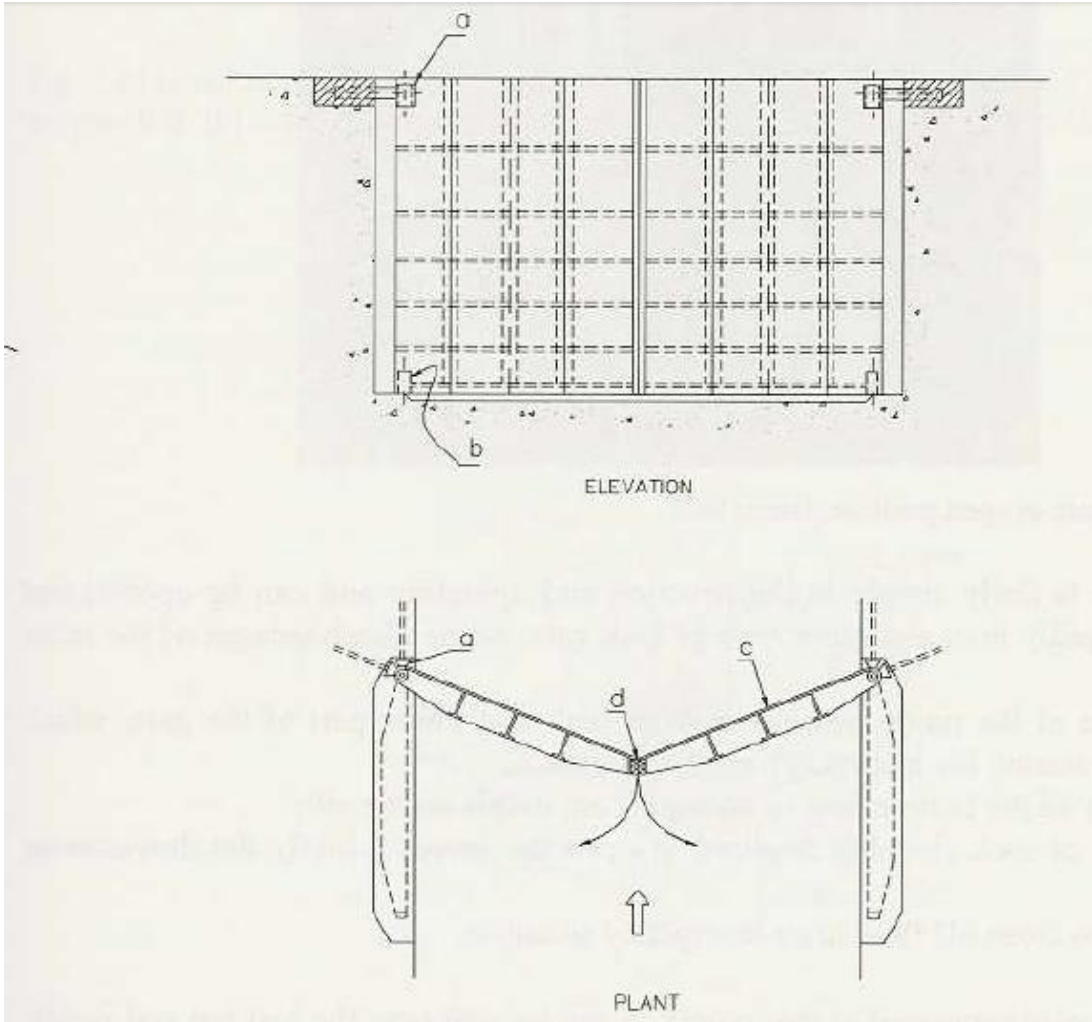


Fig. 2.27 Miter gate
(a) gudgeon; (b) pintle; (c) skin plate; (d) center seal

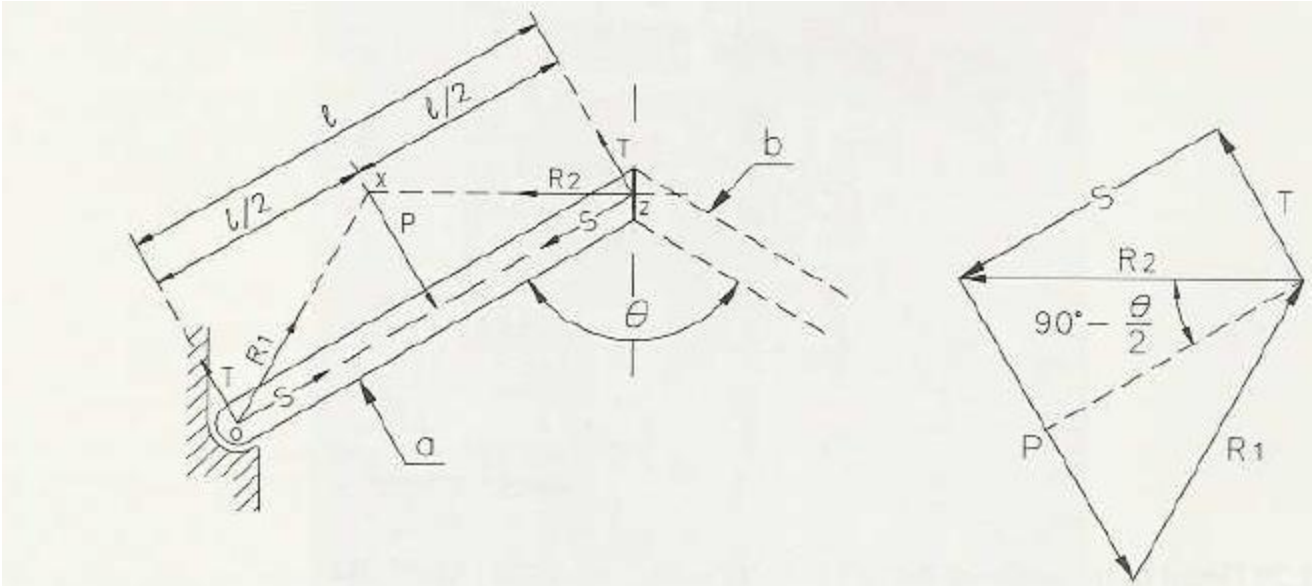


Fig. 2.31 Miter gate reactions, in plan

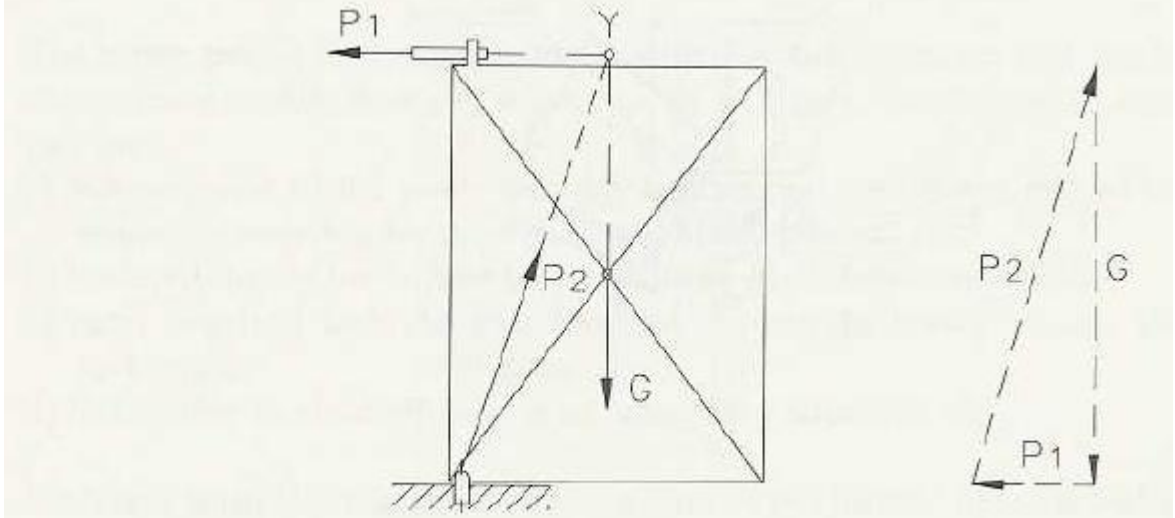


Fig. 2.32 Miter gate reactions, in elevation

Roller Gate

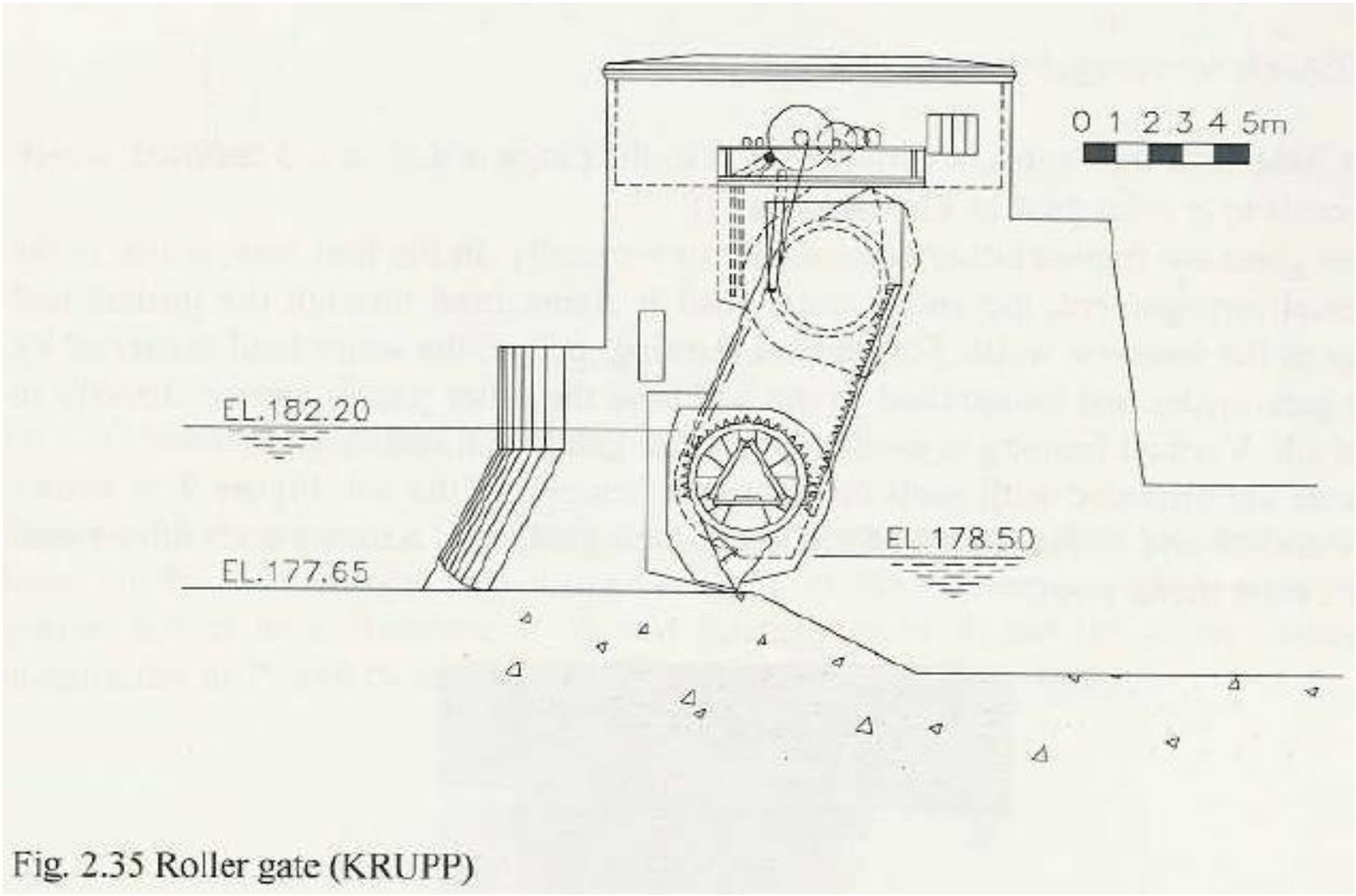


Fig. 2.35 Roller gate (KRUPP)

Segment Gate

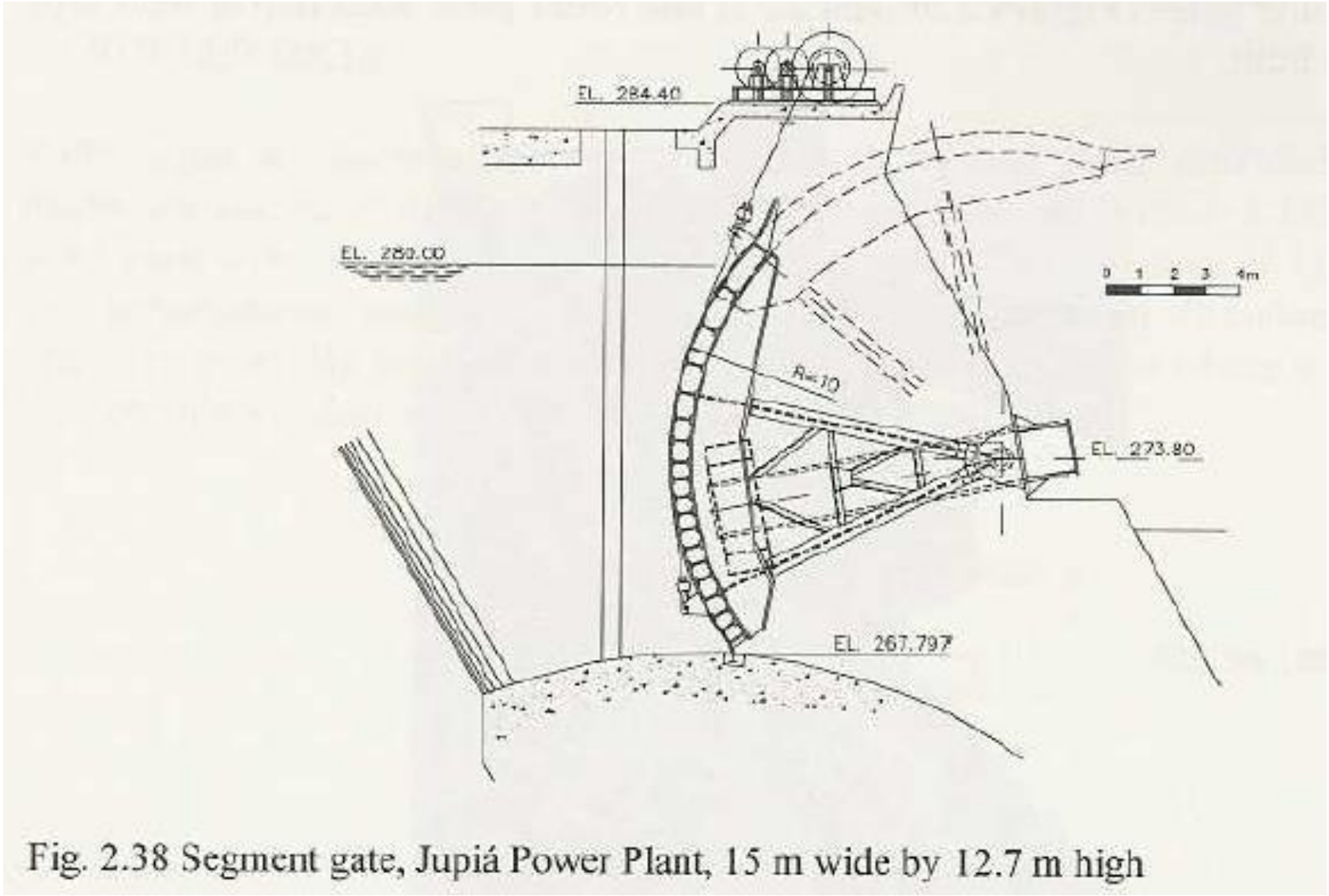


Fig. 2.38 Segment gate, Jupiá Power Plant, 15 m wide by 12.7 m high

Reverse Segment Gate w/ Flap

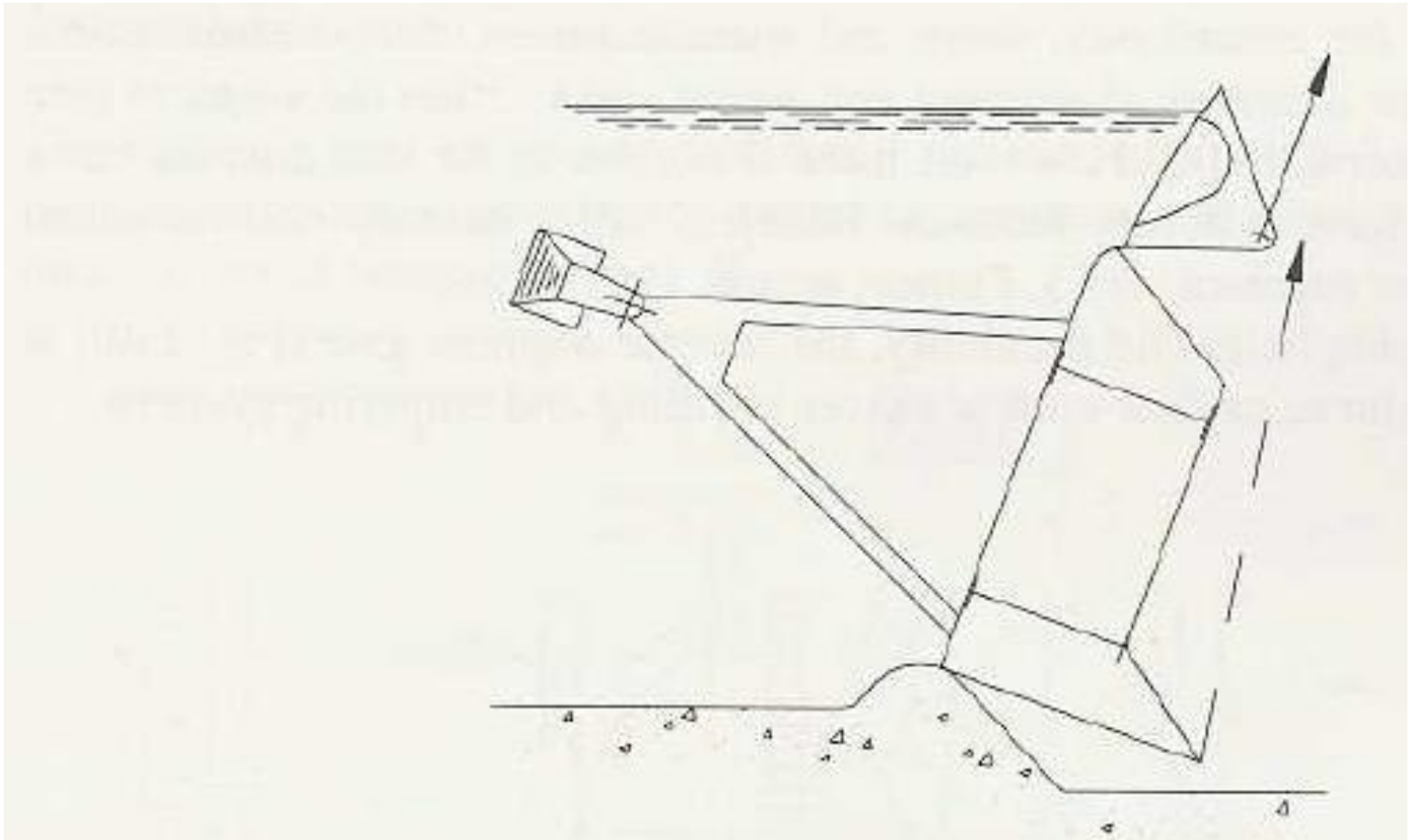


Fig. 2.41 Reverse segment gate with flap gate

Segment Gate

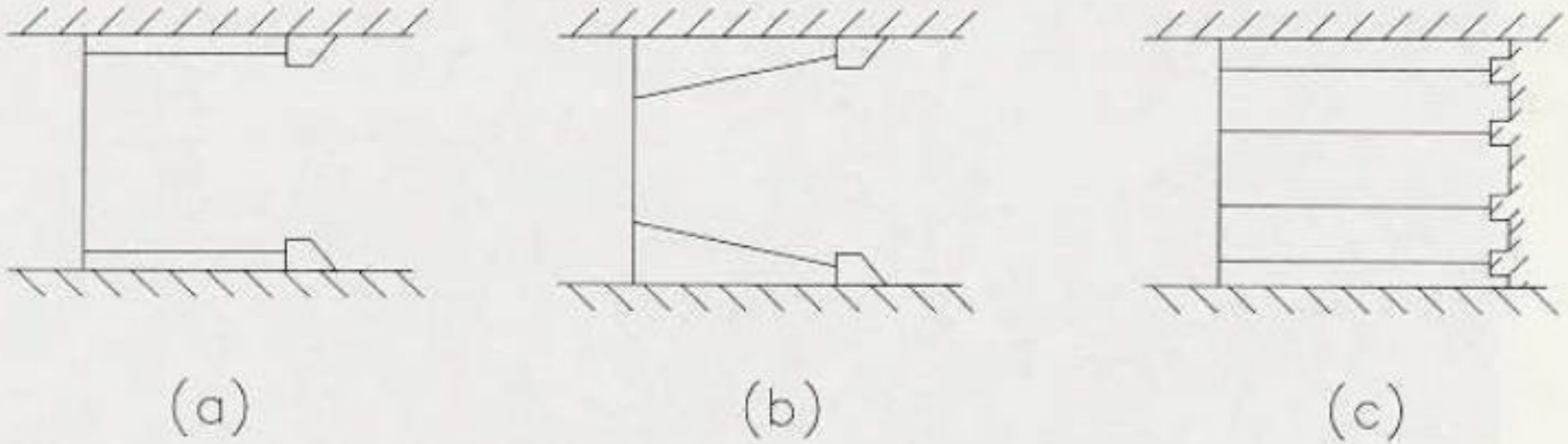


Fig. 2.55 Gate arms arrangement, in plan

Segment Gate

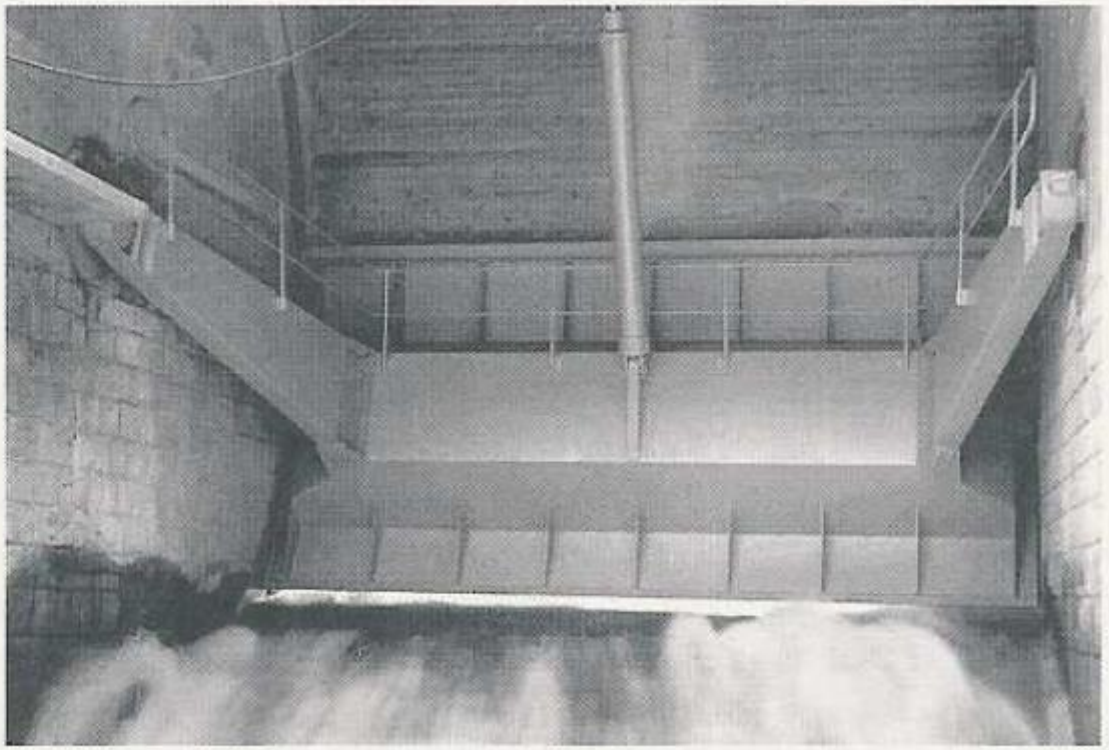


Fig. 2.53 Bottom outlet segment gate, Innerferrera Dam (ZWAG)

Segement Gate

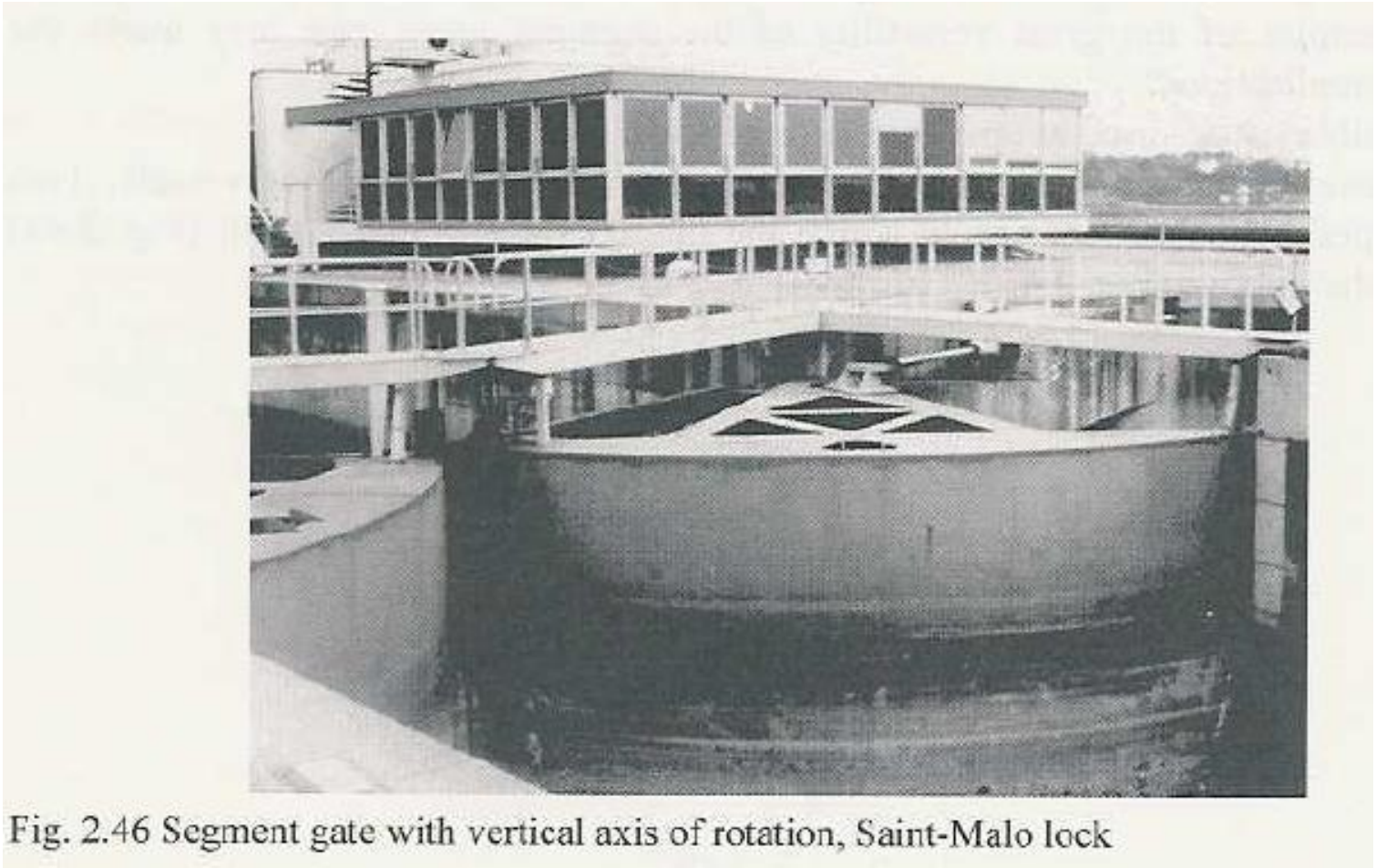


Fig. 2.46 Segment gate with vertical axis of rotation, Saint-Malo lock

Sector Gate

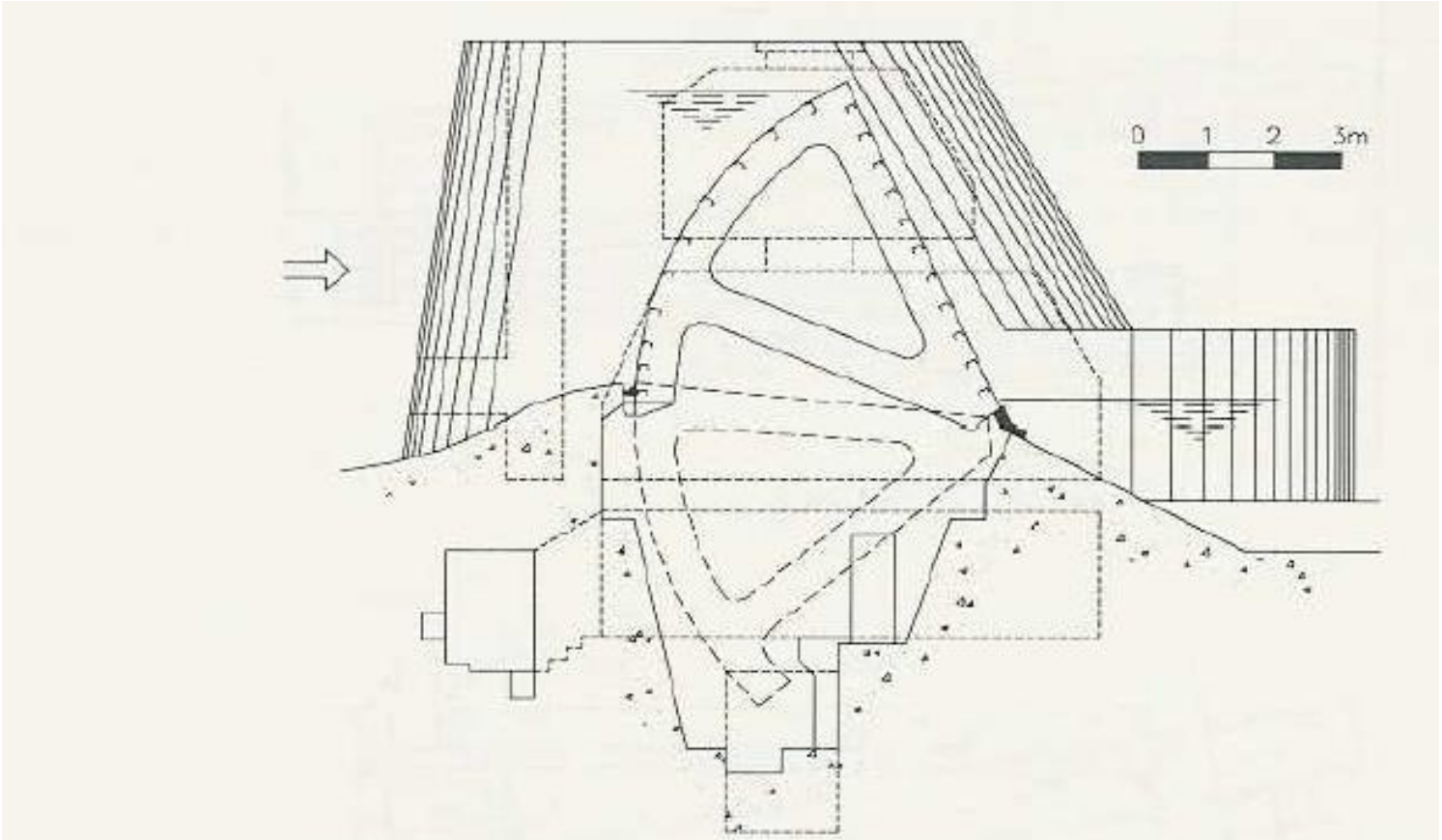


Fig. 2.65 Sector gate, St. Aldegund Dam (DSD-NOELL), 40 m wide by 5.4 m high

Segment & Sector Gates

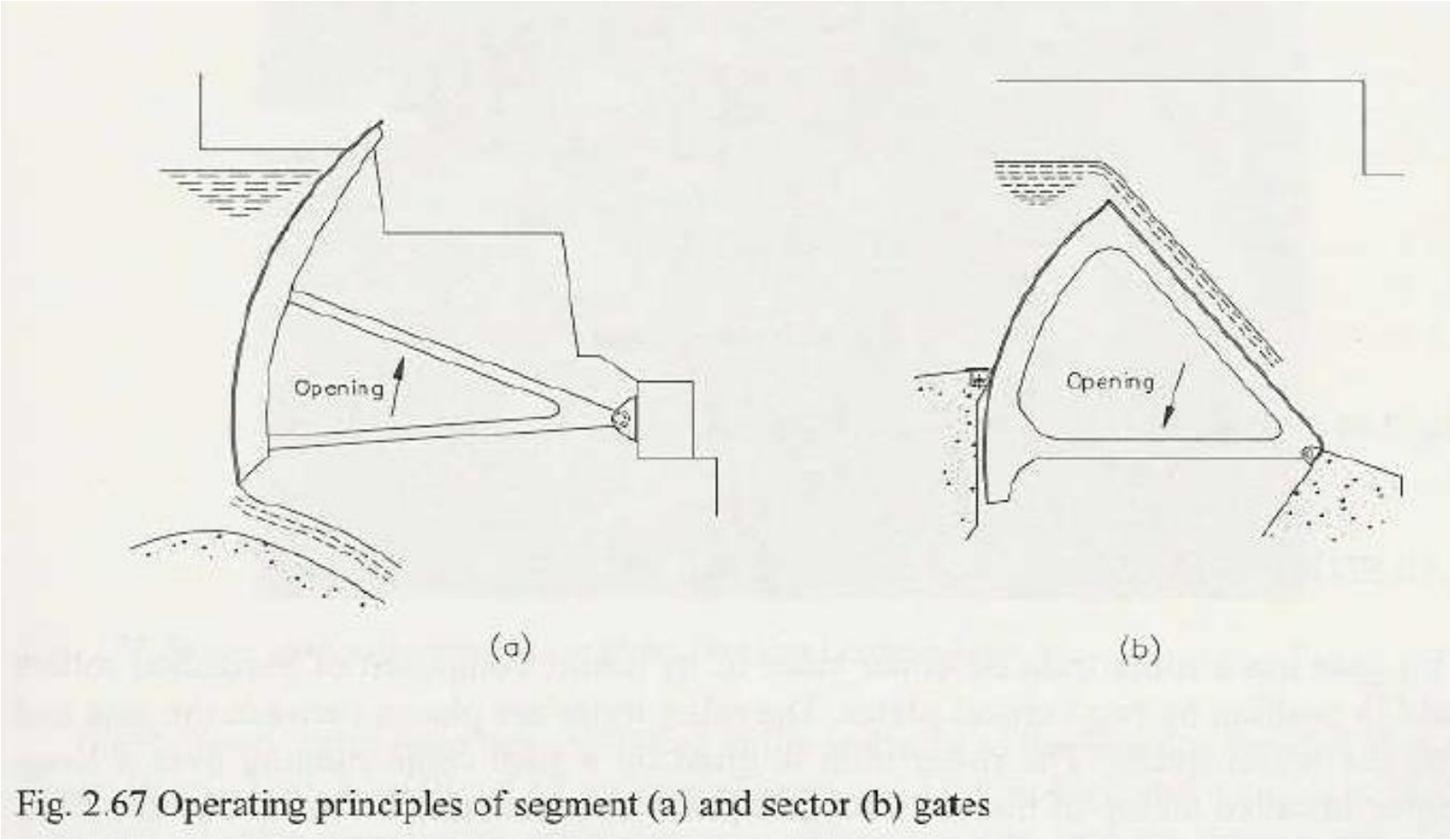


Fig. 2.67 Operating principles of segment (a) and sector (b) gates

Stoney Gate

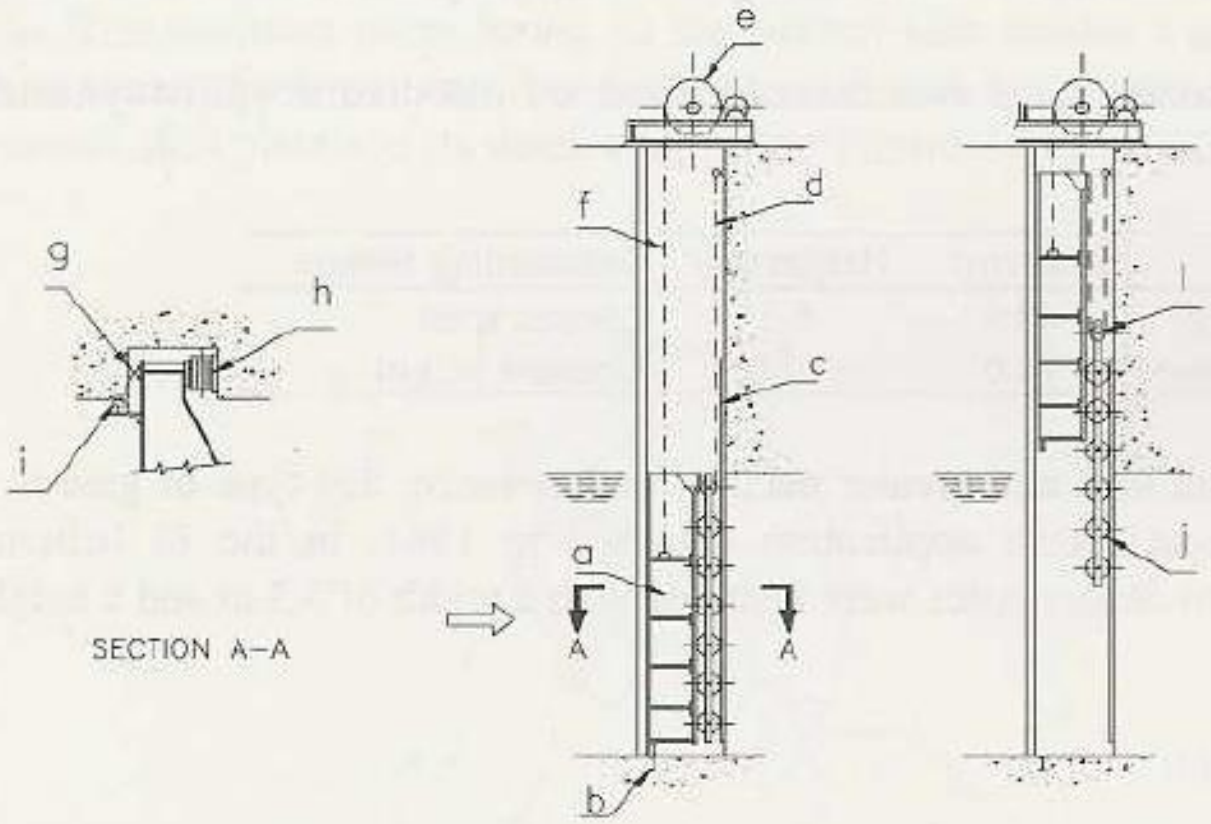


Fig. 2.70 *Stoney* gate
(a) gate leaf; (b) sill beam; (c) roller track; (d) roller train cable; (e) hoist; (f) gate leaf cable; (g) counterguide; (h) roller; (i) lateral seal; (j) roller train; (l) pulley

Drum Gate

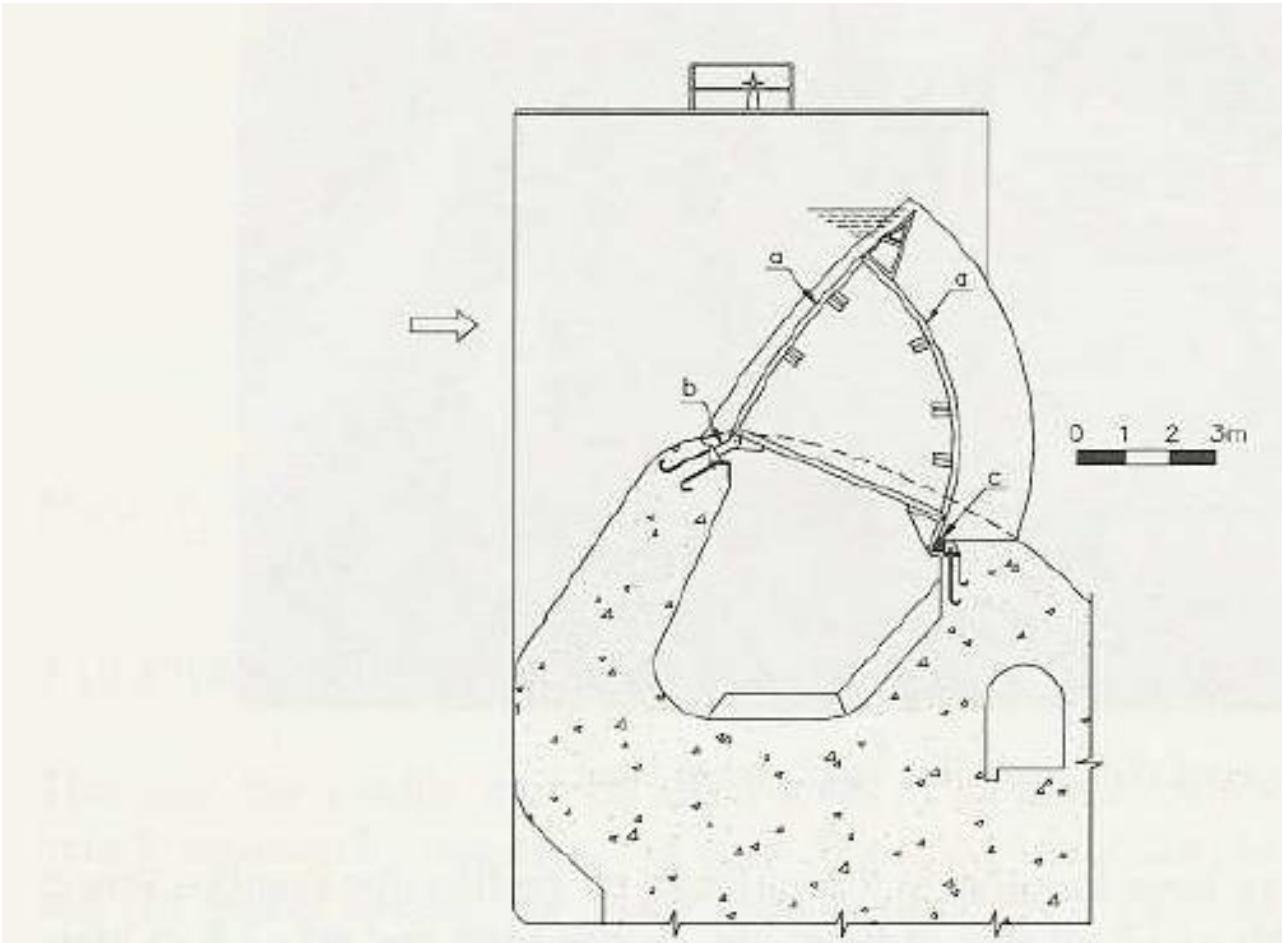


Fig. 2.72 Drum gate, Friant Dam, USA, 30 m wide by 5.5 m high
(a) skin plate; (b) hinge; (c) seal

Drum Gate

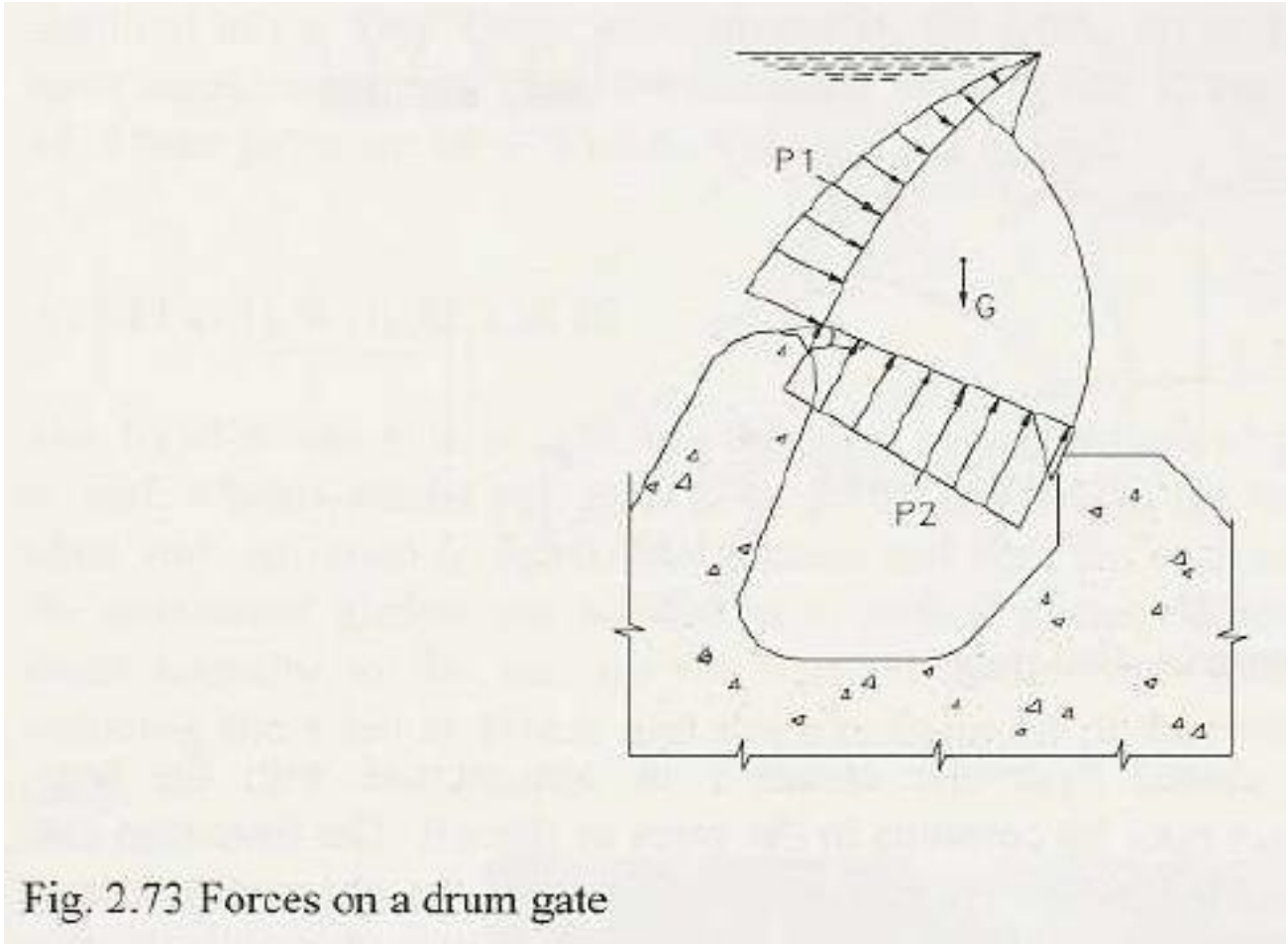


Fig. 2.73 Forces on a drum gate

Fixed Wheel Gate

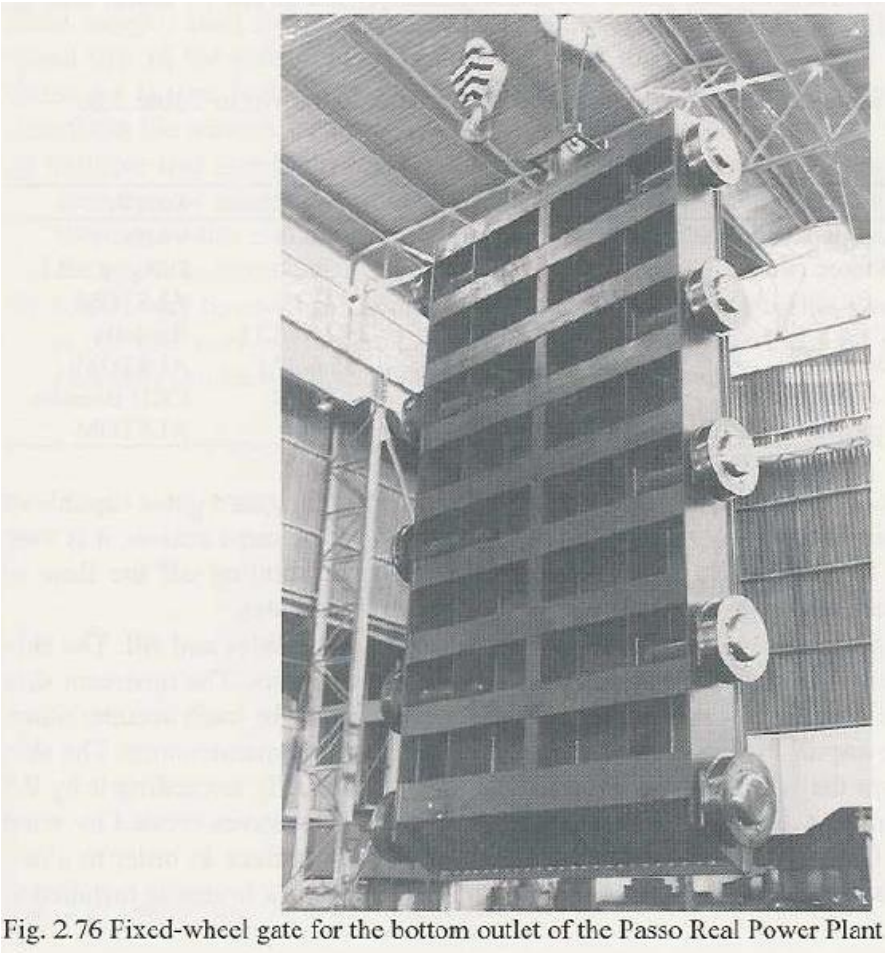


Fig. 2.76 Fixed-wheel gate for the bottom outlet of the Passo Real Power Plant

Fixed Wheel Gate

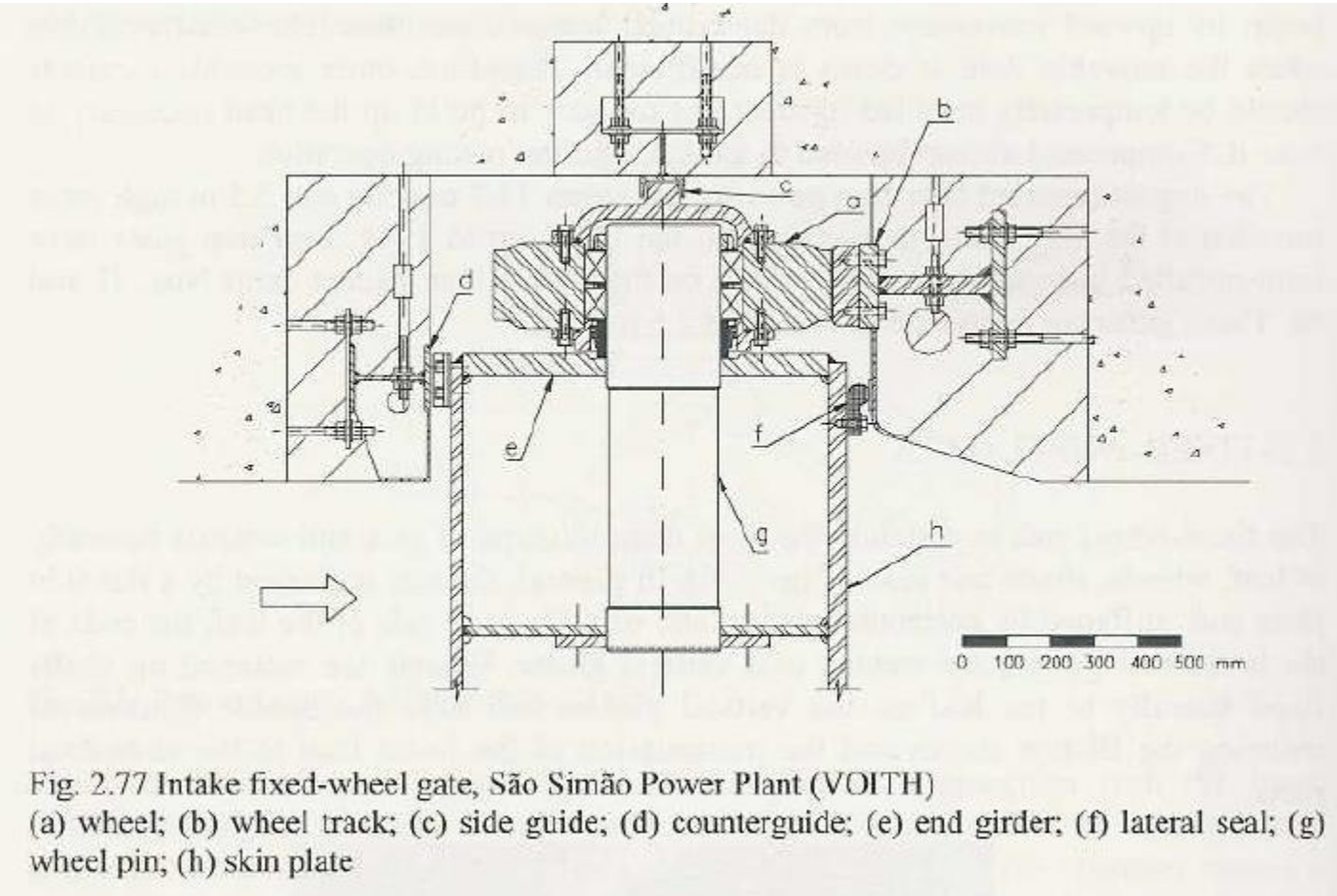


Fig. 2.77 Intake fixed-wheel gate, São Simão Power Plant (VOITH)
(a) wheel; (b) wheel track; (c) side guide; (d) counterguide; (e) end girder; (f) lateral seal; (g) wheel pin; (h) skin plate

Visor Gate

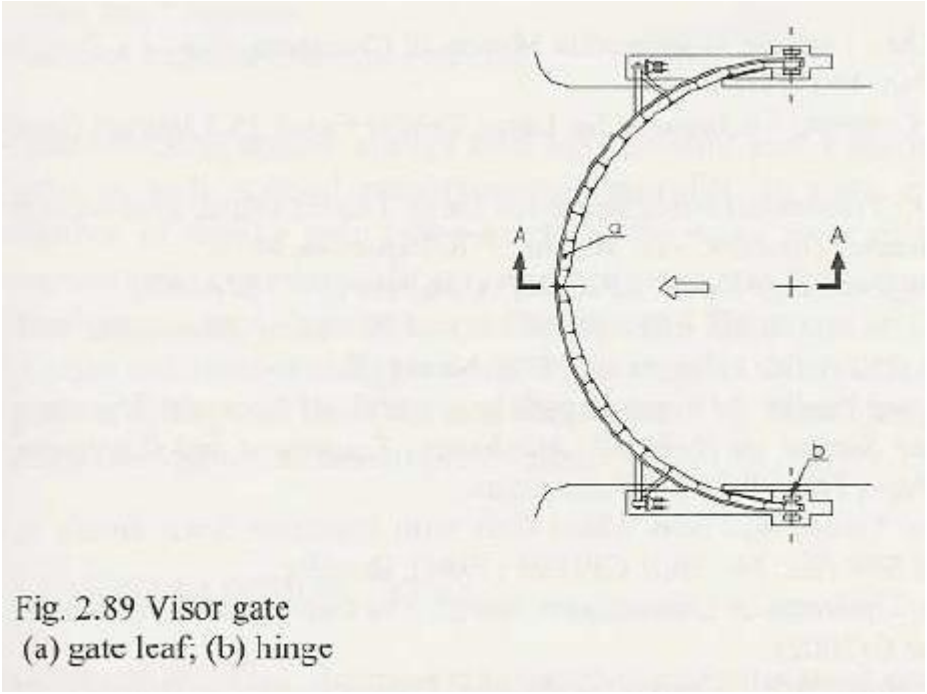
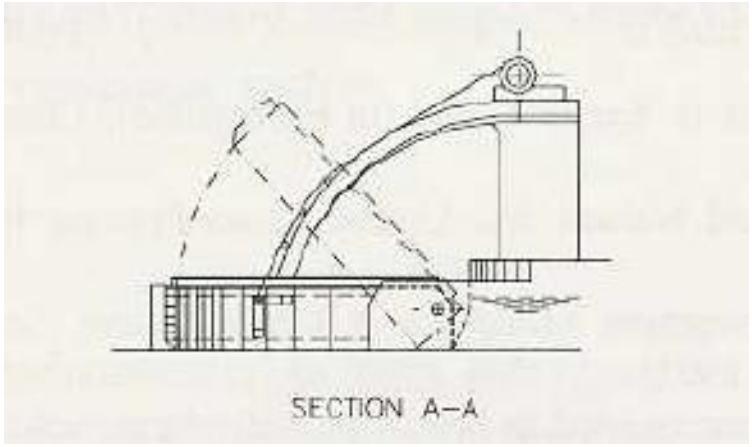


Fig. 2.89 Visor gate
(a) gate leaf; (b) hinge



Bear Trap Gate

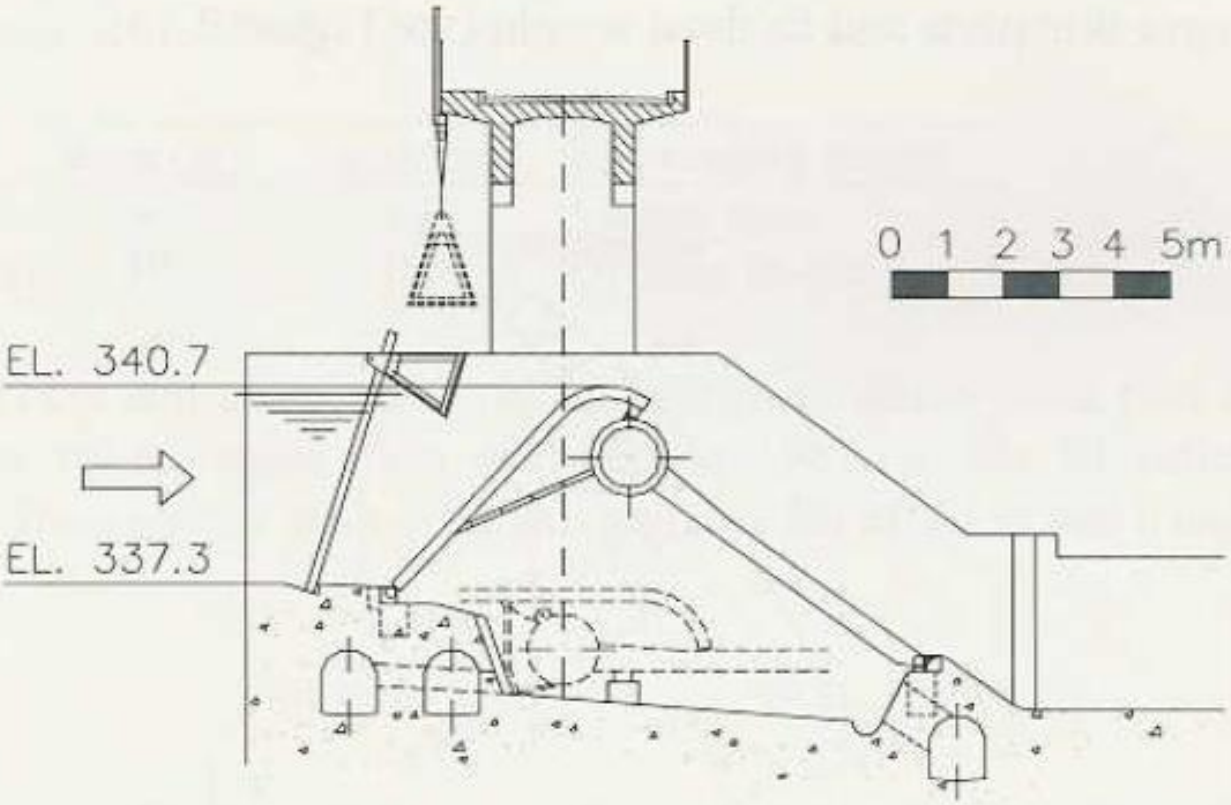


Fig. 2.74 Bear-trap gate, Schinznach-Bad Dam

Bear Trap gate

Fig. 2.75 Bear-trap gate, Fröndenberg Power Plant, 15.5 m wide by 1.5 m high

One of the most important tasks of a design engineer is the selection of a suitable type of gate for a hydraulic installation. As there is no established routine for this, selection should be based on a complete analysis of all factors capable of influencing performance, cost, quality and reliability of the equipment, such as:

- operational reliability;
- reduced weight;
- functional simplicity;
- ease of maintenance;
- advantageous structural requirements (slots, piers, gate chambers, guides etc.);
- magnitude and direction of forces transmitted to the concrete;
- gate hoist capacity;
- ease of transportation and erection.

Generally speaking, the most common types of gates used nowadays are:

- in intakes: fixed-wheel, slide, caterpillar, segment and cylinder;
- in spillways: segment, flap, fixed-wheel, sector, drum, segment with flap, fixed-wheel with flap and double-leaf fixed-wheel hook-type;
- in bottom outlets: slide, fixed-wheel, caterpillar and segment;
- as lock gates: miter, fixed-wheel and segment with vertical rotation axis;
- in lock aqueducts: slide, fixed-wheel and reversed-type segment.

Pemilihan Jenis Pintu

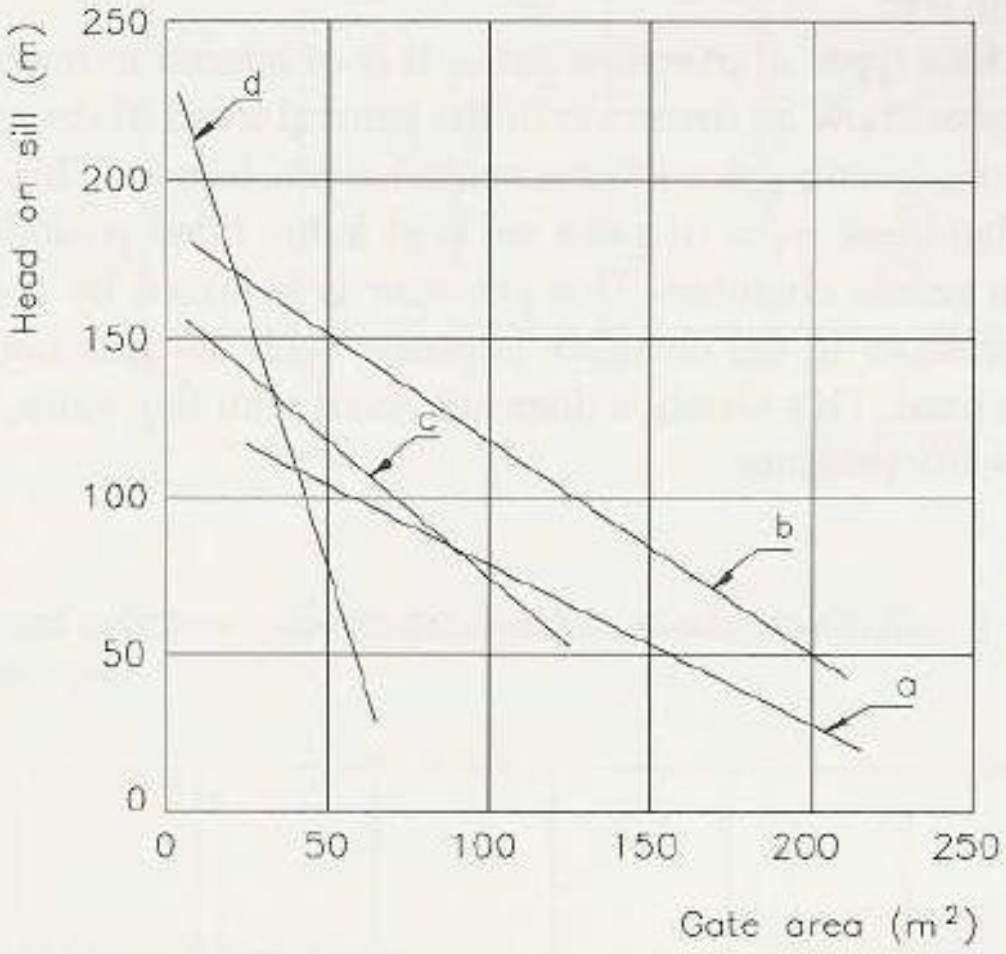


Fig. 3.2 High pressure gates - (a) segment; (b) fixed-wheel; (c) caterpillar; (d) slide

Dimensi Pintu

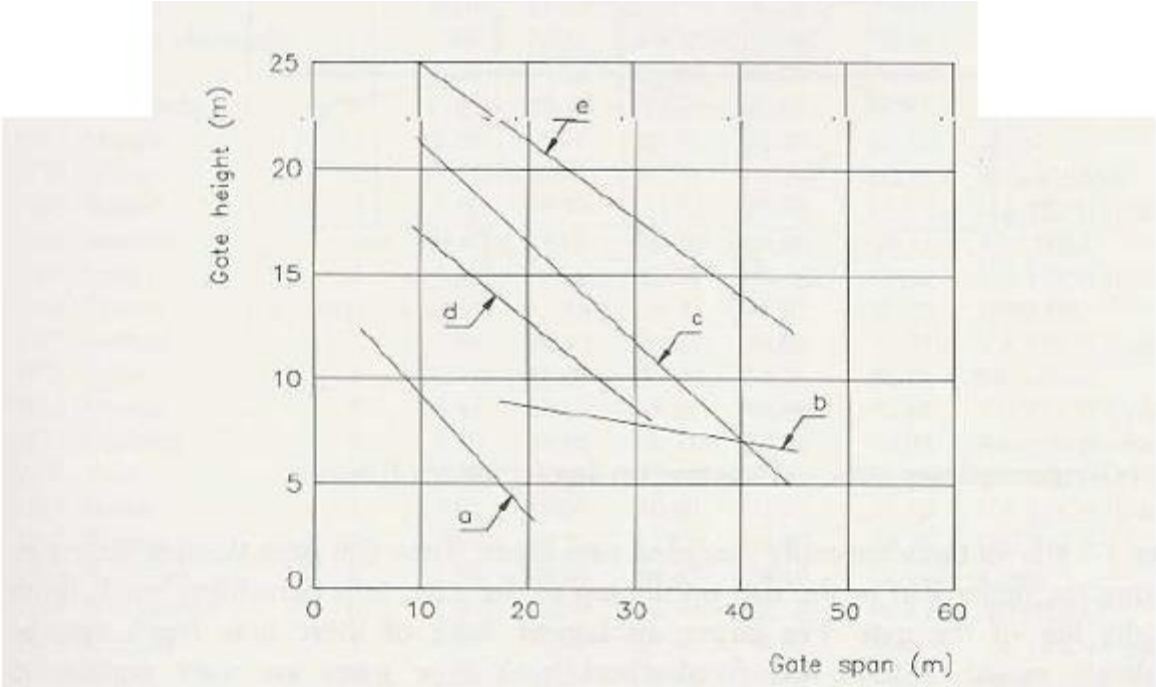


Fig. 3.3 Underflow spillway gates - (a) slide; (b) roller; (c) fixed-wheel; (d) *Stoney*; (e) segment

Dimensi Pintu

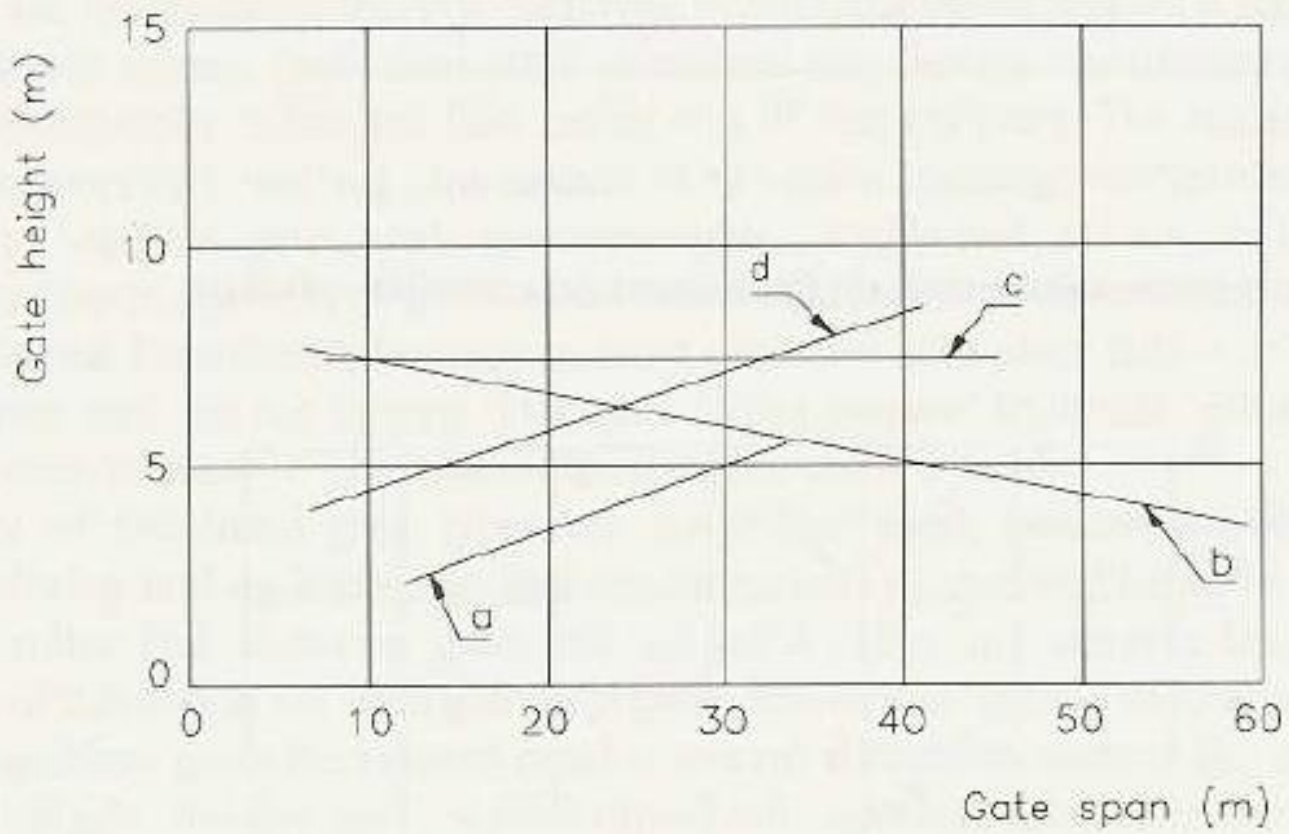


Fig. 3.4 Overflow spillway gates - (a) bear trap; (b) flap; (c) sector; (d) drum

Dimensi Pintu

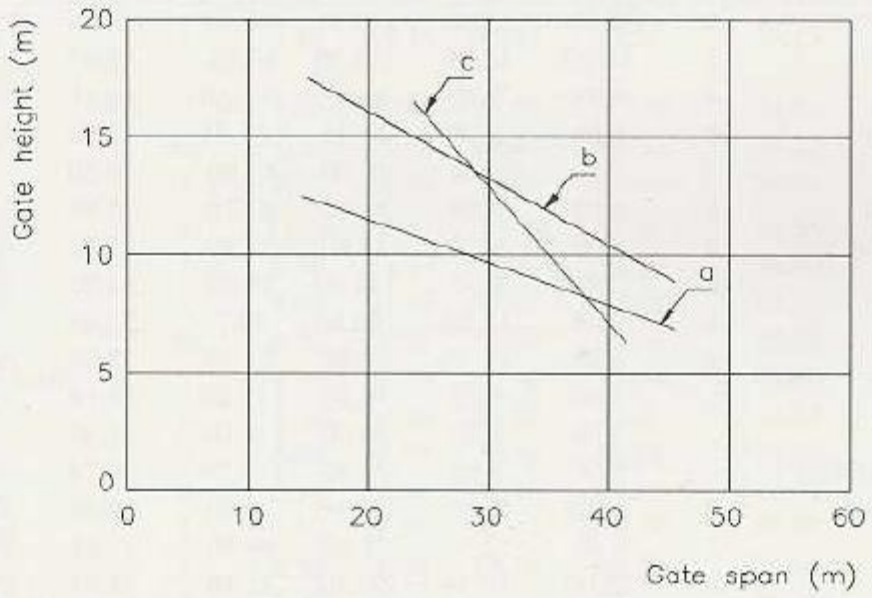


Fig. 3.5 Underflow and overflow spillway gates - (a) fixed-wheel with flap; (b) segment with flap; (c) double-leaf fixed-wheel

HIDROSTATIKA

$$W = \tfrac{1}{2}\,\gamma\, B\, H^2$$

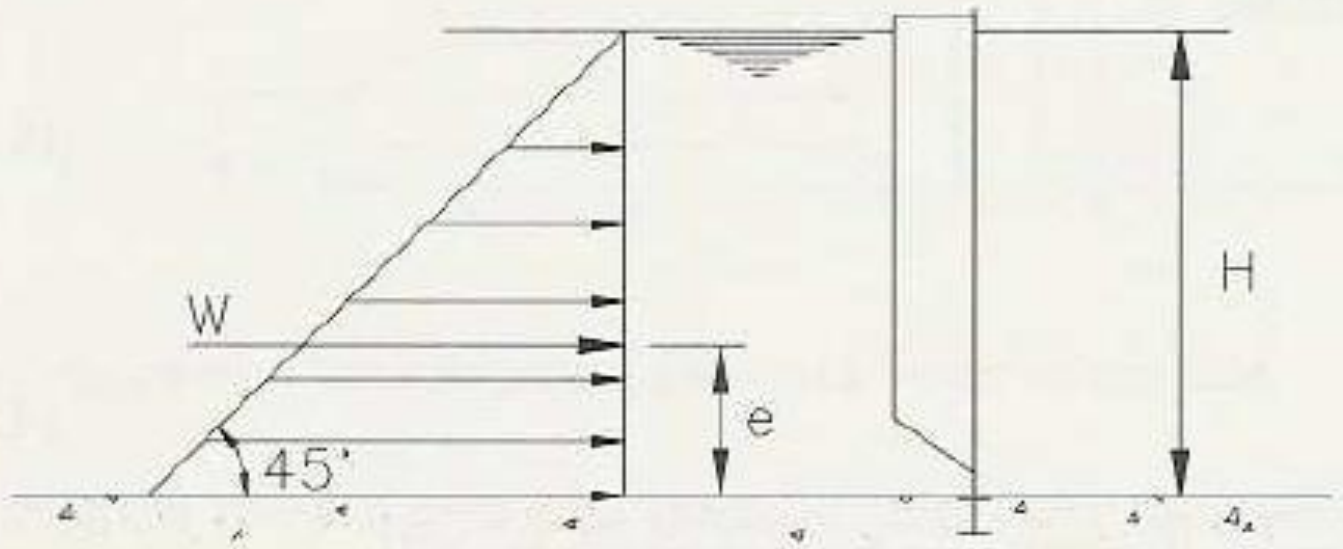


Fig. 4.1 Pressure diagram on flat weir gates with water on one side

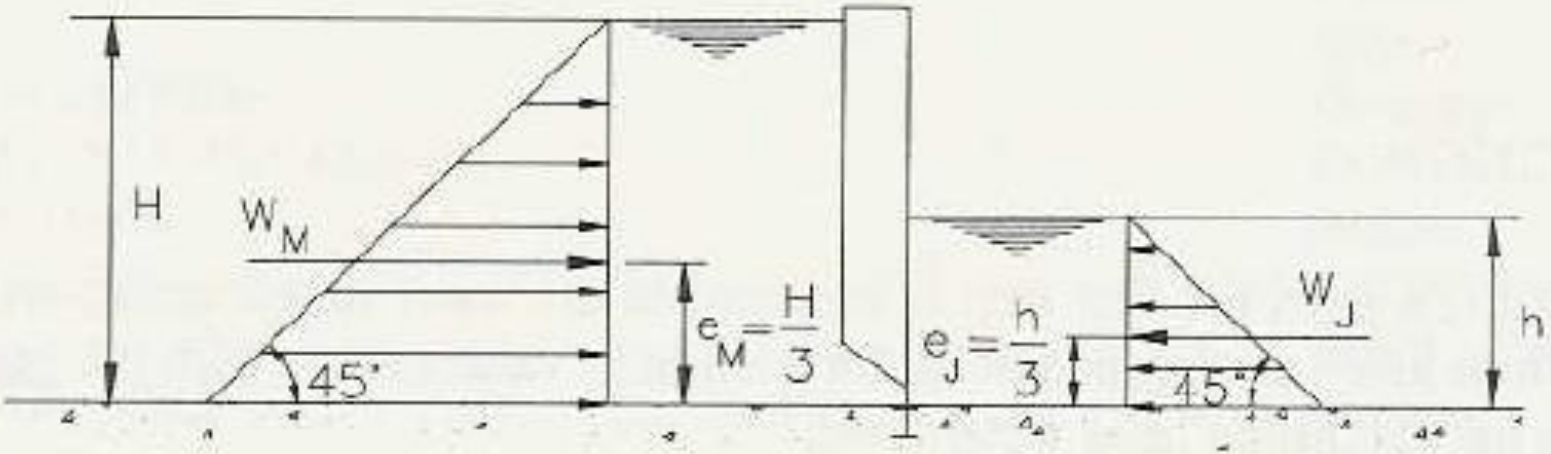


Fig. 4.2 Pressure diagram on flat weir gates with water on both sides

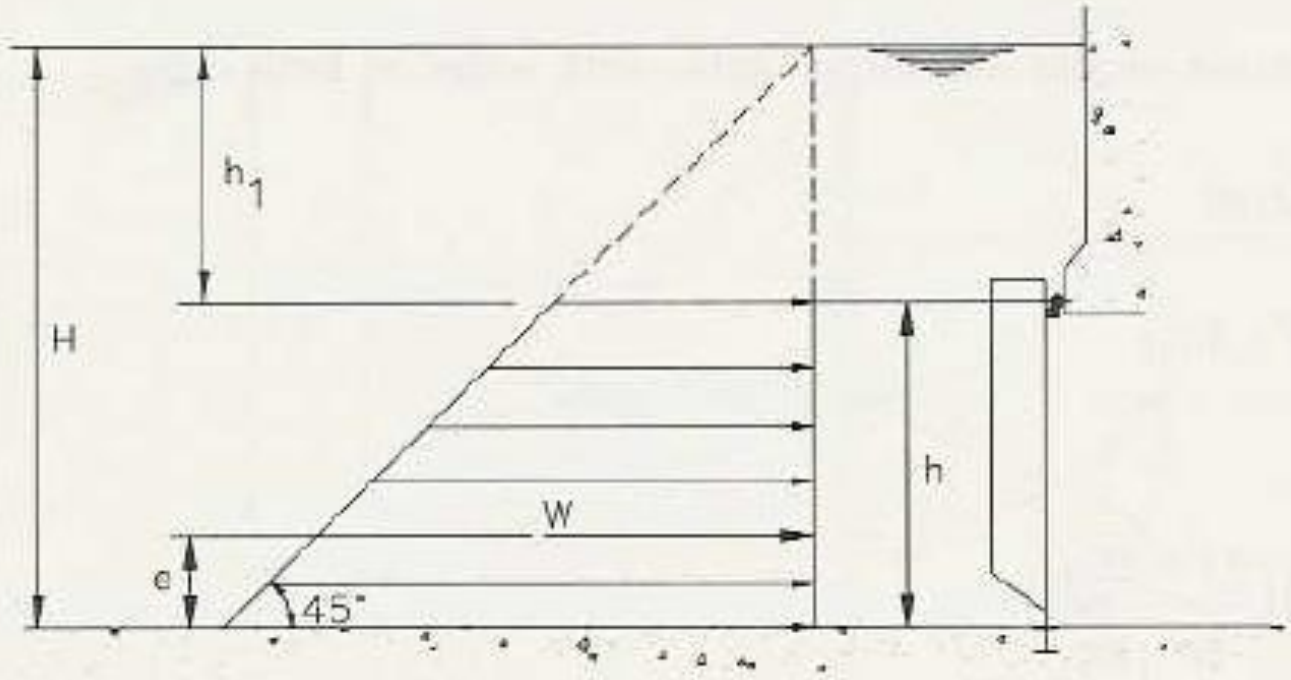


Fig. 4.3 Pressure diagram on flat submerged gates with water on one side

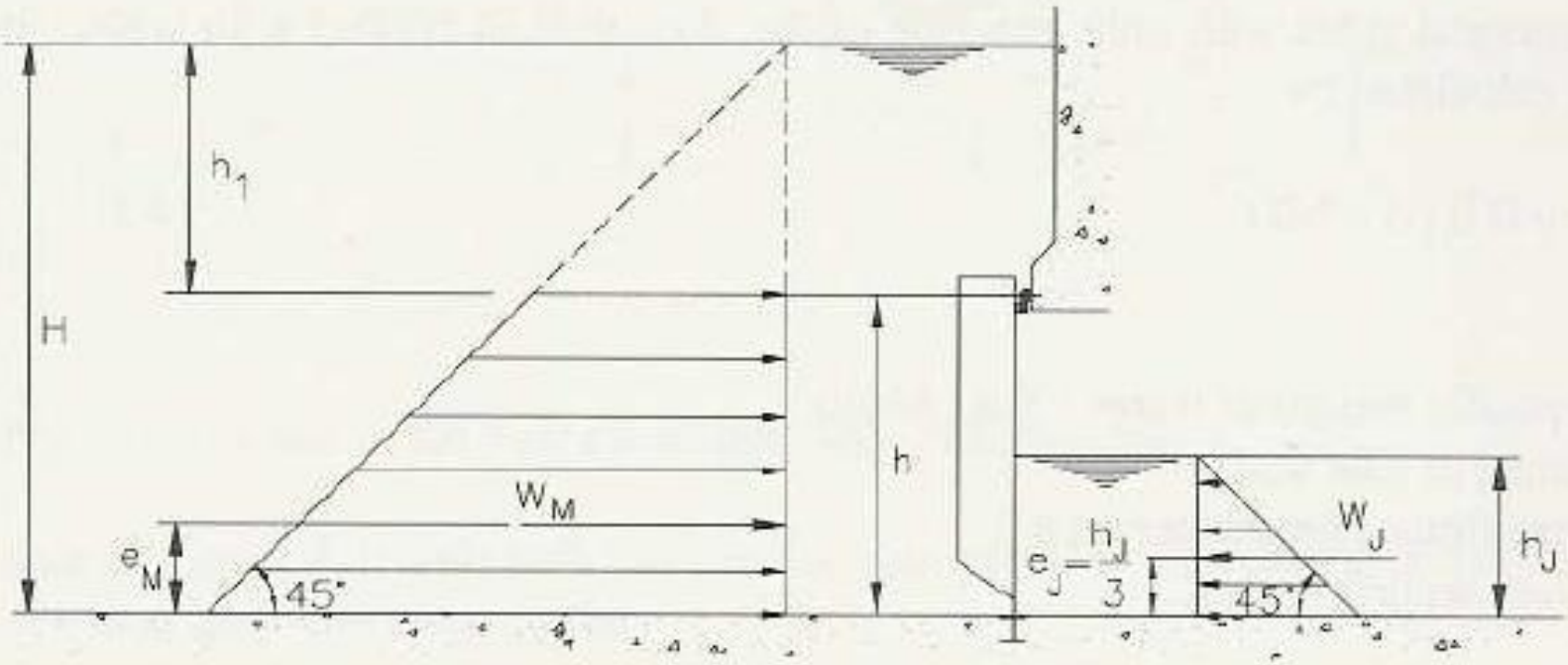


Fig. 4.4 Pressure diagram on flat submerged gates with water on both sides

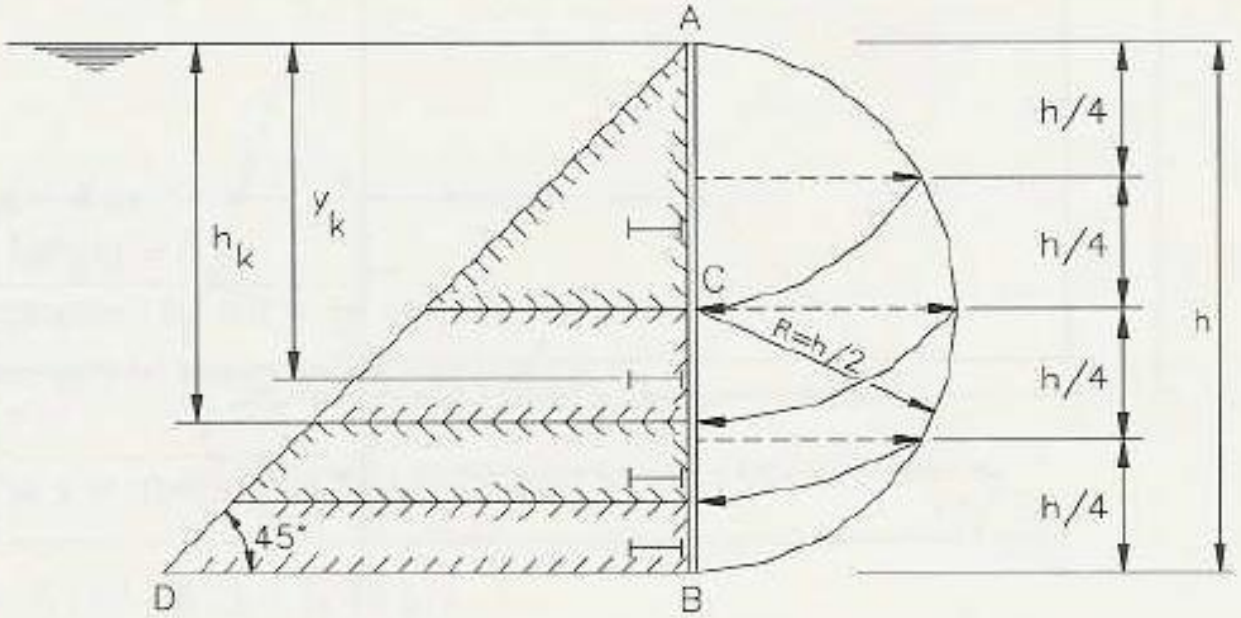


Fig. 4.5 Flat weir gates – Division of the pressure diagram in four equivalent areas

- depth h_k

$$h_k = h\sqrt{\frac{k}{n}} \qquad \text{(where } k = 1, 2, 3 \ldots, n)$$

- depth of the horizontal beams

$$y_k = \frac{2h}{3\sqrt{n}}\left[k^{3/2} - (k-1)^{3/2}\right]$$

where n is the quantity of beams or areas.

b) Submerged gates

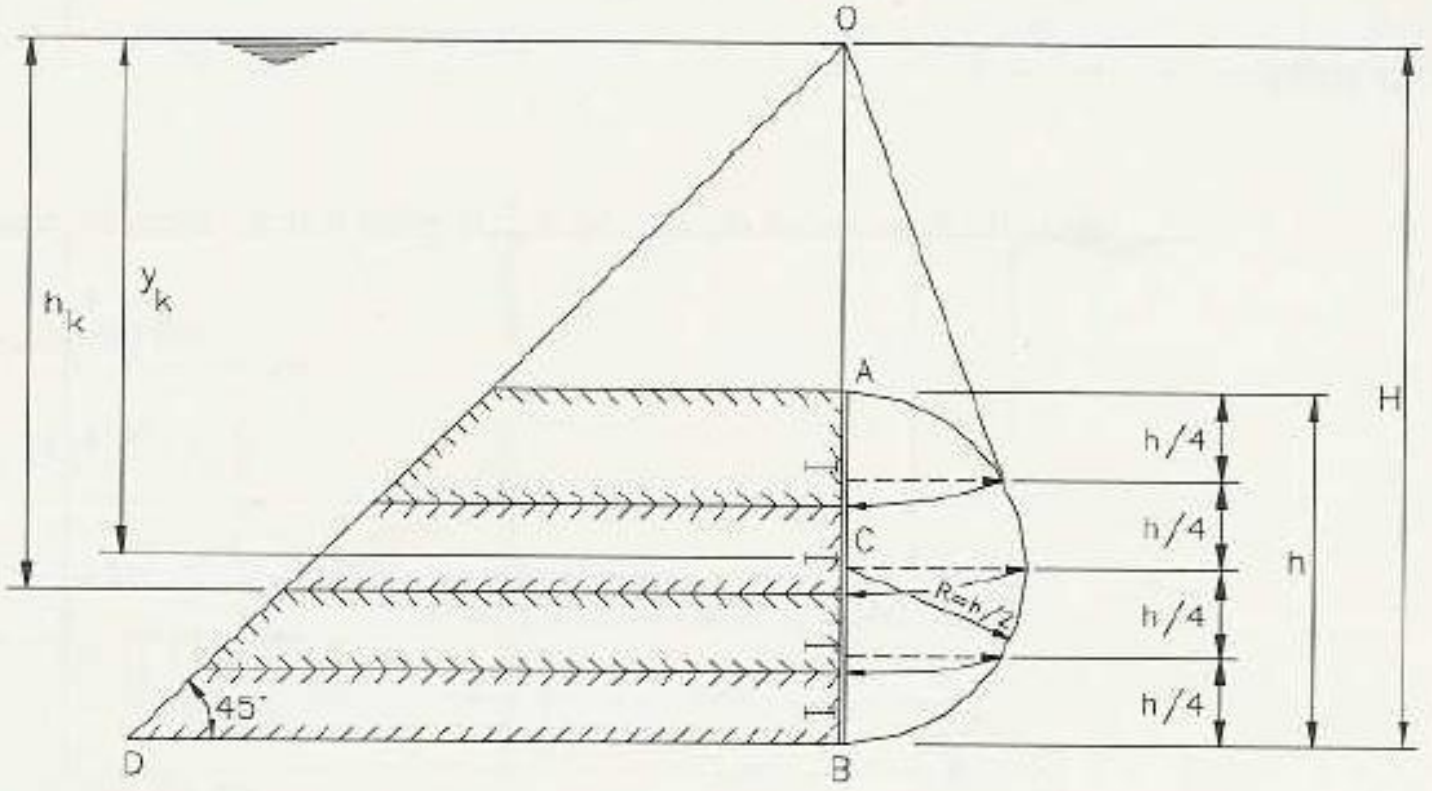


Fig. 4.6 Flat submerged gates – Division of the pressure diagram in four equivalent areas

- Depth h_k

$$h_k = H\sqrt{\frac{k+\beta}{n+\beta}} \qquad \text{(where } k = 1, 2, 3, \ldots, n\text{)}$$

where

$$\beta = \frac{n(H-h)^2}{H^2-(H-h)^2}$$

H = maximum headwater on sill
h = gate sealing height
n = quantity of areas (or beams)

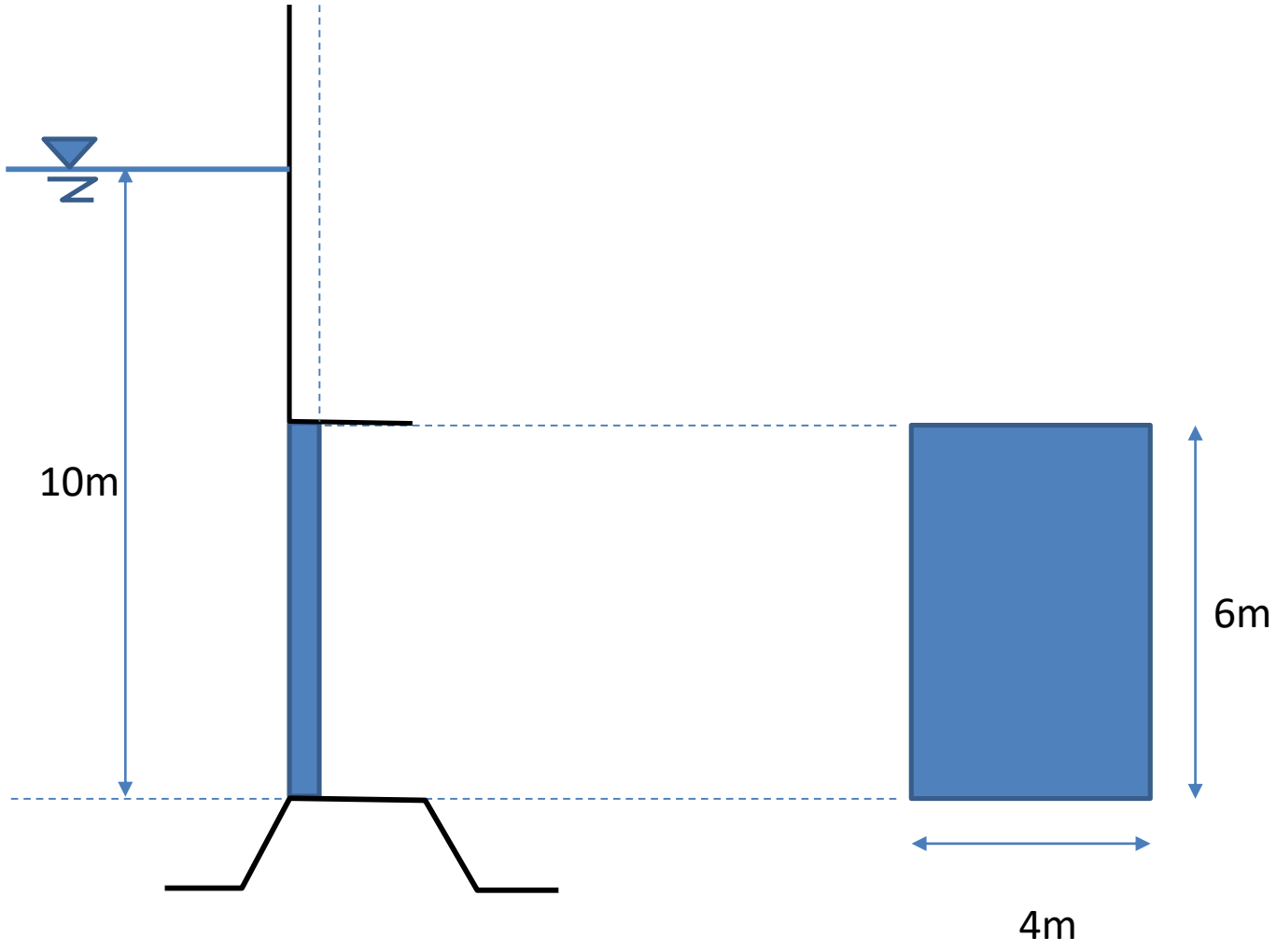
- position of horizontal beams

$$y_k = \frac{2H}{3\sqrt{n+\beta}}\left[(k+\beta)^{3/2} - (k-1+\beta)^{3/2}\right]$$

Example 4.1 A vertical lift gate 4 m wide by 6 m high has six equally loaded horizontal beams and is subjected to a headwater on the sill of 10 m. Determine the maximum water thrust on the gate and its position. Define the location of the horizontal beams.

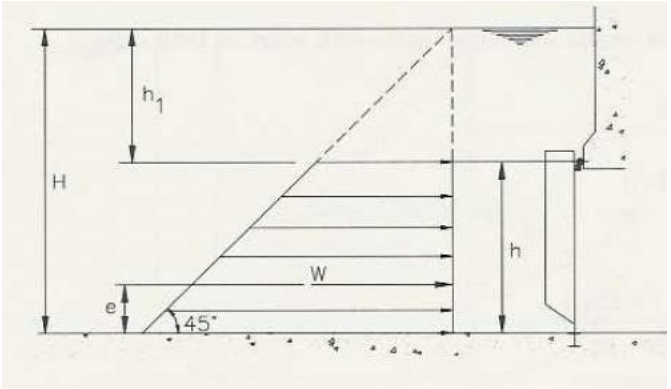
Solution:

B = gate span = 4 m
h = gate seal height = 6 m
H = max. headwater on sill = 10 m
γ = specific weight of water = 9.81 kN/m^3.


N
10m
6m
4m

- Gaya dorong akibat hidrostatik:

$$W = \gamma A y_c = 9{,}810 \times 6 \times 4 \times \left(10 - \frac{6}{2}\right) = 1648kN$$



- Jarak W dengan ambang/sill:

$$e = \left(\frac{H - h_1}{3}\right)\left(\frac{H + 2h_1}{H + h_1}\right) = \frac{6}{3}\frac{10 + 2 \times 4}{10 + 4} = 2{,}57m$$

- Hk,

$$\beta = \frac{n(H-h)^2}{H^2 - (H-h)^2} = \frac{6(10-6)^2}{10^2 - (10-6)^2} = 1{,}143$$

- Hk,

$$h_k = H\sqrt{\frac{k+\beta}{h+\beta}} = 10\frac{\sqrt{k+1,143}}{\sqrt{6+1,143}} = 3,742\sqrt{k+1,143}$$

$$h_1 = 3.742\,(1+1.1428)^{1/2} = 5.48\ \text{m}$$
$$h_2 = 3.742\,(2+1.1428)^{1/2} = 6.63\ \text{m}$$
$$h_3 = 3.742\,(3+1.1428)^{1/2} = 7.62\ \text{m}$$
$$h_4 = 3.742\,(4+1.1428)^{1/2} = 8.49\ \text{m}$$
$$h_5 = 3.742\,(5+1.1428)^{1/2} = 9.27\ \text{m}$$
$$h_6 = 3.742\,(6+1.1428)^{1/2} = 10\ \text{m}.$$

- Yk,

$$y_k = \frac{2x10}{3\sqrt{6+1.1428}}\left[(k+1.1428)^{3/2} - (k-1+1.1428)^{3/2}\right] =$$

$$= 2.494\left[(k+1.1428)^{3/2} - (k+0.1428)^{3/2}\right]$$

$$y_1 = 2.494\left[(1+1.1428)^{3/2} - (1+0.1428)^{3/2}\right] = 4.78\ \text{m}$$

$$y_2 = 6.07\ \text{m}$$
$$y_3 = 7.14\ \text{m}$$
$$y_4 = 8.06\ \text{m}$$
$$y_5 = 8.89\ \text{m}$$
$$y_6 = 9.64\ \text{m}.$$

b) Submerged gates

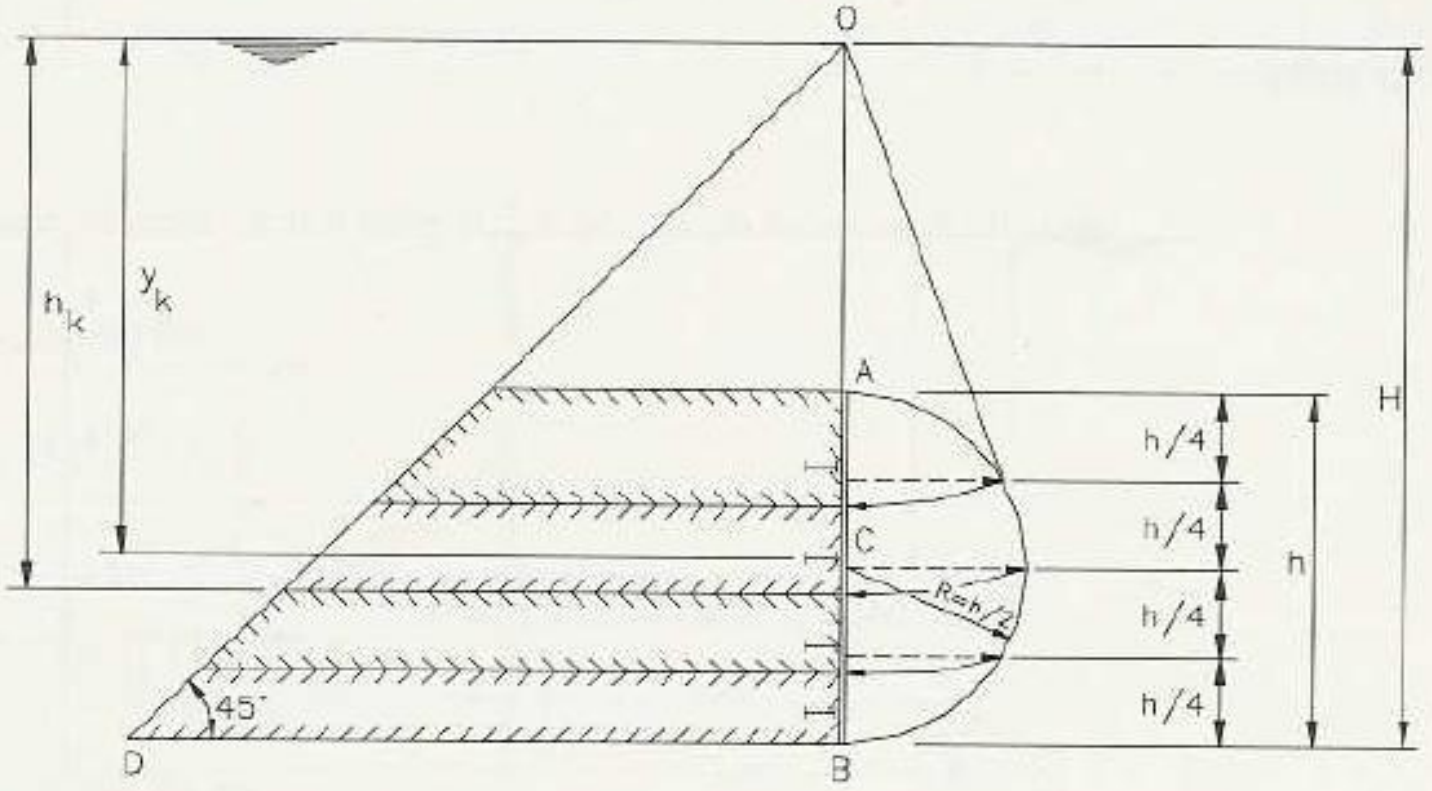


Fig. 4.6 Flat submerged gates – Division of the pressure diagram in four equivalent areas

Pustaka

- Paulo C. Erbisti, “Design of Hydraulic Gates”