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STANDARD DESIGN MANUAL

VOLUME-II: STANDARD DESIGN OF STRUCTURAL MEMBERS

PREPARED BY
STANDARD DESIGN MANUAL COMMITTEE

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INTRODUCTION

H.B/16

The Design offices of BWDB undertake design of huge number of hydraulic structures every year. The design of each of these structure requires computation involving much time and efforts. Most of the time for preparation of detail design report of a structure, structural member of same size and similar loading condition is designed repeatedly and included in the design report of each structure. In order to avoid these repetition and expedite the structural design by minimizing computational efforts, time for design computation and preparation of design report the "Standard Design of Structural Elements" has been prepared. This will provide the designers with design chart for structural members under usual loading condition.

This volume of Standard Design is prepared for the following Structural members of Regulators & Bridges.

Regulator

- Operating Deck.
- Head Wall.
- Extended portion of Abutment and pier.
- Barrel.
- Wing Wall.
- Return Wall.

Bridge

- Culvert
- Deck Slab.
- Girder.
- Traffic Bridge.

This volume of "Standard Design of Structural Elements" will guide BWDB Design Engineers in designing the above structures or components thereof under specified loading condition. In case of special loading conditions or other situations not accounted for, designers have to design the structures individually.

The operating deck on which the gate hoisting equipments rest and from which gates are operated is designed for the following loading conditions.

- A design concentrated load consisting of weight of gate, hoist and hoisting load are considered at the centre of deck slab. In case of lift gate, this load is considered equally shared by the head wall & deck slab.
- The weight of gate, hoist and hoisting load for regulators of 600X900, 900X1200, 1200X1500, 1500X1800 & 1800X2400 are taken as 1 ton, 1.36 ton, 2.06 ton, 2.97 ton and 3.86 ton respectively.
- A uniform live load of 12.0 KN/m² is also added with the concentrated load.

In most of the cases for small vent opening the temperature reinforcement govern the design of operating deck and headwall.

Headwall is designed as a face slab supported by extended part of abutment and pier and is considered fixed at the bottom with top slab of barrel. The headwall is designed following Huntington's design procedure. A surcharge equal to 0.9m height of earth is considered in addition to the horizontal earth pressure due to backfill soil.

The reinforcement details and other member details of Operating Deck and Head Wall are presented in Art 1.0 and Art 2.0 respectively.

The extended part of abutment is designed as a plate fixed at two ends i.e. at vertical side with headwall and bottom with base slab. For low walls of backfill height less than 2.0m, the wall is designed as simple cantilever slab. Details are furnished in Art. 3.0.

Extended part of pier is also designed as plate details of which are furnished in Art. 4.0.

The barrel is designed as box culvert with earth pressure co-efficient at rest. The top slab is subjected to earth pressure and live load. The side walls are subjected to earth pressure with a surcharge load equal to 0.9m height of earth and uniform foundation pressure is considered at the base of the barrel. With above loading conditions moments for different members are computed by the method of moment distribution. The details of reinforcement and member thickness are shown in Art. 5.0.

The wingwalls are designed as U-frame vertical retaining wall with co-efficient of active earth pressure. The details of wing walls are presented in Art 6.0.

The return walls are also designed as vertical cantilever wall with active earth pressure co-efficient, details of which are shown in Art 7.0.

The box culvert is designed with H_{20} loading and earth pressure co-efficient at rest. The details are presented in Art. 8.0.

For pedestrian bridge a uniformly distributed load of 4 KN/m is considered. The details of which is presented in Art. 9.1.

The load for light traffic, medium traffic and all traffic bridges are considered as (H_{10}, H_{15}) , $(H_{15} \& H_{20})$ and H_{20} respectively. The reinforcement details of which are shown in Art. 9.2 to Art. 9.5.

For the design of all the above components, f'_c is taken as 18.0 N/mm² and f_s as 124 N/mm². The unit weight of soil is considered as 18.9 KN/m³.

RCC pipes are designed as per AASHTO MS18 loading with $f'_c = 25.0$ N/mm² and $f_y = 276$ N/mm². Pipes upto 750mm dia is designed considering single layer reinforcement and from 900mm to 1350mm dia is designed considering 2(two) layers of reinforcement. The details are presented in Art. 10.0.

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1.0 STRUCTURAL DESIGN OF OPERATING DECK

1.1 Operating Deck - 1 vent

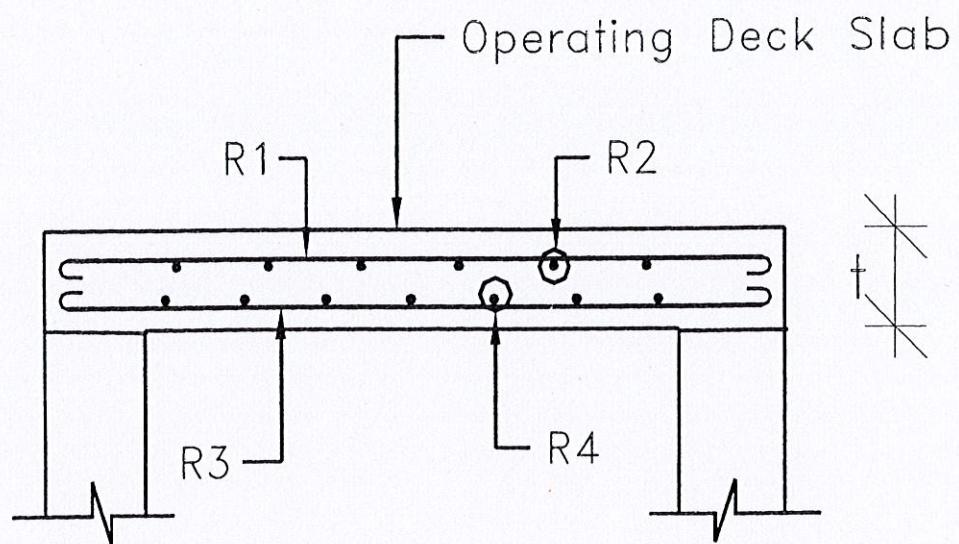


Table No. (Reference Fig.)

Vent Size	Slab thickness t in mm	Reinforcement R1	Reinforcement R2	Reinforcement R3	Reinforcement R4
600x900	225	D 12 @ 250	D 12 @ 250	D 12 @ 300	D 12 @ 300
900x1200	225	D 12 @ 250	D 12 @ 250	D 12 @ 300	D 12 @ 300
1200x1500	225	D 12 @ 250	D 12 @ 250	D 12 @ 300	D 12 @ 300
1500x1800	225	D 12 @ 200	D 12 @ 250	D 12 @ 225	D 12 @ 300
1800x2400	225	D 12 @ 150	D 12 @ 250	D 12 @ 150	D 12 @ 300

* All reinforcing bar diameter and bar spacing are in millimeter

1.2 Operating Deck - 2 Vents

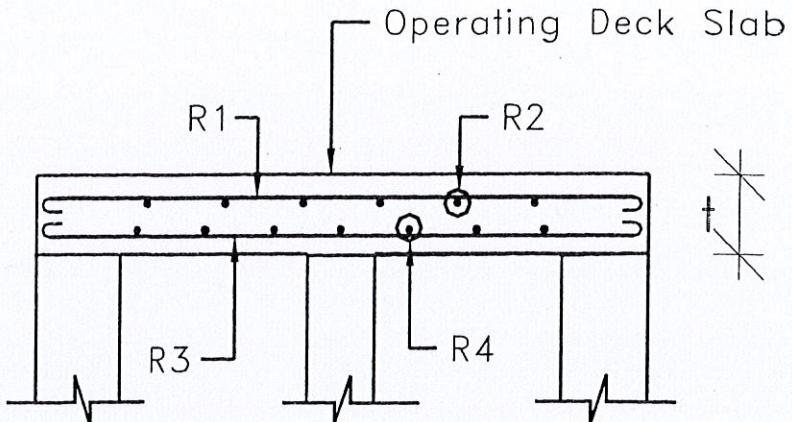


Table No. (Reference fig.)

Vent Size	Slab thickness t in mm	Reinforcement R1	Reinforcement R2	Reinforcement R3	Reinforcement R4
900x1200	225	D 12 @ 250	D 12 @ 250	D 12 @ 300	D 12 @ 300
1200x1500	225	D 12 @ 250	D 12 @ 250	D 12 @ 300	D 12 @ 300
1500x1800	225	D 12 @ 200	D 12 @ 250	D 12 @ 250	D 12 @ 300
1800x2400	225	D 12 @ 150	D 12 @ 250	D 12 @ 150	D 12 @ 300

* All reinforcing bar diameter and bar spacing are in millimeter

1.3 Operating Deck - 3 Vents

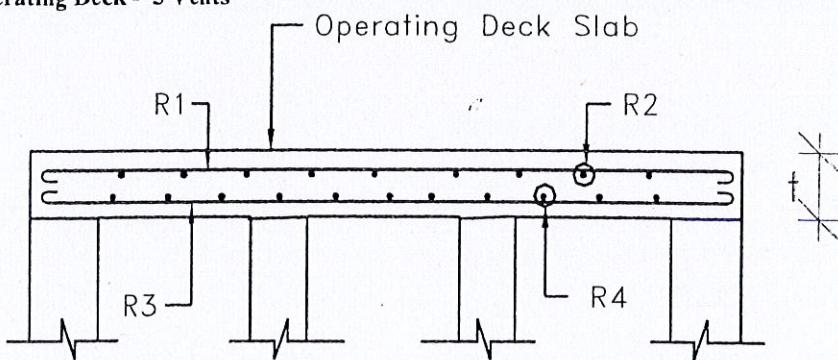


Table No. (Reference fig.)

Vent Size	Slab thickness t in mm	Reinforcement R1	Reinforcement R2	Reinforcement R3	Reinforcement R4
1500x1800	225	D 12 @ 225	D 12 @ 250	D 12 @ 225	D 12 @ 300
1800x2400	225	D 12 @ 150	D 12 @ 250	D 12 @ 150	D 12 @ 300

* All reinforcing bar diameter and bar spacing are in millimeter

2.0 STRUCTURAL DESIGN OF HEAD WALL

2.1 Horizontal earth fill, $\phi = 20^\circ$, Vent size : (600x900), 1 vent

Width of the vent : 600 mm
 γ (moist) : 18.9 KN/m³

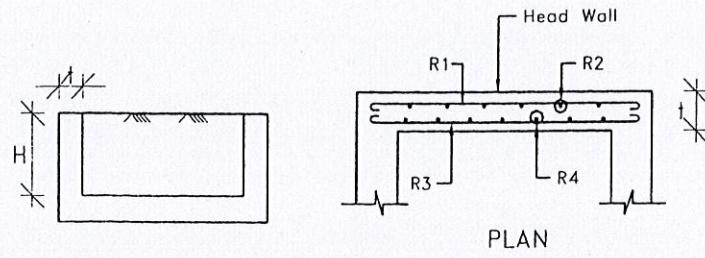


Fig.

Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1 & R3 horizontal reinforcement	R2 & R4 vertical reinforcement
500	150	D 12 @ 300	D 12 @ 300
750	150	D 12 @ 300	D 12 @ 300
1000	150	D 12 @ 300	D 12 @ 300
1250	150	D 12 @ 300	D 12 @ 300
1500	150	D 12 @ 300	D 12 @ 300
1750	150	D 12 @ 300	D 12 @ 300
2000	150	D 12 @ 300	D 12 @ 300
2250	150	D 12 @ 300	D 12 @ 300
2500	150	D 12 @ 300	D 12 @ 300
2750	150	D 12 @ 300	D 12 @ 300
3000	150	D 12 @ 300	D 12 @ 300
3250	150	D 12 @ 300	D 12 @ 300
3500	150	D 12 @ 300	D 12 @ 300
3750	150	D 12 @ 300	D 12 @ 300
4000	150	D 12 @ 300	D 12 @ 300

* All reinforcing bar diameter and bar spacing are in millimeter

2.2 Head wall : Horizontal earth fill, $\phi = 20^\circ$, Vent size : (900x1200), Upto 2 vent

Width of the vent : 900 mm
 γ (moist) : 18.9 KN/m³

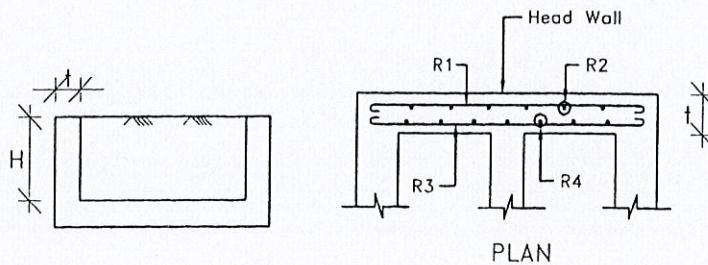


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
4000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250

* All bar diameter and bar spacing are in millimeter

2.3 Head wall : Horizontal earth fill, $\phi = 20^\circ$, Vent size : (1200x1500), Upto 2 vents

Width of the vent : 1200 mm
 γ (moist) : 18.9 KN/m³

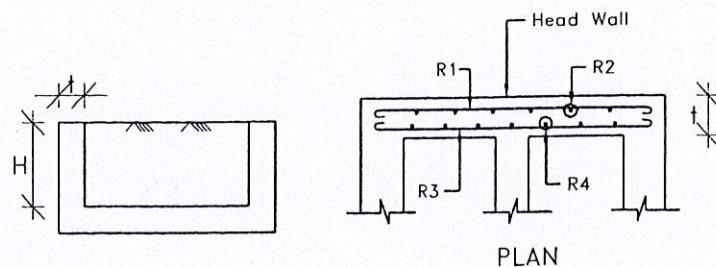


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement exposed face	R4, vertical reinforcement exposed face
500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
✓ 2750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
4000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225

* All reinforcing bar diameter and bar spacing are in millimeter

2.4 Head wall : Horizontal earth fill, $\phi = 20^\circ$, Vent size : (1500x1800), Upto 3 vents

Width of the vent : 1500 mm
 γ (moist) : 18.9 KN/m³

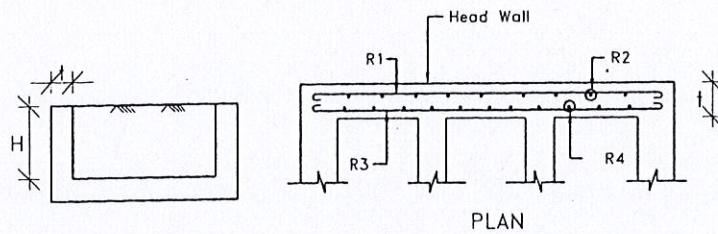


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3.00	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3.25	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3.50	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
4000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180

* All reinforcing bar diameter and bar spacing are in millimeter

2.5 Head wall : Horizontal earth fill, $\phi = 20^\circ$, Vent size : (1800x2400), Upto 3 vents

Width of the vent: 1800 mm
 γ (moist) : 18.9 KN/m³

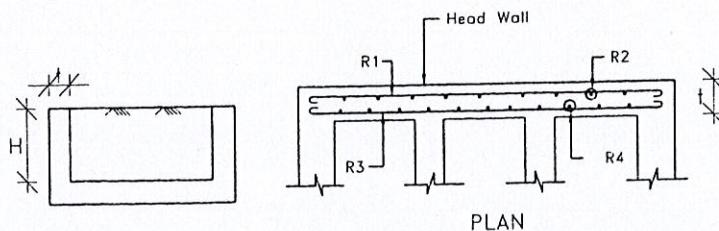
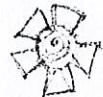


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
4000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180

* All reinforcing bar diameter and bar spacing are in millimeter



2.6 Head wall : Horizontal earth fill, $\phi = 25^\circ$, Vent size : (600x900), 1 vent

Width of the vent : 600 mm
 γ (moist) : 18.9 KN/m³

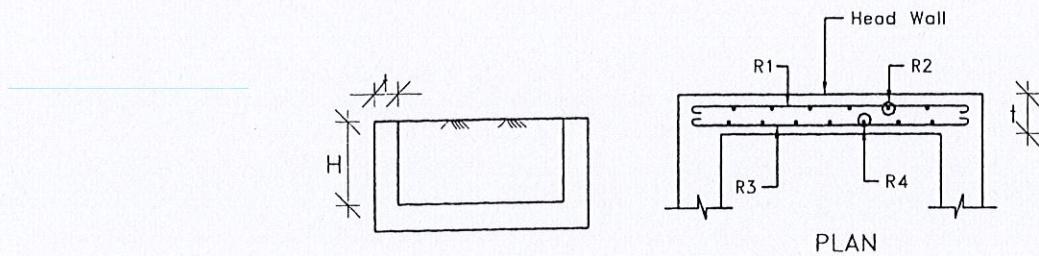


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1 & R3 horizontal reinforcement	R2 & R4 vertical reinforcement
500	150	D 12 @ 300	D 12 @ 300
750	150	D 12 @ 300	D 12 @ 300
1000	150	D 12 @ 300	D 12 @ 300
1250	150	D 12 @ 300	D 12 @ 300
1500	150	D 12 @ 300	D 12 @ 300
1750	150	D 12 @ 300	D 12 @ 300
2000	150	D 12 @ 300	D 12 @ 300
2250	150	D 12 @ 300	D 12 @ 300
2500	150	D 12 @ 300	D 12 @ 300
2750	150	D 12 @ 300	D 12 @ 300
3000	150	D 12 @ 300	D 12 @ 300
3250	150	D 12 @ 300	D 12 @ 300
3500	150	D 12 @ 300	D 12 @ 300
3750	150	D 12 @ 300	D 12 @ 300
4000	150	D 12 @ 300	D 12 @ 300

* All reinforcing bar diameter and bar spacing are in millimeter

2.7 Head wall : Horizontal earth fill, $\phi = 25^\circ$, Vent size : (900x1200), Upto 2 vents

Width of the vent : 900 mm
 γ (moist) : 18.9 KN/m³

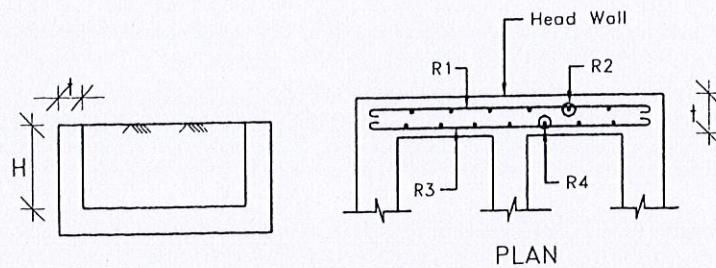


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
3750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
4000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.8 Head wall : Horizontal earth fill, $\phi = 25^\circ$, Vent size : (1200x1500), Upto 2 vents

Width of the vent : 1200 mm
 γ (moist) : 18.9 KN/m³

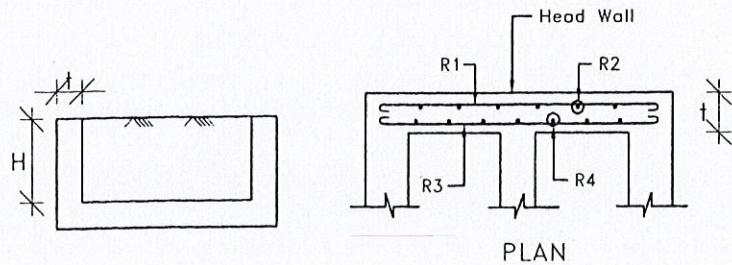


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
3750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
4000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225

* All reinforcing bar diameter and bar spacing are in millimeter

2.9 Head wall : Horizontal earth fill, $\phi = 25^\circ$, Vent size : (1500x1800), Upto 3 vents

Width of the vent : 1500 mm
 γ (moist) : 18.9 KN/m³

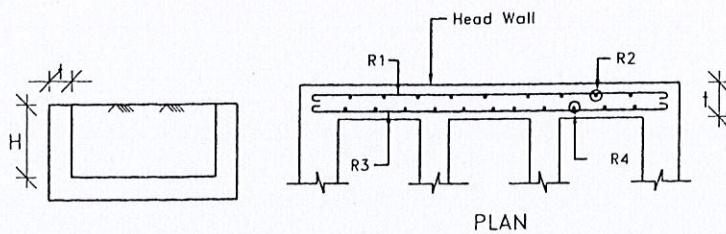


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
4000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180

* All reinforcing bar diameter and bar spacing are in millimeter

2.10 Head wall : Horizontal earth fill, $\phi = 25^\circ$, Vent size : (1800x2400), Upto 3 vents

Width of the vent : 1800 mm
 γ (moist) : 18.9 KN/m³

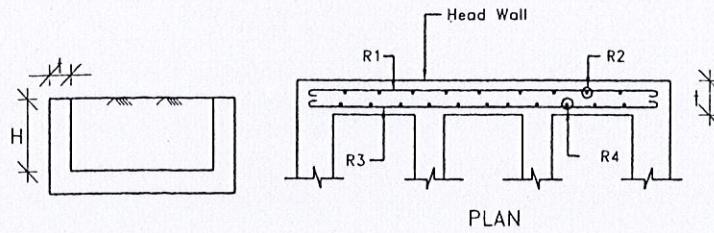


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3250	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3500	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
3750	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180
4000	300	D 12 @ 300	D 12 @ 300	D 12 @ 180	D 12 @ 180

* All reinforcing bar diameter and bar spacing are in millimeter

2.11 Head wall : Inclined earth fill, $\phi = 20^\circ$, Vent size : (600x900), 1 vent

Width of the vent : 600 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

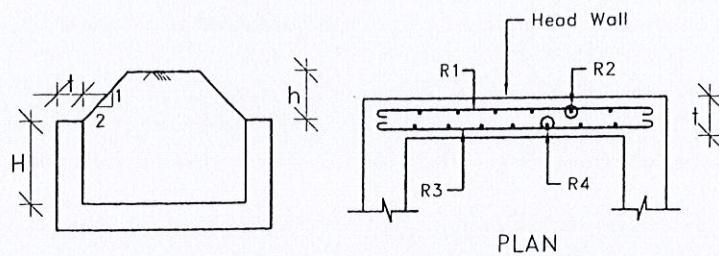


Table No. (Reference fig.)

Height of head wall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
3000	375	D 12 @ 300	D 12 @ 300	D 16 @ 250	D 16 @ 250
3250	375	D 12 @ 300	D 12 @ 300	D 16 @ 250	D 16 @ 250
3500	400	D 12 @ 300	D 12 @ 275	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.12 Head wall : Inclined earth fill, $\phi = 20^\circ$, Vent size : (900x1200), Upto 2 vents

Width of the vent : 900 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

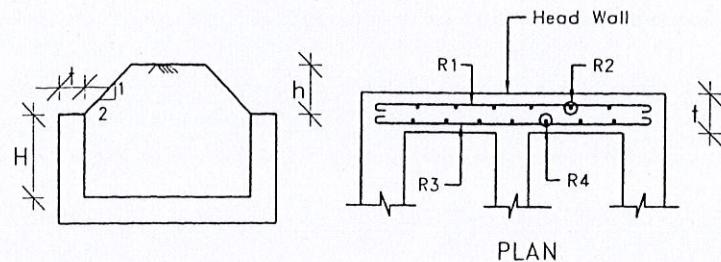


Table No. (Reference fig.)

Height of the head wall H in mm	Thickness t in mm	R1, horizontal reinforcement adjacent to earth face	R2, vertical reinforcement adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
3000	375	D 12 @ 300	D 12 @ 300	D 16 @ 250	D 16 @ 250
3250	375	D 12 @ 300	D 12 @ 237	D 16 @ 250	D 16 @ 250
3500	400	D 12 @ 300	D 12 @ 200	D 12 @ 275	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.13 Head wall : Inclined earth fill, $\phi = 20^\circ$, Vent size : (1200x1500), Upto 2 vents

Width of the vent : 1200 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

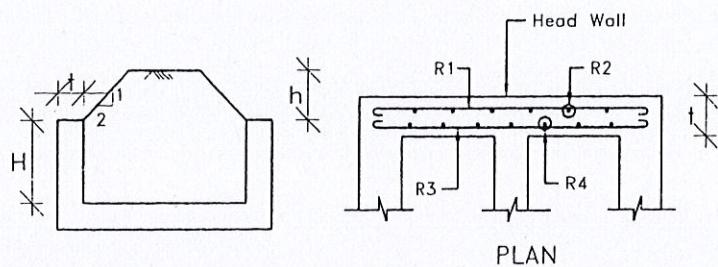


Table No. (Reference fig.)

Height of the headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement at exposed face	R4, vertical reinforcement at exposed face
500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2250	250	D 12 @ 250	D 12 @ 300	D 12 @ 225	D 12 @ 225
2500	250	D 12 @ 200	D 12 @ 225	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 225	D 12 @ 225	D 12 @ 175	D 12 @ 175
3000	375	D 12 @ 250	D 12 @ 250	D 16 @ 250	D 16 @ 250
3250	375	D 12 @ 225	D 12 @ 200	D 16 @ 250	D 16 @ 250
3500	400	D 12 @ 225	D 12 @ 175	D 12 @ 275	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.14 Head wall : Inclined earth fill, $\phi = 20^\circ$, Vent size : (1500x1800), Upto 3 vents

Width of the vent : 1500 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

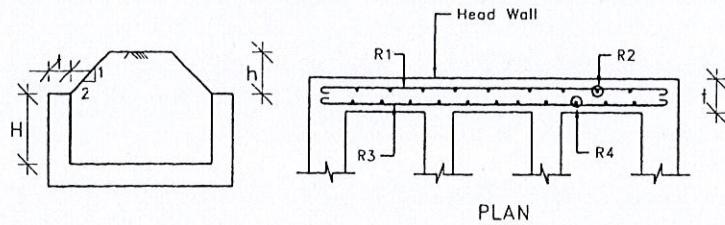


Table No. (Reference fig.)

Height of headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
2000	300	D 12 @ 250	D 12 @ 300	D 12 @ 175	D 12 @ 175
2250	300	D 16 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
2500	300	D 16 @ 300	D 12 @ 250	D 12 @ 150	D 12 @ 175
2750	300	D 16 @ 300	D 12 @ 200	D 12 @ 150	D 12 @ 175
3000	375	D 16 @ 300	D 12 @ 200	D 16 @ 250	D 16 @ 250
3250	375	D 16 @ 300	D 16 @ 300	D 16 @ 250	D 16 @ 250
3500	400	D 16 @ 275	D 16 @ 250	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.15 Head wall : Inclined earth fill, $\phi = 20^\circ$, Vent size : (1800x2400), Upto 3 vents

Width of the vent : 1800 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

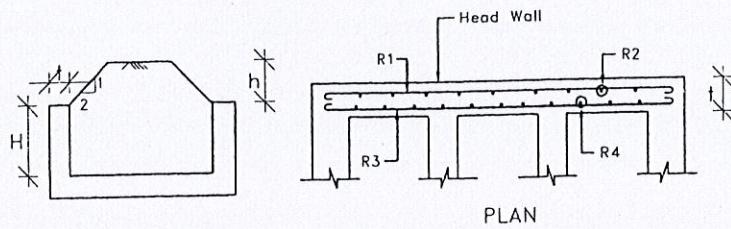


Table No. (Reference fig.)

Height of headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1750	300	D 12 @ 225	D 12 @ 300	D 12 @ 175	D 12 @ 175
2000	300	D 16 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
2250	300	D 16 @ 300	D 12 @ 275	D 12 @ 150	D 12 @ 175
2500	300	D 16 @ 250	D 16 @ 300	D 16 @ 250	D 12 @ 175
2750	300	D 16 @ 200	D 16 @ 300	D 16 @ 225	D 12 @ 175
3000	375	D 16 @ 250	D 16 @ 300	D 16 @ 250	D 16 @ 250
3250	375	D 16 @ 225	D 16 @ 250	D 16 @ 250	D 16 @ 250
3500	400	D 16 @ 200	D 16 @ 250	D 16 @ 200	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.16 Head wall : Inclined earth fill, $\phi = 25^\circ$, Vent size : (600x900), 1 vent

Width of the vent	: 600 mm
Earth fill, h	: 1000 mm
Surcharge	: 9 00 mm
γ (moist)	: 18.9 KN/m ³

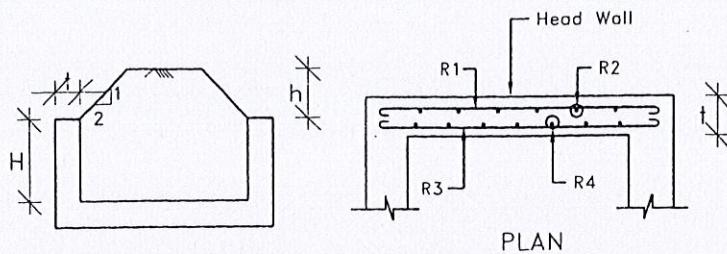


Table No. (Reference fig.)

Height of head wall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
3000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
3250	375	D 12 @ 300	D 12 @ 300	D 16 @ 250	D 16 @ 250
3500	375	D 12 @ 300	D 12 @ 275	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.17 Head wall : Inclined earth fill, $\phi = 25^\circ$, Vent size : (900x1200), Upto 2 vents

Width of the vent : 900 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

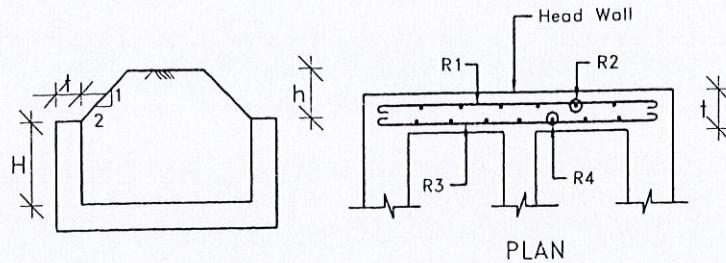


Table No. (Reference fig.)

Height of head wall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1500	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
1750	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2000	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2250	225	D 12 @ 300	D 12 @ 300	D 12 @ 250	D 12 @ 250
2500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
3000	375	D 12 @ 300	D 12 @ 300	D 16 @ 250	D 16 @ 250
3250	375	D 12 @ 300	D 12 @ 237	D 16 @ 250	D 16 @ 250
3500	400	D 12 @ 300	D 12 @ 200	D 12 @ 275	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.18 Head wall : Inclined earth fill, $\phi = 25^\circ$, Vent size : (1200x1500), Upto 2 vents

Width of the vent : 1200 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

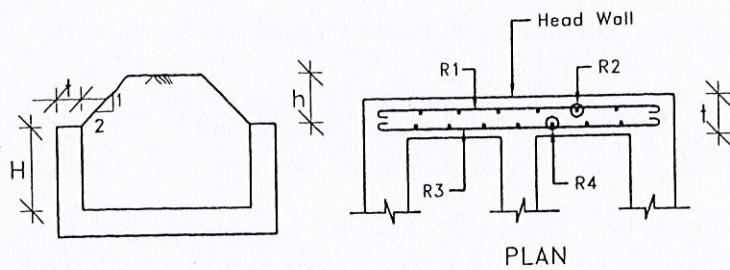


Table No. (Reference fig.)

Height of headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1250	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1500	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
1750	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2000	250	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225
2250	250	D 12 @ 250	D 12 @ 300	D 12 @ 225	D 12 @ 225
2500	250	D 12 @ 200	D 12 @ 225	D 12 @ 225	D 12 @ 225
2750	300	D 12 @ 225	D 12 @ 225	D 12 @ 175	D 12 @ 175
3000	375	D 12 @ 250	D 12 @ 250	D 16 @ 250	D 16 @ 250
3250	375	D 12 @ 225	D 12 @ 200	D 16 @ 250	D 16 @ 250
3500	400	D 12 @ 225	D 12 @ 175	D 12 @ 275	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.19 Head wall : Inclined earth fill, $\phi = 25^\circ$, Vent size : (1500x1800), Upto 3 vents

Width of the vent : 1500 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

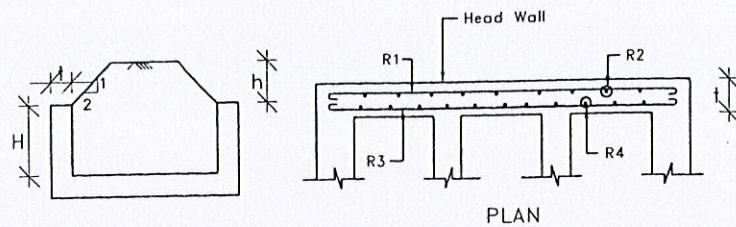


Table No. (Reference fig.)

Height of headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
2000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
2250	300	D 12 @ 200	D 12 @ 300	D 12 @ 175	D 12 @ 175
2500	300	D 12 @ 175	D 12 @ 275	D 12 @ 175	D 12 @ 175
2750	300	D 12 @ 150	D 12 @ 200	D 12 @ 175	D 12 @ 175
3000	300	D 12 @ 187	D 12 @ 187	D 12 @ 150	D 12 @ 175
3250	375	D 12 @ 150	D 12 @ 175	D 16 @ 250	D 16 @ 250
3500	375	D 16 @ 275	D 12 @ 137	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

2.20 Head wall : Inclined earth fill, $\phi = 25^\circ$, Vent size : (1800x2400), Upto 3 vents

Width of the vent : 1800 mm
 Earth fill, h : 1000 mm
 Surcharge : 900 mm
 γ (moist) : 18.9 KN/m³

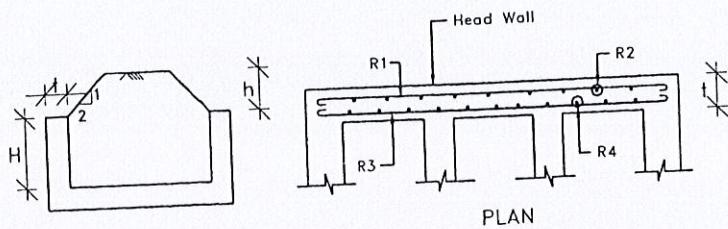


Table No. (Reference fig.)

Height of headwall H in mm	Thickness t in mm	R1, horizontal reinf. adjacent to earth face	R2, vertical reinf. adjacent to earth face	R3, horizontal reinforcement, exposed face	R4, vertical reinforcement, exposed face
500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
750	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1000	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1250	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1500	300	D 12 @ 300	D 12 @ 300	D 12 @ 175	D 12 @ 175
1750	300	D 12 @ 250	D 12 @ 300	D 12 @ 175	D 12 @ 175
2000	300	D 12 @ 225	D 12 @ 300	D 12 @ 175	D 12 @ 175
2250	300	D 12 @ 200	D 12 @ 300	D 12 @ 175	D 12 @ 175
2500	300	D 16 @ 162	D 12 @ 237	D 12 @ 150	D 12 @ 175
2750	300	D 16 @ 237	D 12 @ 175	D 16 @ 225	D 12 @ 175
3000	300	D 16 @ 200	D 12 @ 162	D 16 @ 200	D 13 @ 175
3250	375	D 16 @ 250	D 16 @ 275	D 16 @ 250	D 16 @ 250
3500	375	D 16 @ 200	D 16 @ 225	D 16 @ 200	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

3.0 STRUCTURAL DESIGN OF EXTENDED PORTION OF ABUTMENT

3.1 Extended portion of Abutment, $\phi = 20^\circ$

Unit weight of soil, γ (moist) : 18.9 KN/m³

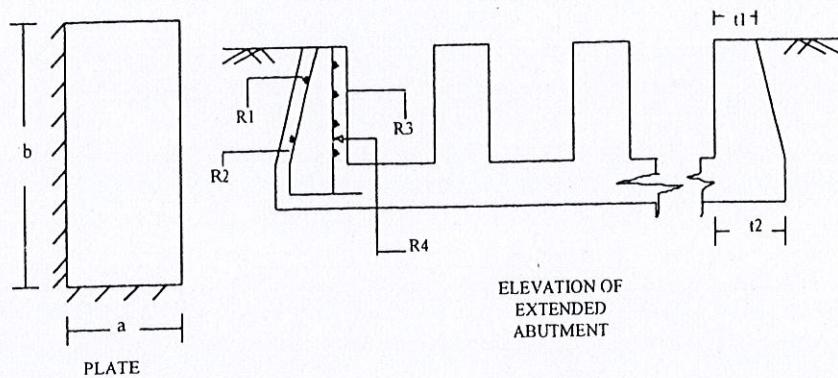


Table No. (Reference fig.)

Height b in mm	Length a in mm	Top thickness t ₁ in mm	Bottom thickness t ₂ in mm	R1, horizontal reinf. at earth face	R2, vertical reinf. at earth face	R3, horizontal temperature reinf. at exposed face	R4, vertical temperature reinf. at exposed face
3000	1500	250	300	D 12 @ 175	D 12 @ 125	D 12 @ 175	D 12 @ 175
3300	1500	250	300	D 12 @ 150	D 12 @ 125	D 12 @ 175	D 12 @ 175
3600	1500	250	300	D 12 @ 125	D 16 @ 150	D 12 @ 175	D 12 @ 175
3900	1500	250	300	D 12 @ 100	D 16 @ 125	D 12 @ 175	D 12 @ 175
4200	1500	250	300	D 12 @ 125	D 16 @ 175	D 12 @ 175	D 12 @ 175
4500	1500	250	350	D 12 @ 125	D 16 @ 175	D 16 @ 275	D 12 @ 150
4800	1500	250	350	D 16 @ 200	D 16 @ 150	D 16 @ 275	D 12 @ 150
5100	1500	250	400	D 16 @ 200	D 16 @ 150	D 16 @ 250	D 16 @ 250
5400	1500	250	450	D 16 @ 200	D 16 @ 150	D 16 @ 250	D 16 @ 250
5700	1500	250	450	D 16 @ 175	D 16 @ 125	D 16 @ 250	D 16 @ 250
6000	1500	250	500	D 16 @ 225	D 16 @ 150	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

3.2 Extended portion of Abutment, $\phi = 25^\circ$

Unit weight of soil, γ (moist) : 18.9 KN/m³

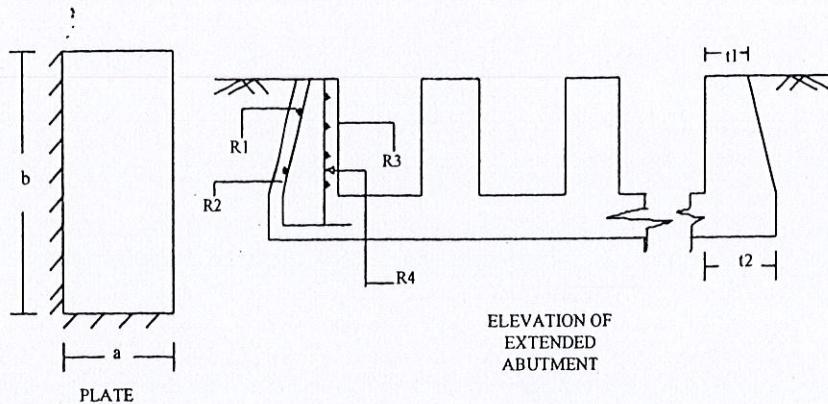


Table No. (Reference fig.)

Height b in mm	Length a in mm	Top thickness t ₁ in mm	Bottom thickness t ₂ in mm	R1, horizontal reinf. earth face	R2, vertical reinf. at earth face	R3, horizontal temperature reinf. exposed face	R4, vertical temperature reinf. exposed face
3000	1500	250	300	D 12 @ 200	D 12 @ 150	D 12 @ 175	D 12 @ 175
3300	1500	250	300	D 12 @ 200	D 12 @ 150	D 12 @ 175	D 12 @ 175
3600	1500	250	300	D 12 @ 150	D 16 @ 175	D 12 @ 175	D 12 @ 175
3900	1500	250	300	D 12 @ 125	D 16 @ 150	D 12 @ 175	D 12 @ 175
4200	1500	250	300	D 12 @ 150	D 16 @ 200	D 12 @ 175	D 12 @ 175
4500	1500	250	350	D 12 @ 150	D 16 @ 175	D 16 @ 275	D 16 @ 250
4800	1500	250	350	D 16 @ 125	D 16 @ 175	D 16 @ 275	D 16 @ 250
5100	1500	250	400	D 16 @ 225	D 16 @ 175	D 16 @ 250	D 16 @ 250
5400	1500	250	450	D 16 @ 225	D 16 @ 175	D 16 @ 250	D 16 @ 250
5700	1500	250	450	D 16 @ 200	D 16 @ 150	D 16 @ 250	D 16 @ 250
6000	1500	250	500	D 16 @ 275	D 16 @ 200	D 16 @ 250	D 16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

4.0 STRUCTURAL DESIGN OF EXTENDED PORTION OF PIER

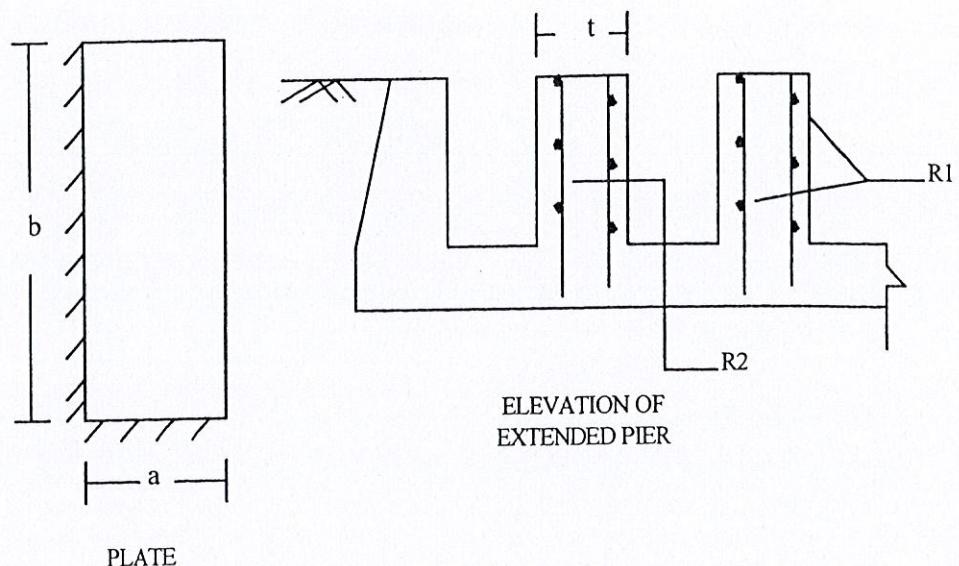


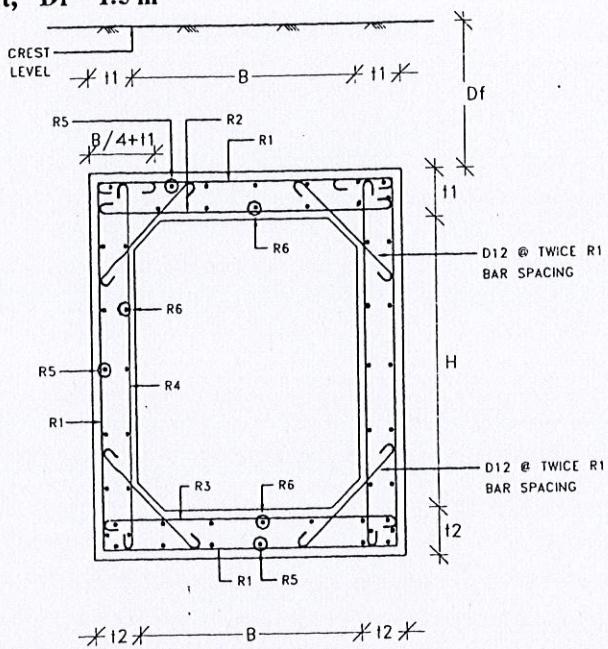
Table No. (Reference fig.)

Height b in mm	Length a in mm	Thickness t in mm	R1, horizontal reinforcement at exposed/water face	R2, vertical reinforcement at exposed/water face
3000	1500	250	D 12 @ 212	D 16 @ 250
3300	1500	250	D 12 @ 200	D 16 @ 225
3600	1500	300	D 12 @ 180	D 16 @ 225
3900	1500	300	D 12 @ 150	D 12 @ 175
4200	1500	350	D 12 @ 150	D 12 @ 150
4500	1500	350	D 12 @ 150	D 16 @ 225
4800	1500	350	D 12 @ 150	D 16 @ 187
5100	1500	400	D 16 @ 200	D 16 @ 175
5400	1500	400	D 16 @ 225	D 16 @ 150
5700	1500	450	D 16 @ 200	D 16 @ 150
6000	1500	450	D 16 @ 250	D 16 @ 150

* All reinforcing bar diameter and bar spacing are in millimeter

5.0 STRUCTURAL DESIGN OF BARREL

5.1 Barrel : 1 vent, $D_f = 1.5 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 1.5\text{m}$. (Reference fig.)

Width B in mm	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
600	900	250	250	D12 @ 300	D12 @ 225				
900	1200	250	250	D12 @ 300	D12 @ 225				
1200	1500	250	250	D12 @ 200	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1500	1800	300	300	D12 @ 150	D12 @ 250	D12 @ 250	D12 @ 250	D12 @ 250	D12 @ 175
1800	2400	350	400	D16 @ 225	D12 @ 200	D12 @ 200	D12 @ 175	D12 @ 200	D16 @ 250

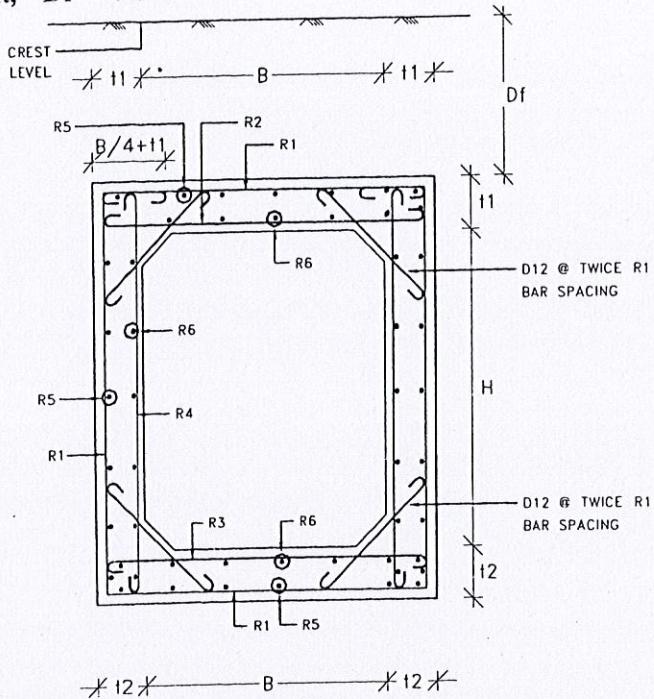
$\phi = 25^\circ$, Loading H_{20} . $D_f = 1.5\text{m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
600	900	250	250	D12 @ 300	D12 @ 225				
900	1200	250	250	D12 @ 300	D12 @ 225				
1200	1500	250	250	D12 @ 200	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1500	1800	300	300	D12 @ 175	D12 @ 250	D12 @ 250	D12 @ 250	D12 @ 250	D12 @ 175
1800	2400	350	400	D16 @ 225	D12 @ 200	D12 @ 200	D12 @ 175	D12 @ 200	D16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

* Fillet size 100X100 upto vent size 900X1200 and for rest 150X150.

5.2 Barrel : 1 vent, $D_f = 2.0 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 2.0 \text{ m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm	Reinforcement							
			t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	250	D12 @ 300	D12 @ 225				
900	1200	250	250	250	D12 @ 275	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1200	1500	250	250	250	D12 @ 175	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1500	1800	300	350	350	D12 @ 150	D12 @ 250	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	400	D16 @ 200	D12 @ 200	D12 @ 200	D12 @ 150	D12 @ 200	D16 @ 250

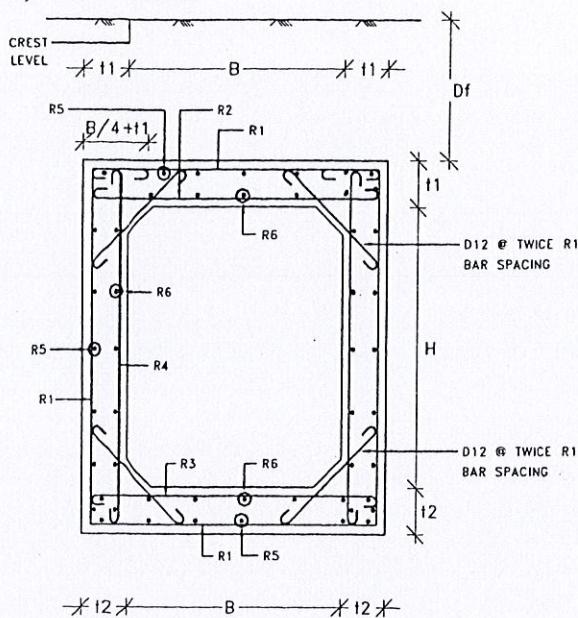
$\phi = 25^\circ$, Loading H_{20} . $D_f = 2.0 \text{ m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm	Reinforcement							
			t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	250	D12 @ 300	D12 @ 225				
900	1200	250	250	250	D12 @ 300	D12 @ 225				
1200	1500	250	250	250	D12 @ 175	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1500	1800	300	350	350	D12 @ 175	D12 @ 250	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	400	D16 @ 225	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 200	D16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

* Fillet size 100X100 upto vent size 900X1200 and for rest 150X150.

5.3 Barrel : 1 vent, $D_f = 2.5 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 2.5 \text{ m}$. (Reference fig.)

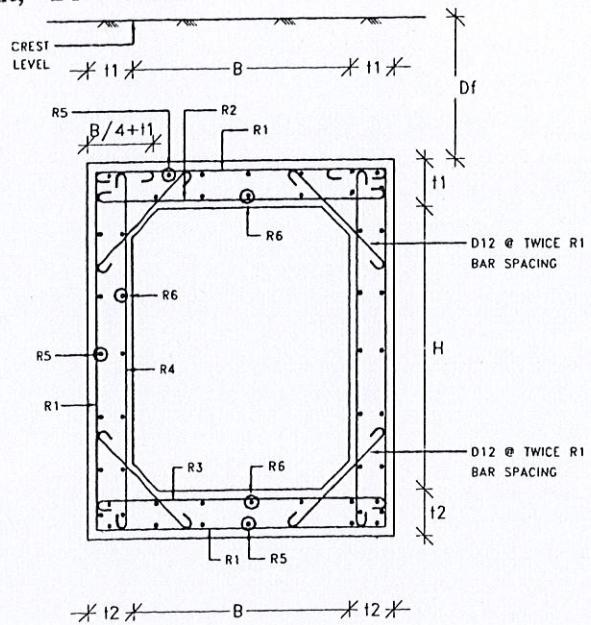
Width B in mm.	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
900	1200	250	250	D12 @ 250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1200	1500	250	250	D12 @ 150	D12 @ 300	D12 @ 300	D12 @ 250	D12 @ 300	D12 @ 225
1500	1800	350	400	D12 @ 150	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	D16 @ 175	D12 @ 200	D12 @ 200	D16 @ 250	D12 @ 200	D16 @ 250

$\phi = 25^\circ$, Loading H_{20} . $D_f = 2.5 \text{ m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
900	1200	250	250	D12 @ 250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1200	1500	250	250	D12 @ 175	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1500	1800	350	400	D12 @ 175	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	D16 @ 200	D12 @ 200	D12 @ 200	D12 @ 175	D12 @ 200	D16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter
* Fillet size 100x100 upto vent size 900x1200 and for rest 150x150

5.4 Barrel : 1-vent, $D_f = 3.0 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
900	1200	250	250	D12 @ 225	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1200	1500	250	250	D12 @ 125	D12 @ 300	D12 @ 300	D12 @ 225	D12 @ 300	D12 @ 225
1500	1800	350	400	D12 @ 150	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	D16 @ 150	D12 @ 200	D12 @ 200	D16 @ 225	D12 @ 200	D16 @ 250

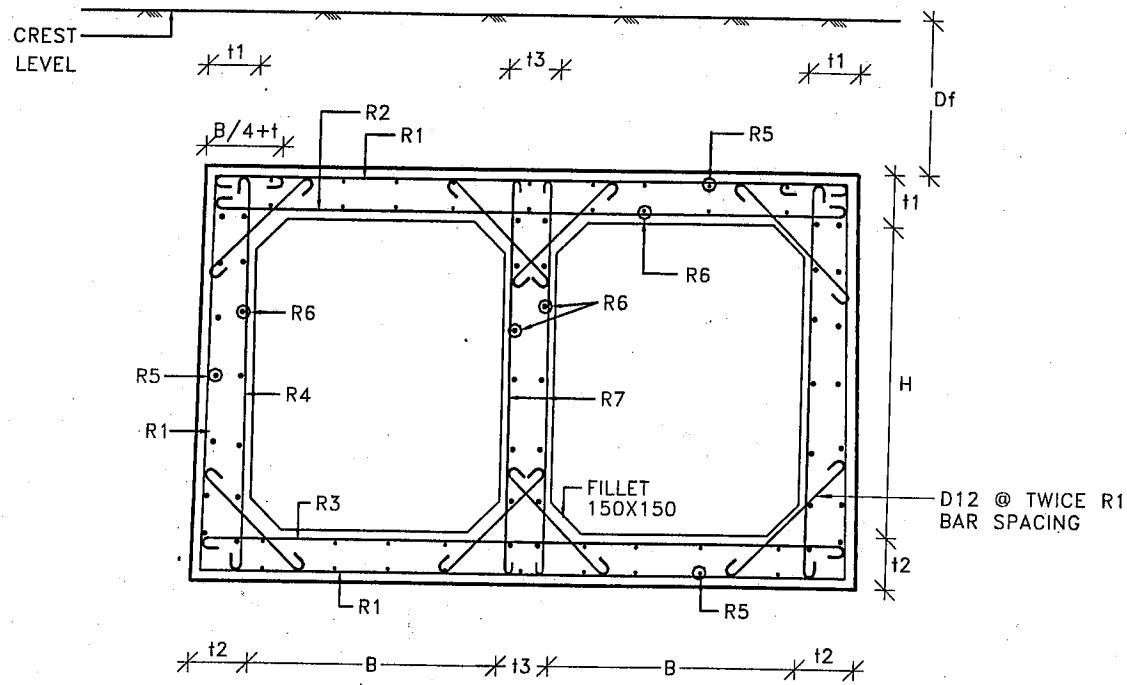
$\phi = 25^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

Width B in mm.	Height H in mm	members thickness mm		Reinforcement					
		t_1	t_2	R_1	R_2	R_3	R_4	R_5	R_6
600	900	250	250	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
900	1200	250	250	D12 @ 225	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 300	D12 @ 225
1200	1500	250	250	D12 @ 150	D12 @ 300	D12 @ 300	D12 @ 275	D12 @ 300	D12 @ 225
1500	1800	350	400	D12 @ 150	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 200	D12 @ 175
1800	2400	350	400	D16 @ 175	D12 @ 200	D12 @ 200	D16 @ 275	D12 @ 200	D16 @ 250

* All reinforcing bar diameter and bar spacing are in millimeter

* Fillet size 100x100 upto vent size 900x1200 and for rest 150x150

5.5 Barrel : 2 vent, Df = 1.5 m



$\phi = 20^\circ$, Loading H_{20} . $D_f = 1.5m$. (Reference fig.)

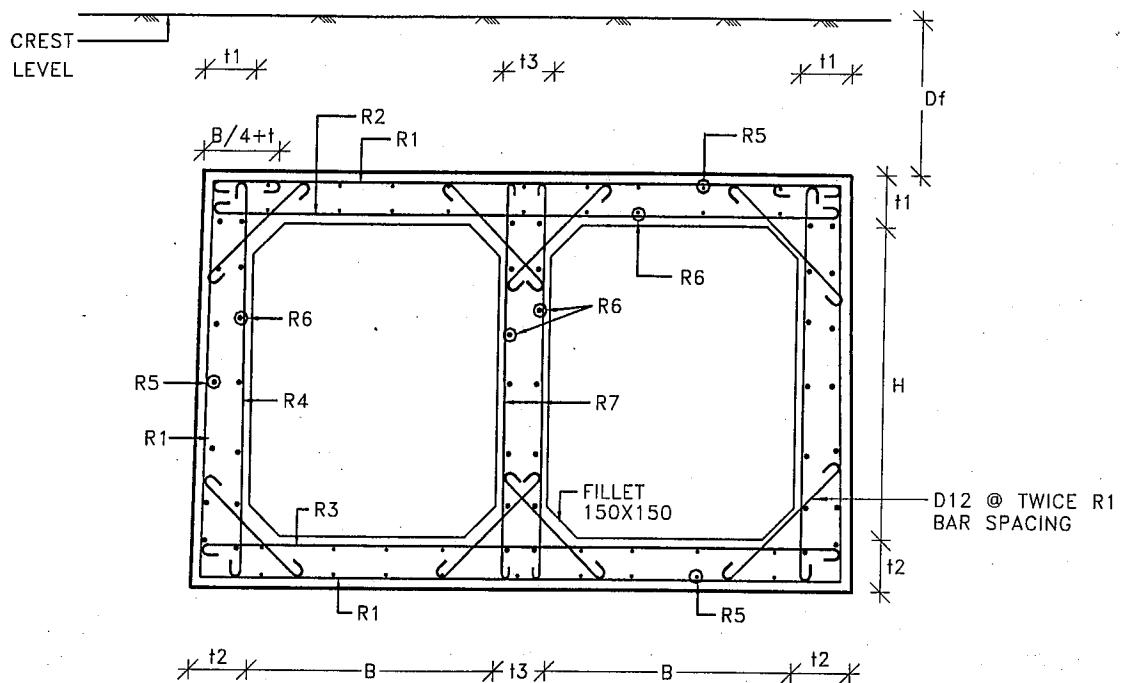
Barrel Width B in mm	Barrel Height H in mm	Member thickness, in mm			Reinforcement						
		t_1	t_2	t_3	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D12 @ 150 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c			
1800	2400	400	450	600	D16 @ 225 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

$\phi = 25^\circ$, Loading H_{20} . $D_f = 1.5m$. (Reference fig.)

Barrel Width B in mm	Barrel Height H in mm	Member thickness, in mm			Reinforcement						
		t_1	t_2	t_3	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D12 @ 150 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 250 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter

5.6 Barrel : 2 vent, Df = 2 m



$\phi = 20^\circ$, Loading H_{20} . $D_f = 2.0\text{m}$. (Reference fig.)

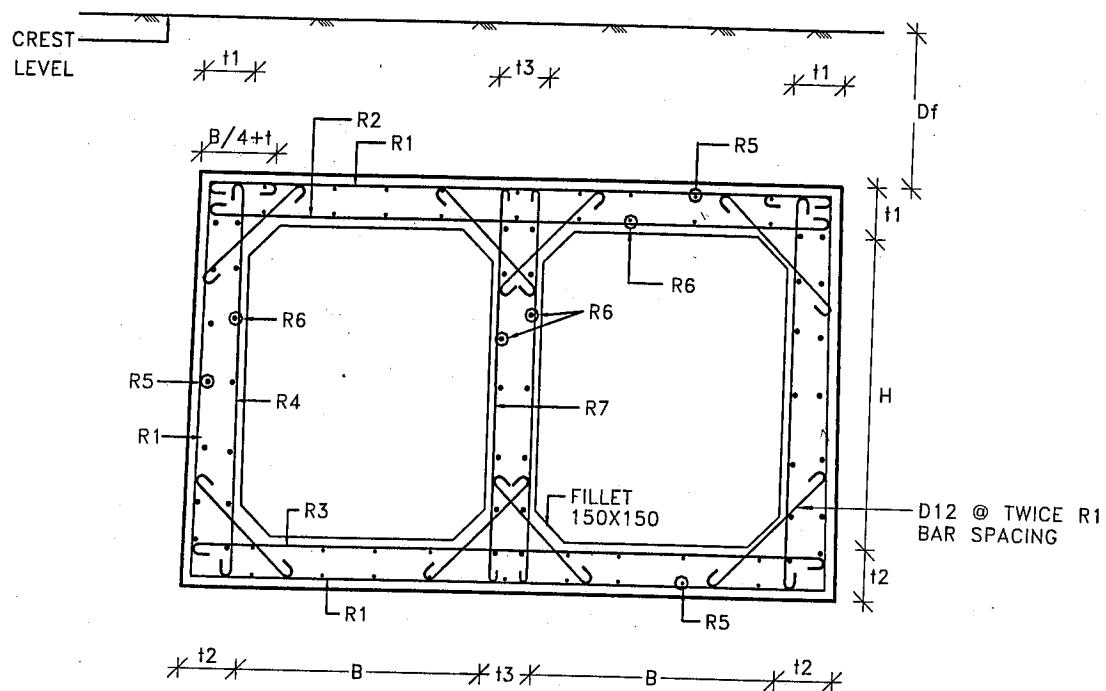
Barrel Width B in mm	Barrel Height H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D12 @ 150 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

$\phi = 25^\circ$, Loading H_{20} . $D_f = 2.0\text{m}$. (Reference fig.)

Barrel Width B in mm	Barrel Height H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D12 @ 150 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 225 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter

5.7 Barrel : 2 vent, Df = 2.5 m



$\phi = 20^\circ$, Loading H_{20} . $D_f = 2.5\text{m}$. (Reference fig.)

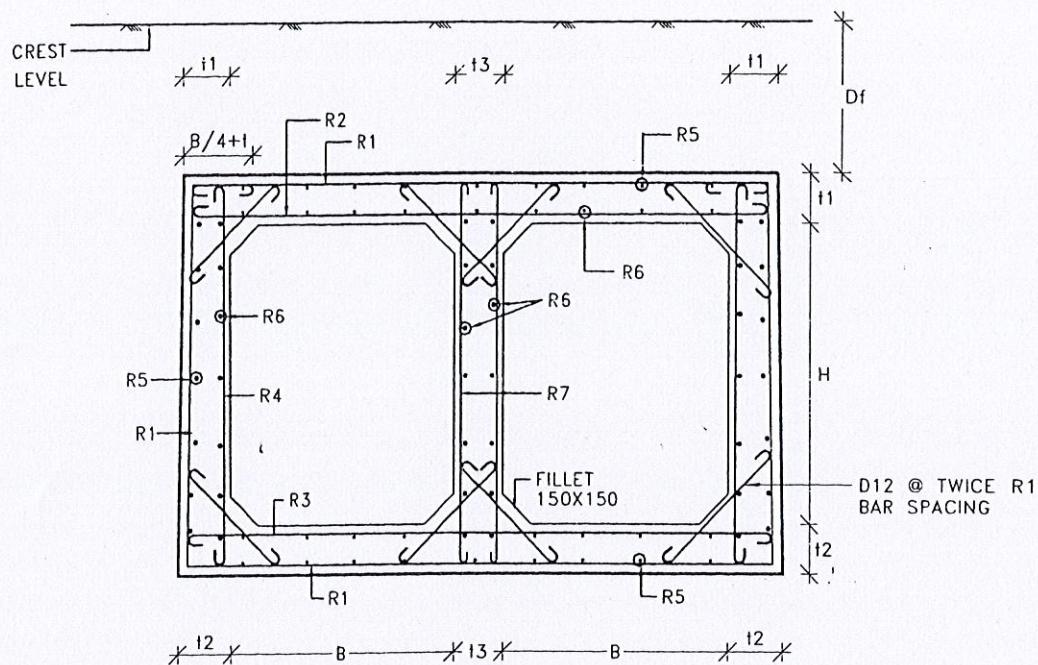
Barrel Width B in mm	Barrel Height, H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 250 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 175 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 175 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c

$\phi = 25^\circ$, Loading H_{20} . $D_f = 2.5\text{m}$. (Reference fig.)

Barrel Width B in mm	Barrel Height, H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 225 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter

5.8 Barrel : 2 vent, $D_f = 3.0 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

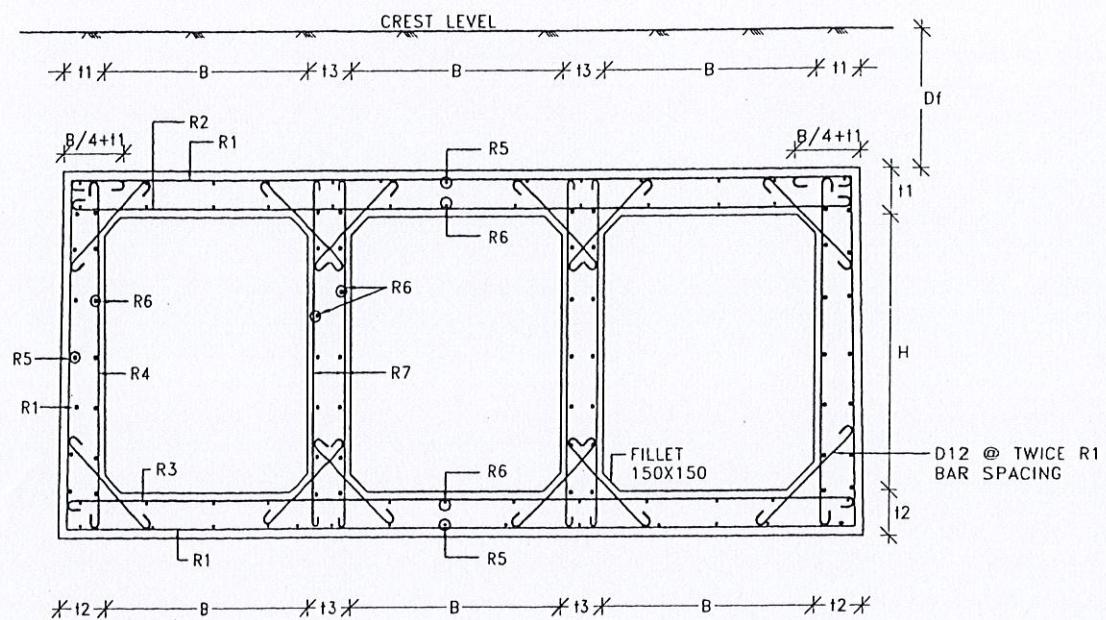
Barrel Width B in mm	Barrel Height, H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 225 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 150 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 150 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c

$\phi = 25^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

Barrel Width B in mm	Barrel Height, H in mm	Member thickness, in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 225 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 175 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter

5.9 Barrel : 3 vent , Df = 1.5 m



$\phi = 20^\circ$, Loading H_{20} . $D_f = 1.5\text{m}$. (Reference fig.)

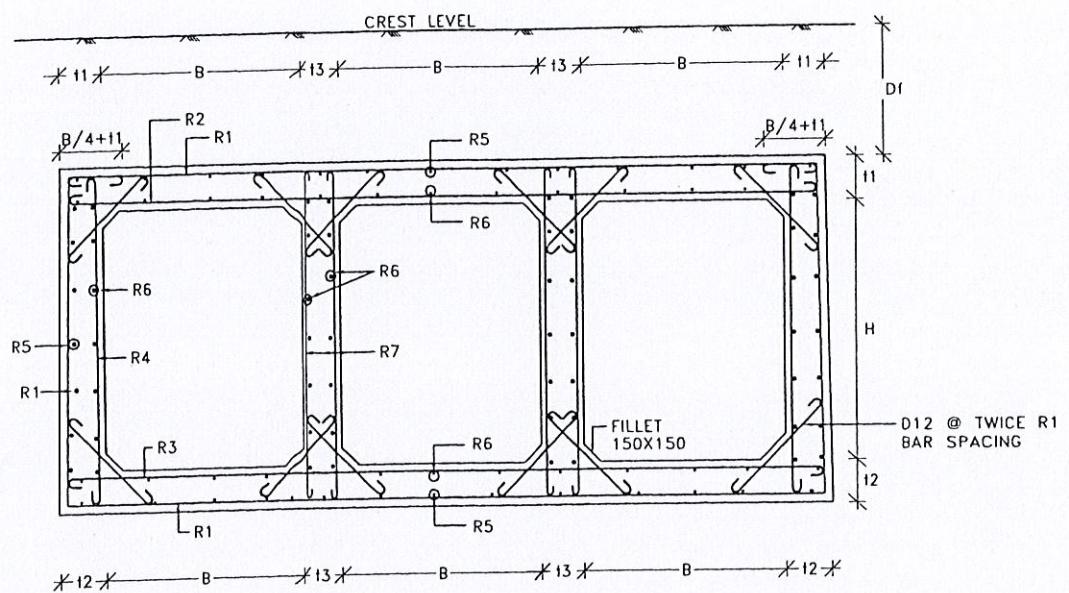
Barrel Width B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t_1	t_2	t_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1500	1800	300	350	600	D16 @ 275 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 225 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

$\phi = 25^\circ$, Loading H_{20} . $D_f = 1.5\text{m}$. (Reference fig.)

Barrel Width B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t_1	t_2	t_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1500	1800	300	350	600	D16 @ 275 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 250 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter.

5.10 Barrel : 3 vent, $D_f = 2.0$ m



$\phi = 20^\circ$, Loading H_{20} . $D_f = 2.0$ m. (Reference fig.)

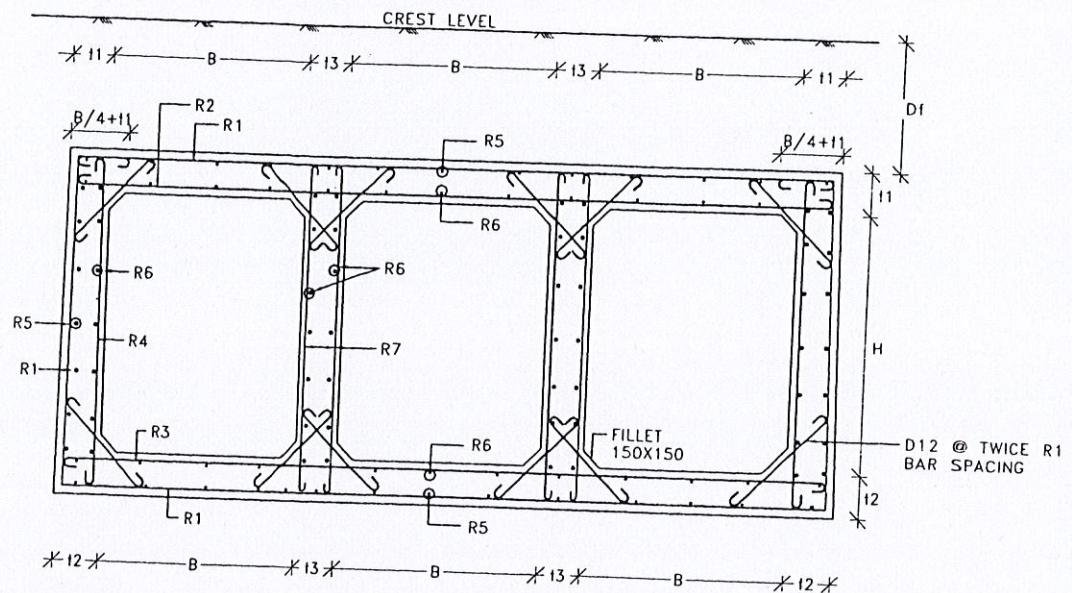
Barrel Width B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 250 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

$\phi = 25^\circ$, Loading H_{20} . $D_f = 2.0$ m. (Reference fig.)

Barrel Width B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 250 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 225 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter.

5.11 Barrel : 3 vent, Df = 2.5 m



$\phi = 20^\circ$, Loading H₂₀. D_f = 2.5m. (Reference fig.)

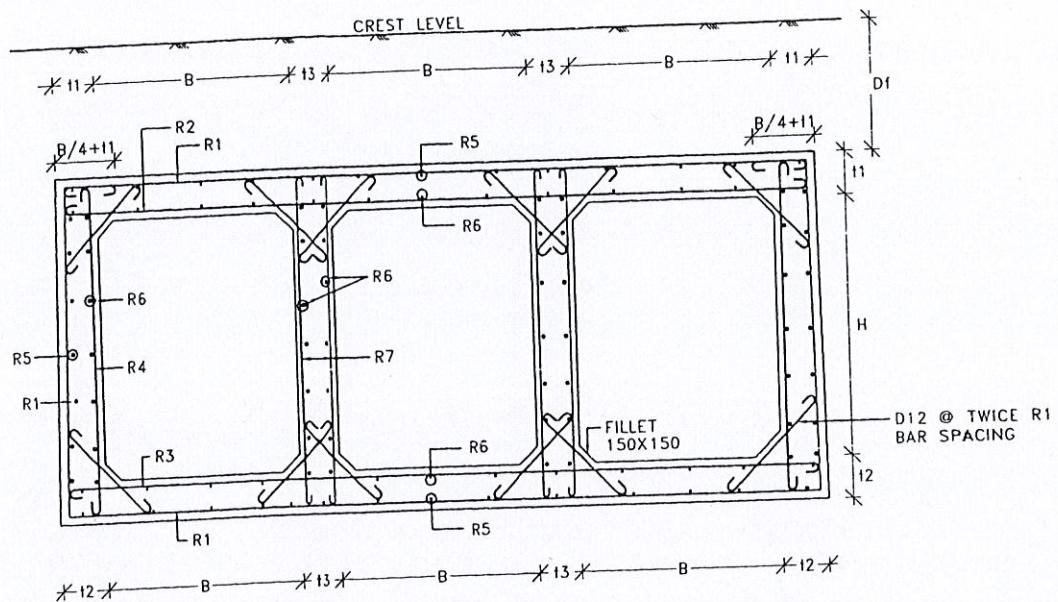
Barrel Width B in mm	Barrel Height H in mm	Member thickness in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 225 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c			
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

$\phi = 25^\circ$, Loading H₂₀. D_f = 2.5m. (Reference fig.)

Barrel Width B in mm	Barrel Height H in mm	Member thickness in mm			Reinforcement						
		t ₁	t ₂	t ₃	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 225 c/c	D12 @ 250 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter.

5.12 Barrel : 3 vent, $D_f = 3.0 \text{ m}$



$\phi = 20^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

Barrel Width B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t_1	t_2	t_3	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c			
1800	2400	400	450	600	D16 @ 150 c/c	D12 @ 200 c/c	D12 @ 200 c/c	D12 @ 150 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c

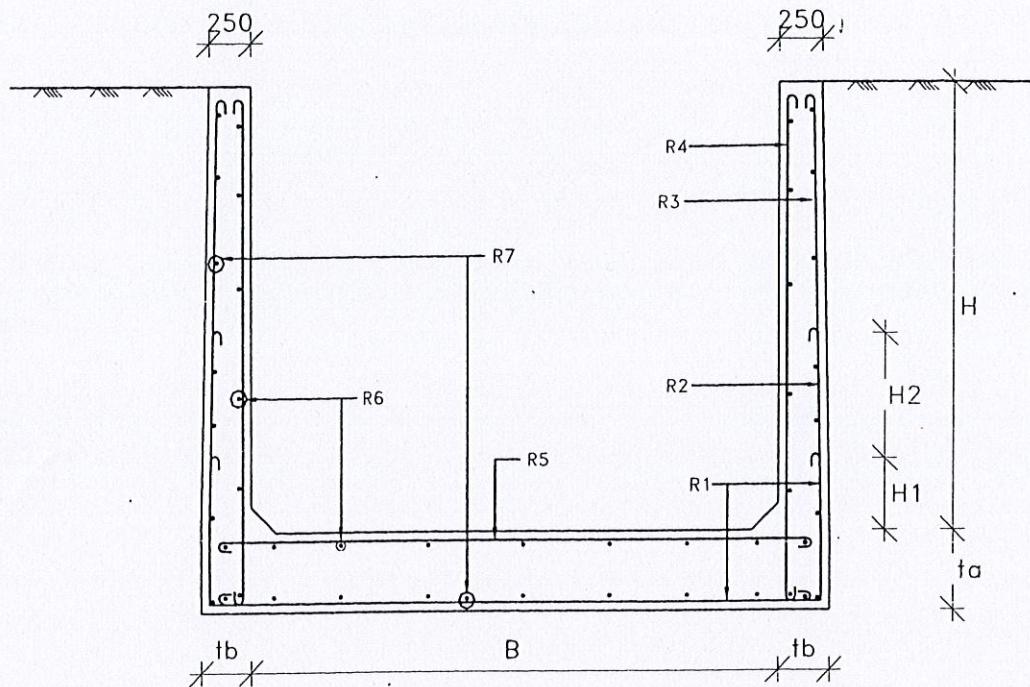
$\phi = 25^\circ$, Loading H_{20} . $D_f = 3.0 \text{ m}$. (Reference fig.)

Barrel Width, B in mm	Barrel Height, H in mm	Member thickness in mm			Reinforcement						
		t_1	t_2	t_3	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
1500	1800	300	350	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 275 c/c	D12 @ 200 c/c			
1800	2400	400	450	600	D16 @ 200 c/c	D12 @ 200 c/c	D16 @ 250 c/c	D12 @ 200 c/c			

* All reinforcing bar diameter and bar spacing are in millimeter.

6.0 STRUCTURAL DESIGN OF WING WALL AND APRON

6.1 Wing wall, B = 1.5 m to 8.5 m



$\phi = 20^\circ$

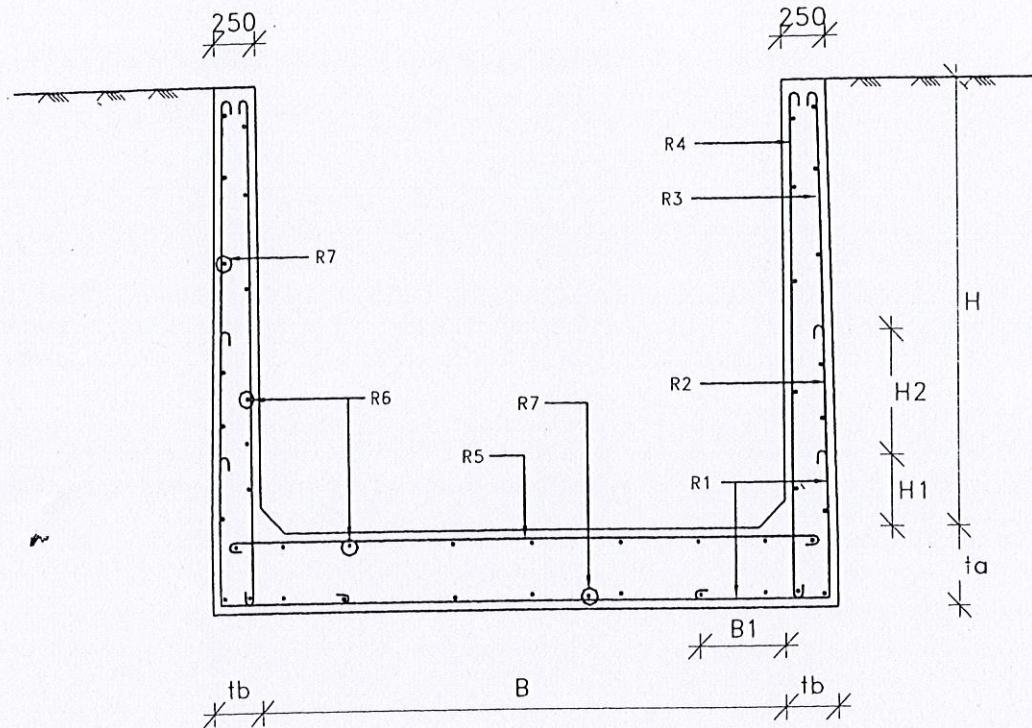
Dimension of Wing wall						Reinforcement of the members							IP
H	H1	H2	B	ta	tb	R1	R2	R3	R4	R5	R6	R7	kn/m
3500	1200	700	1500/ 5500	450	400	D16@ 100	D16@ 200	D16@ 400	D16@ 450	D12@ 200	D16@ 250	D12@ 200	33.48/ 10.70
4000	1400	700	1500/ 6500	500	450	D20@ 100	D20@ 200	D20@ 400	D16@ 450	D12@ 200	D16@ 250	D12@ 200	41.64/ 11.68
4500	1400	800	1500/ 7000	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	50.46/ 13.46
5000	1500	900	1500/ 8500	550	500	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	56.06/ 12.46
5500	1800	1000	1500/ 8500	650	600	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	69.86/ 16.12

$\phi = 25^\circ$													
H	H1	H2	B	ta	tb	R1	R2	R3	R4	R5	R6	R7	IP
3500	1200	700	1500/ 5000	450	400	D16@ 125	D16@ 250	D16@ 250	D16@ 450	D12@ 200	D16@ 250	D12@ 200	33.48/ 11.78
4000	1500	600	1500/ 5500	500	450	D16@ 100	D16@ 200	D16@ 400	D16@ 450	D12@ 200	D16@ 250	D12@ 200	41.64/ 13.65
4500	1500	900	1500/ 6000	550	500	D20@ 100	D20@ 200	D20@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	50.46/ 15.53
5000	1700	900	1500/ 7000	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	56.06/ 14.95
5500	1700	1000	1500/ 7500	600	550	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	65.87/ 16.77

*All reinforcing bar diameter and bar spacing are in millimeter

*IP=Imposed pressure in KN/m

6.2 Wing wall, B = 5.5 m to 13.5 m



$\phi = 20^\circ$

Dimension of the Wing Wall and Apron							Reinforcement of the Members							IP
H	H1	H2	B	B1	t _a	t _b	R1	R2	R3	R4	R5	R6	R7	KN/m
3500	1200	700	6000/ 13500	1900	450	400	D16@ 100	D16 @200	D16@ 400	D16@ 450	D16@ 250	D16@ 250	D12@ 200	9.94/ 4.58
4000	1400	700	7000/ 9000	2100	500	450	D20@ 100	D20@ 200	D20@ 400	D16@ 450	D16@ 250	D16@ 250	D12@ 200	10.90/ 8.59
4500	1400	800	7500/ 10000	2600	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	12.61/ 9.61
5000	1600	900	9000/ 12000	3000	550	500	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	11.80/ 8.97
5500	1800	1000	9000/ 12500	3000	650	600	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	15.20/ 11.20

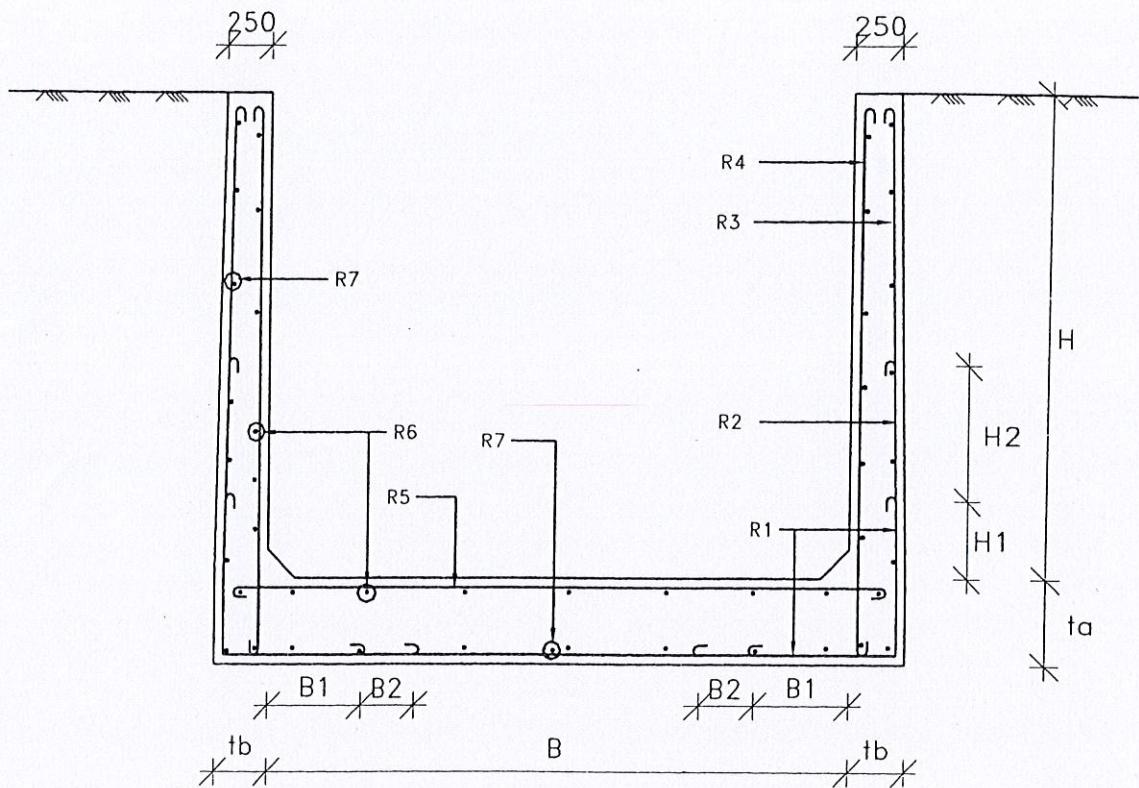
$\phi = 25^\circ$

3500	1200	700	5500/ 12000	1600	450	400	D16@ 125	D16@ 200	D16@ 400	D16@ 450	D16@ 200	D16@ 250	D12@ 200	8.66/ 4.93
4000	1500	600	6000/ 7500	1800	500	450	D16@ 100	D16@ 200	D16@ 400	D16@ 450	D16@ 200	D16@ 250	D12@ 200	12.59/ 10.21
4000	1500	900	8000/ 11000	1700	500	450	D16@ 100	D16@ 200	D16@ 400	D16@ 450	D16@ 200	D16@ 250	D12@ 200	9.61/ 6.04
4500	1500	900	6500/ 8500	2100	550	500	D20@ 100	D20@ 200	D20@ 400	D16@ 300	D12@ 200	D16@ 250	D12@ 200	14.42/ 11.20
5000	1600	900	7500/ 10000	2600	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	14.02/ 10.68
5500	1700	1000	8000/ 11000	2600	600	550	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	15.79/ 11.69

*All reinforcing bar diameter and bar spacing are in millimeter

*IP=Imposed Pressure in KN/m

6.3 Wing wall, B = 9.0 m to 17.5 m



$\phi = 20^\circ$

H	Dimension of the Wing Wall and Apron						Reinforcement of the Members							IP
	H1	H2	B	B1/B2	ta	tb	R1	R2	R3	R4	R5	R6	R7	
4000	1400	700	9000/ 15000	2000/ 1000	500	450	D20@ 100	D20@ 200	D20@ 400	D16@ 450	D16@ 250	D16@ 250	D12@ 200	7.42/ 5.26
4500	1400	800	10000/ 16000	2400/ 1800	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	9.61/ 6.12
5000	1600	900	12500/ 16500	2800/ 2200	550	500	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	8.63/ 6.60
5500	1800	1000	13000/ 17500	3000/ 2200	650	600	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	10.79/ 8.11

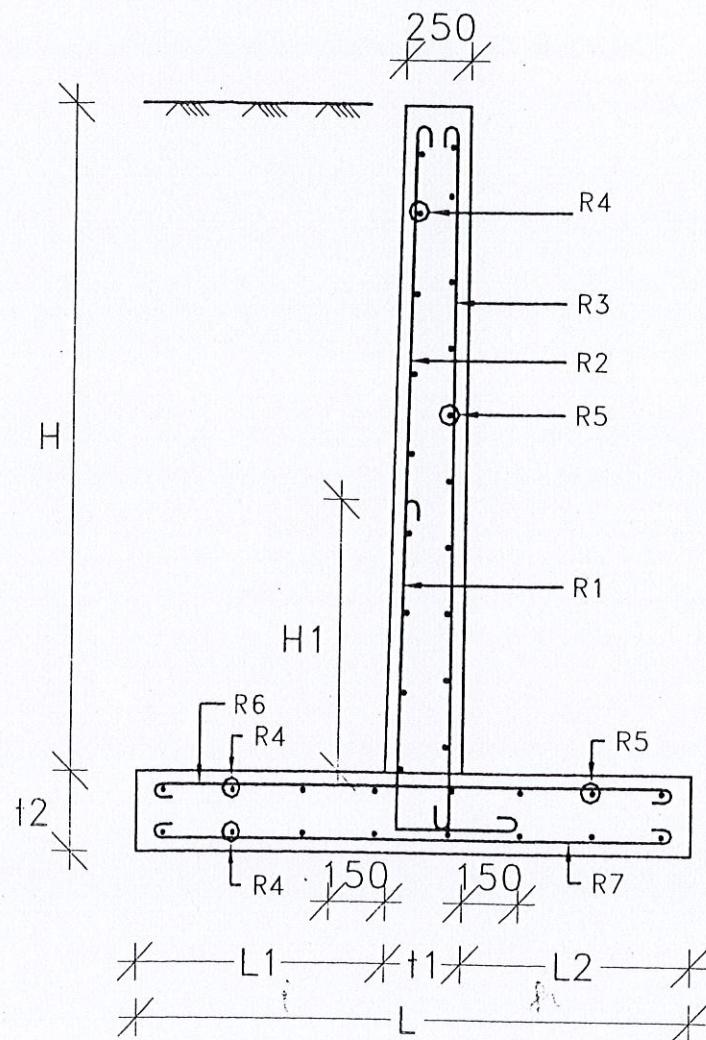
$\phi = 25^\circ$														
4500	1500	900	9000/ 14000	2000/ 1100	550	500	D20@ 100	D20@ 200	D20@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	10.62/ 6.96
5000	1600	900	10500/ 16000	2400/ 1600	550	500	D22@ 100	D22@ 200	D22@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	8.47/ 7.23
5500	1800	1000	11500/ 17000	2600/ 2500	600	550	D25@ 100	D25@ 200	D25@ 400	D16@ 300	D16@ 250	D16@ 250	D12@ 200	11.21/ 7.69

*All reinforcing bar diameter and bar spacing are in millimeter

*IP=Imposed Pressure in KN/m

7.0 STRUCTURAL DESIGN OF RETURN WALL

7.1 Return wall : Height = 2.0 m to 3.5 m, $\phi = 20^\circ$



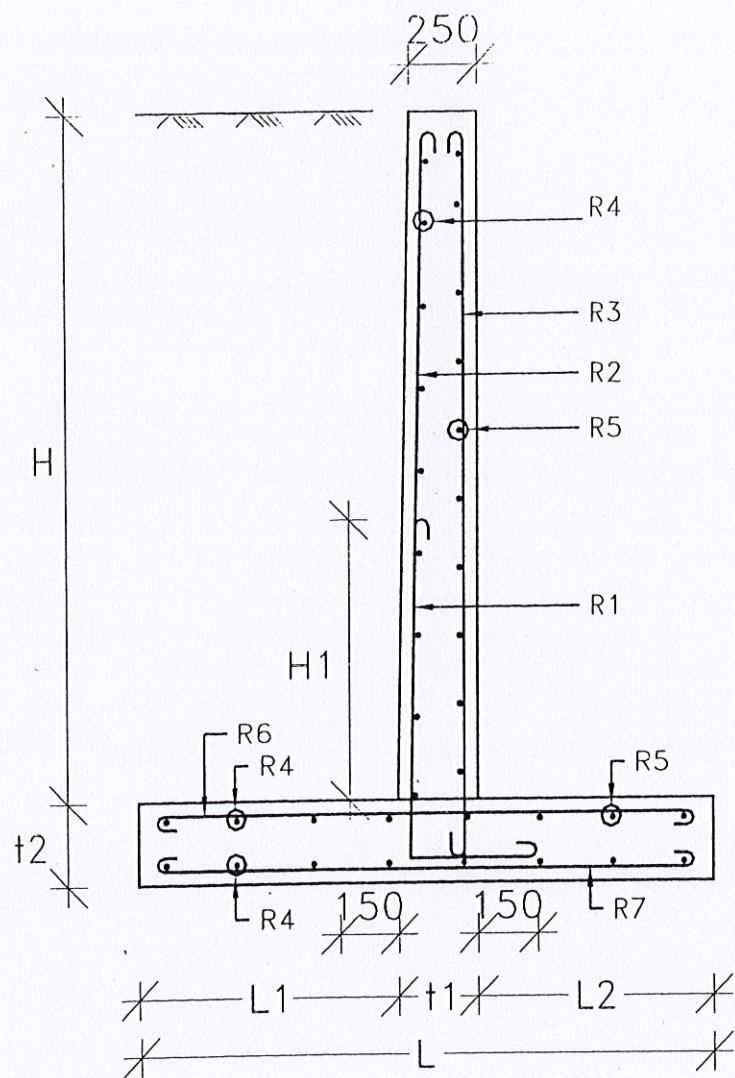
$\phi = 20^\circ$. (Reference fig.)

Member Dimension mm				Curt. Ht. mm	Member Thickness, mm		Base Pressure KN/M ²		Reinforcement						
H	L ₁	L ₂	L	H ₁	t ₁	t ₂	P ₁	P ₂	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
2000	900	700	1850	800	250	250	36.24	26.84	D12@ 150c/c	D12@ 300c/c	D12@ 400c/c	D12@ 300c/c	D12@ 300c/c	D12@ 300c/c	D12@ 300c/c
2500	1000	900	2200	1000	300	300	45.85	29.18	D12@ 150c/c	D16@ 300c/c	D12@ 350c/c	D12@ 300c/c	D12@ 250c/c	D12@ 200c/c	D12@ 150c/c
3000	1400	1000	2700	1100	300	300	52.49	38.79	D16@ 100c/c	D16@ 200c/c	D12@ 350c/c	D12@ 300c/c	D12@ 250c/c	D12@ 200c/c	D16@ 150c/c
3500	1500	1300	3150	1100	350	350	55.97	44.49	D20@ 100c/c	D20@ 200c/c	D12@ 300c/c	D12@ 300c/c	D12@ 200c/c	D16@ 150c/c	D16@ 150c/c

*All reinforcing bar diameter and bar spacing are in millimeter

*P1=Pressure at Toe, P2=Pressure at Heel

7.2 Return wall : Height = 2.0 m to 3.5 m, $\phi = 25^\circ$



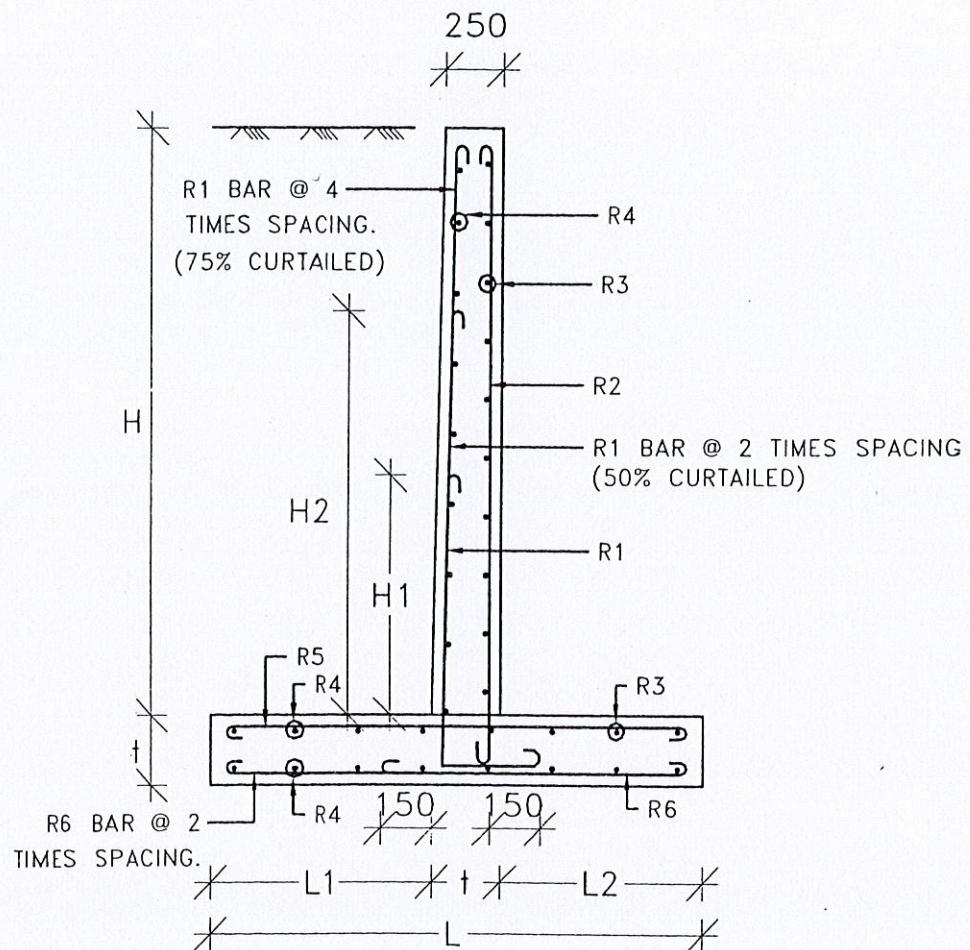
$\phi = 25^\circ$. (Reference fig.)

Member dimension mm.				Curt. Ht. mm	Member thickness mm		Base Pressure KN/m ²		Reinforcement						
H	L ₁	L ₂	L	H ₁	t ₁	t ₂	P ₁	P ₂	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇
2000	900	600	1750	700	250	250	36.69	29.33	D12 @ 150 c/c	D12 @ 300 c/c	D12 @ 400 c/c	D12 @ 300 c/c			
2500	900	800	2000	950	300	300	46.79	29.38	D12 @ 125 c/c	D12 @ 250 c/c	D12 @ 350 c/c	D12 @ 300 c/c	D12 @ 250 c/c	D12 @ 250 c/c	D12 @ 200 c/c
3000	1300	900	2500	1150	300	300	52.14	40.56	D16 @ 125 c/c	D16 @ 250 c/c	D12 @ 350 c/c	D12 @ 300 c/c	D12 @ 250 c/c	D12 @ 125 c/c	D12 @ 125 c/c
3500	1400	1100	2850	1300	350	350	59.91	44.51	D16 @ 100 c/c	D16 @ 200 c/c	D12 @ 300 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 100 c/c	D12 @ 100 c/c

* All reinforcing bar diameter and bar spacing are in millimeter

* P₁=Pressure at Toe, P₂=Pressure at Heel

7.3 Return wall : Height = 4.0 m to 5.5 m, $\phi = 20^\circ$



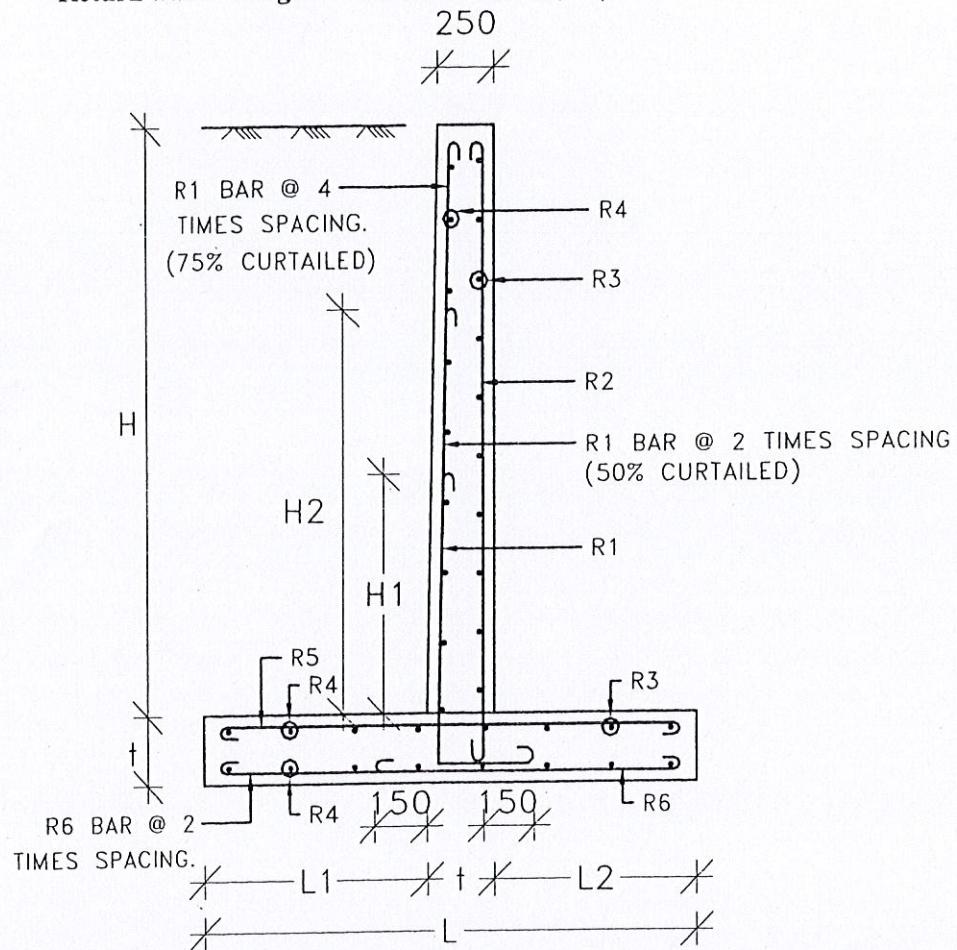
$\phi = 20^\circ$. (Reference fig.)

Member dimension mm.				Th. Of Member mm	Curtailment Height mm		Base Pressure KN/m ²		Reinforcement					
H	L ₁	L ₂	L		H ₁	H ₂	P ₁	P ₂	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
4000	1800	1400	3600	400	1500	2250	67.09	51.33	D20 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D16 @ 125 c/c	D16 @ 125 c/c
4500	2200	1500	4250	550	1650	2500	81.36	63.12	D20 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D16 @ 100 c/c	D16 @ 125 c/c
5000	2400	1700	4700	600	1850	2800	88.61	69.53	D22 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D20 @ 150 c/c	D16 @ 100 c/c
5500	2500	2000	5100	600	2100	3150	89.60	74.59	D25 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D20 @ 100 c/c	D20 @ 100 c/c

* All reinforcing bar diameter and bar spacing are in millimeter

* P₁=Pressure at Toe, P₂=Pressure at Heel

7.4 Return wall : Height = 4.0 m to 5.5 m, $\phi = 25^\circ$



$\phi = 25^\circ$. (Reference fig.)

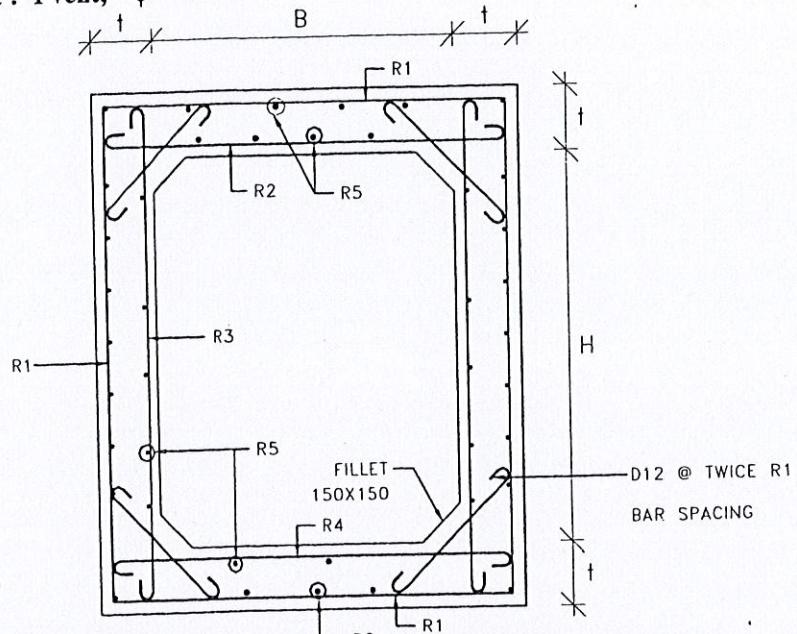
Member dimension mm.				Th. of Member mm	Curtailment Height mm		Base Pressure KN/m ²		Reinforcement					
H	L ₁	L ₂	L		H ₁	H ₂	P ₁	P ₂	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
4000	1700	1200	3300	400	1250	2050	69.99	52.68	D20 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D16 @ 125 c/c	D16 @ 150 c/c
4500	2000	1300	3800	500	1500	2400	82.59	61.62	D20 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D16 @ 100 c/c	D16 @ 150 c/c
5000	2300	1500	4400	600	1800	2750	88.60	73.89	D20 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D16 @ 100 c/c	D16 @ 125 c/c
5500	2400	1700	4650	550	1900	3000	91.36	76.37	D25 @ 100 c/c	D12 @ 300 c/c	D12 @ 200 c/c	D12 @ 300 c/c	D20 @ 125 c/c	D20 @ 125 c/c

* All reinforcing bar diameter and bar spacing are in millimeter

* P₁=Pressure at Toe, P₂=Pressure at Heel

8.0 STRUCTURAL DESIGN OF BOX CULVERT

8.1 Box culvert : 1 vent, $\phi = 25^\circ$

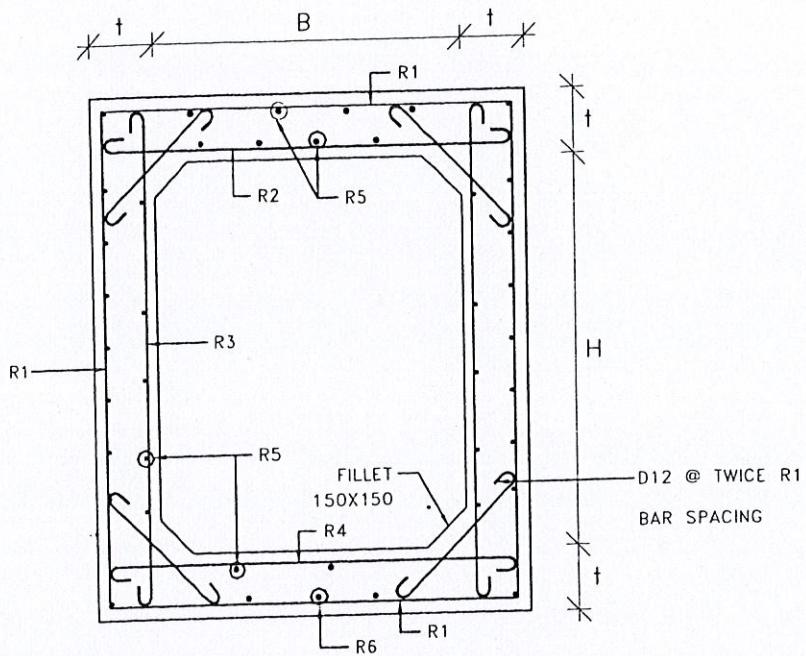


For $\phi = 25^\circ$, Loading H_{20} . Unit wt of soil = 18.9 KN/m³ (Reference fig.)

Barrel Width, B in mm	Barrel Height, H in mm	Thickness of the member in mm	Reinforcement					
			R1	R2	R3	R4	R5	R6
2500	2000	250	D12 @ 125	D16 @ 125	D12 @ 200	D16 @ 225	D12 @ 200	D12 @ 300
2500	2500	250	D12 @ 100	D16 @ 125	D12 @ 200	D12 @ 150	D12 @ 200	D12 @ 300
2500	3000	250	D16 @ 150	D16 @ 125	D12 @ 200	D12 @ 175	D12 @ 200	D12 @ 300
2500	3500	300	D16 @ 150	D12 @ 100	D12 @ 175	D12 @ 175	D12 @ 175	D12 @ 300
2500	4000	300	D16 @ 125	D12 @ 125	D12 @ 125	D12 @ 175	D12 @ 175	D12 @ 300
2500	4500	350	D16 @ 100	D16 @ 125	D16 @ 150	D12 @ 150	D12 @ 150	D12 @ 300
2500	5000	400	D16 @ 100	D12 @ 125	D16 @ 125	D12 @ 125	D12 @ 125	D12 @ 275
3000	2000	300	D12 @ 150	D16 @ 125	D12 @ 175	D12 @ 175	D12 @ 175	D12 @ 300
3000	2500	300	D12 @ 100	D16 @ 125	D12 @ 175	D12 @ 125	D12 @ 175	D12 @ 300
3000	3000	350	D12 @ 100	D16 @ 150	D12 @ 150	D12 @ 150	D12 @ 150	D12 @ 300
3000	3500	350	D16 @ 150	D12 @ 100	D12 @ 150	D12 @ 150	D12 @ 150	D12 @ 300
3000	4000	400	D16 @ 125	D12 @ 125	D12 @ 125	D12 @ 100	D12 @ 125	D12 @ 275
3000	4500	400	D16 @ 100	D12 @ 125	D16 @ 200	D12 @ 125	D12 @ 125	D12 @ 275
3000	5000	450	D16 @ 100	D12 @ 125	D16 @ 150	D12 @ 125	D12 @ 125	D12 @ 275

* All reinforcing bar diameter and bar spacing are in millimeter.

8.2 Box culvert : 1 - vent, $\phi = 20^\circ$



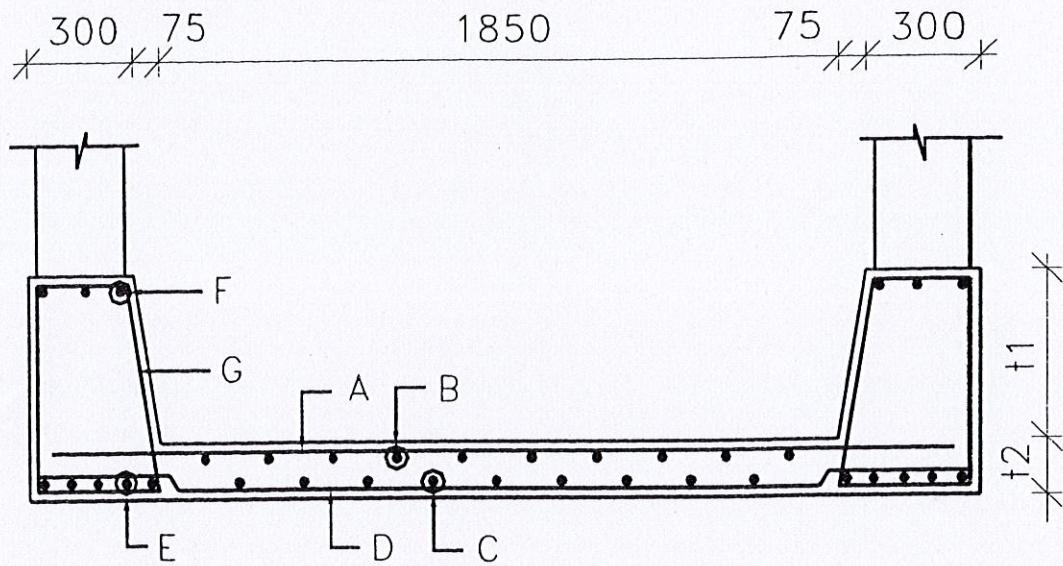
For $\phi = 20^\circ$, Loading H_{20} . Unit wt of soil = 18.9 KN/m³ (Reference fig.)

Barrel Width, B in mm	Barrel Height, H in mm	member thickness in mm	Reinforcement					
			R1	R2	R3	R4	R5	R6
2500	2000	300	D12 @ 150	D16 @ 150	D12 @ 175	D12 @ 125	D12 @ 175	D12 @ 300
2500	2500	300	D12 @ 125	D16 @ 150	D12 @ 175	D12 @ 125	D12 @ 175	D12 @ 300
2500	3000	300	D12 @ 100	D16 @ 175	D12 @ 175	D12 @ 175	D12 @ 175	D12 @ 300
2500	3500	300	D16 @ 175	D16 @ 200	D12 @ 100	D12 @ 175	D12 @ 175	D12 @ 300
2500	4000	300	D16 @ 100	D12 @ 175	D16 @ 150	D12 @ 175	D12 @ 175	D12 @ 300
2500	4500	300	D16 @ 100	D12 @ 175	D16 @ 100	D12 @ 175	D12 @ 175	D12 @ 300
2500	5000	350	D19 @ 100	D12 @ 150	D16 @ 100	D12 @ 150	D12 @ 150	D12 @ 300
3000	2000	300	D12 @ 100	D16 @ 125	D12 @ 175	D12 @ 125	D12 @ 175	D12 @ 300
3000	2500	300	D12 @ 100	D12 @ 175	D12 @ 175	D12 @ 125	D12 @ 175	D12 @ 300
3000	3000	300	D16 @ 150	D16 @ 125	D12 @ 175	D16 @ 250	D12 @ 175	D12 @ 300
3000	3500	350	D16 @ 150	D16 @ 150	D16 @ 150	D16 @ 225	D12 @ 175	D12 @ 300
3000	4000	350	D16 @ 100	D16 @ 250	D12 @ 150	D12 @ 150	D12 @ 150	D12 @ 300
3000	4500	350	D16 @ 100	D12 @ 175	D16 @ 175	D12 @ 150	D12 @ 150	D12 @ 300
3000	5000	400	D16 @ 125	D12 @ 125	D16 @ 300	D12 @ 125	D12 @ 125	D12 @ 275

* All reinforcing bar diameter and bar spacing are in millimeter.

9.0 STRUCTURAL DESIGN OF BRIDGE

9.1 Pedestrian Bridge



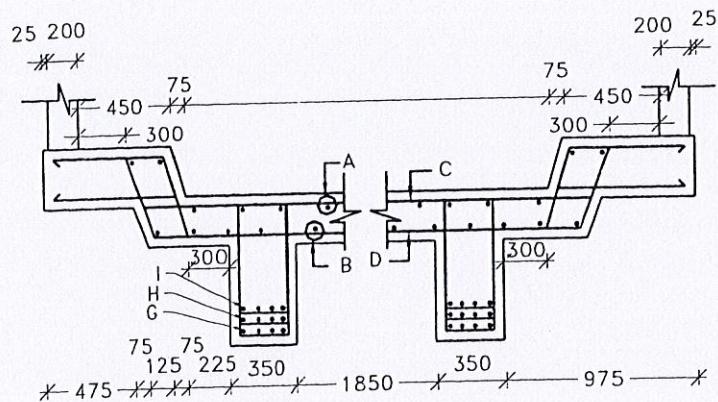
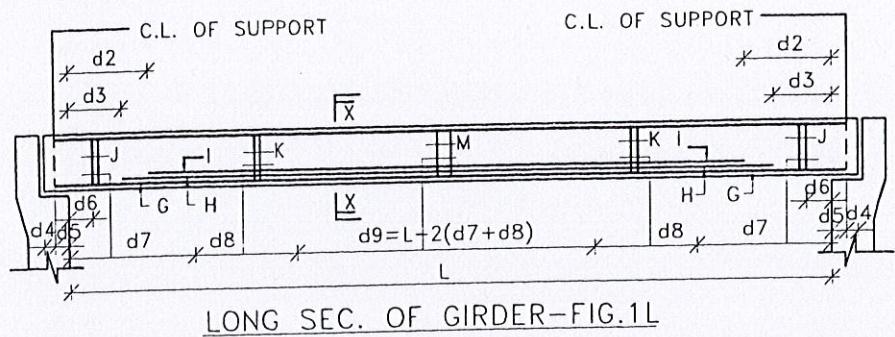
PEDESTRIAN BRIDGE

Table No. (Reference fig.)

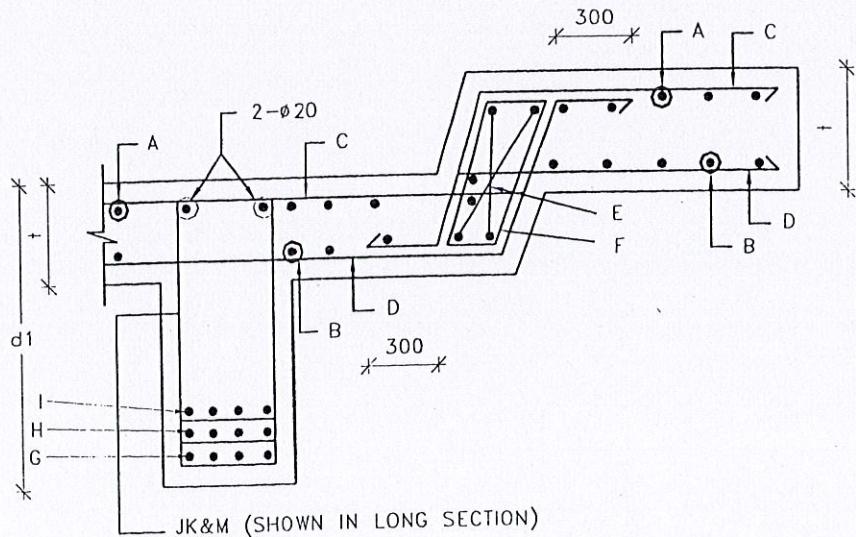
Loading	4 KN/m ✓	
	5m	7m
SPAN	5m	7m
Dimension t_1	450	600
t_2	150	150
Reinforcement A	D 10 @ 300	D 10 @ 250
B	D 10 @ 300	D 10 @ 300
C	D 10 @ 300	D 10 @ 300
D	D 10 @ 150	D 10 @ 150
E	5 - D 20	5 - D 25
F	3 - D 16	3 - D 20
G	D 10 @ 175	D 10 @ 175

* All dimension , reinforcing bar diameter and bar spacing are in millimeter

9.2 Light Traffic Bridge



SECTION X-X FIG. 2L



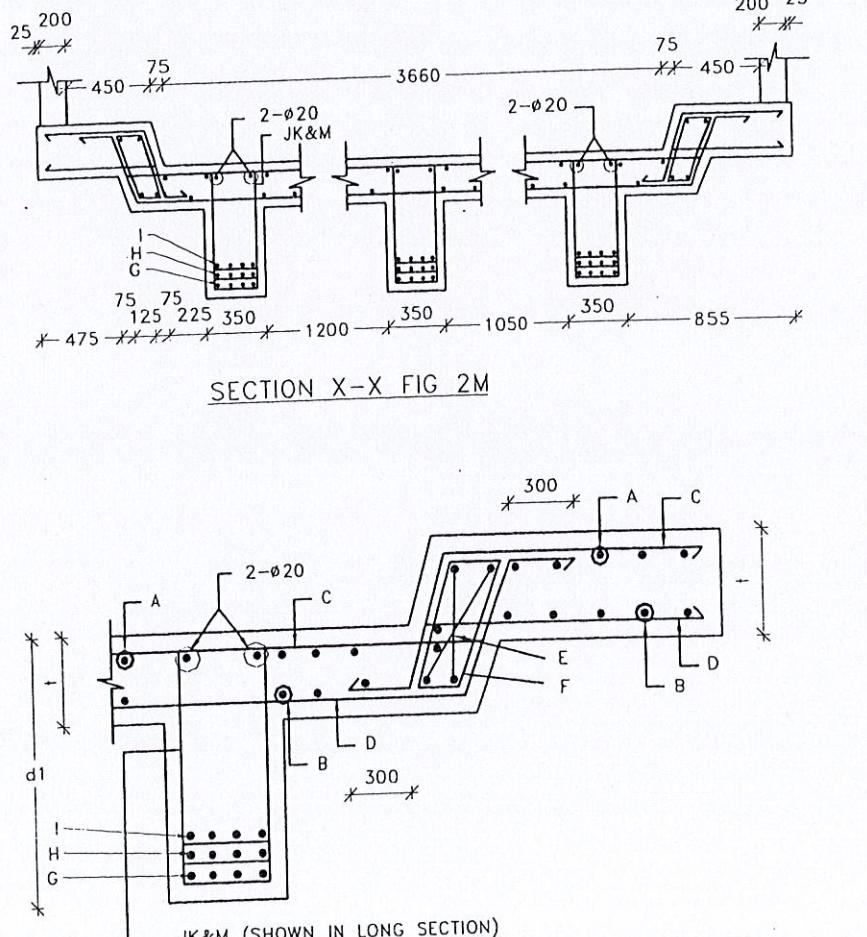
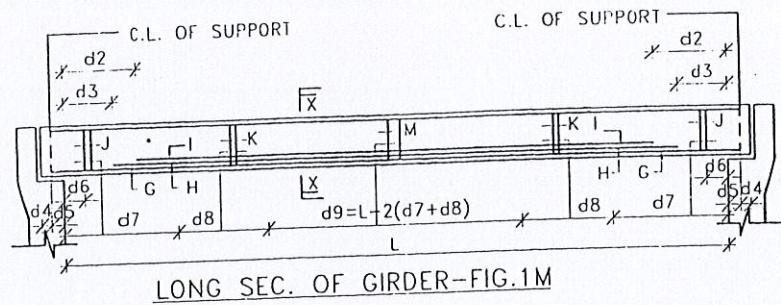
DETAILS REINFORCEMENT OF LIGHT TRAFIC BRIDGE FIG--3L

Reference fig. 1L , 2L and 3L

Loading	H10			H15		
Span L	8000	10000	12000	8000	10000	12000
Dimension d1	375	475	600	475	575	735
d2	2000	1950	2650	1550	1900	2650
d3	500	650	750	500	650	750
d4	225	225	225	225	225	225
d5	300	300	300	300	300	300
d6	62.5	62.5	62.5	62.5	62.5	62.5
d7	1500	1350	1200	1250	1400	1700
d8	100	675	1000	450	1100	1300
t	160	160	160	180	180	180
Reinforcement A	D 12 @ 550	D 12 @ 550	D 12 @ 550	D 12 @ 475	D 12 @ 475	D 12 @ 475
B	D 12 @ 550	D 12 @ 550	D 12 @ 550	D 12 @ 475	D 12 @ 475	D 12 @ 475
C	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 100	D 16 @ 100	D 16 @ 100
D	D 16 @ 150	D 16 @ 150	D 16 @ 150	D 16 @ 125	D 16 @ 125	D 16 @ 125
E	4 - D 12					
F	D 12 @ 300	D 12 @ 300	D 12 @ 300	D 12 @ 225	D 12 @ 225	D 12 @ 225
G	5 - D 25	4 - D 32	4 - D 32	4 - D 28	4 - D 32	4 - D 32
H	5 - D 25	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32
I	3 - D 25	4 - D 28	4 - D 28	4 - D 25	4 - D 28	4 - D 28
J	6 - D 12	7 - D 12	8 - D 12	7 - D 12	8 - D 12	9 - D 12
K	1 - D12	3 - D12	5 - D12	3 - D12	6 - D12	6 - D12
M	D 12 @ 200	D 12 @ 250	D 12 @ 300	D 12 @ 250	D 12 @ 300	D 12 @ 375

* All dimension, reinforcing bar diameter and bar spacing are in millimeter.

9.3 Medium Traffic Bridge (Exterior girder)



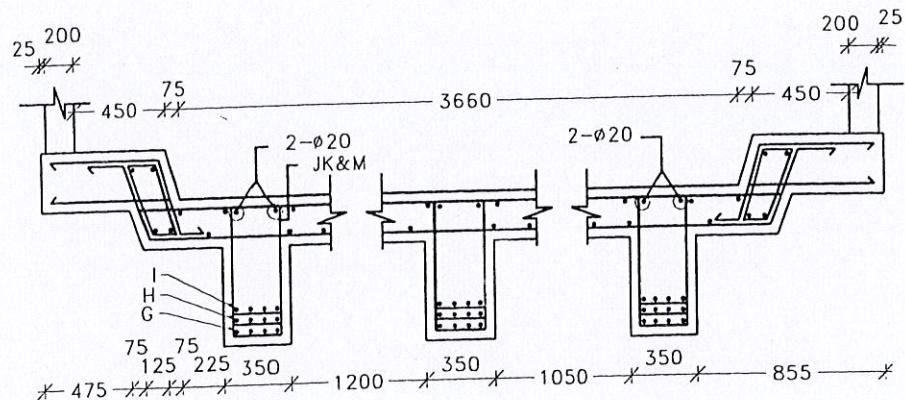
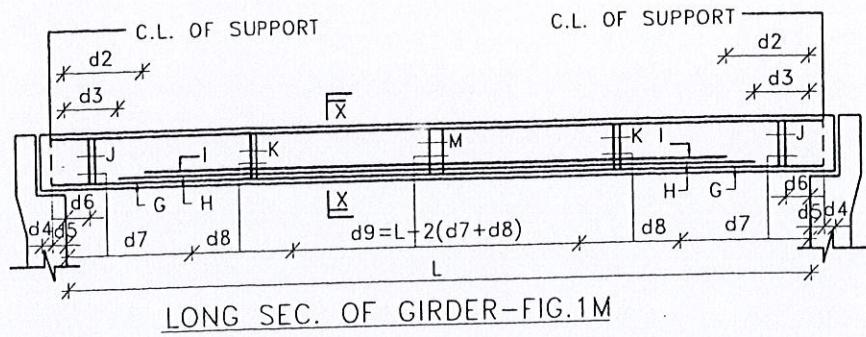
EXTERIOR GIRDER

Table No. (Reference fig. 1M and fig. 2M)

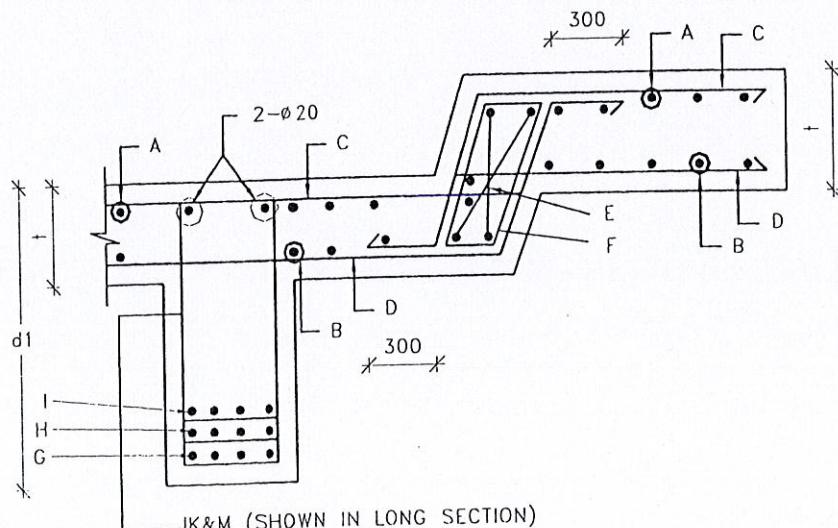
Loading	H15			H20		
Span L	10000	12000	15000	10000	12000	15000
Dimension d1	560	675	775	640	775	900
d2	1950	2300	2850	1900	2300	2850
d3	650	550	700	650	550	700
d4	225	225	225	225	225	225
d5	300	300	300	300	300	300
d6	62.5	62.5	62.5	62.5	62.5	62.5
d7	1400	1850	2000	1750	2050	2200
d8	100	250	1250	250	350	1300
t	165	165	165	180	180	180
Reinforcement A	D 12 @ 525	D 12 @ 525	D 12 @ 525	D 12 @ 475	D 12 @ 475	D 12 @ 475
B	D 12 @ 525	D 12 @ 525	D 12 @ 525	D 12 @ 475	D 12 @ 475	D 12 @ 475
C	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 100	D 16 @ 100	D 16 @ 100
D	D 16 @ 150	D 16 @ 150	D 16 @ 150	D 16 @ 125	D 16 @ 125	D 16 @ 125
E	4 - D 12					
F	D 12 @ 275	D 12 @ 275	D 12 @ 275	D 12 @ 250	D 12 @ 250	D 12 @ 250
G	4 - D 28	4 - D 28	4 - D 32	4 - D 28	4 - D 28	4 - D 32
H	4 - D 25	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32
I	4 - D 25	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32
J	6 - D 12	8 - D 12	10 - D 12	8 - D 12	9 - D 12	11 - D 12
K	1 - D 12	1 - D 12	5 - D 12	1 - D 12	1 - D 12	5 - D 12
M	D 12 @ 275	D 12 @ 350	D 12 @ 375	D 12 @ 325	D 12 @ 400	D 12 @ 450

All dimension , reinforcing bar diameter and bar spacing are in millimeter

9.4 Medium Traffic Bridge (Interior girder)



SECTION X-X FIG 2M



DETAILS REINFORCEMENT OF MED. TRAFIC BRIDGE FIG-3M

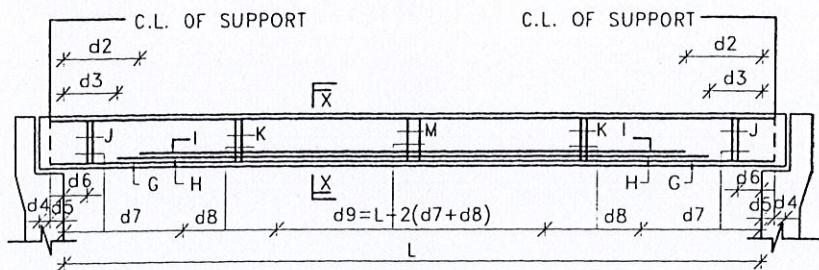
INTERIOR GIRDER

Table No. (Reference fig. 1M , 2M and 3M)

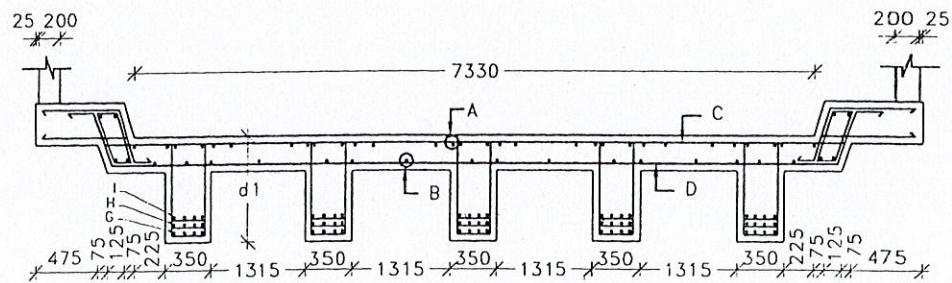
Loading	H15			H20		
Span L	10000	12000	15000	10000	12000	15000
Dimension d1	560	675	775	640	775	900
d2	2200	2300	2850	2200	2300	2850
d3	625	550	700	600	750	700
d4	225	225	225	225	225	225
d5	300	300	300	300	300	300
d6	62.5	62.5	62.5	62.5	62.5	62.5
d7	1650	1825	1850	1750	1950	2250
d8	200	475	1900	550	900	2000
t	165	165	165	180	180	180
Reinforcement A	D 12 @ 525	D 12 @ 525	D 12 @ 525	D 12 @ 475	D 12 @ 475	D 12 @ 475
B	D 12 @ 525	D 12 @ 525	D 12 @ 525	D 12 @ 475	D 12 @ 475	D 12 @ 475
C	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 100	D 16 @ 100	D 16 @ 100
D	D 16 @ 150	D 16 @ 150	D 16 @ 150	D 16 @ 125	D 16 @ 125	D 16 @ 125
E	4 - D 12					
F	D 12 @ 275	D 12 @ 275	D 12 @ 275	D 12 @ 250	D 12 @ 250	D 12 @ 250
G	5 - D 25	4 - D 28	4 - D 32	4 - D 28	4 - D 32	4 - D 32
H	5 - D 25	4 - D 28	4 - D 32	4 - D 28	4 - D 28	4 - D 32
I	4 - D 25	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32
J	7 - D 12	8 - D 12	10 - D 12	8 - D 12	9 - D 12	12 - D 12
K	1 - D 12	2 - D 12	9 - D 12	2 - D 12	4 - D 12	9 - D 12
M	D 12 @ 275	D 12 @ 350	D 12 @ 375	D 12 @ 325	D 12 @ 400	D 12 @ 450

* All dimension , reinforcing bar diameter and bar spacing are in millimeter

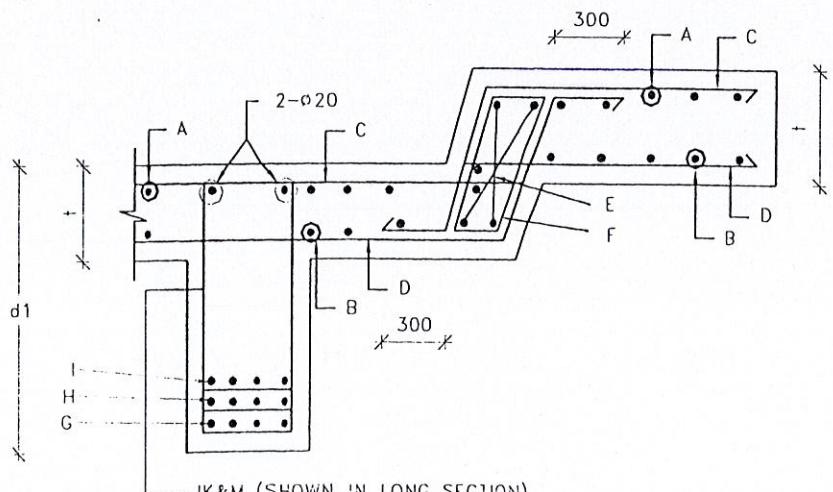
9.5 All Traffic Bridge (H20)



LONG SEC. OF GIRDER-FIG.1A



SECTION X-X FIG. 2 A



DETAILS REINFORCEMENT OF ALL TRAFFIC BRIDGE FIG- 3A

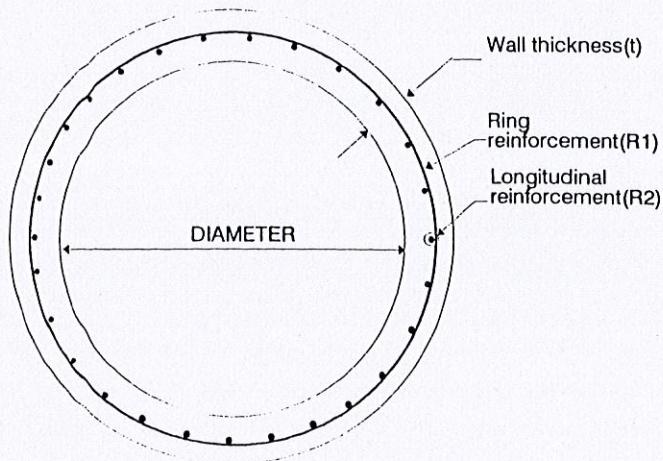
Table No. (Reference fig. 1A , 2A and 3A)

Girder Class		Interior Girder			Exterior Girder		
Span L	10000	12000	15000	10000	12000	15000	
Dimension d1	640	775	900	640	775	900	
d2	1900	2300	2750	1900	2300	2750	
d3	450	750	950	650	550	700	
d4	225	225	225	225	225	225	
d5	300	300	300	300	300	300	
d6	62.5	62.5	62.5	62.5	62.5	62.5	
d7	1800	2000	2250	1800	1950	2250	
d8	900	1100	2600	400	650	1600	
t	190	190	190	190	190	190	
Reinforcement A	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	
B	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	D 12 @ 450	
C	D 16 @ 100	D 16 @ 100	D 16 @ 100	D 16 @ 100	D 16 @ 100	D 16 @ 100	
D	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 125	D 16 @ 125	
E	4 - D 12	4 - D 12	4 - D 12	4 - D 12	4 - D 12	4 - D 12	
F	D 12 @ 225	D 12 @ 225	D 12 @ 225	D 12 @ 225	D 12 @ 225	D 12 @ 225	
G	4 - D 28	4 - D 32	4 - D 32	4 - D 28	4 - D 28	4 - D 32	
H	4 - D 28	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32	
I	4 - D 28	4 - D 28	4 - D 32	4 - D 25	4 - D 28	4 - D 32	
J	9 - D 12	10 - D 12	13 - D 12	9 - D 12	9 - D 12	12 - D 12	
K	4 - D 12	4 - D 12	12 - D 12	2 - D 12	3 - D 12	7 - D 12	
M	D 12 @ 300	D 12 @ 400	D 12 @ 450	D 12 @ 300	D 12 @ 400	D 12 @ 450	

* All dimension, reinforcing bar diameter and bar spacing are in millimeter .

10.0 R.C.C PIPE

10.1 Pipe Section with single layer of Reinforcement



$$f'_c = 25 \text{ N/mm}^2$$

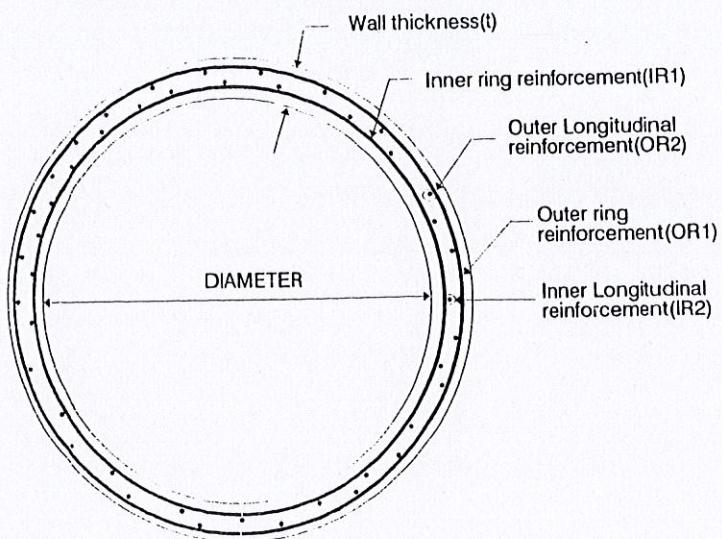
$$f_y = 276 \text{ N/mm}^2$$

Inside dia mm	Wall thickness (t) mm	Reinforcement	
		Ring Reinforcement (R ₁)	Longitudinal Reinforcement (R ₂)
100	25	D6 @ 100 c/c	D6 @ 75 c/c
150	25	D6 @ 100 c/c	D6 @ 110 c/c
225	30	D6 @ 100 c/c	D6 @ 135 c/c
300	45	D6 @ 100 c/c	D6 @ 225 c/c
450	50	D6 @ 100 c/c	D6 @ 225 c/c
500	55	D6 @ 100 c/c	D6 @ 220 c/c
600	60	D6 @ 95 c/c	D6 @ 210 c/c
750	70	D6 @ 85 c/c	D6 @ 200 c/c

* All reinforcing bar diameter and bar spacing are in millimeter.

10.2

Pipe Section with double layer of Reinforcement



$$f'_c = 25 \text{ N/mm}^2$$

$$f_y = 276 \text{ N/mm}^2$$

Inside dia mm	Wall thickness (t) mm	Reinforcement			
		Outer Ring Reinf. (OR ₁)	Inner Ring Reinf. (IR ₁)	Outer Long Reinf. (OR ₂)	Inner Long Reinf. (IR ₂)
900	90	D6 @ 100 c/c	D6 @ 90 c/c	D6 @ 150 c/c	D6 @ 150 c/c
1050	95	D6 @ 100 c/c	D6 @ 80 c/c	D6 @ 140 c/c	D6 @ 140 c/c
1200	100	D6 @ 100 c/c	D6 @ 60 c/c	D6 @ 130 c/c	D6 @ 130 c/c
1350	115	D6 @ 90 c/c	D6 @ 50 c/c	D6 @ 90 c/c	D6 @ 125 c/c

* All reinforcing bar diameter and bar spacing are in millimeter.