

# Foundation for Water Thrust

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## Abstract

For heavy load on foundation base (in case of pier of bridge of pier) and high-rise building, also design of foundations, like wind thrust, seismic force and due to thrust of water or due to heavy rainfall (saturated soil condition) or for cloud bursting, and slide, etc. to be taken into consideration, raft foundation for building or pier in bridge is essential. Also, foundation base size required for pier in bridge or building (i.e., for one column), i.e., total load at foundation base Available bearing capacity of soil (depending upon type of soil at the required depth of foundation found by unit wt. & angle of repose of saturated soil, i.e.  $D_f = \frac{q}{r} \left[ \frac{1-\sin\phi}{1+\sin\phi} \right]^2$  The stability of foundations is significantly influenced by additional forces, such as water thrust, seismic effects, wind load, and soil saturation, during heavy rainfall or floods. In cases of high-rise structures and bridge piers, the design must account for these factors to ensure long-term safety. Raft foundations are particularly effective, as they provide a wider load distribution and resistance against uplift and erosion of the underlying soil. The required foundation depth is determined by considering the bearing capacity of saturated soils, thrust of flowing and standing water, and scour depth. The study emphasizes that properly designed raft foundations with adequate projection and thickness can effectively counter soil erosion, resist external thrusts, and enhance the overall stability of structures under extreme conditions such as cloudbursts, floods, and landslides.

**Keywords:** Foundation stability, raft foundation, bridge pier, saturated soil, water thrust, seismic load, wind load, soil erosion, scour depth, flood resistance, cloudburst, landslide, structural safety

## INTRODUCTION

Like wind thrust, seismic force and thrust of water raft foundation is preferable for safety of foundation. Also raft foundation (R.C.C. slab) should be projected 2 m to 3 m depending upon thrust of water from foundation base & required depth of R.C.C. slab should be provided taking load intensity by load on column of building or load on pier and also thrust of water due to standing water, high velocity of flow in case of flood & also thrust of water (uplift) due to ground water all are added & this intensity will be acting on projected pas of raft R.C.C. base (2 m or 4 m) & on length of base in column & pier & by using bending equation required depth of R.C.C slab is to be found at foundation level which will prevent erosion of underlying soil. Also depth of foundation should be taken at 2 x scoured depth + 2 m depending upon discharge of flow for safety of foundation for road also projection of stabilized soil from embankment of required depth by total load intensity caused by load on pavement

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due to vehicle + thrust of water in case of flood hence extra projection from foundation level to ground level of stabilized soil (stone dust, sand layer), etc. in compact form should be provided to prevent underlying soil erosion in case of flash flood [1–3]. Also, width of foundation for one lane = Load from vehicle at foundation base.

Available bearing capacity of soil depending upon type of soil at the required depth of foundation for saturated soil should be taken.

Also damage occurring due to cloud bursting, land slide, etc. retaining wall of required depth of foundation & thickness should be provided all around building.

To prevent scouring near river due to which building falls down: In summer when no flood R.C.C base, like mat foundation at the required depth of foundation, caused by thrust of water due to standing water in river in case of flood (35), velocity of flow  $1.2 \times$  depth & thrust of water due to velocity of flow + thrust due to underground, i.e., 35 m. Total thrust is found & depth of foundation for R.C.C. base like mat foundation projecting from bank of river 20 m at least & required depth of R.C.C. base due to thrust of water on projected part & per meter length of bank of river & by using bending equation depth of R.C.C. base is to be found at the required depth of foundation or below scour depth so that erosion [4–6].

## RESULTS AND ANALYSIS

Underlying soil should be prevented & scouring will not happen due to erosion of underlying soil. Also, above bed of river sandbags, boulders, etc. should be provided so that scouring will not happen. Retaining walls at the required depth of foundation found by load intensity due to thrust of required thickness & sandbags & boulder along retaining wall near village along bank of river should be provided & village will be safe.

- *Findings:* We have to check erosion of underlying soil hence depth of retaining wall should be provided below  $2 \times$  scoured depth + 2 m extra depth so that erosion of underlying soil should not take place because erosion of underlying soil is building, road or pier in bridge or scouring of river near bank of river is to be checked so that building, road, bridge, village, etc. will be safe [7, 8].

### Analysis of Building for High Velocity of Wind

- *Abstract:* The additional load on column is taken due to wind thrust (very high velocity of wind and analysis for column size & foundation is to be done.
- *Introduction:* Velocity of wind = 400 Km/hr is taken thrust due to wind is to be found & additional load on column is taken.
- *Results & Discussion:* Wind velocity = 400 Km/hr

$$V = \frac{400 \times 1000}{60 \times 60} = 111.11 \text{ m/sec}$$

$$\text{Thrust of wind on building} = \frac{wv^2}{2g} = \frac{12 \times (111.11)^2}{19.62} = 7.55 \text{ KN/m}^2$$

where unit wt of air  $12 \text{ N/m}^3$  taken.

If 10 story building is there at total ht. = 40 meter, ht of one story = 4 m is taken.

Length of building = 30 m.

Spacing between columns = 6 m.

Hence no. of columns = 36 columns (6 x 6).

If slab size = 5m x 5 m taken.

Wt. of slab =  $5 \times 5 \times 0.12 \times 24 = 7.2 \text{ t}$ .

Live load =  $2 \times 5 \times 5 = 5 \text{ t}$ .

Total wt. = 12.2 t.

$$w = \frac{12.20}{5 \times 5} = 0.488 \text{ t/m}^2$$

Spacing = 5 m.

Hence  $w = 0.488 \times 5 = 2.44 \text{ t/m}$ .

Wt. of beam =  $0.6 \times 0.4 \times 5 \times 24 = 2.88 \text{ t}$ .

$$w = \frac{2.88}{5} = 0.576 \text{ t/m}$$

Total wt. on beam from slab =  $2.44 + 0.576 = 3.016 \text{ t/m}$

Hence load on one column =  $\frac{3.016 \times 5}{2} = 7.54 \text{ t.}$

- Considering intermediate columns, 4 beams are meeting at column = Load on column (Total =  $4 \times 7.54 = 30.16 \text{ t.}$

For one story load on column =  $30.16 \text{ t.}$

For 10 story =  $30.16 \times 10.$

Bottom column =  $301.60 \text{ t}$  on thrust of wind acting on  $40 \text{ m ht.}$  of building &  $30 \text{ m}$  length of building  
 =  $7.55 \times 40 \times 30 = 906 \text{ t}$  acting on =  $\frac{30}{5} = 6$  columns.

Length of building and Spacing between columns:

Hence load on one bottom column =  $\frac{906}{6} = 151 \text{ t}$

Hence total load at bottom column =  $301.60 + 151 = 452.60 \text{ t}$

Section of column:

Found by:

1. Direct stress consideration.
2. Bending stress consideration.

Direct stress consideration:

$$\frac{P}{A} = \sigma_{cc}$$

$$\frac{452.60 \times 1000 \times 10}{A} = 10 \text{ (M40 grade of concrete).}$$

$$A = 452600.$$

$b \times d = 673 \text{ mm} \times 673 \text{ mm}$  cross section of column taken.

Since  $452.60 \text{ t}$  vertical load on bottom column.

Lateral load =  $0.217 \times 452.60 = 98 \text{ t.}$

where  $\frac{1 - \sin \phi}{1 + \sin \phi} = 0.217$  [ $\phi = 40^\circ$  for concrete].

$98 \text{ t}$  load acting on  $0.6 \text{ m}$  width of column &  $4 \text{ m}$  ht.

$$w = \frac{98}{4 \times 0.6} = \frac{98}{2.4} = 40.83 \text{ t/m}^2$$

Bending along ht. of column takes place.

$$M = \frac{40.83 \times (4)^2}{8} = 82 \text{ t-m}$$

Using bending equation

$$\frac{82 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times 1000 \times d^3 \times \frac{2}{d}} = 0.488 \text{ t/m}^2$$

$$2167 d^2 = 820000000$$

$$d^2 = 378403$$

$$d = 615 \text{ mm} \times 615 \text{ mm.}$$

Hence cross section of column 700 mm x 700 mm (More value taken).

### Design of Foundation

- Load on column = 452.60 t
- Self ht. of column =  $0.7 \times 0.7 \times 4 \times 24 = 4.704$  t
- Total load of column =  $452.60 + 4.704 = 457.304$  t
- 10% wt of foundation =  $\frac{10}{100} \times 457.304 = 45.730$  t

Hence total load at foundation base =  $457.304 + 45.730 = 503.03$  t.

- Lateral load at foundation base =  $0.217 \times 503.03 = 109$  t

Hence rocky strata bed & raft foundation for heavy load is to be provided having bearing capacity of soil =  $165 \text{ t/m}^2$  greater than 109 t.

$$\text{Hence foundation base size required} = \frac{503.03}{165} = 3.05 \text{ m}^2.$$

Hence foundation base size for one column is to be taken = 1.75 m x 1.75 meter.

Since 36 columns are there, hence total area required for R.C.C. base for raft foundation =  $36 \times 3.05 = 110 \text{ m}^2$

Hence R.C.C. base for area of building  $110 \text{ m}^2$  is required & depth of foundation needed in case of saturated soil condition due to heavy rainfall:

$$D_f = \frac{165}{1.65} \times \left[ \frac{1 - \sin 15^\circ}{1 + \sin 15^\circ} \right]^2$$

$$= \frac{165}{1.65} \times \left[ \frac{1 - 0.259}{1.259} \right]^2$$

$$= \frac{165 \times 0.346}{1.65} = 35 \text{ meter for saturated soil condition below ground level due to heavy rainfall.}$$

Hence at depth 35-meter whole area is to be excavated & 800 mm depth of sand layer (compact) layer is to be provided & over sand layer R.C.C base is to be made & projection from foundation base at 3 m distance lateral taken & 800 mm thickness of R.C.C slab is made [9, 10].

Check against overturning moment & restoring moment at base of building:

Since vertical load = 457.304 t acting on bottom column.

$$\text{Lateral load} = 0.217 \times 457.304 = 99.23 \text{ t}$$

$$\text{Overturning moment at base of building} = 99.23 \times 4 = 397 \text{ t-m}$$

$$\text{Restoring moment obtained by saturated state of bearing capacity of soil} = \frac{165}{2} = 82.5 \text{ t/m}^2$$

$$\text{Restoring moment} = 35 \times 0.7 \times 82.5 \times \frac{35}{2} = 35372 \text{ t} - \text{m} > 397 \text{ t} - \text{m}$$

Hence O.K.

## CONCLUSIONS

- Appropriate depth of foundation for saturated condition of soil is to be taken.
- Raft foundation is to be provided at the required depth of foundation.
- Also, projection of R.C.C. slab of foundation (Projection from foundation base) at least 3 m all around the building & 800 mm thickness from foundation base is to be taken so that erosion of underlying soil should not take place due to heavy rainfall & flash flood.
- Erosion of underlying soil is a big problem due to flash floods in rivers.

Like dam = Depth of water in river = 35 meters.

Thrust of water due to standing water = 35 t/m<sup>2</sup>.

Velocity of flow of water in case of flood = 1.2 d = 1.2 x 35 = 42 m/sec.

Saturated soil conditions, high water levels, and external thrust forces. To ensure safety and durability, the depth of the foundation must be carefully selected to correspond with the saturated state of the soil and the prevailing hydrodynamic pressures. A raft foundation is recommended at the required depth, as it provides uniform load distribution, enhances resistance against uplift forces, and minimizes the risk of structural settlement.

Furthermore, it is essential that the R.C.C. slab projection extends a minimum of 3 meters around the perimeter of the building, with a slab thickness of about 800 mm, to safeguard against erosion of the underlying soil. This projection serves as a protective barrier during extreme events, such as flash floods and prolonged heavy rainfall, where the rapid movement of water can destabilize the foundation.

The problem of underlying soil erosion is particularly severe in areas adjacent to rivers, where sudden floods or cloudbursts may rapidly wash away supporting soil layers. For example, in the case of a dam, if the river depth is 35 meters, the corresponding thrust of standing water is approximately 35 t/m<sup>2</sup>, and the velocity of flow during floods may reach 42 m/s. These conditions generate significant hydraulic pressure and scouring forces on the foundation system, which, if not properly addressed, can compromise the stability of buildings, bridges, or retaining structures.

Hence, a well-designed foundation system with sufficient depth, reinforced raft slabs, and adequate projection is essential to mitigate erosion, withstand hydraulic thrust, and ensure the long-term safety and resilience of Civil engineering structures against natural hazards such as floods, cloudbursts, and soil saturation.

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