# DESIGN FOR COUNTER FORT RETAINING WALL

1.6 Design For Counter Fort Retaining Wall For Heel Slab Design

**Example:6**

Design a counter fort retaining wall based on the following data

Height of wall above ground level =6m

SBC of soil = 160 KN/m^2

Angle of internal friction ϕ =33°

Density of soil = 16KN/m^3

Spacing of counter forts = 3m c/c

Adopt M20 grade concrete and Fe415 HYSD bars

**Solution:**

**Step:1** Dimension of retaining wall

(a) Depth of foundation =P/W(1-sinϕ/1+sinϕ)^2

= 160/16(1/3)^2

=1.11m

Provide depth of foundation =1.2m

(b) Overall height of wall ,H = 6+1.2

H =7.2m

(c) Thickness of base slab = 2LH cm

=2x3x7.2

=43.2cm

Provide 450mm thick base slab

Base width = 0.6H to 0.7H

(0.6x7.2) = 4.32m

(0.7x7.2) = 5.04m

Adopt base width = 4.5m

Toe projection = (1/4)x4.5

=1.1m

**Step:2** Stability calculations

(a) Find load

W1 = b x d x γc

=0.22x6.75x24

=35.64 KN

W2 =b x dx γc

= 0.45x4.5x24

=48.60KN

W3 =b x dx γs

=3.28x6.75x16

=354.24 KN

Total = W1+W2+W3

=35.64+48.60+354.24

=438.49KN

(b) Find moment

M1 = W1 X length

=35.64 x 3.39

=120.80KNm

M2 = W2 X length

=48.60 x 2.25

=109.35KNm

M3 = W3 X length

=354.24x1.64

=580.95KNm

M4 = Moment of earth pressure

ka =Wh^3/6

1/3 =(16x7.2^3)/6

M4 = 331.77KNm ( moment at base )

Total moment,

M = M1+M2+M3+M4

= 120.80+109.35+580.95+331.77

M =1142.87KNm

Distance of the point of application of the resultant from point 'a' is,

Z =∑M/∑W

= 1142.87/438.49

=2.66m

Eccentricity, e = Z- b/2

= 2.66 – 4.5/2

= 0.41m

but, (b/6) = 4.5/6

=0.75m

e < (b/6)

Maximum and minimum pressure at the base are given by,

$\sigma = \sum W/b\ [1 \pm 6e/b]$

$\sigma max = 438.49/4.5\ [1+ (6x0.41)/4.5]$

$= 150KN/m^2$

$\sigma min = 438.49/4.5\ [1- (6x0.41)/4.5]$

$= 45KN/m^2$

The maximum intensity of pressure does not exceed the permissible value of 160KN/m^2

**Step:3** Design of heel slab

Considering 1m wide strip of heal slab near heal end 'a' ,

upward soil pressure = 45KN/m^2

Weight of soil on strip = 16x6.75

= 108 KN/m^2

Self weight of strip = 1x0.45x24

= 10.8 KN/m^2

Total = 108+10.8

= 118.80KN/m^2

Deduct for downward pressure = -45KN/m^2

Net downward pressure = 73.80KN/m^2

Spacing of counter forts =3m

Max negative service BM at counter forts,

M = (73.80x3^2)/12

= 55.35KNm

Factored moment = Mu x 1.5

= 55.35x1.5

= 83KNm

Reinforcement in heal slab,

Mu = (0.87 fy Ast d)[(1-Ast fy)/bd fck]

83x10^6 =(0.87x415Astx400)[(1-415Ast)/(1000x400x20)]

Ast = 600mm^2

Provide 12mm dia bars at 150mm c/c

Ast = 754mm^2

Distribution bar = 0.12% of cross section

=0.0012x1000x450

=540mm^2

Provide 10mm dia bars at 280mm c/c on both faces

Ast = 561mm^2

**Step:4** Design of counter forts

Thickness provide at top = 220+220 = 440mm

Thickness of counterfort = 440mm

Max working moment in counter forts is

M = ka x Wh^3/6 x L

= 1/3 x (16x6.75^3)/6 x 3

=820.12KNm

Factored moment = Mu x 1.5

= 820.12x1.5

=1230KNm

Reinforcement at bottom of counterforts is computed using the relation,

(1230x10^6)=(0.87x 415Astx440)[(1-415Ast)/(440x4400x20)

Ast = 800mm^2

But, minimum reinforcement as per IS code, 456:2000,

Ast = 0.85 bd/fy

= (0.85x440x4400)/415

= 3965mm^2

Provide 5 bars of 32mm dia

Ast = 4020mm^2

**Step:5** Curtailment of bars

h1 = depth at which 1 bar can be curtailed, then

( 5-1)/5 = h1/6.75^2

h1 = 6m from top

h2 = depth at which 2 bars are curtailed,

(5-2)/5 = h2/6.75^2

h2 = 5.2m from top

h3 = depth at which 3 bars are curtailed,

(5-3)/5 = h3/6.75^2

h3 = 4.2m from top

Remaining two bars are taken right upto the top.

**Step:6** Connection between counterforts and upright slab

Considering bottom 1m height of up right slab,

pressure on this strip = 36KN/m^2

Total working load pressure transferred to the counterfort for

1m height = 36(3-0.44)

= 91.8 KN

Factored force = 1.5 x 91.8

=138 KN

Reinforcement required per metre height

= 138x10^3/(0.87x415)

=382mm^2

Minimum reinforcement = 0.0012x10^3x440

=528mm^2

Spacing of 10mm dia bars = (78.5x1000)/52.8

= 148.6mm

This amount of reinforcement is provide as two legged horizontal lines of 10mm dia at 280mm c/c.

**Step:7** Connection between counterforts and heal slab

Working tension transferred in 1m width of the counterforts near heal end

a = 73.80(3-0.44)

= 189KN

Factored tension = 1.5x189

= 283.5KN

Reinforcement required in 1m width

= (283.5x10^3)/(0.87x415)

= 785mm^2/m

Spacing of 10mm dia two legged links

= (2x78.5x10^3)/785

=200mm

Provide 10mm dia two legged links at 200mm c/c.