WALL FOOTINGS

3

3.1) INTRODUCTION

The design of wall footings is much simpler than the design of the other types of foundation : in the case of axially loaded wall footing the stress distribution on the soil is considered uniform and the internal stresses and strains in the foundation follow the rules of the plane strain problems.

The main parameters affecting the design can be summarized as follows :

P : Transmitted vertical load acting at ground surface (t/m')

P_t : Load acting on the soil at foundation level = 1.08 x P (t/m')

p_s : Allowable gross bearing capacity of soil (t/m^2)

The foundation's dimensions will be noted as shown in figure (3.1).

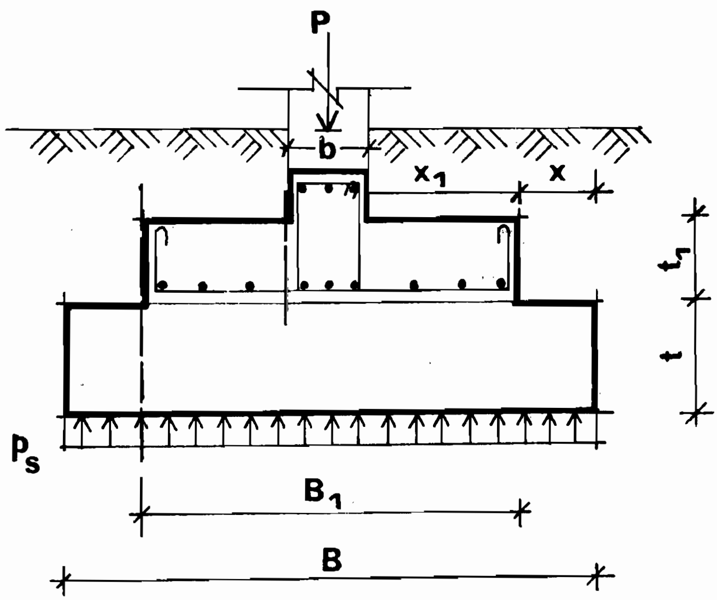

Fig. 3.1

b : Wall breadth (m)

B : Plain concrete breadth (m)

B_1 : Reinforced concrete breadth (m)

t : Plain concrete thickness (m)

t_1 : Reinforced concrete thickness (m)

X & X_1 : Cantilever arms of plain & reinforced concrete footing respectively (m) .

3.2) DESIGN PROCEDURES

3.2.1) The breadth of the footing is obtained from the following expression :

$$B = P_1 / p_s = 1.08 P/p_s \text{ (m)}$$

In very soft soil formation the breadth of the footing is usually very large and in this case it is recommended to use other types of foundations (piles for example). In our calculations (B) will be limited to 4.5 meters.

In very hard soil formation the breadth of footing is usually very small and hence for (B) < 0.8 m it is recommended to use only plain concrete footing having a thickness (t) equal to 0.4 m with the wall directly resting on the top.

3.2.2) The plain concrete thickness is calculated from the following suggested formula :

$$t = 0.15\,B > 0.20 \;(\,m\,). \qquad (3.1)$$

3.2.3) The breadth (B_1) of the reinforced concrete can be obtained from (B) as follows :

$$B_1 = B - 2\,X\,(\,m\,) \qquad (3.2)$$

Where X is the cantilever arm of the plain concrete which for simplicity may be taken here equal to (t) and hence equation (3.2) takes the form :

$$B_1 = B - 0.324\;P / p_s \;>\; (\,0.5 + b\,) \qquad (3.3)$$

3.2.4) The depth of the reinforced concrete footing is obtained from the bending moment at the face of wall beam.

The bending moment (M) is equal to :

$$M = (\,p_s / 1.08\,)(\,B / B_1\,)(\,X_1^{\,2} / 2\,) \qquad (3.4)$$

Taking (k_1)= 0.312 which corresponds to 28 days concrete strength equal to 180 kg/cm^2 , hence the depth will have the following expression :

$$d = 0.312 / 100\,[\,p_s / 1.08\,(\,B/B_1\,)(\,X_1^{\,2}/2\,)\,10^5/100\,]^{1/2} \qquad (3.5)$$

$$d = 0.0671\;X_1\,(\,p_s\,B/B_1\,)^{1/2} \qquad (3.6)$$

The shearing stresses in the wall footings are generally very low.

3.2.5) The main reinforcement of wall footings perpendicular to the axis of the wall is obtained as follows :

The cross-sectional area of the necessary reinforcement per meter length of the footing is dependable upon the bending moment in the footing (equation (3.4)) . The chosen footing depth (equation (3.6) affects the area of steel needed to resist this moment .

$$A_s = \frac{p_s/1.08\ (B/B_1)\ (X_1^2/2)}{0.0671\ X_1\ (p_s\ B/B_1)^{1/2}} \times \frac{10^5}{k_2} \quad (cm^2/m') \qquad (3.7)$$

but not less than 5ϕ13/m' .

The secondary reinforcement will be taken 30% of the main reinforcement (A_s) but not less than 5ϕ10/m' , where (A_s) is the area of reinforcing steel in cm^2 /m'.

3.3) LONGITUDINAL WALL BEAM

3.3.1) Introduction

In case the soil properties are not homogenious along the wall footing, it is recommended to provide the wall foundation with a longitudinal beam, under the wall, the rigidity of which must be sufficient to over-bridge weak regions and hence to minimize the deformation of the wall due to uneven settlement in the longitudinal direction. The criteria of design of this beam are based on the theory of beams on elastic supports. The depth of the beam is calculated such that the ineria of the bearing wall and foundation system together will have the required rigidity. The parameters influencing the behaviour of the foundation wall system are :

(EI) The rigidity of the foundation-wall system (tm^2)

(K_s) Modulus of subgrade reaction (Winkler model) which represents the ratio between the stress on the soil at a certain point and the resulting displacement of this point (t/m^3) . Values of K_s are presented in table (2.1) .

The theory of beams on elastic supports indentifies the rigidity of a structural member by a single dimensionless term having the following expression :

$$\alpha L = L / (4EI / K_s B)^{1/4} = L / L_o$$

where :

L is the member length (m)

B is the member width (m)

L_o is called the transfer length (m) $= \frac{1}{\alpha} = (4EI / K_s B)^{1/4}$.

For very rigid structures (rigid body motion) $L / L_o < 1$

For very flexible structure $L / L_o > 4$.

3.3.2) The Foundation-wall system's rigidity

It is usually uneconomic to neglect completely the rigidity of the wall in case of bearing wall systems. It is suggested for practical rigidity calcutations to condsider the wall as a continuity of the longitudinal beam and contributing equally to the beam itself in the system rigidity . Figure (3.2) shows the proposed theoretical model of rigidity calculation.

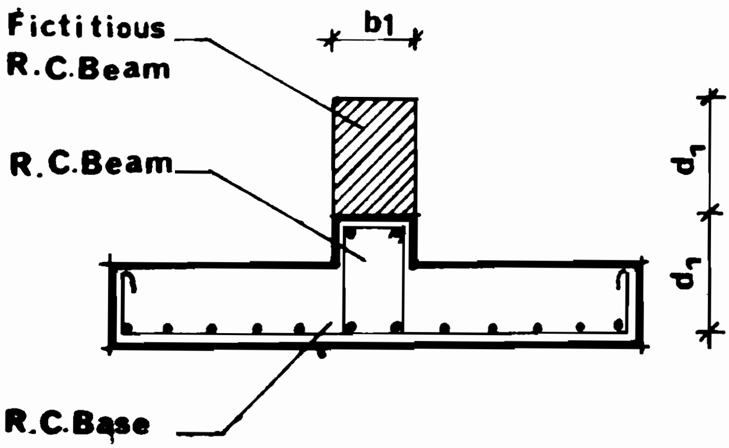

Fig. 3.2

After designing the foundation the only undefined terms affecting the rigidity of the wall footing will be the height (d_1) and the width (b_1) of the beam where b_1 will be taken equal to the wall's width (b), and (d_1) will be calculated such that the value of (α L) will be very close to unity. The depth of the beam is calculated to satisfy the rigidity requirement for walls having a length equal to 2 m, 3 m and 4 m . For walls having lengths exceeding these values the depth of the foundation will be taken equal to the highest values of (d_1) .

3.3.3) *The Modulus of subgrade reaction*

Recommended values of the modulus of subgrade reaction are given in table (2-1). However, for the sake of simplicity, (K_s) can take the following expression approximately :

$$K_s = \lambda \times p_s \ (t/m^3)$$

with λ = 70 - 100 for loose sand

= 250 - 300 for medium to dense sand and stiff clay .

= 450 - 500 for medium to soft clay .

and p_s being the allowable gross bearing capacity of soil .

3.3.4) *Design Curves*

The needed depth and reinforcement of the longitudinal beam are plotted in curves covering the following ranges :

p_s = 2.5 to 30 t/m^2

b = 0.25 and 0.38 m

P = 0 to 40 t/m'

K_s = (100 , 300 and 500) times the p_s value (t/m^3).

L_o = 2 , 3 and 4 .

The bottom reinforcement is recommended to be in the order of about 0.5% of the cross-sectional area of the beam . An equal amount of reinforcement is to be arranged at its top.

It must be noted that the effect of (p_s) on the beam dimensions is very small and hence the values plotted in the following curves represent the average values of depth and reinforcement area with an allowance not exceeding 10% .