

REINFORCED CONCRETE WALL FOOTING DESIGN EXAMPLE

Reinforced concrete wall footing design example

provides a comprehensive understanding of how to plan, calculate, and construct a stable foundation for load-bearing walls. Proper footing design is crucial in ensuring the stability, durability, and safety of any structure. This article offers a detailed example to guide engineers, architects, and students through the essential steps involved in designing a reinforced concrete wall footing, including load assessment, material selection, reinforcement detailing, and compliance with relevant codes.

Understanding the Basics of Wall Footing Design

What is a Wall Footing?

A wall footing is a type of shallow foundation that transmits the load from a wall to the ground. It distributes the load over

a larger area of soil to prevent excessive settlement or failure. Wall footings are typically used for load-bearing walls in residential, commercial, and industrial buildings.

Objectives of Designing a Reinforced Concrete Wall Footing

- To safely transfer the load from the wall to the soil
- To prevent excessive settlement or sliding
- To resist overturning and uplift
- To comply with local building codes and standards
- To optimize material use for cost-effectiveness

Step-by-Step Reinforced Concrete Wall Footing Design Example

1. Define Structural Loads and Dimensions

Suppose we are designing a wall footing for a load-bearing wall supporting a residential building. The following parameters are assumed:

1. Wall length (L): 6 meters
2. Wall height (H): 3 meters
3. Load per unit length of the wall (including dead load and live load): 20 kN/m
4. Soil bearing capacity (q_u): 150 kPa (kiloPascals)
5. Minimum footing width (b): To be determined
6. Concrete grade: C25/30 ($f'_c = 25$ MPa)

7. Reinforcement steel: TMT bars with $f_y = 415 \text{ MPa}$

Note: These values should be refined based on actual structural plans and site investigations.

2. Calculate the Total Load and Bearing Pressure

The total load (W) supported by the footing: $W = q \times L$
Where: - (q) = load per unit length = 20 kN/m - (L) = length of the wall = 6 m
 $W = 20 \text{ kN/m} \times 6 \text{ m} = 120 \text{ kN}$
The average soil pressure under the footing: $q_{\text{soil}} = \frac{W}{A}$ where ($A = b \times d$), with (d) being the effective depth. The maximum allowable soil bearing capacity: $q_{\text{allow}} = 150 \text{ kPa}$
To prevent bearing capacity failure: $A \geq \frac{W}{q_{\text{allow}}} = \frac{120 \text{ kN}}{150 \text{ kPa}} = 0.8 \text{ m}^2$
Choosing a preliminary footing width: $b = \sqrt{A} \approx \sqrt{0.8} \approx 0.9 \text{ m}$
To provide a margin, select $b = 1.2 \text{ meters}$. Note: The footing length (perpendicular to the wall) should be designed to handle uplift and stability, but for simplicity, we're focusing on the width here.

3. Determine the Effective Depth (d)

The effective depth is critical for reinforcement detailing. It should be enough to resist bending and shear. Assuming: - Cover to reinforcement: 50 mm - Diameter of main reinforcement bars: 16 mm (diameter = 16 mm) Calculate the total depth: $d = \text{total depth} - \text{cover} -$

$\frac{\{\text{bar diameter}\}^2}{4}$ Choose a total depth (D):
 $D = 600 \text{ mm}$ Therefore: $d = 600 \text{ mm} - 50 \text{ mm} - 8 \text{ mm} = 542 \text{ mm}$ Round it to 550 mm for practical purposes.

4. Reinforcement Detailing

Designing reinforcement involves determining the amount and arrangement of steel bars to resist bending and shear. a)
 Bending Reinforcement (Main Bars): Using the limit state design method: Calculate the factored load: $W_{\text{fact}} = 1.5 \times W = 1.5 \times 120 \text{ kN} = 180 \text{ kN}$
 Calculate the required moment: $M_u = \frac{W_{\text{fact}} \times \{\text{overhang}\}^2}{2}$ Assuming the load acts at the center, with a simple span: $M_u = \frac{180 \text{ kN} \times 3 \text{ m}^2}{2} = 270 \text{ kNm}$ Determine the required area of steel (A_s): $M_u = 0.87 f_y A_s (d - a/2)$
 Where: - a = depth of the equivalent rectangular stress block - For preliminary calculation, assume $a \approx 0.9 \times d = 495 \text{ mm}$ Rearranged: $A_s = \frac{M_u}{0.87 f_y (d - a/2)}$ Substituting values: $A_s = \frac{270 \times 10^6}{0.87 \times 415 \times (550 - 495)}$
 $A_s \approx \frac{270 \times 10^6}{19,845} \approx 13,620 \text{ mm}^2$ Select reinforcement bars: - Using 16 mm bars ($A_b = 201 \text{ mm}^2$) - Number of bars: $n = \frac{A_s}{A_b} = \frac{13,620}{201} \approx 68 \text{ bars}$ This is impractical; hence, increase bar size or reduce span. Typically, for a wall footing, a practical reinforcement layout might be: - 4 bars of 20 mm diameter ($A_b = 4 \times 314 = 1256 \text{ mm}^2$) - Additional reinforcement as

needed. b) Shear Reinforcement: Design shear reinforcement (stirrups): - Shear force: $V_u = \frac{W_{fact}}{2} = 90 \text{ kN}$ - Shear capacity of concrete: $V_c = 0.6 \sqrt{f'_c} \times b \times d$ $V_c = 0.6 \times \sqrt{25} \times 1.2 \times 0.55 \approx 0.6 \times 5 \times 1.2 \times 0.55 \approx 1.98 \text{ kN}$ Since (V_u) exceeds (V_c) , shear reinforcement is needed. Design stirrups with: - Spacing: $s \leq \frac{0.87 f_y A_{st}}{V_u}$ Assuming 8 mm stirrups: $A_{st} = 8 \text{ mm} \times 2 = 16 \text{ mm}^2$ Calculate: $s = \frac{0.87 \times 415 \times 16 \times 0.55}{90} \approx 33 \text{ mm}$ Practically, use stirrups spaced at 150 mm centers.

5. Checking for Structural Stability

Overturning and Sliding

- The footing must resist overturning moments and sliding forces.
- The soil's passive earth pressure and lateral forces should be evaluated.
- Typically, a safety factor of 3 is used.

Settlement and Bearing Capacity

- The footing width ensures the soil's bearing capacity isn't exceeded.
- Reinforced concrete footings also help distribute loads evenly.

Additional Considerations in Design

Code Compliance

- Follow local standards such as ACI 318, Eurocode 2, or IS 456.
- Ensure minimum reinforcement ratios (e.g., 0.15% to 0.25%).

Construction Aspects

- Proper curing
- Adequate formwork
- Quality control of concrete and reinforcement placement

Environmental Factors

- Use of corrosion-resistant reinforcement if in aggressive environments
- Adequate drainage around the footing

Conclusion

Designing a reinforced concrete wall footing involves a systematic approach that considers load calculations, soil properties, material strengths, reinforcement detailing,

Reinforced Concrete Wall Footing Design Example: A Comprehensive Guide Designing reinforced concrete wall footings is a fundamental aspect of structural engineering, ensuring stability, safety, and longevity of load-bearing walls. This detailed review provides an in-depth example of

designing a reinforced concrete wall footing, covering all critical aspects from load analysis to detailing, with practical calculations and considerations.

Introduction to Wall Footings

Wall footings are structural elements that distribute the load from a wall to the ground, preventing settlement or failure. They are typically used for load-bearing walls in residential, commercial, and industrial structures. Key Objectives of Wall Footing Design: - Transfer wall loads safely to the ground - Resist overturning, sliding, and settlement - Provide adequate bearing capacity - Accommodate settlements without cracking or failure

Step 1: Understanding the Structural Load

The first essential step in designing a wall footing is to determine the loads it must carry. These loads generally include: - Dead Load (DL): Permanent loads such as the weight of the wall, embedded finishes, and structural components. - Live Load (LL): Variable loads like occupancy, furniture, or equipment. - Other Loads: Wind, seismic, or special loads if applicable (though often transferred through other structural elements). Example Data: Suppose we have a load-bearing wall with the following parameters: - Wall length $(L = 6 \text{ m})$ - Wall height $(h_{\text{wall}} = 3 \text{ m})$ - Wall thickness $(t_{\text{wall}} = 0.3 \text{ m})$ - Material densities: - Concrete: (2.4 kN/m^3) - Brick or block infill (if any):

negligible for this example Calculating Dead Load:
$$\text{Dead Load per unit length} = \text{Wall cross-sectional area} \times \text{Density}$$

$$\rightarrow DL_{\text{per m}} = t_{\text{wall}} \times h_{\text{wall}} \times \text{Density}$$

$$DL_{\text{per m}} = 0.3 \text{ m} \times 3 \text{ m} \times 2.4 \text{ kN/m}^3 = 0.3 \times 3 \times 2.4 = 2.16 \text{ kN/m}$$
Total load along the wall:
$$Q_{\text{total}} = DL_{\text{per m}} \times L = 2.16 \text{ kN/m} \times 6 \text{ m} = 12.96 \text{ kN}$$
Adding an estimated live load:
$$LL_{\text{per m}} = 1.0 \text{ kN/m}$$
(assuming typical occupancy load)
Total load:
$$Q_{\text{total}} = (2.16 + 1.0) \times 6 = 3.16 \times 6 = 18.96 \text{ kN}$$

Step 2: Selecting the Footing Type and Dimensions

For wall footings, the common types are strip footings and isolated footings. Given the continuous wall load, a strip footing is typical. Initial Dimensions: - Width (b): to be determined based on load and soil bearing capacity - Thickness (d): generally $(0.5 \times b)$ or as per code

Step 3: Soil Bearing Capacity and Footing Width

The footing must be designed to prevent excessive settlement and bearing failure. Soil Bearing Capacity: - Assume a safe bearing capacity (q_{allow}) of the soil, based on geotechnical report. - For this example, take: $q_{\text{allow}} = 150 \text{ kN/m}^2$ Design Load per unit length: $q_{\text{load}} =$

$\frac{Q_{\text{total}}}{L} = \frac{18.96 \text{ kN}}{6 \text{ m}} = 3.16 \text{ kN/m}$ Minimum Footing Width: $b_{\text{min}} = \frac{q_{\text{load}}}{q_{\text{allow}}} = \frac{3.16}{150} \approx 0.021 \text{ m}$ This is negligible; however, practical considerations require larger widths for stability and constructability. Code Recommendations: - Typical minimum width for a wall footing ranges from 0.75 m to 1.0 m. - For safety and constructability, select $(b = 1.0 \text{ m})$.

Step 4: Checking Structural Stability

4.1. Bearing Capacity Check: Ensure that the pressure transmitted to the soil does not exceed (q_{allow}) : $q_{\text{bearing}} = \frac{Q_{\text{total}}}{b \times L} = \frac{18.96 \text{ kN}}{1.0 \text{ m} \times 6 \text{ m}} = 3.16 \text{ kN/m}^2$ Since $(3.16 < 150 \text{ kN/m}^2)$, bearing capacity is adequate.

4.2. Overturning and Sliding: - The overturning moment around the edge: $M_{\text{overturn}} = Q_{\text{total}} \times \frac{L}{2} = 18.96 \text{ kN} \times 3 \text{ m} = 56.88 \text{ kN} \cdot \text{m}$ - Resisting moment from the weight of the footing and wall: Assuming the footing's own weight acts at its centroid: $W_{\text{footing}} = b \times d \times \gamma_c$ Assuming: - Concrete unit weight $(\gamma_c = 24 \text{ kN/m}^3)$ - Footing thickness $(d = 0.5 \text{ m})$ $W_{\text{footing}} = 1.0 \times 0.5 \times 24 = 12 \text{ kN}$ The resisting moment: $M_{\text{resist}} = W_{\text{footing}} \times \frac{b}{2} = 12 \text{ kN} \times 0.5 \text{ m} = 6 \text{ kN} \cdot \text{m}$ This is less than the overturning moment, indicating the footing is unstable against overturning. To counteract this, the footing width or weight must be increased, or additional

reinforcement provided.

Step 5: Reinforcement Detailing

Reinforcement is key to ensuring the structure can resist bending, shear, and cracking.

5.1. Bending Reinforcement:

- Determine the bending moment at critical sections.
- Use the ultimate moment (M_u): Assuming an ultimate load factor of 1.5: $M_u = 1.5 \times 56.88 = 85.32$, kN $\cdot$ m
- Reinforcement Calculations: Using the simplified formula: $A_s = \frac{M_u}{0.87 \times f_y \times z}$ where:
 - (f_y) = yield strength of reinforcement, say 415 MPa
 - (z) = lever arm, approximately $0.9d$; with ($d = 0.5$, m), ($z \approx 0.45$, m)

$$A_s = \frac{85,320 \times 10^3, \text{ N} \cdot \text{mm}}{0.87 \times 415, \text{ MPa} \times 450, \text{ mm}} \approx \frac{85,320,000}{162,622.5} \approx 524.7, \text{ mm}^2$$

- Reinforcement per meter length: $A_s/m = \frac{524.7, \text{ mm}^2}{6, \text{ m}} \approx 87.45, \text{ mm}^2/\text{m}$
- Rebar selection: Using 16 bars (diameter 16 mm): $A_{\text{rebar}} = \frac{\pi}{4} \times (16)^2 \approx 201, \text{ mm}^2$
- Number of bars per meter: $n = \frac{87.45}{201} \approx 0.43$

Thus, at least 1 bar of 16 mm diameter per meter is sufficient.

5.2. Shear Reinforcement: Calculate shear forces and provide stirrups accordingly, especially near the critical sections.

Step 6: Detailing and

Construction Considerations

Proper reinforcement detailing ensures the structural integrity and durability of the footing. Key Aspects: - Provide main reinforcement bars along the length of the footing. - Use stirrups or shear links to resist shear forces. - Maintain adequate cover (usually 50-75 mm) to prevent corrosion. - Provide development lengths for bars. - Include key or dowel bars if the footing connects to other structural elements. Additional Details: - Reinforcement spacing should be within code limits, typically not exceeding 300 mm. - Use appropriate anchorage and lap lengths. - Ensure proper compaction and curing of concrete.

Step 7: Final Checks and Code Compliance

Ensure the design adheres to relevant standards such as ACI

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Questions & Answers About reinforced concrete wall footing design example

No	Question	Answer
1	What are the key steps involved in designing a reinforced concrete wall footing?	The key steps include determining load requirements, selecting appropriate footing dimensions, calculating reinforcement details, checking for structural stability and serviceability limits, and ensuring compliance with relevant codes and standards.
2	How do you calculate the footing size for a reinforced concrete wall?	The footing size is calculated based on the load transferred from the wall, soil bearing capacity, and safety factors. Typically, the width is chosen to distribute the load effectively, ensuring the soil bearing pressure remains within permissible limits, often using formulas like $B = \frac{\text{total load}}{\text{soil bearing capacity}}$.

3	What factors influence the reinforcement details in a wall footing design?	Factors include load magnitude, footing dimensions, soil conditions, concrete strength, bending moments, shear forces, and code requirements. Proper reinforcement ensures adequate strength and ductility to resist these forces.
4	How is the punching shear checked in a reinforced concrete wall footing?	Punching shear is checked by calculating the shear force around the column or wall base and comparing it with the shear capacity of the concrete and reinforcement. The shear capacity is evaluated using formulas like $V_c = 0.6\sqrt{f'_c} b d$, ensuring the actual shear does not exceed this value.
5	What are common reinforcement detailing practices in reinforced concrete wall footings?	Common practices include providing main reinforcement in the bottom of the footing to resist bending, distribution reinforcement to control cracking, and stirrups or shear links for shear resistance. Reinforcement is typically placed with proper spacing and anchorage as per codes.
6	How do you ensure the stability of a reinforced concrete wall footing against sliding and overturning?	Stability is ensured by checking the factor of safety against sliding (by comparing the frictional resistance and lateral forces) and overturning (by calculating moments about the edge). Adequate weight, friction, and reinforcement details are incorporated to maintain stability.

7	What is the typical concrete strength used in reinforced concrete wall footing design?	A common concrete strength used is M20 to M30 (characteristic compressive strength of 20 MPa to 30 MPa), depending on project requirements, structural loads, and local standards.
8	How does soil bearing capacity affect the design of a reinforced concrete wall footing?	Soil bearing capacity limits the maximum load the footing can safely transfer to the ground. A lower soil bearing capacity requires larger footing dimensions or reinforcement adjustments to prevent excessive settlement or failure.
9	Can you provide a simple example of a reinforced concrete wall footing design calculation?	Certainly! For a wall with a load of 200 kN, soil bearing capacity of 150 kPa, and a footing width B, the minimum footing width is $B = 200 / 150 = 1.33$ m. Reinforcement is then designed based on bending moments and shear forces calculated from the load and footing dimensions, ensuring compliance with code standards.

reinforced concrete footing design, footing load calculation, footing size determination, rebar detailing, footing reinforcement details, load distribution in footings, foundation design examples, concrete strength requirements, footing shear design, footing bending moment analysis

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