GUYANA STANDARD

Code of Practice
for
Buildings – Part 13: Foundations and excavations

Prepared by
GUYANA NATIONAL BUREAU OF STANDARDS

Approved by
NATIONAL STANDARDS COUNCIL

PUBLISHED BY THE GUYANA NATIONAL BUREAU OF STANDARDS,
FLAT 15, SOPHIA EXHIBITION COMPLEX,
GEORGETOWN, GUYANA.

Contents

		Page
Foreword		ii
Members of the National Building Code Committee		iii
Standard		
1.	Scope	1
2.	Definitions	1
3.	Building classification	2
4.	Site investigations	3
5.	Excavations	4
6.	Foundations	6

Foreword

This Guyana Standard was prepared by the **Sub-committee – Foundations and excavations** and approved by the National Building Code Committee and National Standards Council in 2005.

This Standard specifies requirements for excavations and foundations for building construction. It includes residential and non-residential buildings and related civil works and presents good-practice guidelines based on engineering principles to achieve safety and economy. Rigorous design methods are not within the scope of this Code since such methods are adequately presented in several design standards and Codes of Practice, such as the latest edition of BS 8004, BS 5930, Eurocode 7, Uniform Building Code, and CUBIC etc.).

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Code of Practice
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1 Scope

This Code specifies guidelines for excavations and foundations for building construction. These include temporary and permanent excavation for foundation, drainage system, utilities – water supply systems, sanitation systems, electrical cabling, etc., reservoirs and swimming pools. This Code shall apply for low and medium rise buildings. Prescriptive methods for timber pile foundations are also considered.

Comprehensive design methods involving the application of engineering calculations are not within the scope of this Code.

2 Definitions

For the purpose of this Code, the following definitions shall apply:

2.1 **excavation:** An extraction of soil to form a cut in the ground by manual or mechanical means for engineering purposes.

2.2 **foundation:** A system of structural elements forming the sub-structure of a building or other structure to support and transmit the loads to the natural ground.

2.3 **shallow foundation:** A foundation placed on or near the surface of the ground.

2.4 **deep foundation:** A foundation which extends to deep soil strata where the upper strata has insufficient capacity to safely support the building loads.

2.5 **bearing capacity:** The allowable pressure that can be sustained by a soil based on the engineering characteristics of the soil.

2.6 **presumptive pressures:** The assumed permissible bearing capacity based on the soil type instead of established soil parameters.

2.7 **settlement:** The downward displacement of a foundation element or system under the action of the building loads.

2.8 **differential settlement:** The relative settlement of adjacent foundation elements or opposite ends of a continuous foundation element where such settlement is non-uniform.

2.9 **total settlement:** The maximum uniform settlement of a foundation.

3 Building classification

Buildings shall be classified according to:

(a) use and occupancy; and

(b) building height (In terms of number of stories).

3.1 Use and occupancy

Buildings shall be classified in the following categories based on use and occupancy:

(a) **Residential:** Buildings used for domestic purposes, including private and public housing; and

(b) **Non-residential:** Buildings for non-domestic purposes, such as industrial, commercial, or institutional buildings.

3.2 Building height

Buildings shall be classified as low, medium and high-rise based on the number of stories, including the ground floor according to the criteria specified in **Table 1**. This classification applies to residential and non-residential buildings.

Table 1

Classifications of buildings by number of stories

Class	Description	Number of Stories
1	Low-rise	1 – 2
2	Medium-rise	3 – 5
3	High-rise	>5

4 Site investigations

4.1 Site investigations shall be conducted for all excavations and foundation works as specified in **Table 2**.

Table 2

Levels of subsurface investigations

.2

Level	Description	Investigation details	Remarks
1	Preliminary investigation	Test pits, undisturbed sampling; field and laboratory testing for the purpose of soil identification and classification.	Indicative soil characteristics only required.
2	Detailed investigation	Boreholes, disturbed and undisturbed sampling; field and laboratory tests, determination engineering properties (strength compressibility, etc.) for design.	Detailed soil report required.

The following investigation classifications shall apply:

(a) **low-rise residential buildings (Class 1): ** May require only Level 1 investigation for the purposes of excavation and foundation works;

(b) **medium and high-rise residential buildings (Classes 2 and 3):** May require two-stage investigation (Levels 1 and 2) for the purposes of excavation and foundation works; and

(c) **All non-residential buildings (Classes 1-3):** Shall require two-stage (Levels 1 and 2) investigation for the purposes of excavation and foundation works.

5 Excavations

5.1 Stability of excavations

Measures shall be adopted to prevent the sides of excavations from collapsing. The requirements for ensuring stability depend on the nature of the soils and whether the sides of excavations are unsupported or retained.

5.1.1 Stability of excavations in sand

Open excavations in sand soils with unsupported sides shall be sloped at an angle equal to the natural angle of repose of the material, as specified in **Table 3**.

Table 3

Angles of repose for dry sands

Density	Round grains uniform	Angular grains well graded
Loose	28.5^{O}	34^{O}
Dense	33.0^{O}	46^{O}

5.1.2 Stability of excavations in clay

Stability of open excavations in clay soils shall be achieved by restricting the height to a specified critical value or by providing a suitable side slope.

(a) **Critical height – Open excavations in clay**

The critical height for stability of open excavations with vertical faces in clay soils shall be as specified in **Table 4**. Where the height of the excavation exceeds the critical heights or there is evidence of instability due to unfavourable ground conditions the sides of excavations shall have sides sloped as specified in **Table 4**.

(b) **Adjacent to structure**

All excavations with unsupported sides in proximity to adjacent footings and/or other structures shall be located at a distance equal or greater than the depth of the excavation.

Table 4

Critical vertical unsupported height for clay soils

Type of soil	Undrained shear strength Cu (kN/m^2)	Critical height (m)
Very soft	0-18	0-2
Soft	18-35	2-4
Firm	35-70	4-6

Table 5

Recommended side slopes for clay soils

Type of soil	Total height (m)	Side slope (Vertical : horizontal)
Very soft	1-2.5	1:1
Soft	2.5-4	1:1 ½
Firm	4-6	1: ½

5.2 Braced excavations

5.2.1 Where there exist the potential for instability due to poor soil characteristics or excavation depths exceeding the critical heights as specified in **Tables 3** and **4** the sides of major excavations shall be braced by the provision of suitable retaining structures, such as timbering, revetment, sheet-pile retaining walls, etc.

5.2.2 All temporary and permanent excavations adjacent buildings and other vulnerable structures shall be provided with retaining structures so as to safeguard against instability, which may cause damage to structures and injury to occupants. Such retaining structures shall be designed by a qualified engineer to ensure that they will remain stable throughout its design life.

5.2.3 Temporary excavations with vertical faces where the height exceeds the critical heights specified in **Table 3** and **4** shall have the sides protected against collapse by the provision of timbering, sheet-piling or other cofferdam.

5.2.4 Precautions shall be taken against base instability due to ground heave for deep excavations with retained sides in soft clay soils.

5.3 Drainage

Temporary excavations for building works, such as foundations, utility manholes and cabling shall be effectively drained and maintained in a dry condition throughout the duration of the construction works.

Effective dewatering systems shall be designed and installed to drain deep excavations, such as for basements, reservoirs, swimming pools, etc.

5.4 Backfilling

Temporary excavations for foundations, utility cabling, closed drainage systems, and retaining structures, shall be backfilled with suitable granular material. Such backfilling shall be done in layers and compacted using suitable compaction equipment. The depth of backfill to utility cables, pipes, etc. shall be adequate to provide protection from damage due to weight of overburden and traffic.

6 Foundations

6.1 Design requirements

The design of building foundations shall be undertaken by qualified engineers applying one of the following methods:

(a) **calculation methods:** Based on the application of strict engineering theory and principles in accordance with applicable design codes, such as, the latest edition of **BS 8007** and **Eurocode 7.**

(b) **prescriptive methods:** Based on tables of allowable bearing pressures for various classifications of soil and buildings.

All foundations designs for residential buildings shall be certified by a qualified engineer before building approval is granted. The design of foundations for medium and high-rise residential buildings and all categories of non-residential buildings shall be carried out by a qualified engineer.

6.2 Trenching and preparation

6.2.1 Shallow foundations shall be constructed in trenches excavated to specified dimensions.

6.2.2 Trenching for footings shall be made stable against collapse and shall have sides and bottoms suitably shaped and levelled.

6.2.3 Where the supporting soil is clay, a well-compacted layer of suitable granular material shall be placed on which the reinforced concrete footing shall be cast.

6.3 Minimum depth

6.3.1 The following requirements shall apply to placement of foundations:

(a) the minimum depth below the ground surface at which the bottom of foundations shall be founded is 300 mm; and

(b) under no circumstances shall building foundations be placed on the topsoil.

6.4 Materials

Shallow foundations elements and pile caps for deep foundations shall be constructed of reinforced concrete. All materials shall be of acceptable quality and shall meet the minimum strength requirements to ensure structural performance.

6.4.1 Concrete

(a) The concrete grade for footings shall be C25 (25 N/mm^2) or higher.

(b) Concrete shall be kept moist for a minimum period of 7 days to allow curing and development to design strength to occur.

6.4.2 Reinforcement

(a) The steel for primary reinforcement shall be high yield bars ($f_y \geq 410$ N/mm^2) with a minimum size of 12 mm. For secondary reinforcement mild steel bars with minimum size of 10 mm shall be used.

(b) The minimum cover to reinforcement shall be 50 mm.

6.5 Residential buildings

6.5.1 Low-rise buildings

The design of foundations for low-rise residential buildings shall be based on prescriptive methods. This shall require only Level 1 site investigation to classify the soil for the purpose of applying the appropriate prescriptive bearing pressure in accordance with **6.7.3.**

6.5.2 Medium-rise buildings

The design of foundations for medium-rise residential buildings shall be based on prescriptive methods. Where the preliminary site investigation indicates poor subsurface conditions, a two-stage investigation shall be conducted and the foundation design shall be based on calculations.

6.5.3 High-rise buildings

The design of foundations for high-rise residential buildings shall be based on calculation methods with two-stage site investigation to provide the necessary design parameters (bearing capacity, settlement, etc.).

6.6 Non-residential buildings

6.6.1 The design of foundations for all non-residential buildings shall be based on calculation methods based on strict foundation engineering theories and principles.

6.6.2 Design parameters (bearing capacity, settlement, etc.) shall be obtained from a detailed site investigation for buildings.

6.7 Shallow foundations

6.7.1 Shallow foundations shall be adequately sized to ensure that:

(a) the allowable bearing pressure for the supporting soil is not exceeded; and

(b) the permissible total and differential settlements are not exceeded.

6.7.2 Minimum thickness

The minimum thickness of a shallow foundation for a building foundation shall be 250 mm.

6.7.3 Prescriptive pressures

Prescriptive pressures for various soils and foundation types shall be those specified in **Table 6** for sands and **Table 7** for clays.

Table 6

Foundations in sands - Prescriptive pressures for a minimum depth of 0.6m below ground level

Description of soil	N-value in SPT	Presumed bearing pressure for foundation of width (kN/m^3)			
		0.61 m	**0.75 m**	**0.9 m**	**1.2 m**
Very dense sands and gravels	> 50	1000	900	800	600
Dense sands and gravels	30-50	800-1000	700-900	600-800	500-700
Medium-dense sands and gravels	10-30	350-500	300-500	300-400	200-300
Loose sands and gravels	5-10	50-150	50-150	40-150	40-100

Table 7

Foundations in clays –Prescriptive pressures for a minimum depth of 0.6m below ground level

Description of soil	Undrained shear strength	Presumed bearing pressure for foundation of width (kN/m^2)		
		0.75 m	**0.91 m**	**1.22 m**
Firm consolidated Demerara clays (at depth)	40-75	130-150	120-140	100-120
Soft consolidated alluvial Demerara clays	20-40	50-80	40-70	30-60
Very soft consolidated alluvial Demerara clays	>20	40-50	30-40	20-40

6.7.4 Foundation settlements

Tolerable differential settlements for shallow foundations are specified in **Table 8**.

6.7.4.1 Foundations on clays

The recommended design limit for maximum differential settlement is 40 mm. The recommended design limit for total settlements is 65mm for isolated foundations and 65-100mm for rafts.

6.7.4.2 Foundations on sands

The recommended maximum settlement between adjacent isolated footings is 25mm. The limiting maximum settlement for rafts is 25-50 mm.

Table 8

Tolerable differential settlements

Type of structure	**Tolerable differential settlements (See Note)**	**Type of damage**
One or two-storey houses with plain brick bearing walls and light structural frame	0.002 to 0.003	Vertical, horizontal and diagonal tension cracks in walls.
One or two-storey steel frame, truss roof, warehouse with flexible siding	0.006 to 0.008	Distortion of frame
Structures with relatively insensitive interior or exterior finish such as dry wall, moveable panels, glass panels	0.002 to 0.003	Damage to walls and panels, including cracking.
Multi-storey concrete rigid frame on structural mat foundation 1.2m ±thick	0.0015	Cracking by sagging and hogging. Diagonal cracking in walls.
Framed buildings and reinforced load-bearing walls	0.004 0.002	Structural damage. Vertical, horizontal and diagonal tension cracking in walls and partitions.
Unreinforced load-bearing walls	0.0004	Cracking by sagging and hogging.
Timber framed buildings with timber cladding and partitions	0.008	Racking/rhomboidal distortion of walls. Jammed doors and windows.

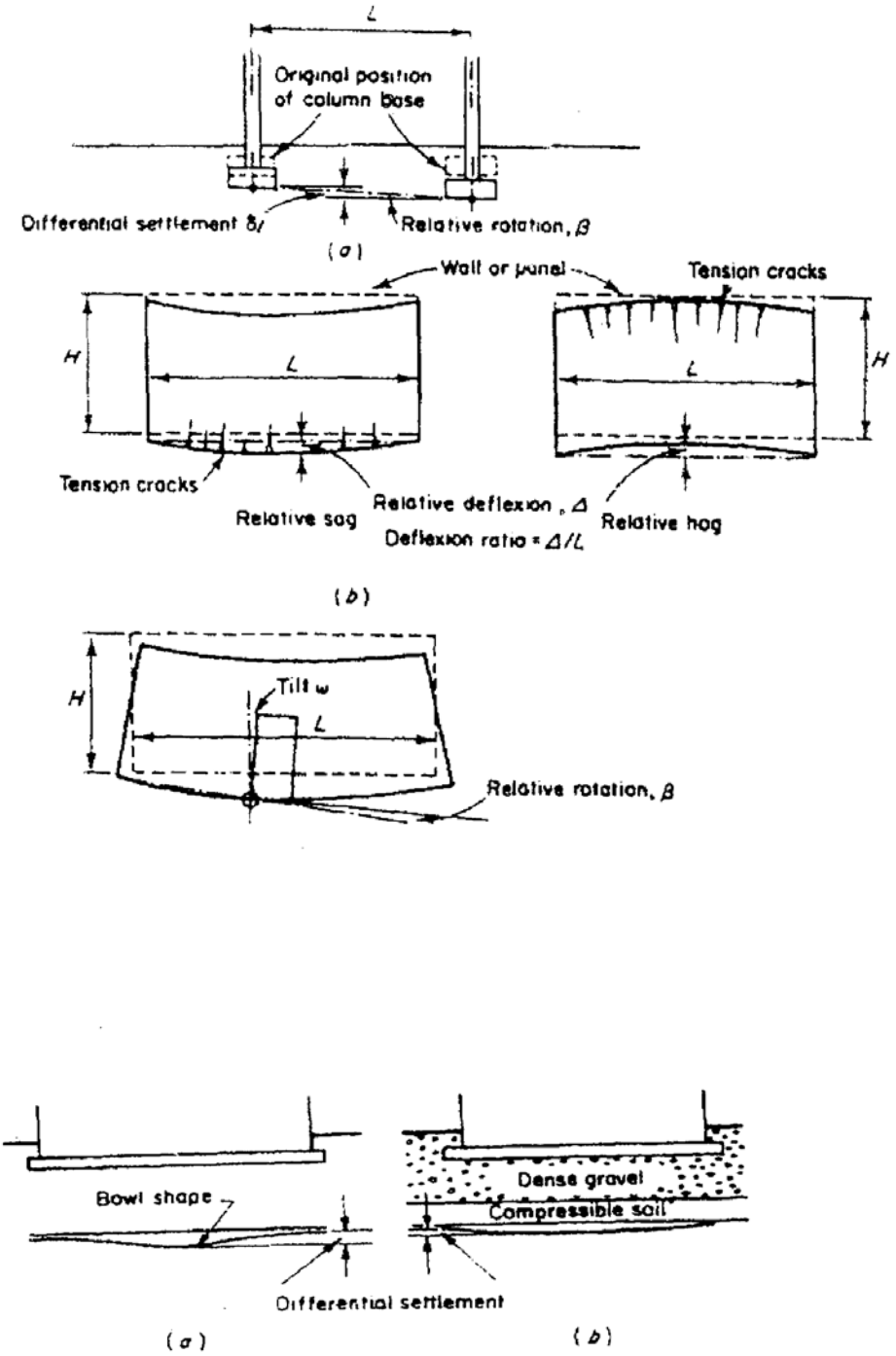
Note: Tolerable differential settlement is expressed in terms of slope of settlement profile as shown in Figure 1.

For example:

Value of 0.001 = 20 mm differential settlement in 6000 mm distance
Value of 0.008 = 50 mm differential settlement in 6000 mm distance
Rotation or angular distortion is 50mm.

Figure 1

Differential settlements



6.8 Isolated footings

Isolated footings shall be adopted to support individual columns or two closely spaced columns supporting a common load. Such foundations comprise reinforced concrete pads placed at a depth below the existing ground level in excavated trenches.

6.8.1 Minimum dimensions

(a) The minimum thickness of isolated footings for residential building construction shall be 250 mm.

(b) The minimum cover to reinforcement shall be 40 mm.

(c) The area of the footing shall be calculated such that the prescriptive bearing pressures given in **Tables 6** and **7** shall not be exceeded.

(d) The minimum size of a footing for residential construction shall be 610 mm x 610 mm.

(e) For foundations on clays, the recommended design limit for maximum differential settlement is 40 mm and for total settlements the recommended design limit is 65mm.

(f) For foundations on sands the recommended maximum settlement between adjacent footings is 25mm.

(g) Tie beams shall be adopted with isolated footings to minimize differential settlement.

6.8.2 Reinforcement

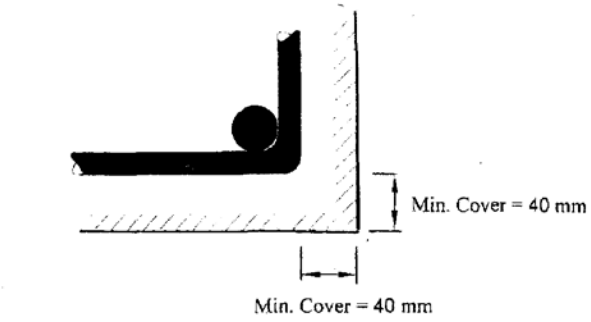
(a) For lightly loaded columns, a single reinforcement mat comprising bars arranged in two orthogonal directions shall be placed near the bottom of the footing with the adequate cover, as shown in **Figure 2**.

(b) For heavy to moderately loaded columns a reinforcement cage comprising bars arranged in two orthogonal directions shall be placed near the top and bottom of the footing with the adequate cover, as shown in **Figure 3.**

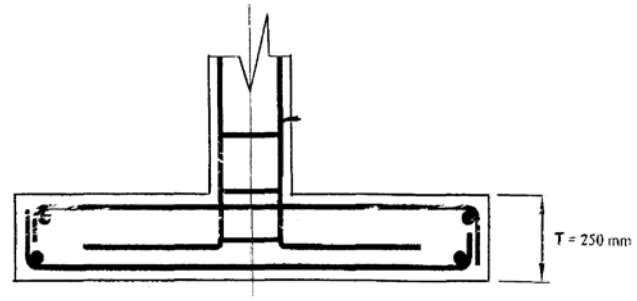
(c) Starter bars shall be fixed to the foundation reinforcement, as shown in **Figure 2**.

Figure 2

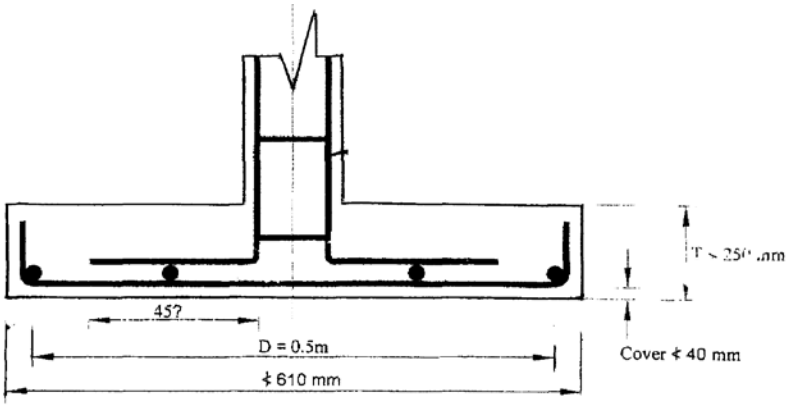
Reinforcement arrangement for pad footings



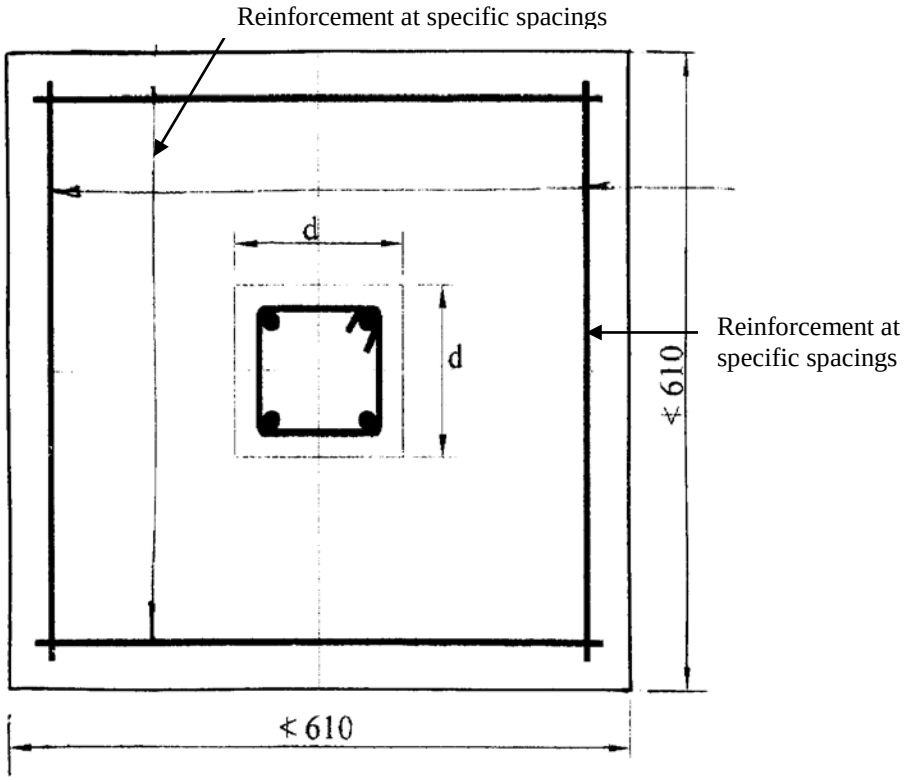
(a) Minimum cover to reinforcement



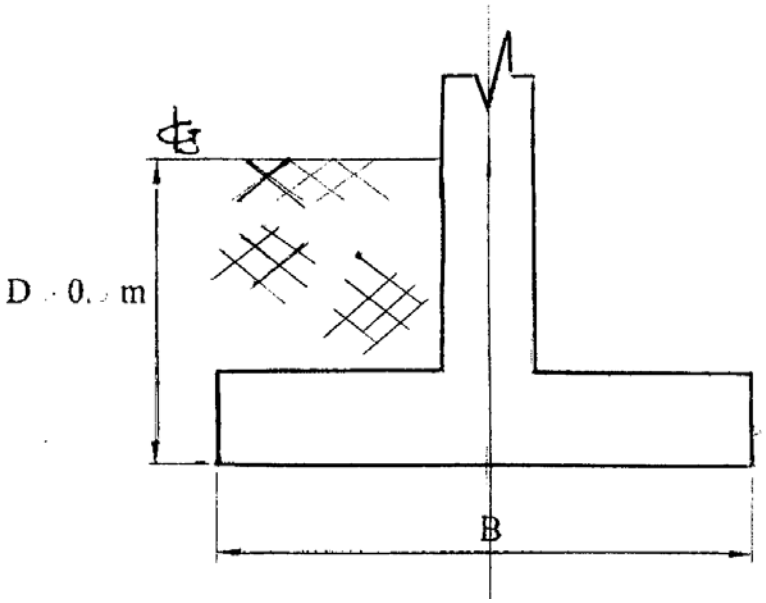
(b) Double layer reinforcement



(c) Single layer reinforcement



(d) Plan of pad footing



(e) Depth of footing below ground level

6.9 Continuous strip footings

Strip foundations shall be employed to support load walls, both bearing and non-load bearing, in buildings. Strip footings shall be adopted to support a series of individual columns. Such foundations would comprise reinforced concrete continuous footings placed at a depth below the existing ground level in excavated trenches.

6.9.1 Minimum dimensions

(a) The minimum thickness of strip foundations for residential building construction shall be 200 mm.

(b) The minimum width of a strip foundation for residential building construction shall be 750 mm.

6.9.2 Reinforcement

(a) Reinforcement shall be arranged in the form of a cage comprising top and bottom longitudinal bars and transverse bars, as shown in **Figure 3**.

(b) The minimum spacing for the transverse bars shall be 100 mm.

6.10 Raft foundations

Raft foundations shall be provided where isolated and continuous strip foundations are found to be inadequate to safely support building loads without exceeding the allowable soil bearing capacity and excessive settlements are likely to occur.

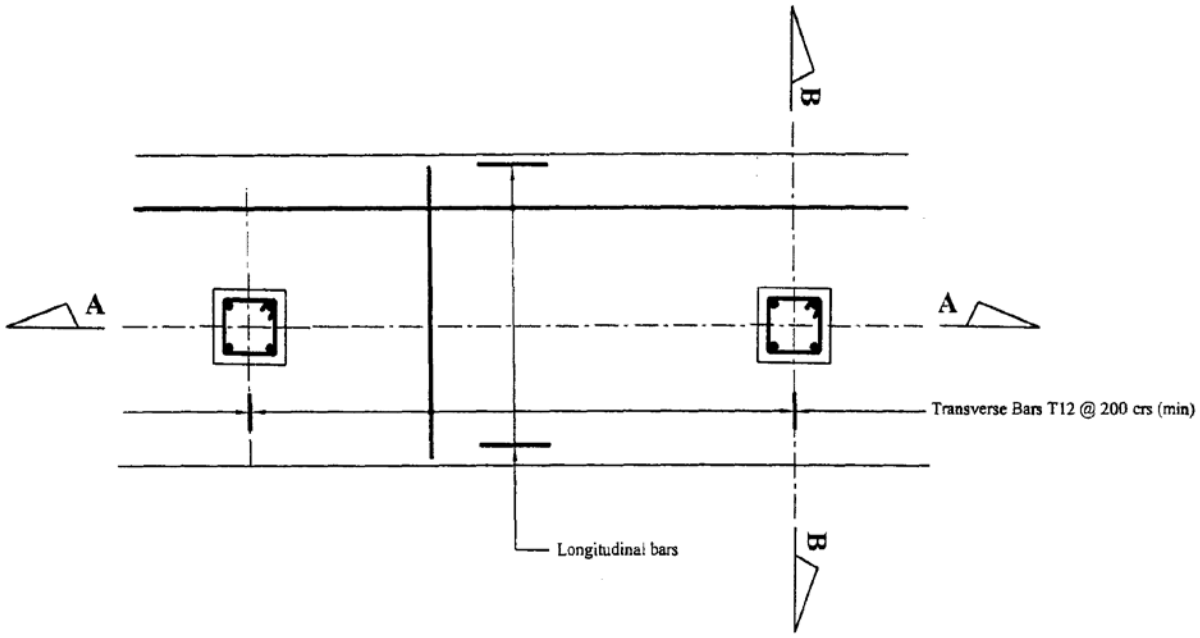
6.10.1 Design requirements

Raft foundations shall be designed by a qualified engineer and shall be designed as rigid or flexible.

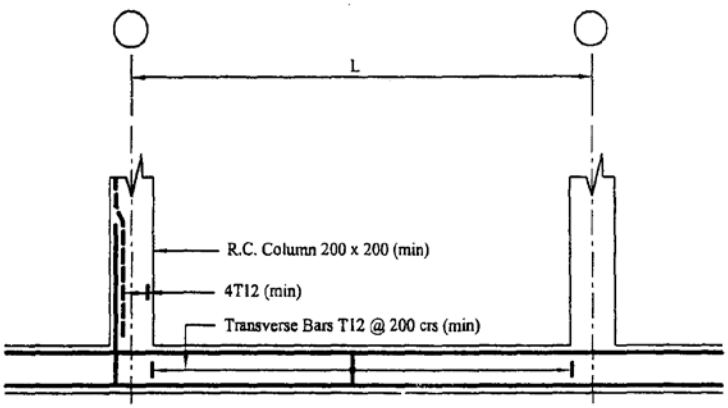
6.10.2 Allowable settlements

For foundations on clay, total settlements, the recommended design limits shall be 65-100mm for rafts. Raft foundations on sands shall be designed for a limiting maximum settlement shall be 50mm.

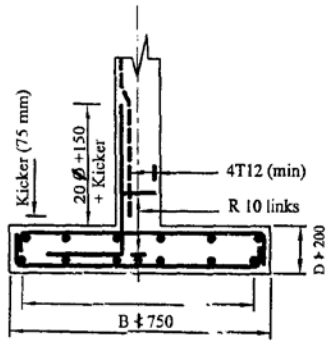
Figure 3
Typical reinforcement arrangement for strip footing



Plan



Longitudinal Section A-A



Transverse Section B-B

6.11 Deep foundations

6.11.1 Timber pile foundations

Pile foundations shall be provided where the upper soil strata consist of soils with very poor strength and compressibility characteristics such that the use of shallow foundations would result in foundation failure from bearing capacity and excessive settlement.

6.11.2 Timber species

Timber species with high natural durability shall be used. Suitable local timber species for piles include Durability Class IV[1] (Greenheart, Mora, Kakaralli, etc.).

6.11.3 Minimum dimensions

The minimum recommended dimensions for timber piles for use in building foundations shall be as follows:

(a) minimum butt diameter: 300 mm

(b) minimum tip diameter: 200 mm

(c) limiting structural defects:

(i) piles shall be free from short or reversed bends, twisted grain and crooks greater than one half of the diameter at middle of the bend;

(ii) a line drawn from the centre of the butt to the centre of the tip shall lie within the body of the pile, as shown in **Figure 4**.

6.11.4 Preparation

(a) All knots and branches shall be trimmed or cut flush with the surface of the pile.

(b) Piles shall be free of all bark including inner skin.

(c) Piles shall sound throughout their entire length and free from decay.

(d) The butt and tip shall be sawn square with the axis of the pile.

1 Guyana Forestry Commission (1978) Guyana Grading Rules for Hardwood Lumber.

Figure 4
Specifications for timber piles