

Centre for Housing Performance Excellence

Guidelines for Foundation Designs in Dolomitic Areas

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GUIDELINES FOR FOUNDATION DESIGNS IN DOLOMITIC AREAS

BACKGROUND

The NHBRC Manual and the Joint Structural Division, Code of Practice for Foundation and Superstructures for Single Storey Residential Buildings of Masonry Construction, provide clear guidelines with respect to foundation design for prevailing soil conditions on a particular site. However, both documents do not provide clear design criteria and guidelines for foundation design in dolomitic areas. Most designers utilise, for design purpose, information published in an article published in the SAICE Journal (vol. 44(3), 2002), namely: *Discussion: Proposed method for dolomite land hazard and risk assessment in South Africa*.

The article was published as a discussion paper, without any alternative guidelines, designers used it as best available information on how to design foundation on dolomitic areas. However, the article had its shortcomings in particular the use of earth mattress for structural purpose (i.e. designed to roof over a sinkhole). Therefore, this document is based on the refined work on the article. In addition, the information in here is to be published in the latest revision of SANS 10400.

PURPOSE

The purpose of this document is to provide designers with the criteria and guidelines for foundation designs in dolomitic areas.

PROCEDURE

1. AREAS DESIGNATED D1 and D2

Foundations to be designed for prevailing soil conditions in accordance to NHBRC Manuals or the Joint Structural Division, Code of Practice for Foundation and Superstructures for Single Storey Residential Buildings of Masonry Construction

2. AREAS DESIGNATED D3

2.1. Principles

2.1.1. The requirements for dolomitic area class designations and general requirements for houses in dolomitic areas are established in the Home Building Manual.

2.1.2. The manner in which risk is managed on D3 dolomitic sites is as follows:

- a) The site is classified in terms of inherent risk classes in the first instance and thereafter in terms of dolomitic area designations by a competent person to ensure that appropriate development takes place.
- b) The township services are installed in accordance with minimum specified requirements and mandatory precautionary measures to minimise concentrations of services.
- c) Houses are constructed observing minimum site precautions to ensure that water does not pond on the site and plumbing requirements to minimise the risk of service pipes from rupturing or leaking.
- d) A soil mattress or reinforced concrete foundation is provided to allow occupants to safely evacuate houses in the event of a sinkhole occurs.

2.1.3 No precautionary measures are required in areas designated as being D1 and no houses may be constructed in areas designated as being D4. Areas designated as being D2 and D3 require minimum precautionary measures as set out in the Home Building Manual. Areas designated as being D3, however, require precautionary measures in addition to those pertaining to the concentrated ingress of water into the ground.

2.2. Performance requirements

2.2.1 The design of a house in areas underlain by dolomites having a dolomitic area class of D3 shall be such that:

- a) a sinkhole having a nominal diameter of 2,0 metres on inherent risk class 5 sites and 5,0 metres on inherent risk class 3 and 4 sites, occurring anywhere on beneath or adjacent to the house (see figure 1), will not envelop the house or result in the toppling or sliding failure of the house or a portion thereof into such a hole;
- b) there is sufficient time for occupants to safely escape from the structure after the occurrence of the sinkhole referred to in a); and
- c) the level of expected damage associated with soil movements unrelated to sinkhole and doline formation in the near surface horizons is within the limits provided for in the Home Building Manual.

2.2.2 The requirements of 2.2.1 may be satisfied by providing an engineered soil mattress in accordance with the requirements of 2.3 on inherent site class 5 sites, or a reinforced concrete foundation with the requirements of 2.4 on inherent risk class 3, 4 and 5 sites.

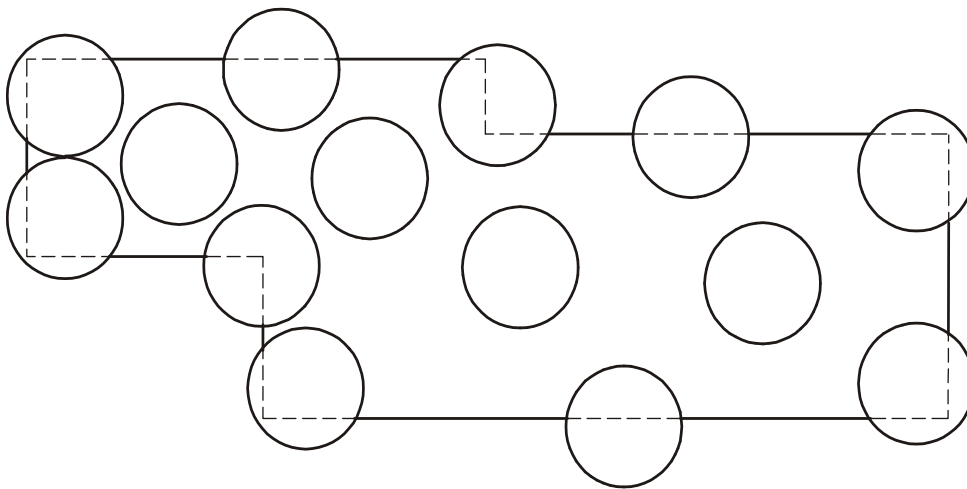


Figure 1: Critical locations of sinkholes under the footprint of a house

- Note:**
- 1) Sinkholes can occur at any point under or adjacent to the footprint of the structure. Apron slabs, which are commonly used to mitigate the effects of differential heave on structures and to move collapse settlements away from the footprint of the structure, have little effect on the location of a sinkhole. Accordingly, sinkholes can be expected to occur anywhere within the footprint of the house. (See figure 1)
 - 2) Dolines occur where the premature termination of sinkhole formation occurs or where the overburden material consolidates due to dewatering or significant seasonal fluctuations. Dolines that are due to the premature termination of sinkhole formation may be dealt with in the same manner as sinkholes. Dolines may also be associated with dewatering where the original ground water level (and fluctuations thereof) is located above the dolomite bedrock in soil material with low dry density, high void ratio and high compression index. In such circumstances, houses straddling the perimeter of the doline will be subject to differential settlements.

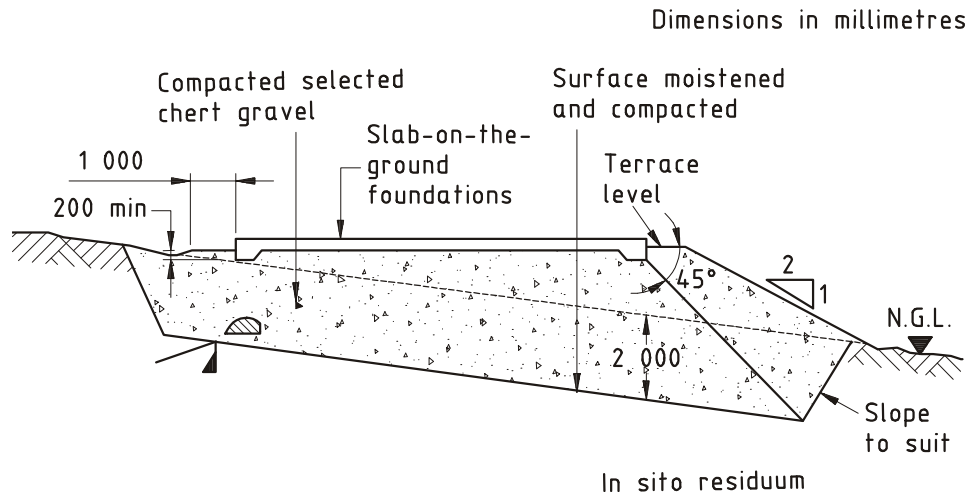


Figure 3 — Typical mattress on sites where the overburden above the pinnacle and boulder dolomite formation exceeds 3 m

- 3 On sites where the overburden above the pinnacle and boulder dolomite formation is less than 3 m and where rockfill is available, the material is typically removed to a depth of about one meter below the tops of pinnacles and large boulders, and is backfilled with rockfill to about 200 mm above the pinnacles. (Alternatively, the pinnacles may be trimmed using pneumatic tools or a blaster experienced to work in dolomitic areas.) Thereafter, the remainder of the soil mattress is constructed with selected chert gravel or other suitable granular material placed under controlled conditions. On sites where the overburden above the pinnacle and boulder dolomite formation exceeds 3 m, the thickness of the mattress is typically between 1,5 m and 2,5 m in thickness below the underside of foundations (see figure 3).

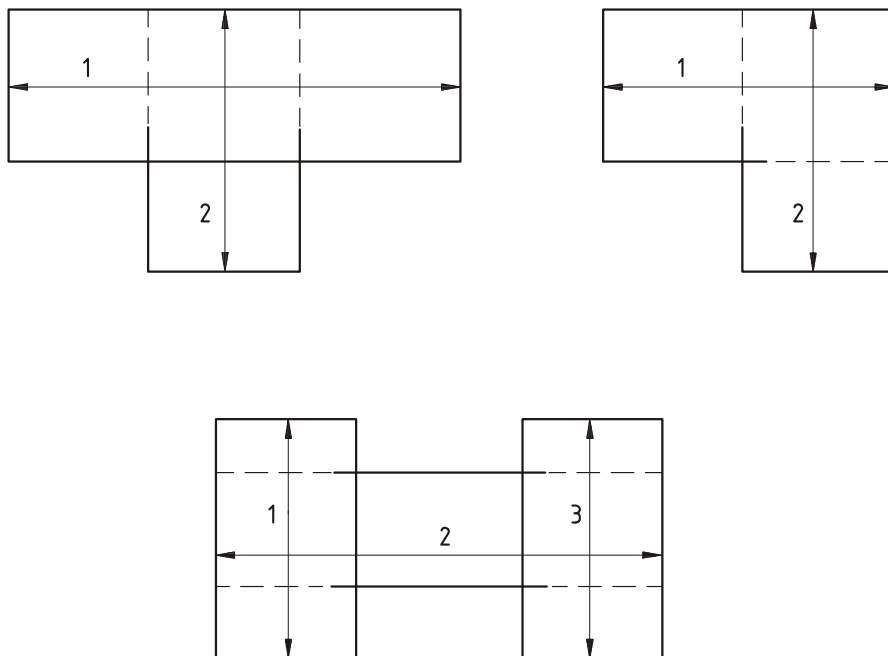


Figure 4 — Design of irregular shaped rafts

- 4 Slab-on-the-ground foundations, are most appropriate where mattresses are constructed as they are relatively shallow and distribute loads effectively. There is no point in providing a mattress and then excavating through it, to found the building.

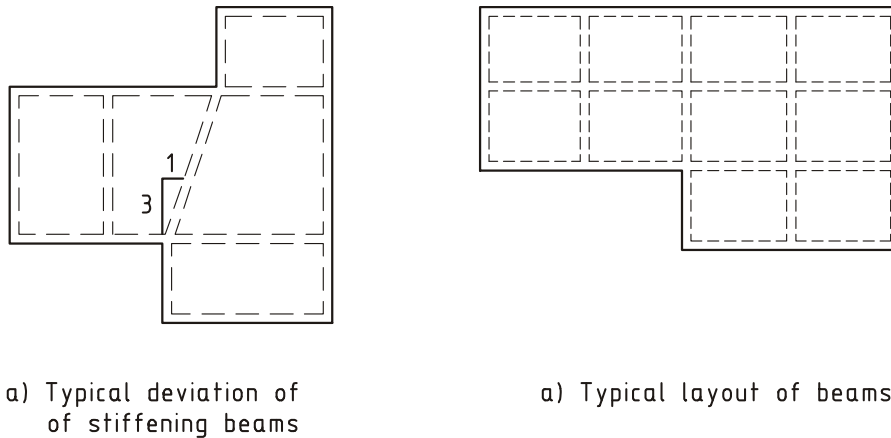


Figure 5 — Arrangement of stiffening beams

- 5 It is difficult to construct mattresses on steeply sloping sites or for a building with the ground floor on different levels as the continuity of the mattress is compromised. In these instances consideration should be given to reinforced concrete foundations.
- 6 Mattresses may require some tension reinforcement to span potential sinkholes or between unyielding points of support (or both)

2.4 Reinforced concrete foundations

2.4.1 The reinforced concrete foundations shall be designed and constructed in such a manner that the house satisfies the performance requirements established in 2.2.1.

2.4.2 The walls and floors of houses shall withstand a loss of support without collapse into the hole, occurring anywhere within the footprint of the house over an area having a diameter of (see figure 1):

- a) inherent risk class 5 sites: 2,0 metres; and
b) inherent risk class 3 and 4: 5,0 metres.

2.4.3 The wall foundations shall be founded:

- a) within the near surface horizons;
b) on piles that have been proof drilled for a minimum of 6 metres of solid rock in order to confirm that piles are socketed into pinnacles or bedrock as opposed to floaters;
c) on stub columns founded on bedrock; or
d) on pinnacles occurring in close proximity to the surface provided that it is established that these pinnacles are attached to the bedrock.

Note: Suitable forms of construction include:

- i) stiffened raft foundations (grid of reinforced/ post tensioned concrete beams cast integrally with the floor slab);
ii) stiffened strip footings (reinforced grouted cavity wall construction with interconnected floor slabs); or
iii) cellular raft foundations (two horizontal reinforced concrete slabs interconnected by a series of webs)

- 2.4.4 Beams may extend beyond the perimeter of the external walls to reduce the span that the house has to cantilever over or eliminate the cantilever resulting from the development of a sinkhole at the corner or perimeter of a house. Such beams shall extend beyond the assumed edge of the loss of support for a minimum length of 1,5 metres and have a bearing pressure of less than 50 kPa.
- 2.4.5 Floor slabs shall be reinforced and positively connected to all edge and stiffening beams.
- 2.4.6 The reinforced concrete foundations when subjected to a loss of support in accordance with the requirements of 2.2.1. and subjected to a load combination of 1,0 x permanent actions + 0,5 x imposed actions, having the following deflection limits (ignoring the stiffness of the superstructure):
- **In risk classes 3 & 4:** not more severe than 1:500 up to 3m nominal sinkhole diameter AND not more than 1:250 for 5m nominal sinkhole diameter.
 - **In risk class 5:** not more than 1:500 up to 2m nominal sinkhole diameter.

Note: It should be noted that SANS 10400 has adopted 1:250 limit for all risk classes 3, 4 & 5.

- 2.4.7 Apron slabs shall be provided around all the perimeters of houses and shall comprise 75 mm concrete slabs, not less than 1,5 m wide, cast to not less than 75 mm falls away from walls. Such slabs unless appropriately reinforced, shall be provided with control joints at centres not exceeding 2000 mm to minimise shrinkage cracks and shall be suitably sealed against the houses.

Reference:

South African National Standards, SANS 10400 (2005). Code of Practice for the construction of Dwelling Houses in accordance with the National Building Regulations, Pretoria, RSA.

Home Building Manuals Parts 1, 2 & 3 (1999), National Home Builders Registration Council, Revision 1, Bryanston, Johannesburg, RSA.

SAICE 1995, Code of Practice: Foundations and Superstructures for Single Storey Residential Buildings of Masonry Construction. The Joint Structural Division of SAICE and IStructE

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