STRUCTURAL ASSESSMENT OF HOUSE LE ROUX, ERF 10716 THORNY BUSH ESTATE, POTGIETERSRUS EXT 25, MOKOPANE

STRUCTURAL INVESTIGATION REPORT REV 02

JANUARY 2024

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Abbreviations / Acronyms / Definitions

DPC	Damp Proof Course
Ext	Extension
GI	Galvanized Iron
NHBRC	National Home Builders Registration Council
SES	Shumba Engineering Services
RC	Reinforced Concrete
SAHITA	South African Home Inspection Training Academy
SANS	South African National Standards

Document Information and Approvals

TITLE		STRUCTURAL ASSESSMENT AT HOUSE LE ROUX, ERF 10716 THORNY BUSH ESTATE, POTGIETERSRUS EXT 25, MOKOPANE
Client		NHBRC
Key Words		Structural engineering services, structural assessment findings, scope of work, conclusions and recommendations
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For: SHUMBA ENGINEERING SERVICES (SES)

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INTRODUCTION

In order to restore house Le Roux to be a functional facility that meets acceptable norms and standards, the National Home Builders Registration Council (NHBRC) appointed Shumba Engineering Services (SES) as professional Structural Engineers to conduct structural investigation, compile detailed report and provide remedial solution for the house. The scope of works included identifying defective structural elements, performing structural infrastructure capacity checks, proposing repair methods and recommendation proposals. SES performed a visual assessment of various elements of the building facility, took photographs, performed structural infrastructure design capacity checks and drew conclusions and recommendations from the information obtained. Remedial proposals and upgrading solutions were tabled for structural engineering defects that were observed.

The general structural integrity condition of the existing exterior walls appears to be fairly good. However, there are cracks on the exterior and interior walls which range from about 1mm (minor) to about 7mm wide (moderate). The main bedroom has a vertical crack on the exterior wall and this crack penetrates both the inside and outside of the room, showing signs of significant foundation settlement. There are vertical and diagonal shear cracks on the interior wall of the bedroom corridor and above the door of bedroom 2 due to foundation settlement. There is a horizontal crack between the foundation wall and the exterior wall at the DPC level in the north-western side of the courtyard which is also attributed to the foundation settlement. The homeowner repaired the horizontal crack in the south-western side of the property, which included the installation of high tensile reinforcement bars. The quality of this work could not be confirmed since the repaired area was closed with mortar and repainted. A movement joint between walls in the south-west side of the building is not properly sealed, which can result in long-term issues of water ingress, moisture leading to mould and affecting the building's structural integrity.

The surface bed floors appear good except for the expansion cracks in bedroom 2 (approximately 4m long) and in the corridor for bedrooms measuring 0.98m. These cracks suggest there was soil heave beneath the property. The width of these cracks is approximately 10mm, which is severe according to the NHBRC classification of floor slab damage.

The structural condition of the roof appears very good showing no signs of structural defects. While the house has gutters and downpipes, there are no stormwater management channels in the premises to direct the rainwater. There are aprons around the building to prevent stormwater from pooling or causing erosion around the house. The Geotechnical Investigation Report indicates that the engineering fill on which the foundations are placed ranges from 0.1 to 0.2m deep and that the strip footings are 0.2m deep which is insufficient given the poor quality of underlying soil layers.

It is recommended that all vertical and diagonal cracks on the interior brick walls less than 5mm be repaired by removing plaster for a width of 300mm on either side of the crack and nail fixing a 600mm wide galvanized 1.2mm wire mesh spanning over the crack and replaster over. All major wall cracks, however, must be repaired as per typical detail in Figure 5. Foundation underpinning with 1.2m x 1.0m x 1.0m concrete sections with a spacing of 2m is recommended to support the existing strip footings in order to counter further differential foundation settlement and horizontal cracks at the DPC level. A non-shrink epoxy grout must be used to fill the cracks on the surface bed by first removing the tiles and cleaning the crack areas. Additionally, the vertical movement joint on the south-western elevation must be closed with a high-performance movement joint sealant. All crack repairs should be undertaken after concrete for the foundation underpinning has reached full strength and the actual remedial works are redefined.

1 PROPERTY DETAILS

House Le Roux is in Extension 12 Mokopane, within Mogalakwena Local Municipality in the Waterberg District Municipality of Limpopo Province in South Africa. The reference coordinates of the site are 24°12'52"S and 28°59'48"E. A map of the general location within the Waterberg District Municipality as well as a locality map of House Le Roux is shown in Figures 1 and 2 respectively.

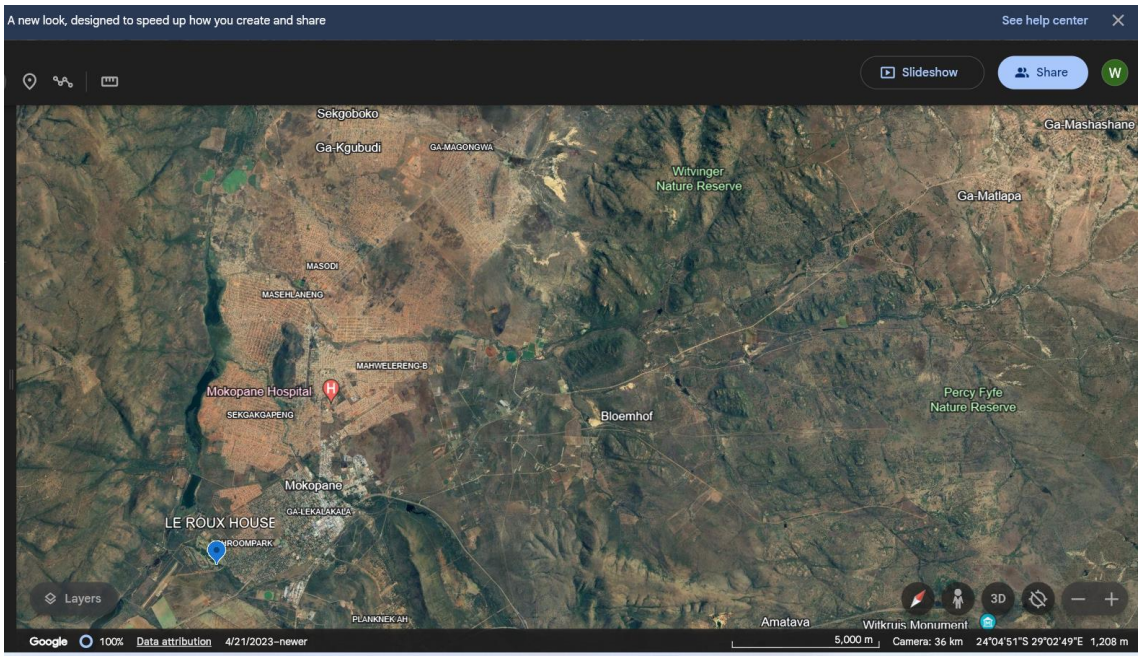

Figure 1 : House Le Roux District Locality Plan adopted from Google Earth on 15 November 2023

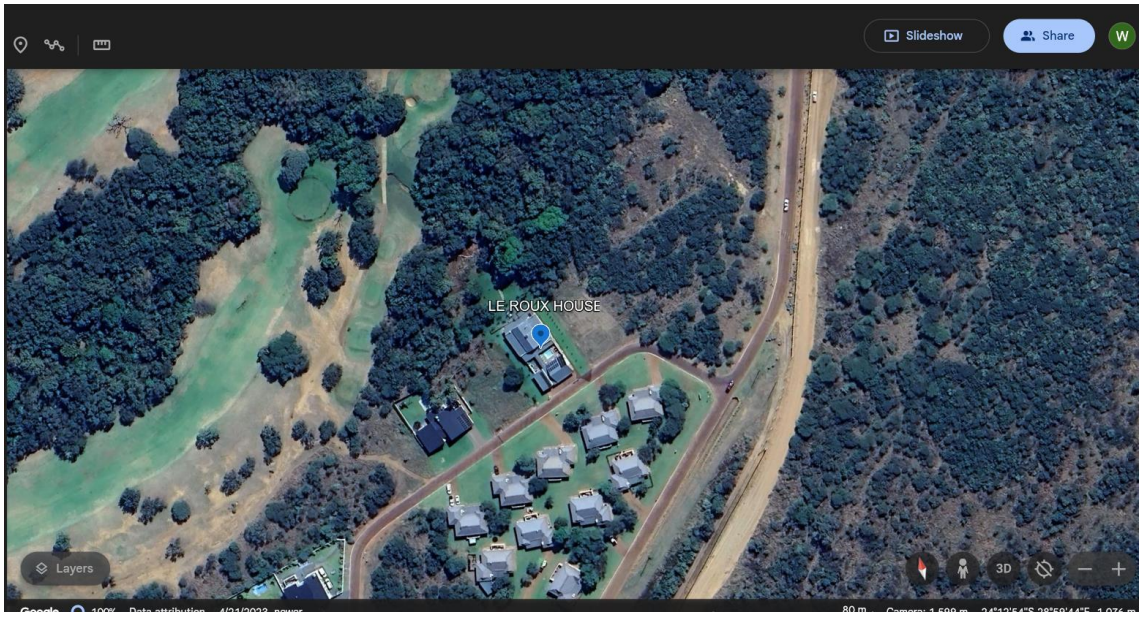

Figure 2: House Le Roux Locality Plan adopted from Google Earth on 15 November 2023

2 BACKGROUND

The house was occupied on 10 May 2018 and the available records indicate that Form 4 Certificate for Structural was issued by a Competent Person with Professional Registration no. 950293 assuming that the structure was designed and constructed in compliance with the National Building Regulations.

3 BUILDING ASSESSMENT

3.1 Method of Assessment

Structural engineering assessment was conducted on the 06th November 2023 in accordance with the following methodology:

An initial visual **site inspection and assessment** were conducted to identify all defective elements. All the information was compiled into this structural investigation report. During the assessment, **consultation** with the homeowner was done to understand any further structural-related problems that they face. Measurements were taken using an electronic measuring tape.

A **desk top study** of the project location, available project information and documentation of photographs taken during the site inspection was undertaken and conclusions drawn from this information. There were no structural drawings, topographical survey and architectural drawings provided at the time of structural assessment. However, a Geotechnical Field Investigation Report undertaken by Dwala Group Geotechnical Engineers was provided to further understand the foundation conditions. The Forensic Engineering Investigation Report compiled by the NHBRC shed more light pertaining to the background of the project.

Documentation of the photographic report and main report framework was performed. Specific remedial measures, specifications and proposed scope of work were drawn and passed on to the project consulting team members. The report should be used as a basis for making decisions regarding the remedial works of various defective structural elements of the building.

3.2 Available Information

The following information was available for consideration:

- Geotechnical Investigation Report
- NHBRC Forensic Engineering Investigation Report
- Certificate of Occupancy

3.3 Reference Literature

The following literature was used for reference purposes:

- Housing Consumers Protection Measures Act 95 of 1998
- National Building Regulations and Building Standards Act, 1977
- NHBRC Home Building Manual
- South African National Standards (SANS) 10400
- South African National Standards (SANS) 10160
- SAHITA - Module 4: The Role of NHBRC
- SAHITA - Module 6: Problem-soils

3.4 Geotechnical Investigation

A copy of a detailed Geotechnical Investigation Report is shown in Appendix D of this report.

3.5 Previous Remedial Works

The remedial works implemented by the homeowner included the installation of the reinforcement dowels between the foundation wall and the exterior wall in the south-western elevation of the house.

3.6 Findings

3.6.1 Foundations

The following observations were made regarding the foundation:

- The building appears to be supported on strip footings;
- No structural drawings are available at this stage and it is unclear whether the foundations are reinforced or not;
- The foundation was laid on a fill material in the north-western side, which seems to have settled over a span of time;
- There is a brick retaining wall to hold the above fill material;
- There was a formation of diagonal and vertical cracks on the exterior and interior walls suggesting there was a significant foundation settlement;
- Horizontal cracks between the foundation wall and the exterior wall at the floor level (DPC level) of the north-western side of the courtyard were observed; and are also attributed to settlement in the foundation; and
- According to the Geotechnical Investigation Report, the engineering fill on which the foundations are placed ranges from 0.1 to 0.2m deep and the strip foundation is 0.2m deep. These are inadequate for the soil condition of the site (Zone H2/S2/P). The extent of the expansive soil (H2) is concerning as it goes up to a depth of 1.3m below the foundation level.

  A copy of the Geotechnical Field Investigation Report is shown in Appendix D of this report.

3.6.2 Surface Bed Floor Condition

The following observations were made regarding the surface bed floors:

- All surface bed floors are tiled with ceramic floor tiles; and
- There was a 4m long expansion crack in bedroom 2 (wall-to-wall) and 0.98m across the corridor for bedrooms, which could be as a result of soil heave underneath the surface bed. These cracks penetrate through the ceramic tiles and seem to be up to 10mm in width, which are severe according to the NHBRC classification of floor slab damage.

3.6.3 Stormwater Management / Site Topography

The following observations were made regarding the stormwater management:

- There are no stormwater management systems on the premises;
- The natural ground slopes to the north-western direction towards a water stream, however, the site was filled and that decreases stormwater flow velocity;
- No indication of flooding, erosion or damages related to stormwater runoff; and
- There are brick aprons around the house to prevent stormwater from pooling or causing erosion around the house. The aprons might contribute to problems by intensifying the

rising dampness in walls when moisture level increases if damp proof courses are inadequate.

3.6.4 Brick Walls

The following observations were made regarding the existing walls of the building:

- The existing structure was constructed out of brick walls consisting of face-brick on the outside face and plastered brick on the inside face of the building;
- The general structural integrity condition of the existing exterior walls appears to be fairly good;
- There are cracks on the exterior and interior walls which range from about 1mm to about 7mm wide, which is moderate in terms of the NHBRC classification of cracks in walls;
- The main bedroom has a vertical crack on the exterior wall and this crack penetrates both the inside and outside of the room, showing signs of significant foundation settlement;
- There are vertical and diagonal shear cracks on the interior wall of the bedrooms' corridor due to differential settlement;
- There is a diagonal crack above the door of bedroom 2, and this crack is also attributed to foundation settlement;
- There is a horizontal crack around the exterior wall at floor level (DPC level) in the north-western side of the courtyard. It appears the horizontal crack is due to a slight foundation settlement;
- A movement joint between walls in the south-west side of the building is not properly sealed, which can also result in long-term issues of water ingress, moisture leading to mould and affecting the building's structural integrity;

A photographic record of the building walls is shown in Appendix A of this report.

3.6.5 Roof Condition

The following observations were made regarding the roof trusses:

- The structural condition of the roof trusses appears very good showing no signs of structural defects;
- There are no roof gutters and there are no rainwater downpipes on the entire building; and
- The homeowner, Mr NF le Roux has confirmed that there were no roof issues.

A photographic record of the building's roof trusses is shown in Appendix A of this report.

3.6.6 Rising Damp

There was no appearance of dampness on the walls at the time of assessment. The building has a damp-proof course to prevent moisture from rising from the foundations.

4 PROPOSED REMEDIAL ACTIONS

4.1 Application of the HCPMA

Following the provisions in Chapter III of the HCPMA, defects were classified into three categories which are:

Category (i) – *"Homebuilder to rectify major structural defects caused by the non-compliance within a period of five years as from the occupation date"* - The major structural defects were identified on the walls and surface bed during the assessment of defects. The assessment, therefore, concluded that there are defects to be rectified as category 1 defects according to the provision in the act.

Category (ii) – *"Homebuilder to rectify non-compliance with or deviation from the terms, plans and specifications of the agreement or any deficiency related to design, workmanship or material within three months as from the occupation date, which can be referred to as the retention period"* - Within the norm of practice, defects within this category can be rectified using the retention fee. This will not be applicable in this case because the three-month retention period has lapsed. The homebuilder was not willing or unable to rectify defects within this period.

Category (iii) – "Homebuilder to repair roof leaks attributable to workmanship, design or materials within a period of 12 months as from the occupation date" – There were no defects identified in relation to the roof and this category will therefore not be applicable in this case.

4.2 Foundations

- Foundation underpinning around the external wall of the north-western wing of the property which is relatively on a high fill platform.

Figure 3: Aerial view of the north-westerly wing

Detailed specifications and drawing for foundation underpinning are entailed in Appendices B and C of this report respectively.

4.3 Brick Walls

On the basis of our analysis of the walls, we recommend the following:

- All vertical and diagonal cracks on the interior brick walls less than 5mm be repaired by removing plaster for a width of 300mm on either side of the crack, cleaning with compressed air to remove dust and loose material, nail fixing a 600mm wide galvanised 1.2mm wire mesh spanning over the crack and replaster over.

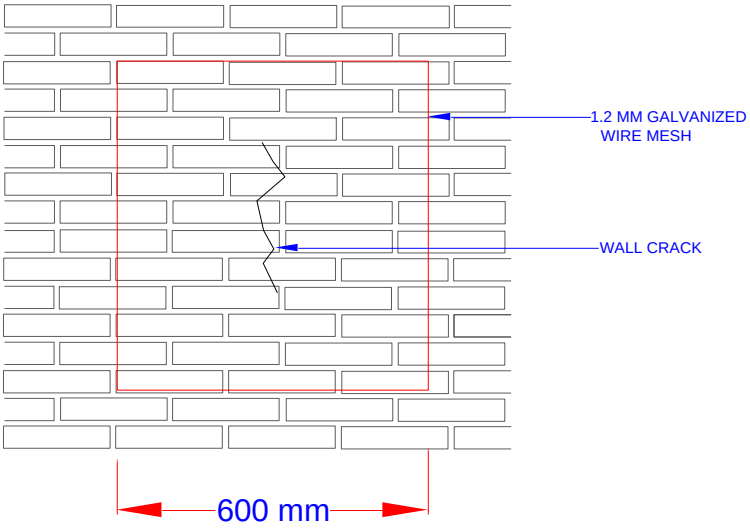

Figure 4: Typical repair of cracks less than 5mm

- All major wall cracks or above 5mm must be repaired as per typical detail in Figure 5 below (not to scale).
- The process involves cutting a slot in the mortar bed just over 500mm on either side of the vertical crack and to a depth of 50mm. Remove all loose material using a blow-out and then flush the joint with water. Pump the SABS approved high-performance cement-based grout to the back of the slot in a continuous even bead to approximately two-thirds of the slot depth. Push the 8mm high tensile bar firmly into the grout, making sure that the bar extends 500mm on either side of the crack. Apply a second bead of grout into the slot making sure that the bar is completely covered and with the trowel provided force the grout into the slot until it is approximately 10mm from the surface and ensuring that the bar and grout are firmly packed.

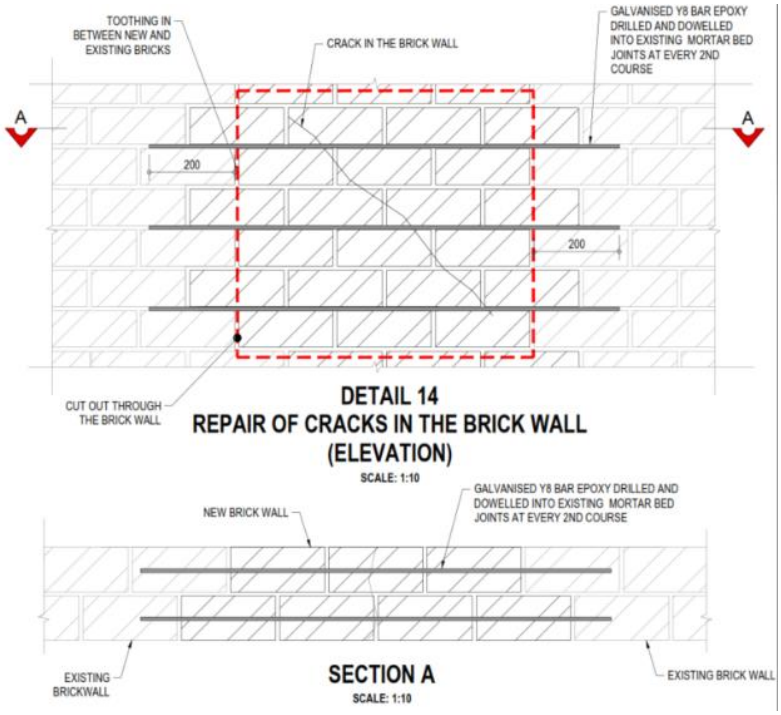

Figure 5: Typical major crack repair

- The vertical movement joint on the south-western elevation must be closed with a high-performance movement joint sealant.
- Hairline cracks on the interior wall should be fixed by cleaning the cracked surface, make the crack moist and applying the acrylic sealant into the crack.
- The interior walls affected by crack repairs need to be repainted to Architect specifications.

4.4 Surface Beds

The cracked surface bed in bedroom 2 and the corridor should be repaired by:

- Applying SABS approved non-shrink epoxy grout into the cracks. The grout should be able to achieve a compressive strength of 600 Kg/cm / 60MPa in three (3) days;
- The crack must be used to fill the cracks on the surface bed by first removing the tiles, cutting out the crack to create a backward-angled cut “V” about 50mm deep, cleaning out any loose material from the crack and applying the grout as specified.

5 Conclusion

The following structural engineering scope of work is therefore proposed:

- Foundation underpinning around the exterior wall of the north-western wing of the property;
- The new foundation be left to reach full strength (at least 28 days), before attending to the cracks;
- Repair cracks less than 5mm wide with mesh replastered over;
- Repair major cracks through reinforced stitching;
- The vertical movement joint on the south-western elevation must be closed with a high-performance sealant;
- Closing of hairline cracks with an acrylic sealant; and
- That health and safety measures be observed during the remedial works.

Document Control and Disclaimer

CLIENT	:	National Home Builders Registration Council (NHBRC)
PROJECT NAME	:	STRUCTURAL ASSESSMENT OF HOUSE LE ROUX, ERF 10716 THORNY BUSH ESTATE, POTGIETERSRUS EXT 25, MOKOPANE
TITLE OF DOCUMENT	:	Structural Engineering Assessment Report

	Prepared By	**Approved By**
ORIGINAL	NAME **THULA SEKHUKHUNE**	NAME **WILLIAM MOLOKOMME**
DATE **18 JANUARY 2024**	SIGNATURE	SIGNATURE 

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(c) SES accepts no responsibility for any loss or damage incurred by the Client or for any conflict of SES interests arising out of the Client's release of this report to the Third Party.

SHUMBA ENGINEERING SERVICES
Courage and Ability Takes You Forward!

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List of Tables:

Table 1: Summary of Findings

Item	Area Description	Defects	Relevant Section for Details
1	Foundation	Movement between the foundation wall and external wall at the DPC level	3.6.1
2	Surface Bed	Cracks in bedroom 2 and corridor	3.6.2
3	Stormwater Systems	No stormwater management systems. The house has aprons	3.6.3
4	Brick walls	Cracks at: ❖ External and internal walls of the main bedroom ❖ Interior wall of bedroom 2 ❖ Internal walls of corridor	3.6.4
5	Roof Condition	No defects observed	3.6.5
6	Rising Damp	None. The house has DPC above the foundation level	3.6.6

Appendices

Appendix A: Photo Report

Project:

Professional Consultancy Services for House Le Roux in Extension 25, Mokopane in the Mogalakwena Municipality

– STRUCTURAL ENGINEERING DISCIPLINE

Report Title:
Roof Leaks Assessment Report

Report Sub-Title:

HOUSE LE ROUX

PHOTO REPORT

Revision:	**02**
Date:	**18-01-2024**

NATIONAL HOME BUILDERS NHBRC REGISTRATION COUNCIL

SES SHUMBA ENGINEERING SERVICES Courage and Ability Takes You Forward!

Page:
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Photo 1: Crack outside main bedroom

Photo 2: Crack inside main bedroom (interior of photo 1)

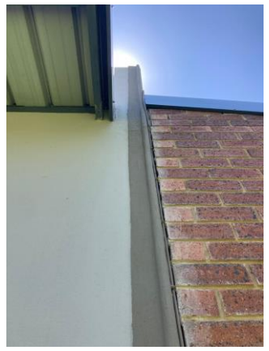


Photo 3: Movement joint not properly sealed

Photo 4: Horizontal crack at DPC level

Photo 5: Horizontal crack at DPC level (Repaired by the homeowner)

Photo 6: Crack on corridor internal wall

Photo 7: Crack on corridor internal wall

Photo 8: Crack on bedroom 2 internal wall

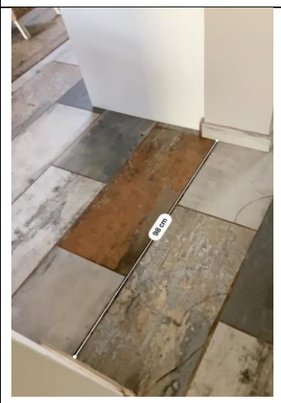


Photo 9: Crack on corridor surface bed

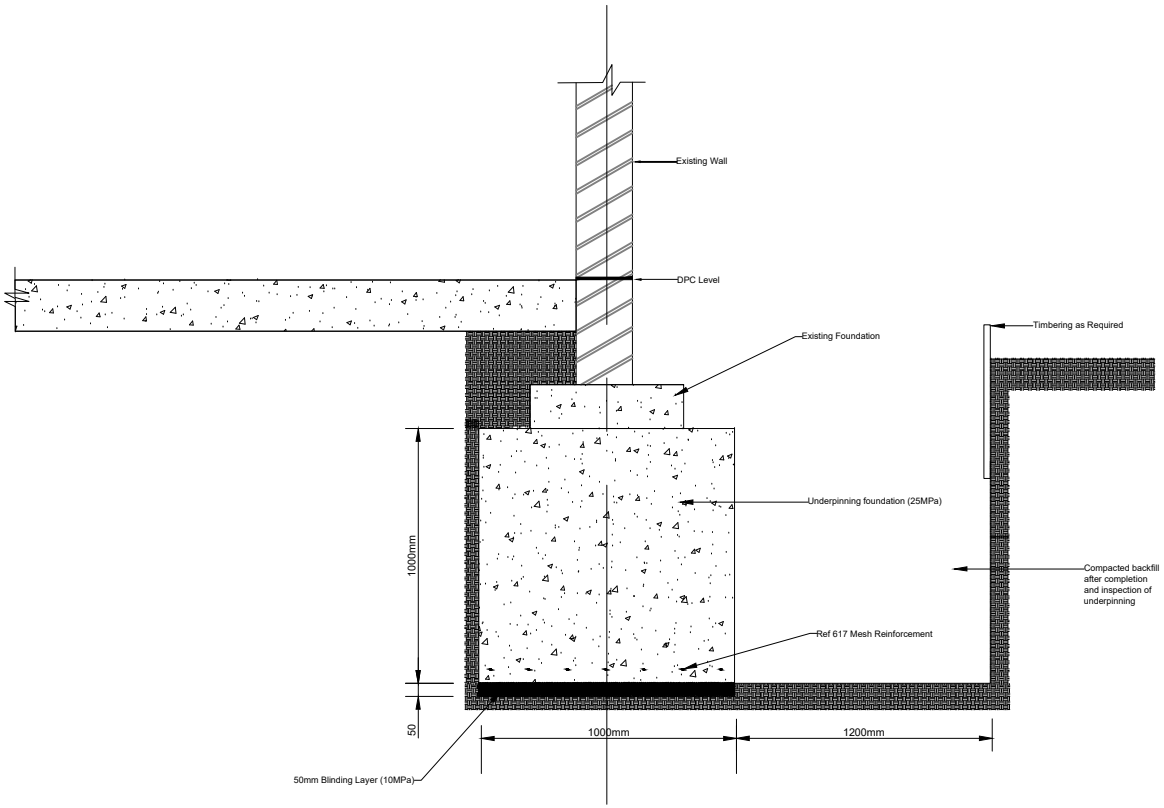
Photo 10: Crack on bedroom 2 surface bed

Appendix B: Specification for Foundation Underpinning

SPECIFICATION FOR UNDERPINNING WORKS

1. Foundation underpinning shall be done around the external wall of the north-western wing of the building which amongst others includes bedrooms and a living area.
2. The Contractor shall submit a proposed sequence of underpinning for approval by the Engineer prior to excavation. For example, the sequence shall be such that all sections marked 1 will be excavated, cast and dry-packed before starting excavation of sections marked 2; and all sections marked 2 will be excavated, cast and dry-packed before starting excavation of sections marked 3, etc.
3. Before starting the work, the Contractor is to check for any services that could be damaged by the underpinning work.
4. The Contractor shall be responsible for ensuring that his operations do not in any way impair the safety or condition of the building both before and during the execution of the work and should immediately inform the Engineer if he considers that more stringent procedures than those specified are necessary.
5. Excavation and concreting of any section of underpinning shall be carried out on the same day.
6. The underside of the existing footings is to be cleaned of all loose materials or soil prior to underpinning.
7. Excavation to any section of underpinning shall not be started until at least 48 hours after completion of any section/s of the work.
8. The disturbed soil beneath existing footings shall be well compacted before constructing any concrete works related to underpinning.
9. Projecting portions of existing footings are to be carefully cut off where directed.
10. A 50mm deep concrete blinding layer of 10MPa strength shall be provided on the compacted soil layer to create a flat surface for work.
11. Underpinning is to be carried out in small sections of 1.2m length x 1.0m width x 1.0m depth. The new underpinning foundation blocks shall be spaced 2m apart.
12. The body of the underpinning is to be constructed in 25MPa reinforced concrete and is to be cast to the widths shown unless otherwise directed by the Engineer.
13. The contractor is to keep a record of the sequence and dimensions of the underpinning carried out, including details of excavation, casting concrete and pinning up for each section.
14. Excavated material intended for backfilling is to be kept protected from drying out or wetting and is to be placed in a maximum of 150mm layers, carefully compacted with a compacting plate.
15. Reinforcement to each section of the underpin will only apply when instructed by the Structural Engineer.
16. And unless a proper dewatering method is used, the works should not be attempted on wet ground.

Appendix C: Drawing for Foundation Underpinning



SECTION FOUNDATION UNDERPINNING (1.2m x 1.0m x 1.0m)

SCALE: N . T .S

18/01/2024

Appendix D: Geotechnical Investigation Report Forensic

GEOTECHNICAL INVESTIGATION REPORT

FOR

ERF 10716 POTGIETERSRUS EXT 25,

THORNY BUSH ESTATE, MOKOPANE

HOUSE LE ROUX

Prepared By:

DWALA GROUP
GEOTECHNICAL ENGINEERING

Prepared For:

NATIONAL HOME BUILDERS
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Document control				
Report title	Geotechnical report for the proposed remedial works for a deforming house (House Le Roux).			
Client	National Home Builders Registration Council (NHBRC)			
Date	**30 October 2023**	**Signature**	**Keywords**	
Compiled by:	Sboniso Zondi		Expansive/ compressible	Soil raft
Approved by:	Nhlanhla Magigaba		Settlement	Underpinning
Rev	00			

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EXECUTIVE SUMMARY

NHBRC appointed Dwala Group to carry out a geotechnical investigation for a deforming structure (House Le Roux). The study area is situated at Erf 10716 Potgietersrus Ext 25, Thorny Bush Estate, Mokopane. The geotechnical investigation comprised desktop study, fieldwork (test pit excavation, soil profiling, and sampling of selected horizon for laboratory testing), laboratory testing and reporting.

The main objective of the investigation was to investigate the cause of the deformation in the existing structure, evaluate the founding conditions, and give recommendations for remedial actions.

The geological profile revealed that the site is underlain by compressible and expansive transported and residual soil materials.

Zone H2/S2/P: This zone covers the entire site and is characterized by expansive soils (clays, silty clays, clayey silts to sandy clay) with a total settlement movement of between 15 and 30 mm and differential movement that is 50% (**H2**). This zone also has fine-grained soils (silty sand to clayey sand) with a total settlement movement exceeding 20 mm and a differential movement that is 50% (**S1**). **P** **(controlled fill)** covers the entire site and is characterized by a controlled/ engineered fill encountered in the excavated test pits.

It was observed during the investigations that the strip footing foundations are placed on an engineered fill (raft foundation) that does not have adequate stiffness to withstand differential settlement. The engineered fill on which the foundations are placed is very thin (ranging from 0.1 m to 0.2 m) and seems to have not been properly compacted. The foundations were also observed to have an inadequate thickness of 0.2m.

Based on the soil profile characteristics and the condition of the structure, it is evident that the structure should have been founded on a foundation of substantial stiffness if it had to perform satisfactorily. This would have required a soil raft of non-expansive/ non-compressible material placed on a concrete raft foundation with high stiffness. This solution would typically be combined with limited articulation and a substantial brick force specification.

Due to the fact that the foundation material below the foundation is expansive and compressible, underpinning of the foundation is considered suitable for strengthening the foundation.

Measures to attempt to stabilise future soil moisture change and hence curb further movement as effectively as possible must be implemented.

1. Introduction

NHBRC appointed Dwala Group to carry out a geotechnical investigation for a deforming structure (House Le Roux). The study area is situated at Erf 10716 Potgietersrus Ext 25, Thorny Bush Estate, Mokopane. Fieldwork, carried out on the 20th of October 2023, included excavation of test pits, soil profiling, soil sampling, and exposing existing foundations of the structure to assess the possible factors that might be causing the house to deform (crack).

The objectives of the geotechnical investigation were to:

- Present a discussion on the prevailing condition of the structure.
- Determine stratigraphy of the site and its geotechnical properties.
- To determine whether any problem soils are present at the site that could have had an effect on either founding or construction methods for the structure to deform (crack).
- To delineate the site into appropriate geotechnical zones according to any essential differences in founding conditions encountered.
- To evaluate the founding conditions at the site and to recommend building precautions necessary for different geotechnical zones
- To obtain basic data concerning the use of the in-situ materials for guideline purposes.
- To present findings and recommend measures to restrict or reduce further structural distress in the structure.

The approach to the investigation was to assess the status quo in terms of the characteristics of the soil profile and the measures implemented (if any) to protect the structure against potential differential movements. This is followed by recommendations on appropriate rectification measures.

2. Available information

At the time of the investigation the following information was available:

- The 1:250 000 scale geological map of the Nylstroom Sheet 2428 (Council for Geosciences, 1978).
- Seismic hazard Map from SANS 10160. (2011). South African Loading Code SANS 10160 Basis for structural design and actions for buildings and industrial structures – Part 4: Seismic actions and general requirements for buildings, 2011.
- Aerial photographs, sourced from Google Earth®.

3. Site locality and description

The proposed site is situated at Erf 10716 Potgietersrus Ext 25, Thorny Bush Estate, Mokopane. It can be accessed via the national road N11 and HF Verwoerd street, onto Pretorious Street. The area consists of residential developments. Figure 1 below shows the investigated area.

Figure 1: Showing the investigated house (red outline) in Thorny Bush Estate, Mokopane.

Topographically, the site occurs in a terrain that is characterised level plains with some relief. The slope is steep, with a slope angle of less than 3˚. A non-perennial stream (striking NE-SW) bounds the study area in the north westerly direction. Vegetation on site comprises short grass.

4. Climate

The climate in Mokopane is a local steppe climate. There is little rainfall during the year. The climate of the area is classified as BSh by the Köppen-Geiger system. The temperature in Mokopane averages 19.0°C. February is the hottest month, with the average temperature of 22.4°C. The temperatures are lowest in July, with an average temperature of 13.1°C. Precipitation is lowest in July, with an average of 3 mm. In January, the precipitation reaches its peak, with an average of 115 mm. The rainfall is around 550 mm per year (Climate-data.org: 2012). The Weinert Climatic N-number for the area (Weinert, 1980) is <5, indicating that the climate is semi-humid and chemical weathering processes are dominant.

5. Investigation Methodology

The geotechnical investigation comprised desktop study, fieldwork, laboratory testing and reporting.

5.1 Test pitting

To meet the requirements for a stand to be registered with NHBRC the investigation was carried out in accordance with the specification for geotechnical site investigations for housing developments (National Department of Housing specification GFSH- 2).

Fieldwork included excavation and profiling of two (2 No) test pits. A two-person team carried out the test pitting in order to comply with accepted safety requirements as reflected in the Site Investigation Code of Practice (SAICE, 2010). The test pits were set out and profiled by a team of engineering geologists/ geotechnical engineers in accordance with South African standards (Standards South Africa. South African. National Standard. Profiling, Percussion Borehole and Core Logging in Southern Africa SANS 633:2012). Test pit details are summarised in Table 1 below.

Table 1: Test Pit Summary

Test Pit No	Coordinates (WGS84)		Depth (m)	Remarks
	Latitude	Longitude		
LR01	24°12'54.13"S	28°59'40.10"E	1.50	No refusal
LR02	24°12'53.84"S	28°59'39.91"E	1.60	No refusal

5.2 Laboratory testing

Representative samples were recovered and submitted to the SANAS-accredited Engineering Laboratory in Pretoria for testing. Soil testing included determination of the Foundation Indicators (comprising sieve and hydrometer grading analyses and Atterberg Limits) as well as determination of in-situ moisture content.

6. Seismicity

On the published seismic hazard figure of South Africa (SANS 10160-4:2011) the seismic hazard is defined in terms of peak ground acceleration. In South Africa two seismic zones are apparent: *Zone I for natural seismic activity* and *Zone II for regions of mining-induced and natural seismic activity*.

According to the seismic hazard map of SANS 10160-4 (2011), the value for the peak ground acceleration of the investigated site occurs in an area with a value of 0.05g, with a 10% probability that this value will be exceeded in a 50-year period as shown in Figure 3 below. In accordance with SANS 10160-4:2011, the site does not fall under either Zone I or Zone II as shown in Figure 2 below. Specific seismic design requirements may therefore not be needed.

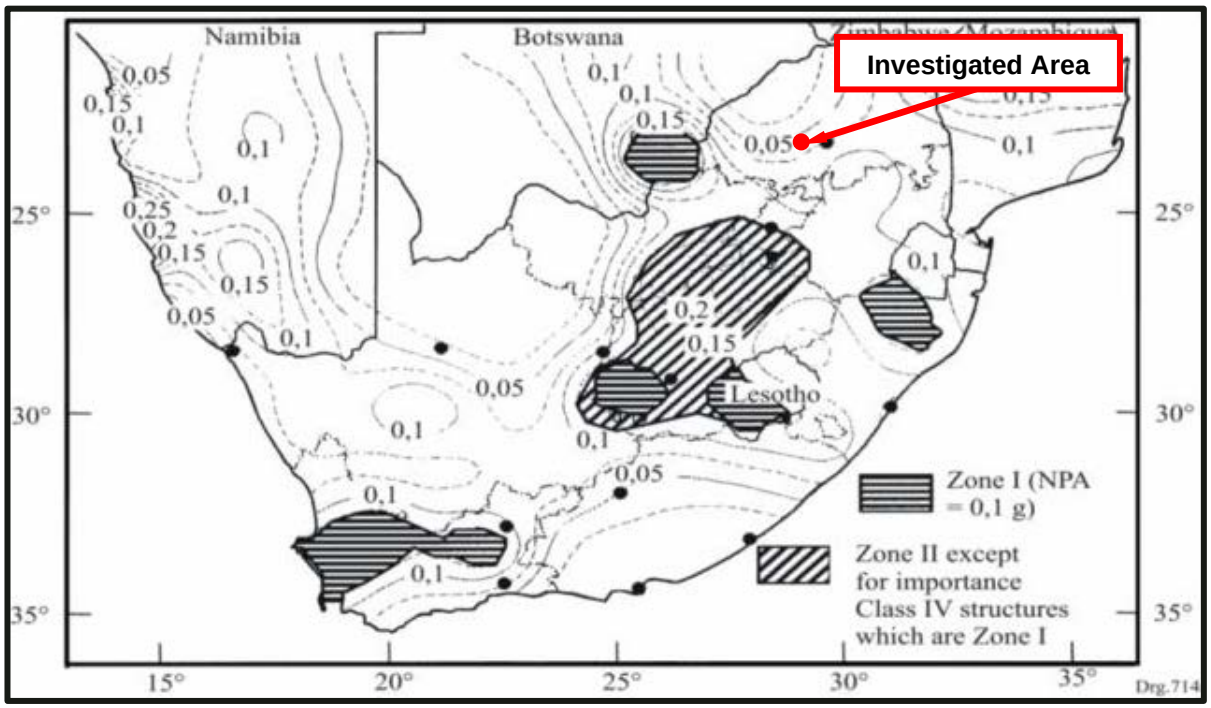

Figure 2: Locality of the site on the seismic hazard map of South Africa.

The peak ground acceleration expresses the seismic hazard and the value of 0.05g may be considered a low level of seismic hazard. A 10% probability exists that this value will be exceeded in a 50-year period.

7. Geology

According to the 1:250 000 geological map of the Nylstroom 2428 Sheet (Council for Geosciences, 1978), the site area is underlain by ferrogabbro, troctolite, anorthosite, magnetite layerand diorite of the Upper Zone of the Rustenburg Layered Suite of the Bushveld Complex as shown in Figure 3 below.

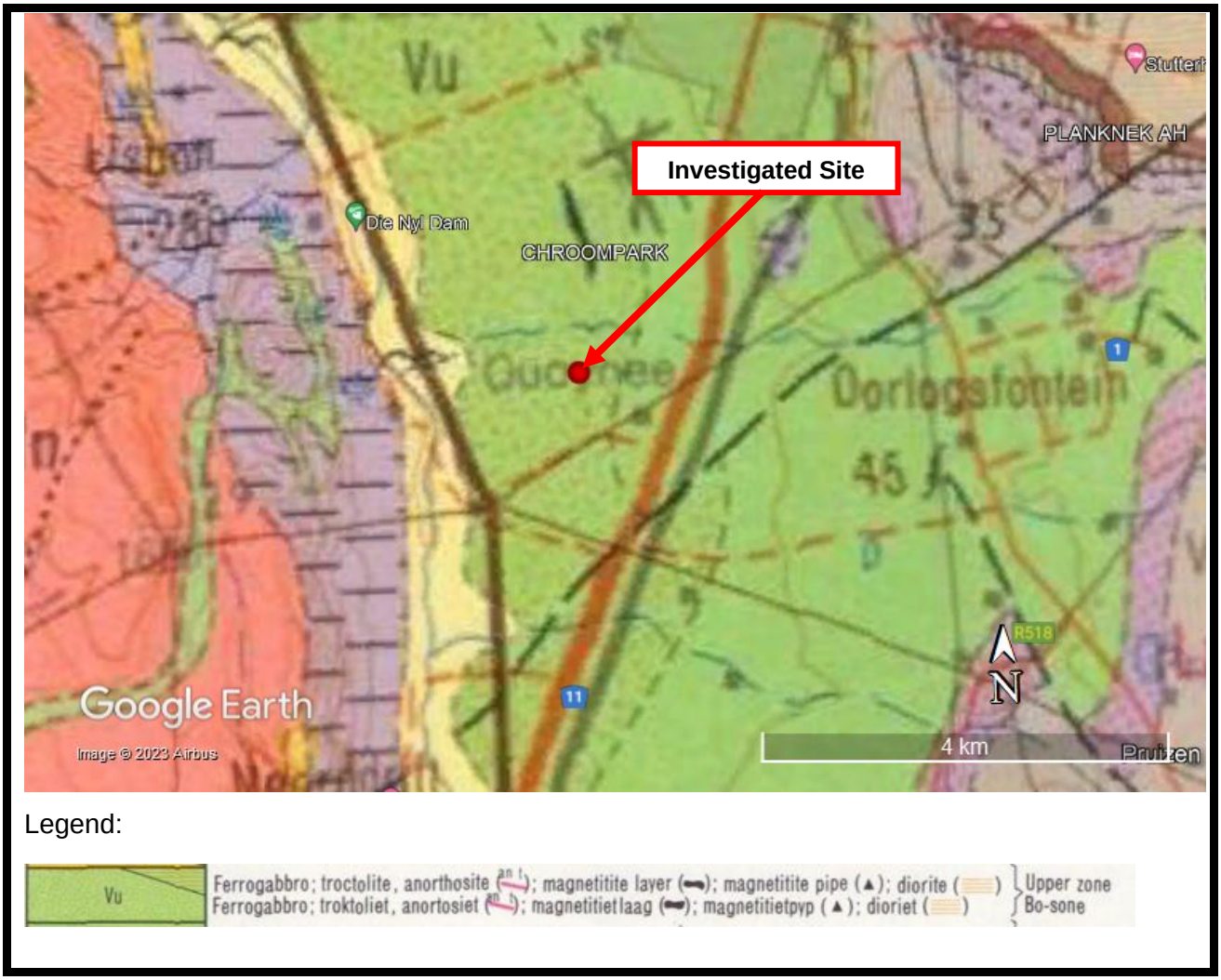

Figure 3: Showing the general geology map of the site (red dot); (Geological Survey, printed by the Government Printer, Pretoria, 1978).

8. Results of Investigation

The detailed descriptions of the soil profiles encountered in the test pits are presented in Appendix B; while the soil profiles for the whole site are summarised below in Table 2.

Table 2: Test pit profile summary

Test Pit No:	Brick Paving	Brick Wall	Concrete Foundation	Concrete underlying foundation	Fill horizon	Transported horizon	Residual horizon
LR01	0 – 0.15	-	-	-	0.15 – 0.80	0.80 – 1.50	-
LR01A	0 – 0.15	0.15 – 0.30	0.30 – 0.50	0.50 – 0.70	0.70 – 0.80	0.80 – 1.50	-
LR02	0 – 0.15	-	-	-	0.15 – 0.90	0.90 – 1.30	1.30 – 1.60
LR02A	0 – 0.15	0.15 – 0.50	0.50 – 0.70	-	0.70 – 0.90	0.90 – 1.30	1.30 – 1.60

The soil horizons intersected are:

- Fill horizon;
- Transported horizon; and
- Residual horizon.

8.1 Fill horizon

An engineered fill horizon was encountered in the two (2 No.) test pits excavated at the site. This horizon is described as slightly moist, light brown gravelly sand. The horizon has a loose to medium dense consistency and extends to a maximum depth of 0.9m in test pit LR02.

8.2 Transported horizon

The transported horizon occurs as slightly moist, dark reddish brown sandy clay. The horizon has a very soft to soft consistency. It extends to a maximum depth of 1.3m in test pit LR02.

8.3 Residual gabbro horizon

The residual gabbro horizon was encountered in test pit LR02. It occurs as slightly moist, dark brown to grey sandy clay. The horizon has a soft to firm consistency.

Figure 4: A typical test pit profile on site.

9. Groundwater conditions

Groundwater seepage was not encountered in the test pits excavated at the site.

10. Laboratory tests

Representative samples of the materials encountered on site were taken and submitted to a soils laboratory where they were subjected to the following tests:

- Grading and Atterberg Limits including moisture content.

The laboratory results are attached as Appendix C to this report.

10.1 Foundation Indicators

Representative samples were collected for laboratory testing and submitted for foundation indicator tests. The test results are attached in Appendix C and summarised in Table 3 below.

Table 3: Summary of Foundation Indicator Tests results

Hole no.	Depth (m)	Soil composition				GM	Atterberg limits			Activity	Moisture Content	Unified soil classification
		Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	WPI (%)	LS (%)			
Transported Horizon												
LR01	0.80 – 1.50	12	20	68	0	0.79	27	7	4.5	Low	14.8	SC
Residual Gabbro												
LR02	1.30 – 1.60	12	28	59	1	0.69	32	11	6.5	Medium	15.9	SC

Where:
GM = Grading modulus
LL = Liquid Limit
PI = Plasticity Index
WPI = Weighted Plasticity Index (PI x % passing the 0.425 mm sieve)
LS = Linear Shrinkage
Activity = Expansiveness of the soil according to Van der Merwe's method
SC = Clayey sand

Table 3 above indicates that:

The **transported soils** underlying the site consists of clayey sand (**SC**) with a high moisture content of 14.8%. The horizon has a moderate grading modulus of 0.79. The fine fractions of this material exhibit a moderate (27.0%) liquid limit as well as a low (4.5%) linear shrinkage. The weighted plasticity index (WPI) of the soil is low (7%). The material has a low potential expansiveness, according to the method proposed by Van der Merwe (1973).

The **residual gabbro** underlying the site consists of clayey sand (**SC**) with a high moisture content of 15.9%. The horizon has a moderate grading modulus of 0.69. The fine fractions of this material exhibit a moderate (32.0%) liquid limit as well as a medium (4.5%) linear shrinkage. The weighted plasticity index (WPI) of the soil is moderate (11%). The material has a moderate potential expansiveness, according to the method proposed by Van der Merwe (1973).

11. Geotechnical Considerations

The following constraints, as proposed by Partridge, Wood, and Brink (1993), have to be considered for the classification of this site.

11.1 Shallow seepage/groundwater level

Groundwater seepage was not encountered in the test pits excavated on site.

11.2 Expansive soil profile

The site is underlain by clayey sand transported and residual materials. The foundation indicator test results indicate the residual layers on the site have a medium potential expansiveness, according to the method proposed by Van der Merwe (1973). These soils must be protected from the ingress of water. The foundation design for rectification must take into cognisance the expansiveness of the underlying transported and residual materials.

11.3 Compressible soil profile

Problems related to compressibility are expected at the site due to the clayey content encountered in the transported and residual materials. It is expected that these materials will be compressible when the moisture conditions change.

12. Current Site Foundation Conditions

Inspection of the foundations of the structure showed that the house is founded on “strip footings” placed on a soil raft of limited with and depth, probably representing a low stiffness ground beam or a low stiffness raft if cast integrally with the floor slab. From the the soil profile at the excavated test pits, the imported sandy gravel (engineered fill) on which the strip footings are placed is very thin and seems to have not been properly compacted. The stiffness of the foundations is inadequate to withstand the differential settlement that has inevitably occurred. The foundations also have a thickness of 0.2m, which is inadequate.

The width of the exposed footing was found to be 550 mm in the excavated test pits. The house is surrounded by brick paving/ apron as shown in Figure 7 below, which is inadequate due to the heaving of the underlying soils, causing spaces in between bricks thus allowing water to infiltrate into the foundations. Brick paving does little in keeping surface runoff away from the foundations.

The high amount of moisture content from the laboratory tests is consistent with the fact that the existing brick paving around the investigated house does little to prevent water from infiltrating into the foundations.

The house under assessment displayed structural distress (vertical and lateral movement) because of compression and heaving, and ultimately differential settlement. The cracks were observed on the walls around the house and on the floor as shown in Figure 8 below. It is worth noting that this site most likely experiencing compression than heaving.

Based on the soil profile characteristics and the condition of the structure, it is evident that the structure should have been founded on a foundation of substantial stiffness if it had to perform satisfactorily. This would have required a soil raft of non-active material of about 1.50 m in thickness, or a concrete raft foundation with high stiffness. These solutions would typically be combined with limited articulation and a substantial brick force specification.

Figure 5: Showing the brick paving around the house.

Figure 6: Showing structural cracks on the investigated house.

13. Engineering Geological Zoning

For urban planning purposes, the site is zoned according to the NHBRC classification systems. Due to the presence of potentially expansive and compressive soil horizons under the entire site, the site has been delineated into one geotechnical zone. The descriptions of this zone are as follows:

Zone H2/S2/P: This zone covers the entire site and is characterized by expansive soils (clays, silty clays, clayey silts to sandy clay) with a total settlement movement of between 15 and 30 mm and differential movement that is 50% (**H2**). This zone also has fine-grained soils (silty sand to clayey sand) with a total settlement movement exceeding 20 mm and a differential movement that is 50% (**S1**). **P** **(controlled fill)** covers the entire site and is characterized by a controlled/ engineered fill encountered in the excavated test pits.

Table 4: Geotechnical Characteristics

Geotechnical Characteristics				
Typical Founding Material	**Character of Founding Material**	**Expected Range of Total Soil Movements (Mm)**	**Assumed Differential Movement (% of Total)**	**Site Class**
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts, and sandy clays)	Expansive soils	< 7,5 7,5 - 15 **15 - 30** > 30	50% 50% **50%** 50%	H H1 **H2** H3
Clayey silts, clayey sands of low plasticity, sands, sandy and gravely soils	Compressible soils	<10 **10 - 20** 20>	50% **50%** 50%	S **S1** S2
Contaminated soils, **controlled fill**, dolomitic areas, landslip, landfill, marshy areas, mine waste fill, mining subsidence, reclaimed areas, uncontrolled fill, very soft silts/ silty clays	Variable	Variable	-	**P**

The expected immediate total settlement of the foundations is 24.00 mm on the untreated residual clayey sand assuming a founding depth of 0.7 m, a strip footing width of 0.55 mm and an in-situ stiffness of 3 MPa (using the method proposed by Janbu et.al, 1956).

Settlement larger than 10 mm is likely to be differential and may compromise the structure of the development. It is therefore recommended that the clay be treated and strip footings are placed on engineered fill. When the in-situ clay is treated and engineered fill placed on top, the settlements can be expected to drop below 10 mm.

14. Conclusions

The conclusion of the investigation can be summarised as follows:

- The horizontal and diagonal cracks on the internal and external walls of the building indicate that the foundation has subsided and settled.
- The transported and residual material comprises predominantly clayey sand material. These materials are expected to be compressible and expansive.
- The laboratory tests indicate that the soil profile has compressible and expansive soils. Based on the laboratory test results, a total settlement of 24.0 mm can be expected.
- The brick paving around the house has little effective moisture barrier and is considered not suitable as an effective moisture barrier around the house. Concentration and discharging of rainwater against the structure will increase the risk of differential settlements.
- Cracks smaller than 0.5 mm could have been caused by a combination of settlement and temperature differences. Other factors may have contributed, but it is difficult to determine (e.g., moisture content in masonry bricks).

15. Recommendations

For purposes of prescribing rectification measures and based on what we have seen first-hand of the actual footings, this information is not critical:

The approach followed in the rectification process represents a dichotomy, viz:

- Underpinning;
- Incorporating measures to attempt stabilising future soil moisture change and hence curb compressibility/ collapse movement as effectively as possible; and
- Protecting the structure against additional potential movement by strengthening the superstructure where necessary, but at the same time providing flexibility to it by way of movement joints (these recommendations will be done by a structural engineer).

15.1 Foundations

Due to the fact that the foundation material below the foundation is compressible and potentially collapsible, **underpinning of the foundation should be considered and investigated**. There is a risk of cracking during the process and the shrinkage of the fresh concrete, but this will stabilize with time. It is also difficult to underpin the internal walls. Should the client select this option, we can prepare a detailed procedure for the process.

15.2 Soil Moisture Stabilisation

Water must be kept away from the foundations. Practical measures to stabilise the soil moisture would involve providing an apron of say 1.5 m width around the structure and constructed in such a way that water does not pond anywhere directly next to the structure. This will require draping of the soil before placing the apron. When carrying out the above it must be confirmed that no services are leaking.

In addition, while the owner may wish to establish a garden, no large trees should be planted on the stand. **Watering of plants close to the house may have a negative effect on the moisture stabilisation below the foundation**.

15.3 Professional Indemnity

Dwala Group has not carried out detailed construction supervision or design and therefore accepts no responsibility for the design and/or failures and consequences therefore that may occur in the future. We would, however, like to assist with recommendation for the repair of the structure.

The recommendations and methods of construction must be finalised with a contractor. It must be emphasised that all measures to render an existing structure crack free, is certainly more difficult to incorporate than in the case of a new structure still to be built. Although there is no guarantee against minor and isolated cracks developing subsequent to implementation of these measures, a high success rate is possible, particularly to the extent of maintaining a high degree of aesthetical appeal.

16. References

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Appendix A

Summary of Standard Soil and Rock Profile Description Terminology

STANDARD DESCRIPTIONS USED IN SOIL PROFILING

1. MOISTURE CONDITION

Term	Description
Dry	
Slightly moist	Requires addition of water to reach optimum moisture content for compaction
Moist	Near optimum content
Very Moist	Requires drying to attain optimum content
Wet	Fully saturated and generally below water table

2. COLOUR

The Predominant colours or colour combinations are described including secondary coloration described as banded, streaked, blotched, mottled, speckled or stained.

3. CONSISTENCY

3.1 Non-Cohesive Soils

Term	Description
Very Loose	Crumbles very easily when scraped with geological pick
Loose	Small resistance to penetration by sharp end of geological pick
Medium Dense	Considerable resistance to penetration by sharp end of geological pick
Dense	Very high resistance to penetration to sharp end of geological pick. Requires many blows of hand pick for excavation.
Very Dense	High resistance to repeated blows of geological pick. Requires power tools for excavation

3.2 Cohesive Soils

Term	Description
Very soft	Easily penetrated by thumb. Sharp end of pick can be pushed in 30 - 40mm. Easily moulded by fingers.
Soft	Pick head can easily be pushed into the shaft of handle. Moulded by fingers with some pressure.
Firm	Indented by thumb with effort. Sharp end of pick can be pushed in up to 10mm. Can just be penetrated with an ordinary spade.
Stiff	Penetrated by thumbnail. Slight indentation produced by pushing pick point into soil. Cannot be moulded by fingers. Requires hand pick for excavation.
Very Stiff	Indented by thumbnail. Slight indentation produced by blow of pick point. Requires power tools for excavation.

4. STRUCTURE

Term	Description
Intact	Absence of fissures or joints
Fissured	Presence of closed joints
Shattered	Presence of closely spaced air filled joints giving cubical fragments
Micro-shattered	Small scale shattering with shattered fragments the size of sand grains
Slickensided	Polished planar surfaces representing shear movement in soil
Bedded Foliated	Many residual soils show structures of parent rock.

5. SOIL TYPE

5.1 Particle Size

Term	Size (mm)
Boulder	>200
Pebbles	60 – 200
Gravel	60 – 2
Sand	2 – 0,06
Silt	0,06 – 0,002
Clay	<0,002

6. ORIGIN

6.1 Transported Soils

Term	Agency of Transportation
Colluvium	Gravity deposits
Talus	Scree or coarse colluvium
Hillwash	Fine colluvium
Alluvial	River deposits
Aeolian	Wind deposits
Littoral	Beach deposits
Estuarine	Tidal – river deposits
Lacustrine	Lake deposits

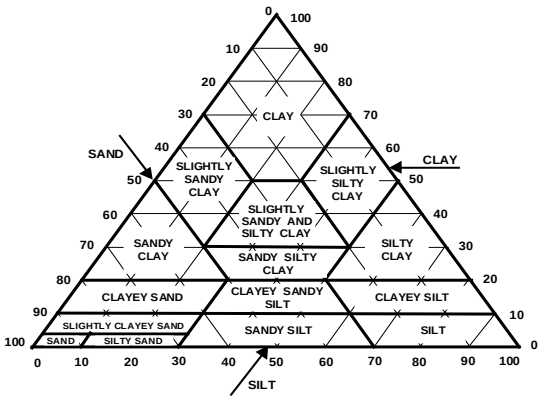
6.2 Residual soils

These are products of in situ weathering of rocks and are described as e.g. Residual Shale

6.3 Pedocretes

Formed in transported and residual soils etc. calcrete, silcrete, manganocrete and ferricrete.

5.2 Soil Classification



SUMMARY OF DESCRIPTIONS USED IN ROCK CORE LOGGING

1. WEATHERING

Term	Symbol	Diagnostic Features
Residual Soil	W5	Rock is discoloured and completely changed to a soil in which original rock fabric is completely destroyed. There is a large change in volume.
Completely Weathered	W5	Rock is discoloured and changed to a soil but original fabric is mainly preserved. There may be occasional small corestones.
Highly Weathered	W4	Rock is discoloured, discontinuities may be open and have discoloured surfaces, and the original fabric of the rock near the discontinuities may be altered; alternation penetrates deeply inwards, but corestones are still present.
Moderately Weathered	W3	Rock is discoloured, discontinuities may be open and will have discoloured surfaces with alteration starting to penetrate inwards, intact rock is noticeably weaker than the fresh rock.
Slightly Weathered	W2	Rock may be slightly discoloured, particularly adjacent to discontinuities, which may be open and will have slightly discoloured surfaces, the intact rock is not noticeably weaker than the fresh rock.
Unweathered	W1	Parent rock showing no discolouration, loss of strength or any other weathering effects.

2. HARDNESS

Classification	Field Test	Compressive Strength Range MPa
Extremely Soft Rock	Easily peeled with a knife	<1
Very Soft Rock	Can be peeled with a knife. Material crumbles under firm blows with the sharp end of a geological pick.	1 to 3
Soft Rock	Can be scraped with a knife, indentation of 2 to 4 mm with firm blows of the pick point.	3 to 10
Medium Hard Rock	Cannot be scraped or peeled with a knife. Hand held specimen breaks with firm blows of the pick.	10 to 25
Hard Rock	Point load tests must be carried out in order to distinguish between these classifications	25 - 70
Very Hard Rock	These results may be verified by uniaxial compressive strength tests on selected samples.	70 - 200
Extremely Hard Rock		>200

3. COLOUR

The predominant colours or colour combination are described including secondary colouration described as banded, streaked, blotched, mottled, speckled or stained.

4. FABRIC

4.1 Grain Size

Term	Size (mm)
Very Coarse	>2,0
Coarse	0,6 – 2,0
Medium	0,2 – 0,6
Fine	0,06 – 0,2
Very Fine	< 0,06

4.2 Discontinuity Spacing

Description for: Bedding, foliation, laminations	Spacing (mm)	Descriptions for joints, faults, etc.
Very Thickly Bedded	> 2000	Very Widely
Thickly Bedded	600 – 2000	Widely
Medium Bedded	200 – 600	Medium
Thinly Bedded	60 – 200	Closely
Laminated	3 – 60	Very closely
Thinly Laminated	<3	

5. ROCK NAME

Classified in terms of origin:

IGNEOUS	Granite, Diorite, Gabbro, Syenite, , Dolerite, Trachyte, Andesite, Basalt.
METAMORPHIC	Slate, Felsite, Gneiss, Schist, Quartzite
SEDIMENTARY	Shale, Mudstone, Siltstone, Sandstone, Dolomite, Conglomerate, Tillite, Limestone.

6. STRATIGRAPHIC HORIZON

Identification of rock type in terms of stratigraphic horizons.

Appendix B

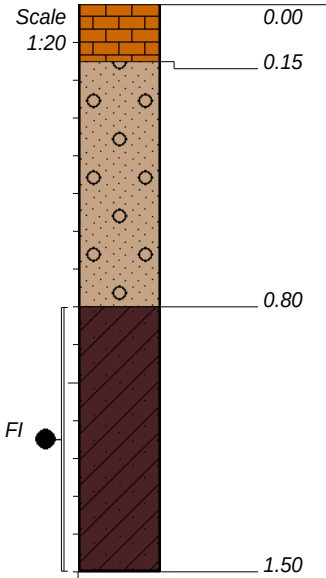
Soil Profile Descriptions

DWALA GROUP
GEOTECHNICAL ENGINEERING

National Home Builders Registration Council (NHBRC)
HOUSE LE ROUX

HOLE No: LR01
Sheet 1 of 1

JOB NUMBER: 100150



Brick paving.

Slightly moist, light brown, MEDIUM DENSE, gravelly sand.
Fill

Slightly moist, dark reddish brown, VERY SOFT, intact, sandy clay.
Transported.

END OF HOLE.

NOTES

1) Sidewalls stable.
2) No refusal.
3) No groundwater seepage intercepted.
4) FI, moisture content sample taken at 0.80--1.50m depth.

CONTRACTOR :
MACHINE : PICKS AND SHOVELS
DRILLED BY :
PROFILED BY : SZ
TYPE SET BY : SZ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 20/10/2023
DATE : 24/10/2023 10:42
TEXT : ..Logs\HOUSELEROUXLOGS.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: LR01
MOKOPANE

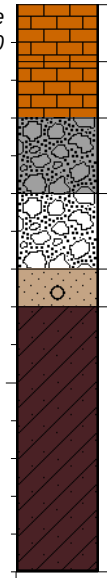
DWALA GROUP
GEOTECHNICAL ENGINEERING

National Home Builders Registration Council (NHBRC)
HOUSE LE ROUX

HOLE No: LR01A
Sheet 1 of 1

JOB NUMBER: 100150

Scale 1:20



0.00	Brick paving.
0.15	Brickwall.
0.30	Concrete foundation.
0.50	Unreinforced concrete underlying the foundation.
0.70	Slightly moist, light brown, MEDIUM DENSE, gravelly sand. Fill.
0.80	Slightly moist, dark reddish brown, VERY SOFT, intact, sandy clay. Transported.
1.50	END OF HOLE.

NOTES

1) Sidewalls stable.
2) No refusal.
3) No groundwater seepage intercepted
4) The footing is placed at the depth of 0.50m; has a thickness of 0.20m and a width of 0.55m.

CONTRACTOR :
MACHINE : PICKS AND SHOVELS
DRILLED BY :
PROFILED BY : SZ
TYPE SET BY : SZ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 20/10/2023
DATE : 24/10/2023 10:42
TEXT : ..Logs\HOUSELEROUXLOGS.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: LR01A
MOKOPANE

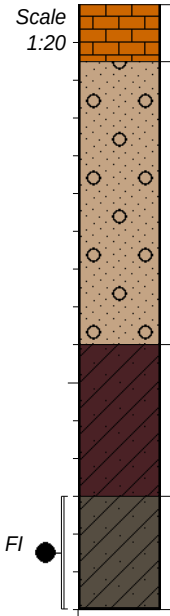
DWALA GROUP
GEOTECHNICAL ENGINEERING

National Home Builders Registration Council (NHBRC)
HOUSE LE ROUX

HOLE No: LR02
Sheet 1 of 1

JOB NUMBER: 100150

Scale 1:20



0.00	Brick paving.
0.15	Slightly moist, light brown, MEDIUM DENSE, gravelly sand. Fill
0.90	Slightly moist, dark reddish brown, VERY SOFT, intact, sandy clay. Transported.
1.30	Slightly moist, dark brown to grey, SOFT TO FIRM, intact, sandy clay. Residual gabbro.
1.60	END OF HOLE.

NOTES

1) Sidewalls stable.
2) No refusal.
3) No groundwater seepage intercepted.
4) FI, moisture content sample taken at 1.3--1.60m depth.

CONTRACTOR :
MACHINE : PICKS AND SHOVELS
DRILLED BY :
PROFILED BY : SZ

TYPE SET BY : SZ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 20/10/2023

DATE : 24/10/2023 10:42
TEXT : ..Logs\HOUSELEROUXLOGS.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: LR02
MOKOPANE

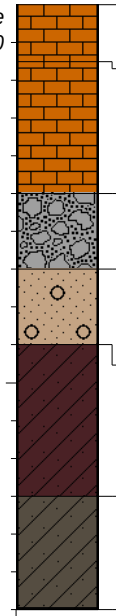
DWALA GROUP
GEOTECHNICAL ENGINEERING

National Home Builders Registration Council (NHBRC)
HOUSE LE ROUX

HOLE No: LR02A
Sheet 1 of 1

JOB NUMBER: 100150

Scale 1:20



0.00	Brick paving.
0.15	Brickwall.
0.50	Concrete foundation.
0.70	Slightly moist, light brown, MEDIUM DENSE, gravelly sand. Fill
0.90	Slightly moist, dark reddish brown, VERY SOFT, intact, sandy clay. Transported.
1.30	Slightly moist, dark brown to grey, SOFT TO FIRM, intact, sandy clay. Residual gabbro.
1.60	END OF HOLE.

NOTES

1) Sidewalls stable.
2) No refusal.
3) No groundwater seepage intercepted.
4) The footing is placed at the depth of 0.90m, has a thickness of 0.20m and a width of 0.55m.

CONTRACTOR :
MACHINE : PICKS AND SHOVELS
DRILLED BY :
PROFILED BY : SZ

TYPE SET BY : SZ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 20/10/2023

DATE : 24/10/2023 10:42
TEXT : ..Logs\HOUSELEROUXLOGS.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: LR02A
MOKOPANE

DWALA GROUP
GEOTECHNICAL ENGINEERING

National Home Builders Registration Council (NHBRC)
HOUSE LE ROUX

LEGEND
Sheet 1 of 1

JOB NUMBER: 100150

	GRAVELLY	{SA03}
	SAND	{SA04}
	SANDY	{SA05}
	CLAY	{SA08}
	LIMESTONE	{SA14}
	CONCRETE	{SA34}
Name	DISTURBED SAMPLE	{SA38}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : SZ
SETUP FILE : STANDARD.SET

DATE : 24/10/2023 10:42
TEXT : ..Logs\HOUSELEROUXLOGS.txt

LEGEND
SUMMARY OF SYMBOLS

Appendix C

Laboratory Results

Benoni Main Office
108 Small Street
Lillyvale, Benoni 1513
Tel: 011 568 0604, Cell: 079 317 2152
Contact Person: Mrs Pearl Ngwenya
Email: pearl@igneoussoillab.co.za
Reg: 2013/230850/07, Vat No: 4080291562

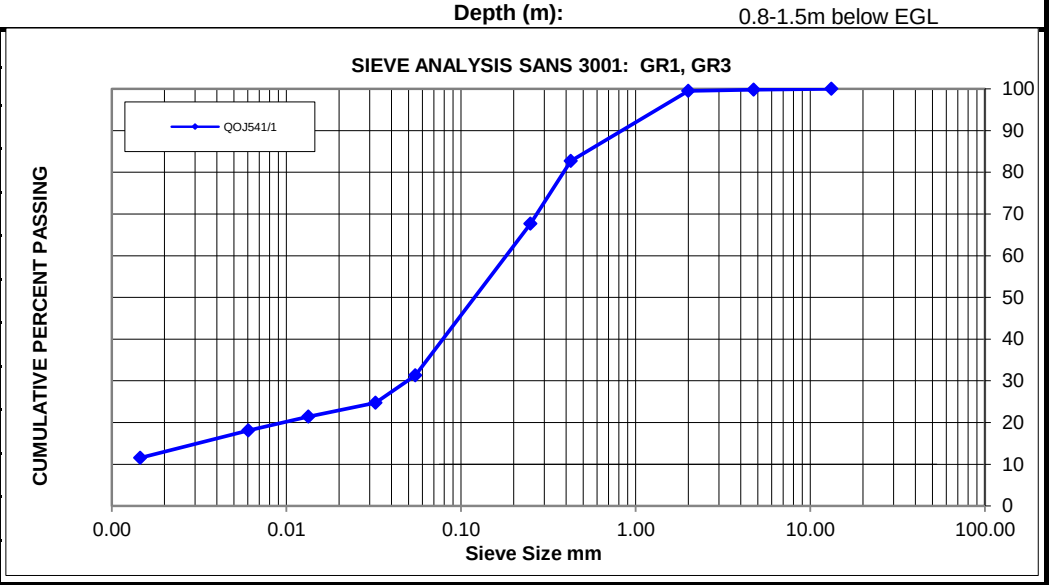
Igneous Soil Laboratory

ilac-MRA sanas Testing Laboratory T0973

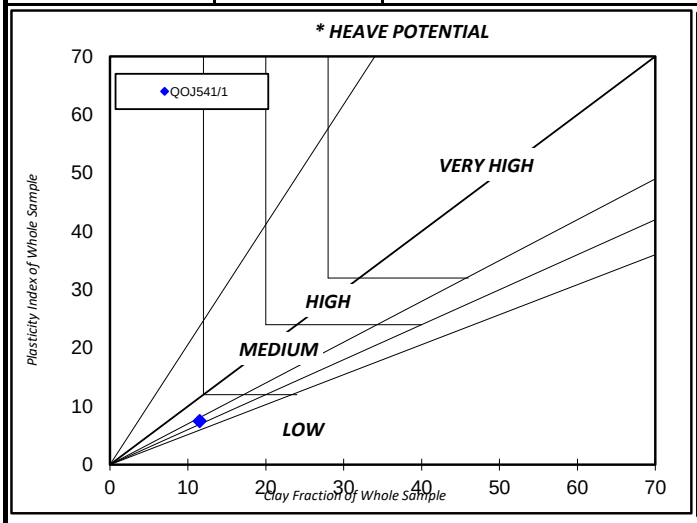
Test Report for Foundation Indicator

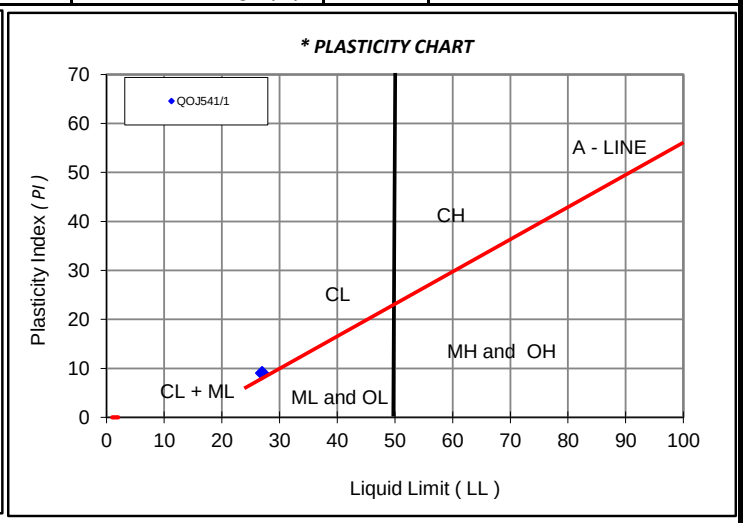
Client Name:	**Dwala group**	**Date recieved:**	23/Oct/2023
Client Address:	Flat 07,680 Pretorius	**Date Tested:**	24/Oct/2023
	St Arcadia	**Date reported:**	25/Oct/2023
	0083	**Report No:**	QOJ541/1(i)
Attetion:	**Nhlanhla**		
Project:	**House Leroux**		
Description:	Material sampled by Igneous soil lab	**Sample No.:**	QOJ541/1
Description:	dusky Red Clayey sand	**Job Number:**	QOJ541
TP :	LR 01	**Depth (m):**	0.8-1.5m below EGL

Sieve mm	% Passing
100.0	
75.0	
63.0	
50.0	
37.5	
28.0	100
20.0	100
14.0	100
5.00	100
2.00	100
0.425	83
0.075	39



## Hydrometer Analysis SANS 3001: GR3		*Classification Grain size Boundaries %		*Grading Modulus SANS 3001 : PR5		*Classifications	
0.055	31	Clay	12	Grading Modulus	0.79	USCS	SC
0.032	25	Silt	20	SANS 3001:GR10		COLTO (1998)	-
0.013	21	Sand	68	Liquid Limit (%)	27	US Highway	A-4
0.006	18	Gravel	0	Plasticity Index (%)	9	Group Index	1
0.001	12			Linear Shrinkage (%)	4.5		





Remarks

Technical Signatory:

Madoda Ngwenya

*Please note that the results apply to the sample as received. Documents may only be reproduced or published in their full context and * All interpretations, Opinions and/or Classifications contained in this report falls outside the scope of SANAS Accreditation.Results marked with ## in this report are not included in the SANAS schedule of Accreditation for the laboratory.*

THE END

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Igneous Soil Laboratory

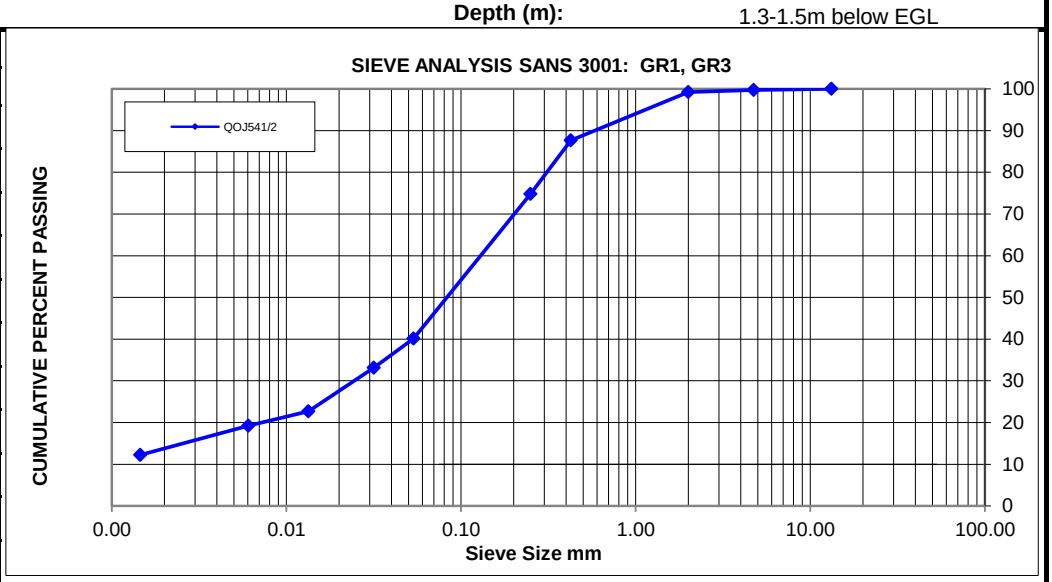
ilac-MRA

sanas Testing Laboratory T0973

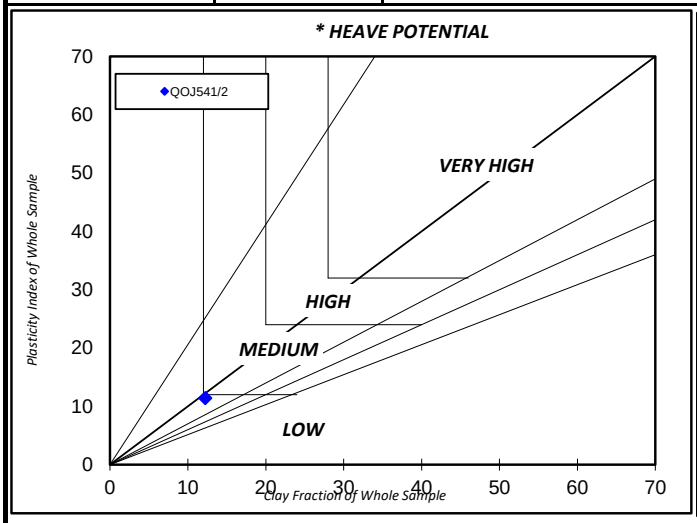
Test Report for Foundation Indicator

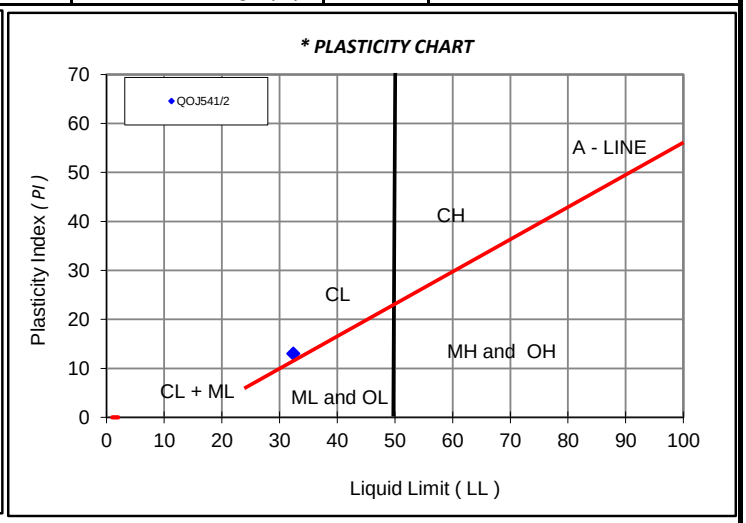
Client Name:	**Dwala group**	**Date recieved:**	23/Oct/2023
Client Address:	Flat 07,680 Pretorius	**Date Tested:**	24/Oct/2023
	St Arcadia	**Date reported:**	25/Oct/2023
	0083	**Report No:**	QOJ541/2(i)
Attetion:	**Nhlanhla**		
Project:	**House Leroux**		
Description:	Material sampled by Igneous soil lab	**Sample No.:**	QOJ541/2
Description:	drk Brown Clayey sand	**Job Number:**	QOJ541
TP :	LR 02	**Depth (m):**	1.3-1.5m below EGL

Sieve mm	% Passing
100.0	
75.0	
63.0	
50.0	
37.5	
28.0	100
20.0	100
14.0	100
5.00	100
2.00	99
0.425	88
0.075	46



## Hydrometer Analysis SANS 3001: GR3		*Classification Grain size Boundaries %		*Grading Modulus SANS 3001 : PR5		*Classifications	
0.053	40	Clay	12	Grading Modulus	0.67	USCS	SC
0.032	33	Silt	28	SANS 3001:GR10		COLTO (1998)	-
0.013	23	Sand	59	Liquid Limit (%)	32	US Highway	A-6
0.006	19	Gravel	1	Plasticity Index (%)	13	Group Index	3
0.001	12			Linear Shrinkage (%)	6.5		





Remarks

Technical Signatory:

Madoda Ngwenya

*Please note that the results apply to the sample as received. Documents may only be reproduced or published in their full context and * All interpretations, Opinions and/or Classifications contained in this report falls outside the scope of SANAS Accreditation.Results marked with ## in this report are not included in the SANAS schedule of Accreditation for the laboratory.*

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Reg: 2013/230850/07, Vat No: 4080291562

Igneous Soil Laboratory

ilac-MRA sanas Testing Laboratory T0973

Test Report for Moisture Content SANS 3001-GR20

Client Name: **Dwala Group**
Client Address: **Flat NO 7, Pretoruis Street**
Arcadia
0083
Attention: Nhlanhla

Date Received: 23/Oct/2023
Date Tested: **24-Oct**
Date Reported: **23/Oct/2026**
Report No.:QOJ 541-1/2

Project: **House Le Loux**
Description: Dusty Red/Dark Brown

Sample No.: QOJ 541/1,2
Job Number: QOJ 541

Moisture Content - SANS 3001: GR20

Sample Number	Sample Position	Material Description	Depth (m)	Tin Mass	Tin + Wet Mass	Tin + Dry Mass	% Moisture
QOJ 541/1	LR01	**Dusty Red**	**0,8 -1,5**	**235.2**	**1376.0**	**1228.3**	**14.8**
QOJ 541/2	LR02	**Dark Brown**	**1,3-1,5**	**233.6**	**1187.9**	**1057.0**	**15.9**
	-		**-**				
	-		**-**				

Technical Signatory:

The above test results are petinent only to the samples as received and tested at the laboratory. This report shall not be reproduced or altered without the prior consent of MS Igneous Soil Laboratory (PTY) LTD, except copied in full.
** Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.*
Results marked "##" in this report are not included in the SANAS schedule of Accreditation for this laboratory.

THE END

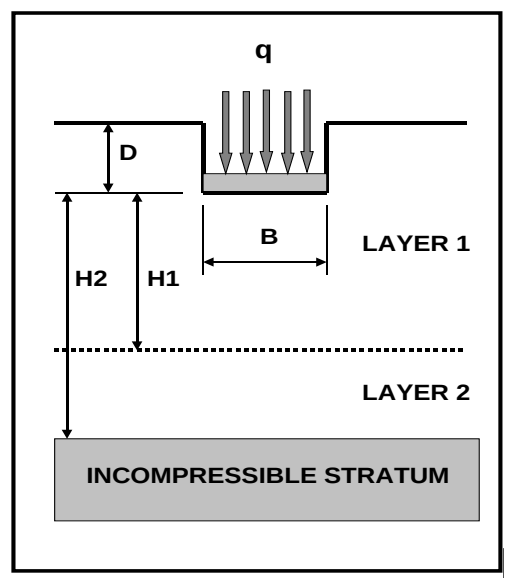
Appendix D

Settlement Calculations

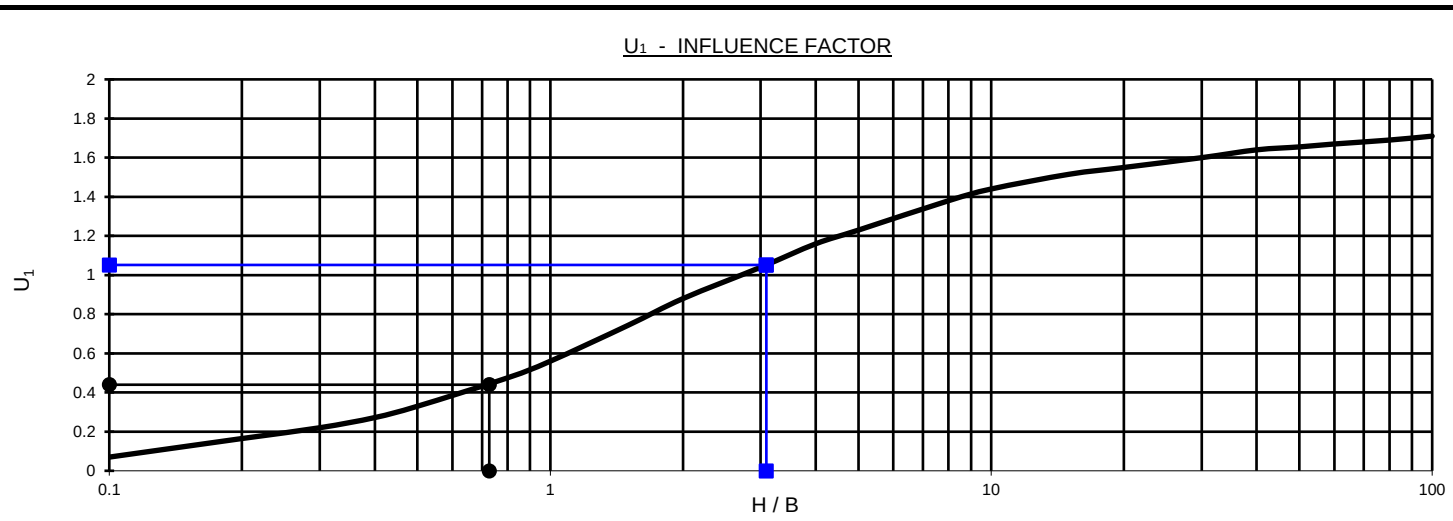
PREDICTION OF THE AVERAGE ELASTIC SETTLEMENT OF A STRIP FOOTING

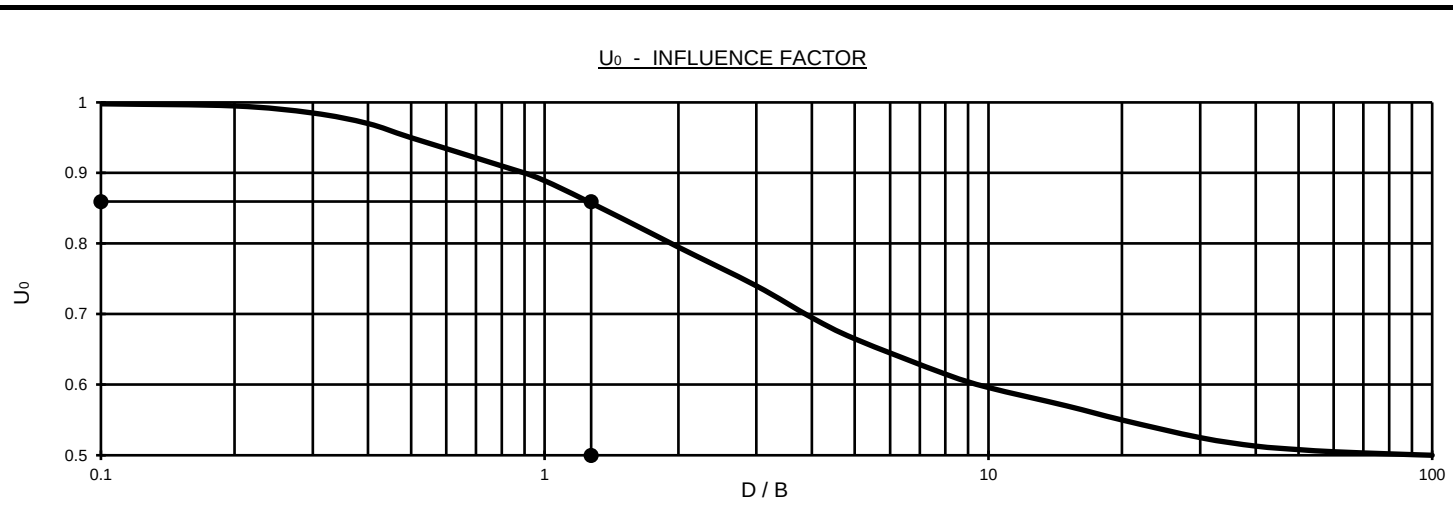
PROJECT NAME	House Le Roux
PROJECT NUMBER	100150
PROBLEM DESCRIPTION	Settlement on In-Situ Materials
LOCATION	Mokopane

INPUT PARAMETER	LAYER 1	LAYER 2	UNIT
FOUNDING DEPTH (D)	0.7	0.7	m
WIDTH OF THE FOOTING (B)	0.55	0.55	m
DEPTH OF LAYER (H1, H2)	0.4	1.7	m
STIFFNESS OF COMPRESSIBLE STRATUM	3	3	MPa
FOUNDATION PRESSURE (q)	150	150	kPa
H / B	0.73	3.09	
D / B	1.27	1.27	
U_1 - INFLUENCE FACTOR	0.44	1.05	
U_0 - INFLUENCE FACTOR	0.86	0.86	
AVERAGE IMMEDIATE SETTLEMENT ***	10	14	mm
TOTAL IMMEDIATE SETTLEMENT PREDICTED		24	mm



*** - After Janbu, Bjerrum and Kjaernsli





Appendix E

Site Plan


House Le Roux
Site Plan
Legend
Test Pit Positions
LR01
LR02
Google Earth
Image © 2023 Airbus
N
80 m

Appendix E: Engineering Investigation Report by NHBRC

NATIONAL HOME BUILDERS
NHBRC
REGISTRATION COUNCIL

INVESTIGATION REPORT ON:

HOUSE (NF LE ROUX)

ERF: UNIT 10716 POTGITER EXT 25

MOKOPANE

CONCILIATION NO. 84476123
03 – AUGUST- 2023

Quality is our priority
Website address: www.nhbrc.org.za
Toll free number: 0800 200 842




OVERALL VIEW OF THE STRUCTURE

FORENSIC ENGINEERING INVESTIGATION REPORT

FOR

HOUSE NF Le Roux

ERF: UNIT 10716 POTGIETERSRUS EXT 25 MOKOPANE

CONCILIATION NO. 84476123

	Prepared by	Checked by
Name / Surname / NHBRC Barcode number	Tshimangadzo Edward Madavhu, Pr. Tech Eng. (ECSA NO.)	
Contact number.	071 913 8445	
Email	edwardma@nhbrc.corg.za	
Date	15 August 2023	
Signature		

DATE	STATUS	PREPARED BY	DESCRIPTION
15 August 2023	v0.0vFinal	Edward Madavhu	- Final: To the Regional Engineer Ms. R Brijbans

Regional Engineer's comments

Name	Date	Signature

CONTENTS

1. INTRODUCTION

Conciliation file was forwarded to NHBRC Technical section. It was required that the internal Engineer should visit the site and compile a report about defects which were identified as reported by the housing consumer and confirmed in the conciliation report. The defects were identified as follows: Cracks on walls and floor, with cracks on the floor dominating or forming a larger pat of the defects. After the perusal of the conciliation report the provincial Engineer identified the need to visit the site to establish the base to concur or provide a second opinion on the defects identified in the conciliation report. The Engineer's report was not provided since the project Engineer was reported to have passed on, ECSA confirmed this to be the reason to cancel the CP registration. The site was visited on the 03 August 2023 by Mr TE Madavhu. The investigation was intended to identify the defects as reported by the housing consumer, observed by the conciliation officer, and proposes remedial solutions to be implemented in accordance with the NHBRC requirements.

2. PROPERTY DETAILS

The house referred to above is owned by Mr N.F Le Roux and is located at Piet Potgieter Ext 12 in Mokopane town. The house is a single storey structure, consists of two bedrooms and two bathrooms, semi open plan kitchen, dining, living room, three garages and caravan carport. The house is plastered and painted internally and constructed with face brick externally. The construction of the house was completed, and it was occupied on the 10 May 2018. From the documented information it appears there has been disagreement between the senior home Inspector Ms. Thabitha Malebe and the competent person where a soil raft construction was questionable. After the complaint was reported, conciliation was requested by the homeowner, and it was scheduled for the 04 April 2023.

Figure 1: Location of property (Google map, 2020)

3. BACKGROUND

3.1. Enrolment

The unit was enrolled as RD2 foundation structure and was constructed by Gailiving (Pty) Ltd T/A Van Dyk Trust. The information was as recorded in the NHBRC enrolment forms. The unit was structurally designed, and construction supervised by the competent person 601649 bar code. The information was as recorded in NHBRC EF 003 and appendix B1 form.

3.2. Conciliation

1. On 20 June 2017, NHBRC recorded a respond email from the competent person to the NHBRC inspector, the respond shown a disagreement concerning foundation fill construction.
2. On the 04 April 2023 the NHBRC recorded a request for conciliation by the owner detailing the defects to be rectified by the homebuilder.
3. On 26 April 2023, NHBRC recorded a conciliation report prepared by the conciliation officer. The report recorded the presence of the NHBRC conciliation officer, homeowner, home builder and the competent person appointed by the homeowner out of B1 requirements.
4. There was no written communication provided directed, to or from the project Engineer.

4. BUILDING ASSESSMENT

4.1. Method of Assessment

The assessment involved visual inspection, which was conducted by Mr TE Madavhu from NHBRC. The main aim of the inspection was to establish the extent and the nature of recorded defects occurred and concur with the conciliation report.

Equipment Used:

- Cell phone Camera
- Measuring tape

4.2. Available Information

The following information was available:

- Architectural drawings (ground and upper floor plan only)
- Conciliation file
- Site classification verification documents.

4.3. Structural design and construction information

- In terms of the **section 13 (2)(b) of the Housing Consumer Protection Measures Act 95 of 1998** as amended, the home builder is obligated to rectify the defects within period stated.
- **Code of Practice: Foundation and Superstructures for Single Storey Residential Buildings of Masonry Construction** and **NHBRC Home Building Manual.**
    a) Design and construction details of foundation for single and double storey residential buildings.
    b) Design and construction details of walls for single and double storey residential buildings.
    c) Design and construction details of roof structures for residential buildings.

4.4. Previous Remedial Works

The homeowner confirmed in the meeting of the 03 August 2023 that the homebuilder constructed remedial works in accordance with the project Engineer's instructions. According to the homebuilder, main cause of the defects was that the owner tested the borehole and left the water pipe adjacent to the foundation wall such that constructed soil raft soaked or saturated. This resulted in the settlement of the engineered fill such that a horizontal crack developed between the top structure and the foundation wall. According to Zumrawi et al (2017) differential movements attributed to moisture difference redistribute loads and concentrate them in specific portions of the foundation, this cause large moments and shear forces which were not accounted for during design. Depending on resistance capacity of the element, the element may resist the loads or fail. The remedial works included the use of chicken mash to repair structural cracks on walls and the installation of Y bars in the first bed joint between the top wall and the foundation wall.

4.5. Foundation type

From enrolment documentations the site class designation was recorded as site class C1. The expected deferential movement of the designated site class is 5-10mm. Following the residential site class design approach, selected foundation design should comply with requirements of the code of practice including foundation configuration. Where these requirements were meet, major structural defects occurrences are minimal. Following the details provided by the competent, there has been a design error in determining the depth of the soil raft. The code of practise requires the removal of in-situ soil to the minimum depth and width which is 1,5m x B (1,5x0,6 = 0,9m), this indicates that the removal depth and perimeter offset should range between 0,9m to 1m. The correct completion of the engineered fill would require a normal foundation construction. The code does not specify the details of the in-situ soil depth to be removed in clay sites, this is because the thickness of the clay underneath the foundation determines the degree of settlement, thinner the clay layer, the lesser the settlement. The defects observed could be linked or associated mainly with the performance of foundation elements.

4.6. Findings

4.6.1. Foundation

As indicated above the defects observed were directly linked with the performance of the foundation structure. The structural defects identified on the floor and walls were directly associated with the performance of the foundation as detailed under the previous remedial works and the type of foundation design solution constructed.

4.6.2. Walls and external works

4.6.2.1. External walls
Structural or structural related defects were observed on the northern external wall. Signs of structural defects were observed on the western side of the foundation wall.

4.6.2.2. Internal walls
Structural or structural related defects were observed on internal walls of the corrido connecting the bedroom, bathroom, and the dining room.

4.6.2.3. External works
The work done was confirmed as apron around the perimeter of the structure, however, the apron provided was not sloped to comply with the technical requirements of the NHBRC.

4.6.3. Roof Structure

4.6.3.1. Roof structure and frame
There was no roof structure or roof leak defect which was observed, however significant movement of the ceiling cornice and closet and door was observed.

4.6.4. Photographic report A (completed remedial work)

The homebuilder was requested to provide photographs of the remedial work completed as an endeavour to solve the problem.

Remedial work photos of the western foundation wall.

Plate 1

Plate 2

Plate 3

Plate 4

4.6.5. Photographic report B (defects recurrence)

The photographic report relates to some of the dissatisfaction raised the NHBRC inspector during the construction of the housing structure foundation.

Plate1

Plate 1 shows the signs of structural defects on the repaired western foundation wall.

Plate 2

Plate 2 supplements plate 1

Plate 3

Plate 3 shows cracks on floor finish in the corrido..

Plate 4

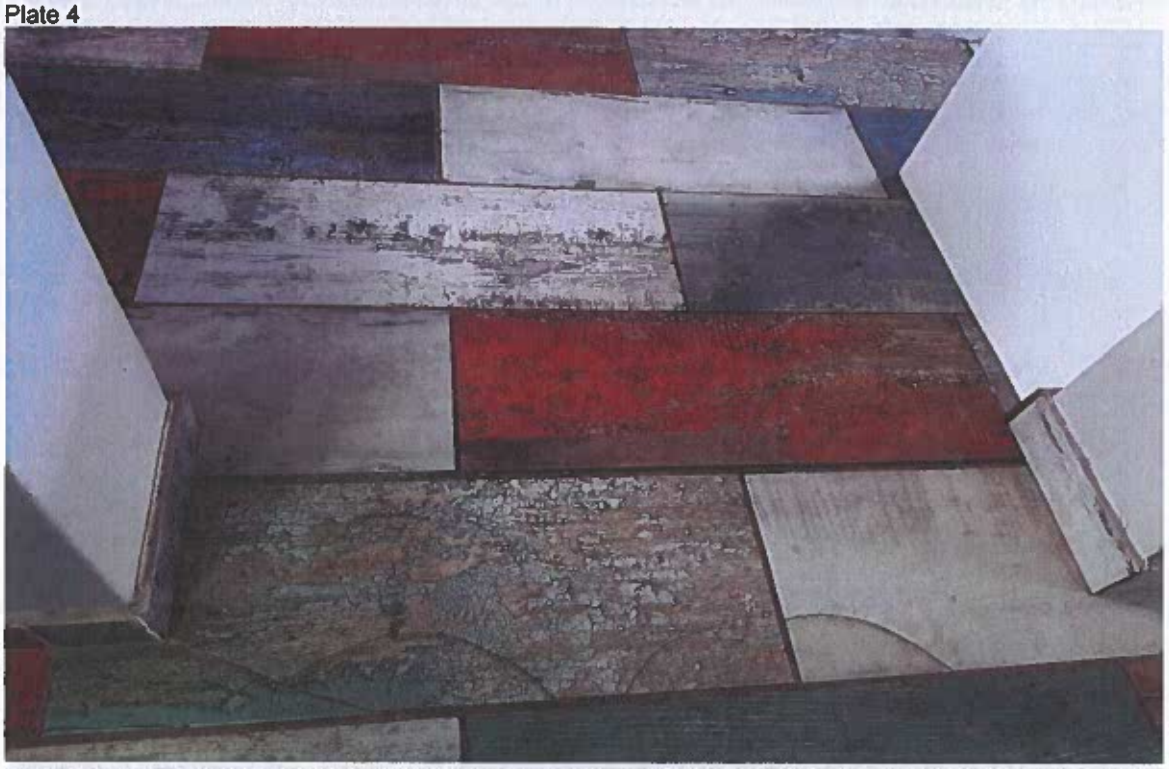


Plate 4 supplements plate 3.

Plate 5

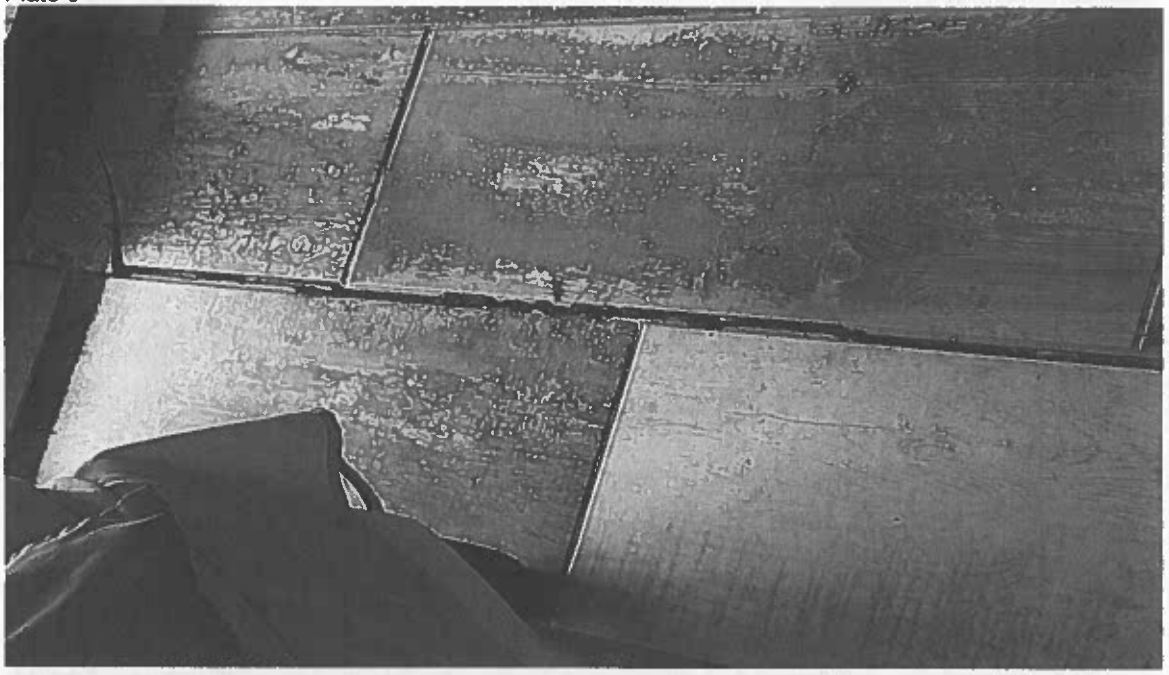


Plate 5 shows a floor crack in the western bedroom. The represent a shift movement to the west and is open the full length of the room.

Plate 6

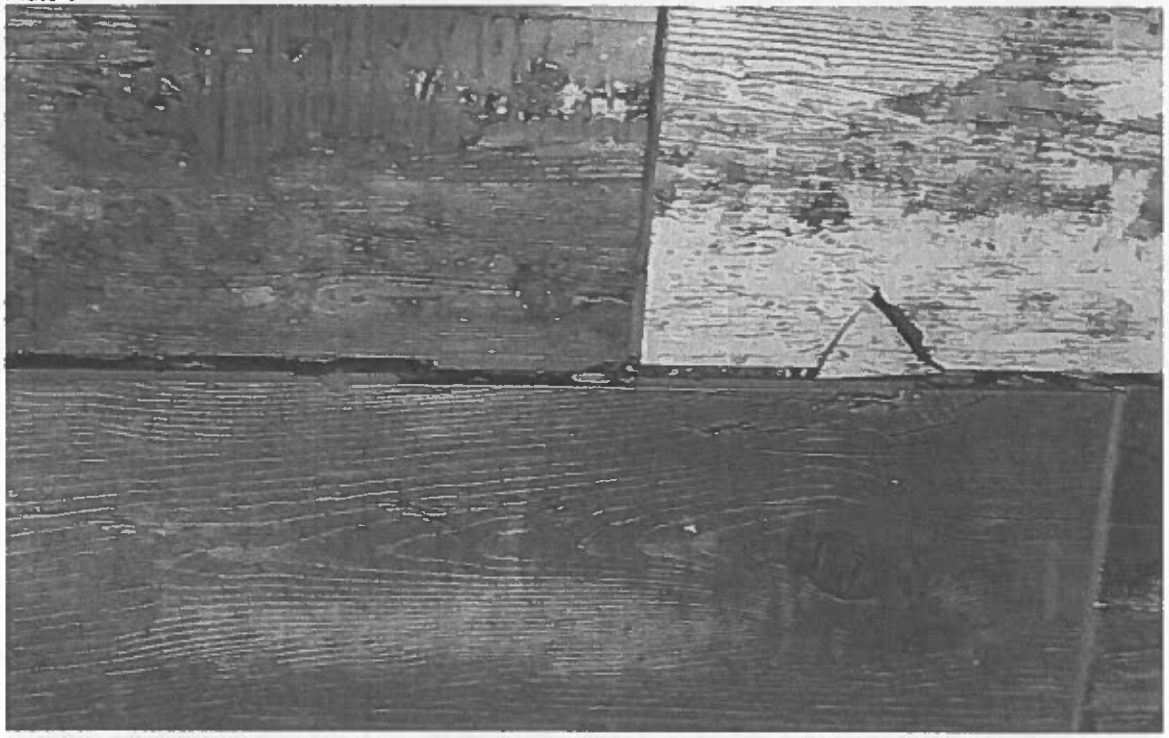


Plate 6 supplements plate 5

Plate 7

Plate 7 shows the recurrence of the repaired crack on the wall of the corrido.

Plate 8

Plate 8 supplement plate 7

Plate 9

Plate 9 shows a crack on the external wall of the dinning area.

Plate 10

Plate 10 supplements plate 9 showing the same crack on the outside.

Plate 11 and 12

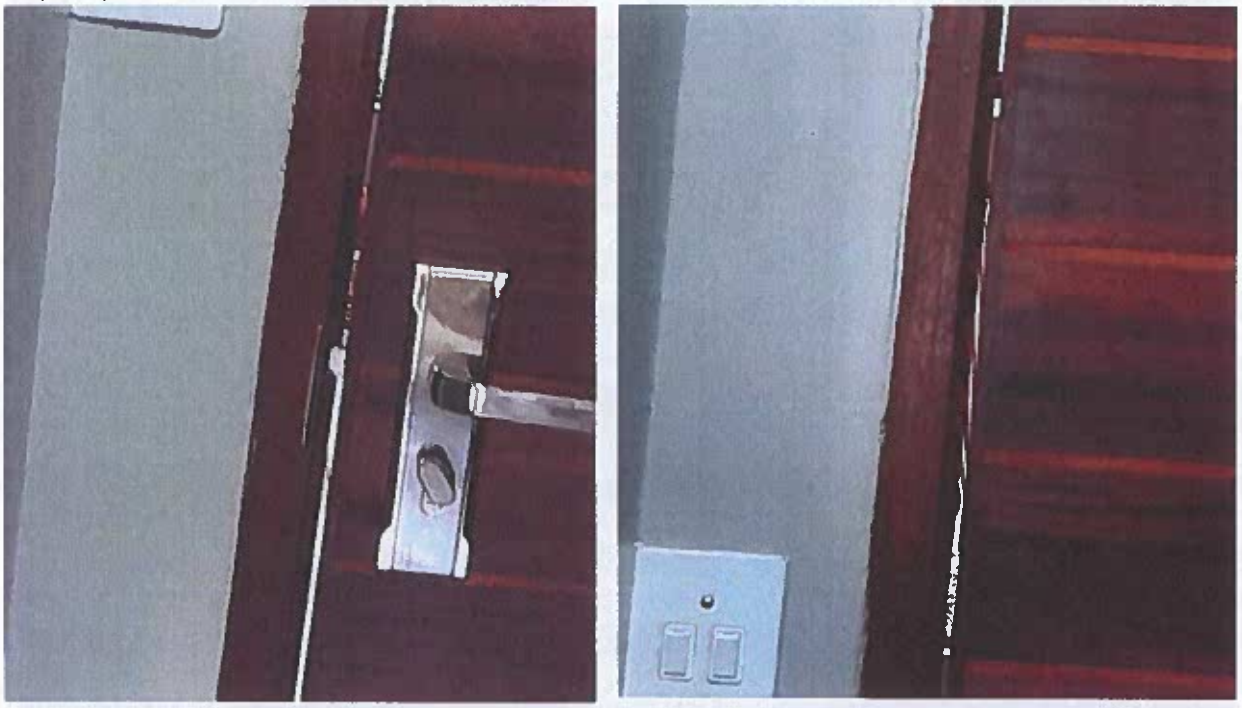


Plate 11 and 12 depict the door gap of the western bedroom attributed to the foundation movement.

Plate 13

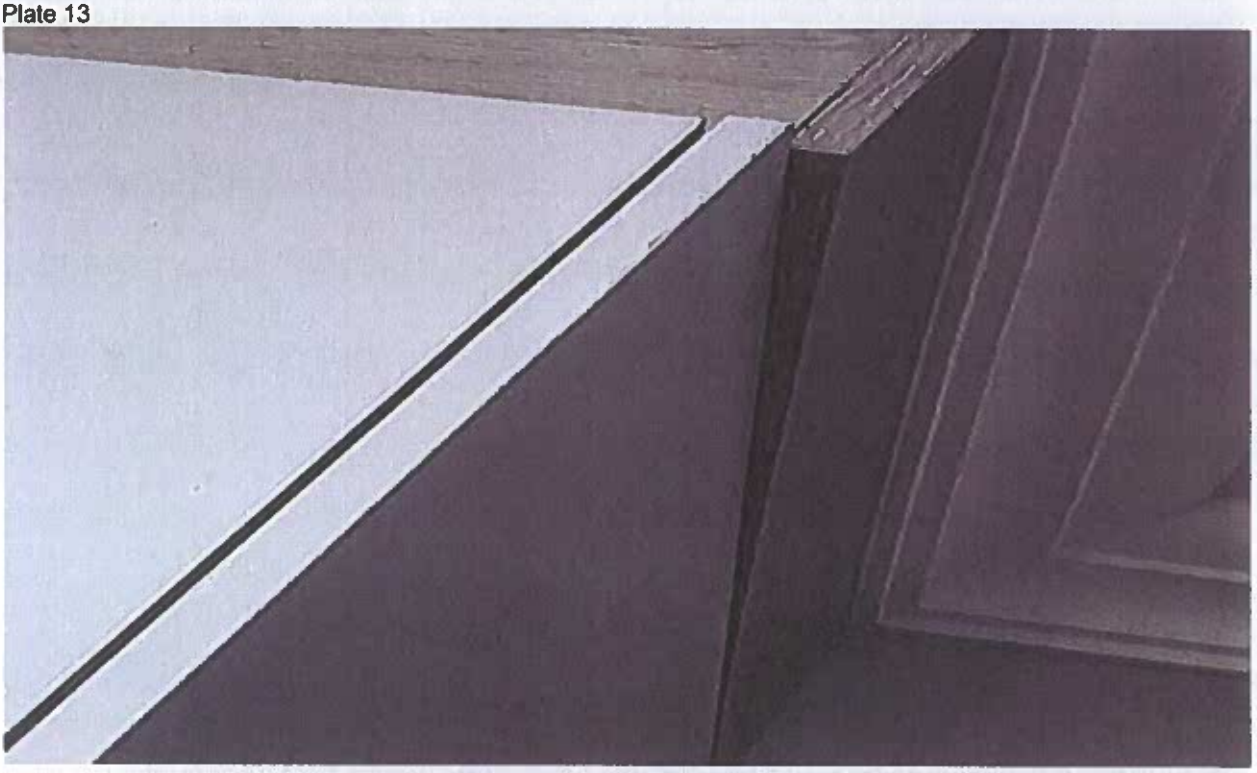


Plate 13 supplements plate 11 and 12 but showing misalignment of the build in closets attributed to the foundation movement.

5. PROPOSED REMEDIAL ACTIONS

5.1. Structural Performance

5.1.1. General performance of the structure

- From available recorded information the details of the foundation footing indicated a design error in specification of a soil raft design in C1/S1 site class designations. A soil raft to the depth of 700mm was specified which is less than strip footing width x 1,5 (0,6m x 1,5).
- The defects observed were dominated by floor and walls cracks which occurred due to the movement of the elastic foundation. Given the site classification designation it is not clear if the cracks were caused by collapse or expansive of the in-situ foundation soil. Further investigation should be conducted to determine the presence of expansive soil on site.
- The structural defects observed were inclined to the western direction of the housing structure around the affected foundation wall.
- The defects identified at this stage, which are within the NHBRC warranty were observed to be the structural cracks on wall and floor of the housing structure.

5.1.2. Defects rectification.

a) Defects rectification may be divided in three categories which are:

- Structural defects on structural elements and consequential damages, which is mainly covered by the NHBRC warranty.
- 1 year Roof leak defects and consequential damages, which is mainly covered by the NHBRC warranty.
- Non structural defects structural defects, which do not fall within the NHBRC 1 year roof leak and 5 years structural defects. The competent persons (Engineer or Architect), therefore should advise the homeowner in detail about defects which do not fall within the NHBRC warranty.

b) Not limited to the following listed items:

- The absence of the Engineer's report opened the gap to provide details of the identified defects.
- The confirmation of the Engineer's permanent absence in the project warrants the need to appoint another the Engineer who shall conduct a detailed investigation and provide a detailed report and remedial solutions.
- The Engineer or the Architect should provide a detailed advice on defects not included in the HNBRC warranty.

6. CONCLUSIONS

After the preliminary investigation of the defects in house NF Le Roux it was concluded that:

6.1. The defects recorded in the conciliation report relate to the structural performance of the foundation structure.

6.2. The defects observed could be directly related to the settlement of the foundation footing.

6.3. Given the confirmation of the passing on of the Engineer, a new competent person should be appointed to provide a detailed report about the roof leaks defects.

6.4. The remedial work constructed by the homebuilder under the instruction of project competent person should be considered to facilitate the defects investigations.

6.5. There were no roof leaks or related defects identified at time of site the investigation.

7. RECOMMENDATIONS

Considering the defects observed the following recommendations were made:

7.1. Detailed geotechnical and structural engineering investigation should be conducted to inform the possible remedial solution.

7.2. Following the passing on of the competent person, the appointment of a new competent person should be emanant, to provide detailed remedial design solution for approval and quantification of the works.

7.3. Where applicable the solutions for defects out of the NHBRC warranty should be provided by the competent person (Architect) for the housing consumer to arrange rectification works where applicable.

7.4. The defects should be rectified.

8. BILL OF QUANTITY

The Quantity Surveyor shall prepare the bill of quantities as instructed by the regional Engineer or shall be provided by the eternal competent person.