TechQ Development

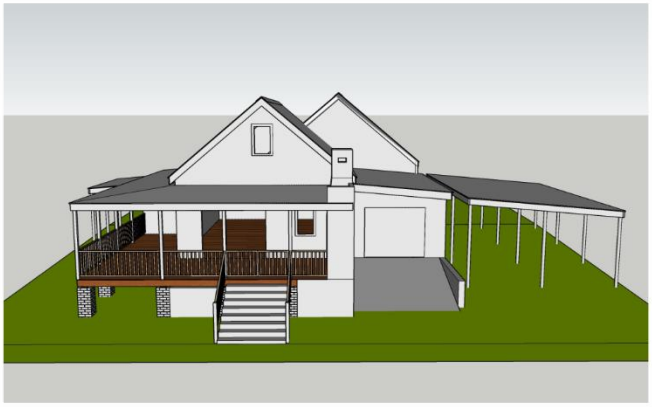
Consulting Engineers, Projects and Construction Managers

Office No. 2
Anchor Bay Building
3 Sir Lowry Street
Gordon's Bay
7140
066 105 1226
techq.development@outlook.com
086 474 1937
www.techq-development.com

Prepared for:

NATIONAL HOME BUILDERS REGISTRATION COUNCIL

NHBRC



Professional Engineering Services for:
House Van Niekerk, Erf 7421 - Swellendam

Forensic Investigation and Structural Engineering remedial solutions

Investigation and Recommendation Report

January 2023 (Rev 01)

Document Control Sheet

Client Project Reference	**Internal Project Number**
Erf 7421 - Swellendam, Cape Town (House Van Niekerk)	TechQ – 010

Title

Professional Engineering Services for Erf 7421 - Swellendam, Cape Town: Forensic Investigation and Structural Engineering Remedial Solutions

Project Stage

Forensic Investigation: Structural Engineering Investigation and Recommendations Report

Version	**Date**	**Comment**
Draft A	15 December 2022	Report submitted for comments and approval
FINAL	19 January 2023	Completion of **Stage 1: Forensic Investigation**
Rev 01	27 January 2023	Revisions / additions to **Section 3 (Remedial A & E)**

Prepared For:

The Project Manager

National Home Builders Registration Council

27 Leeuwkop Road, Sunninghill

Johannesburg

2191

Prepared By:

TechQ Development (Pty) Ltd

Office No.2, ANCHOR BAY Building

3 Sir Lowry Street

Gordon's Bay

7140

Compiled By: Consultant

MJ Badenhorst (Pr.Tech.Eng)

ECSA : Pr. Reg No. 200270009

NHBRC : 601551

Reviewed By: (Client – NHBRC)

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Annexures

EXECUTIVE SUMMARY

This ***Forensic Investigation and Structural Engineering Remedial Solution Report*** (hereinafter referred to as the **Report**) is presented following the approval of the CONCEPT discussion with the NHBRC on 22 November 2022, and based on a *Request for Proposals (RFP)* called by the ***National Home Builders Registration Council (NHBRC)*** in terms of the *Housing Consumer Protection Measures Act (Act 95 of 1998) and Regulations (HCPMA)and the NHBRC Technical Requirements.*

This **Report** provides detail towards the investigations and surveys done, tests conducted and proposed remedial solutions in addressing the Project Scope and objectives for the structural defects reported **at *Erf 7421, Swellendam (House Van Niekerk)***, Western Cape Province.

This **Report** is based on documentation made available to **TechQ** and on-site inspections of the building structure, which included municipal approved Architect's drawings (***Theo Mouton***) and the Occupation Certificate issued by the Swellendam Municipality (September 2018) as noted in **Section 1.3** of this document, attached as **Annexure A**.

A comprehensive structural inspection was conducted to the brick column supported timber-frame structure (property of Mr and Mrs van Niekerk) with concerned visual indications of building material weakening of the brick column foundations and differential movement in the top-structure, with vertical and lateral cracks in the wooden cladding of the timber-frame, due to reasons elaborated on in **Section 3** of this report.

Of further concern is the vast difference in the Architect's site layout and the actual completed building which raise the concern of poor Quality Assurance and Control, and lack thereof, which also leads to suspicious construction workmanship, which contributes to the damaging causes for failure of the structure.

No geotechnical investigations were conducted during this forensic structural investigation. According to the locally appointed Contractor, Mr George Fourie, such investigation was conducted prior to construction, however, no records could be found.

The objective of structural engineering remedial solutions proposed within this report is towards a safe building for a live-span of 50 years, in accordance with the **SANS 10160-1, Table 1**, as detailed in **Section 3** of the **Report**.

The **Project** is implemented in stages of which this ***Forensic Investigation Report*** is submitted with the relevant engineering drawings towards the remedial works as recorded in this report.

Prospective Contractors will be invited to submit financial offers to be procured for the execution of the proposed remedial Works under supervision of **TechQ**. The table below provides detail on the Project Deliverables and targeted due dates.

Project Deliverables and Targeted Dates

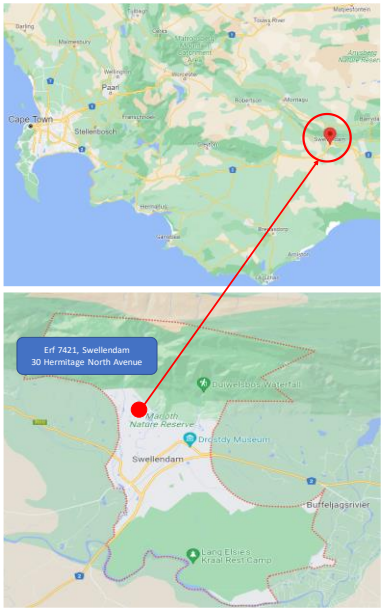
Project Deliverables - Milestones	Targeted Dates
Forensic investigation stage (Physical and analytical assessment of defects)	October 2022 – November 2022
Submit DRAFT report to NHBRC	December 2022
Address NHBRC comments to the report and resubmit	January 2023
Procurement of Remedial Contractor Stage (Site Briefing)	February 2023
Construction/Remedial Stage (Site handover and supervision)	March – June 2023
Project Closure and Sign off	December 2023

--- End of Executive Summary ---

1 PROJECT LOCALITY, SCOPE AND INFORMATION

1.1 Project Locality

Erf 7421, Swellendam (House Van Niekerk), Cape Town (Project Site), is the property of Mr and Mrs van Niekerk, located at *30 Hermitage North Avenue, The Well, Swellendam* within the boundaries of Swellendam Municipality as show on the Figures below. Site coordinates are **South:** 34° 00' 03" **East:** 20° 25' 38"



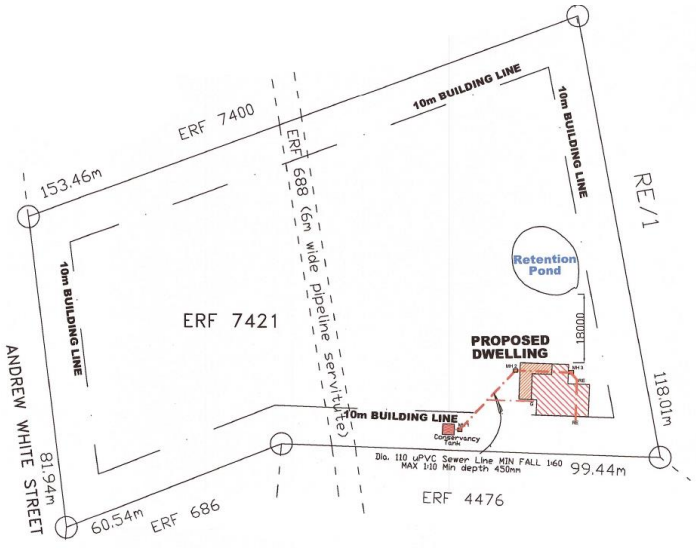


Figure 1: Site Layout

1.2 Scope of Work

TechQ Development (Pty) Ltd was appointed by the **NHBRC** to conduct a *Forensic Investigation* on the single-story building at ***Erf 7421, Swellendam (House Van Niekerk)***, Western Cape Province, with the following summarised deliverables.

- Investigate defects that have manifested at the above mentioned home and classify them in terms of the Housing Consumer Protection Measures Act (Act 95 of 1998) and Regulations (HCPMA) and the NHBRC Technical Requirements.
- Determine the root causes of defects, report on the deformation of the existing structure and provide remedial solutions and specifications including drawings where necessary, towards the following areas as per previous reports filed by the NHBRC:
    - Presence of untreated timber on the timber frame
    - Evidence of swaying of the timber framed house
    - Inadequate hold-down bolts for the timber floor

Throughout the investigation and considerations of remedial works, special attention is drawn to **Chapter III** of the Act, clause 13(1)(b) – (i) "rectify major structural defects" and (ii) "deviation from plans or any deficiency related to design, workmanship or materials".

From visual inspections to the structure in comparison with the information provided, it was noted that several discrepancies exist in the Architectural site layout of the foundations (concrete bases with brick stub-columns supporting the timber floor deck) and the timber-frame material composition of the house compared to the as-built construction of the structure. These are all contributing factors to the possible causes of default.

No structural engineering drawings (foundations and engineering earthworks) were produced or made available during construction stage, as per report of the Owners, also absent during this Forensic Investigation.

1.3 Information Provided

Information provided by the NHBRC, the Home Owners and those obtained during the investigation are listed below and attached as **Annexures**. This information provided valuable intel in support of the investigation, to analyse the structural system and present remedial structural solutions.

1.3.1 Municipal approved Architect drawings

Indicative notes towards the construction of foundations are given on the Architect's drawings, attached as **Annexure A,** however, a note is recorded on the drawings stating that "Foundations to be to Structural Engineering Certification" of which no drawings were presented during the investigation. The following structural elements were noted from the drawings which are raised as concerned "approvals".

- Foundations - "Double wall, mass concrete strip footings for the kitchen and bathrooms"
- Brick pillars - "Filled with weak concrete (10MPa & 13mm stone)"

It must be noted that the strip foundation and concrete surface beds to the kitchen and bathrooms, also indicated on the Architect's drawings, were not constructed. Numerous other deviations from the drawings were observed, however not part of the scope of this investigation.

1.3.2 Occupation Certificate

An Occupational Certificate dated 26 September 2018 was issued by the Town Planning and Building Control department of the Swellendam Municipality of which a copy is attached as **Annexure B**. No other stage inspection sheets or quality assurance control procedural documentation could be obtained.

1.3.3 Form 2: Competent Person

A copy of the Form 2: Application for acceptance of a Competent Person (Structural Engineer) dated 22 May 2017, is attached as **Annexure C**.

The nominated structural engineer, Mr Richard Cooper (ECSA – 8670245) did not continue to participate in the Project due to unknown reasons. No structural engineering drawings or specifications were made available as information.

1.3.4 Photo album during construction period

The Project brief and scope of works alerted to untreated and swagging timber elements as well as inadequate hold-down bolts for the timber floor / deck. Questionable construction methodology and use of materials are evident from the photo album provided by the Owners, also shown below, and considering the construction drawings with limited to no engineering specifications and construction methodologies for the complex site and structure.

Photo Album: Construction Stage

Setting out

Brick Columns

Timber Framework

Isolation and Cladding

The above photos are in support of the concerns raised, and given the forensic investigation conducted by **TechQ Development**, numerous other areas of the structure need to be rectified following the recommended remedial solutions proposed in this **Report** as detailed in **Section 3** below.

2 FORENSIC INVESTIGATION

2.1 Surveys and Investigations

2.1.1 Site Topographical Survey

No site survey information was presented during the investigation. During the investigation the site slope was determined to be almost 2,0m (east to west), which requires proper earthworks and structural engineering foundation designs.

Reference levels were taken on site and along the property boundary to determine for stormwater and drainage options as detailed on the drawings attached in **Annexure D**.

2.1.2 Geotechnical Investigation

No records of a geotechnical investigation prior to design and construction stages were made available during this forensic investigation. According to the locally appointed Contractor, Mr George Fourie, such investigation was conducted with no records to be proven.

2.2 Condition Assessment

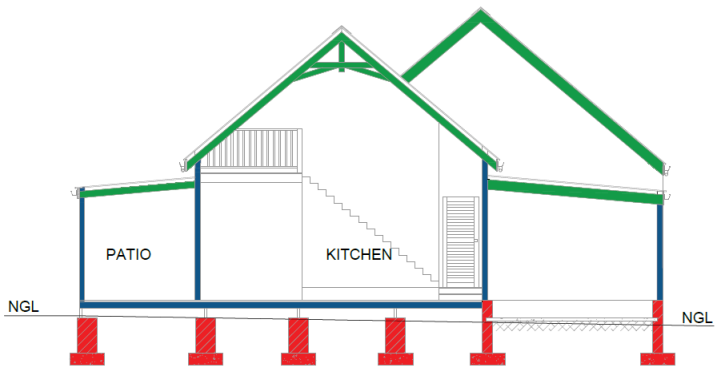
The table below and guided descriptions were used with the assessment and recommendations towards remedial works in securing a safe building.

Table 1: Condition Assessment Ratings

Rating	Action required	Description
5 Very Good	Planned and Preventative Maintenance	New element or has recently been maintained, does not exhibit any signs of deterioration, and satisfies engineering specifications.
4 Good	Condition-based Maintenance	Superficial wear and tear, minor defects, minor signs of deterioration to elements and materials and requires routine maintenance / servicing.
3 Fair	Repairs needed	Require repair, usually by a specialist due to abnormal use or abuse and is in poor state of repair to affect surrounding elements.
2 Bad	Rehabilitation	Deterioration is bad, suffered structural damage and requires renovations. Serious potential of imminent failure which will lead to potential health and safety risk.
1 Very Bad	Replacement	Element has failed its operational functions to the extent that does not justify repairs and needs to be replaced. The condition actively contributes to degradation of safety, health and risks.

The structural condition assessment of the building portraits a very high risk towards the structural integrity of especially the foundations of the building as schematically shown below and further detailed in this section below.

Figure 2: Condition Assessment



Foundations / Bases	Very bad
Foundation / Columns	Very bad
Timber Portal Frame	Good
Cladding and Insulation	Good
Roof structure	Very Good
Stormwater provision	Non existent

2.2.1 Foundations

In the absence of a geotechnical report, no soil classification or precautional measures for engineering earthworks were noted on the construction drawings to inform design and construction of suitable foundations. The in-situ soil is a very loose, dark silty material, high in moisture, however dense enough to ensure good compaction and proper support to foundations.

The photos below show different stage of the foundation construction with no evidence of reinforcement in the concrete bases or starter bars for the brick columns. This imposes a very high risk for deformation and collapsing of the structure following continuous swaging during localised strong winds and abnormal rainfall.

Foundations: Setting out and completion

Setting out of Bases

Excavations for Bases

Brick column - no rebar

Completed columns

Most of the brick support columns are higher than 1,0m (one meter) which in accordance with **SANS 10400 – G** (Foundations), the foundation and supports should have been designed as a retaining structure with proper reinforcement in the concrete bases and also for the loadbearing column supports.

The materials and construction methodology procedures used in the construction of the concrete bases and the brick column supports are also under suspicion. The concrete bases are brittle and is deteriorating, mortar between the bricks is crumbling, bricks are shipping off on the sides and some already cracking under the pinpoint-imposed loads of the timber floor deck structure.

Testing methods of the construction materials and results obtained are elaborated on in **Section 2.3** below.

2.2.2 Surface beds and timber floor deck

The architect's drawings indicates that the two bathrooms and the kitchen to have concrete surface beds, however, only a concrete surface for the garage was constructed on compacted fill. A large percentage area of the wooden floor deck is not fully supported onto the foundation columns which results in oscillation occurrence when walking on the surface and during high-speed winds imposing on the vertical elevations of the building.

The tile flooring in the bathrooms is laid on a layer of screed which elements are both cracking up from the oscillation movement of the structure further caused by inadequate and uneven horizontal, vertical and lateral supports to the structure as shown in the photos below.

Surface beds and timber floor deck

No concrete floor in kitchen

Timber deck not supported

Cracked tiles in bathroom – on screed

2.2.3 Timber frame and Cladding

The approved architect drawings provide typical specification towards the construction of a timber frame building with several reference to **SANS** compliances, however without any structural fixing detail drawings.

The pictures below provide insight to the complexity of the timber frame also evidence that the timber elements were exposed to elements of nature over a long period of time, which could have impacted negatively on the integrity of the completed structure to date.

Timber frame and Cladding

Timber frame

Cladding in progress

Exposed timber sections

Affected timber section

2.2.4 Roof Structure

Notes towards the construction of the roof is given on the architect's drawings to be "as per specialist specifications and designs with certificates" of which no records are available. On inspection, no structural defects or deformation was observed or reported by the Owners.

The photos below show the constructed and completed versions of the roof structure with limited bracings.

Roof structure

Timber frame / cladding

Roof construction

Roof truss completed

Completed roof with sheeting

2.2.5 Stormwater provision

The areas around the house have no effective stormwater barrier/apron. Concentration and discharging of rainwater, via downpipes, is mainly collected against the eastern façade of the building which increases the potential of foundation settlement as shown in the pictures below.

Stormwater provision

Rainwater downpipe

Exterior with no aprons

Remedial and corrective measures are hereafter given to all the above structural and other elements in addressing the Project Brief and Scope of Works, also detailed on the drawings in **Annexure D**.

2.3 Material Testing

2.3.1 Material Testing

The Project brief outlined the initial concern of untreated timber and inadequate hold-down bolts to the timber floor connected to the foundation columns. Closer inspection revealed the possibility of low-grade bricks, concrete and mortar being used in the construction of the foundation bases and brick stub-columns as well as poorly protected timber elements of which is elaborated below.

a) Concrete base foundations and masonry support columns

Core samples of the concrete bases is recommended to be taken during construction for record purposes, however, from visual inspections, the concrete bases to the brick supports are of sub-standard quality.

Random Samples (10 off) of the bricks used in the construction of the masonry support columns was taken to **ROADLAB** (Cape Town) to conduct compression and absorption tests. The table below gives detail of the results, also attached in **Annexure F**, after the bricks were submerged in water for 24 hours.

SANS 227:2007 – compression and absorption test

Sample No.	Brick Mass (g)		Water absorption %	Compress Strenght MPa
	Before	After		
1	2384	2596	8.89%	**5,6**
2	2374	2521	6.19%	**6,1**
3	2447	2706	10.58%	7,7
4	2322	2586	11.37%	**4,4**
5	2499	2769	10.80%	**6,1**
6	2434	2672	9.78%	8,1
7	2411	2621	8.71%	**6,2**
8	2404	2649	10.19%	**4,9**
9	2278	2499	9.70%	9,2
10	2388	2519	5.49%	**6,1**

The allowable percentage (%) increase in mass of **Class 11 masonry bricks** (columns / retaining walls) in accordance with **SANS 10400-K, clause 4.2.5** is **15%,** however, **ROADLAB** reported that a large percentage of water drained from the submerged bricks moments after removed from the water, which is not measurable and will influence the % absorption recorded. This is also a clear, but a concerning factor indicating the bricks to be very porous of which the low compressive test results are evident to.

Of further concern is that **70% of the bricks tested**, the compression test results are **lower than the minimum 7MPa**, thus posing a risk of deformation and collapse of the brick supports and ultimate the structure.

The pictures below give visual evidence towards the susceptive poor materials used in the construction of the concrete bases and masonry brick support columns.

Concrete bases and masonry support columns

Base construction

Deformed base

Damaged bricks

No support or fixing

b) Timber frame, isolation board and wood cladding

Timber portal structures, loadbearing elements and bracings, must be fabricated and treated in accordance with **SANS 10082 / SANS 063 – Part 1** of which the required markings are reflected on the timber elements. The timber elements were exposed to climate change over long periods which give clear evidence that treatment and protection of the timber was compromised as shown in the photos below.

Climate exposed timer elements

Damaged interior elements

Affected timber door frame

Exterior timber panel

Conclusion cannot be made towards the structural integrity of the timber elements, however regular maintenance to the exposed surfaces is recommended to ensure long-lasting life of the structure.

3 ENGINEERING REMEDIAL SOLUTIONS AND RECOMMENDATIONS

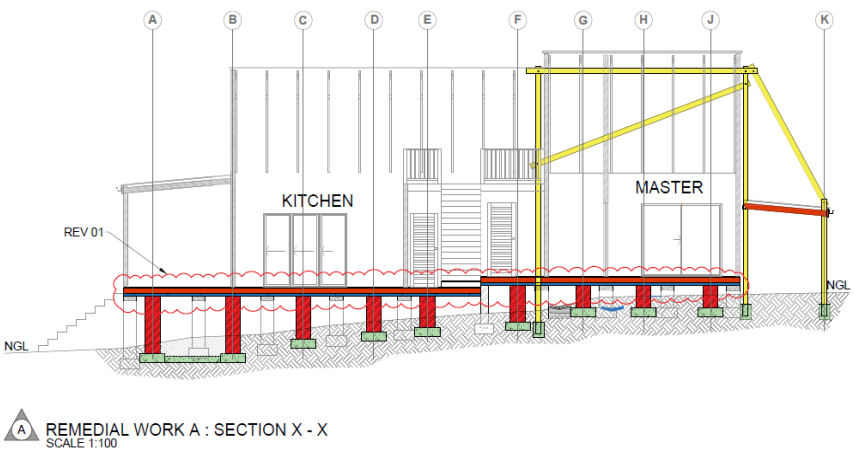
The single storey, double volume dwelling is a timber frame structure with appropriate isolation and wood cladding finishing. Internal walls are timber frame dry walls painted both sides. **Contributing factors** towards the **possible route causes** resulting in the cracks and deformation of the building can be some or a combination of the following.

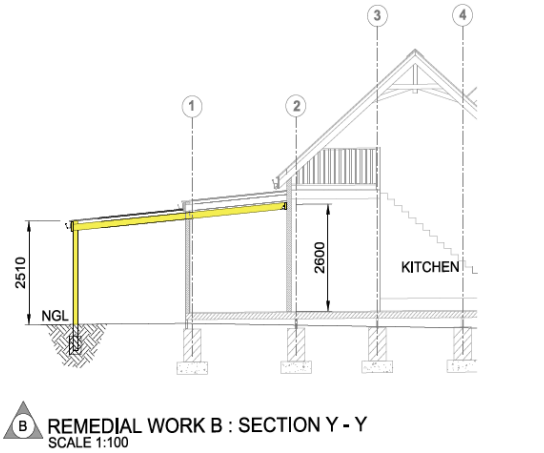
- Lack of Geotechnical investigation report at design stage.
- No engineering details towards proper measures in preventing settlement of soils, underline materials or stabilisation of soils and proper stormwater provision.
- No engineering details towards proper foundation desings taking into consideration the site soil conditions and typography.
- Noticeable changes in the competed building layout compared to the Architect's drawings.
- Poor quality building material and workmanship

The table below gives recommendations towards structural remedial actions.

Section	Structural Remedial Actions
• **REMEDIAL A – Foundations & Floor covering:** Concrete bases and reinforced columns	- Construct new concrete bases (25MPa) and reinforced brick columns filled with Class 25/19 concrete as per **dwg No. HVN – 02(1)** - Resurface entire house floor with vinyl-type wood flooring.
• **REMEDIAL B – Stiffing of Structure: North** Lateral stiffening of timber frame	- Extend existing covered veranda (North elevation) with pergola-type construction according to **Detail 4** on **dwg No. HVN – 02(1)**
• **REMEDIAL C – Stiffing of Structure: East** Lateral stiffening of timber frame	- Construct pergola-type structure as stiffening to the Eastern facade according to **dwg No. HVN – 02(1)**
• **REMEDIAL D – STRUCTURAL BRACING** Structural bracing to timber frame (Eastern façade) and roof structure in Main bedroom.	- Construct structural bracing to the existing timber frame on the Eastern façade and additional cross bracing to the double volume roof structure in the Main bedroom, **Detail 1-5 : dwg No. HVN – 02(1)**
• **REMEDIAL E – Rehabilitate existing covered patio structure (North and West)**	- Remove and replace all existing patio wooden pilar posts. - Provide adequate steel bracing / clamping to all new patio pillar posts and replace balustrades as detailed on **dwg No. HVN – 03(1)**
• **REMEDIAL F – Stormwater provision**	- Construct concrete v-drain and soak-away – **dwg No. HVN – 03(1)**

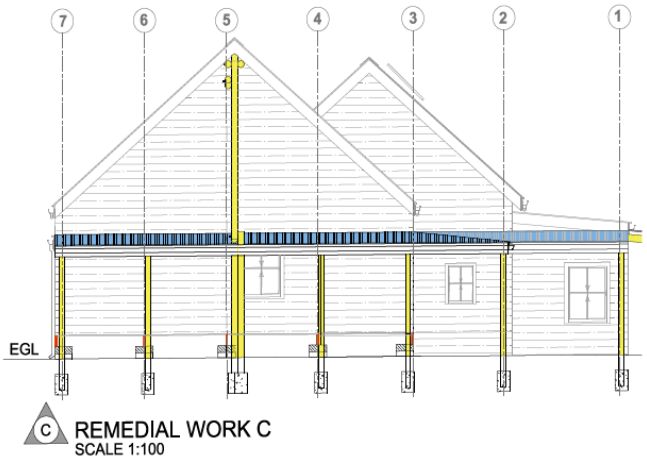
ENGINEERING REMEDIAL SOLUTIONS – Graphical representation

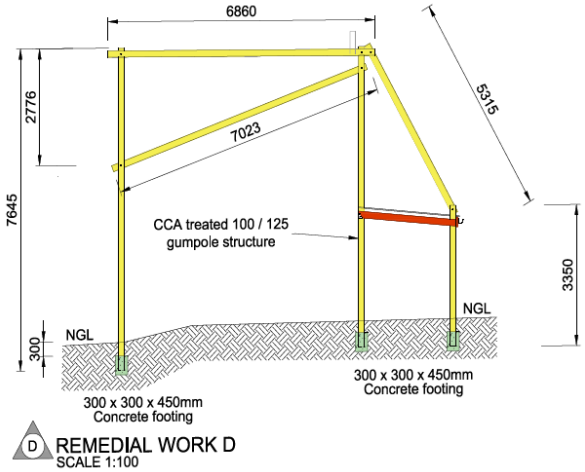




Construct new concrete bases and brick columns

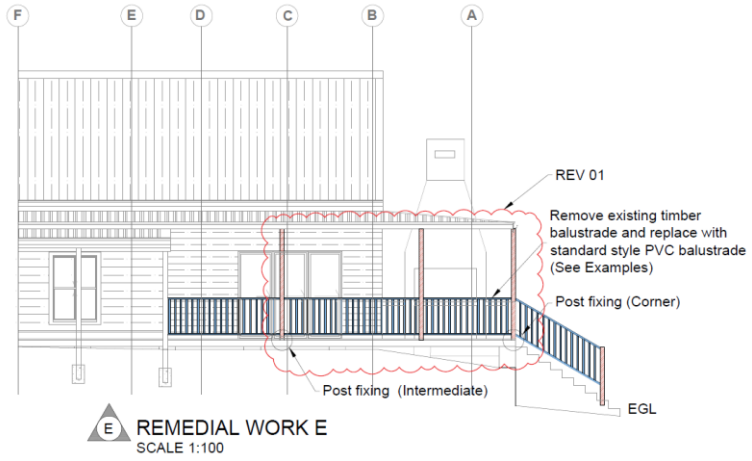
Erect gum pole veranda – North Elevation

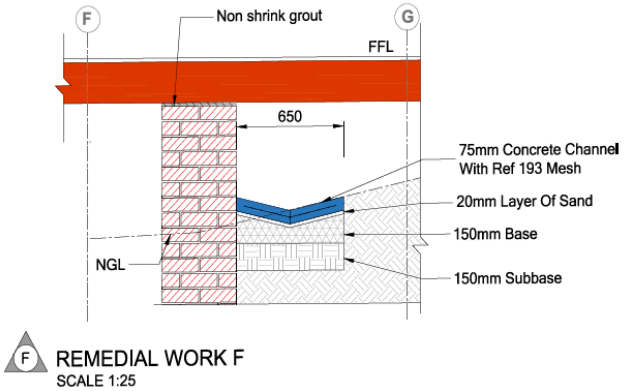




Construct pergola-type structure - Eastern Elevation

Structural bracing to double volume portal frame





Provide steel bracing to existing veranda posts

Construct new stormwater v-drain and soak away

4 DESIGN PARAMETERS

The following section of the **Report** is towards Quality Assurance and Continuous Professional Development to ensure due diligence of **TechQ Development's** approach to engineering solutions and problem solving in following the statutory design standards, regulations and guidelines.

4.1 Design Standards, Regulations and Guidelines

The design of structural elements, additions to, maintenance and/or repair remedial measures of affected *structural engineering elements* for this Project, is in accordance with the guidelines as set out in the latest version of the following South African design standards (SANS) and the National Building Regulations (NBR).

- SANS 10082 / 1063 – Part 1 - Timber wood design
- SANS 10100 - Part 1 - Concrete Design
- SANS 10144 - Detailing of steel reinforcement for concrete
- SANS 0161 - Foundation Design
- SANS 10130-2 - Self-weight and imposed loads
- SANS 1200 - Standardised specifications for construction works

4.2 Design Working Life

All structural elements shall be so designed to have a 50-year lifespan: **SANS 10160-1, Table 1.**

Design working life category	Indicative design working life - years	Description of structures
3	50	Building structures and other common structures

4.3 Design Loads

4.3.1 Dead Loads (Permanent Actions)

SANS 10160-1 read in conjunction with the requirements of **SANS 10160-2** for self-weight and imposed loads is applicable to the following elements.

Load Imposed on	Cause of Load	Load Value
Slab	Screed & tiles	1,2 kN/m²
Slab	110mm Brick walls	19,0 kN/m³

4.3.2 Wind Loads (Variable Actions)

The following inputs are applicable in accordance with **SANS 10160-3** to calculate the peak wind speed pressure:

- Basic wind speed : 40 m/s
- Terrain Category : C (Regular cover of buildings, sub-urban terrain)
- Site Altitude : ± 27,0 MSL

4.3.3 Soil Loads

SANS 10160-1 read in conjunction with the requirements of **SANS 10160-5** will be applied.

4.3.4 Seismic Loads

The Project Site falls within **Zone I** and the basic principles as outlined in **SANS 10160-4:2010, clause 6.1.2** will apply and applicable actions to be implemented towards articulated joints and substantial brick force.

4.4 Design Load Combinations

4.4.1 Ultimate Limit State

Ultimate limit state relates to the safety of the people and the structure. **SANS 10160-01** with reference according to **Table 3** outlines the Partial factors for actions for the ultimate limit state.

Dominating Action	Combination Name	Combination Equation
Self-weight	STR-P	1.35D + 1L
Imposed	STR	1.2D + 1.6L
Wind down	STR	1.2D + 1.3W↓ + 1.6ΨL
Wind up	STR	0.9D + 1.3W↑

4.5 Materials

4.5.1 Concrete and Reinforcement

The following key structural materials and specifications are proposed for the remedial Works.

a. Concrete

All reinforced concrete elements shall be designed in accordance with **SANS 0100-1**. The 28-day characteristic strength of all concrete elements is to be as per the table below.

Structural Elements	Concrete Grade	Stone size
Foundations, Column bases and stub-columns	30 MPa	19 mm
Surface beds	25 MPa	19 mm
Aprons and Ramps	25 MPa	13 mm

b. Reinforcement

- Mild steel or R-Bars f_y = 250 MPa minimum (to SANS 920)
- High yield or Y-Bars f_y = 450 MPa minimum (to SANS 920)
- Welded steel mesh f_y = 485 MPa minimum (to SANS 1024)

Bending schedules for the concrete bases and starter bars to the brick columnsare detailed on the drawings and attached as **Annexure D**.

4.5.2 Masonry works

Where so detailed, specified and indicated on the drawings, typical **Type 2** (min) engineering bricks are to be used giving an **85mm** course height. All brickwork shall be set out in accordance with the relevant drawing layouts. Loadbearing brickwork should have a minimum crushing strength of **7MPa** with maximum 10% water absorption and **Class II** mortar.

4.6 Limiting Factors

Remedial and construction works as specified here within and detailed on the drawings, will require a ***strategic phased decanting program*** to be implemented during construction, drawn up in co-operation with the Home Owners. The safety of the Home Owners and the building need to be paramount, with construction works limiting the disruption of day-to-day and personal activities.

5 RISKS & MITIGATION MEASURES

Qualifications, risks and possible sensitivity issues needs to be taken into account in performing the proposed remedial Works during the construction stage. The main objective of the Project is repair works to the structural deformation of the building, however, the following aspects with mitigation proposals, need to be taken into consideration in the Risk Register of the Project.

Risks and mitigation measures

Nature of Risk	Risk	Mitigation
Site and Construction Risks	Abnormal rainfall and restricted working space	Proper scheduling of Works, being aware of the "critical path" items and implementing effective construction methodologies, Quality Assurance and Controls.
Limiting Factors	Decanting plan	Phased implementation of Works in accordance with proper planned decanting program.
Health and Safety	Delays and Fatal	Detailed OH&S plan compiled.
Quality Assurance	Construction Management	QA and QC Inspection procedures in place and approved
	Sub-standard materials	Quality tests and Agrements in place
OH&S and Environmental	Disturbance to environment, community and workers	Focus on the environment, building rubble disposals, air and noise pollution and disruption of day-to-day operations

--- End of Report ---