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PASSENGER RAIL AGENCY  
OF SOUTH AFRICA

# Geotechnical Interpretive Report for the Durban Lifting Shed

J42000-B-06-05-GEO-REP-0002-00

ORIGINAL

*November 2024*



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## Preliminary

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## Approval

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## Amendment Record

This document is reviewed to ensure its relevance. A record of contextual additions or omissions is given below.

Rev No.	Issue Date	Revision Description	Prepared By	Reviewed By	Approved By
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# 1 Background

GIBB is appointed by PRASA as the EPCM Service Provider for Infrastructure Projects, nationally. Extension and Upgrade of the Durban Lifting Shed falls within this portfolio of Projects.

The PRASA Durban Lifting Shed facility is located some 3km north-north east of the Durban CBD, it is situated to the immediate south west of the Moses Mabhida stadium and accessible from Masabalala Yengwa Avenue near the Durban Station to the south of the site. The approximate centroid GPS coordinates of the facility and assessment area are as follows; 29°49'53.12"S; 31°01'41.07"E. The general location of the site is shown in Figure 1.



Figure 1: Site Location and extent of PRASA Lifting Shed facility (outline in blue).

The site is currently occupied by storage structures, office buildings, lifting shed/workshop, rails/tracks, decommissioned locomotives, parking bays and associated access roads for vehicles.

## 2 Scope of Works

### 2.1 Facilities to be Developed / Upgraded

The various structures/areas within the PRASA facility earmarked for development/upgrade along with the proposed respective renovations is summarized in Table 1.

Table 1: Durban Lifting Shop Upgrades

No	Structure	Description
1	Lifting Shed:	<ul style="list-style-type: none"><li>New train inspection pits to be installed to unknown depth below floor level.</li><li>Ensure forklift compatibility within Lifting shed.</li></ul>
2	Lifting Shed (RHS) Extension:	<ul style="list-style-type: none"><li>30m extension to existing building with forklift compatibility.</li><li>New 55T overhead gantry crane installed with extra height requirement.</li></ul>
3	Storage Building (LHS) of Lifting Shed:	<ul style="list-style-type: none"><li>Renovations to existing buildings for combined new structure with forklift compatibility.</li></ul>
4	Chemical Storage Building:	<ul style="list-style-type: none"><li>Upgrade of existing structure along with forklift compatibility.</li></ul>
5	Office Building:	<ul style="list-style-type: none"><li>Renovations to existing double volume structure including new mezzanine floor and lift shaft.</li></ul>
6	Wash Facility:	<ul style="list-style-type: none"><li>Small wash building structure to be constructed along with possible drainage measures.</li></ul>

The location of the various facilities is indicated in Figure 2.

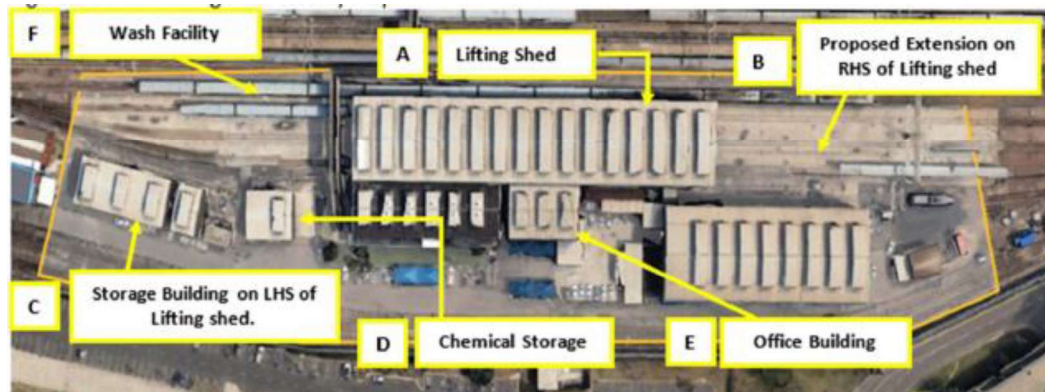


Figure 2: Location of various Facilities at the Durban Lifting Shed

### 2.2 Scope of Geotechnical Investigation

Due to the constrained working areas, and the fact that the various facilities would be operational during the site investigation, it was impractical to dig test pits by means of a TLB. It was therefore decided to core through either the concrete slabs or pavement layers. DCP tests would then be carried out in the underlying materials before augering to determine the stratigraphy and obtain samples for laboratory testing.

The scope of works within each of the above-mentioned testing areas are indicated in Table 2.

**Table 2: Geotechnical Scope of Works**

No	Structure	Scope of Works
1	Lifting Shed:	<ul style="list-style-type: none"> <li>Four (4) inspection points for concrete cores, DCP tests and augering.</li> </ul>
2	Lifting Shed (RHS) Extension:	<ul style="list-style-type: none"> <li>Four (4) inspection points for concrete cores, DCP tests and augering.</li> </ul>
3	Storage Building (LHS) of Lifting Shed:	<ul style="list-style-type: none"> <li>Three (3) inspection points for DCP tests and augering, two (2) for concrete cores.</li> </ul>
4	Chemical Storage Building:	<ul style="list-style-type: none"> <li>Three (3) inspection points for DCP tests and augering, two (2) for concrete cores.</li> </ul>
5	Office Building:	<ul style="list-style-type: none"> <li>Two (2) inspection points for concrete cores, DCP tests and augering.</li> </ul>
6	Wash Facility:	<ul style="list-style-type: none"> <li>Three (3) inspection points for concrete cores, DCP tests and augering.</li> </ul>

The scope of work to be carried out at each inspection point are summarised in Table 3.

**Table 3: Inspection Point Scope of Works**

No	Activity	Scope of Works
1	Concrete Coring:	<ul style="list-style-type: none"> <li>Determine the thickness and condition of the concrete slabs.</li> <li>Obtain concrete core samples for UCS testing</li> <li>Reinstate floor slab upon completion of testing.</li> </ul>
2	Dynamic Cone Penetrometer (DCP) Testing:	<ul style="list-style-type: none"> <li>Determine the consistency of the underlying soils to a depth of 5.0m depth.</li> </ul>
3	Hand Auger Excavations:	<ul style="list-style-type: none"> <li>Determine the subsoil conditions underlying the site including problem soils, groundwater level and for material sampling.</li> </ul>
4	Laboratory Testing:	<ul style="list-style-type: none"> <li>Laboratory testing including Foundation Indicator, Atterberg Limits, Moisture Content, CBR, Mod AASHTO density and Corrosivity of selected representative materials along with UCS testing of concrete cores.</li> </ul>

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## **3** *Local Geology and Stratigraphy*

### **3.1** **Geology**

Review of the 1:50 000 scale Geological Series Map of Durban (2930) reveals that the Durban PRASA Lifting Workshop and the immediate surrounding areas are underlain by alluvial and estuarine deposits known colloquially as the 'Harbour Beds'. These unconsolidated sediments range from sands to clays to soft muds in places, being interstratified and characterised by variation both vertically and laterally which reflects their depositional environments.

From previous nearby investigations and in-house knowledge of the surrounding area, the unconsolidated sediment of the Harbour Beds is likely present to depths in the order of 10 - 12m below natural ground level where it overlies Cretaceous siltstone capping Pietermaritzburg Formation shale at depth.

### **3.2** **Subsoil Profile**

The area was originally occupied by an estuarine or delta environment prior to reclamation and development in the early 1900's, where the land in general was reclaimed by hydraulic pumping of fill to build the land to its current elevation. The hydraulic fill was in turn capped by engineered fill material associated with the development of the area (i.e. railway yards, road layerworks, etc.).

## 4 Seismic Loading

Seismic hazard can be described as being the physical effects of an earthquake or earth tremor. Examples of such phenomenon include surface faulting, ground shaking and ground liquefaction (SANS 10160-4). The peak ground acceleration (PGA) is the maximum acceleration of the ground shaking during an earthquake.

According to the seismic hazard map of South Africa, the peak ground acceleration with a 10% probability of being exceeded in a 50-year period on the site is 0.1g and based on this peak ground acceleration, the risk of seismic events for the site is low risk with very light potential damage to structures. The seismic hazard map is indicated in Figure 3.

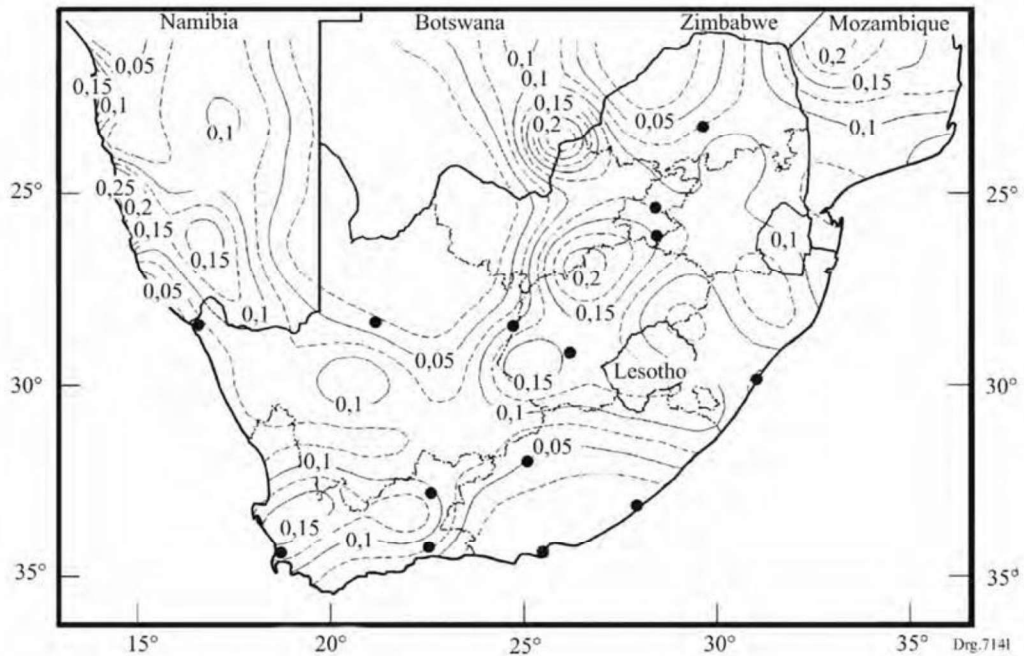


Figure 3: Seismic Hazard Map of South Africa (SANS 10160-4:2010)

## 5 Results from Site Investigation

This report assesses the factual data as presented in the Drennan Maud (Pty) Ltd report titled “Geotechnical Investigation for the Durban Lifting Shed Extension and Upgrade” dated 12th June 2024.

Only summaries of test results are presented in this report and none of the detailed soil profiles, DCP test results, or Laboratory test results are reproduced in this report.

### 5.1 Dynamic Cone Penetrometer (DCP) Tests

Where the Dynamic Cone Penetrometer (DCP) testing was able to penetrate to depth, the results generally indicate that the subsoils beneath the concrete floor slabs and granular base are medium dense. There is an isolated area in the Lifting Shed where the subsoils are very loose. DCP refusal was generally encountered in the areas of the proposed extension to the Lifting Shed, the proposed Washbay Facility and the Chemical Storage area. This refusal occurred on the dense granular base material and it is assumed that the underlying soils would be medium dense.

Assuming the underlying soils are medium dense, then an allowable bearing capacity of 200 kPa may be utilised. This assumes a total settlement of 25mm with a differential settlement of 15mm. Some ground improvement would be required where higher bearing pressures or more stringent settlement criteria are required.

### 5.2 Generalised Soil Profile.

The generalised soil profile encountered across the site is described in Table 4.

Table 4: Generalised Soil Profile

Thickness (m)	Description
<b>0.040 to 0.080</b> <b>0.150 to 0.280</b>	Asphalt, or Concrete (Average UCS = 60 MPa)
<b>Approx 0.600</b>	Yellow brown dense to very dense medium to coarse gravel in sandy matrix with large cobbles and pebble size hard rock / ballast fragments
<b>Approx 1.500</b>	Brown to dark brown sandy gravel to gravelly sand fill dense becoming medium dense at depth, Hydraulic Fill
<b>Below 2.000 to 2.500</b>	Harbour beds: Medium dense to loose / very loose in places fine to medium sand to clayey sand

### 5.3 Groundwater Profile

A perched groundwater table occurs at depths in the order of 2.0 to 2.7 m below ground level and generally coinciding with or just below the contact of the fill and underlying Harbour Beds.

## 5.4 Laboratory testing

### 5.4.1 Grading Analyses, Atterberg Limits and Natural Moisture Content

The results from grading analyses, Atterberg Limits and determination of Natural Moisture Content are summarised in the Table 5.

**Table 5: Grading Analyses, Atterberg Limits and Natural Moisture Content**

Position	Sample Depth (m)	Material Description	Particle Size (%)					GM	NMC (%)	LL %	PI	LS %	Revised US Classification
			Clay	Silt	Sand	Gravel	Cobble						
<b>Lifting Shed</b>													
C2 - C4	0.33/0.55 - 0.75/0.83	Sandy Gravel	7	4	18	63	8	2.4	-	23.2	1.4	1	A - 1 - a (0)
<b>Proposed Wash Facility</b>													
C9 - C11	0.17/0.23 - 0.52/0.65	Sandy Gravel	6	2	19	60	13	2.49	7.44	16.3	0	0	A - 1 - a (0)
C10	0.75 - 0.85	Gravelly Sand	10	7	51	31	0	1.79	9.18	19.6	6.8	1.3	A - 2 - 4 (0)
<b>Chemical Storage &amp; Storage Building on LHS of Lifting Shed</b>													
C14-C16	0.04/0.08 - 0.2/0.52	Sandy Gravel	6	1	26	66	0	2.41	10.14	20.3	0	0	A - 1 - a (0)
C14-C16	0.2/0.52 - 0.68/1.10	Sandy Gravel	5	1	28	64	2	2.44	12.21	21.8	0	0	A - 1 - a (0)
C17	0.18 - 0.40	Gravelly Sand	9	3	70	17	0	1.3	6.18	19.3	0	0	A - 2 - 4 (0)
C17	0.40 - 0.65	Sandy Gravel	7	4	40	48	0	2.03	9.11	22.7	0	0	A - 1 - b (0)
<b>Office Building</b>													
C18-C19	0.4/0.55 - 0.87/1.80	Gravelly Sand	7	1	56	34	2	1.72	9.98	20.3	0	0	A - 3 (0)
C18	1.80 - 2.55	Clayey Sand	32	22	39	1	0	0.56	35.2	19.6	6.8	1.3	A - 4 (1)

LL – Liquid Limit PI – Plastic Limit LS – Linear Shrinkage GM – Grading Modulus

From the above, it can be seen that the subsoils are generally non-plastic with no heave potential.

### 5.4.2 Mod AASTHO and California Bearing Ratio (CBR)

The results from Mod AASTHO and California Bearing Ratio determinations are summarised in the Table 6.

**Table 6: Mod AASTHO and California Bearing (CBR)**

Position	Sample Depth (m)	Material Description	Modified AASTHO		CBR Results						TRH 14 Class
			MDD (kg/m <sup>3</sup> )	OMC(%)	90%	93%	95%	98%	100%	Swell %	
<b>Lifting Shed</b>											
C2 - C4	0.33/0.55 - 0.75/0.83	Sandy Gravel	2048	8.1	29	33	36	53	69	0	G6
<b>Proposed Wash Facility</b>											
C9 - C11	0.17/0.23 - 0.52/0.65	Sandy Gravel	2156	8	33	38	41	50	57	0	G6
<b>Chemical Storage &amp; Storage Building on the LHS of Lifting Shed</b>											
C14-C16	0.04/0.08 - 0.2/0.52	Sandy Gravel	2129	6.9	42	47	50	66	79	0	G5
C14-C16	0.2/0.52 - 0.68/1.10	Gravelly Sand	1874	10.3	10	21	35	54	72	0	G7
<b>Office Building</b>											
C18-C19	0.4/0.55 - 0.87/1.80	Gravelly Sand	1760	10.8	8.8	11	13	16	18	0	G8

From the above results, it can be seen that the coarse gravel underlying the various concrete surface beds classifies as a GP-GW (well to poorly graded gravels with little or no fines) according to the Unified Soil Classification System (USCS) and as a G6 type material according to TRH 14 (1985). As such this material may be utilised as sub-base or selected material provided oversized ballast / hard rock particles are removed.

The general reclamation fill material classifies as GP-GM (poorly graded to silty gravels with little fines) to SP-SM (poorly graded to silty sands with little fines) according to the Unified Soils Classification System (USCS) and as a G7 – G8 type material according to TRH 14 (1985). As such this material may be utilised as selected or sub-grade material. Less gravelly sandy fill (as

encountered) is likely to classify as G9 – G10 material and may also be utilised as selected or sub-grade material.

### 5.4.3 Corrosivity Testing

Corrosivity (Langelier and Aggressiveness Index) testing was carried out on three representative samples taken from the site, namely the common ballast gravel fill, general gravelly sandy fill and clayey sand Harbour Beds sediment. The results from the corrosivity testing are summarised in the Table 7.

**Table 7: Corrosivity Test Results**

Sample	Calculation Results		Index Ranges		Corrosive Characteristics
	Langelier Index	Aggressiveness Index	Langelier Index	Aggressiveness Index	
C9-C11 (0.17/0.23 - 0.52/0.65m)	-0.6	11.1	<-2.0	<10.0	Highly Aggressive
C18-C19 (0.4/0.55 - 0.87/1.8m)	-0.22	11.5	>-2.0 < 0.0	10.0 - 12.0	Moderately Aggressive
C18 (1.8 - 2.55)	-1.37	10.4	>0.0	>12.0	Non-aggressive

The calculated results based on the laboratory derived parameters indicate that all of the representative soil samples fall within the “Moderately aggressive” category.

### 5.4.4 Unconfined Compressive Strength (UCS) testing

The 200mm diameter cores were obtained when drilling through the concrete slabs. These cores were submitted for laboratory testing to determine the unconfined compressive strength. The results from the laboratory testing may be summarised in Table 8

**Table 8: UCS Test Results**

Facility	Core Thickness (mm)	Unconfined Compressive Strength (MPa)
Lifting Shed	150 - 170	Ave = 52.4 Min = 44 Max = 63.2
Extension to Lifting Shed	210 - 280	Ave = 64.6 Min = 60.4 Max = 71.3
Storage Building	150 - 170	Ave = 75.1 Min = 69.2 Max = 80.9
Chemical Storage	170 - 190	Ave = 62.3 Min = 55.9 Max = 68.7
Office Building	170	Ave = 34.2 Min = 31.1 Max = 37.3
Wash Facility	170 - 230	Ave = 75.3 Min = 74.2 Max = 76.9

The above results indicate that, apart from the office floor slabs, the concrete has an average strength of 63.8 MPa, ranging from 44.0 to 80.9 MPa. No reinforcing was visible in any of the concrete cores.

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## 6 Conclusion and Recommendations

Following on from the above, the following conclusions and recommendations are made.

### 6.1 Lifting Shed

#### 6.1.1 New Inspection Pits

New train inspection pits are to be installed in this area. At present the depth below floor level is unknown.

It is anticipated that the pits will be constructed within the hydraulic fill overlying the Harbour Beds. The consistency of this material is generally medium dense with an allowable bearing pressure of 200 kPa. However, an isolated area was encountered where the consistency was very loose. It is recommended that the inspection pits be over-excavated by at least 1.0m and that the in-situ material is replaced and compacted to at least 98% Mod AASTHO to ensure a uniform founding medium.

#### 6.1.2 Forklift Compatibility

The quality of the concrete in the floor slab is good with an average UCS of 52.4 MPa. However, no reinforcing was noticed within the 150 to 170 mm thick concrete cores and a structural check should be carried out to ensure that the unreinforced concrete is capable of handling the proposed fork lift trucks.

### 6.2 Lifting Shed Extensions

#### 6.2.1 Forklift Compatibility

The quality of the concrete in the floor slab is good with an average UCS of 64.6 MPa. However, no reinforcing was noticed within the 210 to 280 mm thick concrete cores and a structural check should be carried out to ensure that the unreinforced concrete is capable of handling the proposed fork lift trucks.

#### 6.2.2 New 55T Overhead Gantry

Only one DCP penetrated the gravelly base material underlying the concrete slab. The consistency of the material underlying the gravelly base is generally medium dense with an allowable bearing pressure of 200 kPa. This assumes a total settlement of 25mm with differential settlements of 15mm. These tolerances are unlikely to be acceptable for the bases for the 55T overhead crane.

It is recommended that either:

- a) The bases be over-excavated by at least 1.0m and that the in-situ material is replaced and compacted to at least 98% Mod AASTHO to ensure a uniform founding medium.

- 
- b) Micro-piles be utilised to support the crane bases to ensure adequate bearing and to minimise differential settlements between bases.

## **6.3 Storage Building**

### **6.3.1 Renovations**

It is proposed to renovate the existing buildings for a combined new structure. As this is a single storey structure, no problems are foreseen with regard to bearing capacity of differential settlement.

### **6.3.2 Forklift Compatibility**

The quality of the concrete in the floor slab is good with an average UCS of 75.1 MPa. However, no reinforcing was noticed within the 150 to 170 mm thick concrete cores and a structural check should be carried out to ensure that the unreinforced concrete is capable of handling the proposed fork lift trucks.

## **6.4 Chemical Storage**

### **6.4.1 Renovations**

It is proposed to upgrade the existing buildings for a combined new structure. As this is a single storey structure, no problems are foreseen with regard to bearing capacity of differential settlement.

### **6.4.2 Forklift Compatibility**

The quality of the concrete in the floor slab is good with an average UCS of 62.3 MPa. However, no reinforcing was noticed within the 170 to 190 mm thick concrete cores and a structural check should be carried out to ensure that the unreinforced concrete is capable of handling the proposed fork lift trucks.

## **6.5 Office Building**

It is proposed to renovate the existing double volume structure by incorporating a mezzanine floor and a lift facility which will have a lift shaft. As this is a double volume / double storey structure, no problems are foreseen with regard to bearing capacity of differential settlement.

## **6.6 Wash Facility**

### **6.6.1 New Wash Building**

It is proposed to erect a small wash building structure. As this will probably be a portal frame structure, no problems are foreseen with regard to bearing capacity of differential settlement.

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## 6.6.2 Drainage facilities

New drains may have to be installed to transport the wash water from the wash facility to the existing drainage system. No problems are foreseen for a cut and cover solution. However, directional drilling may also be employed in order to safeguard the existing concrete slab.