Robert Bird Group

Tbilisi Mall

Stage 1, Inspection Report

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Executive Summary

This report has been commissioned by Rakeen Uptown Development (RUD) with the primary aim of identifying any concerns with the central Dome, the west façade, the retaining wall in Level B4, the general mall traffic flow and the proposed modification to the structure to introduce an entertainment area in one location of the mall.

This report comprises the inspection notes, the structural concerns and the proposed next steps, following Robert Bird Group's site visit conducted on the 27th of November 2019.

The following main actions are proposed, based on our understanding of the project and our site visit.

- Structural Analysis Model
  - Several of the identified issues require more analysis, hence it is recommended that a full structural analysis model of the mall will be completed. This will assist identifying and rectifying the issues observed with the dome, the basement and the proposed entertainment area.

- The Dome
  - A risk assessment and solution optioneering are to be done for the pipes that are not securely fixed in place. A chosen option shall be developed and detailed for implementation.
  - It is further recommended to evaluate whether the support for the square central portion of the Dome internal façade shall be replaced with brackets as used in other areas of the Dome.

- The West Façade
  - Due to the significant area, cost and the impact during the rectification works, it is essential to identify the most appropriate solution to the façade rectification.
  - It is recommended that a consultant will formulate and propose a series of options for RUD to discuss with their contractor of choice and thereafter be detailed and implemented.

- Level 4 Basement
  - It is essential to assess the origin of the cracks in the walls and beams in the basement to understand how to remedy them. Once an understanding of the structural behavior has been established, remediation options for damaged structural elements can be proposed, detailed and implemented.

- Traffic flow
  - Several options have been discussed including, reversing the traffic flow in the basement, elevating the existing road for by-passing traffic, elevating the entrance ramp to avoid the congestion and an alternative entry to the basement car park.
  - To achieve the most viable solution, the traffic flow should be investigated by a specialized traffic engineering consultant along with an Architect.

- The Entertainment Area
  - The proposed entertainment area is a major modification to the existing mall and needs to be carefully investigated and detailed as there are several important concerns to address, such as:
    - The applied loads will locally increase.
    - The roof span will be much longer and supports heavy equipment.
    - Keeping the mall operational during the construction phase.
    - Some columns will be very slender when they become double height.
    - Some cantilevering slab areas will lose their continuity.
  - The constructed foundation design is unknown. Since the loads likely will increase this poses a significant challenge for the further progression of the design. During the concept design of the entertainment area it is therefore essential to focus on minimizing loads, preferably to the original design loads.
  - It is critical that all stages of the construction are documented and checked for strength and stability.
  - Only once an understanding of the structure has been established can alterations such as removing slabs and columns be considered and assessed along with possible retrofitting solutions.
  - 3 Phases for the design is proposed; a verification phase, a Concept/ Schematic Phase and a Detailed Design/ Construction Documentation Phase.

Table of Contents

1.0 Introduction

1.1 Background and Brief

Rakeen Uptown Development (RUD) has engaged RBG to perform an independent structural engineering evaluation of several areas of the constructed development, Tbilisi Mall.

The request is based on RUD's concerns about certain items, identified on site to be of inadequate state, around 7 years after the completion of the mall.

Further RUD envisages that an entertainment area is an attractive investment. RUD is therefore looking into the possibility of incorporating a large entertainment facility into the currently constructed mall.

1.2 Documentation

In addition to conducting a non-destructive and non-invasive site investigation on the 27th of November 2019, RBG has currently received the documentation as outlined in Appendix A.

It shall be noted that RBG currently only have made a cursory review of all the provided information.

1.3 Scope of Works

The scope of Stage 1 of the design review has been limited to a cursory review of the following areas.

- Inspection and identification of RBG's concerns of the dome structure cladding supports.
- Inspection and identification of RBG's concerns of the existing façade structure.
- Inspection and identification of RBG's concerns in L-4 Basement.
- Cursory Review of the Mall Traffic Flow.
- Inspection and identification of RBG's concerns in relation to the existing 3rd and 4th floors to accommodate a proposed new entertainment area.

The review for Stage 1 is not intended to be in-depth and no calculations will be provided. The main purpose is to identify areas of concern in the highlighted areas by RUD and to propose the next steps in the structural evaluation.

1.4 Limitations of Report

This report has been prepared for RUD based on RBG's inspection on site on 27th and 28th of November 2019. It is purely based on the information made available to RBG at the time and our understanding of the structural scheme at the time of writing this report.

Limited to the aims described above, this report does not present a detailed critique or appraisal of the constructed design. It is based on the inspection and the received information alone.

2.0 Dome Structure

2.1 Inspection Findings

The Dome's internal façade is hung from the main triangular cladded space trusses. Due to access restrictions RBG was unable to directly inspect this area, however a team was deployed with a camera, from where the inspection was completed. This gave a somewhat compromised understanding, but RBG believes that the main items have been identified.

The upper internal façade members support the light steel CHS grillage (approximately 20-25 mm diameter pipes) and are hung in the space trusses via steel or aluminum channels.

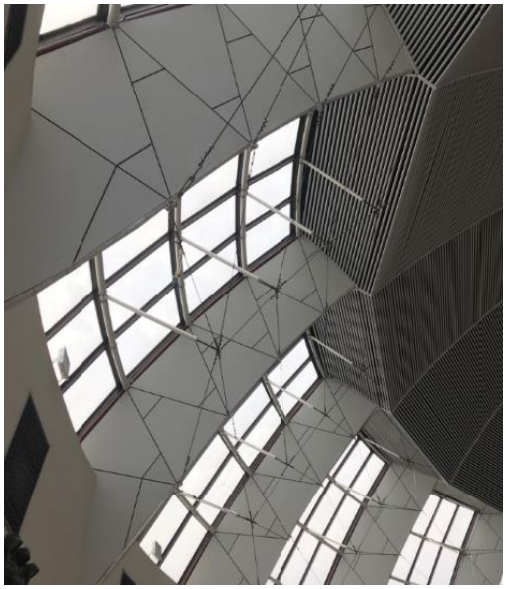

Figure 1 - The Cladded Space Trusses and Lower Part of the CHS Cladding Grillage.

A network of steel bracing cables is providing for additional lateral support to the structure of the dome above the central atrium of the mall. See Figure 1 above.

An arrangement of architectural steel or aluminum pipes is lining the inside face of the top section of the central atrium dome. The pipes located in the uppermost area are arranged horizontally while the remaining sections are arranged tangentially.

Figure 2 - Hung Facade; The red member is the main structural steel truss.

The pipes are supported at each end by steel or aluminum channels. There are numerous instances where the pipes are not connected to the rafters at these support locations and are free to be lifted out of place. Likewise, in many instances, very little bearing is observed.

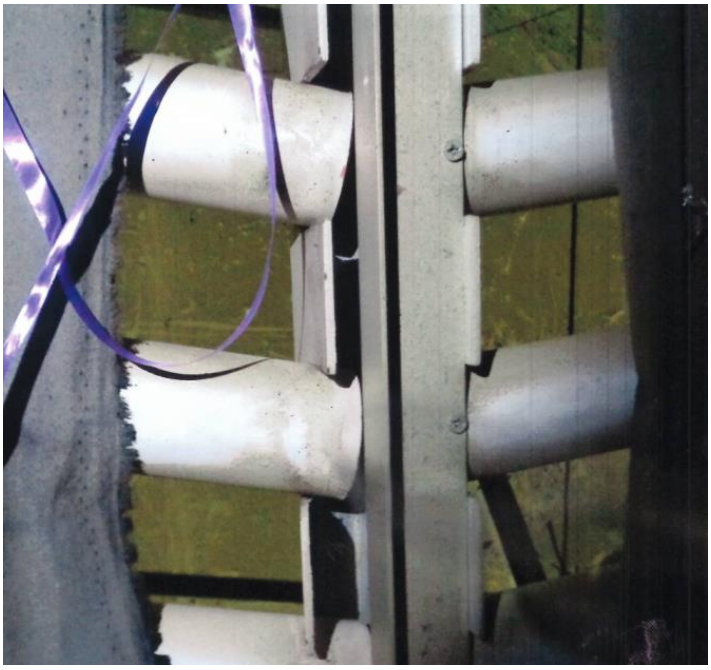

Figure 3 - CHS with limited support.

The rafters that are supporting the pipes in the uppermost area (the central part of the Dome) are connected to the steel truss work of the dome via steel tie wires. These tie wires appear inadequate to provide any lateral stability because they are not braced, in the central dome area.

Figure 4 - Centrally Elevated Unbraced Grillage

2.2 Identified Concerns

RUD raised the concern that the steel bracing cables may be loose and locally corroded. The tightness of these cables was not able to be observed or measured during the inspection due to insufficient access, however RBG assesses that RUD's evaluation appears reasonable. It is however currently unknown whether the tension system is required from a strength perspective. Refer Figure 1.

Currently the individual pipes can potentially move and become dislodged from their supports during any lateral action and could present a serious falling hazard. The witnessed support of the secondary CHS Cladding Grillage does not appear sufficient. Refer Figure 2 and Figure 3.

The combined group of pipes in the uppermost section are not braced and is therefore free to sway. This action could impart forces into the tie wire connections whose capacities are unknown. Refer Figure 4.

2.3 Proposed Actions

A structural model of the main structural elements of the Central Atrium Dome is proposed to be created to properly understand the design requirements of the steel cables within the Dome. Once this is understood, the built structure can be evaluated, and any concerns and/ or recommendations can be communicated along with any recommended tests on the materials.

A risk assessment and solution optioneering are to be done for the pipes that are not securely fixed in place. Following this optioneering phase the most viable option shall be developed and detailed for implementation, if the currently installed cladding solution is found to be inadequate, the most viable option can be implemented.

It is also recommended to evaluate whether the wires supporting the central section of the Dome internal façade are to be replaced with equivalent brackets as used in other areas of the Dome (refer Figure 2) and whether an additional bracing system is to be provided for the design to comply with governing standards.

3.0 Cladding Structure

3.1 Inspection Findings

The cladding on the west (main) elevation of the building was inspected and it was found to consist of:

- A secondary steel framing is supporting the cladding panels (stucco board; a light foam-like boards with a harder outer surface). These appear to have been glued onto the secondary steel framing with a silicone-like product. Not other connection was identified.
- Larger painted panels, which appears to be laterally supported by the block wall behind. The connection between these two is unclear.

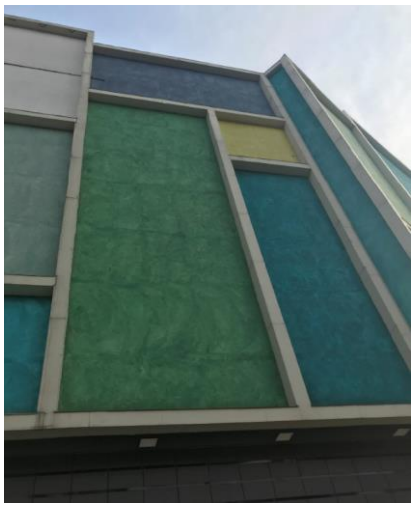

Figure 5 - Typical Area of the West Facade

Instances of deterioration in the cladding that were observed include:

- Corrosion of secondary steel framing members.
- Cracks appearing through the paint/ stucco finish of the cladding.
- Peeling/ bubbling/ delamination of paint.

Figure 6 - Identified Deterioration

3.2 Identified Concerns

There are three primary concerns with the currently installed façade.

1. The steel framing does not appear to have been sufficiently corrosion protected. Typically, aluminium framing is used for this kind of secondary façade-supporting structure, however if steel is selected the protective treatment needs to be selected carefully to ensure adequate durability resistance in both the framing and all connections.

2. The panels do not appear to have been fastened with any physical connection aside from the mastic/ silicone material.

3. The selection of the stucco boards does not seem durability-wise adequate to sustain a significant duration. This obviously depends on the Clients requirements for maintenance and aesthetics.

3.3 Proposed Actions

More investigation needs to go into identifying the best solution for the cladding. Due to the significant area, potential cost and the impact during the rectification works it is essential to identify the most appropriate solution to the façade rectification.

It is recommended that a consultant will formulate and propose a series of options for RUD to discuss with their contractor of choice and thereafter be implemented.

4.0 Level B4 Basement

4.1 Inspection Findings

The basement generally appears to be in a good and dry state, however along the eastern retaining wall in the central part of the building, several cracks in the walls and the beams are observed.

Some localized crack in the floor are also seen. The floor appears to be a floating floor above the raft

4.2 Identified Concerns

In the inspected basement the following main items were identified:

- Obvious cracks are identified along the retaining wall.
- Cracks in the beams between the columns perpendicular to the wall.
- Cracks were also identified in the floor, which appears to be floating above the structural raft.
- It was informed that in the wet season water leaks in through the wall.

Some of the observed cracks in the retaining wall can be seen in Figure 7 and Figure 8.

Figure 7 - Cracks in the Retaining Wall

Figure 8 - Cracks in a Wall Perpendicular to the Retaining Wall

The cracks in the beams follow the same pattern as shown on Figure 9, indicating either an excessive differential settlement or lateral displacement. The foundation system is a raft, except for the towers, which are piled.

Figure 9 - Cracks in Beams

A few of the beams have been locally repaired about 8 months ago, to identify whether the crack was developing. No cracks were opening wider, which appears to indicate that the structure has found an equilibrium.

Figure 10 - Repaired Area of a Beam

4.3 Proposed Actions

It is essential to assess whether the cracks in the walls and beams come from differential settlements or from the 3 levels of unbalanced soil pressure, which is imposed by the basement.

Therefore, it is proposed that a structural model is to be created, to assess the existing structural design to establish if acceptable forces and movements are expected. The design review of the wall and beams will thereby identify whether the design is code compliant and reveal any potential inadequacies.

Only once an understanding of the structural behavior has been established can remediation options for damaged structural elements be proposed and implemented.

5.0 Mall Traffic Flow

5.1 Inspection Findings

The main entrance is problematic as incoming traffic must cross over the outgoing traffic coming from the basement car park.

RBG informed RUD clearly on site that this issue is not related to our core speciality (structural engineering), however our parent company can provide both architectural and traffic consultancy services.

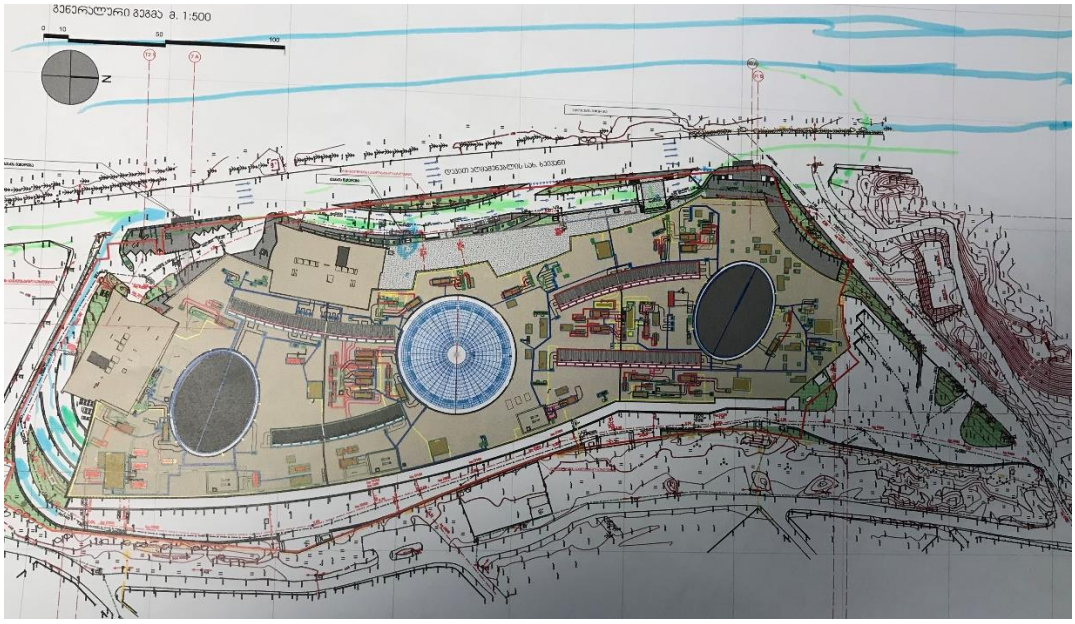

Figure 11 - Mall Overview

5.2 Identified Concerns

Crossing-over of traffic lanes is causing congestion issues, especially during busy periods.

5.3 Proposed Actions

Several options were discussed:

- Reversing the traffic flow in the basement and constructing an additional fly-over ramp for the traffic in the opposite direction (to avoid the congestion from mall visitors exiting the mall and U-turning).
- Elevating the existing road for by-passing traffic.
- Elevating the entrance ramp to avoid the congestion.
- An alternative entry to the basement car park is another possible solution. The effects of removing any walls to enable an alternative entry to the basement car park and to identify any enabling and/or retrofitting works required will have to be investigated.

To achieve the most viable solution the traffic flow should be investigated by a traffic engineering consultant as mentioned above.

6.0 Entertainment Area

6.1 Inspection Findings

The constructed mall appears to comply with the drawing package. Level 4 of the mall is currently not occupied.

Figure 12 - Vacant tenancy space on Level 4.

RUD is considering the removal of columns and areas of the slab to accommodate the newly proposed entertainment area on L3/ L4, refer Figure 13 for a sketch of the proposed modifications.

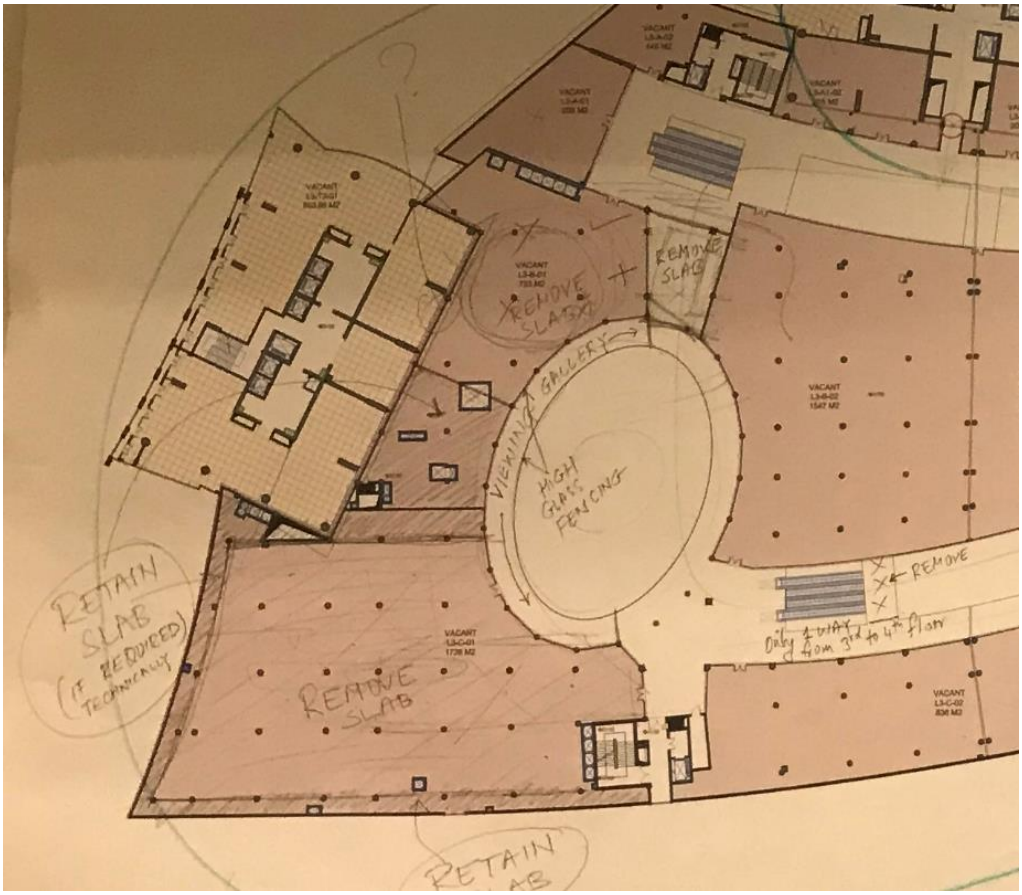

Figure 13 - Sketches of the Proposed Modifications

The roof slab directly above this area is highly loaded due to the presence of MEP plant and equipment.

Figure 14 - MEP Equipment on the Roof

Due to the proposed removal of the slab some areas are very sensitive to the potential loss of stability. Refer e.g. Figure 15, where a 3 m long cantilever will not have its back span. The full structure therefore needs to be evaluated and details to be produced for all relevant areas and all interfaces between the existing and proposed structure.

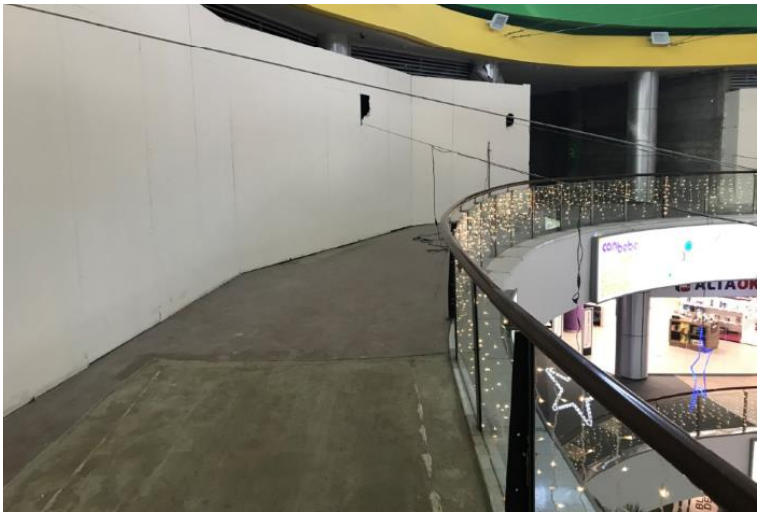

Figure 15 - 3 m Long Cantilever which will not have a back span

6.2 Identified Concerns

The primary concerns in relation to the establishment of the entertainment area are listed below. This list is not conclusive, in the sense that additional points will likely be raised during the course of the design. However, with our current understanding of the structure and the proposed modifications we have noted the following:

- Greater design forces will be applied due to increased loading from entertainment purposes (e.g. “extreme rides”). Loading will be 2 to 3 times more than the original design intent (approximately 12 to 15 kPa compared to approximately 5 kPa).
- Potentially greater design forces due to increased column tributary areas (as a result of increased slab spans caused by the removal of columns).
- Columns will be slenderer due to the double-story high columns.
- The roof span increases from the designed span of 8 m by 8 m to a significantly larger span, approaching 24 to 32 m.
- The roof carries localized heavy-duty MEP equipment which needs to be kept operational during the construction. This poses strict procedures for the construction methodology and erection sequence (CMES).
- The constructed foundation design is unknown. Since the loads likely will increase this poses a significant challenge (risk) for the further progression of the design. During the concept design of the entertainment area it is therefore essential to focus on minimizing loads, preferably to the original design loads.
- Some areas will lose their natural equilibrium, e.g. as outlined in Figure 15. Appropriate measures are critical both in the construction phase and the permanent works design to ensure that the stability is maintained.

6.3 Proposed Actions

A structural model needs to be created to evaluate the existing structure in order to establish if the structure is acceptable and code compliant. Only once an understanding of the structure has been established can alterations such as removing slabs and columns be considered and assessed along with possible retrofitting solutions.

For the design 3 phases is proposed.

1. Verification Phase
    a. Initially the current constructed design shall be verified.
2. Concept/ Schematic Design Phase
    a. An initial phase to allow the engineer to produce the concept for the structure, taking into consideration a probable sequence of work, accessibility, operational requirements and permanent works design.
3. Detailed Design and Construction Documentation Phase
    a. The final design will be detailed and issued to the contractor.

Appendix A
Received Drawings

Appendix B
Site Photos

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