COVEY
ASSOCIATES PTY LTD
Consulting Engineers

Suttons Beach Pavilions – Structural Investigation Report

At

Suttons Beach
50 Marine Parade, Redcliffe

For

Moreton Bay Regional Council

Project No: 223164
Ref: RG/RG/27747Rpt- Issue A
Date: 22 December 2022

DOCUMENT ISSUE APPROVAL

Project No:	223164
Title:	Suttons Beach Pavilions – Structural Investigation Report
Client:	Moreton Bay Regional Council
Date:	22 December 2022
Issue No:	A
Distribution:	Moreton Bay Regional Council – One (1) copy Covey Associates Pty Ltd – One (1) copy

DISCLAIMER OF LIABILITY: - No Liability shall be accepted on an account of failure of the Report to notify any problems in the area(s) or section(s) of the subject property physically inaccessible for inspection, or to which access for Inspection is denied by or to the Inspector (including but not limited to or any area(s) or section(s) so specified by the Report).

[redacted] [redacted]

CONTENTS

1.0 EXECUTIVE SUMMARY 7

2.0 INTRODUCTION 8

2.1 Background 8

2.2 Scope of works 8

2.3 Limitations 8

2.4 Provided Documents 9

3.0 METHODOLOGY 9

3.1 Site visits and inspections 9

3.2 Site works 9

3.3 Testing 9

3.4 Assessment 9
3.4.1 Structural Assessment 9
3.4.2 Durability and Serviceability Assessment 9

4.0 FOUNDATIONS AND FOOTINGS 10

4.1 Current Condition 10

4.2 Assessment 10
4.2.1 Geotechnical and Structural 10
4.2.2 Durability and Serviceability 10

4.3 Remedial Actions 10

5.0 SLAB ON GROUND 10

5.1 Current Condition 10

5.2 Assessment 11

5.3 Remedial 11

6.0 REAR RETAINING WALL 11

6.1 Current Condition 11

6.2 Assessment **12**
6.2.1 Structural 12
6.2.2 Durability and Serviceability 12

6.3 Remedial **12**

6.4 Other Considerations **13**

6.5 Conclusions **13**

7.0 GROUND FLOOR BRICK WALLS AND BRICK COLUMNS 13

7.1 Current Condition **13**

7.2 Assessment **14**
7.2.1 Structural 14
7.2.2 Durability and Serviceability 14
7.2.3 Lateral Loads 14

7.3 Remedial **14**

7.4 Conclusion **15**

8.0 SUSPENDED SLAB 15

8.1 Current Condition **15**

8.2 Assessment **15**
8.2.1 Structural 15
8.2.2 Durability and Serviceability 16

8.3 Remedial **16**
8.3.1 Major Rectification - Removal of Carbonated Concrete and Strengthening 16
8.3.2 Replacement of original suspended concrete slab 16
8.3.3 Remedial works to steel support fame 17

8.4 Other Considerations **17**

8.5 Conclusion **17**

9.0 CONCRETE BEAMS AND SOUTHERN SUSPENDED STAIR 18

9.1 Current Condition **18**
9.1.1 Beam CB2 18
9.1.2 Beam CB1 and Suspended Stair 18

9.2 Assessment **18**
9.2.1 Structural 18
9.2.2 Durability and Serviceability 18

9.3 Remedial **19**
9.3.1 Beam CB2 19
9.3.2 Beam CB1 19
9.3.3 Suspended Stair and landing 19

9.4 Conclusion / Other considerations **19**

10.0 UPPER FLOOR FRAMING 19

10.1 Current Condition **19**

10.2 Assessment **20**
10.2.1 Structural 20
10.2.2 Durability and Serviceability 20

10.3 Remedial **20**

10.4 Other Considerations **20**

11.0 UPPER FLOOR BRICKWORK 21

11.1 Current Condition **21**

11.2 Assessment **21**
11.2.1 Structural 21
11.2.2 Durability and Serviceability 21

11.3 Remedial **21**

11.4 Conclusion **22**

12.0 LINK STRUCTURE 22

12.1 Current Condition **22**

12.2 Assessment **22**
12.2.1 Structural 22
12.2.2 Durability and Serviceability 22

12.3 Remedial **23**

12.4 Conclusion **23**

13.0 EXTENSION COMPONENTS 23

13.1 Current Condition **23**

13.2 Assessment **23**
13.2.1 Structural 23
13.2.2 Durability and Serviceability 24

13.3 Remedial **24**

13.4 Conclusion **25**

APPENDIX A	**REMEDIAL PLANS** **A1 – GROUND FLOOR** **A2 – SUSPENDED SLAB** **A3 – UPPER FLOOR** **A4 – ROOF**
APPENDIX B	**EXISTING BLUE PRINTS**
APPENDIX C	**ORIGINAL ARCHITECTURAL PLANS**
APPENDIX D	**CURRENT ARCHITECTURAL PLANS**
APPENDIX E	**STRUCTURAL SKETCH PLANS SK01-SK03**
APPENDIX F	**ROOF FRAMING PLAN**
APPENDIX G	**GEOTECHNICAL REPORT BY CORE CONSULTANTS**
APPENDIX H	**SUTTONS BEACH PAVILION CONDITION ASSESSMENT REPORT BY BG&E**
APPENDIX I	**SLAB TESTING REPORT BY COVEY & ACOR**
APPENDIX J	**BEAM TESTING REPORT BY COVEY & ACOR**
APPENDIX K	**STRUCTURAL ASSESSMENT OF THE REDCLIFFE PAVILION SUSPENDED SLAB BY BG&E**
APPENDIX L	**FOOTINGS REPORT BY COVEY**
APPENDIX M	**REAR RETAINING WALL REPORT BY COVEY & ACOR**
APPENDIX N	**GROUND FLOOR BRICK WORK REPORT BY COVEY & ACOR**
APPENDIX O	**UPPER LEVEL BRICKWORK REPORT BY COVEY & ACOR**
APPENDIX P	**SUSPENDED SLAB REPORT BY COVEY & ACOR**
APPENDIX Q	**CONCRETE BEAMS REPORT BY COVEY**
APPENDIX R	**REPORT ON LEAKS BY COVEY**
APPENDIX S	**UPPER FLOOR FRAMING & ROOF BY COVEY**
APPENDIX T	**LINK STRUCTURE REPORT BY COVEY**
APPENDIX U	**PAVILION 2 UPPER LEVEL BY COVEY**
APPENDIX V	**SLAB ON GROUND REPORT BY COVEY**

1.0 EXECUTIVE SUMMARY

Covey Associates was engaged by Moreton Bay Regional Council to investigate and assess the structural integrity of the Suttons Beach Pavilions.

The investigations have identified the following:

Pavilion 1

Due to the age and exposure level of the building there are significant areas of extensive deterioration in the structural components, most notably:

- The original suspended slab
- The rear retaining wall

The original suspended slab is structurally inadequate and has no residual life. Major rectification works or replacement will be required to extend the remaining life of the structure.

The rear retaining wall is structurally inadequate for the recommended loads, has drainage issues and needs intervention to extend its design service life. Major rectification works will be required to extend the remaining life of the structure.

Link Structure

This structure is generally structurally sound but needs a new roof and other maintenance works to prolong its service life.

Pavilion 2

The roof has suffered from water ingress causing localised issues for some roof and wall framing. The rest of the roof structure appears to be in good condition. New roof sheeting and localised repairs to roof and wall framing are required to prolong its service life. See Appendix U for more information.

The body of this report provides a summary of the extensive investigation and testing undertaken with more detailed reports included within the associated appendices.

2.0 INTRODUCTION

2.1 Background

Covey Associates was engaged in May 2022 by Moreton Bay Regional Council to investigate and assess the structural integrity of the Suttons Beach Pavilions.

Pavilion 1, is located at 50 Marine Parade, Redcliffe at Suttons Beach. Pavilion 2 is located to the north of Pavilion 1. Both Pavilions are located east of Marine Parade along Suttons Beach beachfront. The Pavilions are joined by a link slab.

Pavilion 1, was constructed as a bathing pavilion in 1937, by the former Redcliffe Town Council, and has undergone a number of modifications and additions, primarily from 1975, and more particularly, since the late 1990's/early 2000's. The building has a history of water ingress issues. Council has initiated a number of engineering reports and investigations, particularly over the past six years.

Pavilion 2 is approximately 20 years old and has also suffered from water ingress issues, including through the external façade/windows, with the windows being replaced by Moreton Bay Regional Council (MBRC) in 2012/13.

The third structural element is the link slab, which effectively joins the two pavilions together. This element was constructed at the same time as Pavilion 2.

2.2 Scope of works

Covey Associates was engaged to prepare, implement and supervise a comprehensive investigation, including testing (non-invasive and invasive) to determine the overall and component structural condition, structural integrity and adequacy, and remaining life (including concrete life, degree of reinforced concrete carbonation and cover to reinforcement) and encapsulate the findings of the investigations and testing into a detailed report.

The report will also determine whether any structural components of concern can be repaired, and if so provide conceptual information of the works required so the associated cost can be estimated.

2.3 Limitations

The investigation of Pavilion 2 was limited to sections of the upper floor walls and roof framing only.

The opinions, conclusions and any recommendations in this report are based on information from, and testing undertaken at or in connection with, specific sample points. Site conditions in other parts of the site may be different to those found at the specific sample points.

The opinions, conclusions and recommendations in this report are based on the assumptions made by Covey Associates and other consultants as described in this report and associated appendices. Covey Associates disclaims any liability arising from any of these assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on the conditions encountered and information reviewed at the date of preparation of the report. Covey Associates has no responsibility or obligation to update this report to account for events or changes subsequent to the date the report was prepared.

The opinions, assessments, conclusions and any recommendations in this report also rely on data and views from other parties. Covey Associates accepts no responsibility for information from other parties.

2.4 Provided Documents

A list of the following documents were provided by MBRC:

- Electronic scanned copy of Original Blueprints from 1937
- Asbestos Management Plan (AMP) Dated 10th February 2015
- Pavilion 1 renovation drawings from 2007 by Designinc Pty Ltd including: A.101 Issue C, A.102 Issue C, A.103 Issue B, A.104 Issue C, A.105 Issue D, A.106 Issue B, A.107 Issue B, A.109 Issue A, A.111 Issue A, A.112, A113 Issue A, A.114 Issue A.
- Numerous old photos from 1937 to the 1970's

3.0 METHODOLOGY

3.1 Site visits and inspections

Site visits and inspections were undertaken by a team of engineers (geotechnical, structural, heritage/structural, and structural/testing), technicians, surveyors, builders, heritage consultant, contractors, etc to inform the preparation of a methodology for stripping out the structure for testing. Particular attention was paid to the historical aspects to ensure any key areas were protected and left undisturbed as much as possible.

3.2 Site works

Prior to any testing works commencing, site works were undertaken which included stripping out internal floor, wall and ceiling linings, framing and claddings, as well as some external to gain visual and practical access to areas for observation, scanning, testing, surveying and documenting. Significant co-ordination of experts, contractors etc, was managed along with providing numerous specifications, methodologies, scope of works, safety, environmental, structural considerations, site meetings and supervision.

3.3 Testing

Extensive testing was carried out by suitably qualified and experienced consultants and contractors. Refer to the relevant appendices for the testing methodology for specific tests.

3.4 Assessment

3.4.1 Structural Assessment

Structural assessments of all the existing structural components were undertaken. Loads considered include Dead, Live, Wind, Earthquake, Earth, Water and combinations of these to current Australian Standards. Details of the structural assessment results can be found in the relevant reports in the appendices. This report will provide a summary of the findings.

3.4.2 Durability and Serviceability Assessment

Durability and residual life of the structural elements were directly associated with the test results – details of the residual life assessment can be found in the relevant reports in the appendices. This report will provide a summary of the findings.

4.0 FOUNDATIONS AND FOOTINGS

4.1 Current Condition

Original footings assumed to be mass concrete and generally in accordance with the original blueprints. Newer extension concrete footings installed circa 2007. More details and photos on current condition can be viewed in the Footings Report in Appendix L.

Walls at 3:C-D have cracking possibly from differential settlement of internal footing. The footing along grid C may not be connected to the rear retaining wall footing.

4.2 Assessment

A geotechnical investigation was carried out and the foundation materials were assessed by a geotechnical engineer (Core Consultants). The report can be viewed in Appendix G.

Concrete testing at exposed footings was carried out. See BG&E report in Appendix H for more details.

Calculations of applied loads on original pad and strip footings were carried out. See Appendix L for more details.

4.2.1 Geotechnical and Structural

The allowable bearing capacity of the foundation material given by the geotechnical engineer is sufficient for the applied loads. The site Reactivity Classification is M (Moderate).

Structurally the original footings and newer extension footings are adequate for current loading conditions.

4.2.2 Durability and Serviceability

A 50 year residual life for both original and newer extension footings can be expected. There are no immediate durability concerns.

Any refurbishments should include detailing to allow for movement suitable for a M class site. Avoid brittle finishes if possible or install with arrangements to assist in coping with the expected movement.

4.3 Remedial Actions

Stabilise foundations at Grid 3C and W through removal of water source and monitor for 6-12 months. Monitor repaired wall cracks for further movement over this time, keep records and advise engineer of results in order to ensure a long term solution.

5.0 SLAB ON GROUND

5.1 Current Condition

Current condition of the original and extension concrete slab on ground is generally good without cracking or obvious defects. Both slabs have been somewhat protected by topping slabs and topping slab coverings.

These coverings consisting of various cementitious layers, vinyl, tile remnants, glue and other coatings are in poor condition.

5.2 Assessment

Original slab on ground has bottom only reinforcement which has no cover in places. The bars in contact with the ground have corroded but the other bars with cover appear intact. Any corrosion is expected to progress slowly due to limited exposure. Currently the slab has adequate strength but the long term durability is uncertain due to some reinforcement in contact with the ground.

Extension slab on ground has adequate strength and durability and has been given a residual life of 50 years. (See Section 6 of the BG&E report in Appendix H).

5.3 Remedial

Existing floor coverings to be replaced and slab surface sealed. See manufacturers for specification and warranty (generally between 10-20 years depending on exposure to sunlight and environment).

Performance of slab to be monitored. Address any issues that arise at regular maintenance intervals (e.g. 10-15 years).

6.0 REAR RETAINING WALL

This wall is to be considered in 3 sections being:

I. Southern Stair Wall at grid 3:A/C also known as the *toilet area*.
II. Main Wall through grids 3:C/W
III. Northern Stair Wall from grid 3:W/Y also known as the *link area*.

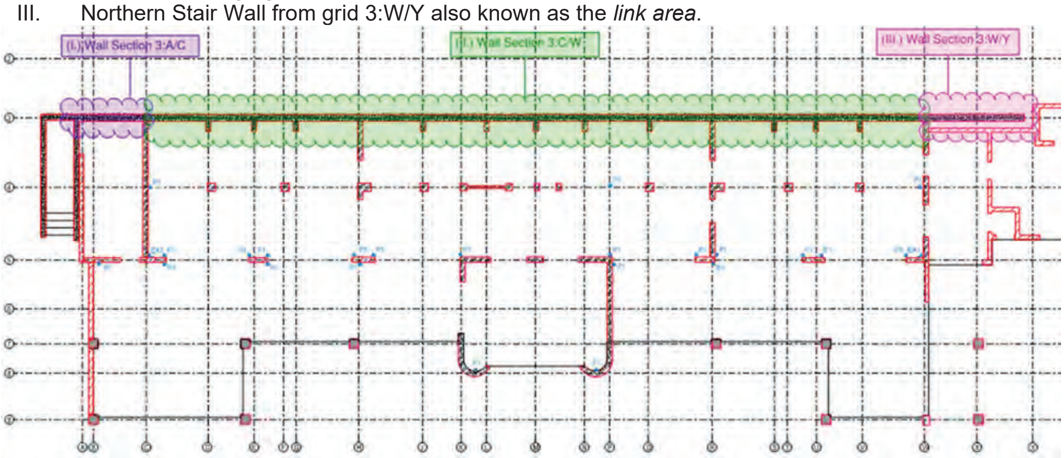

Figure 1: Retaining wall section references.

6.1 Current Condition

Wall section (I.) in toilet area has lots of cracking, water ingress, is carbonated, has chloride ingress and is in poor condition.

Wall section (II.) has cracking on internal face, water ingress at a previous crack repair, water ingress through the upper wall penetrations due to external ground height being above the openings in places, carbonation to reinforcement. Despite this the breakouts in this section of wall at random locations showed the reinforcement had no signs of corrosion.

6.2 Assessment

6.2.1 Structural

Wall section (II.) is structurally inadequate for current design loads and requires strengthening and/or reduction of applied loads (that is relief from surface and subsurface water). Similarly for Wall section (I.)

Wall section (III.) no longer has lateral supports from the stair walls hence it is structurally inadequate for current design loads.

See report in Appendix M for more information.

6.2.2 Durability and Serviceability

Serviceability/amenity issues include moisture ingress, mostly at the bottom section of the wall. Good drainage behind the wall and positive water proofing will prevent this. Adequate surface and subsurface drainage will also reduce loads on wall.

Wall section (I.) is in poor condition and at the end of its service life. It requires remedial work.

Wall section (II.) reinforcement was in good condition, but cannot be left as is due to the carbonation depth and chloride ingress. *On this basis the wall is considered to be at the end of its service life and intervention is required to extend the life of the wall.* But remedial options are more diverse.

Wall section (III.) is expected to be further along the corrosion path than section (II) due to exposure and its exposed reinforcement is already corroding. Hence at best this section of wall should be treated like section (I.)

See report in Appendix H for more information.

6.3 Remedial

An adequate drainage system behind the wall is required to relieve pressure and get water away. Waterproofing to the positive side of the wall is recommended.

Wall section (II.) Since the onset of corrosion of reinforcement has not yet occurred, hence there are more options for remedial intervention. Anti-carbonation coating is the most appropriate method and is expected to have a design life of up to 20 years (depending on the product manufacturers warranty etc.) alternatively sacrificial anodes can be used or replacement is also an option (see report in Appendix H).

Strengthening requirements for all wall sections include: the option of using FRP (Fibre Reinforced Polymer), strips need to be installed on the inside face on larger spans and outside face of the entire wall to strengthen it to meet code requirements. Or install a separate wall internally with adequate spacing between it and the rear retaining wall to allow for waterproofing/drainage. This would also allow the external wall to act as a wet wall and provide a drainage void. Note extensive works have already been carried out for external drainage voids and a detailed design would be needed for an internal one.

Wall sections (I.) and (III.) both require breaking back of all chloride contaminated concrete to the reinforcement and if it is not corroded then sacrificial anodes can be installed and the removed concrete reinstated. Else if corrosion has begun the concrete must be take back to 30mm beyond the steel reinforcement. Clean and coat reinforcement and replacing any that have suffered sectional loss (reduced in size). Followed by installing new concrete and applying protective anti-carbonation coatings.

6.4 Other Considerations

Note that the internal nibs (or buttress columns) along the rear retaining wall internally do not have adequate strength to support the rear retaining wall under load. Hence these also need strengthening. An option to do this is to dowel into existing brick and concrete nibs and extend them by approximately 1200 into the building. Alternatively Steel K-Brace or fabricated frame that would possibly be 200mm shorter could be installed. See marked up plan in appendix A.

Access to the rear of the retaining wall is problematic but it is required for waterproofing, durability and strengthening options (unless a new internal wall is built with an adequate drainage system between the two). The entire upper floor amenities and kitchen area (above the undercroft) is supported by brick walls on high level footings. Any excavation through this area could undermine the walls. Stability of these walls and footings must be maintained during any excavation and construction works.

A new internal wall or internal nib walls would encroach on the useable space internally on the ground floor.

6.5 Conclusions

The rear retaining wall continues to provide the earth retention expected from its original design intent. However, as described within the preceding review and analysis, the wall is:

- Not Code compliant
- Not waterproof
- Suffering carbonation,
- Suffering cracking, and
- Imposing a lateral load on to the building that the structure cannot accommodate.

7.0 GROUND FLOOR BRICK WALLS AND BRICK COLUMNS

This section covers the ground floor original brick elements including:

- The various brick walls, double and single skin with original concrete and brick lintels,
- The brick columns,
- The curved brick walls at the front (ref 8-K/L and 8-N/P).

Consideration is also given to overall lateral load paths in the building subject to earthquake and wind forces.

7.1 Current Condition

Over half of the original brick walls on the ground floor have been removed. The remaining bricks are generally in good condition with isolated bricks showing signs of decay.

All of the original brick columns are still in place and appear to be generally in good condition.

There are numerous cracks in the brick walls that vary in width from minor cracks to severe cracks of over 4mm width.

Some brick columns have a higher moisture readings at the bottom. Similarly the brick walls in direct contact with and running perpendicular to the rear retaining wall have higher moisture readings at the base of the wall and appear to have discoloration indicative of moisture ingress.

No connection between the suspended slab and the rear retaining wall was able to be verified on site, nor is there expected to be any connection between brick walls and the suspended slab.

7.2 Assessment

7.2.1 Structural

High level structural analyses were carried out on various brick masonry walls and columns with the following results summarised from the Ground Floor Brickwork report:

Where loads were supported concentrically over masonry elements, and where the masonry element was of sufficient length, the brick work (as reported) is generally compliant (for strength) with the requirements of AS3700, "Masonry Code".

Where structural elements transfer concentrated loads to the face of masonry walls, the brickwork is non-compliant. Those areas identified as being non-compliant require remediation.

Where masonry anchors have been used to support concentrated loads (on the face of masonry walls) those connections are non-compliant.

See report in Appendix N for more information.

Specific reference to the bricks that have undergone significant shear failure in brick wall on grid W. Note *the depth of supported brickwork is not sufficient to "arch" the span. Therefore, the steel lintel is fully utilised.* Also, there is a large penetration in this brickwork. *The shear crack suggests the brick wall is not sufficient to support the load applied by the steel lintel*. This wall requires remediation or augmentation.

7.2.2 Durability and Serviceability

Bricks that have undergone shear failure on grid W must be repaired or replaced.

There are no concerns regarding durability if the bricks are well ventilated and maintained. See report in Appendix H for more information.

7.2.3 Lateral Loads

The main issue is no connection between the suspended slab and the rear retaining wall or columns along grid 3 (with the exception of 3 small SHS posts on grid 3).

Australian standard requires that *All parts of the structure shall be tied together in Horizontal and vertical planes*.

Bracing capacity of the structural elements on the ground floor to resist lateral forces induced from wind or earthquake is limited to the front half of the building where there are new concrete and steel columns tying the upper floor to the ground floor. The rear section of the building has no ties.

7.3 Remedial

From the Ground Floor Brickwork report:

In areas where successive renovations have contributed to the removal of parts of walls (and decreased the section capacity of that wall), those areas should be re-built as per the original intent

In areas where brickwork has cracked, but the structural integrity remains intact, those areas should be remediated by filling the cracks with and approved product/method.

In areas where brickwork has suffered shear (or similar) failure, and the integrity of the structure is in doubt (locally), those areas should be

- *Reinstated by either approve masonry re-construction methods, or*
- *Augmented with addition structure (for example, structural steel) sufficient to reinstate the integrity of the area.*

In areas where structural beams transfer loads to the face of the masonry wall a vertical structural element is to be placed under the end of the beam at load point that supports the beam and is founded on an approved bearing pad (which may be the existing slab or a new footing) *below. This element could either be structural steel, brickwork, reinforced concrete or reinforced masonry.*

Wall with shear failure on grid W requires the missing bricks to be reinstated with approved masonry reconstruction methods. The steel lintel is to be replaced and supported by two new steel SHS posts on suitable bearing pad. This is to be carried out for both steel lintels on this wall.

See reference in Appendix N for more details and marked up plans in Appendix A.

Structural ties from the suspended slab to ground floor are required in the back half of the building to help resist applied lateral loads and compliance with Australian Standards. This can be done in conjunction with the abovementioned remedial works for the rear retaining wall.

7.4 Conclusion

In general, the brickwork is in reasonable condition but to continue its service life, any cracking requires the appropriate level of repair. The original built in components (brick ties) have very likely deteriorated with age. Shear cracks need further specialist design and repair. Some brick walls have inadequate strength and require augmentation such as steel posts. Other walls are eccentrically loaded about their weak axis and fail in out of plane bending.

8.0 SUSPENDED SLAB

8.1 Current Condition

The original suspended slab is in poor condition.
The steel support framing is in reasonable condition with some surface rust and pitting. Some localised areas and a few connections have undergone more significant corrosion with delamination occurring.

8.2 Assessment

8.2.1 Structural

The structural assessment of the slab found the original suspended slab *not fit for purpose and that it was not capable of carrying any additional loads and potentially susceptible to brittle failure* (see BG&E Report in appendix K). Additional structural assessments also indicate the slab is not adequate for the design loads and must be strengthened.

Slab design checks were carried out in the areas where there were steel support beams as well as areas where there were no new steel support beams. Both areas require additional support.

The existing steel framing beams supporting the suspended concrete slab were also checked and were adequate for current design loads except for beam B1-1 (refer SK102 in Appendix E) which failed to meet code strength requirements.

See report in Appendix P for more information.

8.2.2 Durability and Serviceability

The reports conclude that the suspended slab has no residual life and is need of immediate remedial works or replacement.

8.3 Remedial

There are a number of options explored in Appendix H and P but the two most practical options are *major rectification* or *floor replacement*.

8.3.1 Major Rectification - Removal of Carbonated Concrete and Strengthening

With this option, the slab requires remediation works including removal of the carbonated concrete to the soffit of the slab and cleaning of the corroded steel where it is corroded or replacing of the corroded steel with new steel if practical and applying anti-rust coating to the remaining steel, apply bonding agent to the surface of old concrete and finally applying the new concrete to the soffit of the slab.

As stated by BG&E the perimeter of the slab is at a higher risk of corrosion. Furthermore, much of the suspended slab overhang has been cut and steel reinforcement exposed to the weather or water ingress at the joint to extension slab that leaks in places. There were also large areas of delamination and previous repairs on the soffit at the front *kiosk* area Grids K-P:5-8. Hence, it is reasonable to assume that the area above the old kiosk and 1.5m perimeter of reinforcement would need replacement. Refer mark up plan with areas in Appendix A.

Once the carbonated concrete cover is removed and replaced with new repair concrete, strengthening remedial works can commence. The strengthening works could include CFRP (Carbon Fibre Reinforced Polymer) strengthening to the soffit of the suspended slab to replace the corroded bottom reinforcement or could include adding steel beams and columns to provide additional supports to the existing slab.

The strengthening works may also be a combination of both CFRP and steel framing to the soffit of the slab. These strengthening options require detailed design the next stage of the work in conjunction with an experienced contractor and their engineer as there will be other issues that arise when on site as is typical for rectification works. Such strengthening works must be done to ensure the structure can withstand the full design loads.

Additional steel beams may be used in conjunction with CFRP strengthening.

Following the strengthening works an anti-carbonation coating should be applied to the soffit of the slab to protect the slab from further carbonation of concrete.

The top of the slab should also be coated/sealed internally as it has already been for many years. Updating the internal floorcoverings and sealant is recommended.

Finally, the external tiled terrace areas require the tiles to be removed and a new membrane installed. Prior to the membrane installation all joints between old and new slab are to be inspected and repaired to ensure no future water ingress.

8.3.2 Replacement of original suspended concrete slab

If it is replaced there are other considerations for instance structural connections to supporting elements including existing brick piers and brick walls, as well as the durability of these supporting elements since the connection is only as good as the weakest link. A benefit of replacing the slab would be that the new slab could be designed to span between existing and new supports so that there is no need for steel support beams.

Other considerations include:

- likelihood of having to remove all upper floor walls and roof and associated heritage impacts,
- connecting the replacement slab to existing slab,
- propping existing extension slab if required,

A full detailed structural analysis, design and associated documentation would need to be carried out.

8.3.3 Remedial works to steel support fame

If the slab is not replaced and the steel support frame is kept all steel will need to be taken down to remove rust and pitting from all surfaces. Remedial procedure for each steel member should include but not be limited to:

- Thoroughly clean and remove all corrosion and rust products,
- wire brush/mechanically grind surfaces to achieve smooth and bright metal comparable to class 2.5,
- check for sectional loss,
- weld in strengthening plates or replace beam if required,
- replace connection plates if required,
- apply primer and coating system to manufacturers specification and warranty
- re-apply at end of warranty period or next maintenance period.

8.4 Other Considerations

Other considerations include but are not limited to:

- Removal of the steel support beams to fully access the suspended slab soffit for concrete removal.
- staging of the works, removal and cleaning the steel support framing must be done in stages and the slab propped while beams are removed.
- Likewise, any concrete removal and repairs of the underside of the slab will need to be done in stages
- Many of the steel beams are welded together and only bolted to the rear retaining wall, hence removal of these beams will require on site steel cutting then retrofitting bolted connections and/or site welding.
- Installation of new concrete may be done with a high flow mix requiring formwork.

8.5 Conclusion

Note that remedial rectification work is an iterative process involving the engineer and the Contractor on site to consider all influencing factors.

Notwithstanding, the suspended slab requires substantial remedial works to:
- Rectify those areas currently susceptible to elemental ingress, and
- Strengthen the slab for compliance with current Codes.

The BG&E Report in Appendix K states that *It is also likely that the costs to undertake rectification would significantly exceed the cost of slab replacement*.

9.0 CONCRETE BEAMS AND SOUTHERN SUSPENDED STAIR

9.1 Current Condition

Refer SK102 in Appendix E for beam locations.

9.1.1 Beam CB2

This concrete beam is in poor condition. Active corrosion is occurring in several places along the beam including previously repaired areas.

9.1.2 Beam CB1 and Suspended Stair

The concrete beam at southern stair CB1 is in very poor condition and has no residual life.

The suspended stair and landing soffit is in poor condition with delamination already occurring.

The entire area is currently propped.

9.2 Assessment

9.2.1 Structural

High level structural assessment of CB2 showed that its bending and shear capacities were inadequate. The beam is reliant on steel side beams for strength. Strengthening is needed to provide required shear strength.

Steel side beams are adequate to support CB2 on the longer spans but the bolted connections to the concrete are unknown in terms of the type of anchor and the embedment and may be inadequate for required load combinations.

Assuming CB1 is intact, the reinforcement in the beam is inadequate for shear and crack control requirements of the current Australian Standards so strengthening is required regardless. A suitable new section could be designed with sufficient capacity.

No structural analysis on the suspended stair could be carried out as access to the soffit to scan for reinforcement was prohibited by the ply sheeting and props. Depending on the reinforcement layout the stair could span between the rear retaining wall and the concrete beam CB1. However, beam CB1 is propped and needs repair or replacement so this load path is unavailable. This stair supports foot traffic to the ramp and should be rectified as a matter of priority. Propping should only be a temporary measure.

See report in Appendix Q for more information.

9.2.2 Durability and Serviceability

Beam CB2 is considered to have no residual life and remedial works are considered necessary.

Beam CB1 has no residual life and is in need of immediate remedial works or replacement, although it likely does not have enough suitable concrete left for remediating.

The suspended concrete stair has no residual life and is need of immediate remedial works or replacement.

9.3 Remedial

9.3.1 Beam CB2

Beam CB2 requires strengthening - additional side support beams between Grids K and P similar to the rest of the beam. Alternatively Carbon Fibre Reinforced Polymer strips could be installed on the soffit and sides of the beam to increase bending and shear capacities as required.

Concrete beam CB2 requires remediation works including removal of the carbonated concrete to the soffit of the slab and cleaning of the corroded steel where it is corroded or replacing of the corroded steel with new steel if practical and applying anti-rust coating to the remaining steel, apply bonding agent to the surface of old concrete and finally applying the new concrete to the soffit. CFRP strengthening can then be applied prior to an anti carbonation coating.

The beam CB2 could be replaced in conjunction with the option for replacing the entire suspended slab.

9.3.2 Beam CB1

Replacement of the beam is likely the best option here. However if the beam is to be remediated it will require the removal of all carbonated and Chloride affected concrete and there may not be much left after this. The severely corroded bottom steel must be cleaned with all rust products removed and will need to be replaced or spliced with new steel. Additional strengthening is required for shear and bending reinforcement – which can be new reinforcement or CFRP after new concrete is installed.

9.3.3 Suspended Stair and landing

Remedial works on the stair soffit should adopt a similar approach as for beam CB1/CB2 and the suspended slab in section 9 above.

9.4 Conclusion / Other considerations

Replacement of beam CB1 directly affects the suspended stairs. The top part of beam CB1 is the edge beam of the stair.

Repairs require demolition works as well as construction works and must be staged. Temporary works are required whilst carrying out the demolition works. Also progressive construction works are required along the beam in conjunction with that of the suspended slab.

10.0 UPPER FLOOR FRAMING

This section includes the upper floor timber wall framing, bracing and roof elements.

10.1 Current Condition

Water ingress has led to significant deterioration of some of the structural timber framing. Other timber framing is in good condition.

Steel portals are in good condition.

Roof sheeting, awning and parapet claddings and steel roof rails are all in poor condition. Some areas of roof the pitch is quite low at only 2.5 degrees falling to the box gutter.

10.2 Assessment

10.2.1 Structural

Timber wall framing, tiedown and bracing is inadequate and needs to be supplemented.

Steel portal frames are in good condition but are underutilized since there is no apparent structural load path to transfer bracing forces.

Lintels and jamb studs inadequate for lateral load case.

Rafter sizes appear to be adequate for loads. Trusses must be analysed by truss manufacturer.

10.2.2 Durability and Serviceability

From a durability perspective the termite and water damaged members have no residual design life and must be replaced. As for the rest of the timber frame, all cracks and leaks must be fixed, joints sealed, cracked and worn external cladding replaced and regular maintenance for extended design life.

The steel portals can have 50 year residual life if protective coatings area applied and maintained.

The roof sheeting is at or near the end of its service life. Good flashing and waterproofing is even more important on low pitch roofs.

10.3 Remedial

All water and termite damaged studs, plates, lintels, rafters, trusses and battens are to be removed and replaced. Sizes to be confirmed with a new design to current codes and wind rating requirements. It is estimated that up to 50% of wall framing will need replacing and up to 50% of rafters will need rectification or replacement.

Install additional studs between existing. Additional top plates required.

Install tie down rods at max 1200 centres along all frames.

If rust is found on steel portal frame; expose and thoroughly clean steel and remove any rust product. Mechanically grind surfaces to achieve smooth and bright metal comparable to Class 2.5. Prime and paint with a 2Pac epoxy coating system – specification, warranty and maintenance requirements to be provided by manufacturer.

Design and install additional wall bracing / portal frames, as well as a lateral load transfer system including wind beams, mullions, roof struts and cross bracing. This would likely entail steel mullions and wind beams, steel cross bracing in the roof / ceiling plane.

All roof sheeting, box gutter and other guttering should be replaced.

Parapets to be reclad. Steel rails to be removed and treated with the same procedure as the portal frames only additional protective coatings to be applied for external use and new cleat plates welded onto rails, if salvageable.

10.4 Other Considerations

Other considerations regarding repairs are that the upper floor wall along grid 5 is directly above the join in the slab from old to new and that needs to be exposed and repaired. Hence removal of the upper floor timber stud walls is likely to be required.

11.0 UPPER FLOOR BRICKWORK

This section covers the 3 different remaining original brick elements on the upper floor being:

- The dwarf/parapet wall on the original front terrace.
- The 2 remaining brick columns at U-5-L and U-5-N
- The rear brick wall along grid 2 and its two perpendicular brick walls along grids H and R.

11.1 Current Condition

Over half of the original brickwork on the upper floor has been removed. The remaining bricks are generally in good condition. Cracking in the brick wall along grid 2 and externally along wall on grid R. Diagonal shear cracks also extend through bricks at the concrete lintel support.

Brick ties are corroded.

Brick columns appear to be in good condition.

11.2 Assessment

11.2.1 Structural

Brickwork including walls and columns are compliant for compression loads but inadequate for uplift and bracing*(lateral)* loads. See report in Appendix O for more information.

The dwarf / parapet wall is not adequate to accommodate design loads and is not suitable for use as a sill beam. It would not be possible to retrofit the wall to accommodate the required loads or to act as a sill beam without demolishing a large portion of the original brickwork. Hence a separate structure/wall could be constructed inside it.

See report in Appendix O for more information.

11.2.2 Durability and Serviceability

There are no concerns regarding durability if the bricks are well ventilated and maintained. See report in Appendix H for more information.

11.3 Remedial

Install post-fix brick ties on double skin brick walls.

From the report in Appendix O:

Brick wall along grid 2 supporting roof loads requires additional structural members to restrain the roof structure in uplift. These members may be steel columns bolted to the reinforced concrete slab. Similarly, the two remaining brick columns will need additional steel columns installed to restrain the roof beam along grid 6.

Cracks in rear brick wall along grid 2 to be *filled with appropriate product (such as Sikaflex Pro), that will allow for movement within the brickwork, as would usually be expected during normal serviceability conditions*. All cracks should be monitored regularly after fixing (minimum every 6 months) and any changes be reported to the structural engineer.

Parapet/*Dwarf wall is not adequate to accommodate loads* and requires a crowd barrier or separate wall/structure inside it to prevent it from being loaded. The additional works will also need to be designed to support the dwarf wall.

11.4 Conclusion

Some areas of the upper brickwork are compliant. Other areas, as identified, are inadequate for design loads and must be retrofitted / supplemented with steel columns.

Cracks to be filled and monitored regularly.

See schematics in Appendix A for remedial mark ups on plans.

12.0 LINK STRUCTURE

12.1 Current Condition

Blockwork walls appear to be in good condition, although there is evidence of water ingress along the back and side walls and ceiling. Evidence includes:

- watermarks and staining of blockwork walls,
- efflorescence on blockwork,
- surface rust, pitting and some localised delamination of steel beams,
- surface rust on ceiling battens,
- mould on wall framing and linings,
- mould on top of ceiling lining,

Water appears to be getting in through the roof, at flashings to parapets/walls and along the box gutter.

The roof sheeting is aged and in poor condition. The roof slope is very low being only 3 degrees. Roof sheeting has dints, roof screws look rusted and aged, sealant is weathered and cracked, there is mould at the flashing and some gaps at overlaps.

Retaining wall along grid 3 is part of the original stair/rear retaining wall and is addressed in that section of the report.

12.2 Assessment

12.2.1 Structural

High level calculations were carried out. The link roof framing appears to be adequate for current code requirements.

Block walls should have more than adequate strength.

12.2.2 Durability and Serviceability

Due to water ingress the affected areas of the block wall and roof framing are unlikely to last 50 years without intervention and maintenance.

Other structural roof elements in areas of the roof that are in good condition need to be cleaned and sealed and should last 50 years with standard maintenance regime for structures in close proximity to the ocean.

12.3 Remedial

Roof sheeting should be replaced, along with the box gutter.

Corroding steel roof framing to be cleaned and all rust elements removed before applying a protective coating.

The block walls can be sealed/coated/rendered and painted internally and externally if there is access to prolong its life.

Adequate drainage to be installed along the rear of the pavilions.

12.4 Conclusion

Roof is in poor condition and needs replacing. Block walls are in good condition but leaks must be eliminated.

Steel roof framing is structurally adequate, but needs localised remedial works and a protective coating.

Tie down to existing structure is either inadequate or non-existent. Upgrade of roof tie down will require substantial remedial works.

13.0 EXTENSION COMPONENTS

This section includes extensions to the original pavilion being slab on ground, new columns and block walls, suspended slab extension, parapet and plant room. (Footings are dealt with in Foundation and Footings Section of report).

13.1 Current Condition

Ground floor columns and internal reinforced block columns appear to be in good condition.

Ground floor edge block walls retaining external ground have efflorescence and obvious water ingress.

Suspended slab appears to be generally in good condition. However, the joint between the extension slab and original slab leaks in several locations. There are also areas of the slab with water ingress through the slab (See Appendix R for report on Leaks). Water was seen dripping from cracks in the soffit at these areas. Water ingress must be mitigated.

Parapet appears to be in good condition. There is cracking at the joints to end walls(for example at A:4, K:7 and P:7). Flaking of the protective coating is occurring in a few locations.

Plant room block walls along grid 1 have water ingress and efflorescence on the retained height and the wall along grid 2 has minor cracking.

13.2 Assessment

13.2.1 Structural

A high-level structural analysis of the existing columns, reinforced block blade columns, suspended slab and parapet indicated they were all meeting the current Australian standards for strength requirements.

Scanning of the plant room walls revealed much of the blockwork was hollow and only a few bars were located. Hence these walls do not provide as much bracing. The bottom courses must be filled to be adequate for retaining the bank at the rear of the wall. It is unknown if these are core filled but it is a reasonable assumption. The block lintel appears to just have enough capacity for uplift if there is an N12 bar is at the top and it is fully core filled.

13.2.2 Durability and Serviceability

Durability comments in italics are all referenced from the Condition Assessment report in Appendix H.

Slab section *is considered to have a residual life in excess of 50 years*, provided leaks are fixed, and the maintenance/remedial options below are undertaken as well as routine maintenance is carried out.

Parapet was also given *a residual life in excess of 50 years* by BG&E. However, in order to assure this, the protective coatings and joints/sealant should be maintained and regularly reinstated at the end of the warranty periods (for example every 10-15 years depending on the product and manufacturer.

Like the rest of the new works, the concrete columns and internal block blade columns should also have a residual design life of 50 years. Being built over 15 years ago, the first major maintenance period should have been carried out sometime in the last 5 years. Especially for exposed items like columns and parapet. These items can have a design life beyond 50 years if they are regularly maintained.

The reinforced block walls in contact with the ground should have positive waterproofing. Without this any internal framing/cladding connected directly to the blocks is susceptible to moisture damage. Hence the serviceability of the wall cannot be guaranteed. The wall should be waterproofed on the positive side.

With regards the plant room wall with a similar problem it must be considered that the room has permanent louvres and is well ventilated, although some of these have been covered up internally. This room must have ventilation else the moisture ingress will slowly affect the block wall. This wall should be waterproofed in the retaining section if a 50 year design life is required.

13.3 Remedial

Terrace tiles and existing failed membrane is to be removed.

Surface coverings to be removed, joint between original and extension slabs exposed, investigated, repaired (if required), waterproofed and sealed.

All walls and columns (internally and especially externally) to have protective coatings reapplied regularly as part of routine maintenance.

Block walls in contact with ground to be waterproofed. Adequate drainage to be installed behind all walls retaining.

Parapet wall to be stripped back and resealed/recoated with protective coating (anti-carbonation coating) to prolong it’s design life. Chloride ingress is already at 20mm for the parapet so anti-carbonation coatings will slow process. Joints and cracks must be fixed and sealed appropriately prior to coating.

Plant room retaining wall section should be excavated, waterproofed and adequate drainage installed.

See schematics marked up in Appendix A.

13.4 Conclusion

Other considerations include but are not limited to:

- There is no access to outside block wall along grid A where the heritage stair exists – so no positive waterproofing can be installed here. The block wall and lower block wall in front of the stair should be accessible without affecting the heritage stairs.
- Excavation behind the plant room wall will encounter the remnants of the original brick wall supports for the original tank. It also is in close proximity to the heritage stairs.