Civic Engineers

Job Title
Highland School RAAC Survey – Charleston Academy

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RAAC Survey Interim Report

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Contents

RAAC Survey Interim Report

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1. Introduction

Survey Background

A non-intrusive survey was carried out by [redacted] of Civic Engineers on 5th July 2023 to determine condition and extent of defects of RAAC panels. Following this survey remedial actions were proposed to reduce any areas identified as high risk (according to the IStructE guidance April 2023) to a lower risk category.

The remedial solutions for risk category critical/high and for the roof panels as this is where previous RAAC panels have been known to fail either through water ingress or due to slipping from insufficient bearing. The wall panels are being inspected to identify any cracking or movement. A feasibility to overclad the walls is currently underway in order to determine if the over cladding could be undertaken whilst the school remains operational.

Interim Survey Extents

The remedial works have been ongoing from August 2023 and this interim report captures work done to date and to identify any further changes of condition due to water ingress over the winter period. This non-intrusive survey was carried out by [redacted] of Civic Engineers on 20th Feb 2024.

2. Survey Results

Following review of the defects noted in the previous inspections and the ongoing remedial works the following table identifies the status of each area.

Location	Issue	Risk level pre-remedials	Risk level post-remedials	Further action
Assembly Hall	Wall Panels	Critical	High	**Vertical Crack Noted during inspection – remedial detail to be developed pending high level access by fabricator**
Kitchen and Storerooms	Roof Panels	High	High	Limited access has been available due to operational requirements. This area has been agreed to be surveyed once ceiling tiles can be removed at Easter holidays

Kitchen and Storerooms	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Technical Dept - Workshops	Roof	Critical	Medium	Roof work remedials largely complete – ongoing inspections to be undertaken quarterly. See photo 8
Technical Dept - Workshops	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Technical Dept – Classrooms	Roof	High	High	Panels in reasonable condition generally however shelf angles required where they do not meet bearing requirements.
Technical Dept – Classrooms	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Art Dept & Storerooms	Roof	High	Medium	Roof work remedials largely complete – ongoing inspections to be undertaken quarterly.
Art Dept & Storerooms	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Home Economics Dept & Storerooms	Roof	Medium	Medium	Ongoing inspections to be undertaken quarterly
Home Economics Dept & Storerooms	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Second floor (Science floor)	Roof	High	Medium	Roof work remedials largely complete – ongoing inspections to be undertaken quarterly.

Second floor (Science floor)	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Library	Roof Panels	High	High	Panels in reasonable condition generally however shelf angles required where they do not meet bearing requirements.
Library	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Admin areas	Roof Panels	Critical	Medium	Roof work remedials largely complete – ongoing inspections to be undertaken quarterly.
Admin areas	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Music Dept	Roof Panels	High	Medium	Roof work remedials largely complete – ongoing inspections to be undertaken quarterly.
Music Dept	Wall Panels	Medium	Medium	Feasibility study underway for overclad option
Community Building and gym hall	Roof Panels	Medium	Medium	Feasibility study underway for overclad option
Community Building and gym hall	Wall Panels	Medium	Medium	Feasibility study underway for overclad option

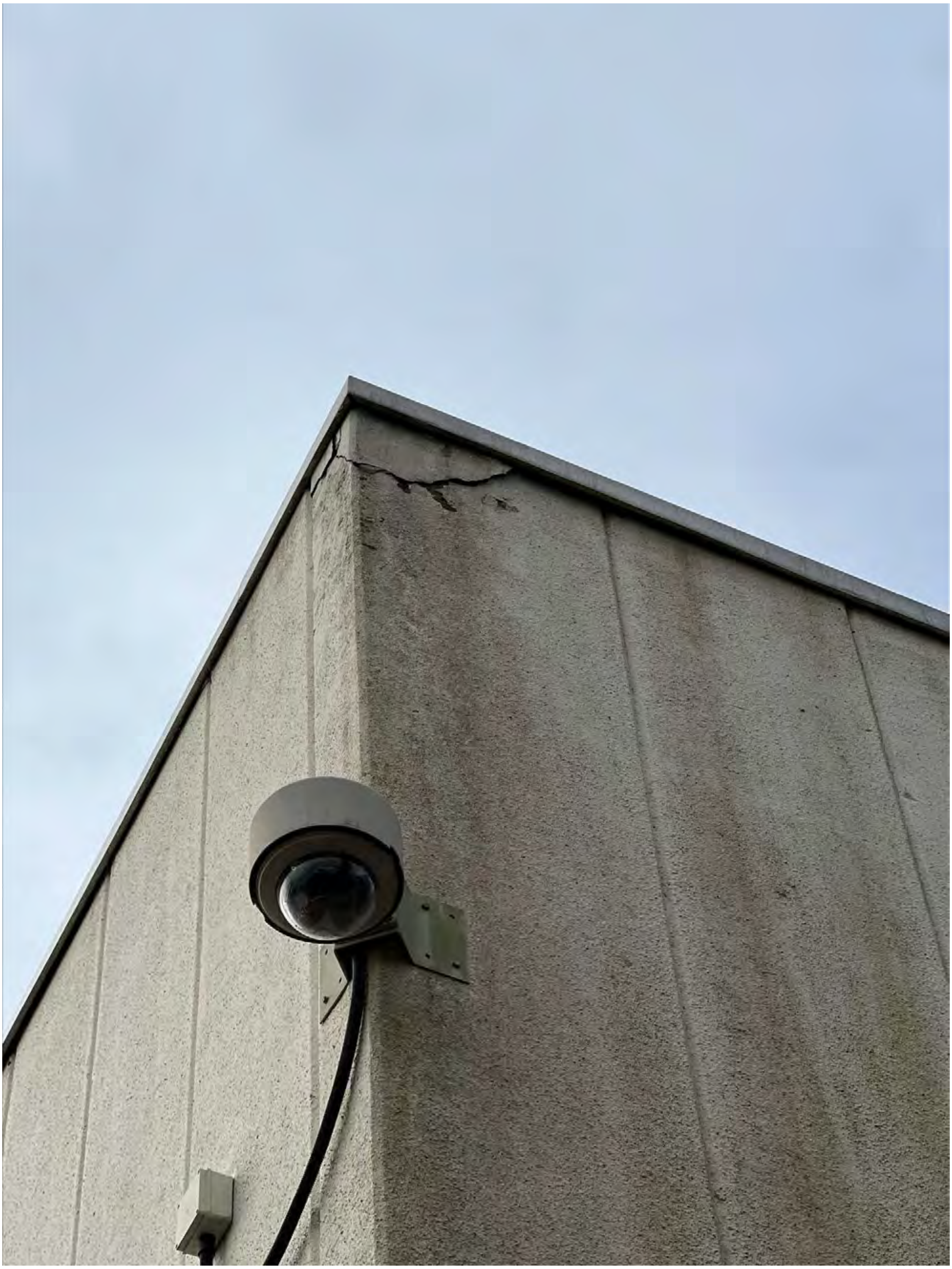
3. Next steps

Remedial details have been established and agreed between Civic Engineers and the steel fabricator. Following opening up works throughout the school and review of existing structure, should any agreed details not be achievable, the fabricator will notify Civic Engineers for review. Any change to existing details or requirement for new details will be coordinated with Civic Engineers and the steel fabricator to implement a cost and time effective solution.

As works were considered critical and carried out as a matter of urgency, a retrospective building warrant will be applied for from the local authority. Civic Engineers will be coordinating a retrospective building warrant package alongside accompanying SER certificate upon completion of the phase 2 works. It is proposed that all works are covered by one SER certificate and a single stage warrant application.

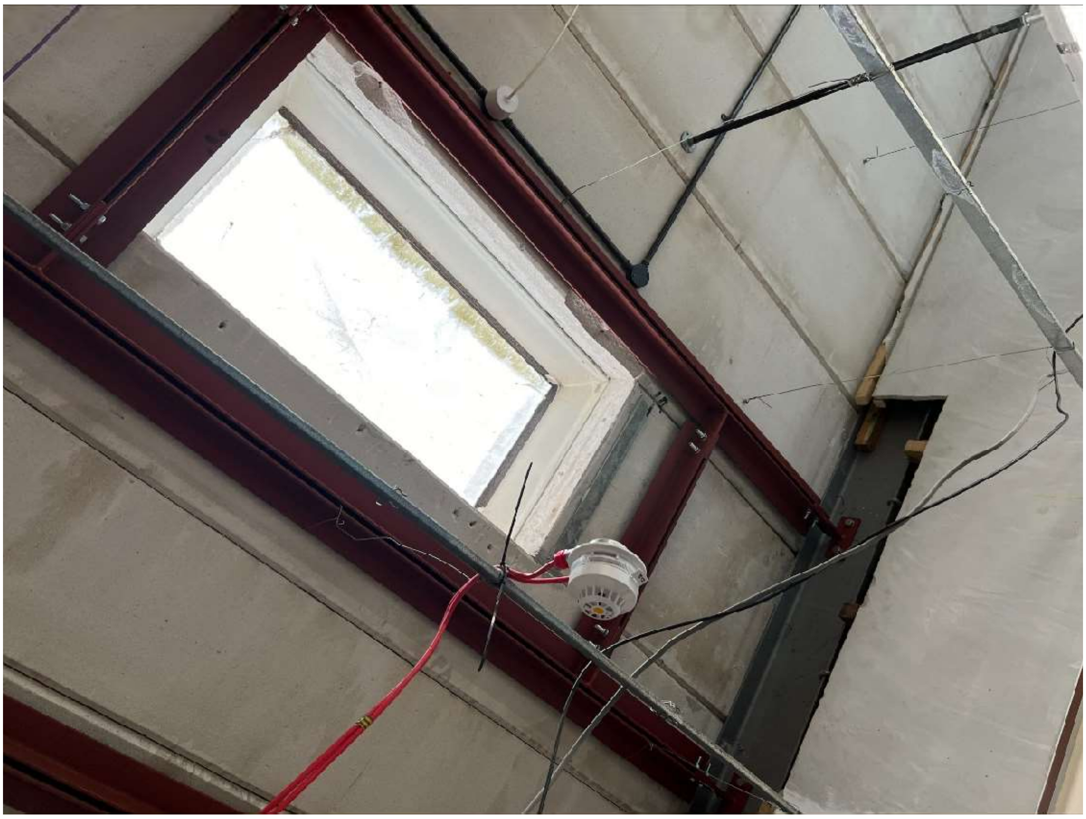
At time of writing as built drawings are awaited from the fabricator to allow the warrant to be submitted and an SER certificate to be raised.

4. Appendix A – Record Photographs



Photograph 1 – Assembly Hall Wall Panel Crack at high level

Photograph 2 – Admin Area roof light remedial supports



Photograph 3 – Admin Area roof light remedial supports

Photograph 4 – Admin Area roof light remedial supports

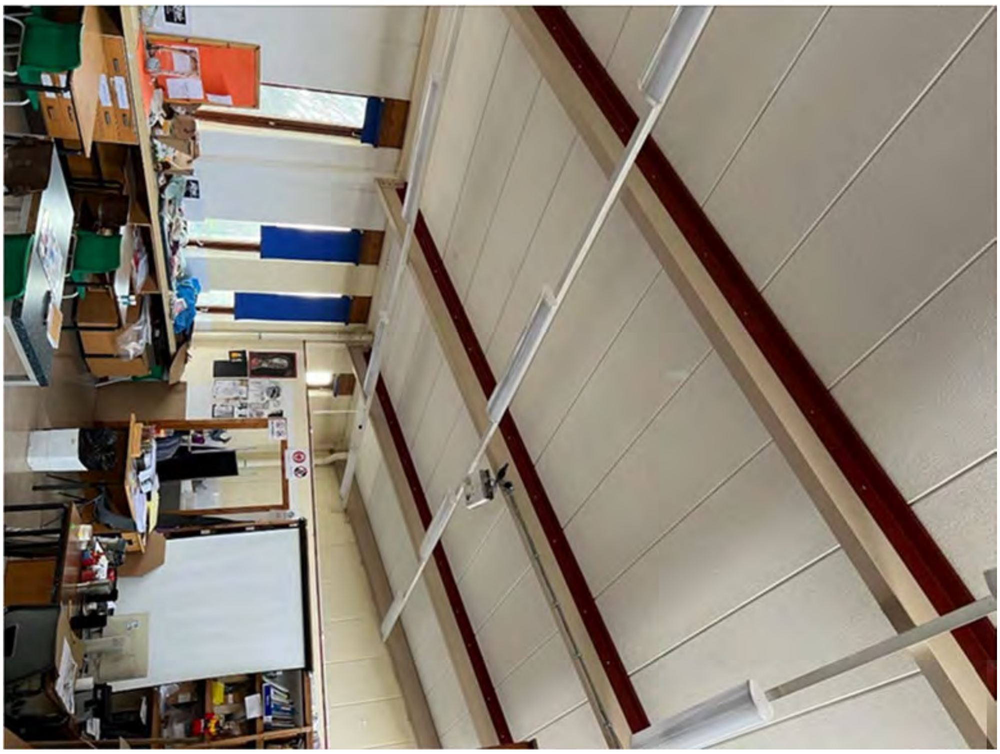
Photograph 5 – Admin Area roof light remedial supports

Photograph 6 – Admin Area roof light remedial supports

Photograph 7 – Admin Area roof light remedial supports

Photograph 8 – Technical Dept Workshop additional supports due to water ingress

Photograph 9 – Technical Dept Workshop Storeroom



Photograph 10 – Art Dept Bearing Supports

Photograph 11 – Art Dept water damaged panel remedial supports

5. Appendix B – IstructE Guidance Extracts

3 Risk factors

RAAC presents a number of risks associated with the original construction form including the materials used, design intent, manufacturing control and construction / installation control. Further risks are presented through the in-service conditions including uncontrolled modifications, changes in loading regime, poor maintenance and ageing.

These are described below.

3.1 End bearing

Poor bearing is a significant risk to the integrity of RAAC roof panels.

The codes of practice associated with the design of RAAC from the 1950's to 1980's were CP114 Reinforced Concrete in Buildings and CP116 Structural Use of Precast Concrete. These codes recommended minimum end bearings of only 45mm for roof panels and 60mm for floor panels. In practice, construction tolerances could have resulted in reduced bearing lengths.

To anchor longitudinal reinforcement, RAAC panels require transverse reinforcement over the bearing support. As noted by testing undertaken by the BRE (BRE IP 10/96), absence of transverse reinforcement at the end bearing can substantially impact on panel performance. The inspection of several buildings has identified that with short bearing lengths there is a risk that this critical anchorage reinforcement can be absent over the support face, presenting an increased risk of panel failure.

For this reason, a minimum as built bearing length 75mm is now considered to be necessary. Any bearing less than 75mm would be considered substandard and present an unacceptable risk to panels from shear failure or slippage and remedial actions are recommended.

Narrow or short bearing lengths may be identified through visual inspection; for example, where panels span from either direction onto a narrow steel beam or masonry wall less than 100mm. These shared bearings on narrow beams or supports can therefore present risks of inadequate bearing length.

Sub-standard bearing on 100mm beam

Figure 3 – End bearing condition

However, in many instances visual inspection alone may be inadequate. Numerous examples have been found of panels having short bearing lengths (<75mm) even when supported on wide steel or concrete beams. Therefore, it is recommended that the bearing length is verified. Intrusive surveys are the only effective method for identifying the bearing length and the position of transverse anchorage reinforcement.

3.2 Anchorage reinforcement

RAAC floor and roof panels require transverse reinforcement to anchor the longitudinal reinforcing bars. This is particularly critical at bearings where transverse bars are needed over the supports as discussed in the previous section.

Where transverse anchorage reinforcement is absent the longitudinal bars will have significantly reduced tensile capacity and there is an increased risk of failure. The mode of failure is still being assessed by academic research, however sudden brittle shear failure is considered possible.

It is not possible to ascertain poor anchorage of reinforcement from visual inspection, therefore intrusive survey techniques are required.

3.3 Cut panels

Cut panels can be created from the manufacturing process where longer panels may have been cast and cut down to create shorter panels or where panels were trimmed at the time of the original construction for building services or other small penetrations.

Original construction techniques used narrow steel trimmers or hangers supported by adjacent panels to form openings in roofs. These steel hangers often have narrow bearing support and have been installed some distance from transverse reinforcement. Therefore, cut panels supporting on hangers present inadequate bearing conditions and poorly anchored longitudinal reinforcement.

Figure 4 – Photo of hangers

Depending on the span of the panel being supported these conditions may present high risk of panel failure.

Cut panels can be identified through visual inspection, where supported on hangers or where panels are visibly narrower or shorter than adjacent panels. However, visual inspection is difficult where panels have been cut as part of the manufacturing process and intrusive surveys may be required.

Cut panels should be identified in all instances. The length of the cut panel, support conditions and defects should be noted.

3.4 Cracking

Cracking and spalling can be a visible indicator of excessive deflections, water ingress, mechanical damage or reinforcement corrosion. It is recommended that all visible defects are recorded during a visual inspection. Where applicable, this should be supported by crack measurement and location for assessment and future review.

It is recommended that cracking and spalling is recorded as either major or minor as defined below:

- Major cracking/spalling: defined where a panel exhibits large/deep cracks that may be accompanied by spalling and in some cases exposed reinforcement
- Minor cracking/spalling: defined where a panel that exhibits small cracks on its surface. These are commonly transverse across the panel width and usually expected to be seen at the centre of the panel

Cracking close to the supports (circa within 500mm) is of significant particular concern because it could be representative of shear cracking. Cracking close to a bearing should be recorded and cracks across the full width of a panel are considered more serious than cracks local to the edges

3.5 Builder's works/building modifications

Builders work that was not part of the original construction can result in panels being cut or drilled for new services.

Sometimes new trimming beams may have been installed but the designers of the trimming may not have been aware of the impact of the loss of transverse anchorage reinforcement at the bearing and therefore the support provided to cut panels may be inadequate.

In some instances, small diameter core holes may result in longitudinal or transverse reinforcement being cut or damaged or mechanical damage to the RAAC panels both of which will weaken RAAC panels presenting a risk of failure as with cut-panels or inadequate bearing lengths.

Note: While fixing into RAAC are outside of the scope of this report, care is needed with fixings due to the low strength nature of the AAC and fixings have been known to pull out. Where critical or heavy services are fixed into RAAC these should be checked.

3.6 Water ingress

Prolonged water ingress can impact on RAAC. Water ingress can saturate RAAC panels giving risk to a potential increase in panel weight. Water ingress has also been noted as adversely impacting on the material strength and is likely to lead to unseen corrosion to the reinforcement.

The increase in weight and loss of material strength adversely impacts on the panel strength and load-carrying capacity.

The corrosion of reinforcement will, over time, lead to spalling of the surrounding RAAC panel resulting in falling debris and potential for loss of panel capacity. The corrosion of reinforcement may also impact on the bond between RAAC and embedded reinforcement, which may adversely impact panel strength.

It should be noted that due to the open nature of the AAC matrix significant levels of corrosion can occur before spalling of the cover concrete occurs. The corrosion can therefore be well established before there are obvious external signs.

Water penetration is normally evident through visual inspection. It can be noted where a panel is showing signs of staining, salt crystallisation or corrosion/spalling.

Water ingress may also be noted through adjacent elements, such as finishes or masonry where salt crystallisation or staining may also be evident.

Water ingress presents a significant contributing risk. Therefore, any panels with water ingress should be recorded and the significance assessed.

3.7 Deflection measurements

There are several factors that may result in high deflections of RAAC panels. RAAC panels which are exhibiting high deflections may increase the risk of water ponding and increases in loading and / or lead to a change in bearing stresses. Both factors being potential failure risks.

The deflection of RAAC panels can often be noted visually, however measurement is required to ascertain accurate deflection data. The deflection of panels should be recorded and the data should be used to classify the deflection of each panel as follows:

- Deflection equal to panel span/100 or greater
- Deflection between span/100 and span/200
- Deflection between span/200 and span/250
- Deflection equal to panel span/250 or less

The differential deflection between adjacent panels should also be recorded, particularly where this is significant. Deflections exceeding 20mm between panels being considered significant.

3.8 Adverse or changes in loading

Poor roof drainage can result in the build-up of water on flat roofs which can be further exacerbated by vegetation build up. These situations can result in elevated and prolonged loading of panels. Changes in roof level can also lead to drifting of snow and locally increased loading.

Any areas where additional loading associated with a change or use, new suspended or supported building services equipment, changes in ceiling or roof finishes should be considered potential adverse loading.

Changes in loading regime beyond that which the structure was originally intended could overload the panels above the original design load allowances.

Any increase in loading could significantly impact on the RAAC installation, particularly when combined with other risk factors; such as poor bearing or water ingress.

4 Assessment of risk

It is recommended that the surveys information is used to assess a risk classification for the panels/building. The below RAG (Red, Amber, Green) risk rating approach is proposed as set out below.

Red risks have been split into High risk and Critical risk. The application of qualified and experienced engineering judgement is required to assess when a Critical risk exists. Critical risks may exist where multiple risks exist for example major cracking and adverse loading conditions. The use of the building may also be a factor in the assessment. **Depending on condition Critical risk areas may need immediate action. Final selection and urgency of mitigation measures to be determined in conjunction with the building owner/occupants.**

Assessment category	Risk category	
Red	Critical risk	Requires urgent remedial works which may include taking out of use or temporary propping to allow the safe ongoing use of a building. Depending on the extent, this may be part or all of the building. Combined with awareness campaign for occupants including exclusion zones.
	High risk	Requires remedial action as soon as possible. Combined with awareness campaign for occupants, which may include exclusion zones, signage, loading restrictions and the need to report changes of condition, eg, water leaks, debris, change in loading, etc.
Amber	Medium risk	Requires inspection and assessment on a regular basis, eg, annually. Combined with awareness campaign for occupants, which may include signage, loading restrictions and the need to report changes of condition, eg, water leaks, debris, etc.
Green	Low risk	Requires inspection and assessment occasionally, say three year period depending on condition. Combined with awareness campaign for occupants, which may include signage, loading restrictions and the need to report changes of condition, eg, water leaks, debris, etc.

Table 1 – Risk categories

6. Appendix C – Civic Engineers Remedial Work Drawings

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