157606

Aberdeen City Council

RAAC Inspections
Balnagask Mono-Pitches

November 2023

FAIRHURST

CONTROL SHEET

CLIENT: Aberdeen City Council

PROJECT TITLE: RAAC Inspections - Balnagask Mono-Pitched Properties

REPORT TITLE: Intrusive Inspection Report

PROJECT REFERENCE: 157606

DOCUMENT NUMBER: 157606/Report

Original Issue	Issue 1	Name	Signature	Date
	Prepared by	[redacted]	[redacted]	15/11/2023
	Checked by	[redacted]		15/11/2023
	Approved by	[redacted]		15/11/2023

Update Record	Issue	Date	Status	Description	Signature	
	2	16/11/23		Corrections to deflection tables and update to Short-term Management Strategy text	Prepared By	[redacted]
					Checked	[redacted]
					Approved	[redacted]
	3	17/11/23		Updated following ACC commnets	Prepared By	[redacted]
					Checked	[redacted]
					Approved	[redacted]
	4				Prepared By	
					Checked	
					Approved	

Contents

1. Introduction

1.1. Fairhurst have been appointed by Aberdeen City Council to carry out intrusive inspections to assess the condition of the Reinforced Autoclaved Aerated Concrete (RAAC) roof panels at the Balnagask mono-pitched type residential properties in Aberdeen.

1.2. This report describes the intrusive inspection, our assessment of the condition and our recommendations for any remedial works and / or management strategies for the following example properties:

- [redacted] **Balnagask Road, Aberdeen**
- [redacted] **Pentland Crescent, Aberdeen**

2. Background and Reference Documents

2.1. Following the sudden collapse of a flat roof, constructed of RAAC panels, in a school in 2018, the Standing Committee on Structural Safety (SCOSS) issued an alert in May 2019 aimed at building owners, consultants and contractors involved in premises with RAAC panel roofs.

2.2. The Institution of Structural Engineers (IStructE) have since issued the following documents, which we have referenced and based our assessment on:

2.2.1. Reinforced Autoclaved Aerated Concrete (RAAC) Panels - Investigation & Assessment - February 2022

2.2.2. Reinforced Autoclaved Aerated Concrete (RAAC) - Investigation and Assessment - Further Guidance - April 2023

2.3. RAAC is a lightweight, 'bubbly' form of concrete, commonly used in construction between the 1950s and mid-1990s. It is predominantly found as pre-cast panels in roofs (commonly flat roofs, sometimes pitched).

2.4. RAAC panels are typically 600mm wide, although this has been known to vary. Their length will vary, typically up to 6m. They typically have a chamfer along their edge meaning there is a distinctive V-shaped groove at 600mm centres between the panels.

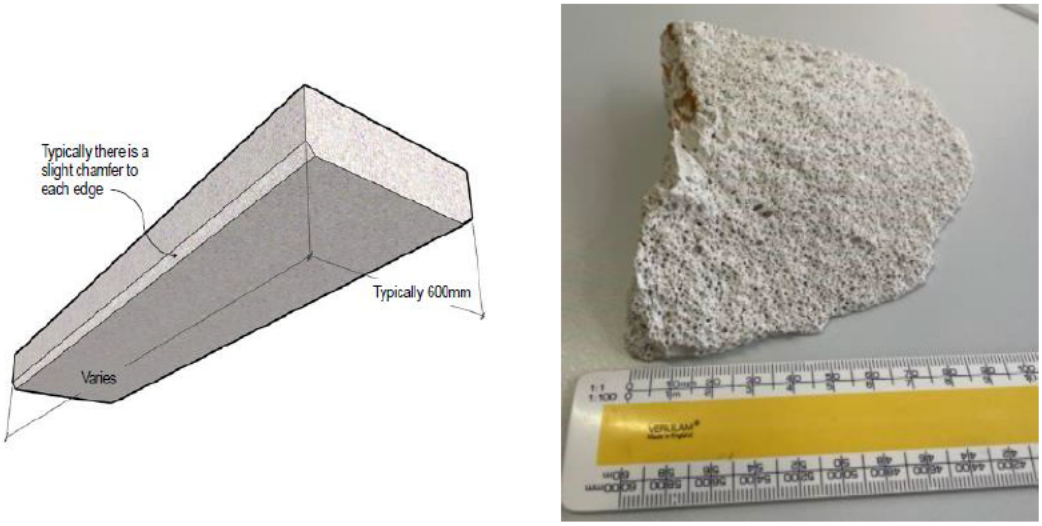


Figure 1: Typical RAAC Construction

3. Existing Construction

3.1. Typically, the properties are two-storey buildings of traditional cavity blockwork wall construction with mono-pitched 125mm (5") thick RAAC roof panels spanning front to back, bearing onto external walls and a 114mm thick central concrete brickwork partition. Please see figures 2-5 showing typical existing building construction.

3.2. Panels span approx. 3.5m at the rear of the property (typically above the living room and bedroom) and approx. 2.5m at the front of the property (typically above the kitchen and bathroom). These are relatively short spans, as RAAC panels can typically span up to 6m.

3.3. The mono-pitched roof construction is typically concealed behind a timber frame and plasterboard ceiling, some of which was retro-fitted (and was removed prior to inspections).

3.4. This property type is either split into ground floor and first floor flats, or is a single two-storey houses.

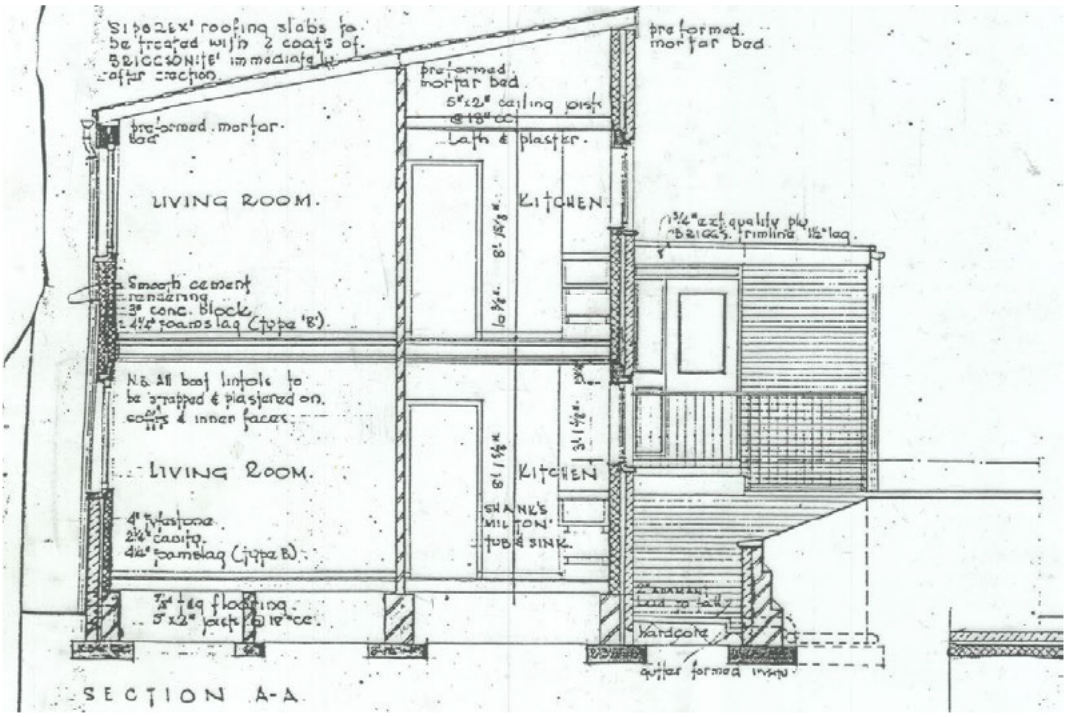


Figure 2: Original section drawing through flatted property

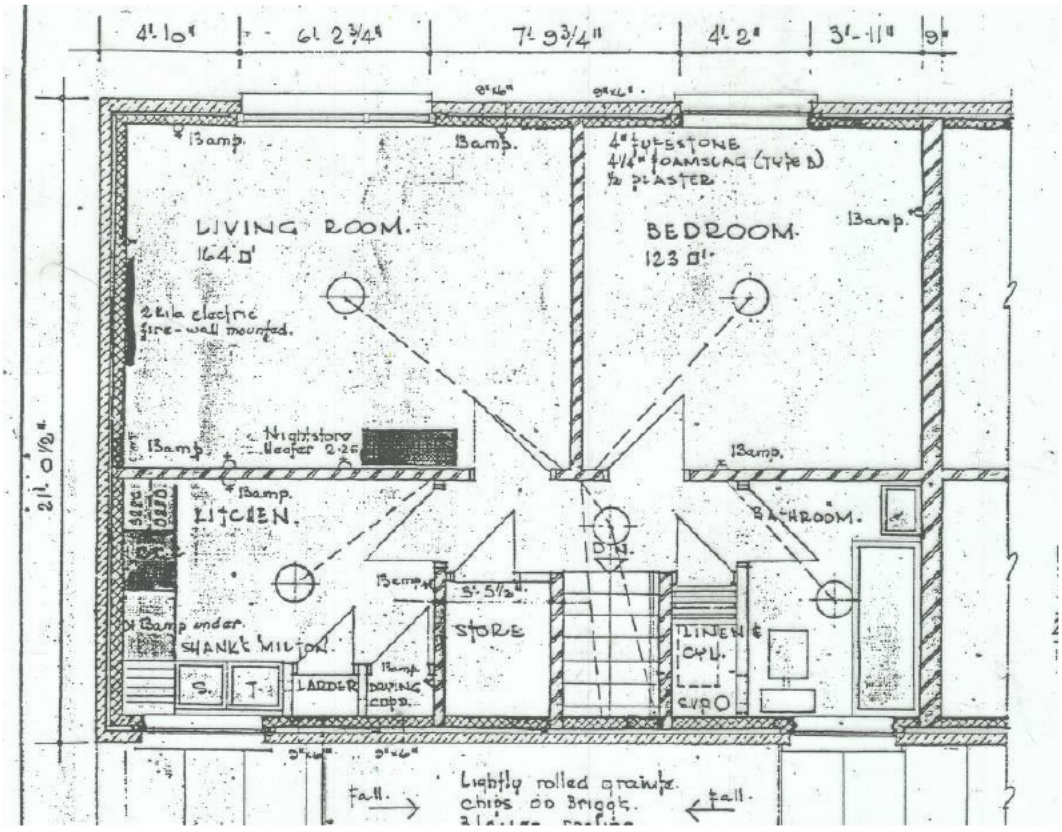


Figure 3: Original floor plan drawing of first floor flat

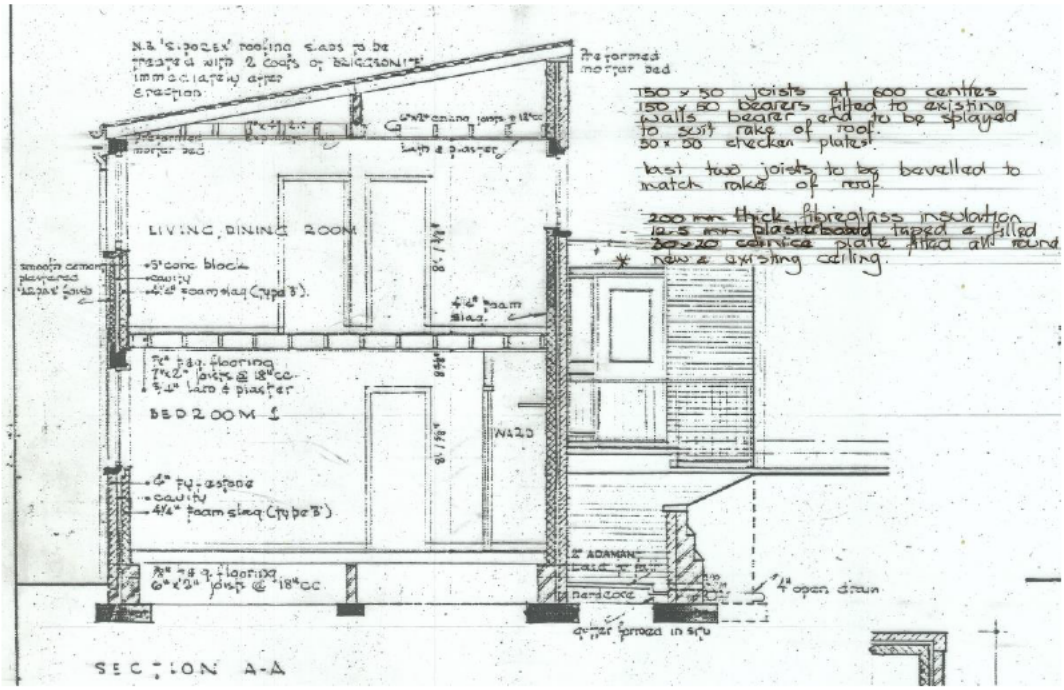


Figure 4: Original section drawing through 2-storey house

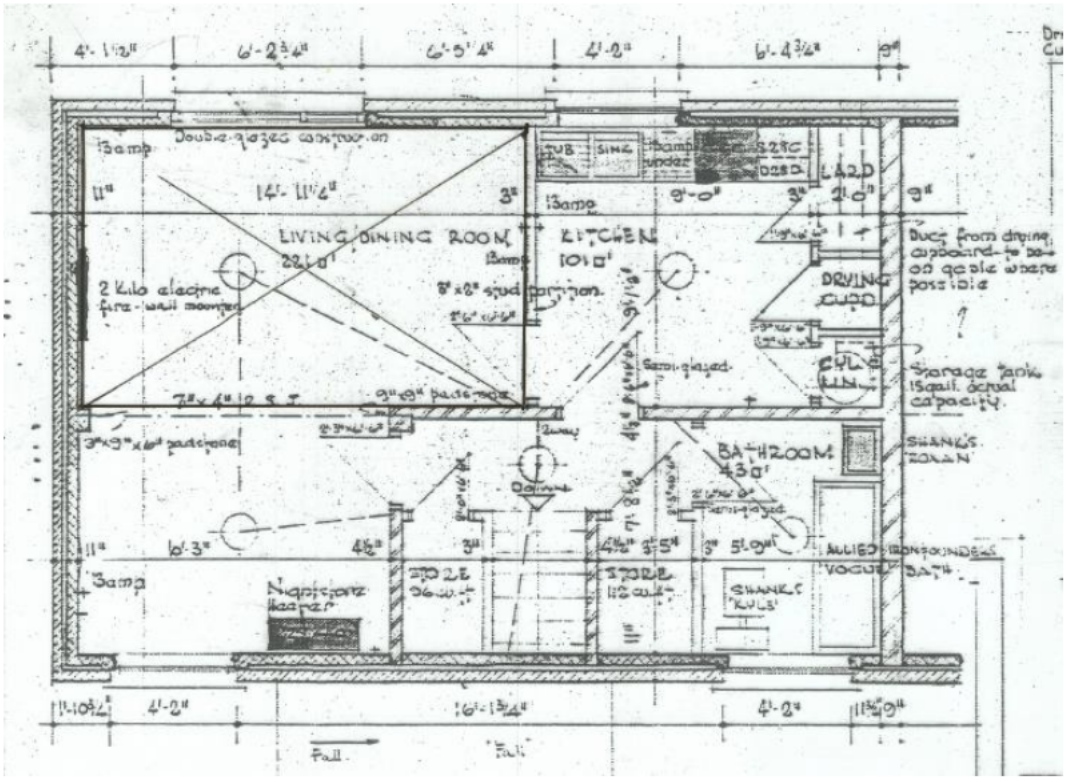


Figure 5: Original floor plan drawing of 2-storey house

3.5. There are also three variations of roof finishes, as per the photographs and architectural details in figures 6-12, below.

Figure 6: Original 'flat' roof system

Figure 7: Refurbished 'flat' roof system

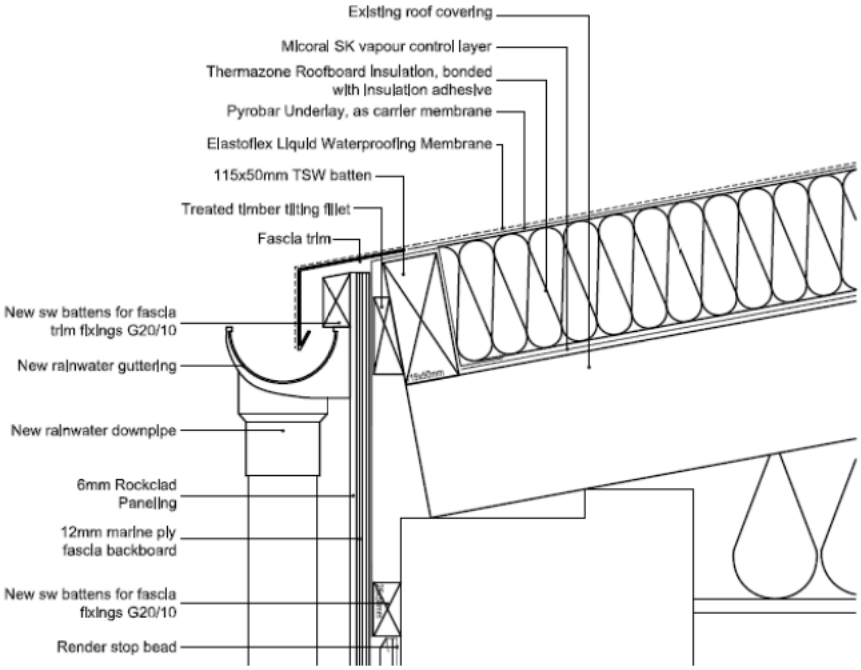


Figure 8: Section detail through eaves of refurbished 'flat' roof system (lower)

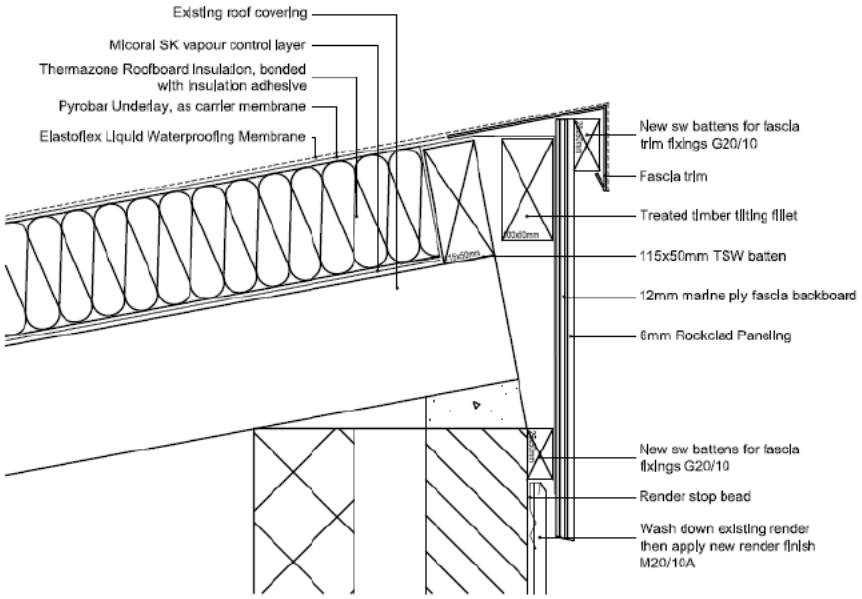


Figure 9: Section detail through eaves of refurbished 'flat' roof system (upper)

Figure 10: Refurbished mansard roof system

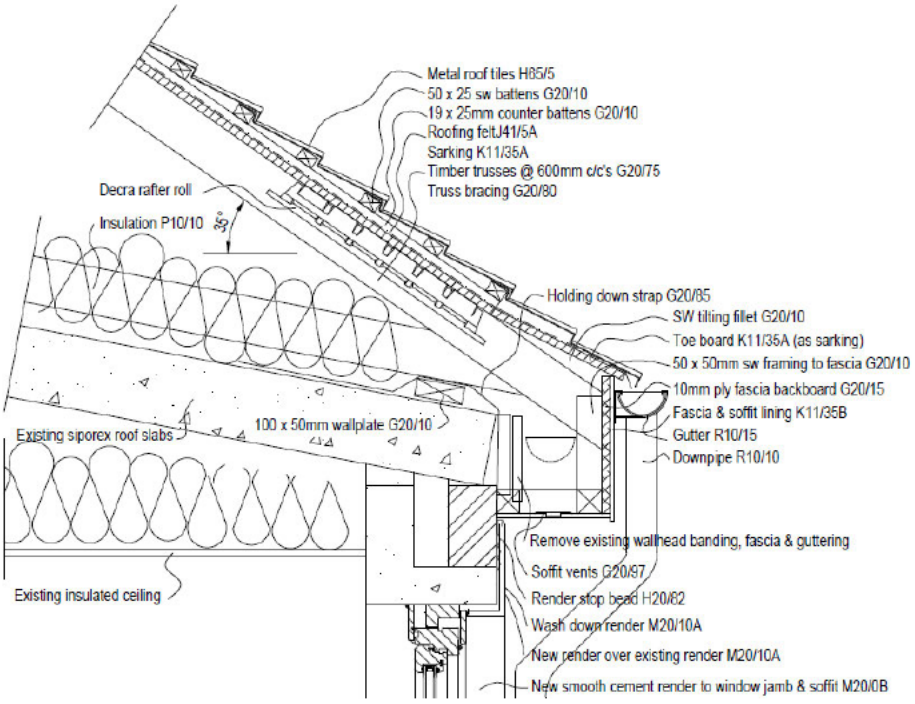


Figure 11: Section detail through eaves of refurbished mansard roof system (lower)

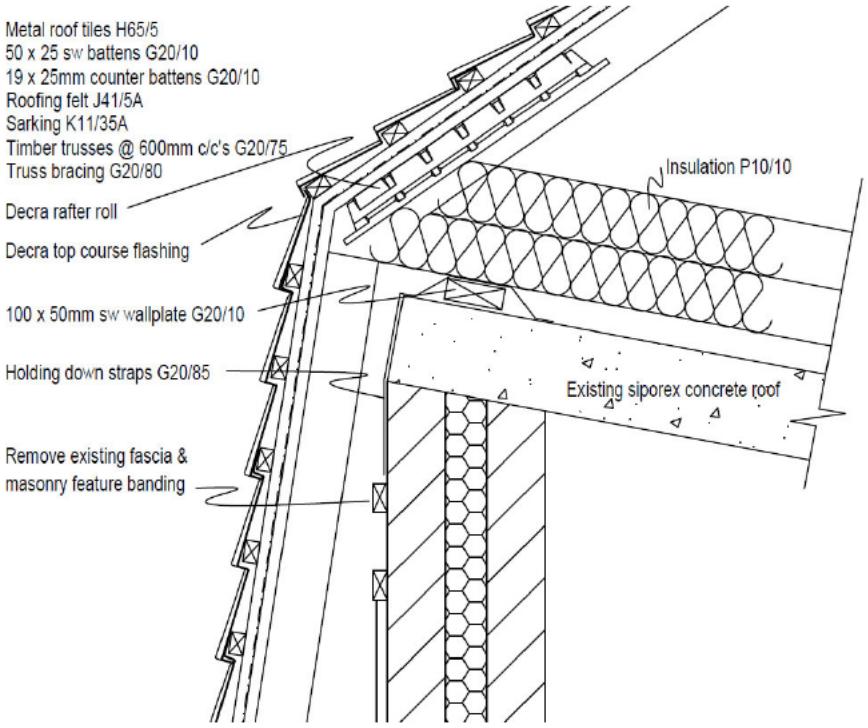


Figure 12: Section detail through eaves of refurbished mansard roof system (upper)

4. Methodology

4.1. The intrusive inspection scope and procedure is based on guidance by The Institution of Structural Engineers (IStructE) - Reinforced Autoclaved Aerated Concrete (RAAC) Investigation and Assessment - Further Guidance - April 2023.

4.2. Following the IStructE assessment guidance, we are aiming to assess the following risk factors:

- End bearing;
- Anchorage reinforcement;
- Cut panels;
- Cracking;
- Builder's works / building modifications;
- Water ingress;
- Deflection measurements;
- Adverse or changes in loading.

4.3. The intrusive inspections therefore consisted of the following works:

4.3.1. Prior to undertaking intrusive surveys, Aberdeen City Council providing confirmation that properties are free of asbestos;

4.3.2. Complete removal of plasterboard ceiling finishes, by contractor;

4.3.3. Erection of access tower, by contractor;

4.3.4. Installation, by contractor, of 2No. props with timber spreader top and bottom within 600mm of the bearing of each slab to be inspected, prior to commencing (as a precaution, should the bearing be insufficient);

4.3.5. Appropriate dust management, by contractor;

4.3.6. Record of deflection of the panels, by Fairhurst;

4.3.7. Record of defects i.e. cut panels, cracks / spalling, builder's works / building modifications, water ingress, by Fairhurst;

4.3.8. Tap test any water damaged areas, by Fairhurst;

4.3.9. Ferro-scan to surface of concrete to locate embedded reinforcement, by Fairhurst;

4.3.10. Breaking-out of concrete at the bearing, by contractor, at the junction between the panels. Record of bearing length, panel depth and anchorage reinforcement arrangement, by Fairhurst;

4.3.11. Breaking out works carried out by contractor using non-percussive drill, hammer, narrow chisel and wire brush;

4.3.12. Broken out areas made good by contractor as follows, ensuring separation is retained between the panels, with all products stored and applied in accordance with the manufacturer's written instructions:

- Bonding primer - Sika MonoTop-1010;
- Repair mortar - Sika MonoTop-615;
- Concrete protection - Sika Ferrogard-903+ liquid corrosion inhibitor;

5. Observations

5.1. Our intrusive inspection observations are based on the guidance by IStructE - Reinforced Autoclaved Aerated Concrete (RAAC) Investigation and Assessment - Further Guidance - April 2023, and examine the following risk factors:

- End bearing;
- Anchorage reinforcement;
- Cut panels;
- Cracking;
- Builder's works / building modifications;
- Water ingress;
- Deflection measurements;
- Adverse or changes in loading;

5.2. Assessment of risk:

5.2.1. The IStructE employs a risk rating approach, as shown below, to assess the risk associated with each inspection factor, with the caveat that the "tables are non-exhaustive and the matrices approach is an initial recommendation. It is expected that the structural engineer will assess each case individually and use their judgement to aggregate the risks, based on the local conditions to determine an appropriate risk category."

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

Fig 13: IStructE Table 1 - Risk Categories;

5.3. End bearing:

5.3.1. The IStructE guidance states that although the Codes of Practice from the 1950's to 1980's (CP114 & CP116) recommended minimum end bearings of 45mm for roof panels, "a minimum as built bearing length of 75mm is now considered to be necessary. Any bearing less than 75mm would be considered substandard". They have 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.";

5.4. Anchorage reinforcement:

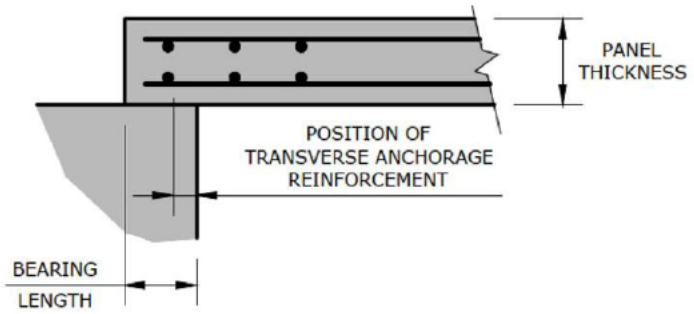


Fig 14: The transverse and longitudinal anchorage reinforcement requirements over supports;

4.1.1 Support condition

Support / bearing condition	Risk category
Bearing investigated and found to lack required transverse reinforcement	Red (critical)
Cut or modified panels, including where cut panels are supported on proprietary hangers	Red (critical)
Bearing <75mm with transverse anchorage reinforcement	Red
>75mm with transverse anchorage reinforcement	Green

Table 2 – Support/bearing risk category

Fig 15: IStructE Table 2 - Support / Bearing Risk Category;

5.4.1. As can be seen from IStructE Table 2, above, the assessment of the risk category that applies depends on the transverse anchorage reinforcement location. The location of which is determined by breaking-out of concrete at the bearing at the junction between two panels. Where transverse anchorage reinforcement is absent, the longitudinal bars will have significantly reduced tensile capacity and there is an increased risk of failure.

5.5. Cut panels:

5.5.1. The IStructE guidance states that cut panels typically "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."

5.6. **Cracking:**

5.6.1. The IStructE guidance states that "cracking and spalling can be a visible indicator of excessive deflections, water ingress, mechanical damage or reinforcement corrosion… 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."

5.6.2. Cracks are defined as major or minor, as below:

5.6.2.1. Major cracking/spalling: defined where a panel exhibits large/deep cracks that may be accompanied by spalling and in some cases exposed reinforcement;

5.6.2.2. 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

5.7. **Water ingress:**

5.7.1. The IStructE guidance states that "prolonged water ingress can impact on RAAC" due to saturated panels leading to an increase in panel weight, impacting material strength and causing corrosion of the reinforcement leading, over time, to de-bonding and spalling of the surrounding RAAC panel, which may adversely impact panel strength;

5.7.2. The IStructE also states 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.";

5.8. **Deflection measurements**

5.8.1. The IStructE guidance states that "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;

5.8.2. The noted deflections are combined with the assessments of the cracks and presence / absence of water ingress, as per tables 3 & 4 below:

4.1.2 Panel construction

The panel condition is a function of cracking, deflection, and water ingress.

Where water ingress is observed it may be difficult to ascertain the period and therefore the impact that this may have had on the panel strength. Therefore, all water ingress is considered Red / Amber risk.

Risk assessment if water ingress is observed				
Deflection	Major cracking or spalling	Minor cracking/ or spalling within 500mm of support	Minor cracking or spalling away from the supports	No visible defect
Deflection >span/100	Red	Red	Red	Red
Span/100<deflection<span/200	Red	Red	Red	Red
Span/200<deflection<span/250	Red	Red	Amber	Amber
Deflection<span/250	Red	Red	Amber	Amber

Table 3 – Risk category with water ingress

Risk assessment if NO water ingress is observed				
Deflection	Major cracking or spalling	Minor cracking/ or spalling within 500mm of support	Minor cracking or spalling away from the supports	No visible defect
Deflection >span/100	Red	Red	Red	Red
Span/100<deflection<span/200	Red	Red	Amber	Amber
Span/200<deflection<span/250	Red	Amber	Green	Green
Deflection<span/250	Red	Amber	Green	Green

Table 4 – Risk category with NO water ingress

Fig 16: IStructE Tables 3&4 - Risk Categories with / without water ingress;

5.9. Adverse or changes in loading:

5.9.1. The replacement roofing system with the additional insulation at the refurbished properties are likely experiencing an increase in dead loading;

5.9.2. There are no parapets at these properties and therefore snow drift is not a concern;

5.9.3. All properties are located within 1.5km of the coastline and therefore present a lower risk of heavy snowfall;

5.9.4. RAAC panels at this type of property would have been designed for a snow load of 0.75kN/m2, however, current standards require only 0.6kN/m2;

6. Summary of Findings

6.1. Following a review of the survey findings, please see below summary table of our risk factor assessment:

Risk Factors	Assessment
End bearing	External wall supports all exceeded 75mm bearing
	Internal wall supports ranged between 40mm - 60mm bearing, with 1No. panel noted to be as low as 10mm
Anchorage/longitudinal reinforcement	Anchorage reinforcement missing to at least 1No. panel
Cut panels	None
Cracking	Transverse cracking found along full length of panel and within 500mm of the support. Spalling and corrosion of rebar also observed
Builder's works / building modifications	Damaged units from cable conduits and SVPs
Water ingress	Dampness has been noted to underside of panels
Deflection measurements	Lowest measurement span / 133, but with major cracking and spalling
Adverse or changes in loading	Replacement roofing systems with additional insulation

7. Remediation and Mitigation Options Appraisal

7.1. Based on the above risk factor assessment, in general, the properties fall into both critical and high risk categories.

7.2. Based on the below risk assessment categories provided by the IStructE, these categories require remedial action urgently / as soon as possible.

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

Fig 17: IStructE Table 1 - Risk Categories;

7.3. We have detailed and reviewed the various options for remedial action and mitigation below, in line with the recommendations outlined by the IStructE:

Option	Scope	Advantages / Disadvantages
Enhanced bearing	Installation of timber/steel runners to both sides of central load-bearing brickwork partition, directly beneath bearing of all panels, fixed into brickwork, to increase the effective bearing length.	– Access to occupied properties required; – Potentially requires temporary decant of residents; – Only rectifies issue with bearing length / anchorage reinforcement with no effect on other noted defects; – Ongoing visual inspection regime required to monitor / assess remaining RAAC panels, with future remedial works likely required.
Secondary support structure (positive / passive)	Installation of timber joists below RAAC panels, across whole roof area, either to provide direct support to the panels or create a protective deck should the panels fail.	– Access to occupied properties required; – Requires temporary decant of residents; – Likely cost prohibitive.
Partial replacement	Removal of individual panels and replacement with new timber roof structure.	– Access to occupied properties required; – Requires temporary decant of residents; – Ongoing visual inspection regime required to monitor / assess remaining RAAC panels, with future replacements likely required.
Complete replacement	Complete removal of all panels and replacement with new timber roof structure.	– Complete replacement eliminates hazards posed by RAAC panels and extends life of properties; – Requires temporary decant of residents; – Likely cost prohibitive.
Planned decant	Decant residents to alternative accommodation and demolition of RAAC affected properties.	– Most disruptive; – Eliminates hazards posed by RAAC panels.

8. Recommendations

8.1. Based on the above risk factor assessment and options appraisal, we recommend thorough re-evaluation of the occupancy condition for the properties identified with RAAC concerns with a particular focus towards rehousing those affected properties as per the IStructE guidance document.

8.2. Medium and long-term management strategies can only be applied to Amber (Medium risk) and Green (Low Risk) RAAC panels. Due to prevalence Red (Critical or High risk) panels within the properties sampled and as per IStructE guidance medium long term management strategies can only be applied if remedial works were undertaken to reduce the risk profile of each property back to a category of Amber (Medium risk) and/or Green (Low risk)

8.3. Alternative remedial action options are typically either cost prohibitive, potentially equally disruptive, or are only a temporary solution for properties beyond their serviceable life, requiring extensive ongoing monitoring and maintenance.

8.4. Priority consideration should be given to first floor flats and 2-storey houses (i.e. those properties directly affected by having RAAC roof panels). This prioritisation would help reduece disruption to the property occupants.

8.5. We also recommend the implementation of the below short-term management strategy for properties. These interim measures should be pursued in a manner that ensures the safety and well-being of occupants while minimising disruption.

9. Short-term Management Strategy

9.1. As the RAAC panels will continue to deteriorate over time, the following short-term management strategy should be applied to properties containing RAAC panels until such time as the property is decanted.

9.2. Visual inspections of occupied properties should be undertaken to continually monitor and assess the condition of the RAAC panels, consisting of the following:

9.2.1. Asbestos survey of ceiling finishes within each property;

9.2.2. Opening and installation of 3No. ceiling hatches within each property, by contractor. Where required instrusive surveys will be carried out by a non-precussive drill to ascertain the as built bearing of the RAAC panels.

9.3. An awareness campaign should be actioned for all owners and occupants, including the following:

9.3.1. Letters / signage indicating the presence of RAAC roof panels within the property, ensuring all owners / occupants / users are aware of the concerns relating to RAAC and providing reassurances that appropriate measures are being undertaken;

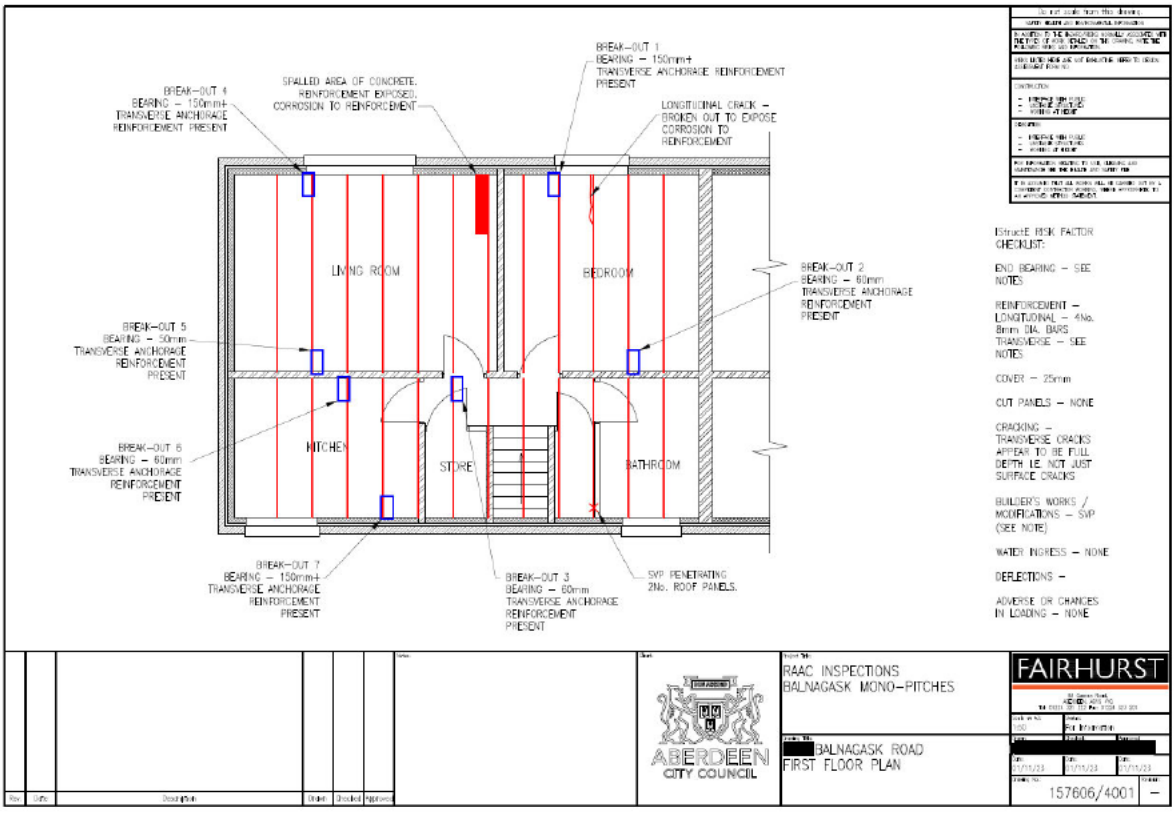
9.3.2. No additional loads are to be applied to any RAAC roof panel. Roof to be treated as a fragile roof by requiring access to the roof;

9.3.3. Building owner / occupant to report any changes of condition (water leaks, cracks, debris etc.);

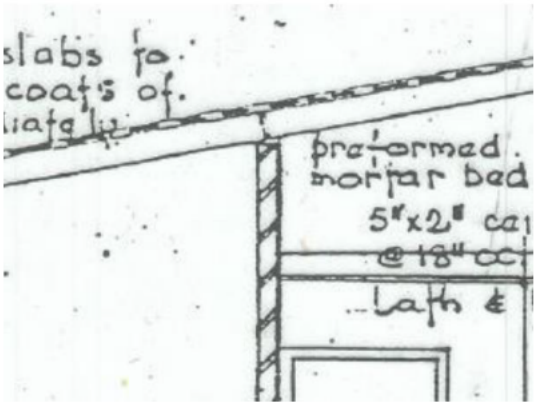
9.3.4. Significant weather events to be monitored by the building owner inc. heavy snowfall, heavy rainfall and storms, at which point, properties still in use should be re-inspected.

10. [redacted] Balnagask Road, Aberdeen

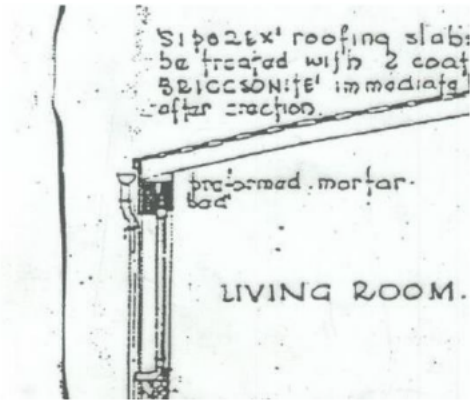
10.1. Fairhurst survey overmark 157606/4001;

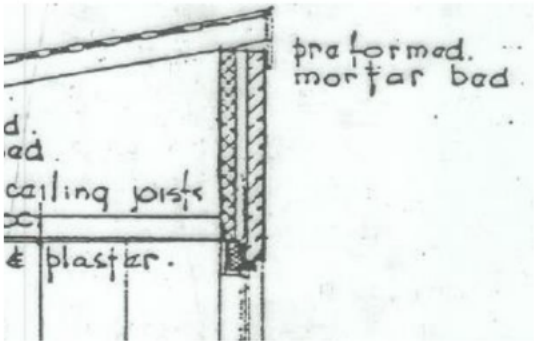


10.2. Panel bearings at central load bearing internal brickwork partition are typically 40-60mm i.e. 2no. panels bearing onto 114mm thk brickwork wall (<75mm requirement);



10.3. Panel bearings at front and rear external walls are typically 150mm+ (>75mm requirement);





10.4. The transverse anchorage reinforcement was present over the bearing at all panels inspected;

10.5. We did not identify any cut panels within [redacted] Balnagask Road;

10.6. Consistent transverse cracks along the full length of the panels and close to the bearings were noted throughout [redacted] Balnagask Road;

10.7. These transverse cracks typically travel through the full depth of the panels, and therefore should be classed as 'major';

10.8. We also noted several longitudinal cracks to the panels. These are typically combined with spalling of the concrete and corrosion of the longitudinal reinforcement bar;

10.9. SVPs were noted at the property. These are located within a cupboard, penetrate two of the RAAC panels and project from the roof. These are shown on the original drawings, however, the penetrations appear to have been carried out on site, with damage to the panel and reinforcement visible;

10.10. No signs of prolonged water ingress were noted at the property;

10.11. 6No. locations were measured for mid-span deflection. 1No. panel was used as a control as it was supported by the internal brickwork partition along its full length. The deflections of the adjacent panels were measured against this control panel, with results as follows:

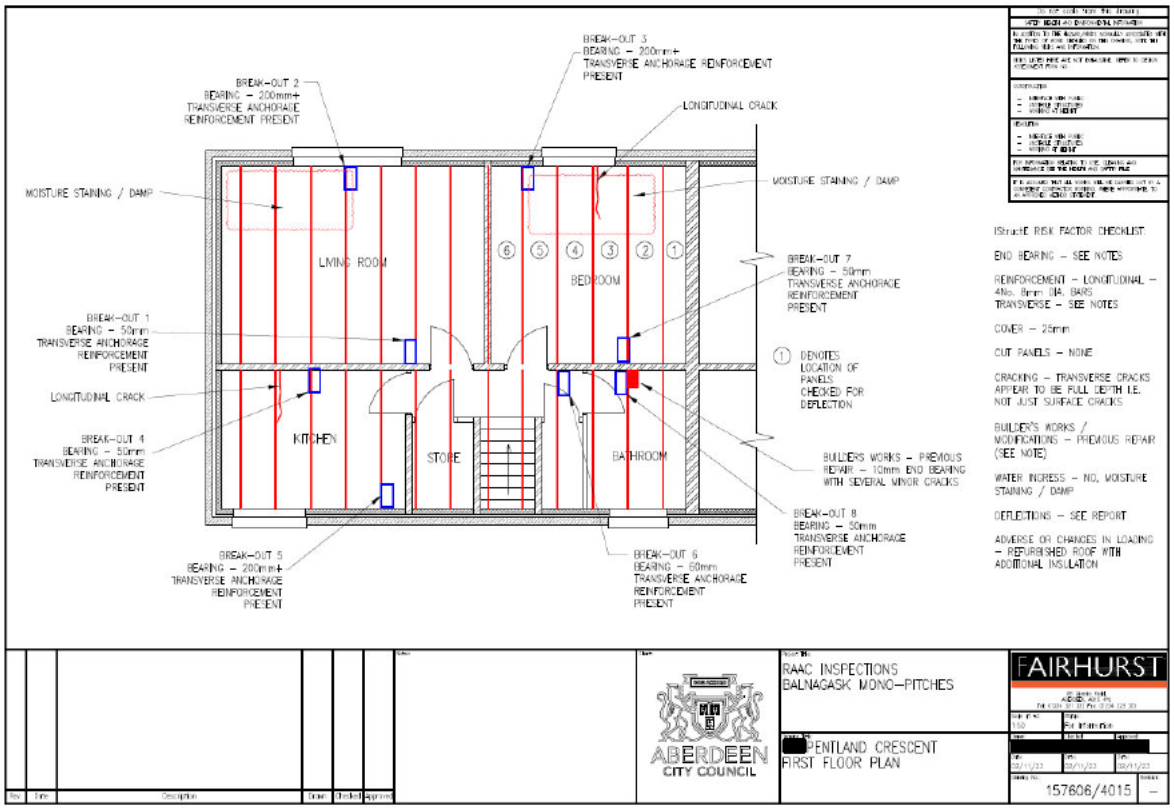
- Mid-span deflection = 0mm (control - full length supported on brick partition)
- Mid-span deflection = 16mm, i.e.: Span/200
- Mid-span deflection = 26mm, i.e.: Span/133
- Mid-span deflection = 15mm, i.e.: Span/213
- Mid-span deflection = 24mm, i.e.: Span/133
- Mid-span deflection = 10mm, i.e.: Span/320

10.12. Following a review of the survey findings, please see below summary table of our risk factor assessment:

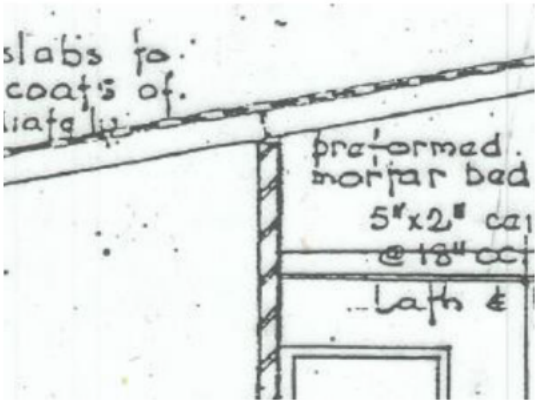
Risk Factors	**Assessment**
End bearing	External wall support exceeds 75mm bearing
	Internal wall support ranged from 40-60mm bearing
Anchorage reinforcement	Found over the support in all areas inspected
Cut panels	None
Cracking	Transverse cracking found along full length of panel and within 500mm of the support. Spalling also found
Builder's works / building modifications	Cored on site with damage to units
Water ingress	None
Deflection measurements	Range span/133 to span/320 with major cracking with in 500mm of supports and spalling
Adverse or changes in loading	None

11. [redacted] Pentland Crescent, Aberdeen

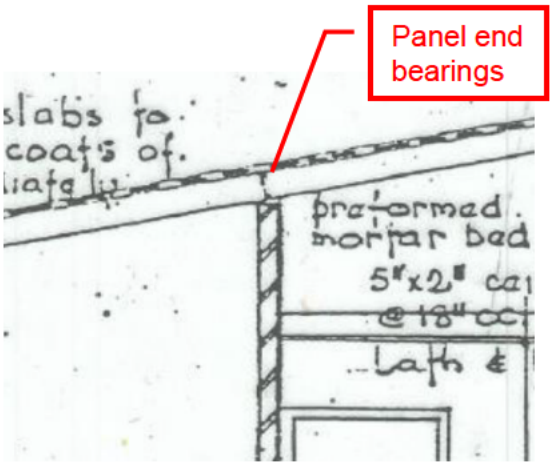
11.1. Fairhurst survey overmark 157606/4015;



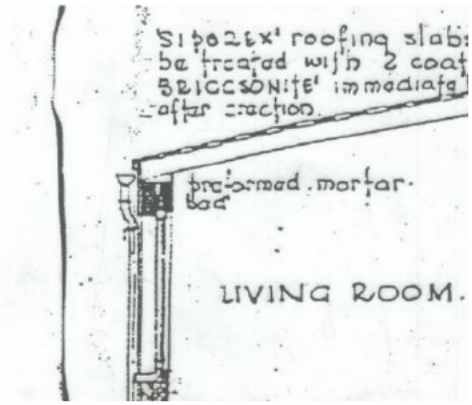
11.2. Panel bearings at central load bearing internal brickwork partition are typically 40-60mm i.e. 2no. panels bearing onto 114mm thick brickwork wall (<75mm requirement);

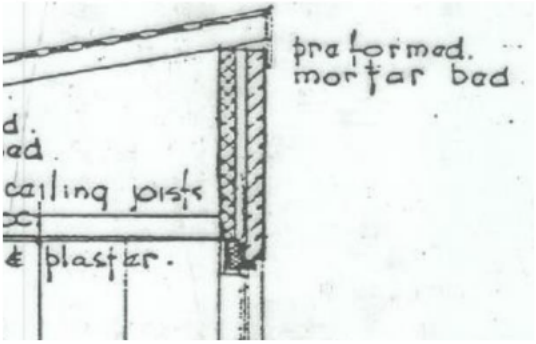


11.3. 1No. panel was seen to have a bearing at the central load bearing internal brickwork partition of approx. 10mm (<75mm requirement), with the gap between the end-to-end panels filled with poor quality infill mortar and general builder's debris.



11.4. Panel bearings at front and rear external walls are typically 150mm+ (>75mm requirement);





11.5. The transverse anchorage reinforcement was present over the bearing at all other panels inspected;

11.6. We did not identify any cut panels within [redacted] Pentland Crescent;

11.7. Consistent transverse cracks along the full length of the panels and close to the bearings were noted throughout [redacted] Pentland Crescent;

11.8. These transverse cracks typically travel through the full depth of the panels, and therefore should be classed as 'major';

11.9. We also noted several longitudinal cracks to the panels. These are typically combined with spalling of the concrete and corrosion of the longitudinal reinforcement bar;

11.10. SVPs were noted at the property. These are located within a cupboard, penetrate two of the RAAC panels and project from the roof. These are shown on the original drawings, however, the penetrations appear to have been carried out on site, with damage to the panel and reinforcement visible;

11.11. No signs of prolonged water ingress were noted at the property, however, there was moisture staining / damp to the underside of the roof panels;

11.12. 4No. locations were measured for mid-span deflection. 1No. panel was used as a control as it was supported by the internal brickwork partition along its full length. The deflections of the adjacent panels were measured against this control panel, with results as follows:

- Mid-span deflection = 0mm (control - full length supported on brick partition)
- Mid-span deflection = 11mm, i.e.: Span/290
- Mid-span deflection = 10mm, i.e.: Span/320
- Mid-span deflection = 8mm, i.e.: Span/400

11.13. Following a review of the survey findings, please see below summary table of our risk factor assessment for [redacted] Pentland Crescent:

Risk Factors	**Assessment**
End bearing	External wall supports all exceeded 75mm bearing
	Internal wall supports ranged between 10mm - 60mm bearing
Anchorage/longitudinal reinforcement	Anchorage reinforcement missing to at least 1No. panel
Cut panels	None
Cracking	Transverse cracking found along full length of panel and within 500mm of the support. Spalling and corrosion of rebar also observed
Builder's works / building modifications	Damaged unit
Water ingress	Dampness marks have been noted
Deflection measurements	Range span/290 to span/400 with major cracking with in 500mm of supports
Adverse or changes in loading	Replacement roofing system with additional insulation