The Royal Oldham Hospital

STRUCTURAL SURVEY REPORT

July 2022

RAAC PANELS

Ref. 222-013

Issued for	*Originator*	*Checker*	*Approved*	*Date*
Draft revision	Michael Carr	Peter Bryan	Peter Bryan	24.01.2022
Rev 02	Michael Carr	Peter Bryan	Peter Bryan	18.0.7.2022

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1. INTRODUCTION

The Alan Johnston Partnership LTD have been appointed by *Northern Care Alliance NHS Group* to undertake a structural review of the roof areas within the hospital estate where RAAC planks have been identified in their construction. Although several areas were not accessible, this report includes primarily the buildings known as Block A and B, although the roof of blocks C and D were accessible from above, it was not possible to survey the planks from the underside due to patient occupation.

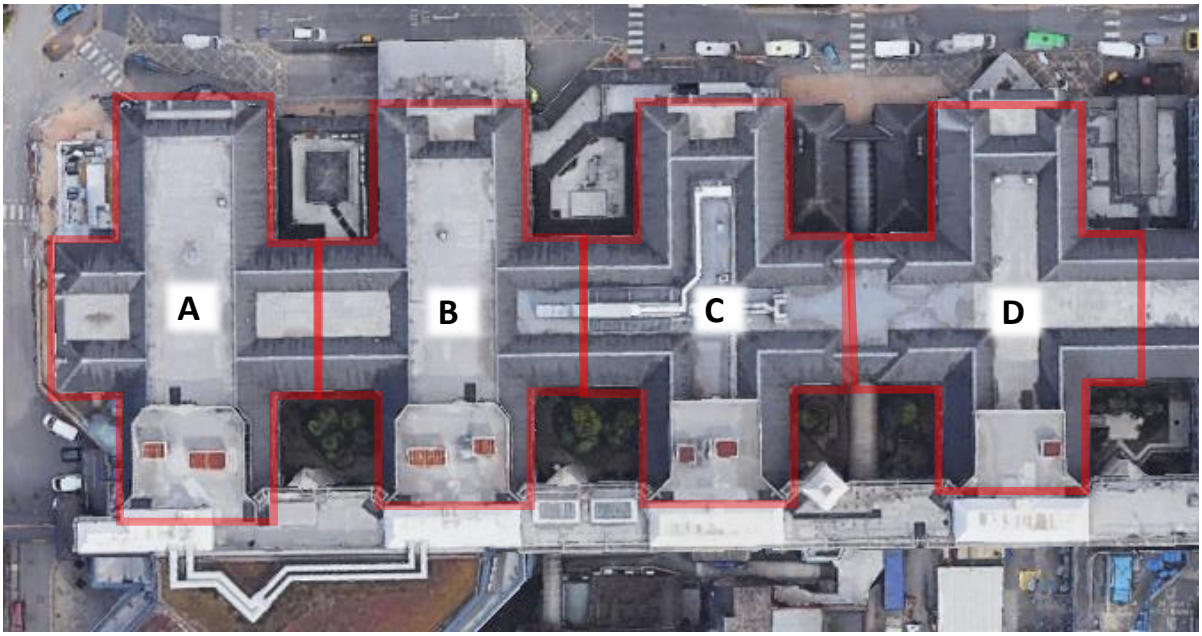

FIGURE 1: SITE PLAN AND BUILDINGS WITHIN SCOPE

Surveying in other areas would be too disruptive to the running of the wards, and would disturb patients

FIGURE 2: AREAS SUCCESSFULLY SURVEYED

Reinforced Autoclaved Aerated Concrete (RAAC) is a construction which has been identified as problematic in certain circumstances and is subject to a checking instruction from the NHSI. This report details the findings of the various inspection carried out since 22nd January 2020, and outlines various recommendations in managing the risks identified.

Schedule of surveys: January 2020, Immediate defects survey
March 2022, Repeat visual survey
April 2022, Covermeter survey
May 2022, GPR survey
June 2022, Repeat visual survey

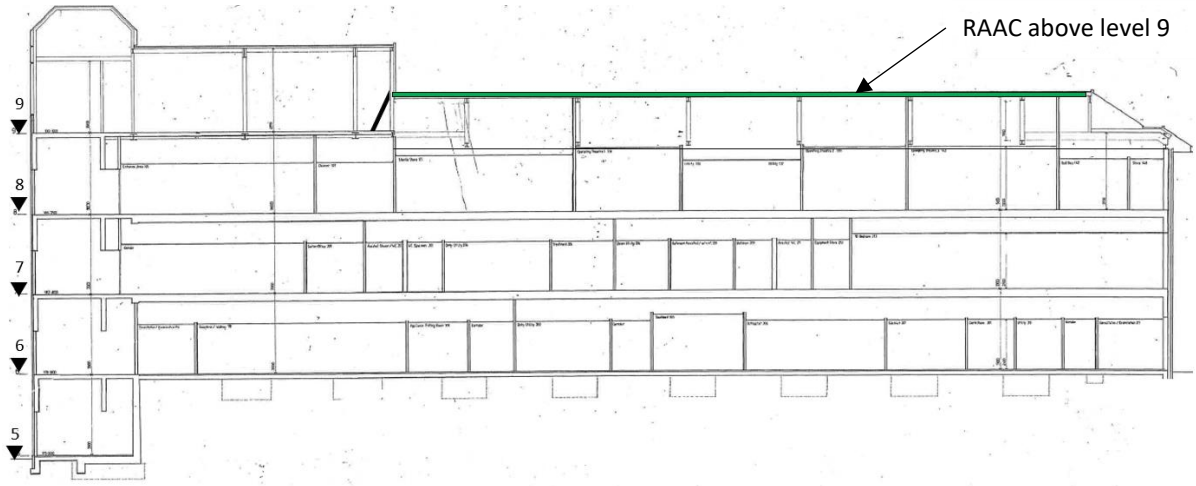

FIGURE 3 – TYPICAL SECTION THROUGH BUILDING

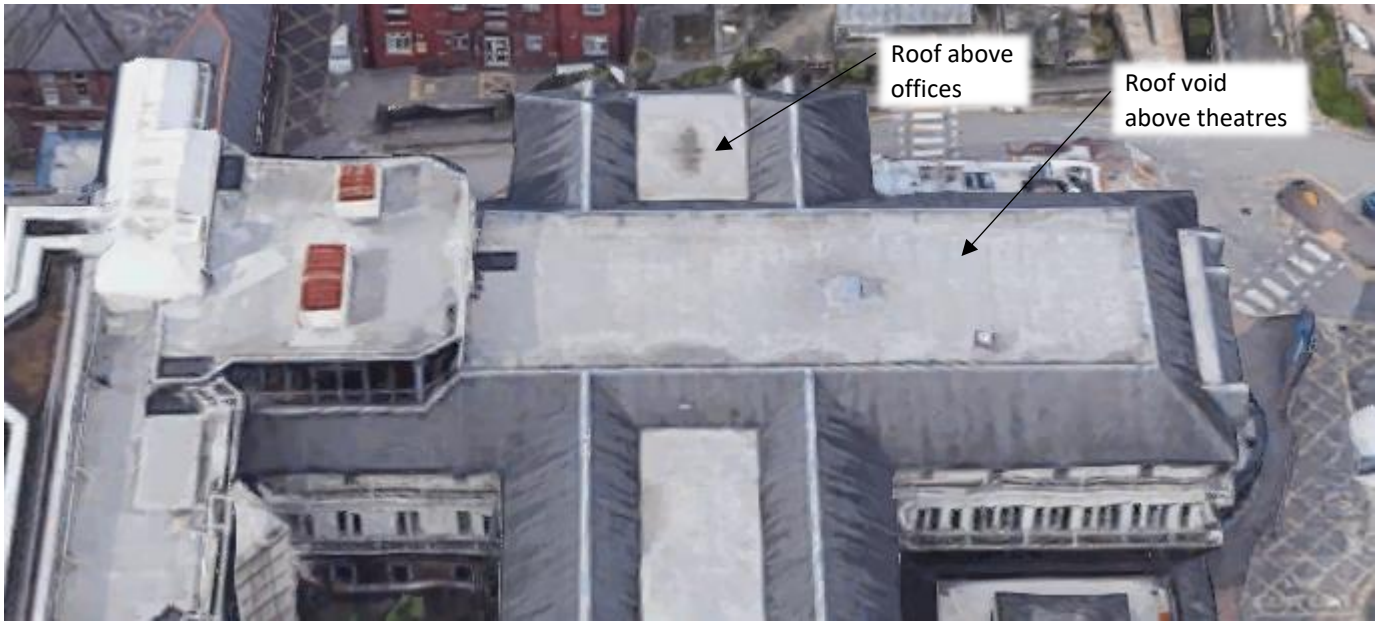

FIGURE 4 – TYPICAL ARRANGEMENT, BLOCK A

2. REINFORCED AUTOCLAVED AERATED CONCRETE

Aerated concrete is different from normal dense concrete. There are no coarse aggregates and the concrete is filled with chemically induced gas bubbles to reduce its weight. It is relatively weak and was used widely in the 1960's – 1980's for roof construction. Several instances of sudden collapse have been attributed to RAAC, which has a useful lifespan estimated to be around 30 years.

In late 2019, the Local Government Association (LGA) drew attention to potential structural issues surrounding RAAC roof plank and made recommendations relating to maintenance and inspection regimes. This was followed by a publication by the Standing Committee on Structural Safety (SCOSS) and the Institution of Structural Engineers (IStructE) which highlights the findings of testing/case studies. Although the brand "Siporex" is common in the North of the UK, wide variations in manufacturing quality and reinforcement arrangements have been identified making it difficult to make assessments based on desktop studies.

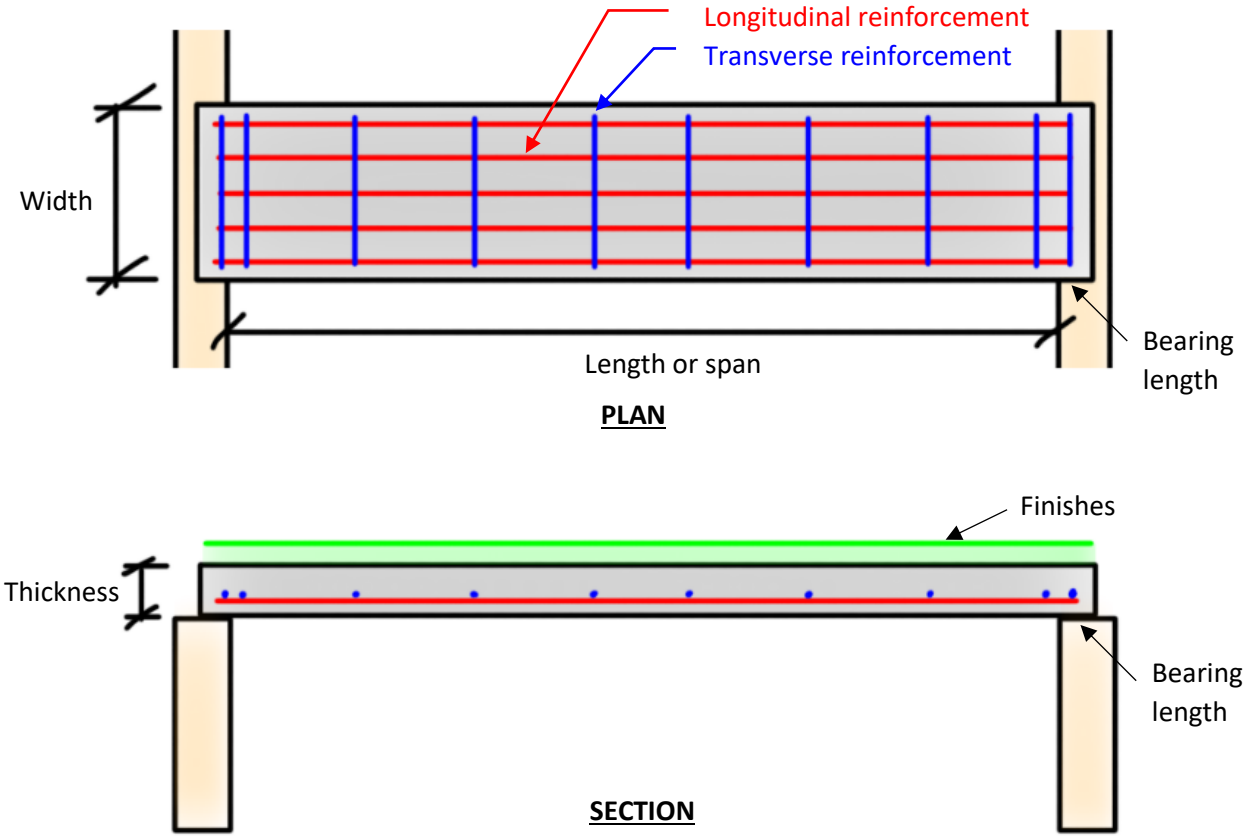

FIGURE 4 – TYPICAL RAAC PLANK

2.1 CAUSES OF RAAC PANEL COLLAPSE

The common causes of plank failures can be summarised as follows:

Insufficient anchorage or missing transverse reinforcement
There can be issues in forming a bond between the AAC and the longitudinal reinforcement due to formation of slip planes or air voids around the bars. This is dealt with by anchoring the longitudinal bars to the transverse bars through welding.

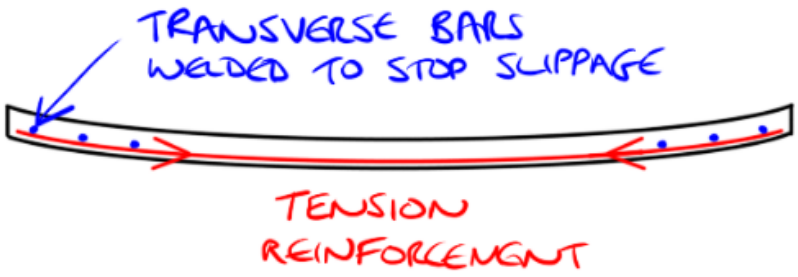

FIGURE 5 – FUNCTION OF TRANSVERSE BARS

Cutting of planks on site
Some planks have been found to feature critical transverse reinforcement in the end of the span only. If the planks are cut, and the transverse bars no longer exist in the plank there is possibility of longitudinal reinforcement debonding and causing plank failure.

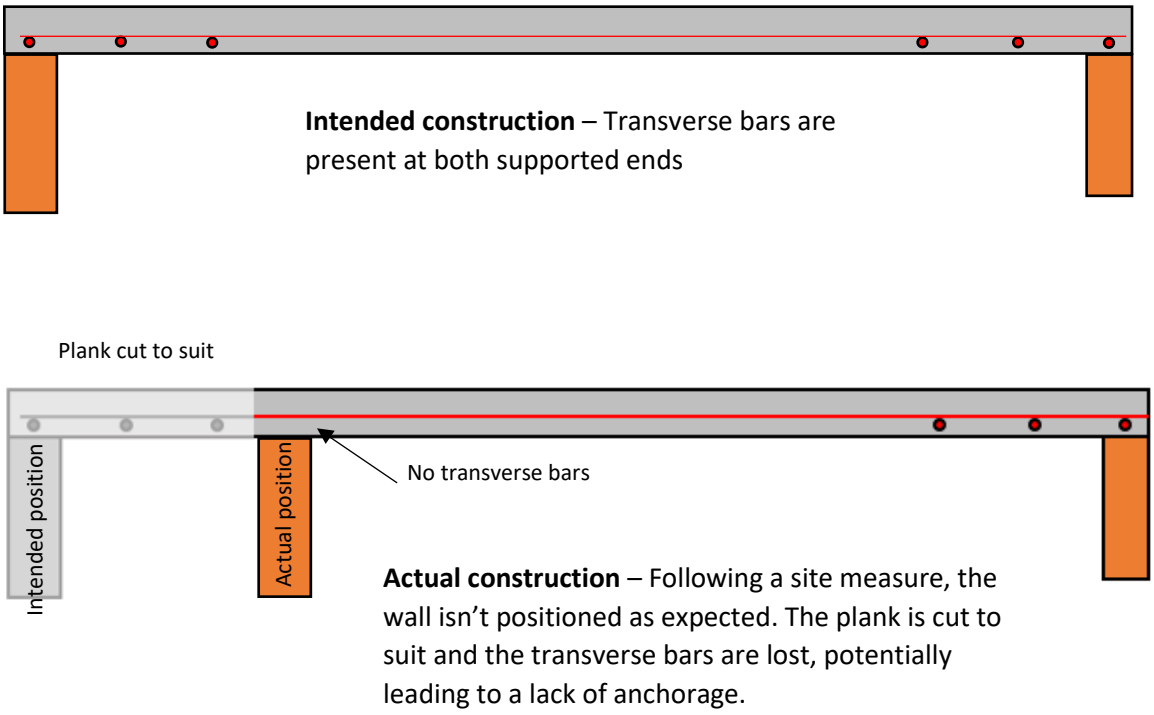

FIGURE 5 – CUT PLANK LEADING TO LACK OF TRANSVERSE BARS

Untrimmed penetrations
Openings formed to allow penetrations to pass through the planks are occasionally left untrimmed and rely on a reduced number of longitudinal bars to carry the load.

Insufficient bearing lengths
Codified minimum bearing length for roof planks is 45mm, unless there is evidence that the transverse bar is over the bearing then an increased risk of sudden collapse remains according to recent hypotheses.

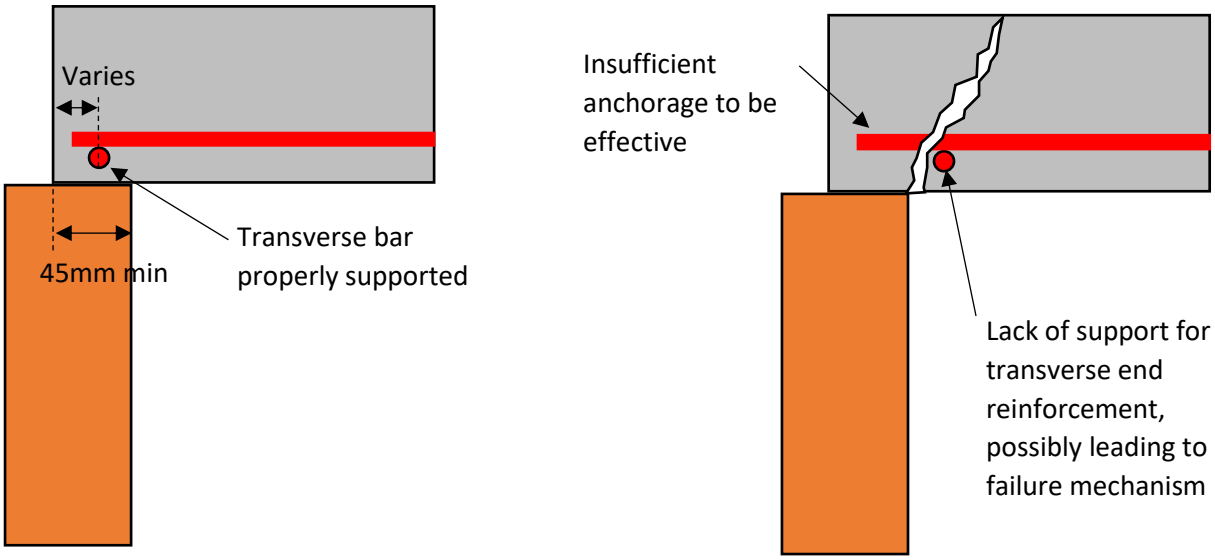

FIGURE 6 – POTENTIAL FAILURE MECHANISM FOR INSUFFICIENT BEARING

Corrosion of reinforcement (due to water ingress and voidage)
Because of the porous nature of the AAC, water can reach the bars quickly if ingress occurs. Spalling does not necessarily occur due to oxide jacking if void space exists around the bar, making it impossible to detect with a visual survey.

Overloading
Ponding of water due to in service deflections/insufficient roof falls, or unexpected plant loads can load the planks beyond their design capacity.

2.2 OTHER DEFECTS

In addition to the causes of failure discussed in the previous section, the following defects also indicate reduced performance of the planks.

Cracking of the soffit
Cycling changes in temperature and humidity can lead to transverse cracks at sporadic intervals along the planks. Excessive deflection caused by overloading of slippage of reinforcement can also cause cracks of a similar nature. Impact damage, spalling or cracking near to the supports are more serious.

Excessive deflection
As outlined previously, the transverse bars provide anchorage to the longitudinal bars if debonding occurs. Although these transverse bars control the ultimate loads, a certain degree of slippage of the

tension bars needs to occur before they are mobilized. This slippage will show itself by way of the planks sagging in service. This may not cause any real issues, but may increase bearing pressure as the plank rotates at the support, increasing the risk of bearing failure.

Deviation from good practice installation

The prominent manufacturer of the planks, Siporex, published technical literature in 1972 which lays out the principles to be adopted when using RAAC planks in roof construction. These recommendations are not always adopted on site, and clips/secondary reinforcing bars are not always present.

3. STRUCTURAL ASSESSMENT METHOD

All inspections were undertaken during normal daytime operation hours with assistance from estates staff where required.

The inspection comprised of a combination of the following surveys:

- Desktop study (DS) – Review of all historical information, very limited details available.
- Visual surveying (VS) – Each visible roof plank was assessed from the soffit.
- Covermeter scanning (CS) – Local sampling, checking the presence of transverse/longitudinal bars.
- Electromagnetic scanning (EM) – Verifying the covermeter results and checking reinforcement presence in all available soffit area.
- Ground penetrating radar scanning (GPR) – Local sampling, assessing bearing length and reinforcement in this area.

The following signs of deterioration/defects were checked for:

- Excessive deflection (VS)
- Signs of water ingress or corrosion of reinforcement i.e staining (VS)
- Insufficient end bearing (GPR & DS)
- Cracking (VS)
- Spalling (VS)
- Non-standard planks sizes (VS)
- Penetrations or cuts that may weaken the planks (VS)
- Ponding of water at roof level (VS)
- Corrosion to reinforcement (CS & EM)
- Missing transverse shear reinforcement near bearing point (CS, EM & GPR)
- Delamination through tap tests (VS)
- Signs of overloading, ponding and resurfacing (VS)
- Cut planks (VS)

The EM and GPR surveying was undertaken by specialists (Bi-TAS) and necessitated the removal of roof finishes which could not be penetrated by the surveying equipment. Removal of the finishes was carried out in several areas and made good immediately, it was not practical to carry out widespread GPR surveys as the roof would have been too vulnerable to water ingress if precipitation occurred.

4. BUILDING SPECIFIC CONSIDERATIONS

The roof void above the theatres is accessible via a suspended walkway circa 900mm wide. The walkway is offset from the centre of the roof line, allowing for direct and detailed inspections of only a number of panels. The soffit is largely unobstructed from view, with sporadic fixings for the suspended ceiling and lighting. Above the former offices, the entire soffit is visible from floor level.

The planks are covered by a waterproof insulated build-up which appears to be original.

5. RAAC SUMMARY AND DEFECTS IDENTIFIED

Referring to Appendix A, circa 1800 individual planks have been identified across the various roof levels. Refer to the Bi-TAS report dated 23rd May 2022 for detailed scan results.

- Plank size - 600mm and occasionally 450mm, 750mm and 1000mm in width, 200mm in depth
- Plank span - Circa 5.4m based on site measurements (span/27).
- Reinforcement – H10 longitudinal bars at 95mm centres, with cover between 19 and 33mm. Transverse reinforcement was present throughout.
- Bearing length - Bearing lengths appeared to be in excess of 80mm (based on a 254UC support beam with tolerance).

As previously mentioned, although limited areas could be fully surveyed, the following pertinent points were noted:

1. Generally, all clips and sundry items appear to have been installed in accordance with Siporex guidance found in historical information
2. Due to the presence of the theatres below, the environment in the roof space is continually warm and dry. No evidence of water ingress/leaking was observed which suggests the roof build-up is effective and watertight.
3. An array of ceiling/services is suspended from the RAAC units using post-fix bolts. In some places, these fixings have been installed too close to the edge of the unit causing the concrete to crack/spall.
4. Several units have spalled or lost concrete, particularly along edge lines. It is likely that this damage occurred during construction and is not deemed detrimental to structural performance. It has been repaired in some instances.
5. Where necessary for practicality, units have been roughly cored to allow rainwater pipes to pass through. In some instances, this not been trimmed or re-supported. Very little/no corrosion is visible on the exposed bars.
6. A large quantity of panels could not be observed in blocks C and D due to the wards being in constant use with patient sensitive zones.

To summarise the assessments completed so far:

CRITERION ASSESSED	***NOTES***
Excessive/differential deflection	There is no visually detectable sagging/bowing in any of the units. Differential deflection between units is very small (<5mm). No cause for concern.
Cracking	Minor cracking is present due to coring. No cause for concern
Spalling	Minor concrete loss was observed on a number of edges, this is likely attributed to damage caused during transportation/installation of the panels. Repairs have been

	undertaken in some locations, as is permitted according to Siporex guidance notes. No cause for concern.
Water ingress, discolouration/staining	The colour is generally consistent throughout. No indication of water ingress was identified.
Condition of concrete near bearing	No deterioration was observed. The BiTAS report indicates that all bearings contained reinforcement conforming to required standards.
Bearing width	A minimum of 45mm bearing is required for roof units according to Siporex guidance notes. The steel supports appear to fulfil this requirement, as confirmed by the Bi-TAS report.
Non-standard plank size	Several planks 450 – 1000mm wide were identified. No cause for concern.
Untrimmed penetrations	Two 150mm cores were identified. No cause for concern provided roof loading is limited to 0.75kN/m².
Missing transverse reinforcement	All reinforcement was identified as expected as confirmed by the Bi-TAS report.
Ponding at roof level	None observed
Delamination of concrete	Tap tests identified solid AAC in all locations which could be reached by hand.
Evidence of roof resurfacing works	The roof finishes appear to be original, any damage has been repaired. No cause for concern.
Susceptibility of roof to unusual loading	Current access arrangements limit the roof to maintenance loads only. Hazard warning signs advise building users of the weight limitation in place prior to access.

Given the lack of defects and generally good condition of the observable planks, no immediate remediation works are deemed necessary in the 'accessible' areas. The panels may deteriorate quickly if water ingress occurs, temperature fluctuates or imposed loading increases. The following recommendations are suggested at this time:

- Undertake routine inspections checking for water ingress/leaks and blocked drainage points at roof level making good where necessary.
- Maintain the current environment as far as possible (warm and dry), this is likely to be inherent provided the floors below continue to be used as theatres.
- Prohibit any further coring through RAAC units.
- Consult the wider NHS site team to explore the possibility of closing wards in blocks C and D to enable AJP to survey these areas unhindered
- Continue with annual surveys until the planks are replaced

There are still outstanding risks which we are unable to reduce at this time, these are namely:

Residual risk	AJP commentary
Due to access difficulties, many of the panels are not readily accessible and therefore cannot be surveyed. There may be defects which we are not aware of.	It would be necessary to temporarily close or cordon large areas of wards in order to reduce this risk.
There is no formal schedule of defects linked to individually referenced planks.	Although this would not change our recommendations, it would enable a full paper trail to be maintained. The trust may wish to engage an external surveying company to record every panel and every defect.

Although BiTAS have scanned 20 locations and found zero defects, there are circa 4000 end bearing locations which have not been scanned. Although extremely unlikely, there is a risk that they may contain defects. Other parties have commented that the scanning does not highlight issues such as corrosion of welds.	The only way to eliminate this risk completely is to physically breakout the concrete at the bearing to expose the reinforcement. This would require roof finishes to be removed entirely, and the subsequent removal of plant on the roof. The planks would be exposed to potential water ingress, and the risk of damaging the plank seems high.

6. PHOTOGRAPHS

PHOTOGRAPH 1 – CORED UNIT

PHOTOGRAPH 2 – EXAMPLE OF UNIT OBSCURED BY INSULATION

PHOTOGRAPH 3 – TYPICAL SOFFIT OF UNITS

7. SUMMARY OF RECOMMENDATIONS

The items below confirm recommendations:

- Restrict access to the roof areas to 0.75kN/m²
- Advise AJP on whether it would be possible to close or cordon off wards in blocks C and D to allow unhindered inspections to take place
- Formulate an eradication strategy, confirming when the planks will be removed.
- At a suitable point in time, prior to 2035, remove the RAAC planks and replace the roof construction.