NHS Property Services

HAVERHILL HEALTH CENTRE

Monitoring and Remedial Strategy

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HAVERHILL HEALTH CENTRE

Monitoring and Remedial Strategy

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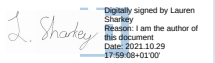
Signature				
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INTRODUCTION

Following known collapses of RAAC panels, public sector bodies have been requested to investigate their estate to determine the presence of RAAC. NHS EI in turn have passed this request to all NHS bodies. NHS Property Services (NHS PS) have appointed WSP UK Ltd to carry out the identification and assessment of RAAC within the estate and to develop remedial and monitoring strategies where RAAC is identified.

NHS PROPERTY SERVICES (NHS PS) ESTATE

WSP UK Ltd have completed a combination of desktop and visual surveys across the NHS PS estate to determine the presence of RAAC panels.

As part of this process Haverhill Health Centre was found to have a RAAC panel roof and further investigation was undertaken to establish the condition of the panels.

PURPOSE OF REPORT

The purpose of this report is to communicate the process that has been undertaken at Haverhill Health Centre since the discovery of RAAC to enable those with a vested interest in the building to gain further understanding of the condition, proposed works, residual risk and management strategy of the panels.

The report outlines the following:

- A summary of the properties of RAAC and the reasons for investigation.
- Investigation surveys
- Proposed remedial solution
- Residual risk statement
- Ongoing monitoring and risk mitigation strategy

RESIDUAL RISKS

WSP UK Ltd can advise on the estimated condition of the panels within the means available and make an assessment of the residual risks. It is the responsibility of NHS PS and tenant employers to accept the residual risks stated within this report and incorporate them into their wider Building and Operational Risk Assessments.

REINFORCED AUTOCLAVED AERATED CONCRETE (RAAC)

RAAC Planks are a pre-cast concrete product used in the construction industry between the late 1950's and 1982. They were predominantly used to form roofs but were also used as floor/wall units and partitions.

Planks were factory formed in moulds, with mild steel reinforcement. The planks are a stable form of calcium silicate hydrate, formed from a chemical reaction between a cement/lime/sand slurry and aluminium powder. As a result, the properties and characteristics of the panels differ from traditional concrete panels, the key items being:

- Lower density, typically 400-700 kg/m3
- Limited bond between the reinforcement and AAC meaning reinforcement anchorage is provided by additional transverse steel, welded to the main bars near the plank ends
- Limited corrosion protection to the steel by the AAC, overcome by provision of chemical coating to the reinforcement

HISTORIC RAAC DEFECTS AND PREVIOUS INVESTIGATIONS

In the early 1990's general concerns were raised over the structural adequacy of RAAC planks. These were based on reports of cracking to the soffit of panels, excessive deflection and rusting of embedded reinforcement leading to cracking/spalling.

The Building Research Establishment (BRE) were asked to advise on reported defects and, undertook a series of tests on a number of panels which led to the following recommendations being published for the maintenance of RAAC panels over 20 years old:

- Reduce loading on RAAC roofs
- Ensure all waterproof membranes are in good condition
- Keep records of deflections of RAAC planks and inspect regularly.
- Inspect annually if the structure is in poor condition, deflections are greater than 1/150th of the span, or the planks are in a moist environment or exhibit rust staining
- 5 yearly inspection intervals should be sufficient if there are no other problems, the structure is in good condition and deflections are less than 1/200th of the span.

In late 2018 a RAAC panel within a school collapsed suddenly which gave rise for the latest SCOSS report published in May 2019. The 'Failure of Reinforced Autoclaved Aerated Concrete (RAAC) Planks' report written by the Standing Committee on Structural Safety (SCOSS)

The SCOSS report outlined the details of the collapse and details a number of warning signs to be aware of that indicates panels may be near failure, defined as follows:

- Significant cracking and disruption of the planks near the support
- Any planks that have deflected more than 1/100 of the span, or a significant number of planks have deflections approaching this magnitude
- A number of the planks have very small bearing widths (less than 40mm)
- The roof has been resurfaced since original construction; this is particularly an issue if the load has been increased or the resurfacing has a black finish and the previous surface did not
- There is significant ponding on the roof
- The roof is leaking or has leaked in the past

RAAC ASSESSMENT STRATEGY

The following section outlines the strategy adopted for the assessment and subsequent action of RAAC panels. The strategy is based upon the BRE/SCOSS recommendations in the previous section.

The workflow (figure 1 below) describes the general strategy, undertaken by WSP, for the assessment of RAAC roof panels. This strategy is refined for each building containing RAAC and is dependent upon the general requirements/proposals for future use of the building.

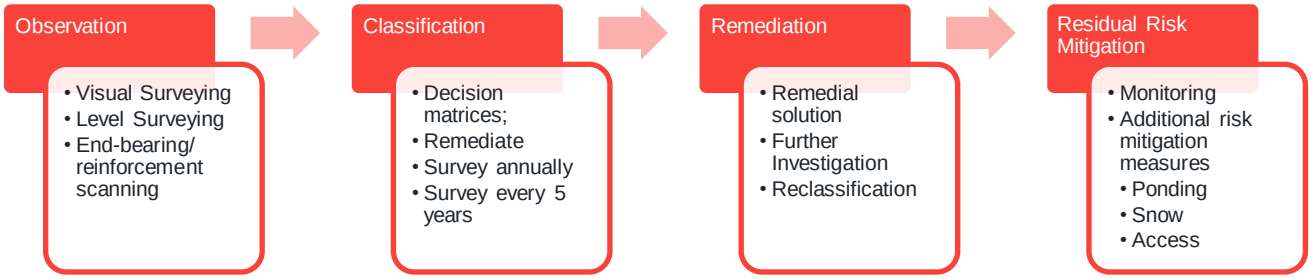


Figure 1 - General RAAC Strategy

A brief description of each stage is provided in the following sections:

OBSERVATION

The purpose of the observation stage is to determine the condition of each RAAC panel.

VISUAL SURVEYS

The visual surveys were undertaken with the following defects noted for each RAAC panel:

- Major Cracking/Spalling
- Water damage
- Minor Cracking/Spalling
- No visible defect
- Panel not visible

LEVEL SURVEYS

To provide a definitive deflection value for each panel, the survey scope required all panels to have the following levels recorded:

- Spot level at each end (support).
- Spot levels in the centre of the panel.

Level surveys are undertaken using laser survey techniques.

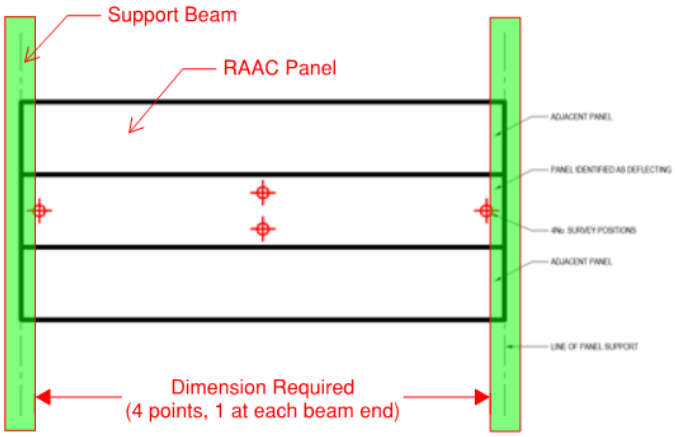


Figure 2 - RAAC panel level survey requirements

Deflection will occur in all structural elements, however; it is the extent of deflection that is to be considered in the assessment of the panels. In consideration of this, four categories/limits have been identified:

Deflection Category	Example Deflections (based on a 4000mm panel)
Deflection equal to panel span/100 or greater	40mm or greater
Deflection between span/100 and span/200:	Between 20 and 39mm
Deflection between span/200 and span/250	Between 16 and 19mm
Deflection equal to panel span/250 or less	15mm or less

END BEARING/REINFORCEMENT SCANS

There are two key factors that have to be present within the as constructed RAAC panels for end bearing to be deemed to have adequate structural integrity:

- End bearing of the panel on its supporting structure
- Location of the bottom layer of reinforcement within the panel, in relation the supporting structure

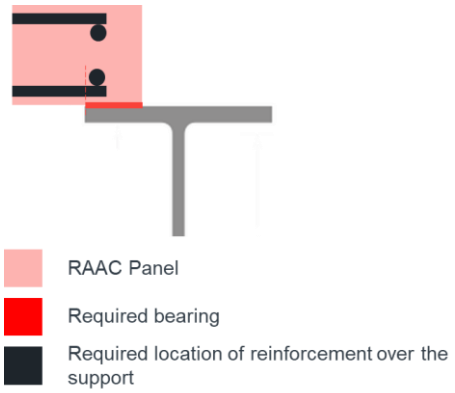


Figure 3 - End bearing requirements

END BEARING OF THE PANEL

Technical literature from the time required a minimum of 45mm end bearing however, current guidance, as published by the BRE, recommends a minimum bearing length of 40mm on the supporting structure. It is this value (40mm) that has been adopted as the minimum required within WSP's assessment of the panels.

REINFORCEMENT IN THE PANEL

The location of the bottom layer of longitudinal and transverse reinforcement is critical to the structural integrity of the panels. The transverse bars must be over the panel support to significantly reduce the chance of the panel dropping under failure of the concrete bearing.

It is important that any cut panels are also determined, as cut panels are likely to have lost structural integrity by removal of the transverse anchor bars.

To have confidence in the structural integrity of the as constructed end bearing of the panel, both of the end bearing requirements must be proven.

Proving reinforcement location and end bearing

The reinforcement location can be determined by two techniques:

- Specialist radar scanning from the top of the panel to identify the location of reinforcement, end bearing can be calculated by adding an assumed minimum cover zone past the end of the reinforcement.
- Intrusive surveys. This involves holes, drilled into the underside of each panel to locate the first transverse bar in the bottom of the slab and observe the end of the panel in relation to the support below

Limitations of radar scanning

There are two main challenges associated with radar scanning:

- Scanning is not possible where a foil backing has been used as part of a reroofing exercise unless the finishes are removed first.
- A 15mm tolerance associated with the technique, as described below:

Radar scanning has an inherent tolerance of 15mm (proven via numerous previous studies) which needs to be applied to the raw results. The primary reason for this is that scanning is only practical from the top surface of the panel meaning that the top reinforcement bars cast a shadow over the bottom bars.

Taking into account tolerance of the radar scanning techniques available, even for a panel that has been constructed with the correct bearing, scanning alone would not prove that there is sufficient bearing. Extensive further intrusive testing would then be required, which may in turn still determine that remedial works are required.

CLASSIFICATION

The following section describes the analysis and assessments that have been made on the data collected from the site surveys.

ASSESSMENT

In order to assess the condition of the RAAC panels WSP have developed a series of matrices, based around the BRE recommendations, the original design criteria and the survey results. The parameters used in this assessment, and their impact are defined as follows:

- **Evidence of water ingress (visual surveys):** This is considered as a key factor in determining the condition of a panel. As with all concrete elements an ingress of water can cause corrosion of the reinforcement which, ultimately, will lead to failure of the element. In the case of RAAC, this is exacerbated as the concrete is porous (aerated) and the reinforcement relies on a coating to the steel. This coating is known to be not very effective at protecting against corrosion. Due to the significance of this risk, water ingress is the first factor considered and is used to determine which matrix is used for the assessment.

- **Cracking/spalling of the concrete (visual surveys):** The presence of cracking within a panel can be considered as a sign of panel failure however, this is dependent on the extent of the cracking present. For example, transverse cracking across the panel width, particularly at the centre of the span is expected for a panel of this type. Diagonal cracking at the support or longitudinal cracking along the length of the panel are more serious and could represent signs of panel failure. The extent of cracking/spalling has been used as a determining factor in each matrix. RAAC panels with no visible defect were recorded as such and are considered to be acting as per the original design criteria.

- **Measured Deflection of the panel (level surveys):**
  As with cracking/spalling the deflection is used as a determining factor in each matrix. Additional consideration was also given to any roof loading applied from the roof plant survey.

The matrices developed from the above are shown below:

MONITORING DECISION MATRIX A

LEVEL CRITERIA	VISUAL CRITERIA WITH PRESENCE OF WATER		
	MAJOR CRACKING/ SPALLING	MINOR CRACKING/ SPALLING	NO VISIBLE DEFECT
SPAN/100 < DEFLECTION	REMEDIAL SOLUTION	REMEDIAL SOLUTION	REMEDIAL SOLUTION
SPAN/200 < DEFLECTION < SPAN/100	REMEDIAL SOLUTION	REMEDIAL SOLUTION	REMEDIAL SOLUTION
SPAN/250 < DEFLECTION < SPAN/200	REMEDIAL SOLUTION	VISUAL AND LEVEL SURVEY ANNUALLY	VISUAL AND LEVEL SURVEY ANNUALLY
DEFLECTION < SPAN/250	REMEDIAL SOLUTION	VISUAL AND LEVEL SURVEY ANNUALLY	VISUAL AND LEVEL SURVEY ANNUALLY

MONITORING DECISION MATRIX B

LEVEL CRITERIA	VISUAL CRITERIA WITHOUT PRESENCE OF WATER		
	MAJOR CRACKING/ SPALLING	MINOR CRACKING/ SPALLING	NO VISIBLE DEFECT
SPAN/100 < DEFLECTION	REMEDIAL SOLUTION	REMEDIAL SOLUTION	REMEDIAL SOLUTION
SPAN/200 < DEFLECTION < SPAN/100	REMEDIAL SOLUTION	VISUAL AND LEVEL SURVEY ANNUALLY	VISUAL AND LEVEL SURVEY ANNUALLY
SPAN/250 < DEFLECTION < SPAN/200	REMEDIAL SOLUTION	VISUAL AND LEVEL SURVEY ANNUALLY	VISUAL AND LEVEL SURVEY ANNUALLY
DEFLECTION < SPAN/250	REMEDIAL SOLUTION	VISUAL AND LEVEL SURVEY ANNUALLY	VISUAL AND LEVEL SURVEY ANNUALLY

Figure 4 - Decision matrices

REMEDIATION

GENERALLY

Based upon the classification of the panels there may be a requirement for remedial actions to be undertaken to provide additional support. The type of support will be determined based upon the requirements for each panel, based upon the following factors:

- Timing of remedial action, either immediate action, for any panels identified with serious defects or short term for panels where defects could cause further deterioration without intervention
- Length of time support is required (i.e. temporary or permanent)
- Type of support required i.e. localised to part of/one panel or a series/bay of panels.

Panels that do not require remediation but are showing signs of deterioration will be subject to an ongoing monitoring regime as defined in the matrix assessment made in the classification section of this report.

END BEARING

The alternative to proving the bearing of the as-constructed panels is to install remedial works. This could be provided by:

- Enhanced end bearing support by greater than 40mm, such as steel support angle or timber
- Significantly reduce the loading on the panel, such as installing intermediate at central or third point supports. For example, where other defects within the panels have been identified and remedial works of this type are already required.
- Assess the risks associated the likelihood and consequence of failure on clinical, operational and life safety.

RESIDUAL RISK MITIGATION

The residual risk mitigation will be bespoke for each RAAC containing building and will be dependent upon the overall findings of the assessment. Factors that will be considered for each building include:

- The level of risk of unexpected panel failure
- The risk the level of further deterioration of the RAAC panels, considering any remedial or monitoring regimes recommended as part of WSP's assessment.
- Any additional safety measures that can be out in place to further reduce the risk to the panels.

HAVERHILL HEALTH CENTRE

The following section describes the works undertaken at Haverhill and covers the following aspects:

- The assessment strategy
- The results of the observation phase of works
- The determination of requirements for remedial actions and ongoing monitoring
- An assessment of the residual risks and further mitigation measures that can be employed

ASSESSMENT STRATEGY

The general strategy for the assessment of RAAC has been refined at Haverhill to remove the requirement for undertaking detailed bearing assessments on the panels. NHS PS have determined that the roof for Haverhill Health Centre will be replaced within 12 to 18 months to remove the ongoing liability of the RAAC panels. This has influenced the strategy of how to assess the panels.

For the observation stage, the following surveys were completed.

- Visual
- Deflection

NHS PS have concluded the following additional potential surveys have been chosen not to be progressed as the roof will be imminently replaced.

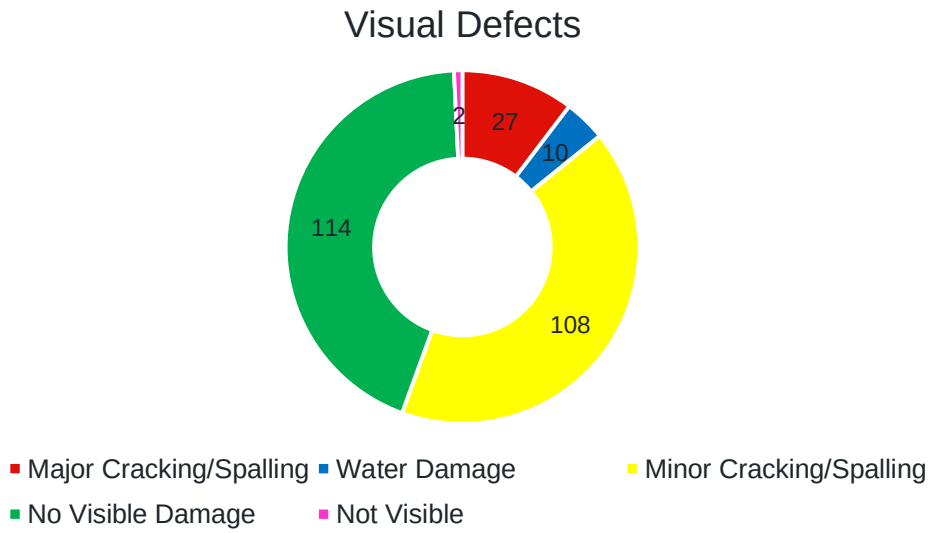
- Investigation of end bearing of panels/investigation of cut panels
- Reinforcement location

It was determined that the disruption associated with carrying out the surveys could not be justified based on the relatively short amount of time prior to full replacement.

OBSERVATION

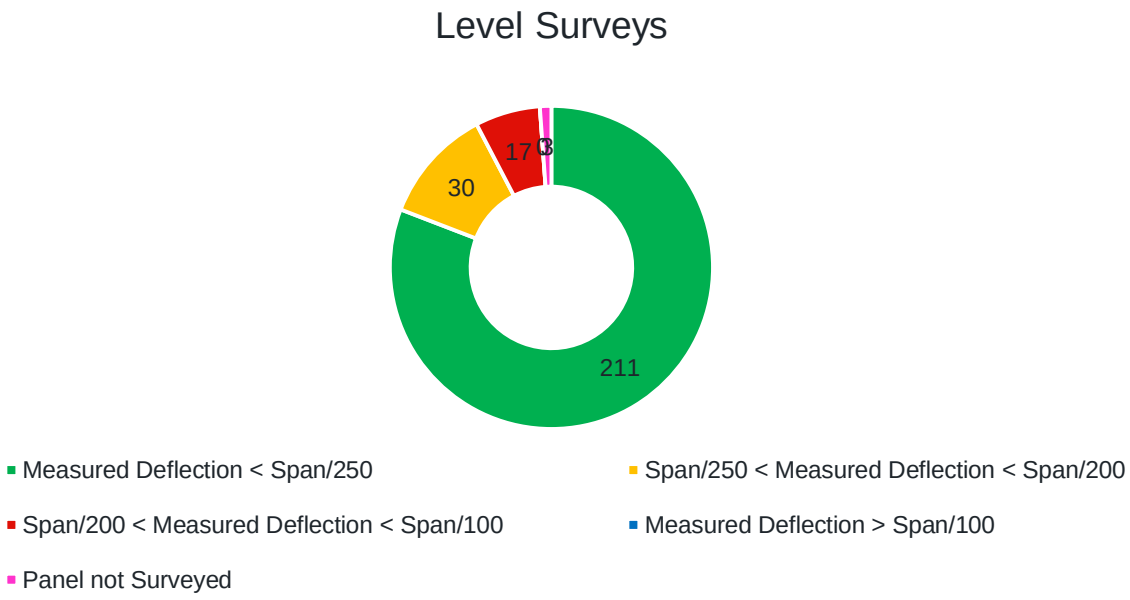
VISUAL SURVEYS

The results of the visual surveys identified the following number/type of defects with the RAAC panels:



LEVEL SURVEYS

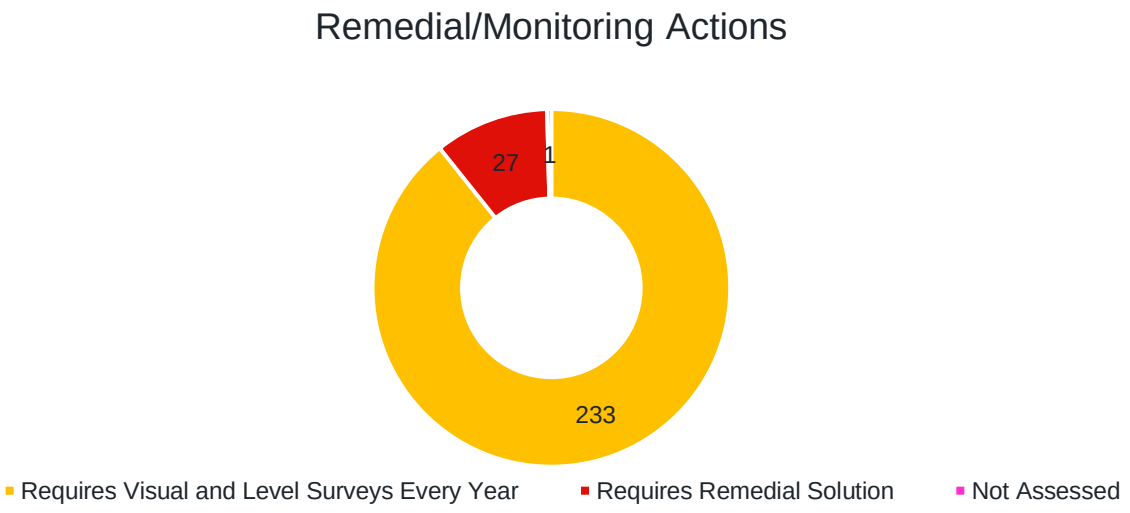
The results of the level surveys identified the following number/type of defects with the RAAC panels:



CLASSIFICATION

The results of the matrix analysis have led to each RAAC panel within the health centre to be classified as to whether it should be subject to a remedial action or, a programme of ongoing monitoring. Based upon the guidance issued by NHS E/I it is assumed that the minimum requirement for any RAAC panel is that ongoing annual monitoring is required. Therefore, visual and level surveying every 5 years can currently be replaced with visual and level annually, until such time NHS E/I requirements change.

The chart below summarises the extent of each category.



REMEDIATION

The roof is proposed to be replaced within 12 to 18 months. In conjunction with NHS PS, a more permanent support solution for panels that require remedial actions was not considered appropriate and therefore a temporary propping scheme was progressed.

The following WSP drawing shows the propping scheme to the panels that require remedial action.

- HVRP-WSP-00-RF-DR-S-200108

The full results of the observation, classification and remediation phases of the assessment strategy can be found on the following WSP drawings:

- HVRP-WSP-00-RF-DR-S-200101
- HVRP-WSP-00-RF-DR-S-200102
- HVRP-WSP-00-RF-DR-S-200103
- HVRP-WSP-00-RF-DR-S-200104
- HVRP-WSP-00-RF-DR-S-200135
- HVRP-WSP-00-RF-DR-S-200136
- HVRP-WSP-00-RF-DR-S-200137

RESIDUAL RISK MITIGATION

GENERAL FAILURE RESIDUAL RISK

For the panels that have been both visually and level surveyed, once remedial work has been completed, the risk of failure from obvious defects has been reduced as far as is reasonably practicable.

END BEARING FAILURE RESIDUAL RISK

There is a residual risk of failure at the ends of panels or from cut panels due to unknown manufacture or construction issues.

The residual likelihood of failure could be viewed as follows. Whilst this likelihood logic has been provided by WSP, it is important to recognise that the risk needs to be assessed by NHS PS and tenant organisations as acceptable.

It is reasonable to estimate that there over 1 million RAAC panels currently in use (the NHS alone has registered approaching 500,000 panels).

Due reported failures, a very conservative estimate of 1 failing per year through end bearing failure of a panel in visually good condition could be take. That gives a probability of any one panel failing which is in otherwise good condition of 0.0001% per year.

Haverhill has 261 panels giving a probability of 0.03% of a panel failing per year. The probability of this causing death or injury could be assessed as the amount of people and the time spent under the panels. 20 people spending 8 hours per day for example would reduce this % by a further factor of 20.

With reference to the thought process above, NHS PS has recommended the removal of this risk through enhanced end bearing support/propping at every panel end.

RISK MITIGATION AGAINST FUTURE FAILURE

Future deterioration of the panels is possible as well as that from inherent manufacture or construction defects as described above.

As stated in the classification section above, it is generally recommended to visually assess panels every year for signs of further general deterioration. End bearing assessments need to be assessed separately based on the level of proof of end bearing.

The following is recommended for ongoing assessments for Haverhill Health Clinic:

Before end bearing enhancement is installed

- Monthly inspection completed by a contractor, supervised by a competent person, of the installed props for hand tightness and stability.
- Monthly visual inspection by a structural engineer of the ends of the panels close to the supports for signs of any distress.

After end bearing enhancement is installed

- Monthly inspection completed by a contractor, supervised by a competent person, of the installed props for hand tightness and stability.
- Annual visual inspection by a structural engineer and level survey of the whole length of panels for signs of any distress or excessive deflection.

RULES FOR ALTERATIONS AND REFURBISHMENT WORKS

To help prolong the life of RAAC panels, the following rules should be adopted generally. A structural engineer should be consulted if the following cannot be complied with:

- No additional loads to be applied to any RAAC panels.
- No new fixings should be installed to the panels
- No additional penetrations should be formed through the RAAC panels without a review from a structural engineer

RULES FOR GENERAL OPERATION

The following should be put in place as operational procedures:

- Where standing water is present on the roof, introduce robust pumping arrangements to discharge excessive quantities of water.
- Snow build up on the roof should not be allowed to generally exceed 200mm. When removing snow, snow should not be piled in any location to height of greater than 300mm.
- If snow does build up greater than 300mm, all accommodation below should be closed to access until the snow has been clear and panels re-assessed by a structural engineer.
- Maintain robust roof permit system to control access to the roof and to inform personnel of restrictions
- No roof maintenance should exceed the design loadings of 0.6kN/m2.

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