Whitchurch Library & Civic Centre

High Street, Whitchurch, SY13 1AX

Technical Overview and Options Appraisal of

Reinforced Autoclaved Aerated Concrete

Property Services Group – Shropshire Council

DOCUMENT HISTORY

This document and its contents have been prepared and are intended solely as information for Shropshire Council use in relation to RAAC Investigations at Whitchurch Library & Civic Centre, High Street, Whitchurch, SY13 1AX.

Revision	Status	Date of issue	Originator	Reviewed by	Date of review	Distributed by	Date of distribution
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DEFINITIONS

ACM – Asbestos Containing Material as defined by the Control of Asbestos Regulations (2012).

Bearing - The width or distance that a RAAC element (panel or plank) sits on the support, measured from the edge of the support to edge of the panel.

Bending - The force within a structural system that causes deviation from a straight line to a curve. Compression - The force within a structural system that pushes down or into an element.

Deflection - The degree to which a part of a long structural element (such as beam) is deformed laterally under a load.

Efflorescence - Efflorescence is a hydroscopic crystalline deposit of salts that can form when water is present in or on brick, concrete, stone, stucco, or other building surfaces. It commonly has a white/grey colour and consists of salt deposits that remain on the surface after water evaporates.

Load - Loads or external forces that act upon a structure. When external forces are applied to a structure, internal stresses (internal forces) develop resistance to the outside forces. The opposition of external and internal forces is what holds the structure together. Examples are compression, torsion, and tension.

Panel - The term to describe the individual RAAC element. May be referred to as 'plank' when considering horizontal elements.

RAAC - Reinforced Autoclaved Aerated Concrete.

Span - The horizontal (or vertical) distance between supports, typically measured from the centreline of the supports. Clear span is often used to describe the distance between the faces of support.

Shear - The force within a structural system that causes slippage on a plane of failure, typically close to a support.

EXECUTIVE SUMMARY

Shropshire Council has been assessing the existing property asset portfolio to identify any presence of Reinforced Autoclaved Aerated Concrete panels (RAAC), following the emerging and urgent Department for Education (DfE), Local Government Association (LGA) and Government guidance.

Shropshire Council's asset - Whitchurch Civic Centre, including the Library and Registrar provision, has been identified as having RAAC roof structure construction, to the vast majority of the property.

Following initial identification and a limited access visual assessment, a further destructive and intrusive external structural engineer inspection has been carried out. This inspection has determined the condition of the RAAC installation to be of poor condition (Red Critical), requiring immediate mitigation by temporary propping and closure of the building to all staff and visitors for general day to day use.

This report provides a technical overview and options appraisal in consideration and to inform the medium to long-term options required to mitigate the RAAC installation and future of the property.

The Library and Registrar functions are currently being provided through alternative means and not included within this report, though further short to medium-term considerations to meet the service area demands of provision are required by association.

Following the findings of the structural engineer's report, an options appraisal with outline budget estimate costs has been provided in consideration of meeting the medium-term and long-term function of the property in providing public services. The viable options include semi-permanent mitigation to allow retention of the existing building by replacement of structural elements and associated remedial work, through to demolition and redevelopment. Based on the economic, social, and environmental factors and aligning to the Shropshire Plan, Climate Strategy and buildability factors, demolition and rebuilding or redevelopment of the site would be considered favourable options to consider.

The report is to inform of the democratic discussion and strategic decision of the property. Post the strategic decision further resource and budget can be considered and identified to further develop the selected option, in accordance with the RIBA Stages of Work.

1. INTRODUCTION

Shropshire Council (Property and Development) have been carrying out desktop and physical assessments of its existing property portfolio assets to determine the presence of Reinforced Autoclaved Aerated Concrete panels (RAAC) in relation to the emerging urgent Department for Education (DfE), Local Government Association (LGA) and Government guidance. There is currently no national or local register for RAAC, confirming where the product may have been used, in the UK.

Shropshire Council is the Landlord for the Whitchurch Civic Centre, including the library and leased Whitchurch Town Council areas.

This report provides a summary of the initial visual physical assessment, following confirmation that RAAC is present at the property. Additionally, the report provides a technical overview following the detailed and technical commissioned structural engineers report. This includes Shropshire Council Property and Development recommendations and consideration of further actions.

2. BACKGROUND INFORMATION ON RAAC

Reinforced Autoclaved Aerated Concrete (RAAC), introduced largely in the UK in the 1950s, and halted in 1982 due to durability concerns. The Standing Committee on Structural Safety (SCOSS) 12th report confirmed its 30-year life expectancy in 1999, indicating a relatively short life span of 30 years.

First created in Sweden in the 1920's as AAC, a lighter alternative to traditional concrete, steel reinforcement was introduced in the 1930's to provide larger structural panels building components.

Whilst RAAC is a lightweight form of concrete. SCOSS noted that: 'Although called "concrete", RAAC is very different from traditional concrete. This form of concrete is less dense with a lack of stone aggregate than traditional concrete. RAAC is formed by a matrix of cement, lime, extremely fine sand or pulverised fuel ash and calcined gypsum, with aluminium powder and water added to form a concrete slurry. Cast in a mould containing the steel reinforcement, the aluminium powder chemically reacts with the lime and water to produce small bubbles of hydrogen gas, which causes the mixture to foam, more than doubling its volume. The hydrogen evaporates leaving behind a cellular lightweight concrete mixture. Once removed from the mould the concrete is cured at high temperatures in an autoclave, causing the sand and lime to form a calcium hydrate crystal. This provides increased strength. The material properties and structural behaviour therefore differ significantly from 'traditional' reinforced concrete. A close example of RAAC can be seen in **Figure 1**.

Figure 1 - Sample of texture of RAAC. Source Institution of Structural Engineers (2019)

With the lightweight properties plus fire resistance and thermal performance RAAC was predominantly used in schools, colleges, and public sector and commercial buildings construction from commonly in the period of the 1950's until the mid-1990's and generally not incorporated into buildings prior to this timeframe. However, with manufacture of RAAC from the 1930's, where unsure of the date of construction and/or modification of buildings, it is advised to assess all buildings thought to be constructed between the mid-1930s and mid-1990s (DfE, 2022). It is unlikely to occur in significant quantities after 1980 but RAAC planks were imported in the UK until 1998.

The planks initially prompted concern, were designed before 1980 due to the 30-year life design span. RAAC is commonly used as lightweight roof decks, floors, and internal partitions, but can also be used as an external wall material. The characteristics of RAAC can be found in **Appendices A**.

In addition to the advantages of lightweight, thermal performance and fire resistance, it can be easily modified such as nailed, fixing and sawn with conventional hand tools.

Following a sudden failure of a RAAC roof structure in a school in 2023, the DfE (2023) updated its guidance and requested that all the country's schools be checked if they contain RAAC. Additionally to this the LGA encouraged all responsible bodies to check their public buildings for RAAC.

Elasticity and Creep: The aerated nature and lack of coarse aggregate means that RAAC panels experience a greater degree of creep and long-term deflection when compared to traditional concrete.

Shearing, sagging and deterioration present concerns. As such, the most notable concern with RAAC planks is their potential for sudden shear failure. If a building structure is going to fail, it is preferable that occurs incrementally in order that warning signs are presented rather than immediate catastrophic failure. Shear failure is caused by issues with the steel reinforcement, typically at the transverse end of the planks, as indicated in **Figure 2.** Often cut or sawn ends reduces structural strength of reinforcement to plank.

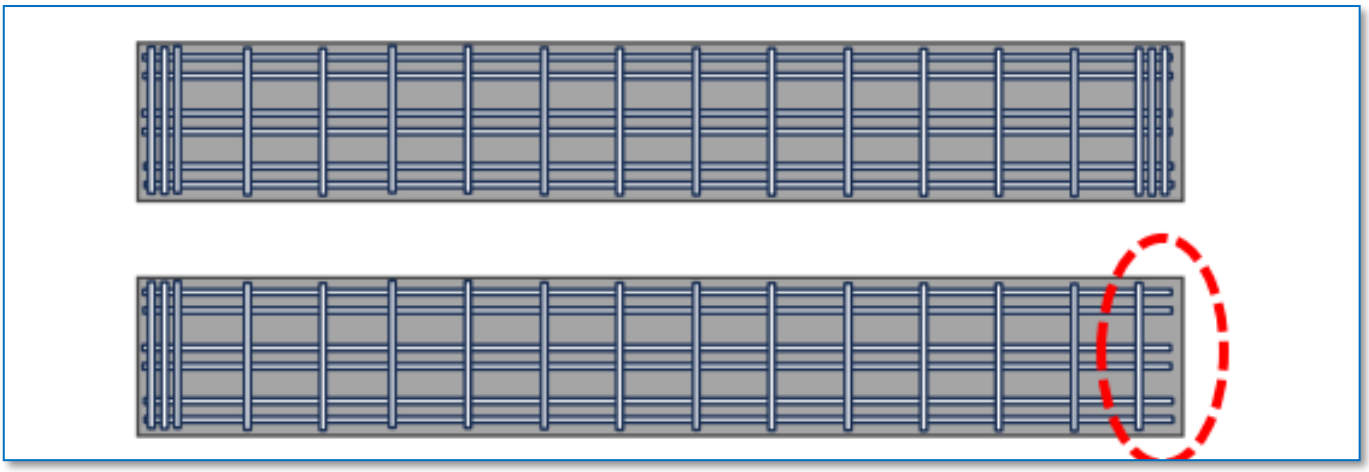


Figure 2 - Cut end of RAAC Plank - transverse reinforcement. Source RICS (2023)

The compressive strength (in addition to flexural, shear and tensile), are much lower than traditional concrete. **Figure 3** shows a compressive shear strength test but illustrates the end bearing and failure from a load above.

Figure 3 - Laboratory Setting of Compressive Strength of RAAC panel end bearing. Source Loughborough University

Reinforcement anchorage: Due to the aerated nature of the AAC, it will not form adequate bond strength with the reinforcement. The reinforcement used in RAAC panels was often smooth and not ribbed, as with traditional reinforced concrete. The two layers of reinforcement are expected to be positioned, with the transverse perpendicular reinforcement in a similar layout and concrete coverage shown in **Figure 4.**

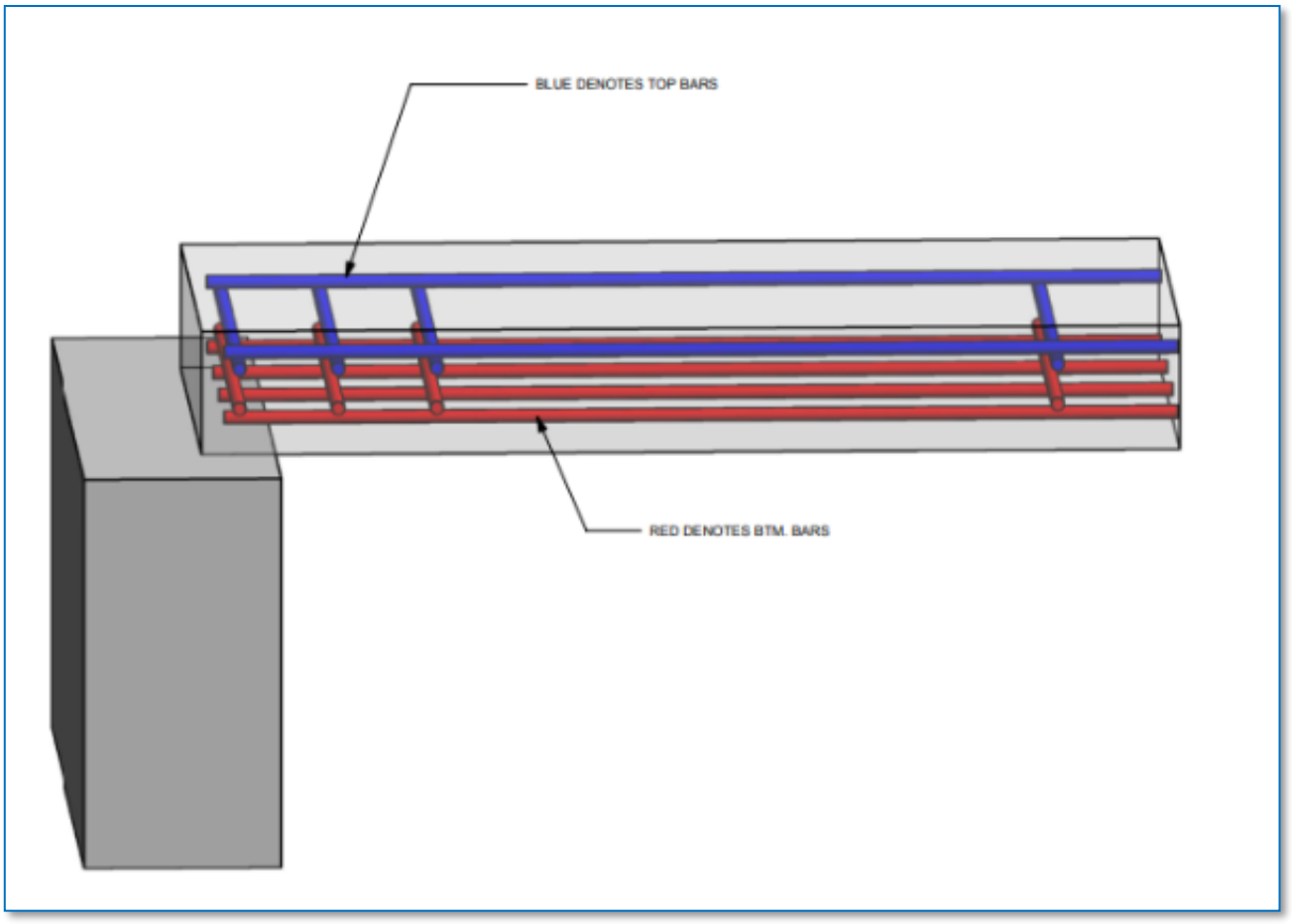


Figure 4 – Typical position of reinforcement with RAAC planks. Institution of Structural Engineers (2022)

Permeability: The aerated material is highly permeable, so cover to the reinforcement does not protect against environmental conditions in the same way as with traditional concrete. Prior to manufacture, the reinforcement was typically coated to protect it against corrosion.

Risk Factors

Risk factors can also allow the deterioration of RAAC planks, potentially affecting their structural stability. RAAC has a high elastic modulus capability when compared to normal concrete (meaning then can sag/deflect under similar loadings). This can be caused by:

- Incorrectly detailed, calculated, and undersized at manufacture.
- Reinforcement inadequate or placed in incorrect areas.
- The reinforcement or RAAC plank has been cut/modified or damaged effecting structural stability.
- Corrosion of reinforcement, weaking effectiveness of reinforcement.
- End Bearing limits are not met (see **Figure 5**). 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.
- Exposed to moisture, becoming susceptible to corrosion. It also leads to a reduce compressive strength. Water may also pond on a sagging roof, increasing the weight load and potentially leading to further moisture ingress as well as exposure of the steel reinforcement, corrosion, and cracking.

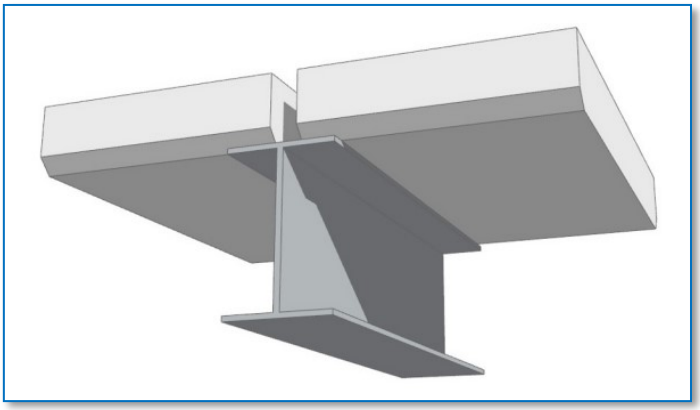


Figure 5 - Substandard bearing on a 100mm wide steel beam. Source (Institution of Structural Engineers, 2023)

Shropshire Council have undertaken initial assessments of its assets for the potential of RAAC as per the guidance stages illustrated in **Figure 6.** A further detailed flow chart found in **Appendix C.**

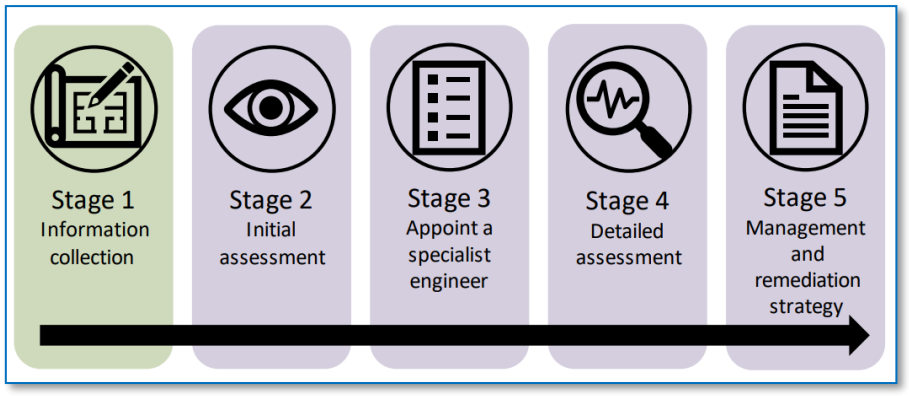


Figure 6 - RAAC Guidance Stages. Source DfE (2023)

3. SUMMARY OF WHITCHURCH CIVIC CENTRE - SITE

The two storey Whitchurch Civic Centre originates from circa 1970 and includes Whitchurch Library within the building at ground floor level. Within the Library area is also the statutory service of Shropshire Council Registrars. Additional ground floor provision includes a reception foyer area with offices, welfare facilities and tourist information service, a six-meter-high main theatre hall with performance stage, and a large open space Market Hall connected by a covered internal walkway corridor. The first-floor Civic area facilities include the Edward German meeting room, Marrie England lounge/bar social area at the front of the property and theatre changing rooms above the rear (East) stage area. The rear of the property includes an open covered canopy walkway extending from the internal walkway, wrapping around the back of the theatre area to the Market Hall. This walkway also provides a fire escape route from the theatre first floor changing rooms. The site is complimented by front and rear car parks and an external north storage area, provided to the north elevation.

The Civic Centre front elevation has a red-brown stretcher bond brick facade to ground level with timber beam and horizontal timber cladding to the first-floor balcony area. The rear elevation comprises of dark brown stretcher bond brick façade. The roofs to the Civic Centre at first and second floor levels are asphalt flat roofs with retrospectively applied reflective waterproof coatings and small areas of felt detailing to copings.

The Market Hall comprises of a stretcher bond dark brown brick facade and inset glazed panels with dual mono pitched tiled roofs, with photovoltaic panels to the southern elevation. The rear external north store area is of masonry wall to wall “garage type construction” construction with a corrugated Asbestos cement mono pitch roof with Perspex skylights.

An illustrative location plan can be found below in **Figure 7**. Further scaled location/site plans and block/floor plans can be found in **Appendix D**.

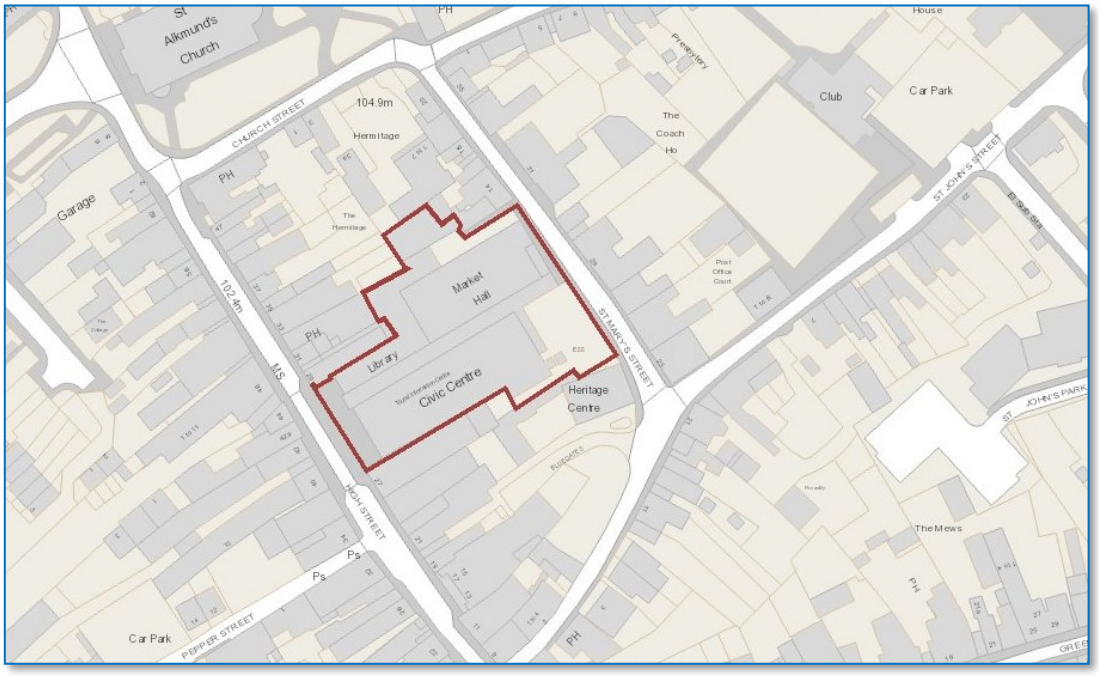


Figure 7 - Whitchurch Civic Centre - Location Plan (not to scale). Source Shropshire Council (2023)

The property has a Display Energy Certificate/Energy Performance Certificate rating of C (73).

The property is located within the designated Whitchurch Conservation area but is not a listed building (as indicated in **Appendix E**).

The Gross Internal Area of the Library is 348.63m² with the Civic Centre Gross Internal Area £2,362.63m². The Gross external area of the site is 2,999.27m². Shropshire Council is the freehold "Landlord" for the entire Whitchurch Civic Centre site, including the library with leased areas to tenant Whitchurch Town Council. The outlined demarcation of leased areas is illustrated in **Figure 8**.

Legend of Leased Areas

Shropshire Council - Library/Registrars
Whitchurch Town Council Leased Areas

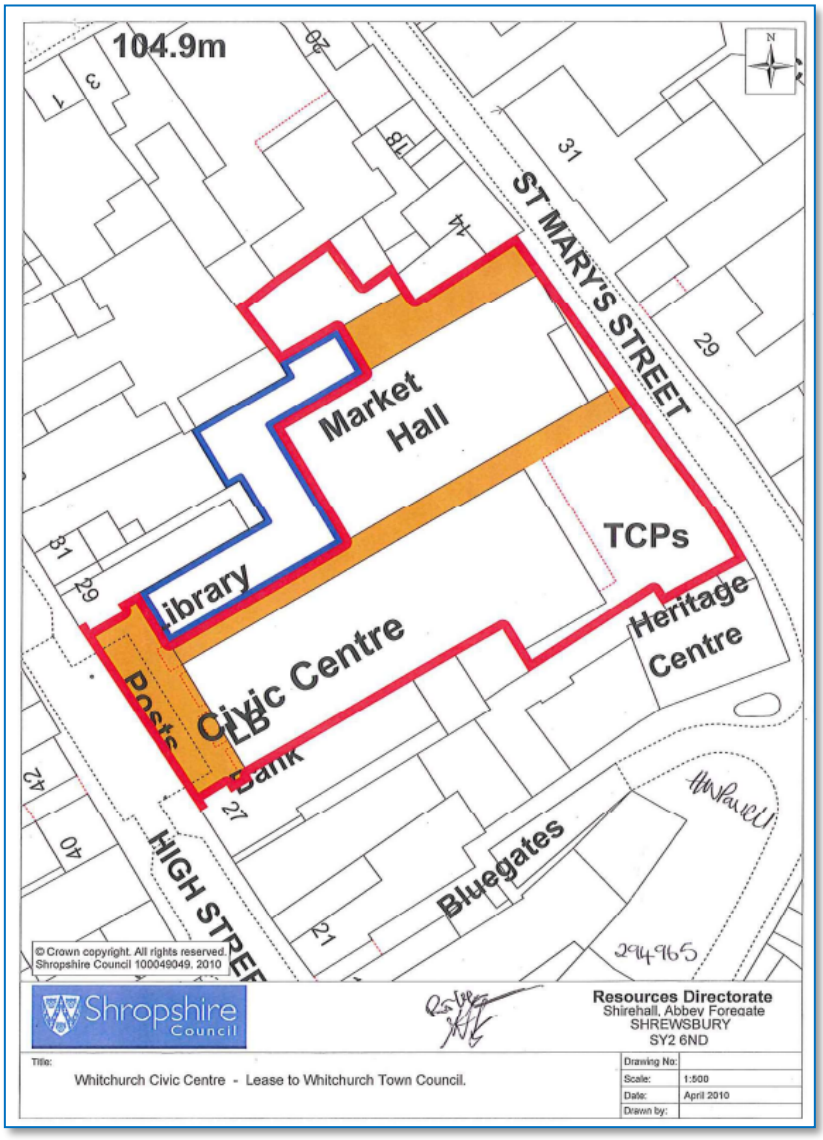


Figure 8 - Leased areas within Whitchurch Civic Centre. Source Shropshire Council (2023)

4. INITIAL INSPECTION FINDINGS AND MITIGATIONS

The age of the building is within the “scope range” of current RAAC desktop assessments. Archive microfiche plans of the building were limited in extent and content. Following investigations of RAAC in Shropshire Council buildings and a programmed capital re-roofing scheme to the Library roof (only), the presence of RAAC was detected in the roof area to the rear of the library. A sample of external penetration testing shows the “bubbly concrete” formation as an indicator that RAAC may be likely.

Figure 9 - Sample of roof library roof deck. Source Author

This sample informed a further initial assessment physical inspection to the library area in accordance with the industry guidance, to expose areas of the library. Where concealed by accessible suspended ceilings these were accessed where safe to do so, considering precautions for Working at Height Regulations (2005), Control of Asbestos Regulations (2012), Shropshire Council’s Asbestos Policy and RICS Surveying Safely Guidance (2018). This further initial inspection was also accompanied by commissioned external Structural Engineers. This assessment confirmed the presence of RAAC to the Library/Registrar areas.

Following this positive identification the initial physical assessment was extended to the Civic Centre, though this was limited due to the initial inaccessible six-metre height of the main theatre area, fixed/suspended ceilings and also potential presence of Asbestos Containing Material (ACM). The condition of the RAAC planks observed in the library/registrar area where of general concern with evidence of water ingress, historic modifications of planks, reduced end bearing widths and minor cracking to walls in rear non-public areas. See **Figure 10** for examples.

		
Library – Cut end of RAAC Plank	Library – Internal Rainwater Downpipe with indication of water ingress to RAAC	Theatre/Stage – Visible RAAC Planks

Figure 10 - Initial RAAC physical inspection

However the unconcealed area above the stage was exposed and a visual assessment from the stage indicated the presence of RAAC planks laid on steel beams that likely carried on through the roof of the entire main first floor area roofs. This also extended to the internal walkway and rear changing rooms. The external canopy construction was exposed also revealing the presence of RAAC.

Figure 11 indicates the inaccessible/fixed ceilings preventing access.

	
Theatre ornate acoustic ceiling	Bar Area – fixed panel suspended ceiling

Figure 11 - Civic Centre - fixed/concealed ceiling example. Source Author

The library front area (perpendicular to the reception/foyer of the Civic Centre) and Civic Centre reception foyer/welfare areas and intermediate first floor construction were confirmed not to be RAAC but modern block and beam construction and in reasonable condition. The Market Hall was confirmed not to contain RAAC as was the external store area.

A floor plan of the areas confirmed as containing RAAC and those not containing RAAC can be found in **Figure's 12** and **13**. Larger scale versions of these floor plans can be found in **Appendix D**.

Figure 12 - Whitchurch Library & Civic Centre – Ground floor areas of confirmed RAAC at roof level.

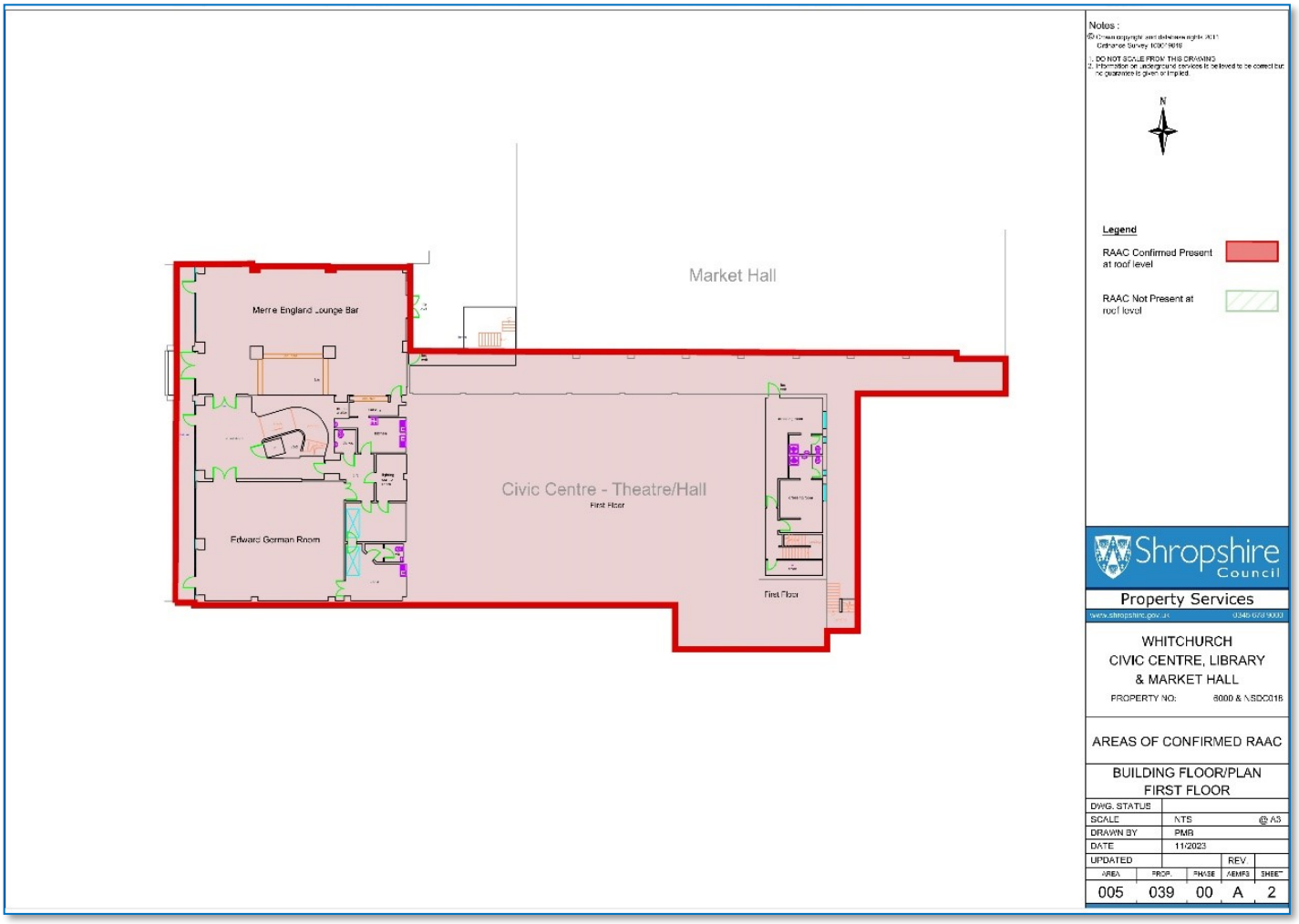
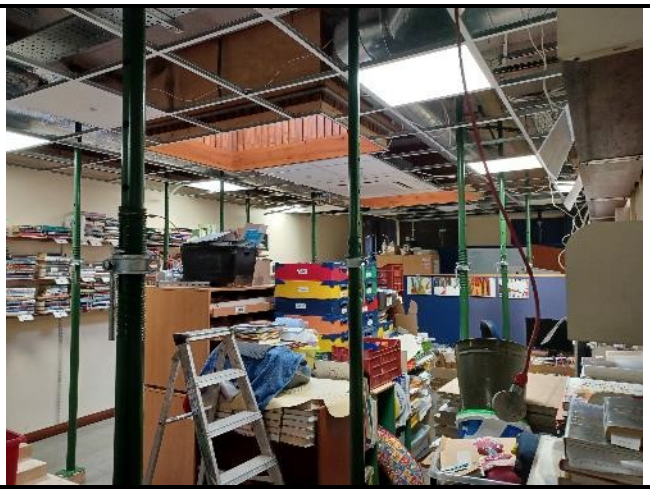


Figure 13 - Whitchurch Library & Civic Centre - First Floor areas of confirmed RAAC at roof level

The initial limited physical assessment identified concerns of poor condition RAAC within the Library and Registrars. Additionally, where exposed in the Theatre/external walkway. Further areas of concern were identified planks of limited bearing detailing, poor end support detailing to roof lights in addition to moisture ingress, longitudinal cracking and modification. Due to the positive identification of RAAC in the known areas and based on the visual condition the Structural Engineer strongly recommended propping to be installed to mitigate collapse and damage to the structure, due to potential plank failure. This was arranged with immediate effect and put in place. Due to the height of the theatre ceiling/roof it was not practical to prop.

Shropshire Council informed Shropshire Fire & Rescue Service colleagues with the presence of RAAC and condition to inform their operational crews in case of emergency attendance. Insurance and Risk Management colleagues were also informed.

During further visual assessment additional defects were observed requiring a significant amount of additional propping and installed at close centre spacing by the Structural Engineer. As per industry guidance and Structural Engineer observations informed the Council's decision to vacate the Library/Registrars with immediate effect on a safety-first risk assessment approach. See **Figure 14**. Additionally, the building was limited in access and security fencing placed to the rear areas with a calculated crash deck fan constructed to the Market Hall car park public access route.



Library – Example of internal propping mitigation

Security Fencing to car park elevation and crash scaffold fan to allow access into the Market Hall

Figure 14 - Example of initial mitigation safety work

Mitigation by propping to the front block and beam intermediate first floors of the library and reception/foyer were not initially required. The initial Structural Engineer calculation determined the block and beam floor would withstand any potential velocity impact from an unlikely potentially uncontrolled RAAC roof planks collapse, though this is noted before the invasive detailed assessment.

Based on the findings of the initial Structural Engineer assessment a full physical invasive inspection (within finger touch distance), determination of end bearing, and deflection tests informed through 3D Point Cloud scans was required and immediately instructed.

To facilitate the invasive survey the remaining concealed/inaccessible ceilings required full removal and further investigating of potential ACM's. An Asbestos Refurbishment Demolition Survey (an enhanced invasive asbestos survey to that of the Asbestos Management Plan information) was instructed to Shropshire Councils Asbestos sample provided, in accordance with legislation and policy. This resulted in the positive identification of Chrysotile and Amosite asbestos debris. Due to requirements of speed to access and notifiable timescale for removal the debris was encapsulated by licensed Shropshire Council asbestos contractors. Following this controlled works and air clearance testing the fixed/concealed ceilings to areas were removed.

Following the encapsulation of ACM's, the concealed ceilings, services, fixtures and fittings were removed to permit the physical invasive structural inspection and deflection scan. This was carried out in early October 2023, with results expected to be 3-4 weeks post survey.

See **Appendix F** for general photographs.

5. STRUCTURAL ENGINEER REPORT – OVERVIEW OF FINDINGS

Property Services Group (PSG) commissioned Thomas Consulting Structural & Civil Engineers to carry out a structural inspection to establish if RAAC was present at the property. Following confirmation of the presence of RAAC as noted in Chapter 3, the limitations of access to high level areas and obstructions (ceilings/services) a further intrusive structural investigation was requested with the findings summarised in this report.

To enable the intrusive survey, obstructions such as fixed suspended ceilings in the Theatre areas, internal walkway and Social Bar area were needed to be removed. This was organised following an Asbestos Refurbishment Demolition Survey to comply with Control of Asbestos Regulations (2012) and Health & Safety executive guidance.

Guidance produced by the Institution of Structural Engineers (2023) provides advice on the form and scope of surveys to be adopted for RAAC panel installations. This identified the need to survey the panels for:

- Recording of visual cracks and defects
- Recording evidence of moisture ingress
- Hammer tap testing for signs of debonding concrete
- Recordings of panels cut after manufacture
- Recording of any alteration or penetration through panels after construction
- Measurement of deflections

Also, recent experience has emphasised the significance of the end bearing, and the investigation of the end bearings is now required to assess the structural risks. RAAC panels present highly individual results when surveyed with adjacent panels often exhibiting varied deflections, cracking, etc. Given this variance in RAAC panel construction it is recommended that all panels are visually assessed. Additionally, the measure of deflection is required and informed through accurate laser scanning technology.

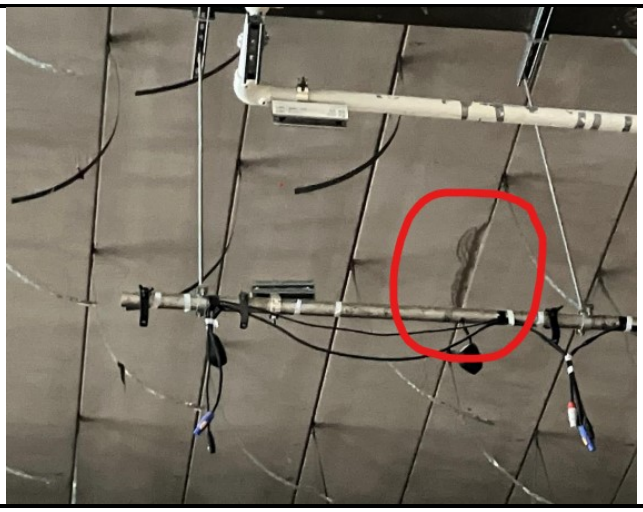
Therefore, an invasive visual condition assessment and deflection survey were carried out to further inform on the RAAC condition at the property.

5.1 VISUAL OBSERVATIONS

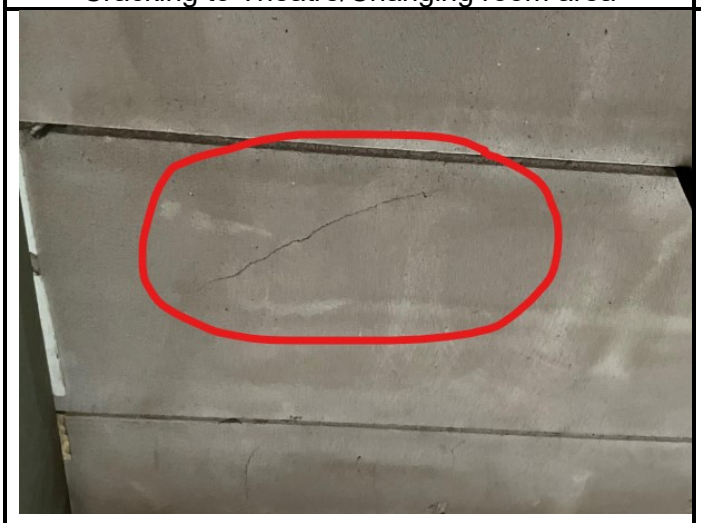
The initial visual assessment carried out observe the physical condition of the RAAC planks within the property.

The RAAC planks to ground floor and first floor roof areas are supported largely by I steel beams, with castellated steel beams to the main theatre area. Noticeable movement of the Library roof was observed. However some areas, such as the changing rooms/external walkway appear to differ with support from timber joists which do not contain strutting/noggins to provide lateral support and indicated buckling or twist through torsion from structural loads. Surface cracking to various planks was observed throughout the property. See **Figure 15** below.

Cracking to Theatre/Changing room area



Spalling to Theatre plank



Surface cracking to plank to Merrie England Lounge Bar

Spalled/damaged panel to first floor area with additional historic timber joist support

Figure 15 - Examples of visual inspection cracking and spalling. Source Thomas Consulting (2023).

During the period of construction, the bearing design would have been 40mm. However current guidance is a minimum of 75mm. Various locations sampled indicate less than the optimum bearing distance of 75mm with several bearings sharing 100mm wide support (therefore offering only 50mm of bearing). Sampling of planks also revealed only one transverse reinforcement bar as being visible, where additional would be anticipated. The roof lights to the library are not adequately detailed to provide suitable end bearing support to the planks. There are a several historic extract fans cut into planks with inadequate unsupported edges. See **Figure 16**.

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Example of exposed end reinforcement and reduced end bearing</td><td>Example of single transverse reinforcement bar</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Typical extract fan modification to plank with inadequate supported end bearing</td><td>Theatre Changing room – modification and large unsupported large opening</td></tr>
</table>

Figure 16 - Examples of modification and penetrations to planks. Source Thomas Consulting (2023).

Reinforcement pattern or ghosting is visible to the underside some planks, indicating low coverage of reinforcement within the concrete. A selection of planks in the Theatre illustrates honeycombing and voids within the planks (at the time of manufacture). See **Figure 17** below.

	
Honeycombed plank	Ghosting of reinforcement near surface

Figure 17 - Examples of honeycombing and ghosting of reinforcement. Source Thomas Consulting (2023).

Visual observations of the invasive survey revealed further evidence of historic damaged and modified RAAC planks. This includes general spalled sections but also openings/penetration and fitting of services to RAAC planks throughout the complex. Several areas have original planks being replaced with an insitu cast section. See **Figure 18**.

	
Historic services penetration and void. Spalled surface and reinforcement	Infill of planks with insitu concrete and penetration of services and timber joists

	
First Floor area – redundant flue modification of plank opening	Modification for internal rainwater downpipe

Figure 18 - Examples of damage and modification of services. Source Thomas Consulting (2023)/PSG (2023).

There is evidence of significant moisture ingress to the rear Library area, Registrar's office, and Theatre roof areas indicated by staining of planks and efflorescence salts to the surface. It was observed of damaged panels to the first floor with missing sections of concrete to planks revealing the underside of the roof membrane. See **Figure 19** below.

	
Library – efflorescence inline with moisture ingress	Library - Spalling and moisture ingress staining

	
Cracking to Merrie England Lounge/Bar area revealing roof membrane	

Figure 19 – Evidence of moisture ingress and roof exposure. Source Thomas Consulting (2023

The external walkway indicated extensive moisture ingress with modified and inadequate supported panels in areas with steelwork heavily corroded. Cracking of panels is evident. See **Figure 20**.

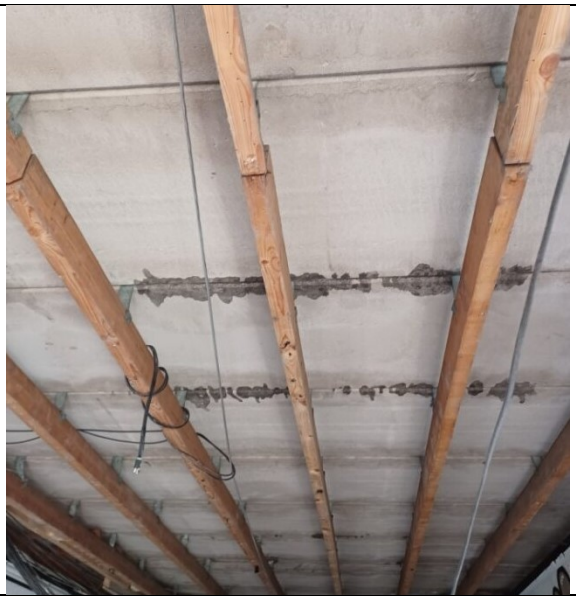
	

Figure 20 - External Walkway - Unsupported modified planks, surface cracking and efflorescence from moisture

The Institution of Structural Engineers – Support Bearing condition show in **Table 1**, based on the distance of bearing i.e. <75m or >75mm but also with consideration of modified planks or inadequate transverse reinforcement.

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 1 - Support/bearing condition risk category. Source Institution of Structural Engineers (2023)

Based on the visual observations noted above and the risk category in accordance with Table 1, this would classify the condition and support bearings observed in the Red (critical) category.

5.2 DEFLECTION OF RAAC PLANK OBSERVATIONS

In addition to the visual assessment a detailed 3D Point Cloud scan was carried out to measure any deflection of the RAAC planks to further determine their structural performance.

Deflection measurement of panels can assist in the assessment of panels performance. The measurement of each panel deflection, as illustrated in **Figure 21**, will allow the greatest level of assessment. However, where this is not possible, measurement of deflection of a representative sample should be undertaken. A minimum recommended sample size should be proportional to the size and scale of the building or structure being assessed but should typically not be less than 10% of the total number of panels.

The panels selected should provide a representative sample including:

- Structural spans.
- Panel width and depth.
- Increased loading resulting from roof access.
- Loading from a supported plant/machinery.
- Different internal environments, for example, any dry, damp, or humid areas.
- Areas where there could be an accumulation of external load factors such as a build-up of water/drifting snow.

In addition to the above consideration of transient behavioural activity should also be considered. The measurement of any panels affected by past or current water leaks would also be of assistance in accessing any detrimental impact of effects of moisture ingress.

The span of panels should be recorded together with their mid span deflection.

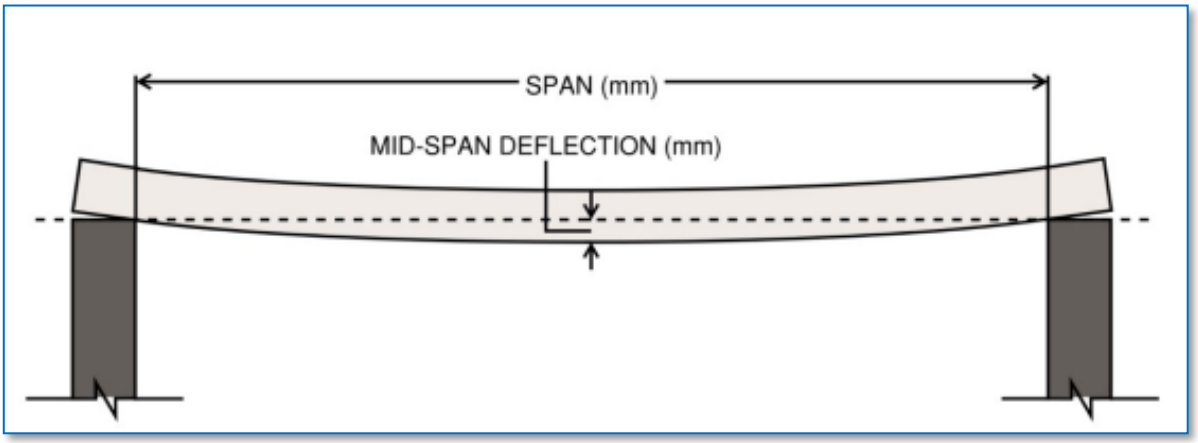


Figure 21 – Measurement of deflection of RAAC Plank. Source Institution of Structural Engineers (2023)

Due to the natural design gradient of a flat roof (to allow drainage to formed gutters and internal rainwater outlets/downpipes) a datum level was taken at a suitable point. The deflection or “sag” is measured in millimetres with the 3D Cloud scan imagine illustrated by colours which indicates the amount of deflection.

There are several variance factors that can result in deflection of RAAC planks. Where high levels of deflection are noted, this may increase the risk of water ponding and therefore additional load onto the roof from water volume.

The classification of deflection is:

- 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

A risk assessment of the span deflection is referred to **Table 2** below, following the observation of cracking, spalling and moisture ingress. (Institution of Structural Engineers, 2023).

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 2 - Risk Assessment of deflection. Source Institution of Structural Engineers (2023)

As illustrated in **Figure 22,** the fall of the Library roof is indicated from the external permitter towards the Library. The deflection test indicates areas of deflection of 4omm and deviation of deflection between panels to various areas of the roof. Areas of inadequately supported openings such as skylights etc and longitudinal cracking also indicate large readings of deflection. This indicates spans in reference to Table 2, of span deflections of span/100. The deflection scan of the Library Garage roof (not shown) is largely uniform without significant deflection.

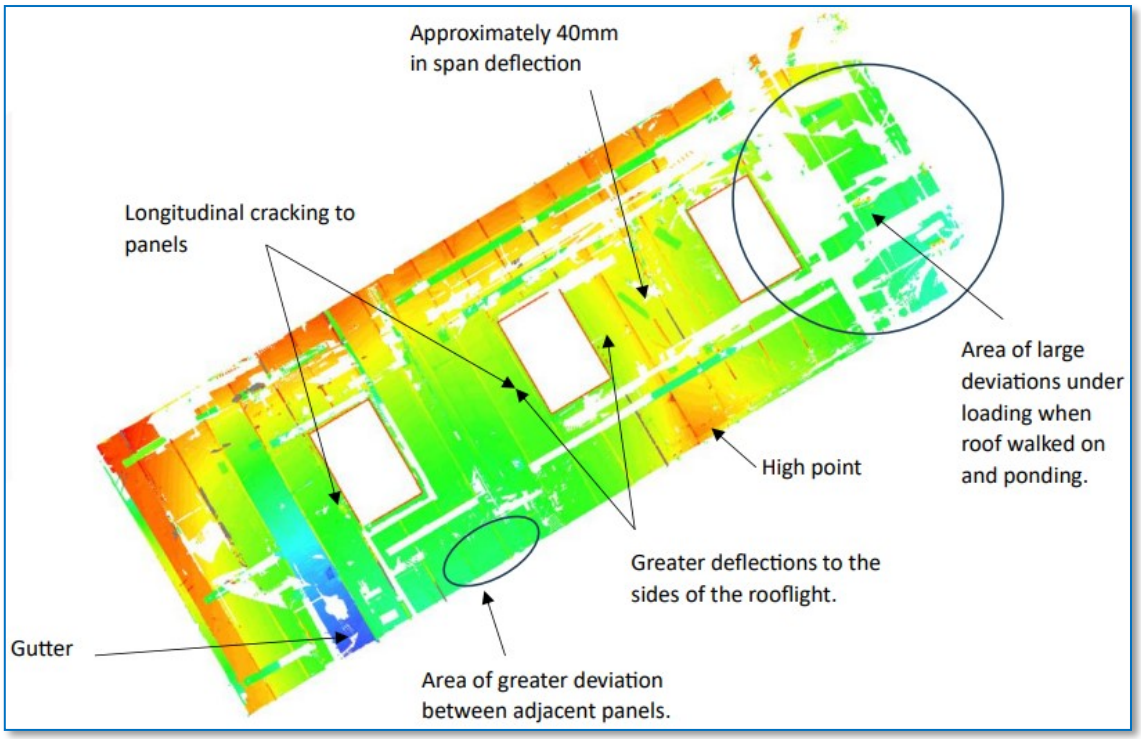


Figure 22 - Deflection Scan of Library Roof. Source Thomas Consulting, 2023

The deflection scan of the Civic Centre first floor Social bar area roofs is shown in the annotated Figure 23, with deflection noted is circa 28mm and span less than span/100.

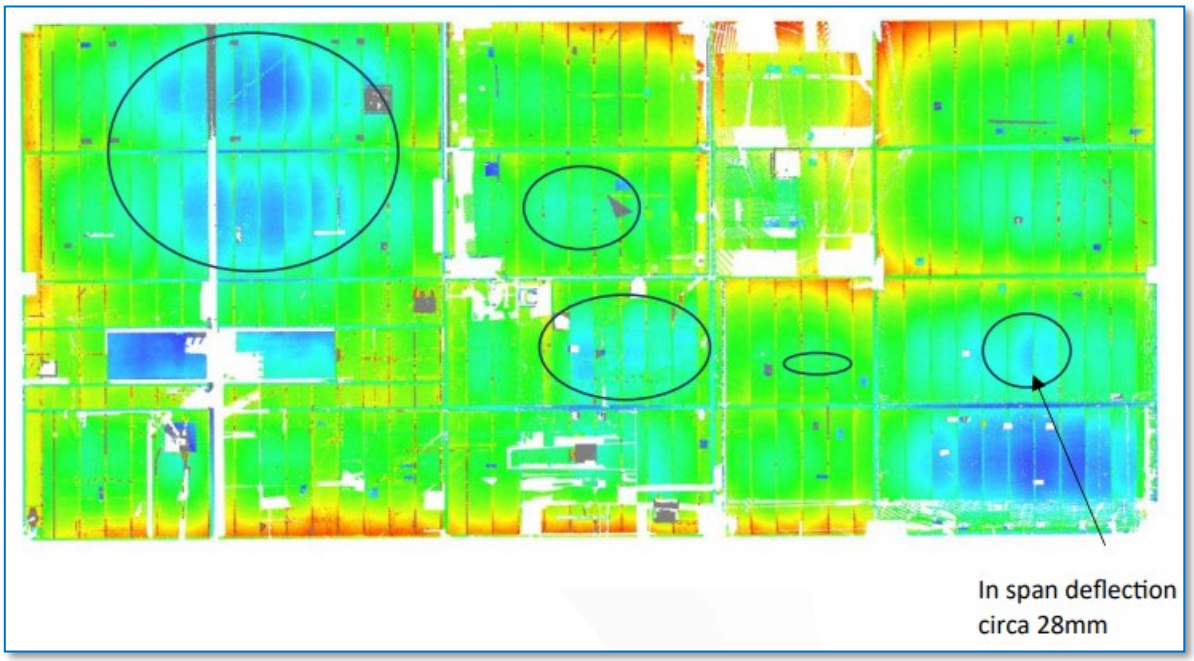


Figure 23 – Deflection scan of first floor Social/Bar areas. Source Thomas Consulting, 2023

The deflection scan of the Civic Centre Theatre/Changing Room area roofs are shown in **Figure 24**, which indicate typical spans of deflection span/200 to span/250.

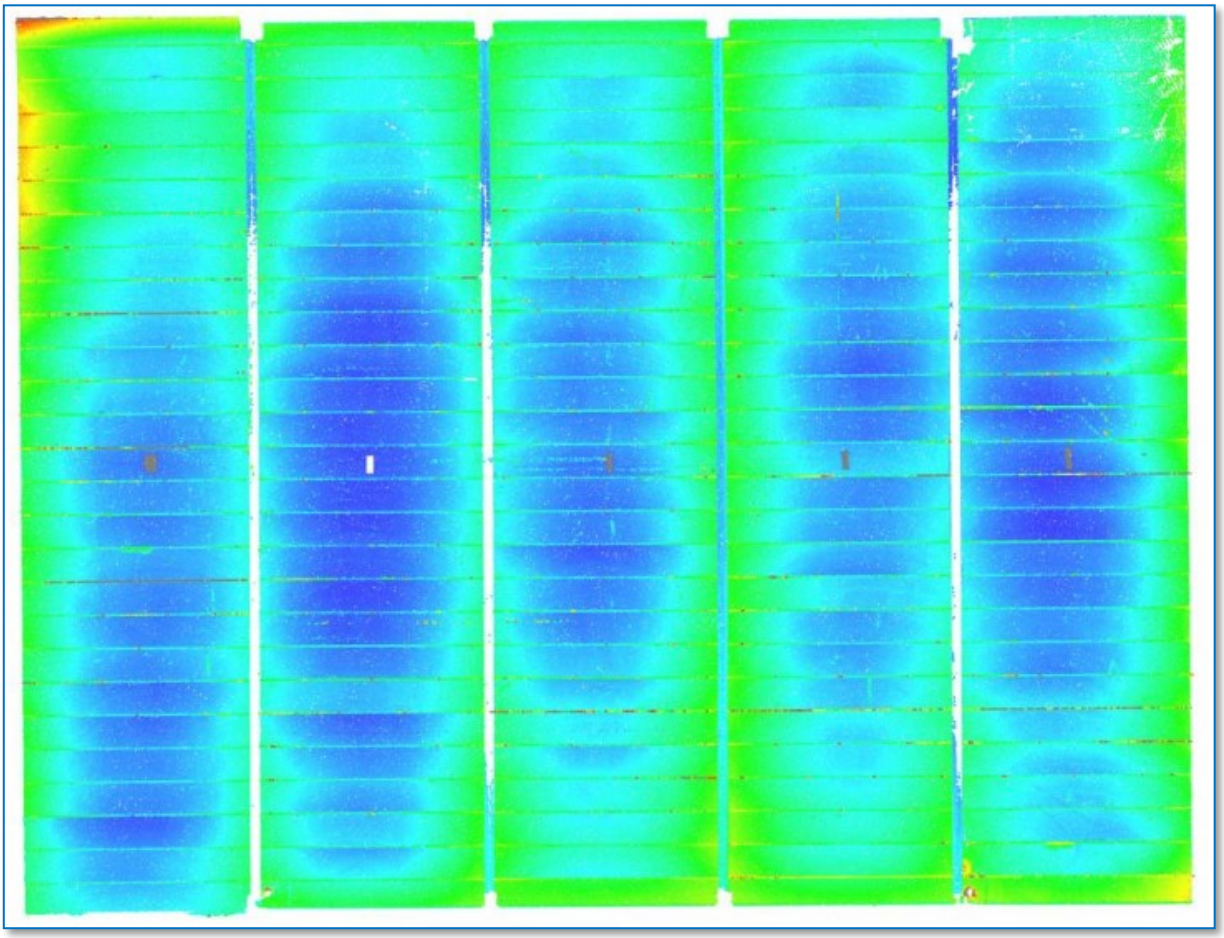


Figure 24 - Deflection scan of Theatre/Changing Rooms. Source Thomas Consulting, 2023

The deflection inspection concludes all the roofs at the complex based on their scores and relating to the risk category in Table 2 are considered as Red category.

In conclusion of Thomas Consultants structural report the following key observations are noted:

- Unsupported or inadequately supported planks affecting suitable loading under current structural safety parameters.
- Adaptions of RAAC planks to the detriment of stability.
- End bearings in assessed areas are <75mm.
- Reinforcement and transverse reinforcement being compromised in areas due to modification.
- Deformation and displacement of RAAC planks in areas indicated by deflection.
- Historic penetrations/fixings and moisture ingress to areas of RAAC impacting on condition of planks.

Based on the visual assessment noting the condition, spalling to areas, cracking, reinforcement, and unsupported adaptions etc. the RAAC planks at the complex are classed as Red and Red Critical in risk categorisation as shown in **Table 3**.

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 3 - Risk Assessment Category. Source Institution of Structural Engineers (2023)

This categorisation suggests extensive remedial work through the property as soon as possible.

Prior to the report being provided the structural engineer made Property & Development aware of the initial observations and urgent additional propping was installed to the Library area, in addition to other mitigation

and exclusion factors including continued closure of the building and control measures for limited essential controlled access. Should the Library or Social area need to be occupied further point load propping to these areas would be required at first floor and mirrored ground floor location. In addition to risk factors this would make the areas unfavourable for practical use. Other remedial work which could be considered are:

- Additional steelwork (internal skeletal type frame) at bearing positions and spans to reduce deflection.
- Additional support at all cut or damaged planks.
- Complete replacement of all roof membranes.
- Remedial work to spalled concrete.

The above would require further investigation and assessment.

The Structural Engineer has commented on the extent of the condition and its complexities, with consideration of CDM Regulations (2015) and Building Safety Act (2022) but also cost effectiveness to consider replacement of the structural roof and replacement.

7. OPTIONS APPRAISAL & CONCLUSION

Due to the severity of the categorisation of Red (Critical) shown in Table 3 and in conclusion of the structural engineer's findings, mitigation management is not an option to be considered.

Based on the structural conclusion please see Table 4, for a summary of the options appraisal, including notes and high-level budget estimate costs. These costs are based on existing information and assumptions at this stage.

Option	Option Description	High Level Estimate £	Considerations
Option 1	Do nothing and close the building permanently	£60,000 - £100,000	Liability concerns and responsibilities. Risk of roof structure collapse. Ongoing inspection and contractor costs. Additional propping to first and ground floor front locations
Option 2	RAAC to remain in place and mitigated through internal structural framework, repairs to spalled concrete and full replacement of roof membranes	Unknown	RAAC exceeded design life and mitigation could not be guaranteed. Replacement ceilings to allow for regular inspection/surveys Ongoing revenue cost burden for regular inspections. Lack of confidence in use of building. Dependent on further structural calculations if viable.
Option 3	Replacement of structural roof and associated essential items	£2,360,000 to £2,450,000	Replacement to current Building Regulations. Cost consideration to include replacement suspended ceilings, services i.e. lighting/fire alarm. Minor internal decoration/flooring of essential and affected areas only.
Option 4	Demolition and clearing of site	£510,000 - £600,000	Conservation Area. Party Walls of neighbouring properties.
Option 5	Demolition and Rebuild as existing facilities provision.	*£6,035,000 - £7,635,00	Demolition budget outline estimate provided in Option 4 and rebuild based on the existing like for like provision* Any change variance of requirement would need an outline scope and feasibility of redevelopment requirement be established to inform outline budget cost.

Table 4 - Options Appraisal - High level estimate costs

Please note that none of the above options include costs for the temporary relocation or provision of a Library and Civic Centre facilities.

Option 1

Should the building remain empty for an extended period if no action is determined, or other options considered (which will have a period of design/procurement/mobilisation) the addition point load propping mentioned in Chapter 6 to the first floor social/bar area and corresponding ground floor areas would be advisable mitigation. The cost for this is unknown due to the length of time but will be considerable and in addition to the costs of existing propping arrangement. In action is likely to contribute to further deterioration of the RAAC planks and risk to the safety of the structure.

Option 2

Whilst the structural engineer has commented, with further investigations required to determine a potential level of mitigation and remedial work could be considered to the existing RAAC planks. This may possibly be achieved by design an internal bracing skeletal framework to support the structural load applied to the RAAC in the property.

It was determined that the lifespan of RAAC roof planks is approximately 30 years. The Civic Centre date of construction is circa 1970s, therefore this currently exceeds the 30-year life design span. However as per Chris Goodier (Loughborough University, 2023) comments, this alone should not determine the need for replacement, with need for consideration of the condition assessment, which in this case is Red Critical.

In addition to this work continued monitoring and assessment would be required post completion. This would also require reinstalling all ceilings and services. This is likely not to be considered of economic value for money. In addition and consideration of social behaviour this may influence a lack of confidence to users of the building such as staff and the public.

Option 3

As noted in the Structural engineers report the mitigation of the existing RAAC insitu may not be suitable or considered an economic viable option. This option considers the replacement of the entire roof structure and replacement with new structural elements and water proofing system. Replacement RAAC planks initial case studies (though of a simpler building and location) such as Sir Thomas Boughey Academy (Garland UK, 2023) and Royal Blackburn Hospital (Britmet UK, 2023) indicate that removal and replacement of the structural roof deck is in theory possible. However this would require a detailed feasibility stage assessment to further inform of this option buildability and viability.

A potential replacement roof methodology may be to remove the structural RAAC planks and built-up roof construction for full replacement with an alternative product, using the existing support steel beams, subject confirmation of suitability. Where timber beams are present it is envisaged, these will need full replacement. The removal of the RAAC planks may require an internal crash deck scaffolding to be formed as a safe working platform with additional external scaffolding encasing the roof/building to ensure weather protection during the project.

The roof replacement would be required to achieve current Building Regulation standards which range from structural, fire safety to conservation of fuel/power (thermal performance). A potential positive consideration would be further introduction of Photovoltaic panels (not included in estimate costings) as part of any design to assist with further operational sustainability. Full ACM removal will be required before any roof removal etc can take place. In addition to any structural roof replacement the reinstatement of all services (lighting, emergency lighting, stage lighting, ventilation, etc) and replacement suspended ceilings would be required. Other consequential improvements and internal remediation will need to be considered and have been

included in the budget cost estimate. Further improvement of facilities would need identifying and additional consideration. The budget cost estimate includes for BCIS (2023) forecast adjustment for 2024 construction cost increases.

Option 4

The economic viability of the previous options need consideration of retaining the existing building with ongoing life cycle of costs including items not in scope such as plant etc. An alternative to Option 3 is to remove the risk factor at lower cost though ongoing management of the cleared site would be required, including security to avoid anti-social behaviour etc. The property is located within the denoted Whitchurch Conservation area and would need to be considered. Services and plant would require safe isolation and removal.

Mitigation of neighbouring properties and party walls (Party Wall Act, 1996) will need consideration, assessment and monitoring for any additional support etc. or effect from demolition.

Due to the confined nature of the site it would be envisaged that a deconstruction method of demolition would be suitable.

This option does not provide replacement facilities on this site.

Option 5

*The budget estimate cost utilises the current insurance valuation for rebuild is based on a like for like existing provision of the current design and designation. This is within similar guidance costs utilising SPONS Architects' and Builders' Price Book (2024) estimated price book and BCIS (2023) case study information. The above valuation includes basic inclusion for demolition cost. To allow for potential market variation (based on the like for like replacement) the budget cost estimate includes for BCIS (2023) forecast adjustment for 2024 construction cost increases to provide a range consideration.

However, the above is based on a replication of the existing facilities. Should consideration of redevelopment of this site for be for facilities yet to be determined or scoped then a further strategy and brief will be required to inform further. A new development will need to meet current Building Regulations, Shropshire Council Climate Change Strategy (2020), sustainable factors such as BREAAM (2022) carbon neutral building and meeting the requirement of Net Zero Strategy (2021), Net Zero Estate Playbook (2021) and the Public Sector Decarbonisation (2020).

Alternatively the site could be demolished and leased as freehold or sold for development to others realising the land value. Provision of existing service provision would need to be considered in any alternative location. The Gross Development Value and budget estimate cost for this option cannot yet establish due to the unknown factors or requirement.

Further outline feasibility and scope should be determined as per the RIBA Plan of Work (2020) through an assembled project team, as illustrated in **Figure 25.**

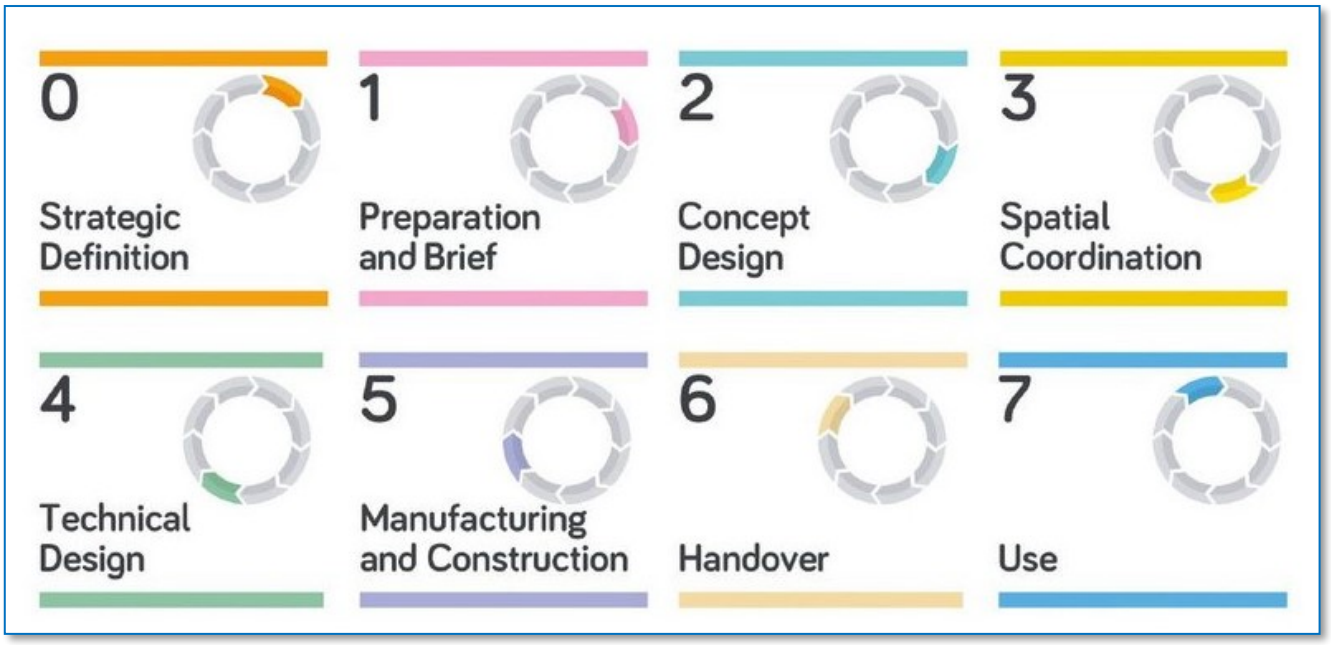


Figure 25 - RIBA Plan of Work - Stages (2020)

CONCLUSION

It was determined that the lifespan of RAAC roof planks is approximately 30 years. As this construction was last used in the 1980s or mid 1990's all RAAC roof decks have in theory now exceeded their estimated lifespan and may require to be replaced in their entirety.

The knowledge of the recent and sudden failure of a DfE school property with RAAC. in August 2023, and national concerns must be weighed with consideration of risk compared with the information provided by the structural assessment. In the case of the Civic Centre the condition informed by the Structural Engineer of Red Critical – being the most serious condition, in consideration of any remedial mitigation, assessment of safe operation should also be balanced with practicality/suitability and economic viability.

In this recommendation Option's 1 and 2 may not be desirable given the extended life span, condition and complexity and value for money. The remaining options will require consideration of the social, environmental, and economic factors and alignment to the Shropshire Plan (2022) and based on the economic long-term provision and Council asset strategy.

Should any of the remaining options be considered as viable, further outline feasibility and scope should be determined as per the RIBA Plan of Work (2020) through an assembled project team commission, to provide more accurate detailed options and estimate costs.

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APPENDIX A - VISUAL CHARACTERISTICS OF RAAC PLANKS

This guide will help you identify where RAAC panels may be present in your buildings. In many cases, RAAC panels can easily be identified if a building's structure is not covered by finishes or decoration (such as ceilings). RAAC panels have some distinctive features as shown on pages 12-13. If you can view the structure and identify one or more of these, RAAC may be present in your building. Note: Consult guidance about managing asbestos in accordance with Control of Asbestos Regulations (2012) and the building's asbestos management survey register prior to any invasive investigation.

Typically RAAC panels are typically 450- 600mm wide though this can vary. The length will also vary but commonly up to 6m in length. Panels typically have a 'V' groove chamfer along their edge as seen in **Figure 26.** RAAC panels are quite soft and subject to ACM consideration etc can be tested by penetration tools, allow an indentation. RAAC panels may present bowing or deflection.

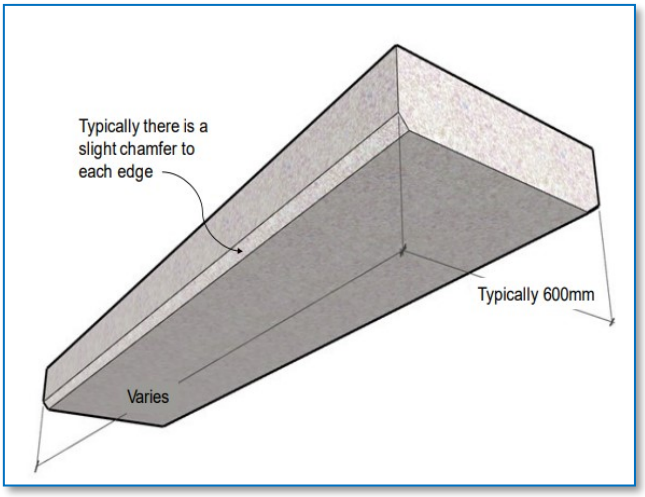


Figure 26 - Typical RAAC Profile. Source DfE (2023)

Typical locations RAAC Panels are commonly found.

Flat roofs/floors as **Figure 27.**

Figure 27 - RAAC roof/Floor. Source DfE (2023)

RAAC in Wall external and internal construction as **Figure 28**

Figure 28 - RAAC Wall Construction. Source DfE (2023)

Typical construction using RAAC Planks as **Figure 29**

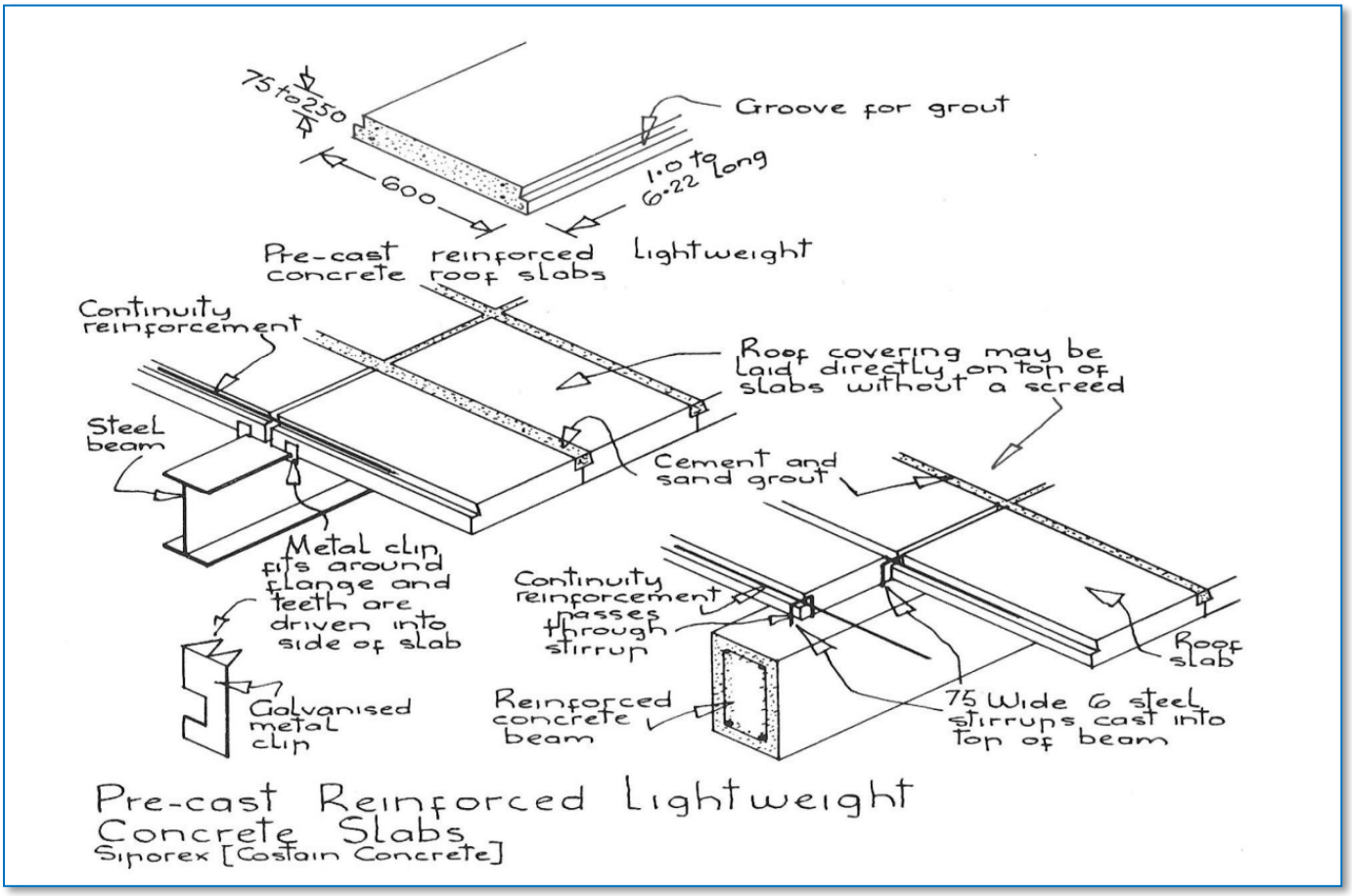


Figure 29 - Typical RAAC Construction. Source Barry (1971)

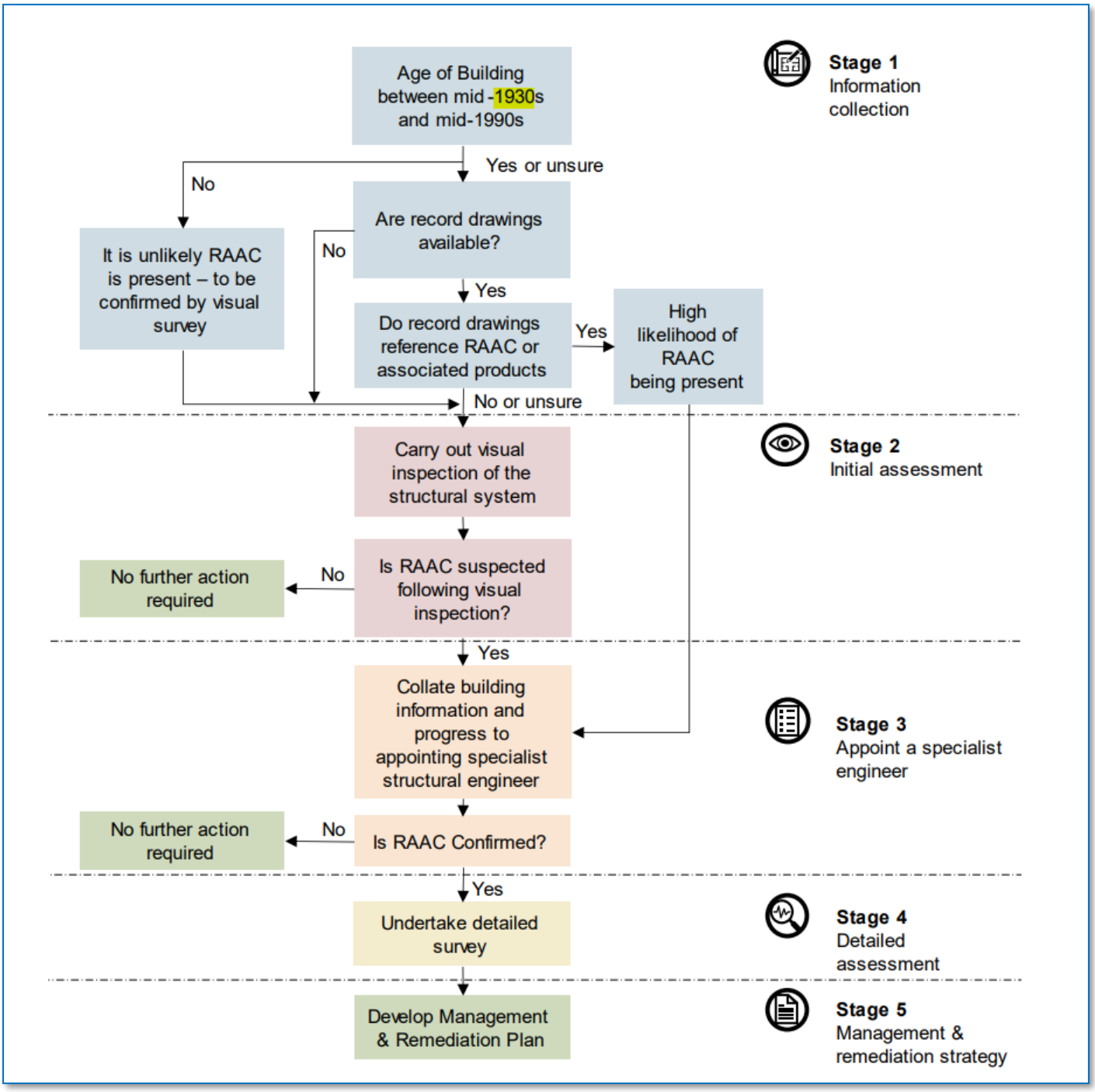
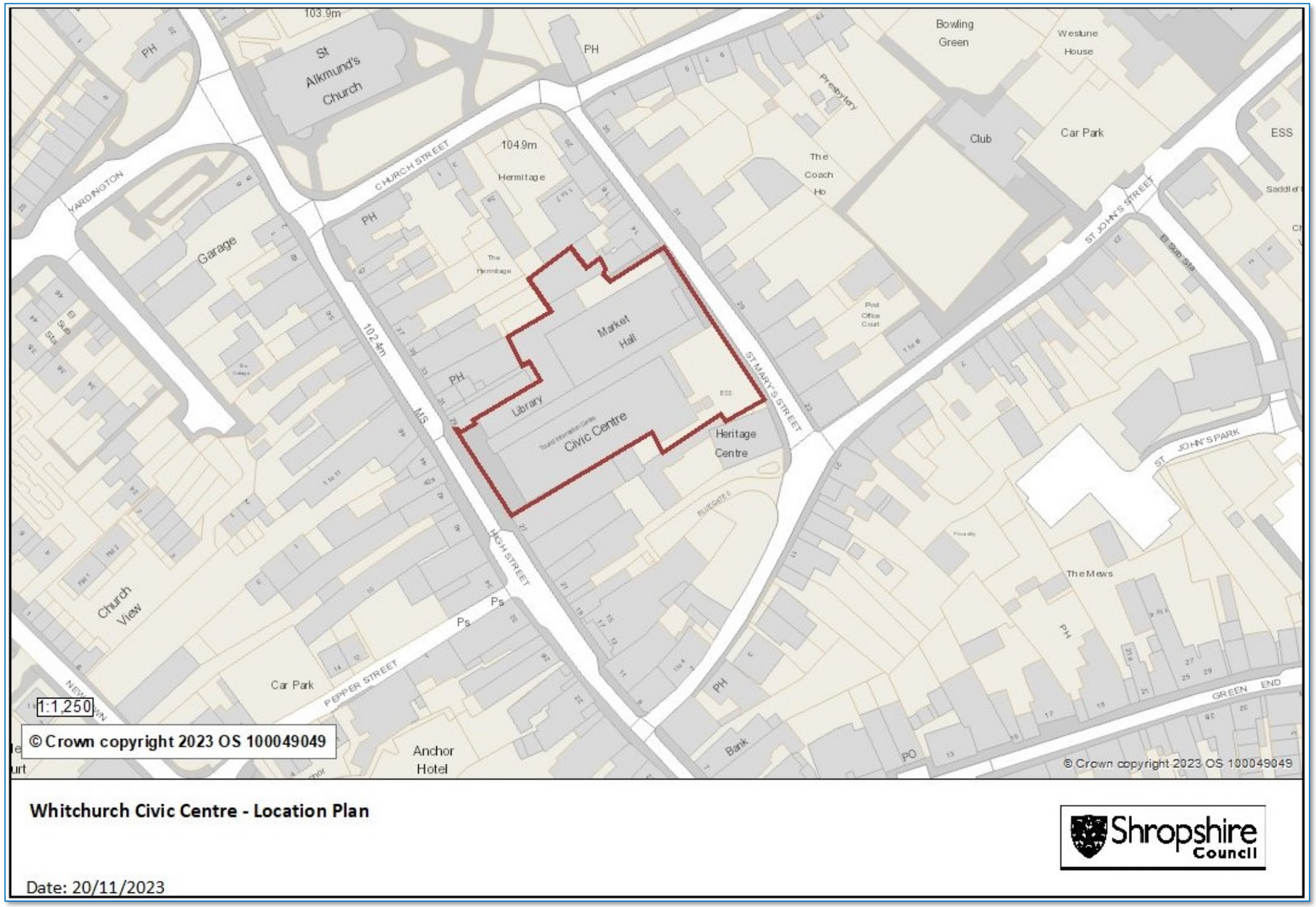
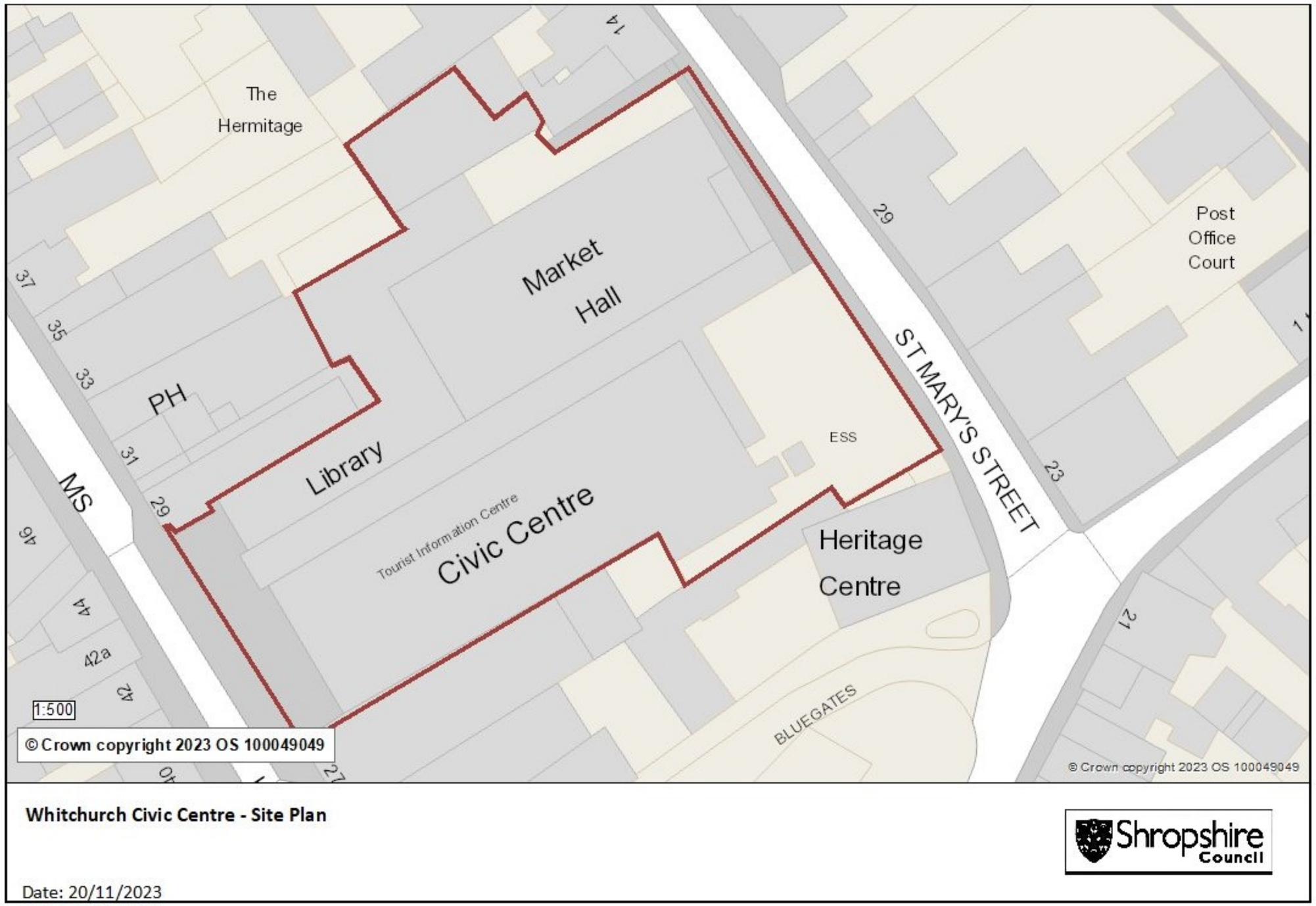


Figure 30 - Investigation of RAAC Guidance Stages. Source DfE (2022)

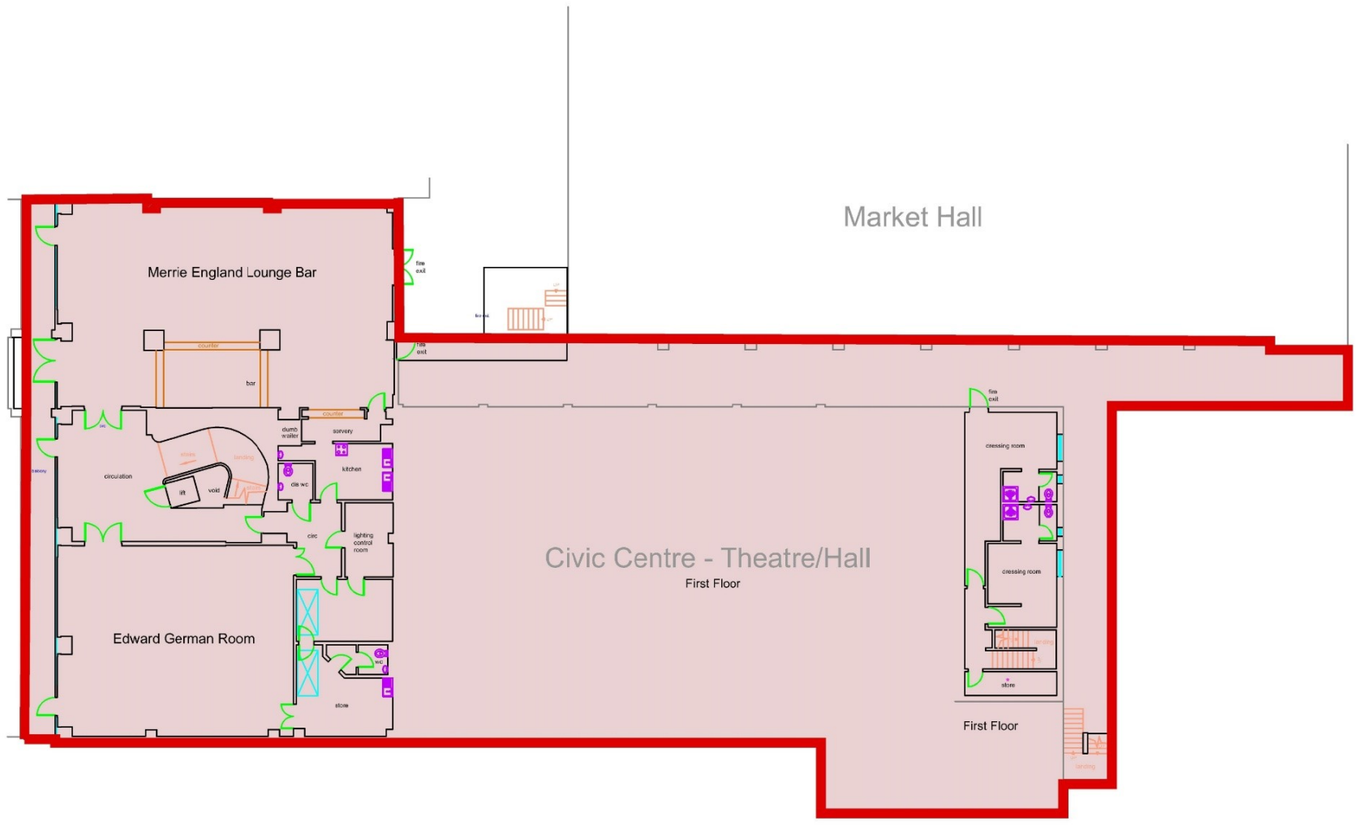
Location Plan – 1/1250 A3. Source Shropshire Council (2023)



Site Plan – 1/1250 A3. Source Shropshire Council (2023)



RAAC Confirmed Floor Plan. Source Shropshire Council (2023)



Notes :

1. DO NOT SCALE FROM THIS DRAWING
2. Information on underground services is believed to be correct but no guarantee is given or implied.

N

Legend

RAAC Confirmed Present at roof level

RAAC Not Present at roof level

Shropshire Council

Property Services

www.shropshire.gov.uk 0345 678 9000

WHITCHURCH
CIVIC CENTRE, LIBRARY
& MARKET HALL

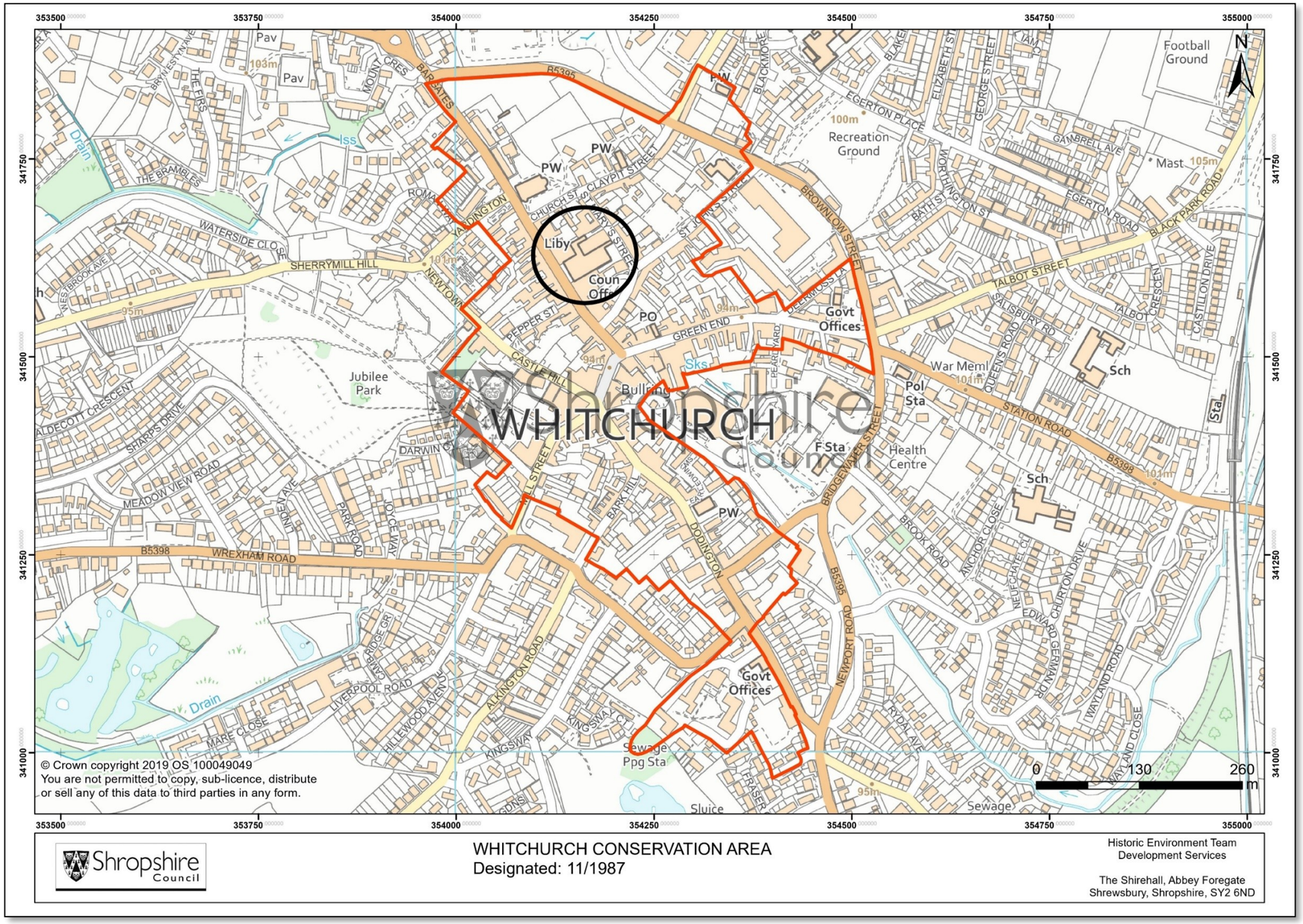
PROPERTY NO: 6000 & NSDC018

AREAS OF CONFIRMED RAAC

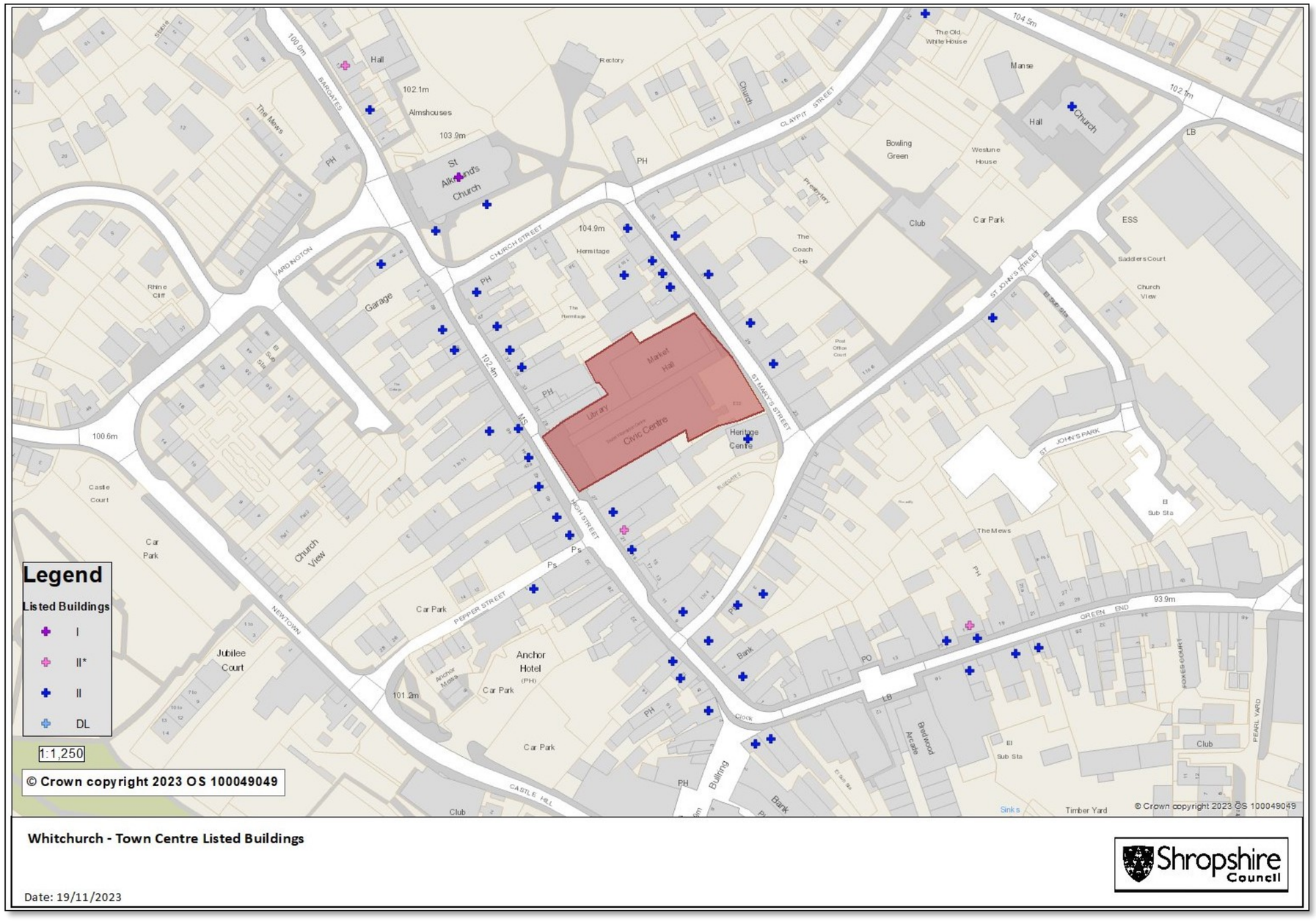
BUILDING FLOOR/PLAN
FIRST FLOOR

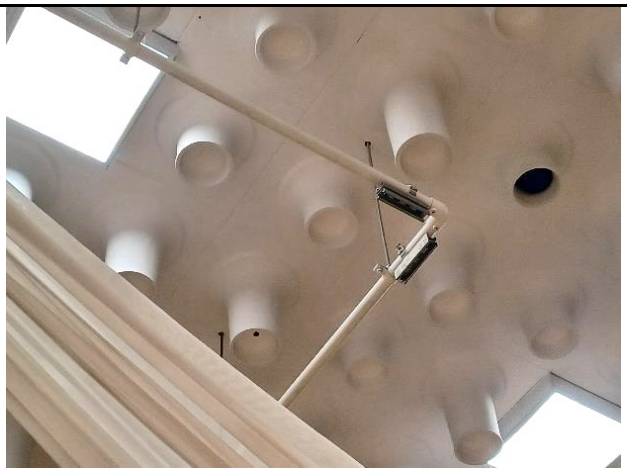
DWG. STATUS				
SCALE	NTS			@ A3
DRAWN BY	PMB			
DATE	11/2023			
UPDATED			REV.	
AREA	PROP.	PHASE	AEMFS	SHEET
005	039	00	A	2

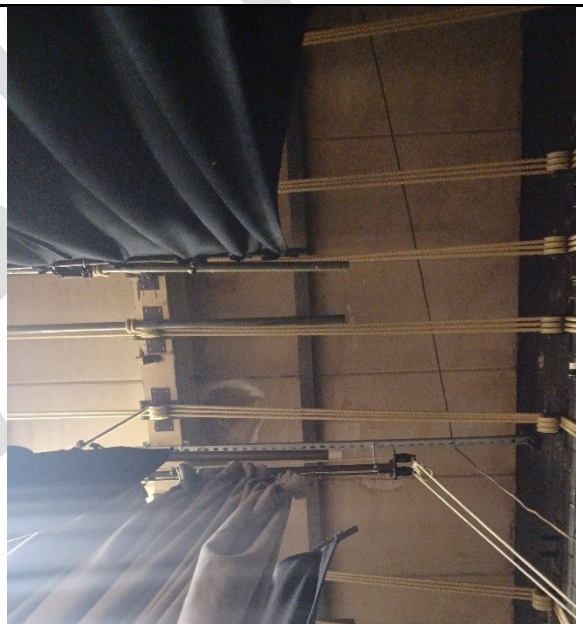
Conservation Area Map. Source Shropshire Council (2017)



Listed Building Location Map. Source Shropshire Council (2021)



	
Library rea asphalt flat roof	**Library rear Asphalt flat roof**
	
Theatre fixed ceiling – pre removal close up	**Theatre fixed ceiling – pre removal**

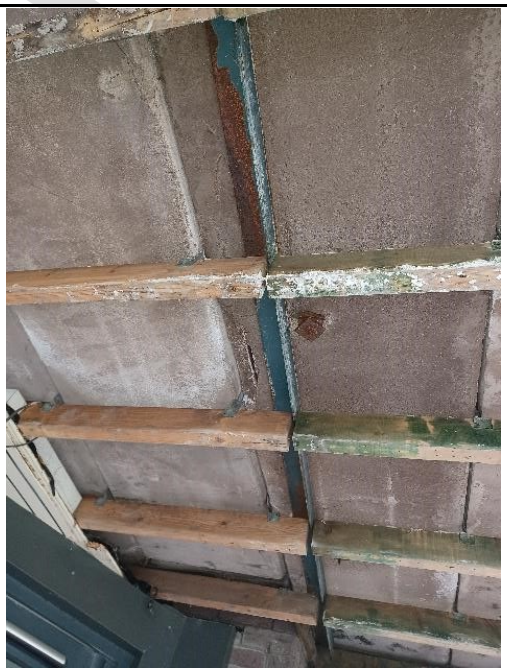
	
Theatre - Post ceiling removal – showing castellated beams and fixings to planks.	**Theatre – Example of rear of plastered suspended tile.**
	
Theatre Stage area ceiling showing RAAC planks	**Theatre Stage area – damage and moisture stained RAAC plank**

Cut opening to RAAC Plan and damage to concrete exposing reinforcement bar

Social Area ceiling removed and fixing/ghosting to planks

Damaged to RAAC plank

Damage to concrete cover and exposed reinforcement bar, efflorescence

	
Above suspended ceiling to Social bar area - services	**Timber beams to underside of RAAC planks**
	
Covered internal walkway RAAC plank penetration, timber beam support and corrosion to steel work beam. Evidence of moisture ingress.	**Covered internal walkway RAAC plank penetration, timber beam support and corrosion to steel work beam. Evidence of moisture ingress.**

External canopy, corrosion of steel beam and support propping

External view of internal covered walkway canopy asphalt roof

External view of internal covered walkway canopy asphalt roof

External (part) view of external covered walkway canopy asphalt/felt roof