



URS BUILDING REFURBISHMENT

EXTERNAL CONCRETE REPAIR – HERITAGE OFFER

JUNE 2024

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1 INTRODUCTION

1.1 EXECUTIVE SUMMARY

The purpose of this report is to set out the findings of the concrete survey and give an overview of potential concrete repair at the URS Building at the University of Reading. Works to repair the defects assessed here will be presented as a proportionate public benefit in connection with the ongoing, phased refurbishment of the building. This document is accompanying Stage 2 of the process which is concentrated on external works. The current planning application seeks planning permission and listed building consent for *“External refurbishment, repairs and alterations consisting of replacement windows and doors; replacement roofs, including new roof lights, cowls and lanterns; soffit replacement; and concrete repairs.”* As part of this application, the university intends to implement a package of repair works based on the findings of the survey. The detailed scope of these works will be agreed upon in consultation with Wokingham BC and other stakeholders including the Twentieth Century Society.

To inform the decision-making process and assist in the definition of the heritage offer, the University of Reading commissioned a concrete survey report. This report was carried out by Purcell and assessed all external areas of the URS Building.

2. SIGNIFICANCE

2.1 INTRODUCTION

A full assessment of the significance of the Grade II listed URS Building is contained within the Heritage Impact Assessment (HIA), completed by Purcell that accompanies this application. Based on the history of the building, its design concept and surviving materiality, conclusions about the relative significance of its built fabric have been made. The following sections on significance are edited versions taken from the HIA and are used here in support of the survey work and methodological framework that will underpin the package of repairs. The repairs package will have a relationship to but not be solely based on, this assessment. For the purposes of this document only the architectural and aesthetic significance sections are here included.

2.2 SIGNIFICANCE ASSESSMENT

KEY ELEMENTS OF SIGNIFICANCE

- *As a Grade II listed building designed by one of the leading practices of the Post-War Period, HKPA*
- *As a key building in the wider historic campus of Reading University*
- *For its impressive structural qualities derived from a variety of lines of architectural enquiry including Brutalism and Japanese methods of construction*
- *For its designed setting including the reimagining of the historic carriageway and ornamental pond and the use of colour as a metaphor for the surrounding landscape*
- *For the contextual and rare use of pigmented concrete in two tones*
- *For the expression of 'vertebrate architecture' as a means of spatial planning and educational engineering in building design*
- *For the consistent use of materials on the interiors, including timber and steel, which give a coherence and unity across the building*

ARCHITECTURAL & AESTHETIC

"The ways in which people draw sensory and intellectual stimulation from a place."

BY ELEVATION:

NORTH – HIGH

SOUTH – MEDIUM

WEST – HIGH

EAST – LOW

INTERIORS – VARIED SEE PLANS

INTRODUCTION

The architectural value of the URS Building rests on a number of interrelated values to do with its design, materiality and setting. These elements are below taken in turn as a prelude to significance judgements about the four principal elevations and their settings. Plan form and key interior spaces are then discussed. The values given in the text are then expressed in a series of coloured plans which are given at the end of the section.

DESIGN

The URS building is architecturally distinctive and is a developmental expression of a number of sensibilities of the HKPA practice throughout their active years. Of primary value to the aesthetic of URS is HKPA's collective interest in expression of structure and the legibility of structural components in any given design. Although this is seen in a number of HKPA buildings, the scale and repetition of the beams at URS make it one of the most expressive of any of their major works and the trabeation is an important visual component in this regard. This element of the design also had an important relationship to Japanese architecture, which was a touchstone for a number of important architects Post-War, including the Smithsons. There is also value in the expression of 'vertebrate architecture' where functional sequences of spaces were designed as nodes off a main, central spine and where the movement of people was a considered element of the design. HKPA were concerned with this in most of their projects and it again echoed wider preconceptions of the period – particularly in higher education. Sir Denys Lasdun's Academic Teaching Wall at the University of East Anglia (UEA) was a larger version of this socially-engineered solution for largescale teaching spaces where laboratory, seminar and faculty accommodation was concentrated in repeating sequences off a central spine corridor that had a social function. Some of those ideas are expressed – albeit in a smaller way – at URS, with stairwells, corridors, atria and communal breakout spaces expressed centrally on plan as part of circulation.

MATERIALITY

Concrete was the chosen material for HKPA on a number of their most important projects and the firm developed a high level of sophistication in using both in situ and precast types of the material. The firm's oeuvre has been widely characterised as Brutalist and this indeed holds true for many of their major, early works including Roehampton and Acland Burghley School, both of which rely on exposed concrete finishes for their aesthetic character. Acland Burghley is rather a pre-cursor to URS as the structure is a combination of pre-cast and in-situ concrete elements, clad with pre-cast panels with an exposed aggregate finish of Walley flints. At URS, the distinctive two-tone colouring does carry significance both as an interesting contextual design element and as an aesthetic choice.

SETTING

The immediate setting of the building is part of its architectural design and there is a formal and designed relationship between some of the internal and external spaces. Most significant in this regard is the covered walkway to the northern side, Chancellor's Way. This is a modern interpretation of a historic route and shows a deference in the architectural design to the historic context of the site. An ornamental pond to the west is another element and there is an internal courtyard on plan. The wider parkland setting was also a highly considered element in the design and the building was meant to respond to the existing planting and trees – some of this planting has gone but the echoes of it are carried in the building's visual identity.

ELEVATIONS

For the combined expression of these elements, there is a differential in significance between the various facades, how they are seen in near and long views and how they sit within the landscape. The northern and western elevations are considered to be high for their expression of architectural form and visual relationship with the formal and informal landscape settings. The southern elevation is medium as it is not as appreciable from any distance and is seen as part of the wider built environment of the campus to the south. The eastern end is considered to be low for the same reason and because it has less visual interest than the other elevations.

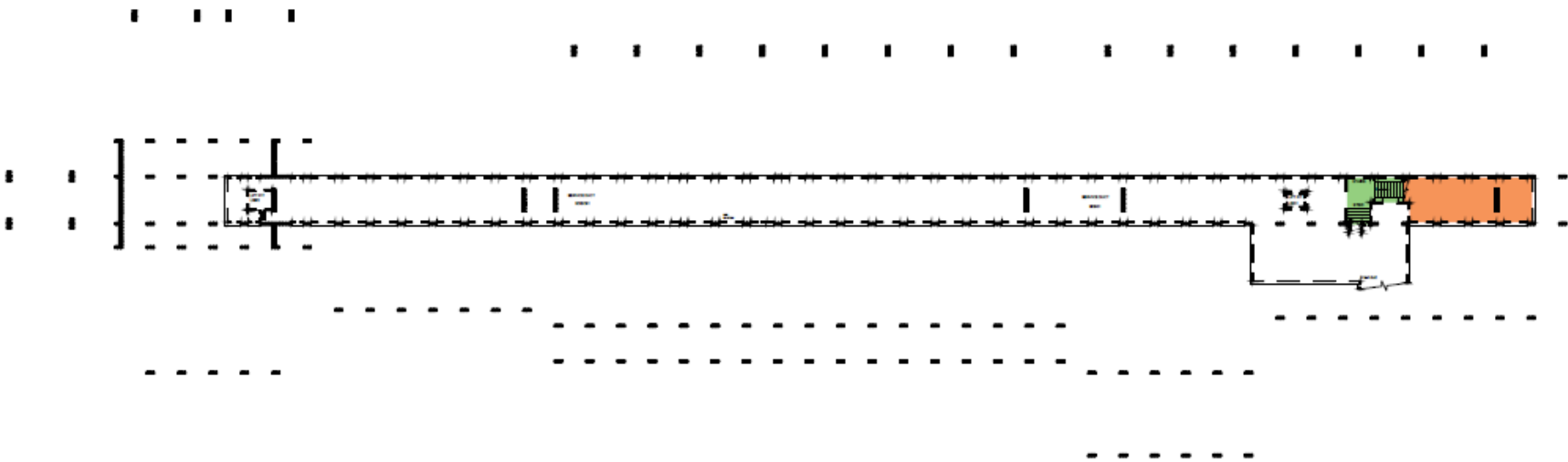
2.3 SIGNIFICANCE PLANS

The following plans relate to all the internal spaces at URS and such is the relationship between the internal and external structure that weight has been given to the expression of structural make-up on the inside of the building in these conclusions.

BASEMENT

- High
- Medium
- Low
- Neutral
- Detrimental

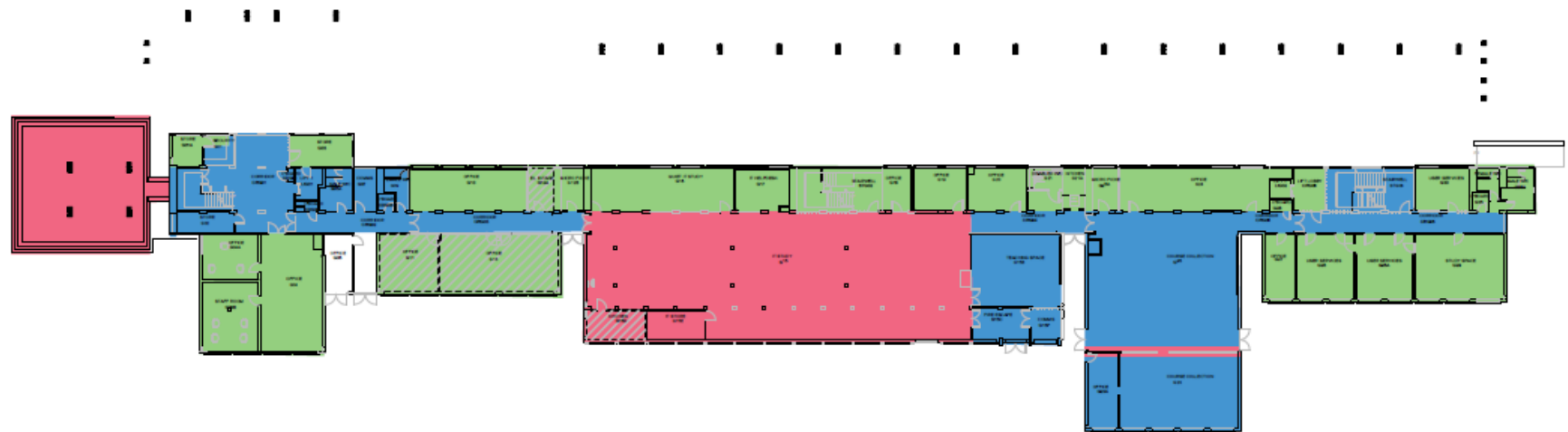
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GROUND FLOOR

- High
- Medium
- Low
- Neutral
- Detrimental

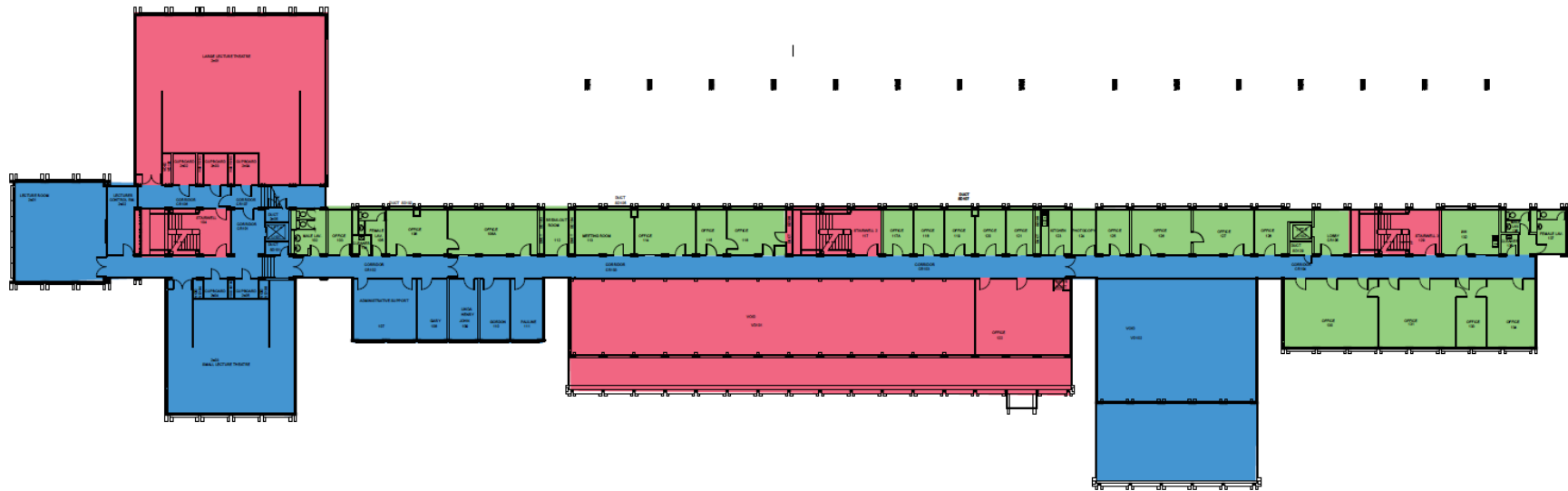
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FIRST FLOOR

- High
- Medium
- Low
- Neutral
- Detrimental

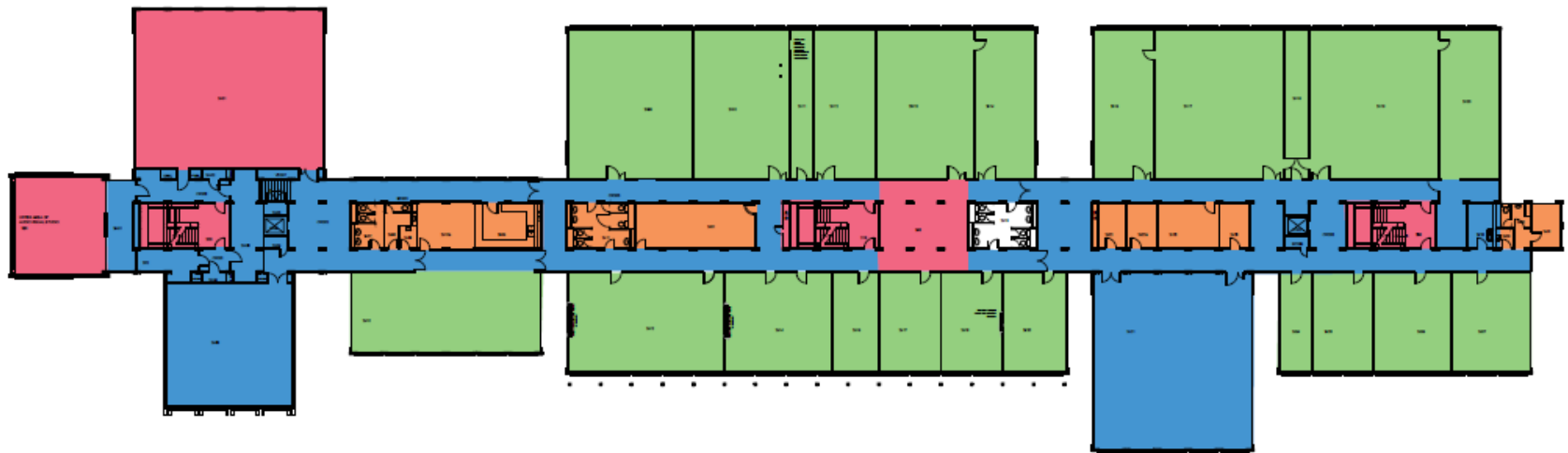
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SECOND FLOOR

- High
- Medium
- Low
- Neutral
- Detrimental

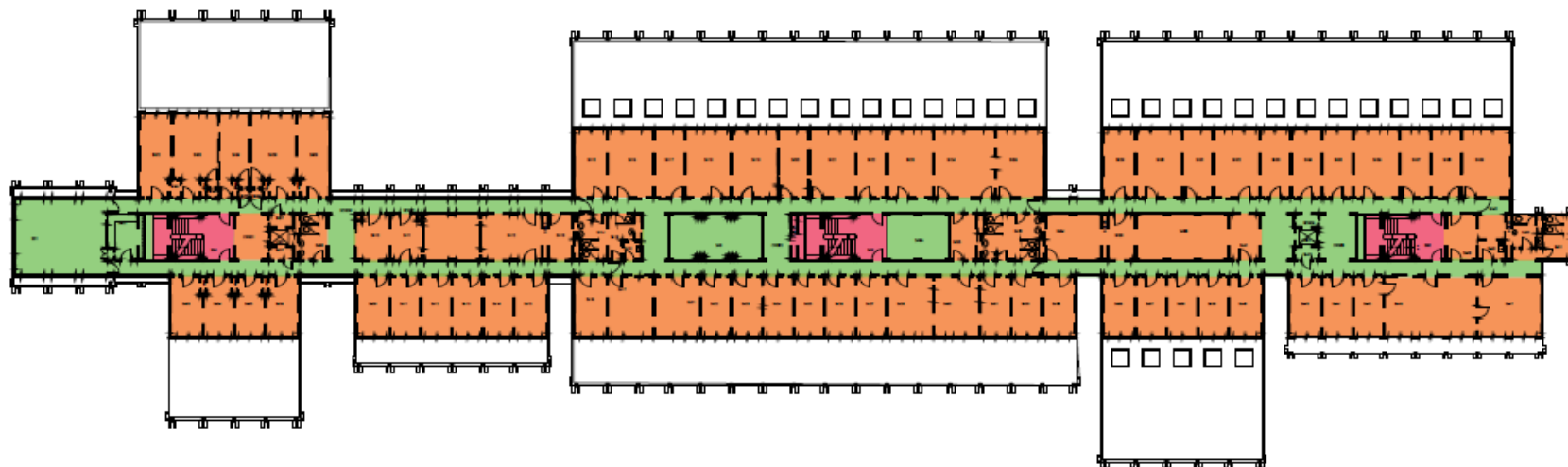
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THIRD FLOOR

- High
- Medium
- Low
- Neutral
- Detrimental

This plan is not to scale



- High
- Medium
- Low
- Neutral
- Detrimental

3. SUMMARY OF SURVEY FINDINGS, DEFECTS AND REPAIR TYPES

3.1 INTRODUCTION

This section sets out the findings of the survey and details the defect types which will be the focus for a range of repair strategies as well as the outline repair strategies themselves.

Purcell was commissioned to prepare a concrete repair strategy for the external concrete building elements at the URS Building, in line with recommendations set out by the Getty Conservation Institute in their publication, *Conservation Principles for Concrete of Cultural Significance*. We undertook a detailed visual inspection of the building and identified a series of defects which have been assigned priority ratings depending on their condition and location. The outline repair methodologies set out below will require trialling and refining prior to implementation.

Our assessment focuses on improving the overall appearance of the building as part of the wider redevelopment and addressing poor previous interventions. The nature of the concrete repairs are aesthetically rather than performance driven. A structural assessment of the building has been undertaken by Structural Engineers, Curtins, with intrusive investigations being carried out by CRL. Recommendations for structural repairs and potential future protection of the structure, including cathodic protection and the application of anti-carbonation coatings will be addressed by Curtins in the Phase 3 planning application. The specification and application of structural repairs will be closely informed by Purcell's concrete repair strategy, to ensure acceptable aesthetic finishes.

3.2 DEFECT AND REPAIR TYPES

The following specific defect types are found to the exterior of the URS Building. Each defect type is followed by the proposed repair methodology which will be subject to further development and additional investigations and consents once agreed and which are to be secured in connection with the grant of planning permission and listed building consent.

A – Cracking

A1 & A2 – Small and Large Cracks

There are numerous small / fine cracks across the building together with some large cracks (classified in this report as being over 3mm wide). Cracking is a natural feature of concrete structures and in many cases will have little effect on strength and durability. Some of the cracks will be non-structural and will have developed during the construction process or be the result of thermal variation.

Much of the cracking appears to be the result of corrosion of the reinforcement and is a precursor to spalling. The cracks provide a route for water to ingress the structure and exacerbate the corrosion process. Many of the cracks were viewed from a distance and so should be assessed close up to establish whether they are a sign of more extensive spalling. Cracking along the top edge of transfer beams, as viewed to the gridline return elevations may be due to spalling of the upper reinforcement bars, although further investigation is required.

A lot of the cracking that has been observed is hairline cracking. Generally, this occurs to the large transfer beams to the undercroft, taking the form of diagonal cracks extending upwards and outwards from the bearings of the beams on the principal concrete piers. The Structural Engineer has assessed these cracks to be sheer cracking due to deflection. At present this cracking is not considered to be a cause for concern. With these very fine, hair line cracks, no action is recommended at this time, although the Structural Engineer may recommend ongoing monitoring.

Cracking across the building has been assessed by a Structural Engineer to identify anything that is a structural cause for concern. Where the Structural Engineer does consider cracking to be a structural concern, then a strategy for remedial works should be developed by the Structural Engineer, utilising components of the outline repair strategy proposed in this report, to ensure that repairs are visually acceptable and compatible with the existing fabric.

Where cracks appear to be the result of corrosion of reinforcement then they should be treated as for a spall with cutting out of the cracked and spalling material, removal of corroding material from the reinforcement and a concrete repair. Elsewhere a variety of repair strategies have been provided for filling cracks depending on their size and whether they are static or active.

Active cracks should not be repaired until the cause has been identified and progressive movement arrested, otherwise there is a risk of abortive work. On the basis of our inspection, it is not possible to identify which cracks are active and which are not and further investigation and monitoring of some of the cracks will be required. Repair of non-progressive cracks is by means of resin injection, to accommodate small amounts of movement but prevent water ingress.



Example of Defect Type A1



Example of Defect Type A2

A – Cracking

Further investigation and review by a SE will be required to determine whether cracks are active or static, or whether any further works are required.

DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
A1 Hairline cracking to concrete less than 3mm.	RA1A	Cracking 0 to 3 mm width: do nothing, monitor through periodic inspection.
	RA1B	1.HAND PLACED – SMALL STATIC Mortar/grout samples required for prior approval and subject to testing/trials. Remove loose materials and flush out fine cracks with a sharp tool and water to remove dirt/debris and prepare surface. Using a fine tool, apply the approved mortar mix to the crack, being careful not to smear mortar across the adjacent surface. Once the crack is full, carefully clean the surface with a damp sponge and allow to set. Dry brush surface after 24 hours to remove any excess material and ensure finish matches adjacent. OR

		2.GROUT INJECTION – LARGER STATIC Mortar/grout samples required for prior approval and subject to testing/trials. Remove loose materials and flush out fine cracks with a sharp tool and water to remove dirt/debris and prepare surface. Drill very fine holes at intermittent centres along the crack and insert bleeder tube secured with plasticine. Insert grout mix on lowest bleed tube (working from the base up) and fill for established time (duration to be established as part of trials process). Remove grout feeder after established time period. Insert the grout feeder tube on the bleeder tube above and repeat the process until all bleeder tubes are filled. Once initial set is achieved, remove plasticine and grout tip from wall and allow to fully cure. OR 3.ACTIVE (resin inject and surface repair to fill cracks 0.1-10mm) Sealing or undertaking a mortar repair to the crack is the first stage, and is to be undertaken as outlined in RA1B-1/RA1B-2(dependent on the size of the crack), prior to undertaking the resin repair to address the ongoing movement. Note: the area must be dry, free from dirt, dust, grease and debris. Drill a series of injection points at intermittent locations along the crack using a 6mm drill, to a depth of 50mm. The distance between ports should be 1.5x the estimated depth of the crack. Flush through the holes with clean water to remove any debris/drill dust. Insert the resin/feeder tubes along the line of the crack and grouted on the surface. Allow to set. Prepare the resin mix using a slow speed drill. Transfer the mix to a suitably sized injection syringe. Attach the syringe to the feeder tube and slowly inject the resin until it appears out of the end of the next feeder tube. Record the amount injected (at each injection point). Close the feeder tube and move the syringe to the port above and repeat progressing up the crack until all ports are fed and closed. Allow to cure, only then removing the injection tubes and making good any holes as RD1A. At all stages care is to be taken to avoid bleeds/smears/seepage onto adjacent concrete. <i>Note: Where cracks are repairs to previously painted/coated surfaces, paint/coating is to be reapplied following crack repair, to nearest junction/edge. Extent of recoating to be confirmed by architect.</i>
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A2 Hairline cracking to concrete more than 3mm.	RA2A	1.HAND PLACED – SMALL STATIC Mortar/grout samples required for prior approval and subject to testing/trials. Remove loose materials and flush out fine cracks with a sharp tool and water to remove dirt/debris and prepare surface. Using a fine tool, apply the approved mortar mix to the crack, being careful not to smear mortar across the adjacent surface. Once the crack is full, carefully clean the surface with a damp sponge and allow to set. Dry brush surface after 24 hours to remove any excess material and ensure finish matches adjacent. OR 2.GROUT INJECTION – LARGER STATIC Mortar/grout samples required for prior approval and subject to testing/trials. Remove loose materials and flush out fine cracks with a sharp tool and water to remove dirt/debris and prepare surface. Drill very fine holes at intermittent centres along the crack and insert bleeder tube secured with plasticine. Insert grout mix on lower bleed tube and fill for established time (duration to be established as part of trials process). Remove grout feeder after established time period. Insert the grout feeder tube on the bleeder tube above and repeat the process until all bleeder tubes are filled. Once initial set is achieved, remove plasticine and grout tip from wall and allow to fully cure. OR 3.ACTIVE (resin inject and surface repair to fill cracks 0.1-10mm) Sealing or undertaking a mortar repair to the crack is the first stage, and is to be undertaken as outlined in RA1B-1/RA1B-2(dependent on the size of the crack), prior to undertaking the resin repair to address the ongoing movement. Note: the area must be dry, free from dirt, dust, grease and debris. Drill a series of injection points at intermittent locations along the crack using a 6mm drill, to a depth of 50mm. The distance between ports should be 1.5x the estimated depth of the crack. Flush through the holes with clean water to remove any debris/drill dust. Insert the resin/feeder tubes along the line of the crack and grouted on the surface. Allow to set. Prepare the resin mix using a slow speed drill. Transfer the mix to a suitably sized injection syringe. Attach the syringe to the feeder tube and slowly inject the resin until it appears out of the end of the next feeder tube. Record the amount injected (at each injection point). Close the feeder tube and move the syringe to the port above and repeat progressing up the crack until all ports are fed and closed.
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		Allow to cure, only then removing the injection tubes and making good any holes as RD1A. At all stages care is to be taken to avoid bleeds/smears/seepage onto adjacent concrete. <i>Note: Where cracks are repairs to previously painted/coated surfaces, paint/coating is to be reapplied following crack repair, to nearest junction/edge. Extent of recoating to be confirmed by architect.</i>
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B – Spalling/Damage

B1 & B2 – Spalling or damaged surface with and without reinforcement bar visible

Spalling of concrete occurs where the steel reinforcements have corroded, and the expansion of the metal exerts pressure on the surrounding concrete. The principal causes are shallow cover of concrete to the reinforcement bars, progress of carbonation to the depth of the concrete cover, or beyond, and water ingress. Spalling could be seen to all areas around the building and to both in situ and pre-cast concrete components. In some areas the loss of concrete has exposed the reinforcement bars. Spalling is more notable to exposed areas of concrete, including post and beam ends, and also to soffits where water has tracked into the structure via open construction joints.

In a few locations, where spalling concrete has previously been removed, the exposed reinforcement has received some form of protective coating, although the specification of the coating is unknown.

Some of the spalling material is at high level and over areas where contractors, consultants and other visitors to site may be and poses a considerable health and safety risk. In these areas loose material should be removed as a matter of urgency.

Areas of spalling concrete will require cutting out of the cracked and spalling material, removal of corroding material from the reinforcement and a concrete repair. The preferred approach to replacing spalled fabric is for a poured concrete repair, or a hand placed mortar repair, as these are most compatible with a conservation approach to repairs using like-for-like materials and achieving coloured and textured finishes to match the existing fabric.

Where spalling has occurred to originally painted soffits, the use of proprietary repair mortars may be appropriate. Careful replication of surface texture and overpainting will ensure that the proprietary repairs have limited visual impact on the appearance of the building.



Example of Defect Type B1



Example of Defect Type B2

B – Spalling		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
BI Spalling or damaged surface – reinforcement bar is visible	RBIA	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/cutting out The affected area is to be cut out back to sound substrate, removing all carbonated/contaminated concrete, including behind reinforcement bars where necessary. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed due to insufficient cover or has suffered significant corrosion or loss in section, cut back to sound material, this may extend behind the reinforcement. The extent of cutting out should be determined as part of the trial repairs and will likely vary across the building, but should extend a minimum of 30mm behind the reinforcement in carbonated/chloride contaminated areas. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Corroded reinforcement bars should be cleaned by hand or by grit blasting. Prior to any repairs/mortar application the exposed/cleaned re-bars will need to be re-passivated by applying an alkali cement slurry. Where exposed reinforcement has an existing protective treatment, this should be removed. Treatment of the reinforcement is to be agreed by a structural engineer. Where possible, the existing reinforcement may be able to be pushed back further into the concrete, to allow sufficient cover between the reinforcement and the new repaired finished face of the concrete. Where new reinforcement is required, this is to be specified by a structural engineer.

		Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer. Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters likely to be made from plywood to match the fair faced finish. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. Allow to make good if necessary. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis). <i>NOTE: To painted soffits, it may be appropriate to use a proprietary repair mortar, subject to agreement with the architect, trials, and further discussion with the relevant stakeholders. Proprietary mortars to be installed in accordance with manufacturer's instructions, surface finish to match adjacent surface and to receive paint finish to match adjacent surfaces.</i>
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B2 Spalling or damaged surface – reinforcement bar is not visible at this stage (note, once defective material removed/ further investigations are completed, reinforcement may be found and the repair type will revert to RB1A)	RB2A	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RB1A for the repair methodology. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer. Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters likely to be made from plywood to match the fair faced finish. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is
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		completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis). <i>NOTE: In some instances, a precast unit may be deemed more appropriate. This is subject to further review and discussion, for example to the damaged concrete ventilation grilles to ground floor perimeter.</i> <i>NOTE: To painted soffits, it may be appropriate to use a proprietary repair mortar, subject to agreement with the architect, trials, and further discussion with the relevant stakeholders. Proprietary mortars to be installed in accordance with manufacturer's instructions, surface finish to match adjacent surface and to receive paint finish to match adjacent surfaces.</i>
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B3 – Impact Damage

There are a very small number of instances of impact damage to both in situ and pre-cast concrete panels, where there is a small loss of concrete but with no exposure of reinforcement bars. There is no notable pattern to the impact damage and so there are no obvious management actions to avoid future mechanical damage. As noted above, where there has been a loss of concrete, this can reduce the amount of cover over steel reinforcement and pushes the carbonation front closer to the reinforcement, increasing the risk of corrosion and spalling. Localised concrete repairs should be undertaken to reduce the risk of more extensive damage.



Example of Defect Type B3

B3 Impact damage	<i>RB3A</i>	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RBIA for the repair methodology.
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		Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer. Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters likely to be made from plywood to match the fair faced finish. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete.
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		Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis).
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B4 – Concrete Compaction Issues

Honeycombing and voids are inherent problems relating to poor workmanship and the original construction materials. They are the result of poor compaction and are mostly found in corners where the presence of a concentration of reinforcement makes access for compaction difficult. The cement paste does not surround aggregate, so the particles are loosely bound. The consequence of honeycombing and voids can be enhanced rates of carbonation.

There are examples of honeycombing and voids across the building but most notably in the following locations. Firstly, to the sides of concrete beams where there is slight honeycombing in occasional vertical strips and also occasional individual voids. Secondly, to the base of the base of beams within the undercroft areas. There is corresponding spalling of concrete in these positions, potentially the result of honeycombing.

The honeycombing and voids to the sides of beams are relatively minor and are unlikely to be having a significant impact on the rates of carbonation and there is no evidence of cracking or spalling in these areas. The Structural Engineer has expressed no concerns regarding the structural integrity of these areas. Generally, no action is recommended, although deep voids can be filled with a colour matched mortar repair. Alternatively, coating the interior of the void with an anti-carbonation coating could provide some protection should this approach be taken to the building more generally.

Where honeycombing is more extensive to the undercroft posts and cracking and spalling have been observed, cutting out the honeycombed concrete and undertaking a cast in situ concrete or hand-placed mortar repair is recommended and these defects should be assessed by the Structural Engineer.



Example of Defect Type B4

B4 Compaction Issues	<i>RB4A</i>	Voids less than 1.25mm deep: do nothing, monitor through periodic inspection.
	<i>RB4B</i>	Identify repair mortar from approved samples as closest match to parent material avoiding large aggregate. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out Remove all loose/defective material from in and around voids. Ensure edges of void are perpendicular to surface or slightly dovetailed, to improve adhesion of patch repair. Clean substrate and remove all loose material, dust, etc. Where reinforcement is exposed, refer to RB1A for the repair methodology. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. For hand placed repairs, apply and build up the repair in layers. Use only enough mixing water to create mortar with a stiff consistency but with sufficient workability for handling and placing. Curing time will be subject to environmental conditions. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete.

B5 – Timber inclusions in in situ concrete

In a number of locations, small pieces of timber were observed, embedded in the concrete. It is likely that these were used as spacers, not removed before the concrete was poured, or as fixing blocks installed after construction. In either case, the presence of the timber on the surface of the concrete is likely to enhance the rate of carbonation in a localised area and should be removed and replaced with a hand-placed mortar repair.



Example of Defect Type B5

B5 Timber inclusions in cast concrete	RB5A	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all timber inclusions and loose/defective material. On removal of timber inclusions, the void may be suitable for direct repair. Where the surrounding concrete is in poor condition or unsuitable for immediate repair, further cutting out and preparation may be required, in accordance with recommendations for repairs to spalls.
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		Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RBIA for the repair methodology. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer. Hand placed repairs For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete.
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		Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis).
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B6 – Small pieces of corroding metal in underside of cast concrete

To all undercroft areas, numerous small pieces of metal debris were observed to the underside of the concrete beams and beam ends. These appear to be mostly steel wire off-cuts, which have been cut when tying the reinforcement and allowed to fall into the bottom of the formwork, subsequently being cast into the beams. The metal debris is now corroding and causing small amounts of concrete to spall from the underside of the beams. The presence of small amounts of corroding metal wire on the underside of the beams and minor spalls are unlikely to affect the overall integrity of the concrete structure and reinforcement. Removal is likely to be very disruptive for the limited benefits that it offers and so it is considered to be preferable to leave the metal debris in place and to remove any loose material. Removal of loose and spalling material will need to be undertaken periodically to ensure that falling material does not affect people using the building.

Due to the extensive nature of these defects, they have only been recorded once in the Schedule of Defects and Defect Drawings (Appendix F and Appendix H).



Example of Defect Type B6

B6 Small pieces of corroding metal in underside of cast concrete	<i>RB6A</i>	Using hand tools, carefully remove loose concrete spalls and corroding material from the surface of the beams, avoiding damage to surrounding fabric. For large spalls or voids, or where reinforcement has been exposed, refer to RB1A for the repair methodology. <i>Note: The underside of beams will need monitoring and period removal of loose material to reduce the risk of falling material in public areas.</i>
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B7 – Uneven finish to pre-cast panels

The building has two types of pre-cast panel. Smaller spandrel panels have a water-wash, exposed aggregate finish to the bottom and sides and an untextured upper face incorporating a shallow channel for drainage. These smaller panels are generally in good condition with few apparent defects. Larger walling panels also have a water-wash finish to the front face and generally have untextured chamfered edges and sides while a smaller number have a water wash finish to the sides without any chamfer. The aggregate is a Thames valley gravel, and the cement matrix has a slight reddish-ochre tint.

To some of the large pre-cast panels, to the south elevation in particular, the cement matrix in which the aggregate is embedded appears to have weathered away resulting in an uneven appearance and localised failure of the exposed aggregate with some loss of gravel/aggregate. This only appears to be a localised problem to a small number of panels and may be the result of poor original workmanship or the specification of the concrete and may even be an original construction defect of these panels.

A tactile inspection should be undertaken to assess to what extent the loss or absence of cement matrix has destabilised the aggregate or whether the impact is mostly superficial and whether the condition can be monitored for deterioration with only limited and localised repairs. The tactile inspection should be reviewed in conjunction with the outcome of intrusive investigations by CRL, to establish whether the loss of cement matrix and aggregate corresponds with a loss of cover to the reinforcement and evidence of associated corrosion.

Where the loss of matrix and aggregate is not extensive, then localised, cast in situ or hand-placed repairs can be undertaken with particular care being paid to the choice of aggregate and mortar mix, based on detailed investigation of the existing and on-site trials and samples.



Example of Defect Type B7

B7 Uneven finish to pre-cast panels Spalling or damaged surface – reinforcement bar is not visible at this stage (note, once defective material removed/ further investigations are completed, reinforcement may be found and the repair type will revert to RB1A)	RB7A	Note: Prior to repairs, undertake tactile inspection of pre-cast panels to ascertain extent of defects. Review findings in conjunction with findings of CRL's intrusive inspections. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RB1A for the repair methodology. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer.
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		Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. Note: In some instances, a pre-cast unit may be deemed more appropriate. This is subject to further review and discussion, for example where the cement matrix is extensively compromised, there is extensive loss of aggregate and where there are other structural defects to the panel.
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C – Previous Repairs

C1 – Poor Previous Repairs

Following previous programmes of intrusive concrete investigations, core drilled holes, opening up and areas of cracked or spalling concrete were repaired using proprietary repair mortars. These repairs were noted to both the in-situ and pre-cast concrete elements. While a reasonable number of the repairs are performing adequately, they are a poor match in terms of texture, colour, profile and overall appearance and are visually jarring.

A sizeable proportion of repairs are failing with cracking and spalling which appears to be the result, at least in part, of continued corrosion of the steel reinforcements. The failing repairs will require cutting out and replacement to prevent further corrosion of the reinforcement and more extensive damage.

Across the building, the poor previous repairs should be renewed with new in-situ concrete or hand-placed mortar repairs, designed to blend with the original concrete fabric.



Example of Defect Type C1

C – Previous Repairs		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION

C1 Poor previous repair	<i>RCIA</i>	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RBIA for the repair methodology. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut-out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required, and designed by a suitably qualified engineer. Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters likely to be made from plywood to match the fair faced finish. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in
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		batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis).
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C2 – Construction phase making good

Across the building there are numerous small holes which have been filled with a mortar that matches reasonably closely to the structural components. Many of these filled holes are located in similar locations to the sides or tops of pre-cast panels and other pre-cast components and the mortar appears to fill threaded metal sockets cast into the components, presumably installed to facilitate transport and lifting. The sockets would have been filled as part of the original construction process. The mortar fills are not always a perfect colour match, but they are much better than more recent repairs and only require replacement if they are failing. Where the mortar has fallen out of the socket, there appears to be some light surface corrosion to the inside of the threaded socket. The extent of corrosion is unknown, but only a few loose or missing fills were noted and there were not obvious signs of cracking or spalling of the concrete components around the metal socket positions.

Where the mortar fills are cracked, loose or missing they should be refilled to reduce the risk of corrosion and associated cracking and spalling. Where the socket is heavily corroding, and this is causing damage to the concrete panel a more extensive repair will be required involving the removal of the socket and an in-situ concrete or hand-placed mortar repair to fill the void. Further investigation will be required to establish the relationship of the socket.

Due to restricted sightlines, only a small number of visible defects are recorded in the Schedule of Defects and Defect Drawings (Appendix F and Appendix H), but it is anticipated that more of these defects will be identified once close inspection to all parts of the elevations is available.



Example of Defect Type C2

C2 Construction phase making good	RC2A	Do nothing, monitor through periodic inspection.
	RC2B	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas). Drill to a suitable depth to remove mortar fill. Remove any loose material and brush clean etc. Remove rust back to bare metal prior to application of mortar repair.

		Shutters & Formwork & Hand placed repairs For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair To outer concrete, wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. For hand placed repairs, apply and build up the repair in layers. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. <i>Note: where the socket is heavily corroding and this is causing damage to the concrete panel a more extensive repair will be required involving the removal of the socket and an in-situ concrete or hand-placed mortar repair to fill the void. Further investigation will be required to establish the relationship of the socket to the reinforcement and a Structural Engineer should be consulted.</i>
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D – Holes

D – Holes and Fixing Holes

Holes in the concrete are vulnerable to water ingress which could result in corrosion of the steel reinforcements, they also increase the depth of carbonation within a localised area, which also increases the risk of reinforcement corrosion and associated spalling. Holes that are not required for a specific purpose should be filled with a suitable repair mortar and, where still required, holes should be provided with suitable weatherings to reduce the risk of water penetration.



Example of Defect Type D1

D – Holes		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
D1 Holes and fixing holes (no fixing present).	RDIA	Hole 25mm diameter and below (for larger holes, consult architect, in-situ repair may be required): Remove loose material etc. Mask/protect adjacent surface to prevent dust residue/smearing to adjacent concrete. Drill (with drill guide) to min depth of 15mm. Fill with mortar to full depth (as approved from samples) to match adjacent concrete in colour and texture and ensure flush finish. Finish to match adjacent surfaces and ensure surfaces are clean.

D2 – Redundant Fixings

There are numerous fixings around the building, many of which appear to be redundant. In some instances, the fixings are corroding with the potential to cause cracking and spalling of the concrete as well as more superficial rust staining to the surface. A review should be made of the fixings to ascertain which are still required and which are redundant. Where redundant, the fixings should be removed, and the hole filled with a suitable repair mortar. Where the fixings are still required, it may be necessary to change the fixings for a non-ferrous alternative.



Example of Defect Type D2

D2 Redundant fixings (fixing present)	RD2A	Hole 25mm diameter and below (for larger holes, consult architect, in situ repair may be required): remove fixing / fitting (rawl plug, screws etc). Where fixings are large/resin fixed, localised cutting out may be required with an in-situ repair to follow as RB1A or RB2A. Remove loose material etc. Mask/protect adjacent surface to prevent dust residue/smearing to adjacent concrete. Drill (with drill guide) to min depth of 15mm. Fill with mortar to full depth (as approved from samples) to match adjacent concrete in colour and texture and ensure flush finish. Finish to match adjacent surfaces and ensure surfaces are clean.
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D3 – Testing/investigation holes made by contractors

Over the past 10 years there have been a series of intrusive concrete investigations undertaken by CRL, under the supervision of the Structural Engineers at the time. The investigations have involved drilling holes, taking core samples, opening up works to inspect reinforcement and fixing details, hammer testing and various other intrusive investigations, undertake with the objective of understanding the composition and current condition of the concrete and reinforcements and to assess the extent and rate of deterioration since the previous investigations. The result has been the formation of numerous holed and openings in concrete components across the building. While the holes have generally been filled with proprietary mortars, at the time of the inspection, a new round of intrusive investigations were underway and a number of openings had been formed. It may be that these have subsequently been filled with proprietary repair mortars. In either case, the outline repair methodology for poor previous repairs should be applied.



Example of Defect Type D3

D3 Testing/investigation holes made by contractors	RD3A	Identify repair mortar from approved samples as closest match to parent material. Mask/protect adjacent surface to prevent dust, residue/smearing to adjacent concrete. Concrete breakout/Cutting Out The affected area is to be cut out back to sound substrate, removing all loose/defective material. Mark out damaged area. Extent and shape to be agreed with architect. Use a diamond core drill (diameter size dependent on size of repair areas) with drill guide to mark rounded corners of repair area to prevent spalling/damage to the adjacent fabric (sharp corners are to be avoided). Drill to a suitable depth to reach sound material. Follow by cutting along the edges of the repair area with a diamond blade to the internal angles of the corner. Undercut by 2-4 mm and to a depth of 25mm to create a dovetail to improve adhesion of patch repair. Where delamination is severe, the depth of the repair should be a minimum of 40mm depth to provide sufficient cover. The amount of material removed must however be minimised to ensure the area is not undermined structurally. Where reinforcement is exposed, refer to RB1A for the repair methodology. Carefully break out the remainder of the repair area, taking care not to bruise or damage the substrate using a sharp chisel or jack hammer held at a shallow angle. Remove any loose material and brush clean etc. The base of the cut out area should be left rough to aid the key/adhesion of the repair material. Temporary structural support is to be provided for the duration of the repair where required and designed by a suitably qualified engineer. Shutters & Formwork & Hand placed repairs Shuttering and formwork design will vary and is subject to the area under repair and should replicate the existing finish/profile/details. Shutters likely to be made from plywood to match the fair faced finish. Shutters to be sized according to repair area and butt jointed and sealed to the perimeter to prevent seepage. Insert a letterbox into the top of the formwork/shuttering for the concrete to be poured into. Coat the shuttering with a release agent or retarder as required prior to use. Additional fixings for formwork/shuttering to be avoided where possible. For hand placed repairs, once the repair area has been broken out, prime the repair area using a cement slurry, prior to application of the repair mortar. Implementing repair Wet the area, sufficiently to avoid the parent material absorbing all water, but do not over wet to avoid poor adhesion. In some instances, a bond coat may be beneficial. Pour the concrete mix (as per agreed sample) in
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		batches through opening/letterbox to repair area and tamp/vibrate to eliminate air until the formwork is completely filled and all air gaps eradicated. Ensure water content is minimised to prevent shrinkage. Allow to set before removing the shuttering. Curing time will be subject to environmental conditions and all repairs should be covered in damp blankets. For hand placed repairs, apply and build up the repair in layers. Surface finish Finishing will be subject to trials/sample areas. Finish to match adjacent/original surface finish, and cover with damp hessian/blankets to ensure sufficient hydration. Ensure access is retained to provide access until curing is complete. Reapply coatings as required and in accordance with manufacturer's instructions (coatings specification subject to trials and analysis).
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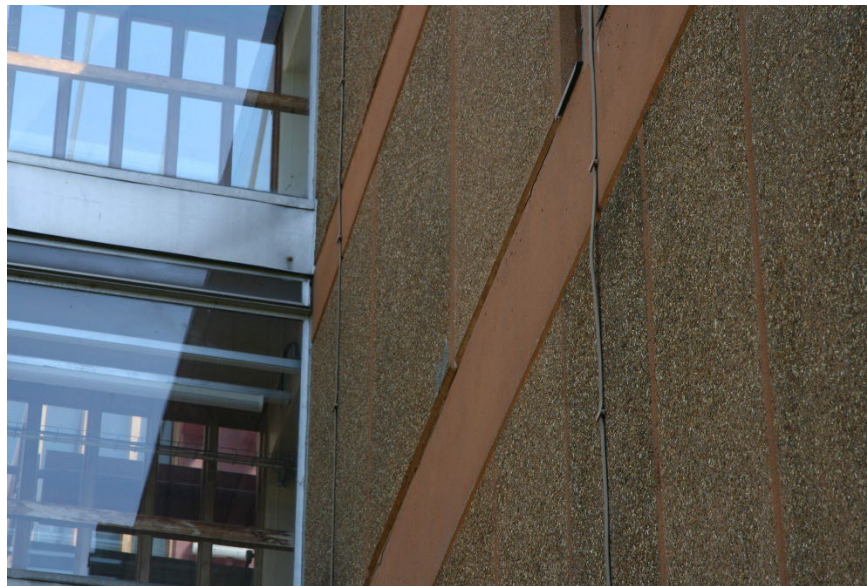
E – Concrete out of Plumb

E1 Pre-cast panels out of plumb / displaced

A number of pre-cast panels were noted to be out of plumb, either with the bottom edge appearing to have moved outwards beyond the concrete beam upon which it is supported, or with two adjacent panels moving outwards at their vertical meeting point. Previous intrusive investigations by CRL have established the nature of the pre-cast panel fixings. The bottom edge is secure by metal pins fixed into the bottom of the panels which are located and grouted into a channel on the top edge of the concrete beam and the top corners are secured by angle brackets. Investigations have shown that some of the pins are not securely grouted and this could be the cause of movement to the panels. It is also possible that outward movement of the bottom of the panels has caused the disturbance noted elsewhere to the top edge of the beams.

Investigations into the condition of the panel fixings and an assessment of their structural stability is in progress at the time of writing, with investigations carried out by CRL under the supervision of the Structural Engineers, Curtins. At this time it is anticipated that some grouting of the lower pins will be required, as well as some discrete additional fixings to the rear of the panels, where they have been displaced to ensure their stability. Details of these structural repairs will be prepared by the Structural Engineer for submission as part of a subsequent planning and listed building consent application.

The Structural Engineer will review and advise on whether the extent of displacement requires the full replacement of any of the pre-cast panels. Replacement should be on the basis of like-for-like replacement with regard to form, colour, aggregate, and finish.



Example of Defect Type EI

E – Concrete out of plumb		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
EI Concrete out of plumb.	<i>REIA</i>	Consult structural engineer to ascertain soundness of structure; remedial works according to structural engineer advice on underlying structure to be carried out, with appropriate repair type to be carried out subsequently (e.g. reinstatement of loose concrete, new precast unit etc).

G – Mastic sealants

G1 – Failure of mastic seals

There are mastic seals across the building. These are mostly found at junctions between different concrete sections. Depending on the type of sealant used and the specific conditions of the location applied, seals can last between 5 and 20 years. The condition of the seals will be affected by the quality of application, temperature and UV. All of the seals have reached the end of their service life with evidence of shrinkage, cracking and hardening to all parts.

Failure of the seals will affect the performance of the building envelope, potentially causing water ingress into the building and the building structure, accelerating decay. The seals should be renewed across the building.

Where corrosion and spalling were noted to the outer corners of soffits, to the south elevation in particular, it is thought that this is a result of water ingress via the junctions between concrete beams and posts. It may be that water ingress is due to the failure of mastic seals in these locations, although the actual weathering details could not be observed due to restricted sightlines. If on closer inspection it is found that there are failing mortar weatherings to these joints or no weatherings further consideration will be required to establish the best means of weathering these joints.



Example of Defect Type G1

G – Mastic		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
G1 Mastic seals/movement joints have failed.	RG1A	Remove existing material (mastic/silicone/strip etc), taking care not to damage adjacent fabric. Ensure all residues are cleaned off from adjacent surface. Clean out joint and ensure dry and free from dirt/grease/debris. Renew mastic joint/movement joint, specification/colour TBC to match adjacent finish. Structural engineer to inspect to check what ongoing movement may be occurring, prior to installing new mastic/silicone etc.

H – Surface Deposits

H1 – Calcium deposits

Where water has penetrated through the concrete structure it has caused the calcium hydroxide in the concrete mix to dissolve and leach out of the structure. On contact with the atmosphere the calcium hydroxide reacts with carbon dioxide to form calcium carbonate. As the water evaporates on the surface, hard white deposits are left, which in places form stalactites. At the URS Building the calcium deposits can be found in several locations to the north undercroft. The cause of the water penetration is unknown and should be investigated and remedied.

While the deposits themselves are a cosmetic issue, the process of leaching can lead to durability problems. Water ingress through the structure also risks the corrosion of the steel reinforcements.



Example of Defect Type H1

H – Calcium Deposits		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
H1 Calcium deposits	<i>RH1A</i>	Where deposits project above 3mm from concrete surface, carefully tool off, taking care not to damage substrate or adjacent finish. Apply acetic acid (dilution/dwell time TBC subject to trials) and gently aggravate using natural bristle or phosphor brushes (subject to trials) until encrustations can be removed. Rinse immediately with clean water to the area before repair. Acid run off is not to extend to adjacent areas as this can cause damage to the unaffected surface.

		Where deposits are located over a joint e.g. u/s balcony, removal should not extend into the joint as it is anticipated that the material will have become autogenous.
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H2 – Salt deposits

Salt deposits or efflorescence were observed in a number of locations across the building, but most notably as tide mark to the exposed beam ends which experience frequent cycles of wetting and drying. Water soluble salts migrate to the surface of the concrete and evaporate, leaving powdery white deposits. While generally a cosmetic issue, salts that evaporate below the surface can cause spalling of the concrete. Where practicable, water penetration issues should be addressed, and the salts brushed off.

Light efflorescence was observed to the sides of transfer beams in the undercroft to the north side of the building in particular. This was in the form of water runs. The wide spread of the staining across the undercroft would indicate that it is not related to a specific plumbing leak. It is possible that instead it is the result of condensation to the soffits. As the condensation has evaporated it leaves a pattern of white salt staining corresponding with the water runs. While the appearance of the water runs is relatively limited and brushing off the salts may be considered adequate, further consideration will be required as to how to reduce the future risk of condensation forming to the soffits.

Due to the extensive nature of these defects, they have only been recorded once in the Schedule of Defects and Defect Drawings (Appendix F and Appendix H).



Example of Defect Type H2

H2 Salts deposits	<i>RH2A</i>	Brush off all surface salts, monitor for reappearance.
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J – Coating and Surface Finishes

J1 – Crazing/cracking to render finishes

To the south side of the building there is a small area of cement render. The substrate to the rendered panel is unknown.

There is crazing and cracking to the render. The precise cause of the crazing and cracking is unknown but could relate to the quality of the materials and workmanship or the condition of the underlying substrate. Damaged render finishes should be cut back, the substrate inspected for defects, and the render coat renewed.



Example of Defect Type J1

J – Coating and Surface Finish		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
J4	RJ4A	Carefully remove existing fairing coat/render back to sound substrate and nearest edge/building joint line. Structural engineer to inspect condition of substrate prior to repair to surface.

<i>Crazing/cracking to render/finish</i>		<i>Prepare and apply new fairing coat/render (specification TBC and subject to trials to match concrete finish as closely as possible) in accordance with manufactures instructions. Profile/detail of original/adjacent concrete panels to be retained/reformed.</i> <i>Where applicable, corner beads should be renewed in stainless steel, for example to entrance planters.</i>
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K – Mortar

K1 – Damaged or missing mortar

Where mortar joints are visible between concrete components or between concrete components and windows many of these are cracked and loose. In a number of locations mortar is missing from joints altogether. Open and missing joints can allow water to penetrate the fabric/structure with the risk of damage and decay to adjacent fabric. This could be observed where water has tracked in above beam ends and has caused dampness and spalling to the adjacent soffits although it is not clear without close inspection whether this is due to defective mortar or mastic joints, or the absence of weatherings altogether. The defective mortar should be raked out and the joints repointed in a suitable mortar.

Due to the extensive nature of the cracking of mortar around windows, this defect has only been recorded a limited number of times in the Schedule of Defects and Defect Drawings (Appendix F and Appendix H). As the windows are due to be replaced it is anticipated that all mortar joints around windows will be renewed.



Example of Defect Type K1

K – Mortar		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
K1 Missing or damaged mortar	RK1A	Rake out and remove loose/defective material. Brush clean. If necessary, hand grout to solid fill the joint to appropriate depth for pointing. Repoint in mortar to the approved mix / specification (TBC).

S - Staining

S1 – Biological growths/staining

There is an accumulation of algal growths in various locations around the building, including to spandrel panels below windows, to beam ends and to the sides of concrete beams. The accumulations tend to be where the concrete is more exposed or where there is water run off down the concrete due to poor detailing of roofs and rainwater goods. In many of these locations there is also an accumulation of lichens, although these were also noted to high level concrete components more generally. Algal staining to vertical surfaces was seen in conjunction with an accumulation of moss to sky facing surfaces. The biological growths can contribute to the deterioration of the surfaces on which they colonise by the following means:

- causing water retention;
- producing organic acids; and
- for mosses and lichens, causing mechanical deterioration by anchoring to the surface with their rhizoids.

Mosses, algal staining and to a lesser degree lichens, should be removed to improve the appearance of the building and to reduce the risk of deterioration of the fabric. Where the algal staining is the result of poor detailing of roofs and rainwater goods, this should be addressed by the proposals for renewal.



Example of Defect Type S1

S – Staining <i>All cleaning methodology is subject to stakeholder discussion, trials and input from specialists.</i>		
DEFECT TYPE	REPAIR TYPE	REPAIR DESCRIPTION
S1 Biological growths / Staining	RS1A	Surfaces to be cleaned using superheated steam cleaning system. Care should be taken to ensure that steam cleaning does not cause deposits to move to the edge of the cleaning area, giving an uneven appearance. An even finish should be achieved by blending zones from cleaned to non-cleaned areas and high operative skills. Trials should be carried out to ascertain the effect of steam temperatures on the concrete, render, painted finishes and their joints. Specification (pressure etc) TBC further to trials.
		Brush surplus moss and algae using phosphor bronze brushes or wood spatulas taking special care to prevent damage to existing building fabric during removal works. Protect surrounding surfaces that could be damaged by the subsequent treatment – mix solution of biocide in water according to manufacturer's recommendations. Leave for 2 weeks; remove organic growth using phosphor bronze brushes and water. Re-apply biocide solution to inhibit re-growth. Sweep and bag waste organic matter. Steam clean/wash off residues on completion.

S2 – Pyrites and rust staining

Small mineral deposits in the concrete aggregate mix called pyrites (iron disulphide) can corrode and leave rust staining to the surface of the concrete. This staining is a cosmetic problem only and will not affect the long-term performance of the concrete structure but is visually obtrusive.

Elsewhere rust staining is the result of the corrosion of fixings or structures fixed to the building. There are a number of instances of redundant fixings which are corroding. As well as causing superficial staining, the expansion of the corroding fixings can cause cracking and spalling to the surrounding concrete which increases the risk of water ingress into the structure and corrosion of the metal reinforcements. The corroding fixings should be removed and the fixing holes made good in an appropriate mortar.



Example of Defect S2

S2 Pyrites and rust staining	RS2A	Removal of Pyrites Provide a plywood template over the pyrite (sized to a diameter corresponding with pyrite size e.g. 30mm), Carefully drill to a suitable depth to enable defective aggregate to be extracted, ensure minimum drill depth of 15mm to allow for adequate depth of mortar repair. Remove loose material. Brush clean. Select appropriate mortar match from approved samples and apply mortar in situ repair taking care to protect adjacent surface from smearing and apply repair mortar to a flush finish to match the fair faced finish. Prior to full set, inspect surface finish to ensure surface finish replicates original and match prior to full curing. Ensure water content is minimised to prevent shrinkage. Removal of associated rust staining Apply acetic acid to the affected area (dilution and dwell time subject to trials). Care to be taken with the use of acid on the alkali concrete surface. Rinse with water after dwell period.
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S3 – Environmental dirt

As with algal staining, environmental dirt comprising heavy accumulations of dirt and pollution deposits can be found on high-level and exposed or sky facing concrete surfaces and immediately below sky-facing surfaces. The dirt is most notable to the podium boxes, the sloping sections of the towers and below ledges to the towers and flank return walls of the flats. Not only is the dirt unsightly but depending on the makeup, can also accelerate corrosion of the reinforcement and can cause gypsum and ettringite to form which can result in spalling of the concrete. The dirt should be removed together with associated algal staining.

In removing the dirt, it is likely that poor quality patch and plaster repairs to the concrete will become much more apparent and there will be a stronger justification to replace them for aesthetic reasons and not just where they are failing or defective.

S3	<i>RS3A</i>	Verification required of surface deposits to establish nature of cleaning method.
Environmental dirt		Surfaces to be cleaned using superheated steam cleaning system. Care should be taken to ensure that steam cleaning does not cause deposits to move to the edge of the cleaning area, giving an uneven appearance. An even finish should be achieved by blending zones from cleaned to non-cleaned areas and high operative skills. Trials should be carried out to ascertain the effect of steam temperatures on the concrete, render, painted finishes and their joints. Specification (pressure etc) TBC further to trials. It is anticipated that a superheated steam cleaning system will remove the majority of the staining however, some areas may benefit from additional cleaning with abrasive/chemical.

3.3 REPAIR PACKAGES

It is the University's intention to implement an initial package of repairs focussing on high priority defects in specific locations as part of the current proposals and then to roll out the concrete strategy over the coming years through further packages of repairs. The detailed scope of these works will be agreed upon in consultation with Wokingham BC and other stakeholders including the Twentieth Century Society.

3.4 IMPLEMENTATION OF CONCRETE REPAIR STRATEGY

This section sets out the process by which the Heritage Offer will be delivered.

1. Identification of a series of repair packages by the University of Reading to be implemented across a number of phases. Packages to be selected taking into account location, significance and priority rating.
2. Technical team and HC to undertake further and specific research into the material construction of the building and concrete properties (inc. original specification and subsequent alterations), and obtain any relevant missing information.
3. Discussion on cleaning in relation to chosen package area and wider building strategy
4. Engage contractor for enabling contract – and determine location in which to carry out tests and trials
5. Consents – gain consent from WBC for the trials/test (locations TBC)
6. Testing – testing of concrete in package area to establish mix/properties, existing coatings etc
7. Trials – undertake samples of each repair type for sign off
8. Verification survey with contractor of chosen package area(s) including high level access
9. Application for consent to implement programme of repairs to chosen package area
10. Engage contractor for implementation of repairs
11. Implement works with appointed contractor

4. HERITAGE IMPACT ASSESSMENT

The conclusions of the Heritage Impact Assessment completed by Purcell outlined the levels of impact of the Ayre Chamberlain Gaunt External Works Package (Stage 2). Throughout the course of the development proposals, heritage impact has been a key focus for the project team and the heritage consultant has been embedded in the design evolution at every stage.

The completion of the survey was a major step in understanding the range of issues the historic concrete of the URS Building is facing. Together, the significance assessment and the survey constitute a considerable knowledge base from which the project team can develop an offer that will have considerable heritage benefit for the building and provide a framework for concrete repair and maintenance in the future.

The concrete at URS is the primary material and, in its use, and form, it conveys the modernity and structural power of the building. Its striking visual identity, based partly on the trabeation and partly on the two-tone red colour, is highly distinctive and there is not a comparable structure elsewhere in a national context for those reasons. The appearance of the concrete has been impacted by a number of things since construction and these include the range of defects identified in the survey. The range of repairs which will come as a result of the survey work constitute a considerable enhancement of the architectural and aesthetic of the asset and will therefore constitute a high beneficial impact on the fabric of the building.

It is therefore the finding of this report that the overall heritage impact of proposals to repair whatever areas are outlined within a package will constitute an enhancement of significance as defined in NPPF Paragraph 203, the conservation of areas of concrete at URS will constitute public benefit and, in our view, should be weighed in the planning balance for the schemes coming forward.