



URS BUILDING REFURBISHMENT

EXTERNAL CONCRETE REPAIR – HERITAGE OFFER ADDENDUM

SEPTEMBER 2024

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1 INTRODUCTION

1.1 EXECUTIVE SUMMARY

Purcell were commissioned in Spring 2024 by the University of Reading to carry out a concrete condition survey of the URS Building to identify non-structural defects to the external concrete building components and to develop a strategy for concrete repairs. The report and appendices were submitted with the current planning and listed building consent applications together with a Heritage Offer document. The purpose of the Heritage Offer was to set out the findings of the concrete survey and give an overview of potential concrete repairs. The Heritage Offer included a broad description of 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 Heritage Offer stated that a detailed scope of the works would be agreed in consultation with Wokingham BC and other stakeholders including the Twentieth Century Society.

This addendum to the Heritage Offer has been prepared following feedback to the planning and listed building consent applications from Wokingham BC, further discussion with the University of Reading and a review of the concrete condition survey findings. The document sets out the detailed scope of repairs that are being put forward as part of the current applications with the purpose of addressing a significant proportion of the identified defects at the URS Building and ensuring the longevity of the listed building. This addendum should be read in conjunction with the original Heritage Offer report and Purcell's Concrete Condition Survey report with appendices.

2. CLARIFICATION OF HERITAGE OFFER

2.1 SCOPE OF PROPOSED CONCRETE REPAIR PACKAGE

As part of the current planning and listed building consent applications, it is proposed to carry out all of the high priority defects that were identified by Purcell's Concrete Condition Survey. The defects are identified in the searchable Defects Schedule spreadsheet (Appendix F) and in the Defect Drawings (Appendices HI-6). Of the 720 defects identified by the survey across the exterior of the URS Building, just under a third (209) have been categorised as high priority. The Concrete Condition Survey Report defines high priority defects as being those where repairs are required for legal or safety reasons or to prevent imminent damage or rapid deterioration and where there has been a significant impairment to the structural integrity of the structure/component. Generally, areas of spalled concrete and exposed reinforcement have been classed as high priority due to the potential for rapid deterioration with the potential for health and safety risks. It is recommended that repairs to high priority defects should be completed within 2 years. The table below shows the spread of high priority defects across the building.

Location Ref	Elevation	No. of High Priority Defects
NE	North Elevation	45
EE	East Elevation	6
SE	South Elevation	86
WE	West Elevation	19
R	Gridline Return Elevations	20
S	Soffits	33

A number of high priority defects were specifically identified as posing a health and safety risk and are marked as such in the Defects Schedule (Appendix F). Health and safety risk items principally related to loose or spalled sections of concrete at risk of detachment from a height. All 26 health and safety risk items identified during the survey have been assigned a high priority rating and will be addressed by the current phase of work.

The Concrete Condition Survey Report identified the following 23 different repair types:

- **A1 – Small cracks**
- **A2 – Large cracks**
- **B1 – Spalling or damaged surface with reinforcement bars visible**
- **B2 – Spalling or damaged surface without reinforcement bars visible**

- B3 – Impact damage
- B4 – Concrete compaction issues
- B5 – Timber inclusion in in-situ concrete
- B6 – Small pieces of corroding metal in underside of cast concrete
- B7 – Uneven finish to pre-cast panels
- **C1 – Poor previous repairs**
- **C2 – Construction phase making good**
- D1 – Holes and fixing holes
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- **D3 – Testing/investigation holes made by contractors**
- **E1 – Pre-cast panels out of plumb / displaced**
- G1 – Failure of mastic seals
- H1 – Calcium deposits
- H2 – Salt deposits
- J1 – Crazeing / cracking to render finishes
- **K1 – Damaged or missing mortar**
- S1 – Biological growths / staining
- S2 – Pyrites and rust staining
- S3 – Environmental dirt

Of the 23 repair types, 9 will be addressed by undertaking repairs to all of the high priority defects across the building and these are highlighted in **bold** in the list above. Trials will be undertaken and samples of the repair types will be prepared for approval by WBC. There is a great deal of cross over between the various repair types, many of which involve cutting out defective concrete or inappropriate inclusions and redundant fixings and installing hand-placed mortar repairs and so the approval of cutting out techniques and repair mortar mixes are likely to be applicable to multiple repair types. It is the University's intention to undertake trials and prepare samples that would enable sign off by WBC of most if not all of 23 repair types as part of the current phase of work. This will enable not only the implementation of the high priority defect repairs and the efficient future roll out of repairs to the medium and low priority defects, but also the timely repair of any future defect that might develop. Approval of cleaning trials to address different types of staining will have the added benefit of enabling the university to develop a wider building cleaning strategy for the future that could be implemented beyond the current phase of works.

The proposed repair package provides the following benefits:

- Repair to the fabric to prevent further deterioration and ensure the long-term future of the building;
- Addressing safety issues and significantly reducing the risk of injury or loss of life from detached and falling fabric as well as associated reputational damage; and
- Improving the appearance of the building to the public benefit by removing unsightly failing previous repairs and visually prominent degraded fabric and implementing carefully specified and matched conservation repairs.

Alternative repair packages have been considered based on repairs to single elevations, but no single elevation-based package of repairs would offer the benefits of addressing such a high proportion of high priority defects and health and safety items. Addressing high priority defects to all elevations and soffits as part of the first phase of the project demonstrates the University's long-term commitment to protecting the fabric and significance of the listed building.

2.2 DEFECT AND REPAIR TYPES

Defects identified as being high priority include the following specific defect types. 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 shear 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.

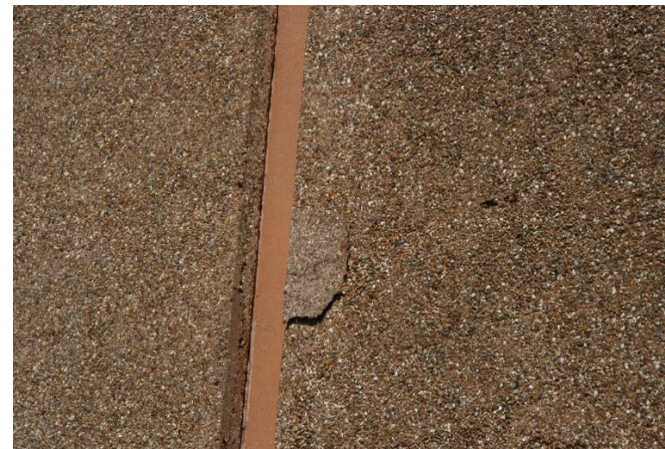
Some of the spalling material is at high level and over areas where contractors, consultants and other visitors to site may be and poses a considerable health and safety risk. In these areas loose material should be removed as a matter of urgency.

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
B1 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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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	RC1A	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 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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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

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	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.
Testing/investigation holes made by contractors		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 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
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		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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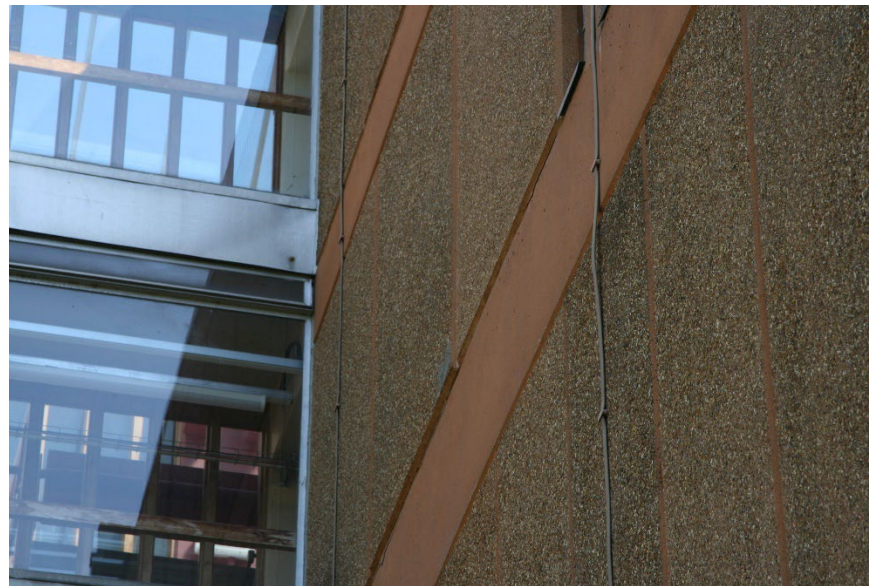
E – Concrete out of Plumb

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.	REIA	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).

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).

2.3 IMPLEMENTATION OF CONCRETE REPAIR STRATEGY

The following list sets out the process by which the Heritage Offer will be delivered. The list remains the same as presented in the Heritage Offer documents, although it should be noted that the first item of the list (in italics) has now been implemented

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 completion of a detailed survey of the concrete at URS was a major step in understanding the range of issues the building is facing. Together, the significance assessment and the survey constitute a considerable knowledge base from which the project team and the university have developed an offer that will have considerable, lasting heritage benefit for the building and provide a framework for concrete repair and maintenance in the future. The survey is, in its own right, considered to be beneficial to the long-term care and maintenance of the listed building.

The concrete at URS is the primary structural material. Due to the nature of the HKPA design, the concrete is also the primary visual material and plays a considerable role in the visual identity of the building. The quality of the concrete, its condition and aesthetic appearance are consequently of paramount significance to the listed building and the manner in which it is appreciated and experienced. Views from both inside and outside the building are impacted by any concrete defects, due to the nature of the construction. The scale of the URS Building is also noteworthy and due to the variety of functional spaces within, it can be experienced piecemeal. Unity and unity of visual identity of all areas is therefore an important component of its architectural character and the building should therefore be approached holistically in any conservation efforts.

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 nature of the architecture 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 areas of high priority defects 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 scheme.