Structural Inspection Report

of

Covent Garden Multi Storey Car Park

Warwick District Council

Issue Number 01

Document History

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1.0 Reference and Instruction

1.1	PE Report Reference	:	STR/NCC/210467/17.2/R001
1.2	Client	:	Warwick District Council Riverside House Milverton Hill Leamington Spa CV32 5HZ
1.3	Telephone Number	:	N/A
1.4	Inspected Property	:	Multi-storey car park Covent Garden Russell Street Leamington Spa
1.5	Instruction		
1.5.1	On behalf of	:	Warwick District Council

1.5.2 Brief

- To carry out an updated visual inspection of Covent Garden multi-storey car park and provide a Structural Engineer's Condition Report to compare against the last inspection undertaken in 2015 and 2018/19 by Pick Everard.

- Provide recommendations and budget costs based on the observations to date.

2.0 Scope of Investigation and Report

In accordance with the aforesaid instructions, the following investigations have been undertaken: -

(a) An updated visual non-intrusive inspection of the superstructure, and where possible comparing the present structural condition with that recorded in previous reports, undertaken in 2015 and 2018/19. By Pick Everard

The investigations and this report are confined to the technical assessment of the load-bearing elements of the structure, the identification of damage in these elements at the time of our inspection, the cause of damage and the type and scope of measures necessary to repair that damage. Whilst every endeavour will be made to provide a positive and helpful report, we cannot predict the future behaviour of the structure or its components. Therefore, a Guarantee cannot be given that the property will be free from future damage or that existing defects will not suffer further deterioration or lead to damage.

This report is not to be used for any other purpose or by any third party and should not be taken as a specification for remedial action or works.

It is not a "Building Survey" as defined by RICS and is therefore not concerned with building defects and/or damage, other than those relating to the load-bearing elements.

The visual inspection of the superstructure was made on 12th April 2021, and detailed site notes and record photographs are retained on file. The weather was cold and dry.

No breaking out or opening of the building fabric was undertaken at that time, and no part of the property that was not readily accessible or covered or otherwise concealed was inspected. The absence of a report on any such part is not to be taken to be free from defect. Such unexposed parts might contain problems and special arrangements that would need to be made for these areas to be investigated (where practicably possible) if confirmation were required about their condition.

2.1 Classification of Visible Damage to Walls and Ceilings

For the purposes of this report, the width of cracks is used as a basis for the classification of visible damage, broadly in compliance with the damage classifications defined by Building Research Establishment Digest 251, revision of 1991: -

Description	**Approximate crack width**	**BRE Category of Damage**
Hairline cracks	Barely visible, less than 0.1mm wide	0
Very slight cracks	Up to 1mm wide	1
Slight cracks	1mm to 5mm wide	2
Moderate cracks	5mm to 15mm wide	3
Severe cracks	15mm to 25mm wide	4
Very severe cracks	Greater than 25mm wide	5

2.2 Orientation

The damage and defects observed within the structure are indicated on the drawings provided in Appendix A. However, where reference to the various walls and elevations has been made within this report, these have been related to the points of the compass.

2.3 The Site

2.3.1 O.S. Grid Reference:		SP 316661
2.3.2 Topography	:	Ground levels fall in the region of 1-3m from the East to the West elevations of the car park and fall in the region of 1m from the South to North elevations. Walls to floors at ground level and level 1 are partially retaining.
2.3.3 Substrata/Geology	:	Reference to British Geological Survey data, indicates no superficial deposits but Bromsgrove Sand foundation.

3.0 The Construction

3.1.1 The structure is a 9-level multi-storey car park, constructed c 1960. Its construction comprises an in-situ reinforced concrete frame, supporting in-situ concrete slabs at each floor level with access ramps between levels and two brick/block stair cores at either end of the car park.

3.1.2 Exterior wall details comprise 230-300 mm thick insitu concrete parapets 665-750mm high and faced with pre-cast aggregate concrete panels. All levels have metal handrails 220mm off the top of the parapets.

3.1.3 Level 1 is situated partially below ground level, and hence brick retaining walls 1.8 m high form the perimeter of the external face.

3.1.4 Each insitu reinforced concrete deck is approximately 150-200 mm thick and topped with structural screed. Deck levels 7 & 8 (top decks) have been finished with a protective coat.

3.1.5 An expansion/movement joint runs through the centre of the upper decks from the east to the west elevations.

3.1.6 Concrete ramps using the same reinforced in-situ deck detail allow access to the upper decks near the north and south elevations, while descending ramps from each deck are located near the centre of the car park.

3.1.7 Surface water drainage is provided by cross falls on the upper decks, falling to gullies inset near the centre of the car park near each internal step level. Water discharges via vertical cast iron drainage pipes to below ground drainage.

3.1.8 The stairwells to the north/south elevation of the car park comprised an external brick face and assumed concrete internal walls supported off the main concrete structure.

4.0 Previous Surveys and Investigations.

4.1 JNP Group Inspection 2014

4.1.1 Pick Everard were provided with a General Structural Inspection report of Multi-Storey Car Park dated, 11th March 2014 undertaken by JNP Group, carried out on behalf of Warwick District Council.

4.1.2 The JNP Group Report Summary recommended the following: -

- Clean out all existing drainage systems.
- Check all existing cast iron pipework and prevent rusting by use of inhibitors.
- Remove all moss/lichen from walls and decks.
- Refurbish crash barriers.
- Replace sealant to main movement joint.
- Repair cracking in South Elevation brickwork.
- Repair internal cracking to stairwells.
- Replace waterproof membrane to deck 7 and 8 (top decks)
- Repair cracks to the soffit of deck 7 and 8 simultaneously as the waterproof membrane is replaced.
- Apply sika ferrogard to the top and bottom of all ramps and seal joints.
- Carry out an annual inspection of decks and panels to the south elevation and crack in the basement wall.

4.2 Pick Everard Concrete Testing 2015

4.2.1 In 2015 Pick Everard undertook testing. The results are contained in Previous testing report R006bNCC – 150215 17.2 – Structural Condition Survey Report Covent Garden

4.2.2 From reviewing the concrete testing, the structure appears to be categorised as a low risk of corrosion from carbonation and chlorides, with only one area to the soffit to the ramp to the top deck showing significant corrosion. The previous JNP Group report also confirmed similar results, with only two localised areas indicating higher carbonation.

4.2.3 The area of significant concern raised by the concrete testing results was the presence of alkali-silica found in the parapet insitu concrete walls. The alkali-silica reaction (ASR) damage has contributed to the corrosion of the embedded steel reinforcement within the concrete parapet wall by creating microscopic pathways for air and moisture to penetrate the concrete structure.

4.3 Visual Inspection 2018

4.3.1 Monthly visual inspections were carried out by Pick Everard at the end of 2018 to identify and changes over 6 months. The results indicated no significant structural change.

4.4 Summary of Investigation Results carried out June 2019.

Nicholls Colton Testing were appointed in June 2019 to undertake several intrusive and non-intrusive investigations. A summary of the results is as follows; -

4.4.1 Concrete Cover

4.4.1.1 67 test locations were investigated across all levels to check cover to the steel embedded reinforcement.

4.4.1.2 Decks and beams generally have reasonable cover, with approximately 18-20% showing inadequate cover based on the best practice and guidance.

4.4.2 Carbonation

4.4.2.1 The results of the carbonation testing to the car park varied between 3 and 6mm, across all levels. None had reached the level of steel reinforcement in any location, and as such, the carbonations levels do not pose an issue at these depths.

4.4.3 Chloride Ion Content

4.4.3.1 The chloride ion test results at the depth of the steel reinforcement at the 67 test locations indicated the following:

4.4.3.2 Most locations showing a negligible risk of corrosion, 10 areas show low to moderate risk of corrosion.

- 2 areas showing high risk of corrosion.
- 3 areas showing extremely high risk of corrosion.

4.4.3.3 The high and extremely high areas at risk of corrosion to the steel reinforcement are to a mixture of decks (level 2 to 5).

4.4.3.4 The levels of chlorides have increased significantly at the level of the steel reinforcement, with the previous results all showing negligible readings in 2015 at a depth of the steel reinforcement.

4.4.4 Half-cell Electro Potential Testing

4.4.4.1 Half-cell electro potential testing at 20 test locations revealed areas with an isolated high risk of corrosion. These areas are mainly decks/soffits and beams to level 6 through to 8 and deck, parapet, and columns to level 3 and 2. 34 test locations were showing a medium risk of corrosion. 13 test locations were showing a low risk of corrosion.

4.4.4.2 These results show an increase in corrosion potential, in localised areas, predominantly to the decks and areas identified with increased chlorides, though not to all. The other areas of increased risk of corrosion are assumed to be due to water ingress, primarily to the upper decks/levels due to a failure of the top deck coating.

4.4.5 Corrosion of the embedded reinforcement.

4.4.5.1 16 test locations received additional breakouts to confirm the condition of the steel reinforcement. At all locations, each reinforcement bar (varying sizes between 8 and 15mm) showed partial or complete surface corrosion, but no section loss.

4.4.5.2 The only exception to this was test panel 7, which was the parapet between level 7 and 8, which showed a minor area of section loss. The amount of section loss is not significant at this time. However, it is likely to result from poor drainage and water ingress due to water collection to the gulley on level 8.

4.4.5.3 The levels of corrosion appear to be similar to previous investigation results, with the ramp and parapet to the top level the only areas showing the section loss corrosion to date.

4.4.6 Alkali Silica Reaction (ASR)

What is ASR?

4.4.6.1 ASR is a chemical process which can occur within the concrete, in which alkalis, usually predominantly from the cement, combined with certain types of silica in the aggregate when moisture is present. This reaction produces an alkali-silica gel that can absorb water and expand to cause cracking and disruption of the concrete. In order to check for ASR a petrographic analysis is required, this is obtained from taking cores from the structure.

4.5 Previous ASR Testing in 2015/16

4.5.1.1 The initial petrographic analysis carried out by Nicholls Colton in June/July 2015, this indicated that the insitu concrete parapets to the North and South Elevation to all levels behind the precast cladding panel in the test location have been subject to alkali-silica reaction. This has caused cracking that has affected the pre-cast cladding panel in front, causing cracking in the external face. The test location also indicated that due to the crack in the cladding panel, the embedded steel was starting to corrode.

4.5.1.2 Nicholls Colton identified 6 cores out of 27 as being at risk, due to the evidence of structure defect corresponding to possible ASR. These were to areas other than the parapet.

4.5.1.3 The Petrographic analysis of the six cores indicates a minor amount of reactive aggregate in all cores that can cause a potential alkali-silica reaction. This reactive aggregate (Chert 3% of the total aggregate), along with quartz and sandstone used in the original construction of the structure, was found to be causing minor traces of the alkali-silica gel, which can potentially lead to microfractures and cracks which allow water into the concrete, which create further ASR reactions and can accelerate the corrosion of embedded reinforcement.

4.5.1.4 However, although the aggregate that can contribute to ASR was found to be present in the six cores, it is not causing significant micro cracking at this time, which indicates ongoing ASR reaction other than in the parapets, which have cracked already. This differs from the ASR previously identified in the insitu concrete parapet behind the cladding panel to the North and South Elevations, which show visual evidence of cracking and confirmed in the petrographic analysis. The ASR in these parapets has previously indicated that ASR and the gel it produces is causing ongoing structural cracking. This suggests that the insitu concrete parapet has an ongoing reaction occurring (ASR), possibly due to increased exposure to moisture or the increased amount of the Chert reactive aggregate found (up to 10% as identified by the Investigations).

4.5.2 Visual Inspection/Investigation including additional ASR tests, 2019.

4.5.2.1 Following our visual inspection in 2019, and additional breakouts to the external insitu parapet panel to level 8 and ground level, these appeared to show surface rust to the steel reinforcement but again no serious section loss of section.

4.5.2.2 Half-cell testing of these areas indicated only low and moderate risk of corrosion potential at this time.

4.5.2.3 No new areas of micro-cracking, which is indicative of ASR was observed during the inspection.

5.0 Observations (Current Survey 2021)

We have outlined below a summary of the significant new structural defects that were evident during our visual inspection, and which have appeared since our last inspection, carried out in 2018/2019.

The referenced photographs have been included in Appendix B.

All significant new observations and defects have been recorded on drawings in Appendix A (new damage marked in red).

5.1 External

5.1.1 North Elevation

5.1.1.1 Inspection of the North elevation and specifically the areas showing crazed cracking, which indicates Alkali Silica Reaction. We have observed no change from the current inspection of the insitu and precast panels when compared against the last inspection in March 2019. **(Photograph No. 1 – 4)**

5.1.2 South Elevation

5.1.2.1 Inspection of the South elevation and specifically the areas showing crazed cracking, which indicates Alkali Silica Reaction. We have observed no change from the current inspection of the insitu and precast panels when compared against the last inspection in March 2019. **(Photograph No. 5-8)**

5.1.3 East Elevation

5.1.3.1 Slight diagonal cracking observed in some of the ground floor precast cladding panels. **(Photograph. No 9)**

5.1.3.2 Corrosion staining observed in several external locations at ground level adjoining the columns, suggesting water ingress and internal reinforcement corrosion. **(Photograph. No 10)** The corrosion staining appears to occur to numerous insitu concrete perimeter walls all along the East Elevation.

5.1.3.3 Slight diagonal cracking in the insitu parapet wall adjoining the column was observed in various locations. **(Photograph. No 11)**.

5.1.3.4 Slight horizontal/diagonal cracking observed to the outer face on several the columns along the elevation. The cracking appears most evident to the top of the columns to level 4 and above, which is currently undecorated.

5.1.4 West Elevation

5.1.5 Slight horizontal/diagonal cracking observed to the outer face on several the columns along the elevation. The cracking appears most evident to the top of the columns to level 4 and above, which is currently undecorated **(Photograph. No 12-14).**

5.2 Internal

5.2.1 Ground Floor

5.2.1.1 Slight diagonal cracking observed to the internal masonry brick retaining walls. These appeared to be a localised issue and not thought to be structurally significant.

5.2.1.2 Numerous areas of corrosion staining were evident to the soffit to the level above **(Photograph. No 15-16)**. Although the corrosion staining was minor, it does indicate that ongoing corrosion of the steel reinforcement is evident in the concrete structure.

5.2.2 Level 1

5.2.2.1 Similar extensive minor corrosion staining was noted throughout the soffit to the floor above. The amount of staining was not considered significant but is indicative of ongoing corrosion of the steel reinforcement to the floor above.

5.2.2.2 As well as corrosion staining, minor spalling was evident to various areas of the soffit and to the external and internal parapet walls **(Photograph. No 17-18).**

5.2.3 Level 2 and 3

5.2.3.1 To the soffit of level 2, there was no significant change in the condition of the existing crack, and only a few minor new corrosion stains evident. The number of corrosion stains appears to be significantly less than what was viewed on the ground and first floor to the soffits. **(Photograph. No 19)**

5.2.3.2 To the soffit of level 3, slight cracking and corrosion staining were most evident to the soffit of the ramp in the centre of the structure and the ramp leading up to level 4. **(Photograph. No 20)**

5.2.4 Level 4 and 5

5.2.4.1 Several new slight horizontal and diagonal cracks are now evident to the external outside face of several the columns near the head of the column connection tot eh beam on both level 4 and 5 to East and West elevations. **(Photograph. No 21 - 23)**

5.2.4.2 Existing cracks on level 4 and 5 to soffits and decks appear visually to be the same and have not deteriorated.

5.2.4.3 Several new slight cracks appeared to be evident to the soffit at the outer edge to level 5. **(Photograph. No 24)**

5.2.4.4 Exposed steel reinforcement is now visible in several locations to the soffit on level 4 due to spalling concrete.

5.2.4.5 Numerous new locations of corrosion staining were evident to the soffit viewed on level 4. **(Photograph. No 25)**

5.2.4.6 Slight horizontal cracking is evident between the external precast cladding panel and the insitu concrete parapet wall behind the outer perimeter on level 4 and 5. **(Photograph. No 26)**

5.2.5 Level 6

5.2.5.1 Several new slight horizontal and diagonal cracks are now evident to the external outside face of some of the columns on both level 4 and 5 **(Photograph. No 27)**

5.2.5.2 Water is ponding on the deck in areas to level 6, the ingress of water appears to be originating from the down ramps from the floors above. **(Photograph. No. 28)**

5.2.5.3 Failure of a localised repair and grout infill to the head of a column in the centre of the floor between level 6 and Level 7. **(Photograph. No. 29)**

5.2.5.4 The channel drains to the centre of the building between each level appear block and in need of cleaning out as they are blocked with detritus.

5.2.5.5 Evidence of ongoing water ingress observed in some of the existing cracks to the soffit. These would be water ingress from the floor above due to the failure in the deck coating to the roof level.

5.2.6 Level 7 and 8

5.2.6.1 Previous crazed cracking observed in the external precast parapet walls is potentially caused by ASR, see section 4.4.6. However, visually the cracks do not appear to have deteriorated since our last inspection. **(Photograph. No 30)**

5.2.6.2 All the metal support frames that hold the pedestrian restraint mesh to prevent access to the top level are covered with surface corrosion. **(Photograph. No 31)**

5.2.6.3 Widespread lichen/moss growth was observed to Level 8 external parapet walls and to the wall/floor junction, indicating possible ponding water, which is most likely entering the structure at these locations.

5.2.6.4 Extensive spalling on the internal insitu parapet wall between Level 7 and 8. The spalling appears to correspond to the fixings for the Pedestrian mesh fixed to the face of the internal parapet wall on Level 7. **(Photograph. No 32)**

5.2.6.5 The crash barriers to the top decks are in poor condition, with extensive failure of the plastic coating and corrosion of the barriers. **(Photograph. No 33)**

5.2.6.6 The head of one column appears to have spalled in the centre of the building to Level 8. This appears to have been caused by corrosion of an embedded fixing to the head of the column or possible ASR. **(Photograph. No 34)**

5.2.7 ASR and external Panels

5.2.7.1 The insitu cladding panels to the North and South Elevations does not visually appear to have deteriorated since the last inspection.

5.2.7.2 Some of the internal faces of the Level 7 insitu parapet show evidence of limited crazed cracking, which could be indicated of ASR or general corrosion of the embedded reinforcement. These, though, do not appear to have visually deteriorated since the last inspection.

6.0 Other Non-Structural Observations

6.1 Vehicle Impact Protection

6.1.1 The vehicle impact protection on the decks is provided by an individual 640-680mm high x 80mm wide x 10-15mm thick vertical steel post in the centre of each car parking bay. The barrier is fixed to the deck with a holding down plate with two approx. 8-12mm dia bolts. The barrier has a painted finish.

6.1.2 The vehicle impact protection (post) shows extensive failure of the paint coating and rusting in many areas and are unlikely to meet current standards or pass load testing against vehicle impact.

6.1.3 A common defect relating to the post is corrosion to the bolt fixings to the concrete deck. The fixing is susceptible to corrosion from chloride contaminated water ingress and can result in the weaking of the capacity of the bolt in shear (beneath the bolt head and/or at the junction of the bolt and the concrete deck). This defect could not be determined from the visual inspection.

6.2 Pedestrian Protection

6.2.1 Staircase

6.2.1.1 Some slight to moderate cracks are evident both to the external brick face and internal blockwork to both the north and south stairwells **(Photograph. No 35-36).** Of the two enclosed stairwells, the cracking in the southern stairwell appears to be more numerous, suggesting the cracking is thermal due to its southerly exposure.

6.2.1.2 The damage observed within the stairwells did not appear to be structurally significant, with the defects observed being attributed to the normal thermal movement in the blockwork and between pre-cast concrete panels and general wear/weathering.

6.2.1.3 Spalling to the soffit of the stairs observed to level 2 to the South Elevation, this should be repaired in the short term. **(Photography. No 37)**

6.2.2 Drainage

6.2.2.1 The decks have very slight falls to drainage gullies located in channel drains built into the decks at the centre of the car park, near the split levels. The channel drains are approximately 150mm wide. The drainage appears to be blocked in many places and contained a lot of silt and debris, which over time could cause water to pass through to the internal parapet wall.

6.2.2.2 Cast iron drainage pipes also showed extensive surface corrosion. The internal condition of the pipework is unknown, but as part of any remedial works, it is recommended that the internal face is CCTV surveyed and subject to a condition, refurbished or be replaced.

7.0 Conclusion

7.1 General

On nearly all levels, there is evidence of ongoing corrosion and new damage of the deck or soffit when compared against the last inspection in 2018/2019. The spalling and cracking of the concrete is a result of corrosion of embedded steel reinforcement in the concrete.

Most of the new observed damage appears to be minor at this stage and is not structurally significant but is generally an indication of ongoing corrosion of the reinforcement in the structure.

The only significant area of deterioration is spalling to the parapet to level 7 and 8 and serious spalling to the head of the column on the top deck next to the stairwell on level 8.

Numerous slight horizontal and diagonal cracking was evident to the external face of the columns from level 4 upwards. This may a result of possible carbonation of this area, as it is not evident to the lower levels which appear to have been protected with a protective coating. The protective coating has been applied to level 0 to 4 only. Cracking at the top of the column to level 4 and above could also be a sign of stress and yielding and could be a potential structural issue. As such these should be monitored monthly for up to a year to measure if there is any ongoing movement.

As these cracks to the columns are on the east and west elevations, they will likely need a cherry pick to access and monitor these cracks. This will likely require footpath and parking bay closure, especially on the east elevation.

If movement in the columns is observed, we would recommend a full structural analysis is carried out.

The Structure is capable of lasting another 10 years plus, so long as measures are put in place to mitigate further deterioration to the alkali silica affected areas and prevent further chloride (salts) ingress and the cracking to the columns is monitored to ensure the new cracks are not a result of overstressing of columns.

Therefore, we would recommend that if the car park is to be kept in the long-term various options are considered as detailed in section 9.0 Recommendations. The sooner protective measures and repairs are carried out, the earlier the water and chlorides are prevented from entering the structure and causing further corrosion. Early repair and protective measures will also reduce the cost of future repairs.

7.2 Alkali Silica Reaction

There is no evidence of any new Alkali Silica Reaction damage occurring in the structure.

To the North and South Elevations insitu cladding panels, where there historic is evidence of ASR, the existing damage does not appear to have deteriorated since our last inspection.

Internal parapet walling to level 7, again appears to be the same, the only area which has deteriorated is the head of one of the columns in the centre of the structure between level 7 and level 8.

However, where cracking has already occurred, water can enter the crack and cause corrosion of the embedded steel reinforcement even if the alkali silica reaction has not deteriorated. This corrosion of the rebar will not show visible signs of deterioration until the corrosion causes the concrete to spall or corrosion staining is evident. Spalling concrete still poses a potential Health and Safety risk and measures to reduce or eliminated water ingress should be considered to lower the risk of spalling concrete falling to the footpath below.

8.0 Health and Safety Concerns

The following is a list of significant structural related Health and Safety concerns observed in the car park and a risk rating on the Health and Safety risks it poses to the car park and its users.

This is not a full list of all the Health and safety concerns, just the risk associated with the main structural issues observed at the car park.

Red – undertake the work urgently/as soon as possible.

Yellow – monitor and undertake the work within 1 – 5 years.

Green - No issue but monitor for future deterioration.

8.1 Observations

8.1.1 Alkali Silica to the North and South Elevations. The cracking visually does not appear to have deteriorated but existing cracks are a direct avenue for water to enter and corrode the reinforcement. When the reinforcement corrodes it will expand and cause the concrete to spall, posing a risk when this falls off the face of the concrete.

Risk - Red – Either monitor for evidence of corrosion of the rebar and further spalling or undertake works to mitigate the risk i.e., repair and prevent further water ingress.

8.1.2 Additional areas of ASR appear.

Risk – Yellow - Monitor annually to ensure no other areas of ASR occur, or alternatively apply protective coatings to the decks and concrete areas to prevent water ingress which is needed for ASR to occur.

8.1.3 Cracks to outer face of columns.

Risk – Red, the cracking should be monitored to see if the cracks are progressively worsening. This should be carried out prior to any other major remedial works.

8.1.4 Various cracking and spalling to decks and soffits. This is likely been caused by water ingress to the top decks and chlorides to the lower decks causing corrosion of the embedded rebar/reinforcement inside the concrete. This will continue until protective measures to reduce water ingress are carried out. Repair costs will increase the longer it is left.

Risk - Red to yellow. The structure is not likely to suffer structurally collapse, however the longer the issue is left untreated, the risk of spalling concrete from the soffit potentially hitting users of the car park increases.

8.1.5 Existing crash barriers to the centre of the car par. External barriers replaced following the 2015 report but internal barriers were not replaced due to the perceived less risk.

Risk – Yellow - The barriers to the centre of the car park is now substandard and unlikely to be compliant. Consider replacing as part of possible refurbishment works.

8.1.6 Spalling to Soffit of stairwell (South) see photograph 37.

Risk Red – Risk of further spalling concrete or failure or closure of staircase. Repair as soon as possible to prevent deterioration.

9.0 Recommendations

9.1 Option 1 – No work/ minimal repairs

Do not undertake any remedial works or preventative measures. This option would appear to have the lowest initial costs, but would pose a high risk of spalling concrete, which will need to be managed. The risk of new and continued ASR and water ingress into the existing structure would continue, Akali silica cracking leading to the existing reinforcement corroding would be high.

The alkali silica at present does appear to pose a structural risk to the structure, however the biggest risk is either continuing water ingress through the existing cracking and corrosion of the steel reinforcement in the external concrete parapet panels to the North and South Elevation. If these panels continue to deteriorate, the risk of spalling concrete onto the pedestrian path and road below is considered high and is a Health and Safety risk.

Carry out regular monitoring to the North and South Elevation to monitor cracking to the concrete panels affected by alkali silica.

Carry out monthly monitoring of the cracking to the outside face of the column for 12 months.

Undertake a full structural assessment prior to any remedial works being undertaken, this would be needed if monitoring showed ongoing movement to the cracking to the columns.

Monitoring and Inspections budget costs £20-40 K based upon 1 year inspection.

9.2 Option 2 - Essential Repairs and most urgent preventative measures

This option would appear to have elevated initial costs and will pose lower risk of spalling concrete which will need to be managed. The recommended works are stated below:

- Carry out regular monitoring for any additional alkali silica reaction and inspect reinforcement to measure the degree of corrosion and ASTR damage in external panels/ parapet to the North /South Elevations.
- Carry out monthly monitoring of the cracking to the outside face of the column for 12 months.
- Undertake a full structural assessment prior to any remedial works being undertaken, this would be needed if monitoring showed ongoing movement to the cracking to the columns.
- Undertake localised proprietary concrete repairs at most serious areas of concrete spalling and delamination.
- Top deck remains closed. Localised redecoration to the pedestrian mesh to the top decks to prolong life.
- Apply waterproof deck coating to the roof level 7 & 8 and decks 2 & 3 only. Repair specification to be confirmed by specialist deck coating subcontractor.
- Repair existing drainage system and reseal existing waterproof coating adjacent to drainage outlets. Replace downpipes where necessary.
- Repoint brickwork around the perimeter of the building.
- Apply anti carbonation or other coating to the external cladding panels suffering alkali silica reaction and external columns level 4 to 8 only (previously uncoated).

- Undertake visual inspection to confirm if the building complies with current Building Regulations.
- Undertake a Fire Strategy review and Equality Act survey.
- Implement an annual routine inspection and maintenance strategy to identify any defects going forward and carrying out suitable remedial works to ensure the integrity of the structure.
- Replace corroded barriers with new to the centre of the structure.

It is considered that the above works would reduce the rate of deterioration of the structure. However, periodic maintenance would be required to mitigate the risk of concrete spalling.

Depending on the rate of deterioration of the structure and the required lifespan, remedial works included in Options 2 may need to be implemented on a regular basis throughout the remaining lifespan of the structure. The frequency of repairs may in the long run push costs above option 3 in the long run.

Budget estimate of costs - £600,000 -850,000. (depending upon final specifications

9.3 Option 3 - Essential Repairs and Additional Remedial Works. 10 – 20-year life span

Undertake repair options proposed following the previous concrete testing, which included short-, medium- and long-term repairs. Produce a life care plan as recommend by the ICE Recommendations for the inspection, Maintenance and Management of Car Park Structures, and undertake the proposed works over several programmed years.

A summary of the recommended works is stated below:

- Carry out regular monitoring to the North and South Elevation to monitor cracking to the concrete panels affected by alkali silica.
- Carry out monthly monitoring of the cracking to the outside face of the column for 12 months.
- Undertake a full structural assessment prior to any remedial works being undertaken, this would be needed if monitoring showed ongoing movement to the cracking to the columns.
- Undertake localised proprietary concrete repairs at limited areas of concrete spalling and delamination. This is to include the existing alkali silica reaction areas where existing cracking is apparent. These external panels and the fixings inspected to confirm if they are adequate. Serious deterioration in either may require the panel to need replacement.
- Apply an anti-carbonation paint to the concrete as per the manufacturer's specifications at all areas to be repainted as part of the proposed redecoration works for additional protection to the structure.
- Apply waterproof coating at all levels to prevent water ingress and deterioration of the underlying structure. Repair specification to be confirmed by specialist deck coating subcontractor. We presume the specialist subcontractor would provide a warranty if this methodology were followed. Deck coatings will prevent further ingress of chlorides into the structure.
- We recommend a corrosion inhibitor is then locally applied to these the lower levels to attempt to reduce the chloride levels.
- Repair existing drainage system and replace downpipes where necessary.
- Repoint brickwork around the perimeter of the building and providing column / parapet encasement where mortar has eroded.
- The alkali silica risk can be reduced by localised repairs and application of anti-carbonation paint system as recommended above.

- Undertake visual inspection to confirm if the building complies with current Building Regulations.
- Undertake a Fire Strategy review and Equality Act survey.
- Implement an inspection and maintenance strategy every 2-3 years to identify any defects going forward and carrying out suitable remedial works to ensure the integrity of the structure. This may include future testing for Alkali silica and ensuring the reinforcement in existing ASR has not corroded significantly to pose a risk of significant spalling.
- Replace crash barriers to the park bays in the centre of the car park between the split levels and the top deck if the top deck is to be reused.
- Lighting is poor in areas, consideration on replacing lighting with new LED.
- Reroof staircases (flat roofs).
- Make good cracking in stairs and redecorate.
- Repair damage to top deck ramp internal reinforcement which has corroded.
- Consider implementing electric charging points. (wiring may also need investigation.)
- Possible strengthening works to columns if monitoring shows ongoing movement.
- Reopen top deck and repair ramps and soffits.

These remedial works would have higher initial costs but will reduce the risk profile further to the structure, including concrete spalling.

Budget estimate for the above works £ 1.5 – 2. 75 million. (depending on final specification and scope)

Please note the nature of concrete repairs means repair costs are never full known until repairs works are started and the degree of damage to internal reinforcement in concrete exposed. Costs can go up or down.

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Appendix A Marked up drawings showing new areas of damage.

NO DIMENSIONS TO BE SCALED FROM THIS DRAWING

Notes
1. All dimensions are an approximation.
2. Concrete beams span between all columns, but have been omitted for clarity.
3. Levels GF, 1, 2 & 3 have had a newer coating of paint applied, therefore cracks in the beams aren't visible.
4. Hairline cracks in the soffit spanning the full length of each level coincide with construction joints at deck level above.
5. Generally repairs have been undertaken on hairline cracks in the soffit.
6. Intermittent areas of the soffit showing signs of delamination. Severity varies on different levels.
7. The majority of external columns have had cracks repaired.

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CDM - RESIDUAL RISKS

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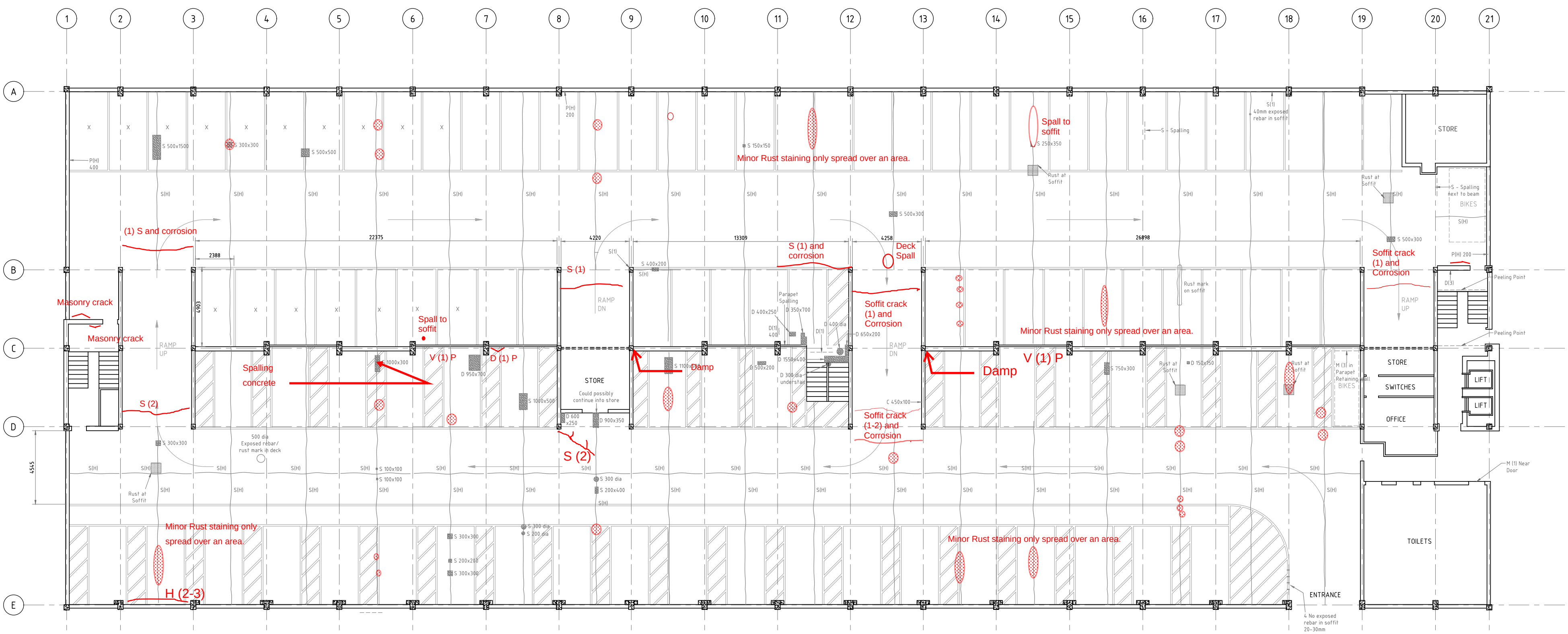
LEVEL 1



GROUND LEVEL

Key Observed Damage Survey 2021
B - Damage to Beam
D - Damage to Deck
S - Damage to Soffit
P - Damage to Parapet
C - Damage to column
M - Damage to Masonry

(H) - Horizontal crack, (V) - Vertical crack, (D) - Diagonal Crack
(1) - Wide of the the crack i.e 1mm, etc

New rust staining

KEY Historic Damage in previous surveys

B	-	Damage to beam
D	-	Damage to deck
S	-	Damage to soffit
P	-	Damage to upper parapet
C	-	Damage to column
M	-	Damage to masonry
PL	-	Damage to lower parapet
PU	-	Damage to upper parapet
PD	-	Diagonal Damage to parapet
X	-	Bay unavailable for deck inspection due to obstruction (parked cars). Visual soffit inspection only.

(H)=Horizontal, (V)=Vertical, (D)=Diaganol 400 - Hairline/ shrinkage crack approx. 400mm long

- Grout filler between beam and new support column cracked heavily
(1) - 1mm wide crack
26 No B(H) V - 26 no. of vertical hairline cracks along face of beam
250x100 - Approx. area of delamination
- Approx. area of delamination
- Approx. area of rust

P02	Updated Damage Location (August 2018) + Job Number	...	SG	NC
P01	First issue	...	SSI	NC
Revisions		Date	Drawn	Chk'd

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PROJECT
Covent Garden Car Park

DRAWING TITLE: Ground Level & Level 1 Damage Location	PICK EVERARD PROJECT No. **180089**
	SCALE - unless otherwise stated 1:125 at A1
	STATUS S2 / PURPOSE OF ISSUE INFORMATION
DRAWING NUMBER **215-PE-CG-ZZ-DR-S-1101**	REV **P02**

Notes
1. All dimensions are an approximation.
2. Concrete beams span between all columns, but have been omitted for clarity.
3. Levels GF, 1, 2 & 3 have had a newer coating of paint applied, therefore cracks, if present, in the beam aren't visible.
4. Beams shown in dashed lines have been chosen at random to determine an average amount of hairline cracks per beam, which is approximately 30 on each face (levels 4, 5 & 6).
5. Hairline cracks in the soffit spanning the full length of each level coincide with construction joints at deck level above.
6. Generally repairs have been undertaken on hairline cracks in the soffit.
7. Intermittent areas of the soffit showing signs of delamination. Severity varies on different levels.
8. The majority of external columns have had cracks repaired.

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CDM – RESIDUAL RISKS

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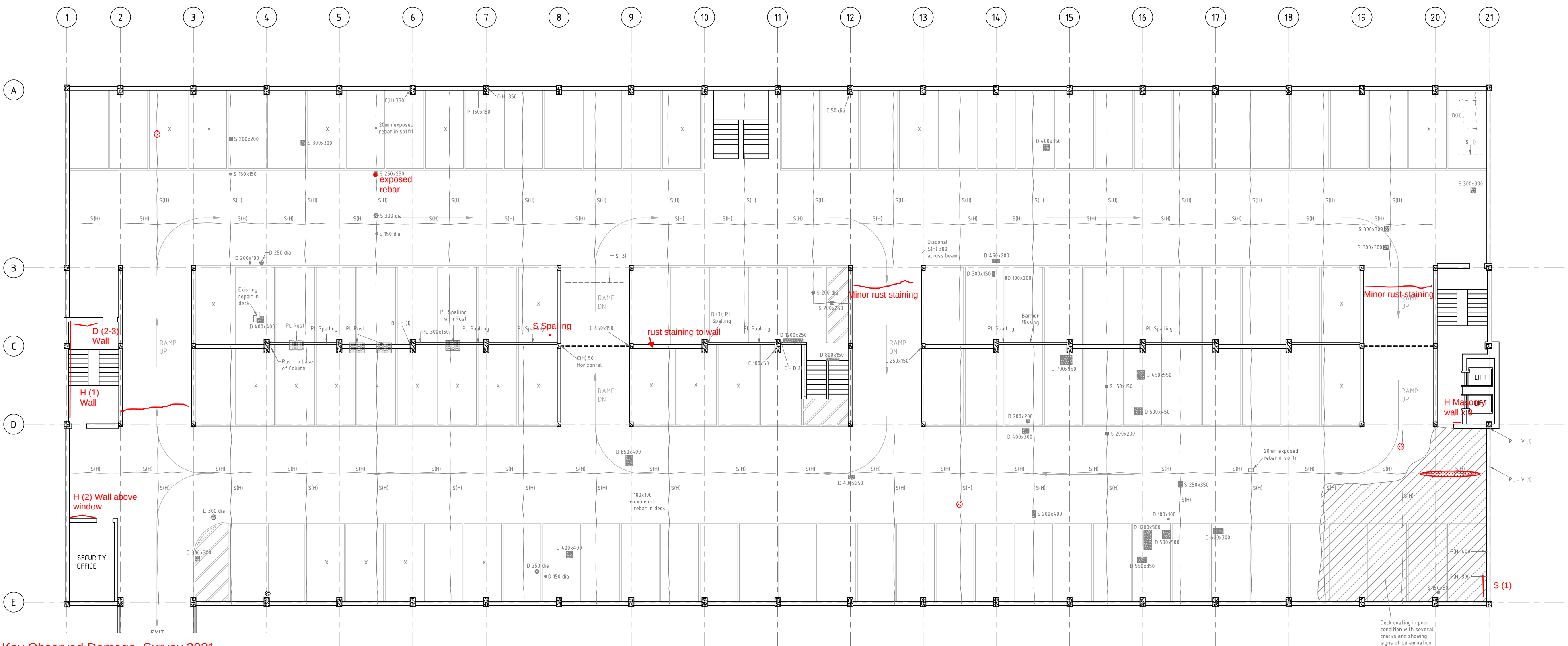
LEVEL 3



LEVEL 2

Key Observed Damage Survey 2021
B - Damage to Beam
D - Damage to Deck
S - Damage to Soffit
P - Damage to Parapet
C - Damage to column
M - Damage to Masonry

(H) - Horizontal crack, (V) - Vertical crack, (D) - Diagonal Crack
(1) - Wide of the the crack i.e 1mm, etc

New rust staining

KEY Historic Damage in previous surveys
B - Damage to beam
D - Damage to deck
S - Damage to soffit
P - Damage to upper parapet
C - Damage to column
PL - Damage to lower parapet
PU - Damage to upper parapet
PD - Diagonal Damage to parapet
X - Bay unavailable for deck inspection due to obstruction (parked cars). Visual soffit inspection only.

(H)=Horizontal, (V)=Vertical, (D)=Diaganol 400 – Hairline/ shrinkage crack approx. 400mm long

- Grout filler between beam and new support column cracked heavily
(1) - 1mm wide crack
26 No B(H) V – 26 no. of vertical hairline cracks along face of beam
250x100 – Approx. area of delamination
– Approx. area of delamination
– Approx. area of rust

P02	Updated Damage Location (August 2018) + Job Number	...	SG	NC
P01	First issue	19.05.15	SSI	NC
Revisions		Date	Drawn	Chk'd

CLIENT
Warwick District Council

PROJECT
Covent Garden Car Park

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DRAWING TITLE
Level 2 & Level 3
Damage Location

PICK EVERARD PROJECT No. 180089
SCALE - unless otherwise stated 1:125 at A1
STATUS S2
PURPOSE OF ISSUE INFORMATION
DRAWING NUMBER 215-PE-CG-ZZ-DR-S-1102
REV P02

Notes
1. All dimensions are an approximation.
2. Concrete beams span between all columns, but have been omitted for clarity.
3. Levels GF, 1, 2 & 3 have had a newer coating of paint applied, therefore cracks, if present, in the beam aren't visible.
4. Beams shown in dashed lines have been chosen at random to determine an average amount of hairline cracks per beam, which is approximately 30 on each face (levels 4, 5 & 6).
5. Hairline cracks in the soffit spanning the full length of each level coincide with construction joints at deck level above.
6. Generally repairs have been undertaken on hairline cracks in the soffit.
7. Intermittent areas of the soffit showing signs of delamination. Severity varies on different levels.
8. The majority of external columns have had cracks repaired.

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CDM - RESIDUAL RISKS

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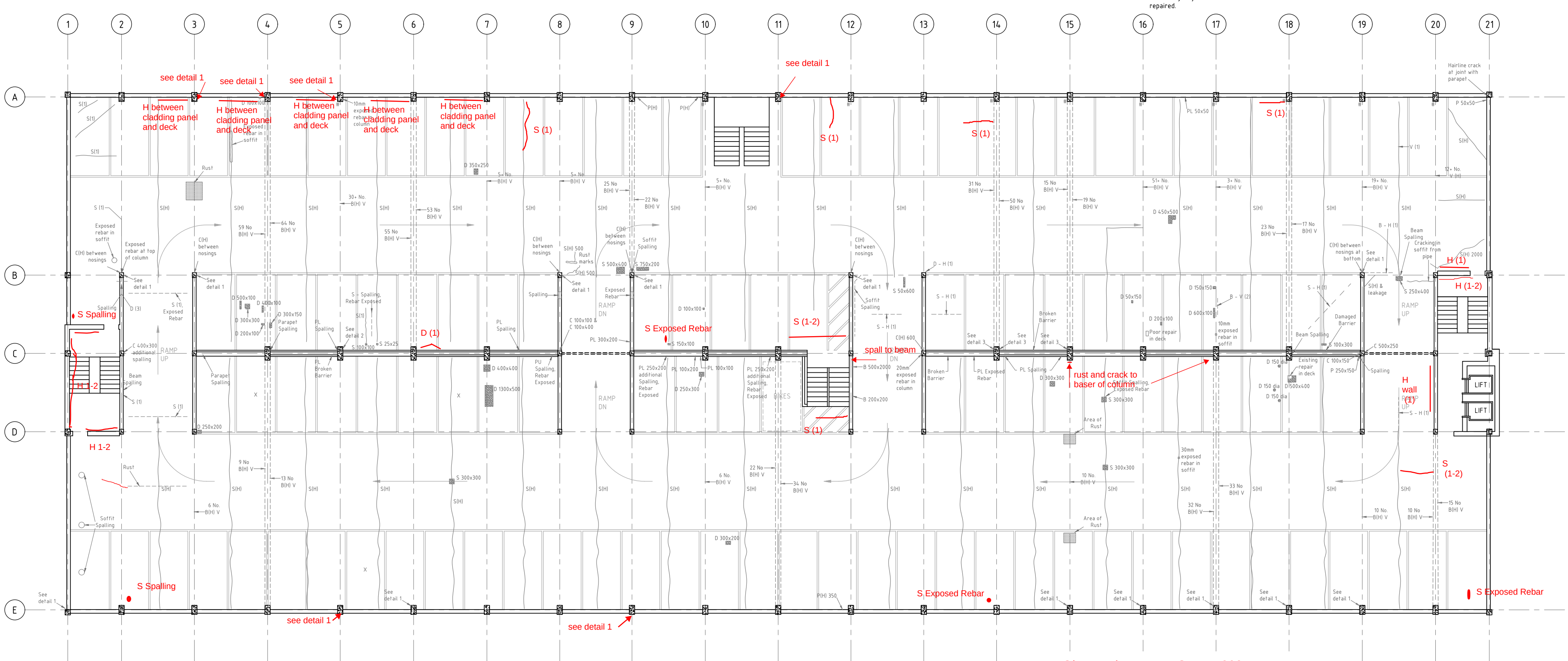
LEVEL 5

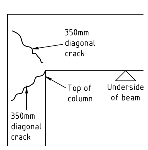


LEVEL 4

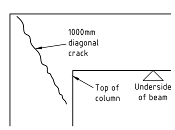
KEY Historic Damage in previous surveys
B - Damage to beam
D - Damage to deck
S - Damage to soffit
P - Damage to upper parapet
C - Damage to column
PL - Damage to lower parapet
PU - Damage to upper parapet
PD - Diagonal Damage to parapet
X - Bay unavailable for deck inspection due to obstruction (parked cars). Visual soffit inspection only.

(H)=Horizontal, (V)=Vertical, (D)=Diaganol 400 - Hairline/ shrinkage crack approx. 400mm long

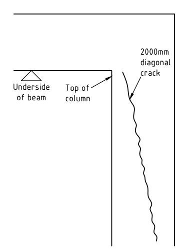
- Grout filler between beam and new support column cracked heavily
(1) - 1mm wide crack
26 No B(H) V - 26 no. of vertical hairline cracks along face of beam
250x100 - Approx. area of delamination
- Approx. area of delamination
- Approx. area of rust



DETAIL 1



DETAIL 2



DETAIL 3

Key Observed Damage Survey 2021
B - Damage to Beam
D - Damage to Deck
S - Damage to Soffit
P - Damage to Parapet
C - Damage to column
M - Damage to Masonry

(H) - Horizontal crack, (V) - Vertical crack, (D) - Diagonal Crack
(1) - Wide of the crack i.e 1mm, etc

New rust staining

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Covent Garden Car Park

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DRAWING TITLE	PICK EVERARD PROJECT No.	
Level 4 & Level 5 Damage Location	180089	
	SCALE - unless otherwise stated: 1:125 at A1	
	STATUS: S2	PURPOSE OF ISSUE: INFORMATION
DRAWING NUMBER: 215-PE-CG-ZZ-DR-S-1103	REV: P02	

Notes
1. All dimensions are an approximation.
2. Concrete beams span between all columns, but have been omitted for clarity.
3. Levels GF, 1, 2 & 3 have had a newer coating of paint applied, therefore cracks in the beam aren't visible.
4. Beams shown in dashed lines have been chosen at random to determine an average amount of hairline cracks per beam, which is approximately 30 on each face (levels 4, 5 & 6).
5. Hairline cracks in the soffit spanning the full length of each level coincide with construction joints at deck level above.
6. Generally repairs have been undertaken on hairline cracks in the soffit.
7. Intermittent areas of the soffit showing signs of delamination. Severity varies on different levels.
8. The majority of external columns have had cracks repaired.

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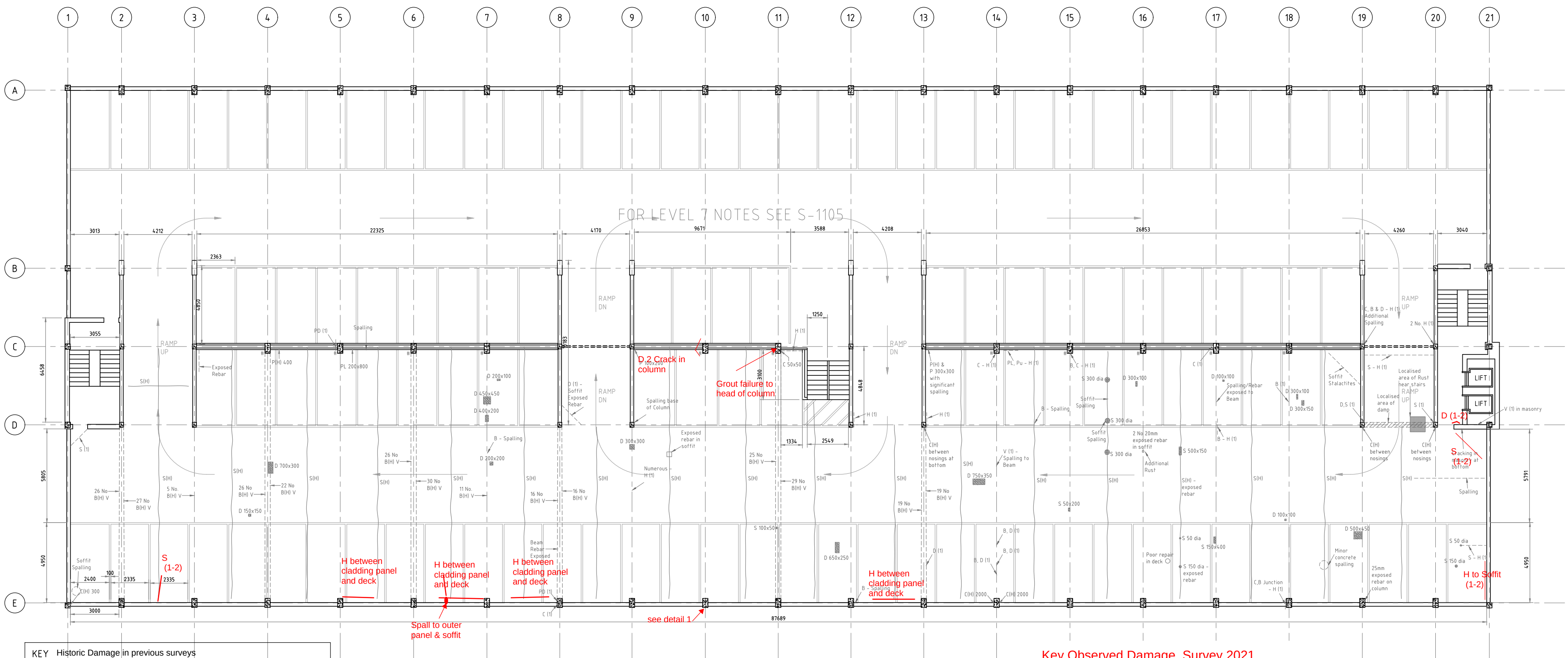
LEVEL 7



LEVEL 6

KEY Historic Damage in previous surveys

B - Damage to beam
D - Damage to deck
S - Damage to soffit
P - Damage to upper parapet
C - Damage to column
PL - Damage to lower parapet
PU - Damage to upper parapet
PD - Diagonal Damage to parapet
X - Bay unavailable for deck inspection due to obstruction (parked cars). Visual soffit inspection only.

(H)=Horizontal, (V)=Vertical, (D)=Diaganol 400 - Hairline/ shrinkage crack approx. 400mm long

- Grout filler between beam and new support column cracked heavily
(1) - 1mm wide crack
26 No B(H) V - 26 no. of vertical hairline cracks along face of beam
250x100 - Approx. area of delamination
- Approx. area of delamination
- Approx. area of rust

Key Observed Damage Survey 2021
B - Damage to Beam
D - Damage to Deck
S - Damage to Soffit
P - Damage to Parapet
C - Damage to column
M - Damage to Masonry

(H) - Horizontal crack, (V) - Vertical crack, (D) - Diagonal Crack
(1) - Wide of the the crack i.e 1mm, etc

New rust staining

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PROJECT
Covent Garden Car Park

DRAWING TITLE	PICK EVERARD PROJECT No.	
Level 6 Damage Location	180089	
	SCALE - unless otherwise stated: 1:125 at A1	
	STATUS: S2	PURPOSE OF ISSUE: INFORMATION
DRAWING NUMBER: 215-PE-CG-ZZ-DR-S-1104	REV: P02	

Notes
1. All dimensions are an approximation.
2. Concrete beams span between all columns, but have been omitted for clarity.
3. Levels GF, 1, 2 & 3 have had a newer coating of paint applied, therefore cracks, if present, in the beam aren't visible.
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5. Hairline cracks in the soffit spanning the full length of each level coincide with construction joints at deck level above.
6. Generally repairs have been undertaken on hairline cracks in the soffit.
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CDM – RESIDUAL RISKS
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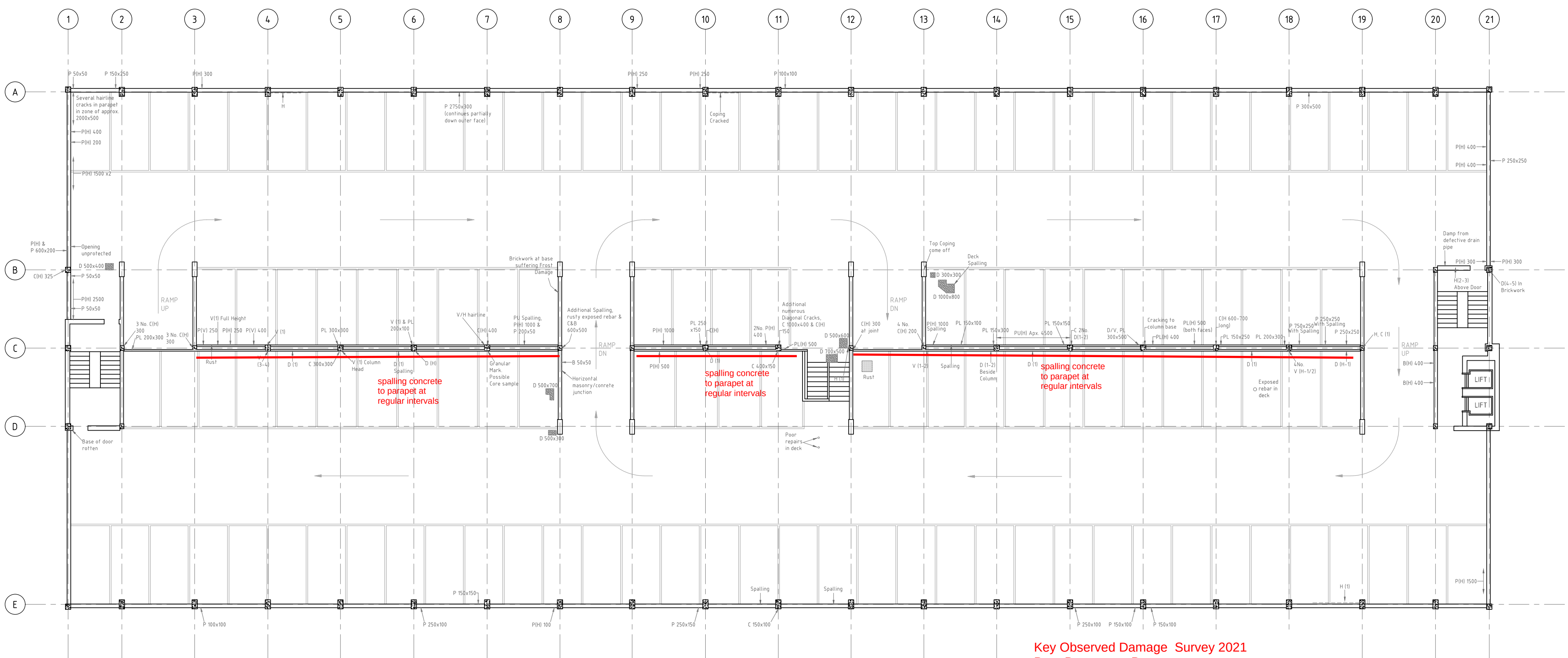
LEVEL 7



LEVEL 8

KEY Historic Damage in previous surveys
B - Damage to beam
D - Damage to deck
S - Damage to soffit
P - Damage to upper parapet
C - Damage to column
PL - Damage to lower parapet
PU - Damage to upper parapet

X - Bay unavailable for deck inspection due to obstruction (parked cars). Visual soffit inspection only.

(H)=Horizontal, (V)=Vertical, (D)=Diaganol 400 - Hairline/ shrinkage crack approx. 400mm long

(1) - 1mm wide crack

250x100 - Approx. area of delamination
- Approx. area of delamination
- Approx. area of rust

Key Observed Damage Survey 2021
B - Damage to Beam
D - Damage to Deck
S - Damage to Soffit
P - Damage to Parapet
C - Damage to column
M - Damage to Masonry

(H) - Horizontal crack, (V) - Vertical crack, (D) - Diagonal Crack
(1) - Wide of the the crack i.e 1mm, etc

New rust staining

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PROJECT
Covent Garden Car Park

DRAWING TITLE: Level 7 & Level 8 Damage Location	PICK EVERARD PROJECT No. 180089
	SCALE - unless otherwise stated: 1:125 at A1
	STATUS: S2 / PURPOSE OF ISSUE: INFORMATION
DRAWING NUMBER: 215-PE-CG-ZZ-DR-S-1105	REV: P02

Appendix B – Photographs

Photo No.1 2018

Photo No. 2 2021 Survey

Photo No. 3 2018

Photo No. 4 2021 Survey

Photo No. 5 2018

Photo No. 6

Photo No. 7 2018

Photo No. 8 2021 Survey

Photo No. 9

Photo No. 10

Photo No. 11

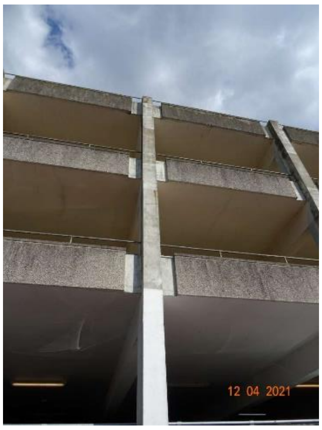

Photo No. 12

Photo No. 13

Photo No. 14

Photo No. 15

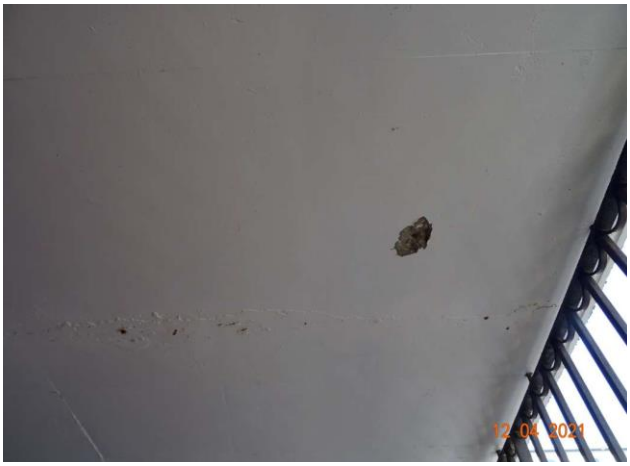

Photo No. 16

Photo No. 17

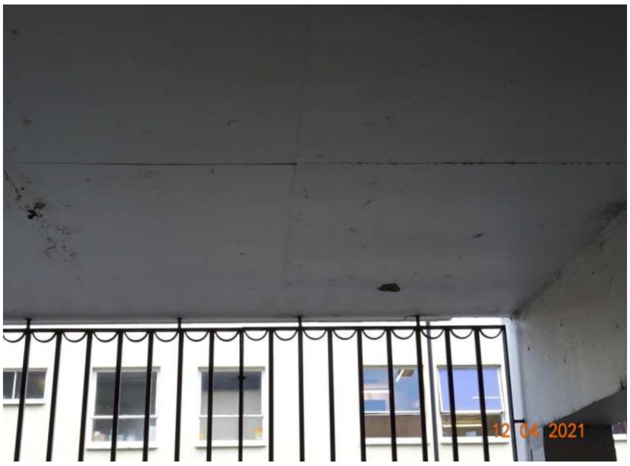

Photo No. 18

Photo No. 19

Photo No. 20

Photo No. 21

Photo No. 22

Photo No. 23

Photo No. 24

Photo No. 25 | **Photo No. 26**

Photo No. 27 | **Photo No. 28**

Photo No. 29 | **Photo No. 30**

Photo No. 31

Photo No. 32

Photo No. 33

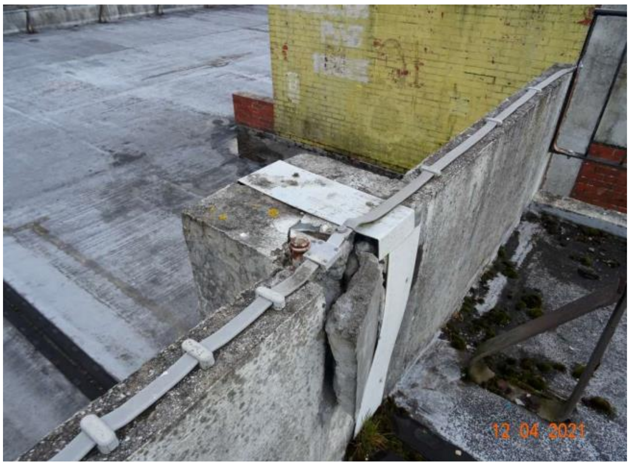

Photo No. 34

Photo No. 35

Photo No. 36

Photo No. 37