Dorman Long Tower
South Bank, Teesworks

South Tees Development Corporation

Structural Appraisal Report

Document reference: STDC-ATK-SBK-ZZ-RP-S-0001

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Notice

This document and its contents have been prepared and are intended solely as information for and use in relation to the South Bank Dorman Long Tower, STDC Site, Redcar.

Document history

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Client Signoff

Client	STDC
Project	Dorman Long Tower Structural Appraisal
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Contents

1. Executive Summary

Atkins has been instructed by the South Tees Development Corporation (STDC) to carry out a visual inspection and desktop structural review of the redundant Simon Carves Coal Bunker at South Bank, on its site at Redcar, also known as the 'Dorman Long Tower'. Considering the results of the technical survey, Atkins have been asked to provide guidance on future considerations for extending the life of the asset, as a possible national heritage monument, to be fit for its new location within the modern and fully developed future Teesworks site.

The structure is by current codes/standards, and the standards of the day, significantly past its original design life. The structure is generally robust and we don't consider there is a risk of imminent local or catastrophic collapse, however the structure is unsafe to enter. Externally the risk of falling debris exists.

The main observed defects can be classified as:

- Endemic concrete carbonation causing reinforcement corrosion and concrete spalling – this is ongoing and is not reversible.
- Severe cracking of concrete elements – due to a variety of reasons but primary load shedding and thermal expansion and contraction.
- General "wear and tear" (age related deterioration) – corrosion of steelwork, weathering and degradation of timber and brickwork, water/plant damage etc.

The main influence on the future life of the Tower structure is the historic and ongoing carbonation of the concrete. Carbonation affects all exposed concrete and occurs where atmospheric carbon dioxide penetrates the concrete cover to the reinforcement and reduces its alkalinity. Once the alkalinity of the concrete is neutralised the reinforcement starts to corrode (with moisture and oxygen). The corroding reinforcement causes expansive pressures in the concrete and it is eventually pushed off or spalls. **This process is ongoing and irreversible**.

Current repairs for this type of localised defect typically come with a 10–15-year guarantee/life and in the meantime other un-repaired areas continue to corrode and eventually require repair. With significant investment and ongoing repair we suggest the remaining life for the asset could be 15-20 years, at which point it would require demolition.

Keeping the asset for 50-60 years as a low maintenance monument to the steelworks is not feasible, given the above and the imminent development of Teesworks. Therefore the scenarios to consider are: -

- Re-life the Tower for 15-20 years with ongoing maintenance and repair (high cost and risk)
  - As a monument <u>without</u> public access
    - Budget cost for initial works — £4.7m
    - Budget cost for ongoing repairs — £325k/5yrs, £2m with inflation over 15-20 yrs
    - Future budget demolition costs in year 15-20 — £2.5m (allowing for inflation and complexity of demolition within fully developed Teesworks operating facility)
  - As a monument with public access
    - Budget cost for initial works — £7.2m
    - Budget cost for ongoing repairs — £325k/5yrs, £2m with inflation over 15-20 yrs
    - Future budget demolition costs in year 15-20 — £3.0m (allowing for inflation and complexity of demolition within fully developed Teesworks operating facility)
- Demolition in 2021 and consider alternative opportunities for a monument elsewhere on Teesworks site utilising the digital data obtained and modelling undertaken **- recommended**
    - Budget cost for demolition — £1.0m

2. Introduction

2.1. General

Atkins has been instructed by the South Tees Development Corporation (STDC) to carry out a visual inspection and desktop structural review of the redundant Simon Carves Coal Bunker, South Bank, on its site at Redcar, also known as the 'Dorman Long Tower'. The concrete structure is situated in the South Bank Coke Oven plant area, south of the By-Products area and north of the Middlesbrough to Saltburn Network Rail lines.

The 'Dorman Long Tower' is an iconic local structure that at 209ft (56.4m above surrounding ground level) tall has represented steelmaking on Teesside since 1956. It is visible for miles and particularly when driving along the local A66. The name Dorman Long is synonymous with Teesside steelmaking and bridge building. The company was established in 1875 and was a major steelmaker until 1967, when it was nationalised along with 13 other independent steel makers, to become part of the British Steel Corporation. The sides of the coal bunker carry the Dorman Long name, in recessed letters, several metres high.

The majority of the steelworks, including the Redcar blast furnace, Redcar and South Bank coke ovens and the BOS (Basic Oxygen Steelmaking) plant at Lackenby closed in 2015. The steel making site at Redcar is now undergoing major redevelopment.

The structure is currently redundant (since 1973) and derelict/dilapidated. It was used to primarily store $^{1}/_{8}$" rough ground oxidised coal. Initial discussions regarding its demolition have raised local interest however and alternatives to demolition are being considered. These might mean the re-purposing of the tower, perhaps as a restaurant, office accommodation or visitor attraction. It might mean maintaining the structure as a heritage monument or viewing platform from which to view the changing industrial landscape.

Figure 2.1 Current southern elevation.

Figure 2.2 Original southern elevation

2.2. Desk based Study

A proportion of the record drawings have been located. These indicate construction sizes, reinforcement and concrete cover. Key drawings of the main walls and internal structure are however missing. The desktop review is therefore based on the drawings that exist and engineering judgement. We have a drawing register for the structure, included on the general arrangement drawing 1. An extract of the drawing is included below, with those drawings we have received highlighted.

South Bank Service Bunker - List of Detail Drawings.

No.	Title	No.	Title	No.	Title
398/1.	Gen. Arrangement - Sections.	398/26	Charging Car Floor - Sections.	398/51	Lining to Bunker Bottoms.
2	Gen. Arrangement - Plans.	27	Operating Platforms.	52	Lining to Bunker Bottoms.
3	Gen. Arrangement - Elevations.	28	Bunker Bottoms - Plans.	53	Lining to Bunker Bottoms.
4	Piling Plan	29	Bunker Bottoms - Sections.	54	Lining to Bunker Bottoms.
5	Plan on Basement Floor.	30	Coke Side Wall - Third Lift.	55	Lining to Bunker Bottoms.
6	Foundations.	31	Ram Side Wall - Third Lift.	56	Lining to Bunker Bottoms.
7	First Lift Frames. - A-D	32	Spillage Hopper Housing.	57	End Wall ∇+173'-0" to Roof.
8	First Lift Frames - E-H.	33	Cancelled.	58	Shuttlebelt Floor Plan & Section
9	First Lift Frames. - J-M.	34	Secondary Frames ∇+85'-0"-150'-0"	59	Lining to Bunker Bottoms.
10	First Lift Frames - N-Q	35	Secondary Frames ∇+150'-0" to Roof	60	Concrete Letter.
11	First Lift Frames - R-U.	36	Main Frame on R-U ∇+85'-0"-173'-0"	61	Lift Shaft Above ∇+173'-0"
12	First Lift Frames - V-Y.	37	Centre Wall on N-Q ∇+85'-0"-173'-0"	62	Tank Floor Beams.
13	First Lift Frames - Z-C₁	38	Main Frame on J-M ∇+85'-0"-173'-0"	63	Pent House.
14	Retaining Walls at Basement.	39	Coke Side Wall ∇+85'-0"-150'-0"		
15	Ram Side Wall - First & Sec. Lift.	40	Coke Side Wall ∇+150'-0" to Roof		
16	Coke Side Wall - First & Sec. Lift.	41	Ram Side Wall. ∇+85'-0"-150'-0"		
17	Oven Sole Floor - Plan.	42	Stairwell ∇+82'-0"-173'-0".		
18	Oven Sole Floor - Sections	43	Ram Side Wall +150'-0"- Roof.		
19	2nd. & 3rd Lift Frames. - A-D	44	End Walls ∇+85'-0"-173'-0".		
20.	2nd. & 3rd. Lift Frames - R-U	45	Concrete Letters		
21	2nd & 3rd. Lift Frames - N-Q	46	Concrete Letters.		
22	2nd & 3rd Lift Frames - V-Y	47	Main Frames ∇+173'-0" to Roof.		
23	2nd & 3rd Lift Frames - Z-C₁	48	Tank Floor - Plan & Sections.		
24	Spillage Hopper Roof	49	Roof - Plan & Sections.		
25	Charging Car Floor - Plan	50	Lining to Bunker Bottoms.		

9'-0"

Figure 2.3 Bunker Drawing List

2.3. Visual Survey

A visual survey has been carried out using binoculars and drone of the external elevations only, the inside of the structure being unsafe to enter. The drone flight has enabled the construction of a 'Digital Twin', a 3D digital model of the external elevation. Screen shots of this model occur throughout this report.

The inside of the tower was not accessible for health and safety reasons. Access stairs, platforms and ladders are either broken, severely corroded or have been removed to prevent unauthorised access. We have also been made aware that up to 800 tonnes of oxidised coal remains in the bunkers two compartments, that will have degraded over time and will prove difficult to remove as it is likely hardened and stuck to the bunker walls. The structure is predominately above ground but there are below ground cellars and redundant plant rooms, which again are unsafe to enter.

Inspection is therefore limited to the external elevations. Due to the condition of the structure a drone survey provided the safest means of assessing the full exterior condition of the building. As well as capturing still and video imagery, a photogrammetry survey has been undertaken that will allow for the production of a detailed Digital Twin' of the building.

Photographs of the inside of this structure have been taken from previous reports and historical data sources on the internet. These have been reviewed and considered in this report.

3. Structural Form and Arrangement

The main bunker structure is essentially a reinforced concrete box with a central division wall to create two steel lined coal hoppers with a combined capacity of 5,000t. The hoppers were top fed by a conveyor on the northern side. The hoppers fed the coke ovens and a coal bagging facility at low level.

The bunker box is stiffened on all sides, with a slightly different structural arrangement on each face. There are fin stiffeners to the east and west elevations. On the west face there is also a low-level projection to enclose the spillage and test area floor. On the north and south faces the bunker walls steps out in the central panels to increase storage volume. On the southern face, with the deep triangular corbels, the entire projection is used to increase the bunker volume. On the north face, one of the two bays of the square bottomed projection is used for an access stair to the roof.

Above the bunker box there are reinforced concrete water tanks that provide fire protection for the bunkers below.

Below the bunker box the structure comprises five principal reinforced concrete frames, with smaller frames to the low-level extensions to the east and west side. Between the frames on the northern and southern sides there are reinforced concrete walls panels. The walls between the principal frames are often 4” or 100mm thick and singly reinforced. This suggests that they are not ‘structural’ in the sense that they are critical to overall stability but are more likely to represent insitu concrete cladding panels.

The east and west elevations are open between the bunker bottom and the Charging Car Floor and therefore rely on frame action for stability in the north-south direction. Frame action may provide stability in the east west direction also (at least in terms of structural design), but the connecting infill walls in this direction will greatly increase stiffness in this direction.

Below the Charging car floor there are various intermediate levels and platforms, but no rigid floor or wall elements except for the Oven Sole Floor. We assume that frame action therefore takes lateral loads down to foundation level.

The foundations essentially comprise two very large reinforced concrete piled footings, one common footing for the structural frames’ northern columns and one for the southern columns.

The Charging Car Floor, the visible base of the tower is elevated above the surrounding ground level at battery base level and sits over a basement area. To the east and west of the tower’s main structure there are small extensions up to Charging Car Floor level. These extensions appear to connect to the tower with a roof slab at Oven Sole Floor level, sitting on corbels to permit some relative movement or articulation.

See Figure 3.1 overleaf for a marked up typical section

See Figure 3.2 to 3.5 further below for 3D model views of each elevation.

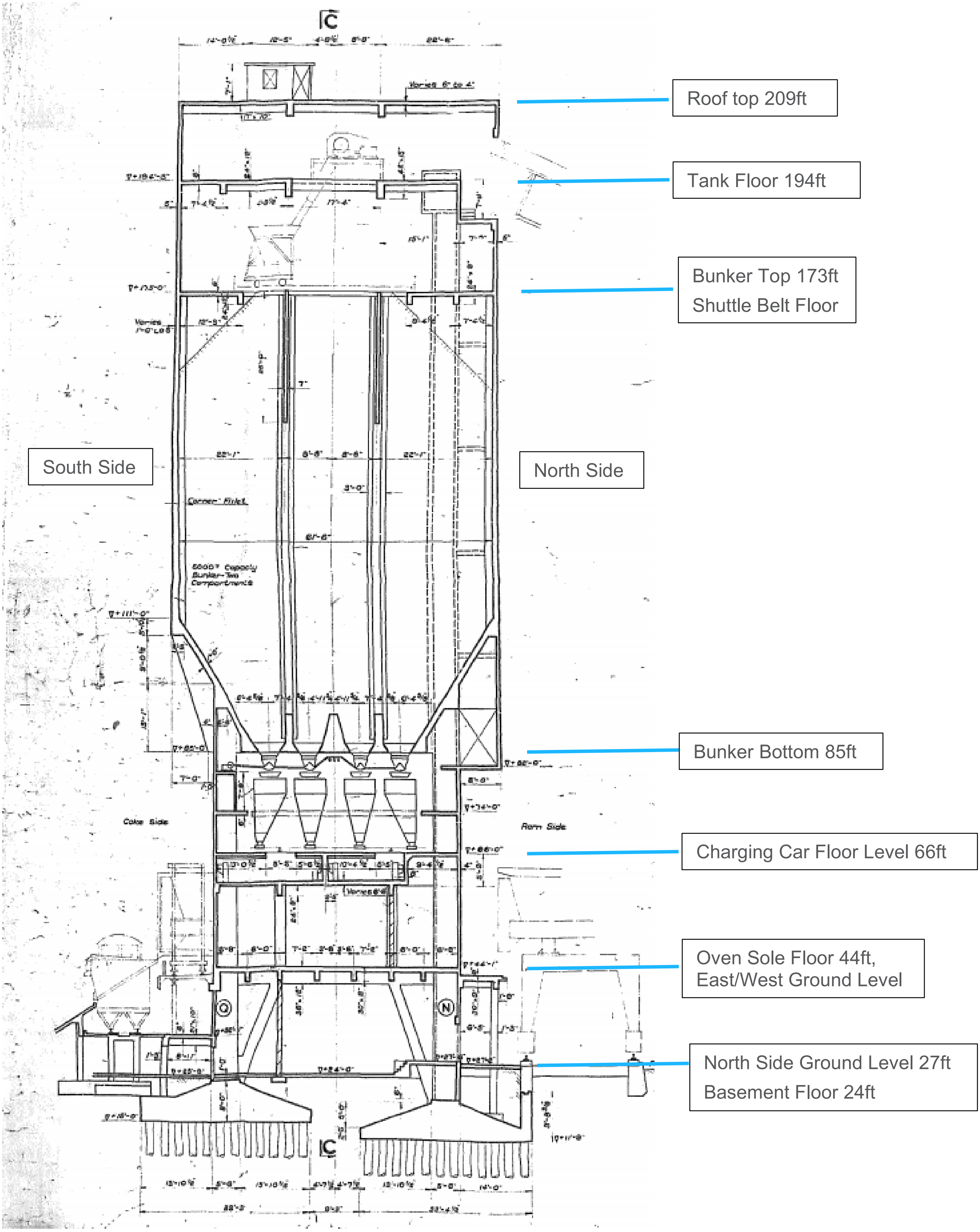
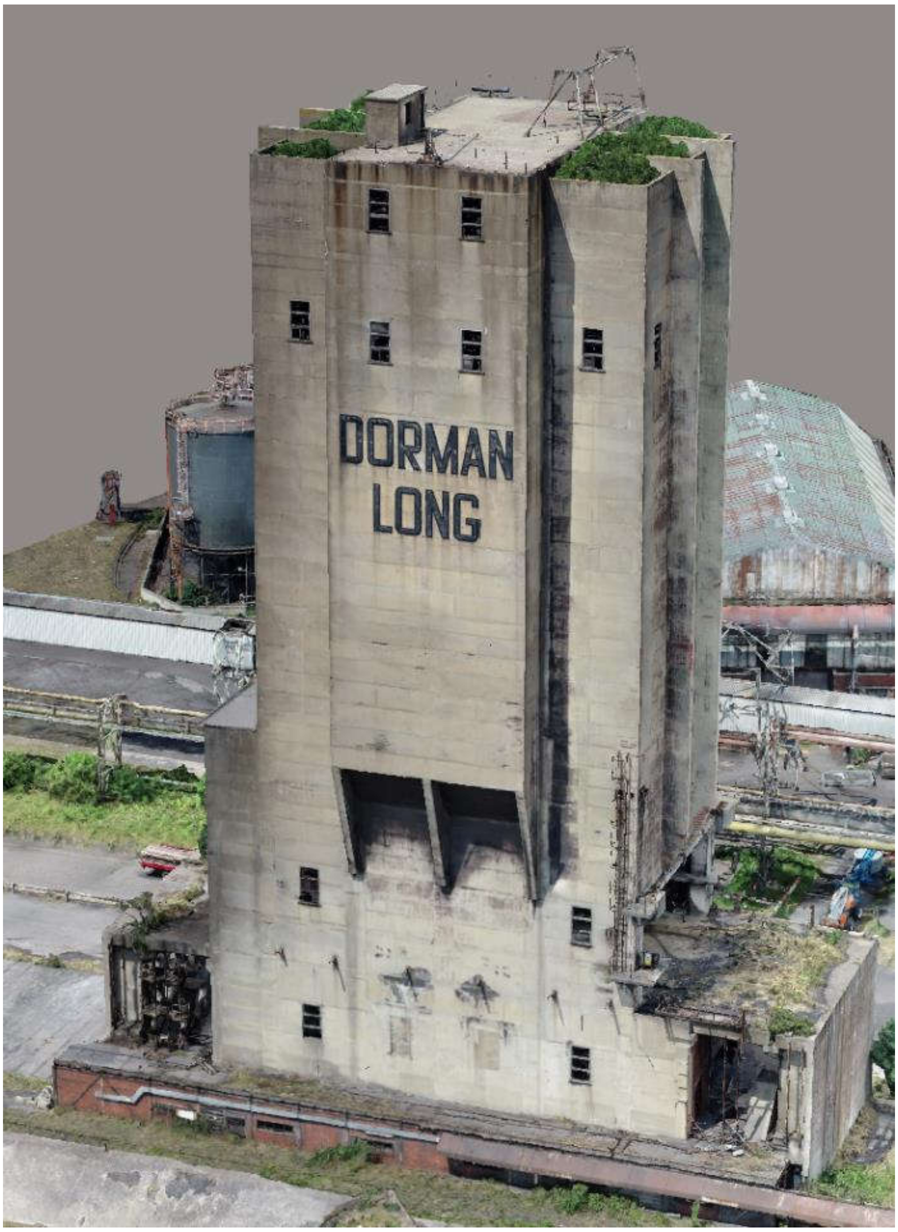


Figure 3.1 Section through bunker structure.

Figure 3.2 - Southern Elevation



Note:

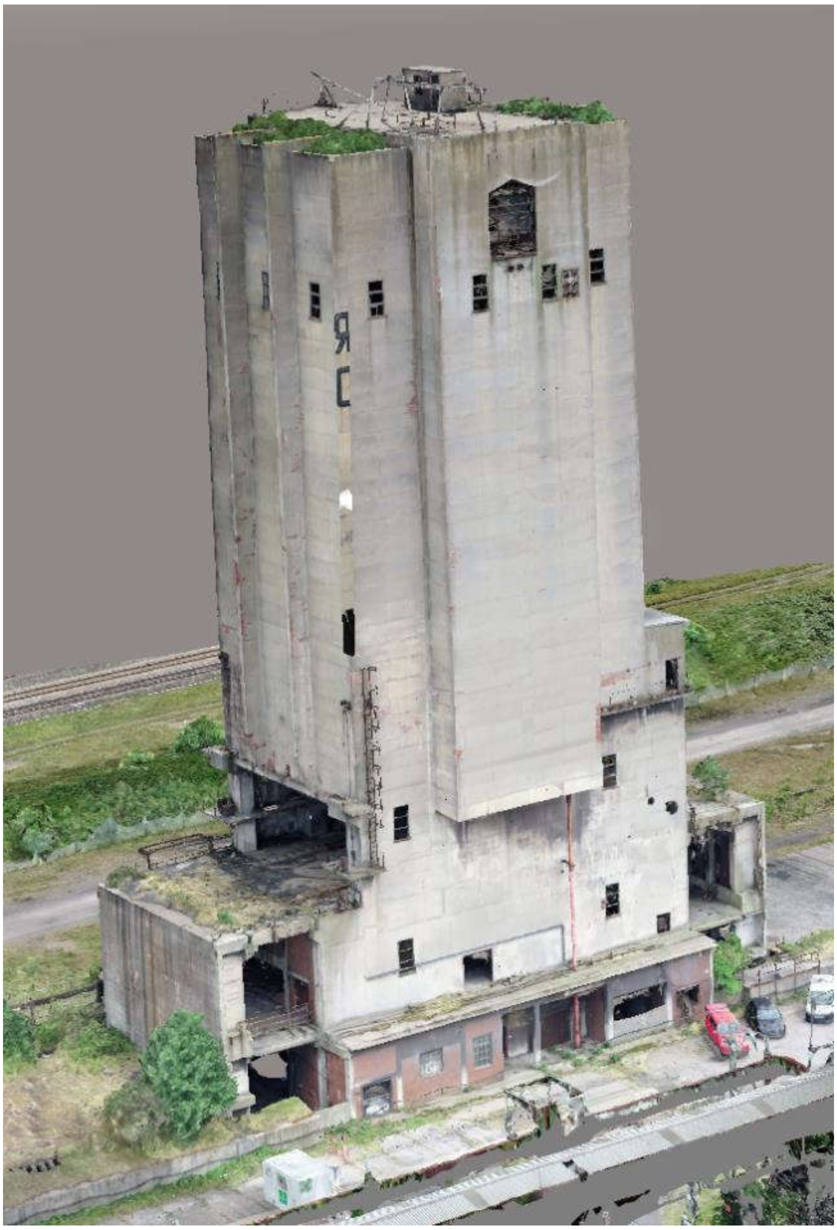
- The three fin walls and bunker projection in the centre of the elevation which provide additional bunker volume.
- The iconic 'Dorman Long' recessed lettering at high level. Each letter is approximately 2.4 metres high with a border recessed 50mm into the concrete panel. Overall, the lettering occupies an area 9 metres wide and 6 metres high.
- The low-level extensions on the east and west elevations, the slabs connecting at Charging Car Floor and Oven Sole Floor levels being on corbels to allow articulation. The base of the extension is at battery floor level, since demolished but elevated above the surrounding ground level. In the foreground the battered slope down to general ground level.

Figure 3.3 – Eastern Elevation

Note:

- The two stiffening fins over the height of the bunker.
- The open frame structure between the bunker bottom and Charging Car Floor level.
- The window openings in the Shuttle Belt Floor

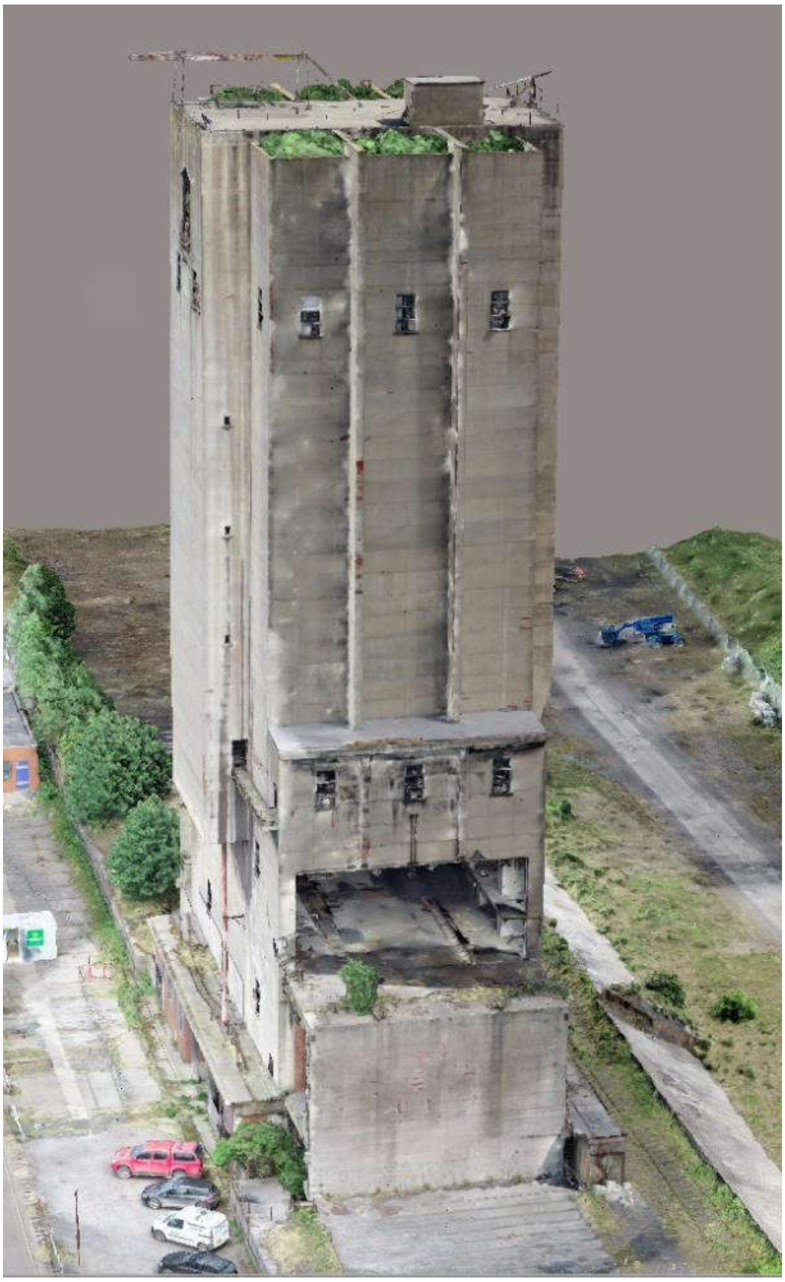
Figure 3.4 – Northern Elevation



Note:

- The central, square bottomed extension in the height of the bunker. The walkway to the right of the base of the extension leads to a staircase giving access to the roof. Half of the extension is therefore stair void; the other half is part of the bunker volume. Also note the opening for the bunker feed conveyor at high level.
- The low-level extensions on the east and west elevations, with corbels supporting simply supported roof and floor slabs.
- The small low-level extension to the north. The basement level, only visible on this elevation, with brick infill panels and levels similar to the adjacent road. On the southern side is an embankment, to the east and west the raised levels of the demolished battery units.

Figure 3.5 – Western Elevation



Note:

- The stiffening fins over much of the height, but also the narrow extension at the base of the bunker, making this different from the opposite side.
- The walkway and doorway opening into the right half of the northern elevation bunker extension.
- The open section between the bunker bottom and Charging Car Floor level.
- The battery unit base slabs in the foreground and the low-level extension at the base.

4. Visual Survey (Inspector & Drone)

The visual inspection was carried out on 2nd July 2021. The weather was dry and warm, slightly overcast with little wind.

4.1. Drone Inspection

The drone inspection was conducted in several flights by a Phantom 4 Pro drone to capture high definition still images and high-resolution video footage of the structure, supplemented by high-definition images from a DSLR camera.

As well as capturing still and video imagery a photogrammetry survey was undertaken to allow the production of a details 'Digital Twin' of the building. This digital twin contains data from the external elevations only, with limited detail of the open charging car floor area.

It should be noted that in some instances the structure appears to lean. This is not the case and has been corrected on later editions of the model. This was caused by the large mass and steel content of the bunker interfering with GPS and WIFI signals.

The assembled model can be viewed in various software, the simplest of which is “Context Capture Viewer” by Bentley and is free of charge. The model is sufficiently accurate to identify spalling, cracking and other defects.

We have used the software to measure the lengths of cracks and the areas of spalling. This data has been compiled into a defect schedule for pricing.

4.2. Structural Inspection

Structural engineers accompanied the drone team during the survey and suggested areas of particular interest. Again, no inspection was possible internally, in the basement or bunker areas because of unsafe access conditions. The structural engineers noted the significant defects and the overall structural arrangement with the help of binoculars from ground level.

5. Structural Condition

5.1. Overall Impression

The overall impression is of an efficiently designed and detailed structure that is fairly robust and has served well.

We did not note any catastrophic defects and the overall impression is that the structure is generally ‘safe’, ‘stable’ and not undergoing significant settlement or movement.

Defects were not evident from a distance. Concrete defects however, become more evident at closer distances, the site maintenance team having painted exposed and corroding reinforcement with a zinc rich paint to provide temporary protection.

The most heavily affected areas appear to be the two low level wings. The end walls of these extensions are in very poor condition.

Structural steelwork is generally in a poor condition and many handrails, platforms, ladders and stairs are unsafe. We understand some access ladders have been removed by vandals over the years. Some dilapidated structures (crane beams, davits, ladders etc.) overhang the edge of the structure at roof and mid-levels.

Generally all doors/door frames and windows/window frames appear rotten and the glass broken.

There is pattern cracking to some of the walls. Record drawings show that the main structure is very large, with columns of up to 5ft x 4ft, 1500mm x1200mm on plan. However, the infill walls are often 4” (100mm) thick and singly reinforced. It is no surprise that the relative stiffnesses in this arrangement mean that the walls tend to crack but the columns do not. It appears from some of the cracking that the infill walls are trying to resist lateral loads even if they were not designed to do so. The shuttering lines indicate that these thin walls might have been cast later, as an alternative to a masonry or other cladding panel. It is likely that differential thermal expansion and contraction has caused or at least exacerbated the visible cracking.

There is some cracking to the hopper walls, though not as significant as the lower walls. The hopper walls are stiffened by vertical concrete ribs and vary in thickness, between 12” (305mm) at the base and 5” (125mm) at the hopper top. The wall is thickened by 2” (50mm) on the southern elevation to allow the casting of the Dorman Long name with a 2“(50mm) deep rebate groove around each letter.

The roof is made up of a large flat concrete slab, without waterproofing or roofing coverings. The water tanks are open to the atmosphere. A small maintenance room sits on the very top in a corner. Rainwater is allowed to run through the structure and steelwork on the roof is in poor condition e.g. handrails, davit, crane beam etc.

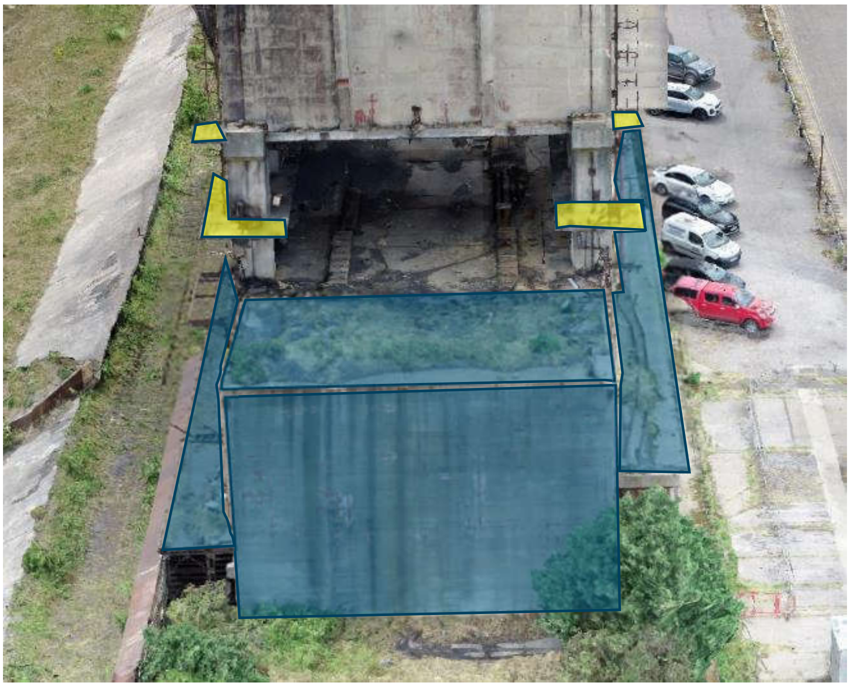
5.2. Northern Elevation

The shaded areas are the east, west and northern low-level extensions. All are in very poor condition and do not contribute to the overall stability of the tower.

It is recommended that in the case of the tower remaining these are cut back and removed due to their overall poor condition.

The main cracking has been highlighted in black. These cracks indicate that the outlying wall panels are trying to disperse lateral loads, something they may not have been designed to do. Note that almost all of the cracking lies outside the line of the main outer columns, numbered 1 to 5. The outstand bay on the right, supporting the spillage and testing office also has a number of large service penetrations

5.3. Eastern Elevation

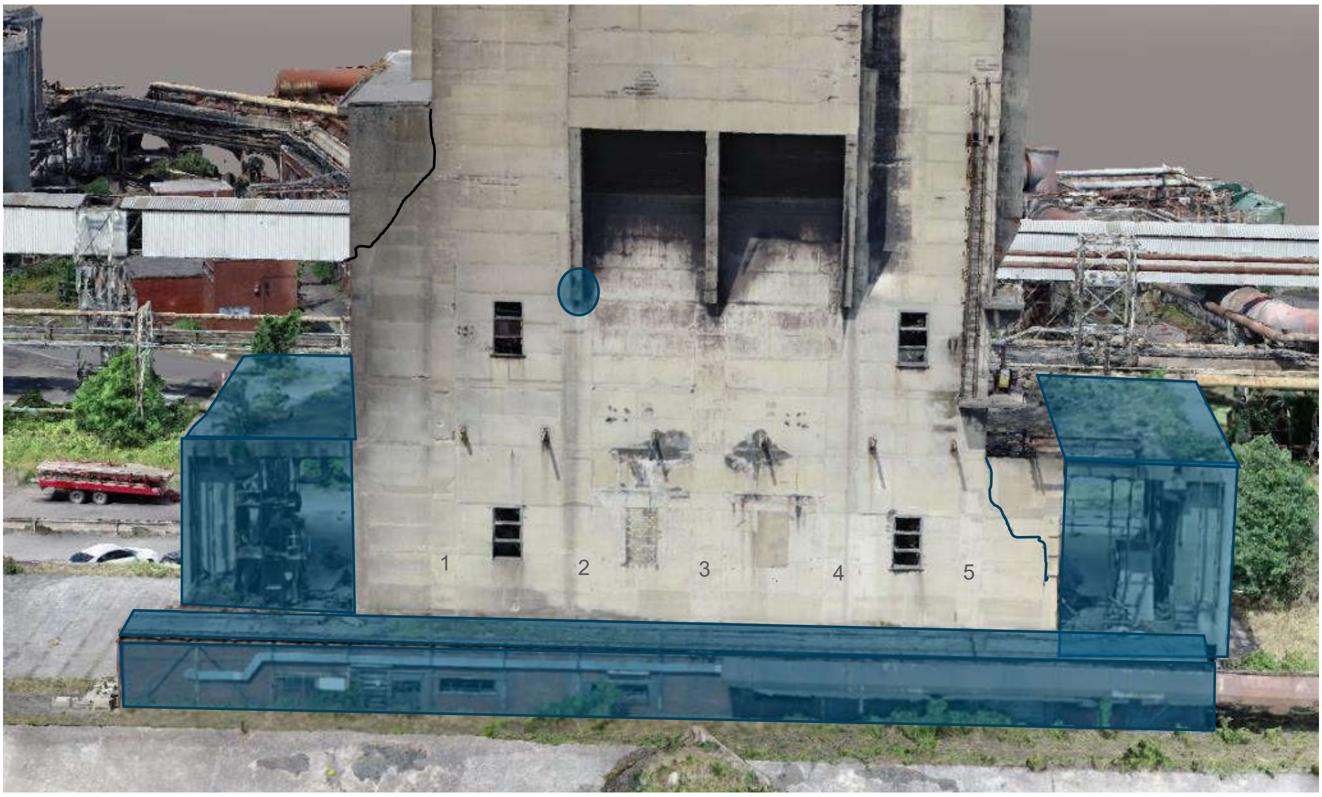


The shaded areas are the east, northern and southern low-level extensions. All are in poor condition and do not contribute to the overall stability of the tower. It is recommended that in the case of the tower remaining these are cut back and removed due to their overall poor condition.

There is no significant cracking of note on this elevation.

Also note the concrete corbels, landings and platforms that should be removed if the structure is to be retained, highlighted in yellow.

5.4. Southern Elevation



The shaded areas are the east, west and southern low-level extensions. All are in poor condition and do not contribute to the overall stability of the tower. It is recommended that in the case of the tower remaining these are cut back and removed due to their overall poor condition.

The main cracking has been highlighted in black. These cracks indicate that the outlying wall panels are trying to disperse loads, something they may not have been designed to do. Note that all of the major cracking lies outside the line of the main outer columns, numbered 1 to 5.

The oval indicates an area of heavy spalling and corrosion at the tips of the three concrete wall corbels. We suspect this area is affected because of the high density of steel reinforcement in this area and the limited concrete cover.

Also note the numerous steelwork brackets, corbels, cables and ladders that all need to be removed if the structure is to be retained.

5.5. Western Elevation

The shaded areas are the west, southern and northern low-level extensions and the spillage/testing room. All are in poor condition and do not contribute to the overall stability of the tower. The lower (thicker) half of the testing room wall is structural and must be retained. It is recommended that in the case of the tower remaining these shaded areas are cut back and removed due to their overall poor condition.

The main cracking has been highlighted in black. These cracks indicate that the end wall panels of the spillage and testing room is trying to span across the opening as a beam, again trying to spread load that it may not have been designed to resist.

6. Gaps and Limitations

We were unable to inspect the inside of the Tower structure for health and safety reasons. Many of the internal stairs and access walkways were either unsafe or have been removed. We are therefore unable to confirm the condition of:

- The basement;
- Low level floors like the Oven Sole Floor and Charging Car Floor;
- Intermediate landing and walkways;
- The internal faces of the bunkers; and
- High level floors like the Shuttle Belt Floor and Tank Floors.

The condition of the roof as reported is based upon the video footage and photographs obtained from the drone survey.

Photographs from a previous inspection are included in Appendix C. We suggest that for the purpose of planning and estimating we assume that the internal defects are at least as extensive as the external defects.

7. Outline Options and Recommendations

7.1. Summary

Considering the results of the technical survey, Atkins have been asked to provide guidance on future considerations for extending the life of the asset, as a possible national heritage monument, and fit for its new location within the modern and developed future Teesworks site.

The structure, whilst clearly robust and not in imminent danger of collapse has exceeded its originally design life and deterioration is ongoing. Carbonation and associated reinforcement corrosion is underway and is extensive. Re-use of the structure may therefore be technically feasible but is prohibitively expensive and offers a limited life.

Unfortunately due to the ongoing and extensive carbonation of the concrete cover and associated/ongoing damage it would not be feasible to extend the life significantly beyond 15-20 years. This limitation is driven by:

- Endemic concrete carbonation causing reinforcement corrosion and concrete spalling – this is ongoing and is not reversible; and
- The life of typical repair solutions and coatings (10-15 years).

7.2. 15 to 20 Year Life, No Public Access

The tower is an ageing, life expired asset and will need regular scheduled ongoing inspection and repair if it is to be retained as a landmark structure.

The schedule of defects for the tower is included in the appendices and described in Section 6 and 7. Concrete defects are numerous and extensive.

Since extensive reinforcement corrosion has begun it is effectively too late to significantly extend the life of the structure beyond the life of current repair strategies (10-15 years). Further spalling can be expected during and after the repairs already identified have been carried out. There remains a risk to pedestrians and plant below unless a detailed examination is carried out and areas of further spalling identified. It may be necessary to hammer test all the existing surfaces to identify any other loose or hollow areas. The true extent of concrete repairs might be twice the visible area already recorded or more. This would need to be checked on a regular and ongoing basis.

We have not inspected the internal structure of the tower and the bunkers in particular are likely to have suffered significant sulphate and impact/abrasive attack from the storage of the coal.

The tower is very tall (approx. 56m) and a major part of its' maintenance costs will be in providing access for repairs. Much of the elevation might be reached by MEWP (the largest we are aware of has a maximum reach of 43m). A firm and level base would be required around the perimeter of the tower for MEWP access. Some repair might be carried out by roped access specialists. Widespread and high-quality repair works however are likely to require a full scaffold. Future plans for the area around the tower are constrained and proximity to new roads and 3rd party assets will make work more difficult than current arrangements.

The primary mechanism for corrosion is carbonation, where atmospheric carbon dioxide penetrates the concrete cover to the reinforcement and reduces its alkalinity. Once the alkalinity of the concrete is neutralised then the reinforcement starts to corrode, providing there is a source of moisture and oxygen. This process is ongoing and irreversible. As the reinforcement corrodes the volume change in oxidisation presses on the concrete cover and the concrete spalls. At this point the reinforcement has no protection and is exposed to the full effects and acceleration of corrosion.

The concrete cover to reinforcement in the tower varies but typically the walls have ¾", or 20mm. We have not found references to the concrete grade used, but these were generally low in 1956. British Standard CP114 (1948 to 1969) typically had strengths of 21, 25 and 30N/mm^2.

Current standard BS8500 would suggest exposure classes of XC3/4 and XF1 for the tower walls. For a 50-year design life a 50N/mm^2 concrete is recommended, at a 25-30mm nominal cover. Clearly the design doesn't meet current expectations in terms of durability for even a 50-year design life.

Surface coatings are available that limit the surface penetration of carbon dioxide and moisture. Application will slow the rate of decay but the best time to apply these coatings is before corrosion has begun. Given the external and maritime/coastal environment we doubt the effectiveness of any coating at this stage. Many of these coatings are also cement slurry based and are either brush or trowel applied. Their application will therefore change the entire character of the tower, but at least blend with the many concrete patch and crack repairs.

We suggest the minimum input required would be:

- Concrete patch repairs as scheduled.
- Concrete crack repairs as scheduled.
- Anti-carbonation coating to all surfaces.
- Isolation of mechanical and electrical services.
- Filling of basements, drains and sumps.
- Creation of a level perimeter access for MEWPS and cranes.
- Removal of all embedded metal bolts and fixings.
- Removal of metal walkways, handrails and ladders, to prevent unauthorized access.
- Removal of all windows and doors.
- Removal of all 'thin' concrete sections, i.e. concrete landings and walkways.
- Removal of the two low level wings and upper section of Waste/Testing room (see Figure 9.1 below).
- Removal of all plant, cabling, pipework.
- Removal of all animal nests, waste and vegetation.
- Removal of coal waste.
- Removal of asbestos waste if present.
- Drilling of drain holes in slabs and tanks to prevent ponding.
- Power provision.
- Architectural lighting, general lighting / emergency lighting.
- Fire and security alarms systems.
- CCTV coverage.
- New roof to seal the structure and prevent water ingress.
- Stair and stair tower.
- Access road, car parking, landscaping and associated drainage.
- Land remediation.

The predictability of the partial or complete structural collapse of aging assets is notoriously difficult and inaccurate. Hence prior to and during any early works the risks of falling material would need to be mitigated. Given access restrictions and the poor condition of the asset this mitigation work would be such that the hazards could expose personnel to unreasonable risks.

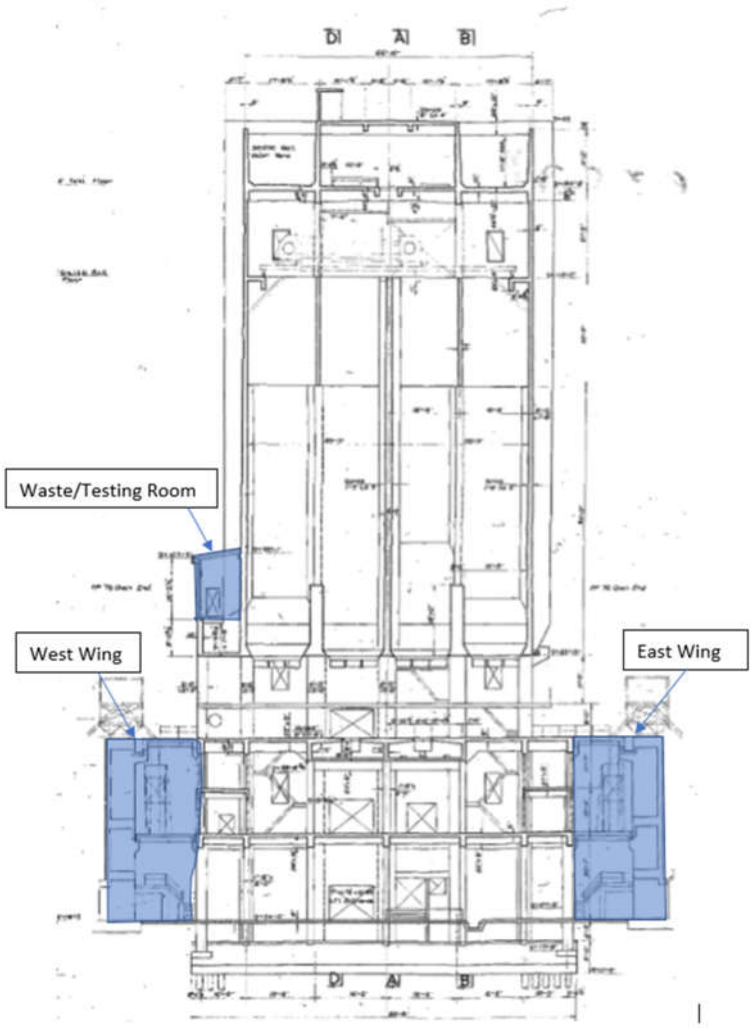


Figure 9.1 - Concrete portions to be removed in the Do Nothing, Basic Repair and Make Safe option.

Note that in order to carry out some of this work, temporary internal and external access will be required.

In any event, the tower will continue to degrade and will need to be periodically inspected, perhaps every 5 years, and repaired. It will eventually require demolition. Most concrete repairs and coatings carry a guarantee or warrantee for 10-15 years. Beyond this time the repairs themselves may have failed, any coating might have become ineffective and widespread decay will have resumed.

7.3. 15 to 20 Year Life, With Public Access

The existing tower has an internal staircase from bunker bottom at 85ft to bunker top at 173ft. There are window openings on all sides of the Bunker Top / Shuttle Belt floor at 173ft level. Therefore, providing access can be restored over the full height, the 173ft level might be used as a viewing platform.

Alternatively, new access might be provided internally, up through the bunkers themselves. Removing part of the bunker floor would give two areas of approximately 17ft (5.2m) square for a new access stair and/or lift.

See Figure 9.2 below:

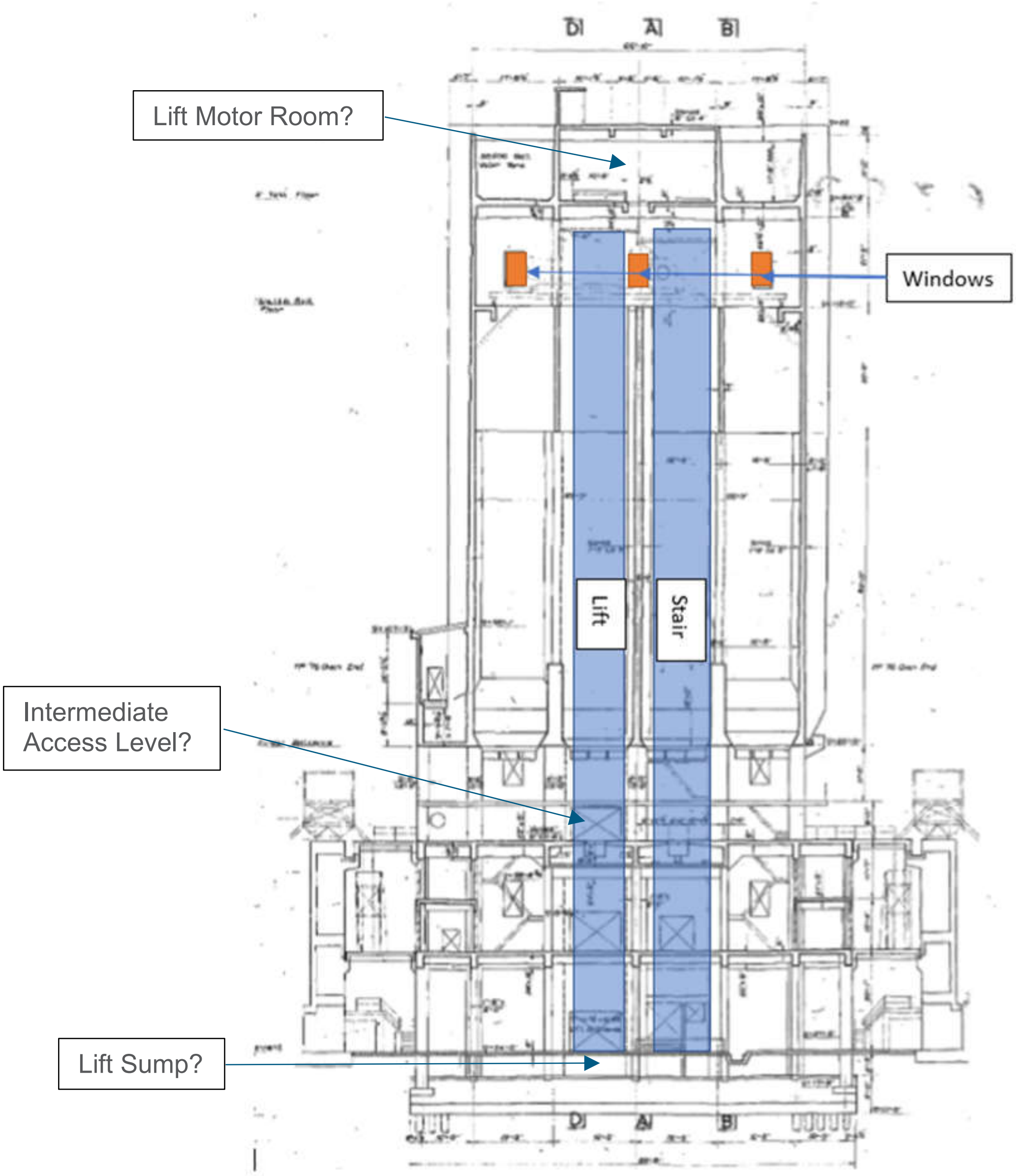


Figure 9.2 - New Lift Shaft and Stair, one in each side of the bunker.

In addition to the No Public Access option above therefore, the scheme might need to include:

- Additional power provisions.
- Additional site/tower lighting to meet public safety requirements.
- Enhanced fire and security alarms systems to meet public safety requirements.
- Significant structural modifications of floors to meet crowd loading parameters.
- Lift and steel framed lift shaft.
- Enhance public access stair and stair tower (fire escape considerations).
- Enhanced public access barriers, handrails, windows etc.
- Security attendants / office / ticketing area.
- Toilets and amenities.
- Enhanced access road, car parking and landscaping.
- Decorative fencing and improved public access controls.

7.4. Full Demolition

7.4.1. Demolition by Explosives

If demolition was proposed for 2021/22, when the site is being regenerated, we would suggest the safest and most cost-effective demolition option might be by explosives, as the structure has an obvious weakness in the framed construction at the charging floor level. Removal of one line of columns or the other would be critical and bring about the complete collapse of the tower. Removing the northern columns would cause the tower to rotate and fall northward, away from the Network Rail train line, but onto pipework trestles and other structures already scheduled for demolition. The tower is 209ft tall, approximately 64 metres. The track is located approximately 67 metres way and the network rail boundary fence 35 metres away to the south.

A demolition contractor has been consulted for a planned and costed scheme, including services isolation, removal of secondary structures and asbestos if present, demolition and crushing and removal of the demolition material. They in turn have coordinated with an explosive demolition specialist for the proposed blow-down.

Their current proposal is to fall the tower to the east, parallel with the railway, as figure 9.3 below. This requires a ‘wedge’ of the building 21m metres wide and up to 9m high (on the eastern face) to be removed to ensure full rotation, as the tower is considerably longer than it is wide. The demolition requires a significant amount of preparation and pre-weakening. All basement masonry and concrete walls and the two low level side extensions are to be removed by mechanical means and much of the concrete columns will have the reinforcement bars cut prior to detonation.

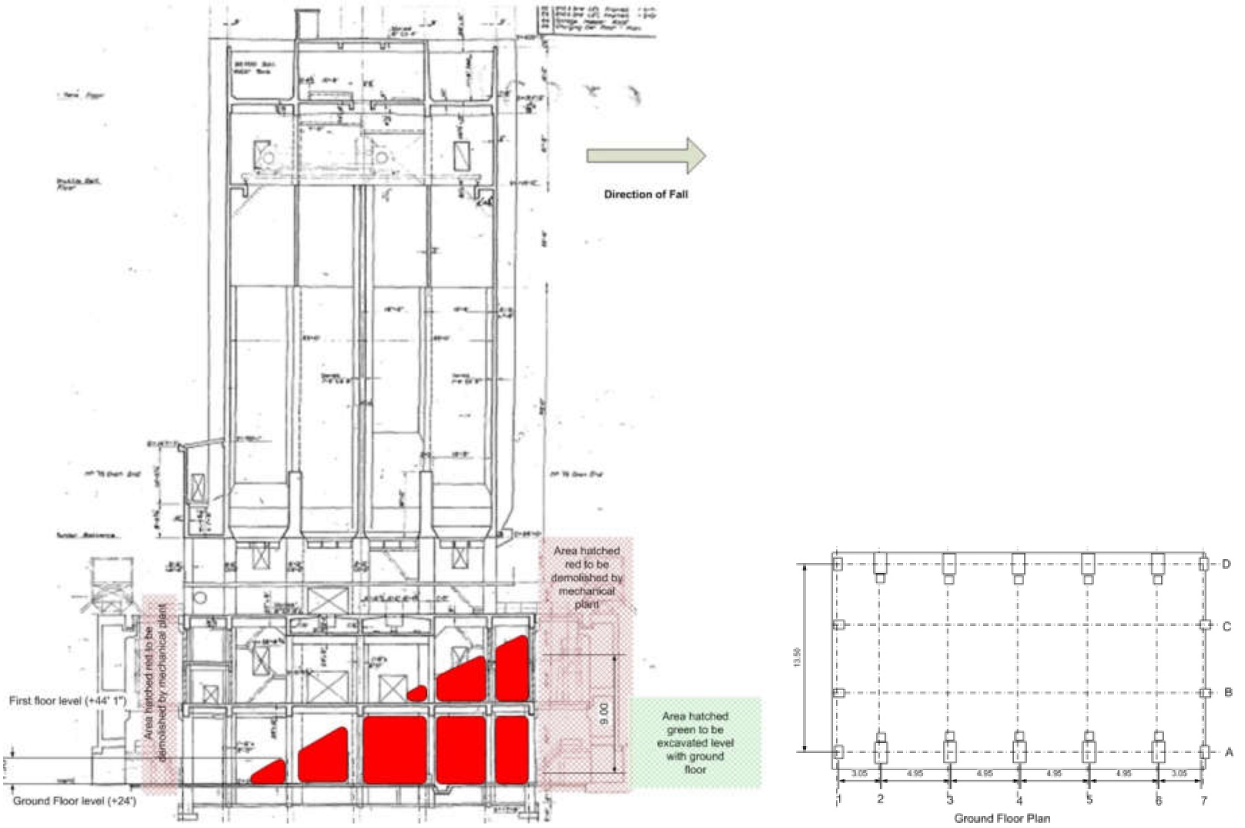


Figure 9.3 Blast zone to demolish the tower eastward. Note the low level ‘wings’ to be removed by traditional means. Sketch courtesy of explosive demolition specialist.

The specialist recommends an exclusion zone of 150m and this clearly includes the railway and other site roads. Network Rail must therefore be consulted, and the work carried out during a line closure.

In addition, the status of the bunker coal is not known, although it is understood this is likely to be effectively 'stuck' to the walls and may amount to some 800t. This may need to be removed prior to demolition if present in large quantities that would potentially affect any rotation. The steel lining to the bunkers may add strength and stiffness and may need to be pre-cut or weakening so as not to influence to the desired failure mechanism.

7.4.2. Demolition by Traditional Methods

If demolition was proposed to take place in say 15-20 years (after say refurbishment of the tower as indicated in 7.2 and 7.3) then the site would be operational. At this time we would suggest the constraints present might force a more traditional approach to demolition, which would be more costly and involve more risk. At this time the site would be bound by a much closer road network and closer 3rd party facilities.

This could require a full external scaffold and the use of mini loaders and concrete breakers. Remote controlled breakers might be used, starting at the roof and working downwards slowly. The hoppers themselves might act as a chute to direct the crushed concrete to ground level for removal and further crushing. It should be noted that there are few floors in this structure and the walls are relatively thin. Most work would therefore be carried out from the scaffold at high level. When demolition gets below a certain level the scaffolding might be removed and demolition continue with long reach excavator's, dependant on noise and dust constraints.

It is expected that demolition by this method would take many months, be labour intensive and therefore be very expensive.

7.5. Reuse of the 'Dorman Long' Name

As we now have a digital twin of the Tower it would be possible to design and detail a new slab that visually matches the existing. This could be letter by letter or as a complete slab. This would be designed and fabricated to current standards and could then form part of an alternative monument to steelmaking and at a height and location to be agreed.

The associated "greenfield" costs and risks of this approach would be significantly less than that required to say safely remove the existing and would still provide an opportunity for Teesworks to continue the association with the Dorman Long name.

8. Recommended Next Steps

8.1. Budget Cost Evaluation

	Title	Initial Cost	5-year Inspection / Repair Allowance.	3 Cycles of maintenance to extend life by 15 - 20 years (incl for inflation)	Running Costs / OPEX	Project End Cost (Demolition)	Total Estimated Cost
1	Full Re-life	Not feasible given condition					
1a	15 to 20 Year Life, No Public Access	£4.7m	£ 325k / cycle	£2m	Excluded	£2.5m	£9.2m
1b	15 to 20 Year Life, With Public Access	£7.2m	£325k / cycle	£2m	Excluded	£3m	£12.2
2	Full Demolition in 2021/22	£1m	£0	£0	£0	£ incl	£1m

8.2. Recommendation

It is our understanding that of the options considered, the most cost effective is demolition by controlled explosion in 2021/22. Every other option requires the eventual demolition of the tower, which will become more expensive and constrained by the imminent and future development of Teesworks, and also includes an element of ongoing maintenance and management.

Whilst the Heritage argument should not be dismissed, sources of revenue to support long term operational and maintenance requirements would need to be found. It is unlikely that the asset (attraction) itself could generate sufficient income.

It is possible that an interactive 'Digital Twin' or a physical model (part or full) generated from the 'Digital Twin' might be a better heritage museum exhibit. Similarly, recasting the Dorman Long lettering and dedicating a part of the Teesworks site might be a fitting tribute.

8.3. Health and Safety Recommendation

We recommend that as soon as practicable a health and safety HAZID is carried out to consider the risks of falling debris and consider providing an exclusion zone 3 to 5 m wide around the tower. This exclusion zone would provide a secure zone for debris to fall into. This area should be secure and have appropriate signage. Some examples of at-risk items is shown in the Figures below:

Appendices

Appendix A. Defect Photos

A model was produced from the drone survey and viewed using Bentley ContextCapture Viewer to perform a visual survey. The survey consists of screenshots taken from the model and arranged by elevation (North, East, South and West) with the identified defects highlighted in yellow or red and a reference number.

Key:

= Concrete Spalling = Concrete Cracking

The reference number which each defect is tagged with refers to a spreadsheet attached in Appendix B which comprises a list of the defects, approximate measurements of defect lengths and areas, some notes and whether any exposed rebar included in the defect has been painted with a protective coating.

If the exposed reinforcement does not have the red protective coating covering the surface of the steel, it can be assumed that either this defect has appeared after the last protective paint coating was applied which was in 2015, or the defect may not have been accessible at the time given the height or any other constraint.

It is important to note that during the drone survey on site the drone pilots experienced magnetic interference with the compass on the drone, most likely from the mass of steel reinforcement within the structure. This drew the drone closer towards the bunker during the flight than planned and may have caused issues in the data produced. The main issue is that the bunker appears to be leaning over to the south in the model, which isn't the case on site. However, for the purpose of the visual survey, the model had sufficient detail to identify the areas with spalling concrete and other defects.

North Elevation

Figure 1: North Elevation

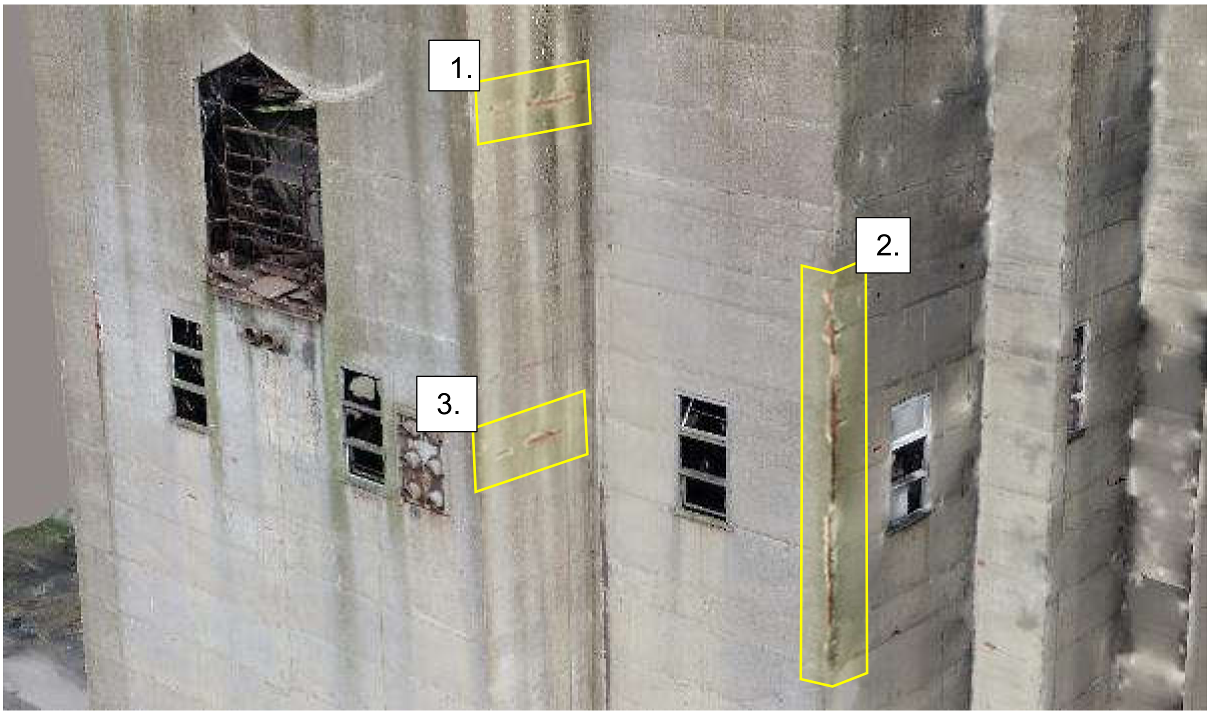


Figure 2: North Elevation - Defects 1-3

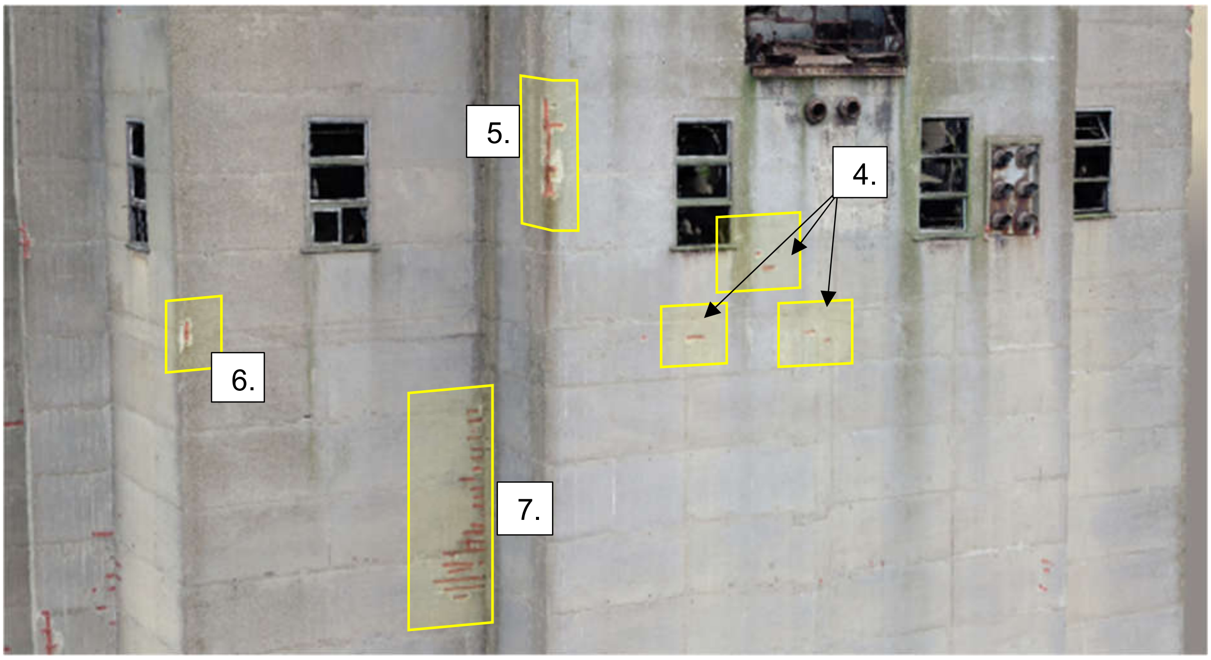


Figure 3: North Elevation - Defects 4-7

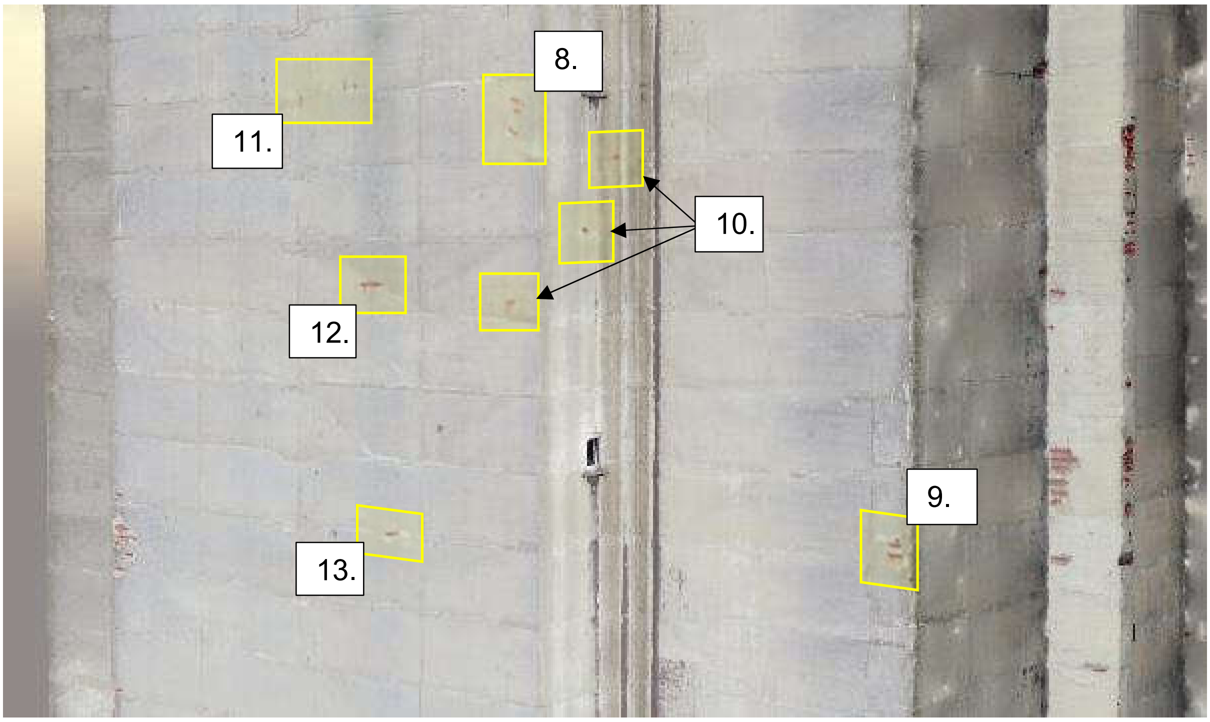


Figure 4: North Elevation - Defects 8-13

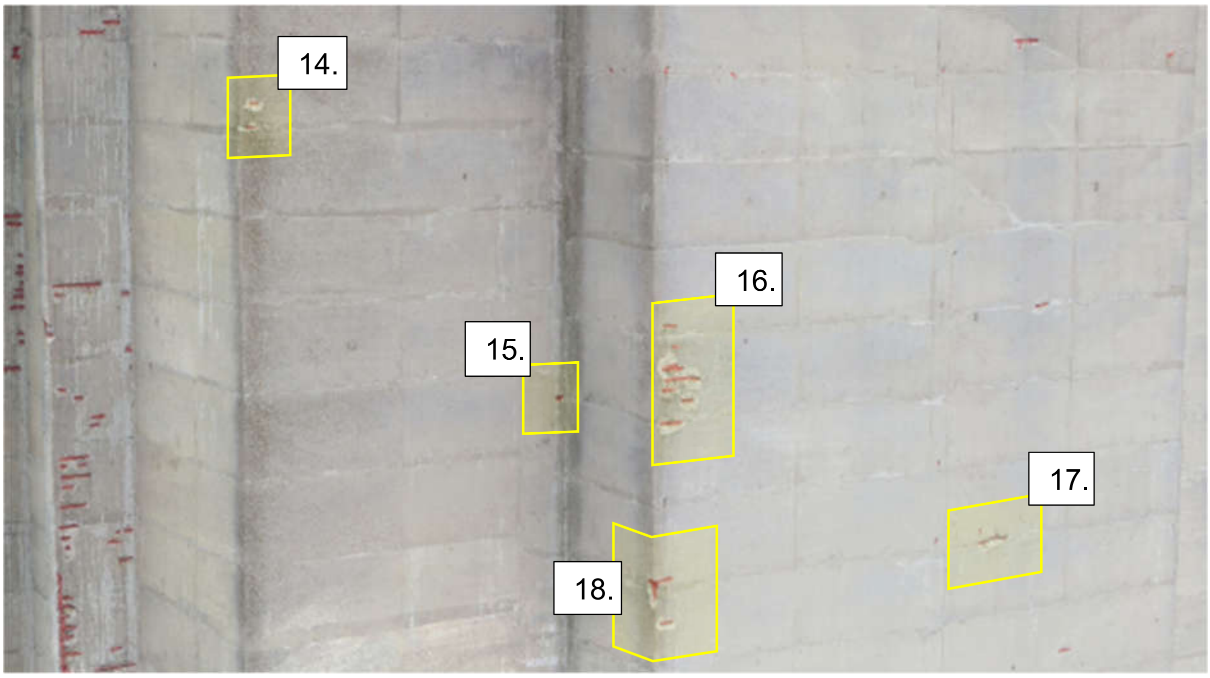


Figure 5: North Elevation - Defects 14-18

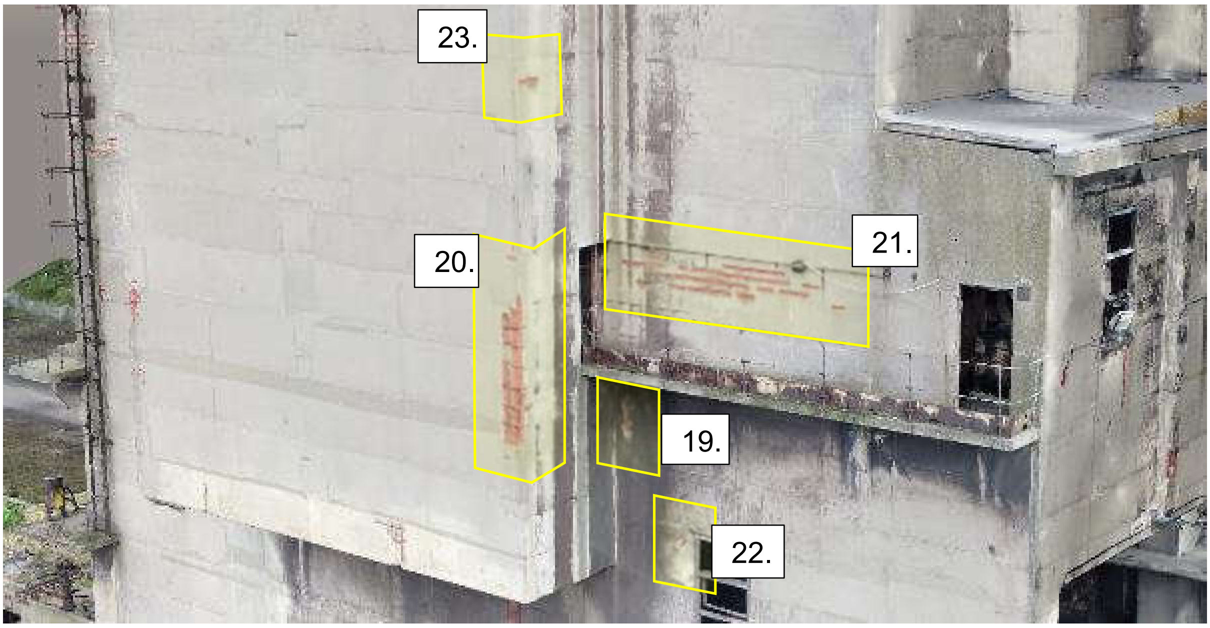


Figure 6: North Elevation - Defects 19-23

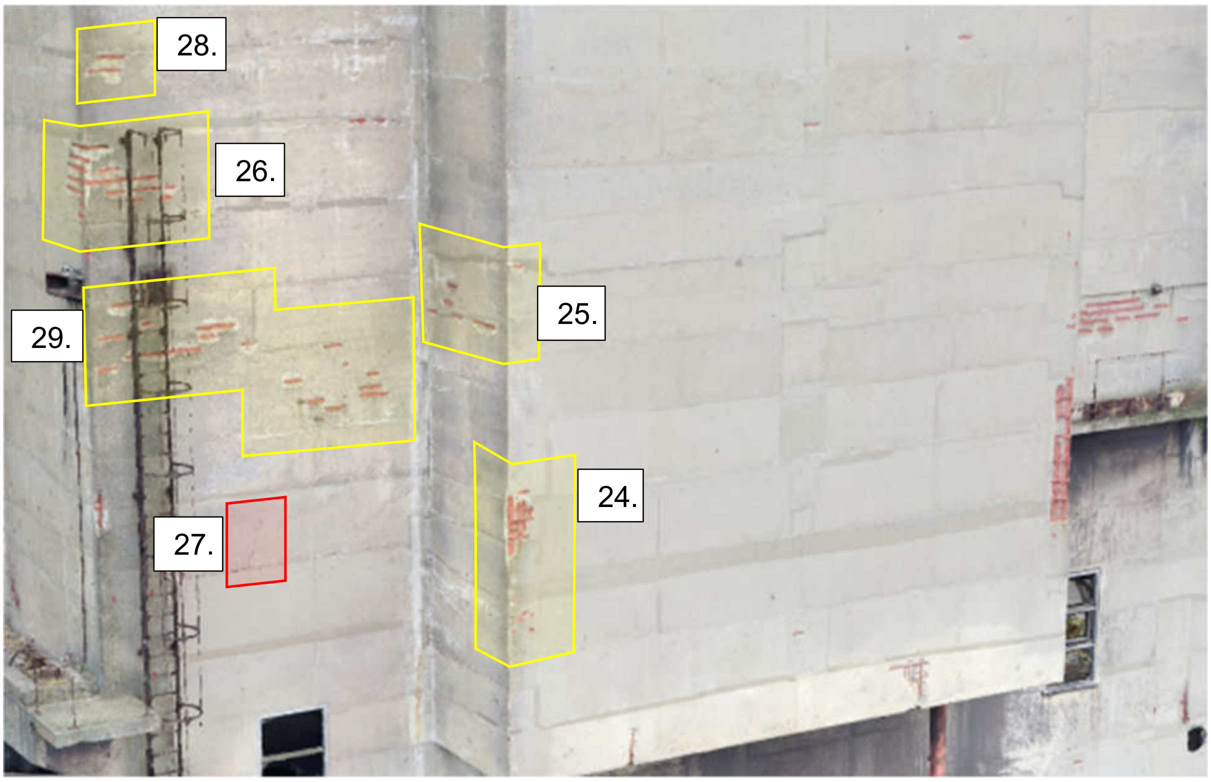


Figure 7: North Elevation - Defects 24-29

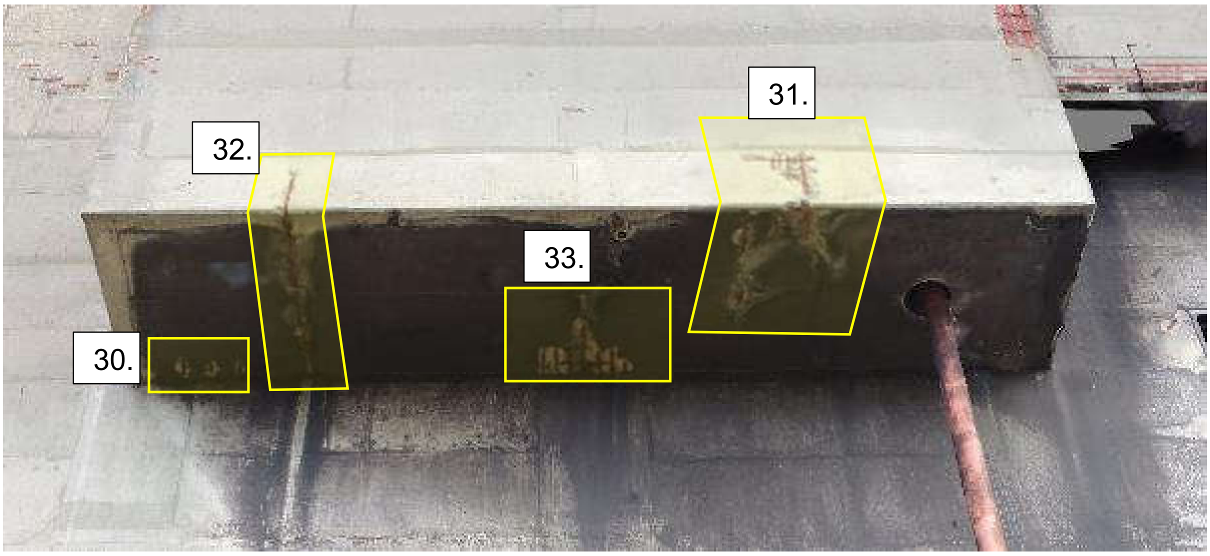


Figure 8: North Elevation - Defects 30-33

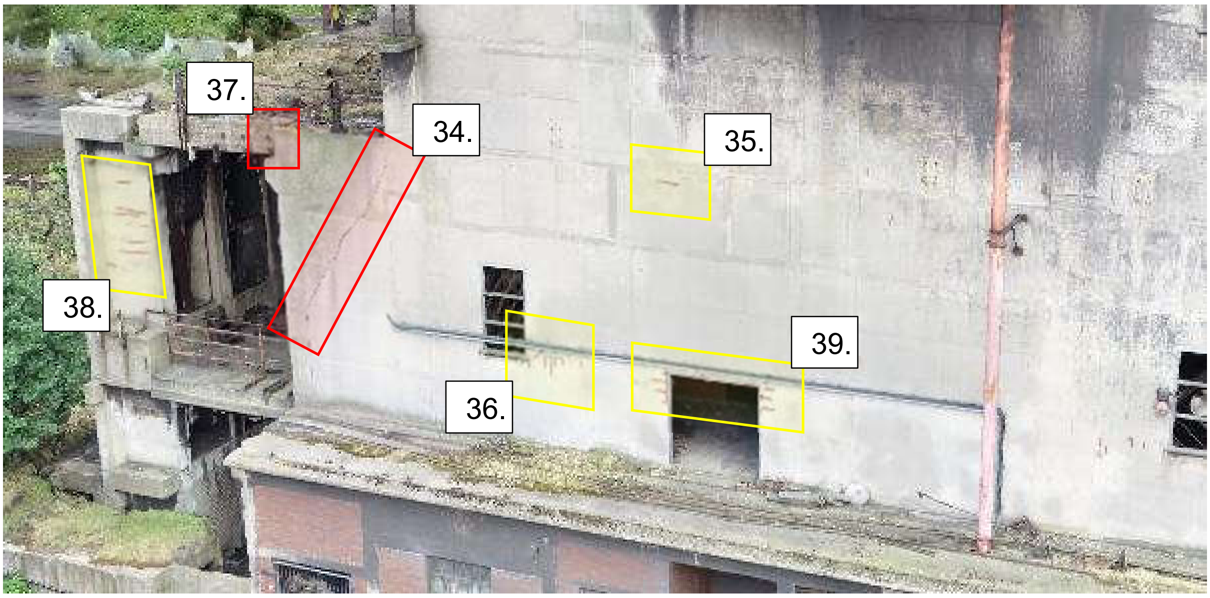


Figure 9: North Elevation - Defects 34-39

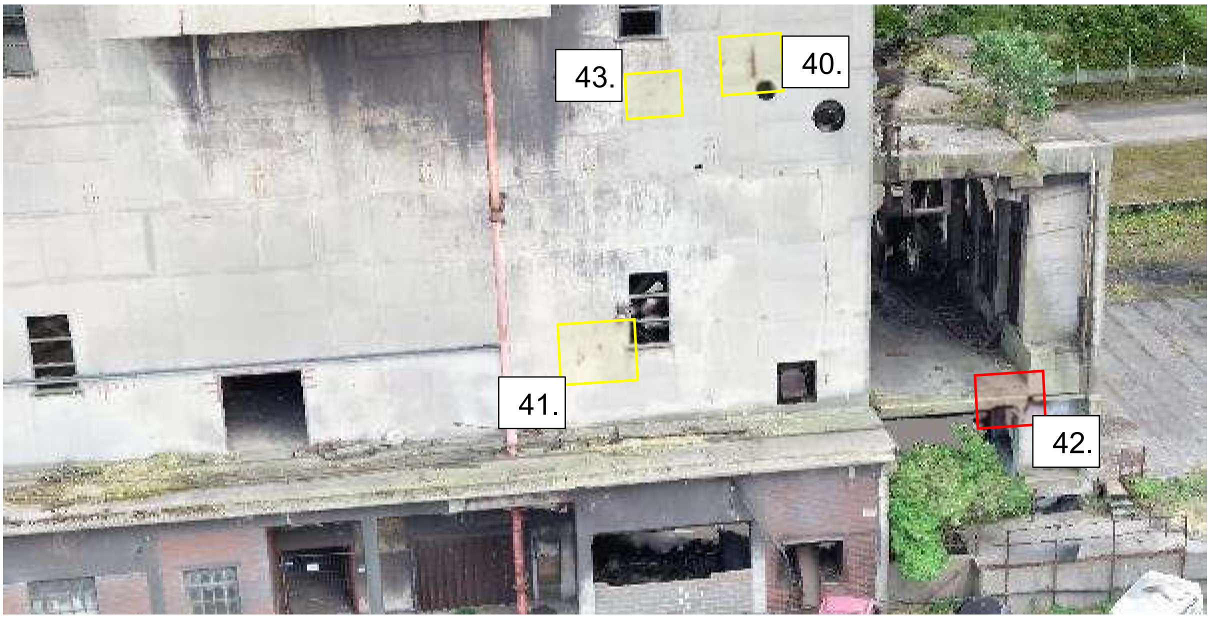


Figure 10: North Elevation - Defects 40-43

East Elevation:

Figure 11: East Elevation

Figure 12: East Elevation - Defects 1-2

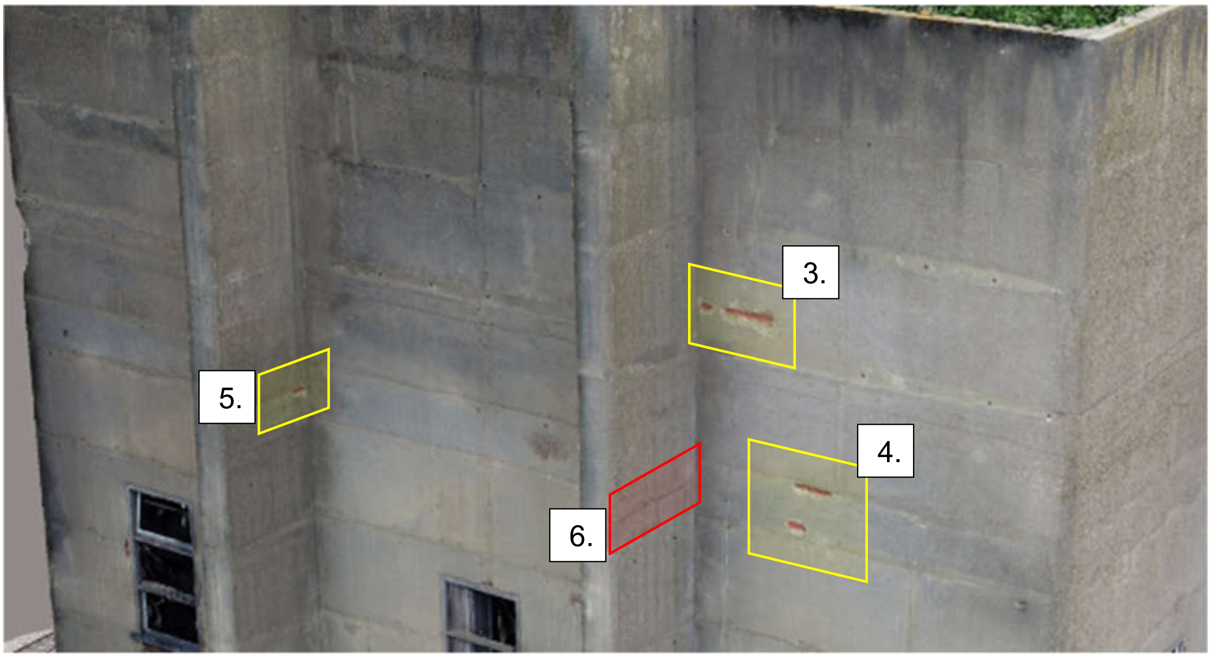


Figure 13: East Elevation - Defects 3-6

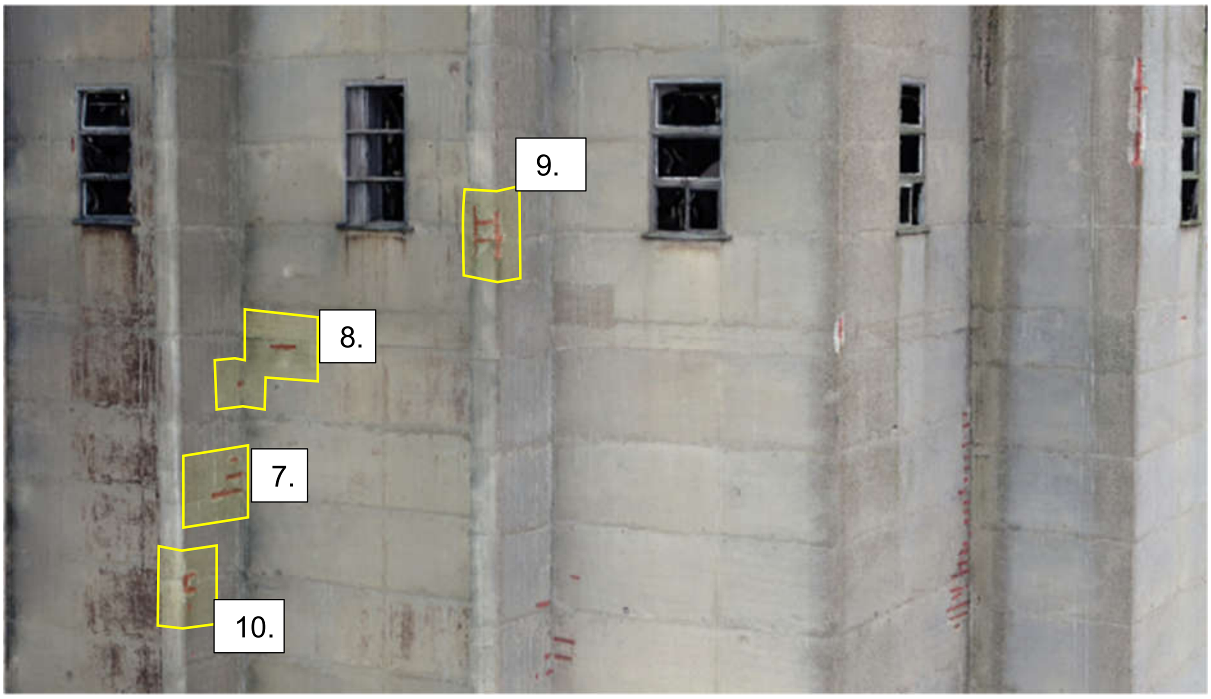


Figure 14: East Elevation - Defects 7-10

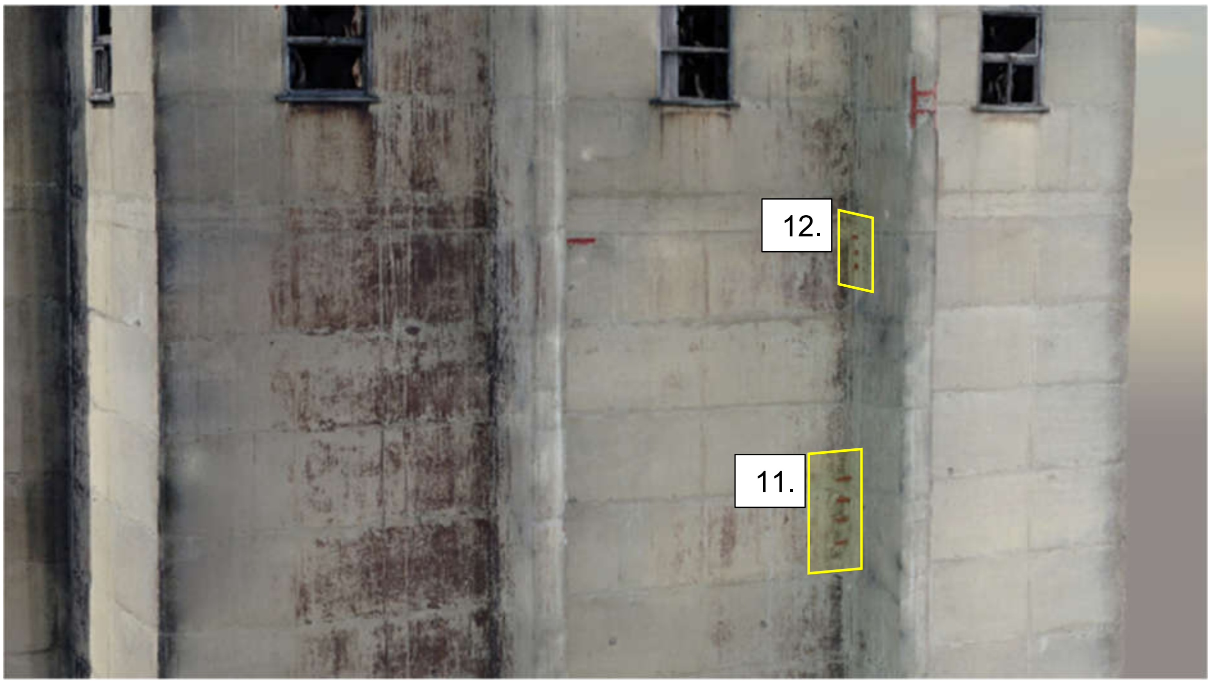


Figure 15: East Elevation - Defects 11-12

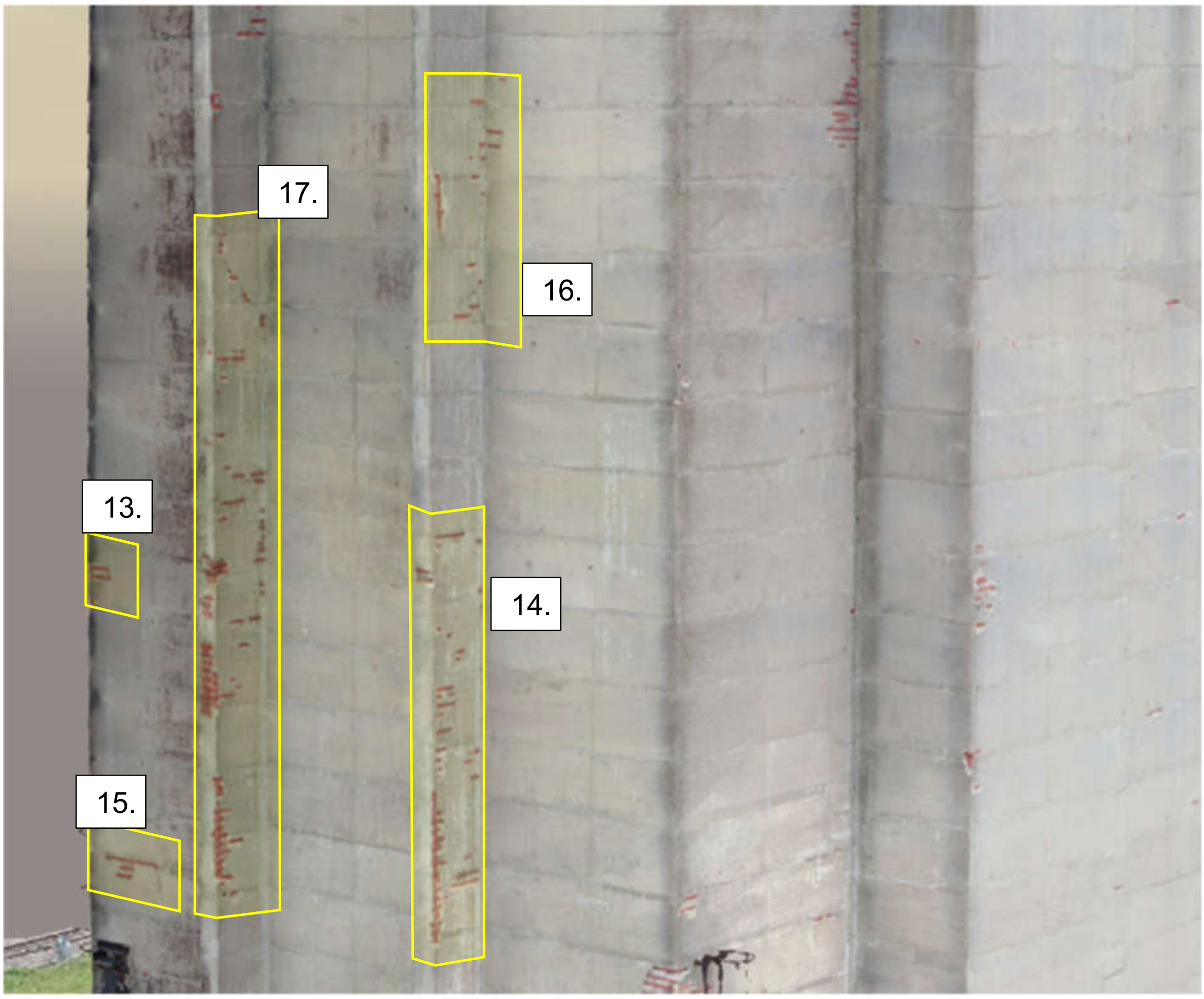


Figure 16: East Elevation - Defects 13-17

Figure 17: East Elevation - Defects 18-19

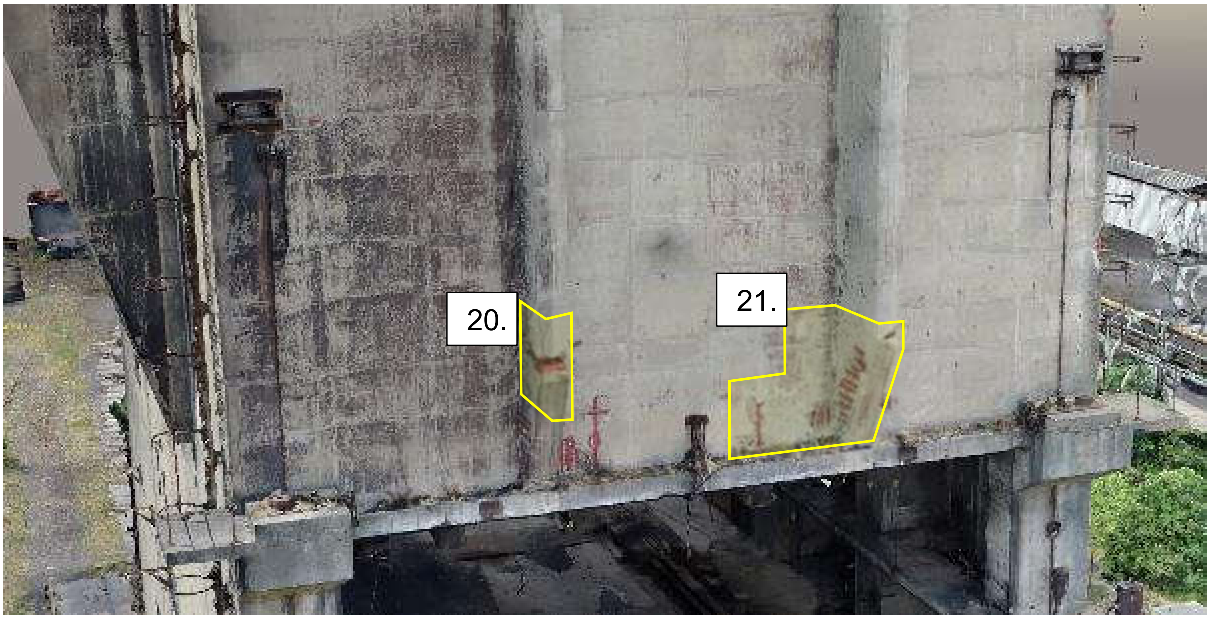


Figure 18: East Elevation - Defects 20-21

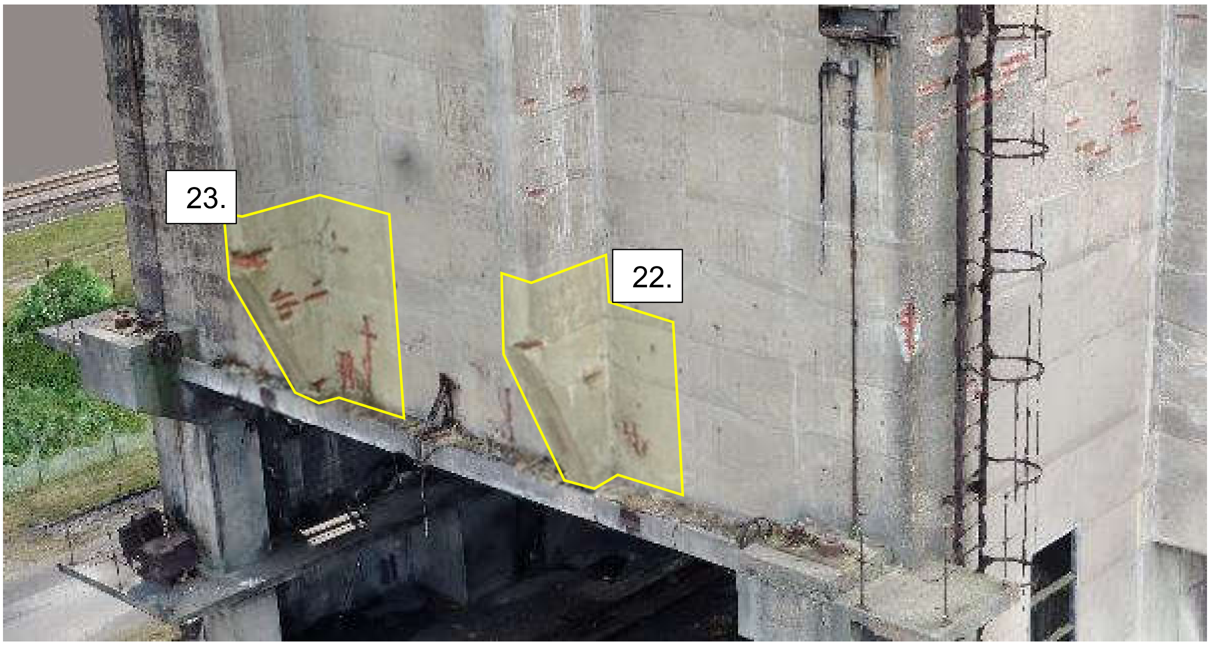


Figure 19: East Elevation - Defects 22-23

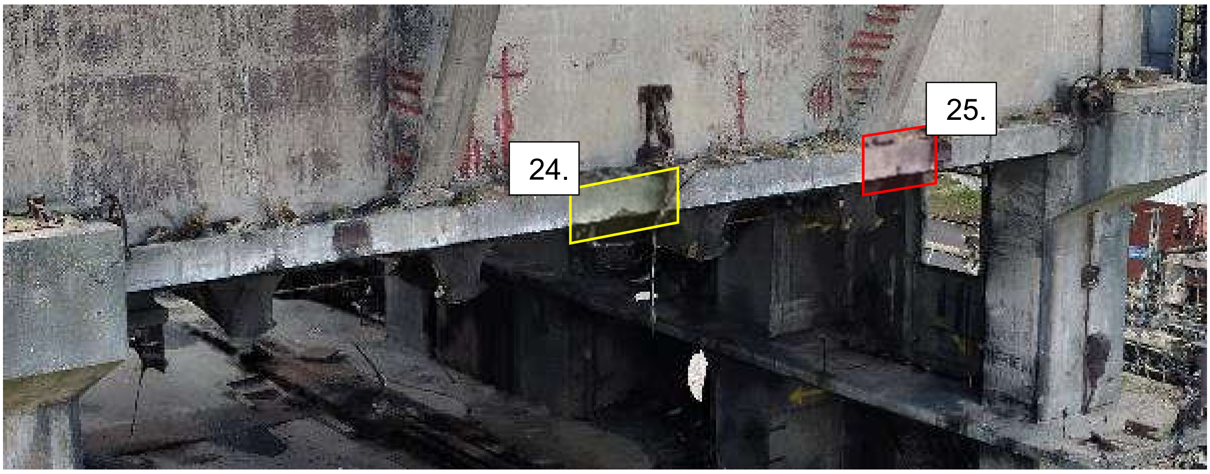


Figure 20: East Elevation - Defects 24-25

Figure 21: East Elevation - Defect 26

South Elevation

Figure 22: South Elevation

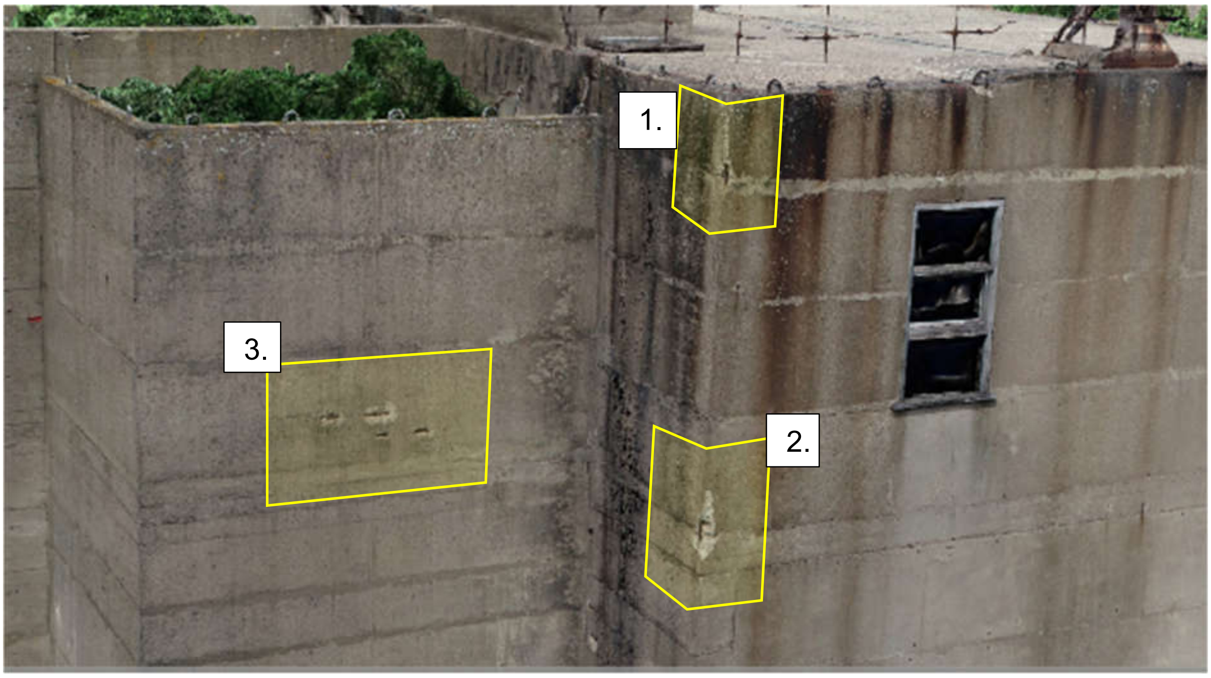


Figure 23: South Elevation - Defects 1-3

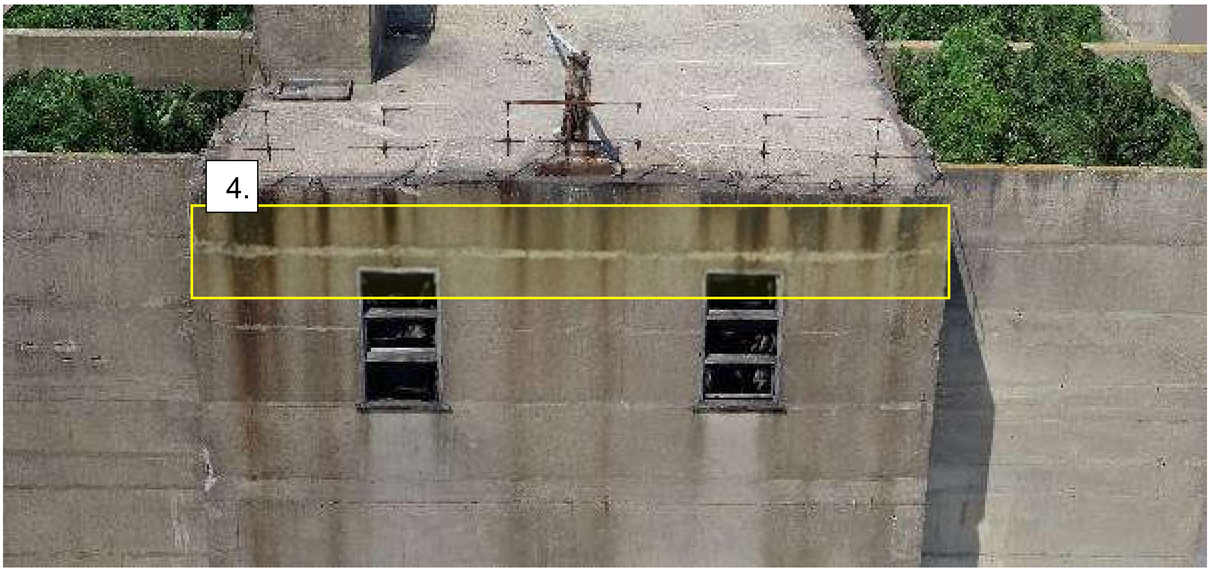


Figure 24: South Elevation - Defect 4

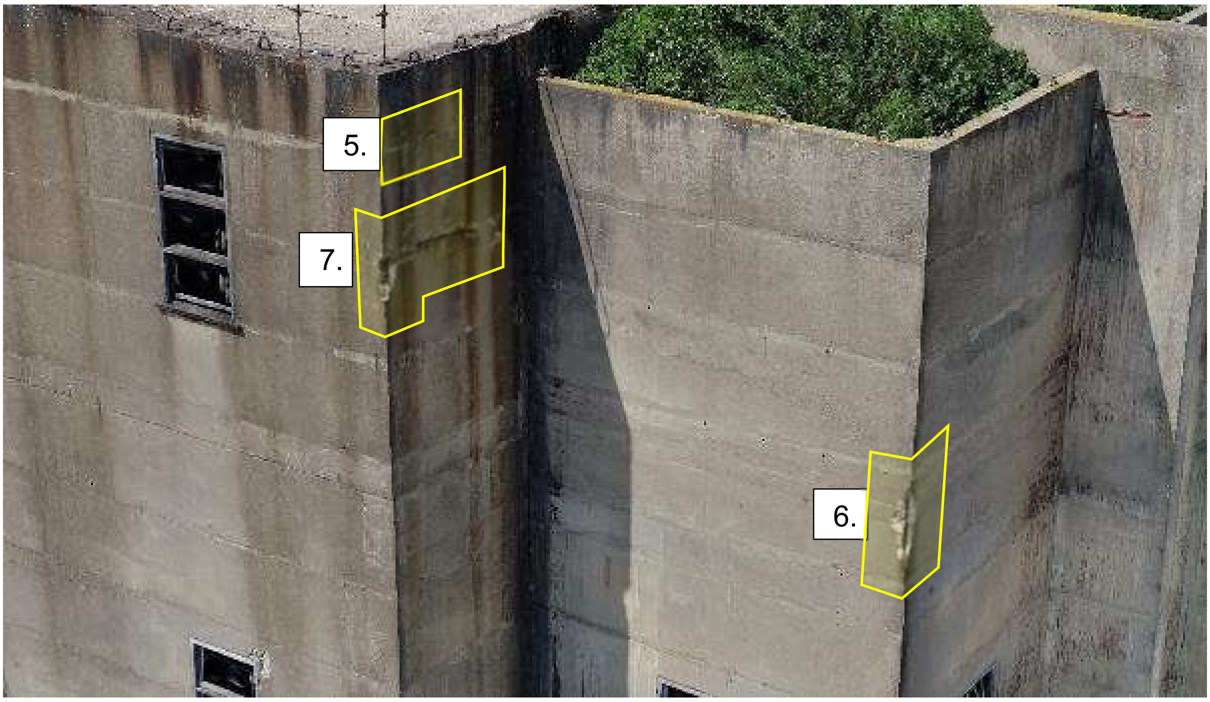


Figure 25: South Elevation - Defects 5-7

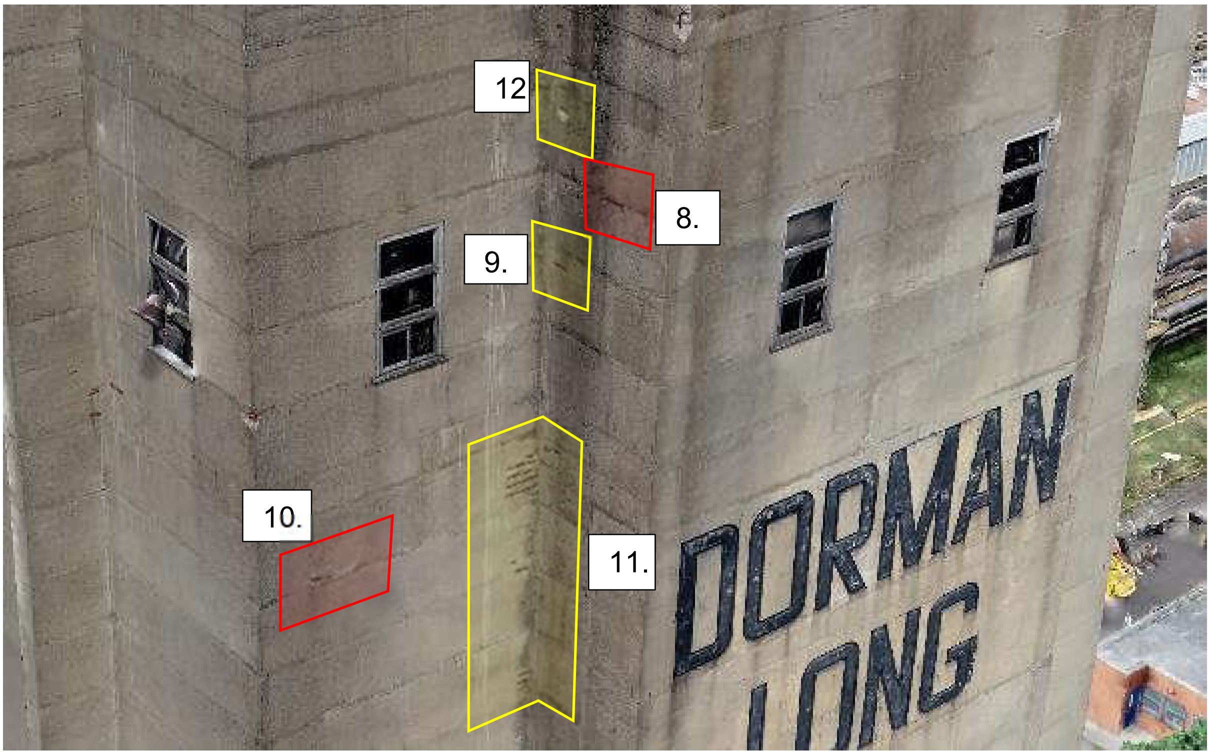


Figure 26: South Elevation - Defects 8-12

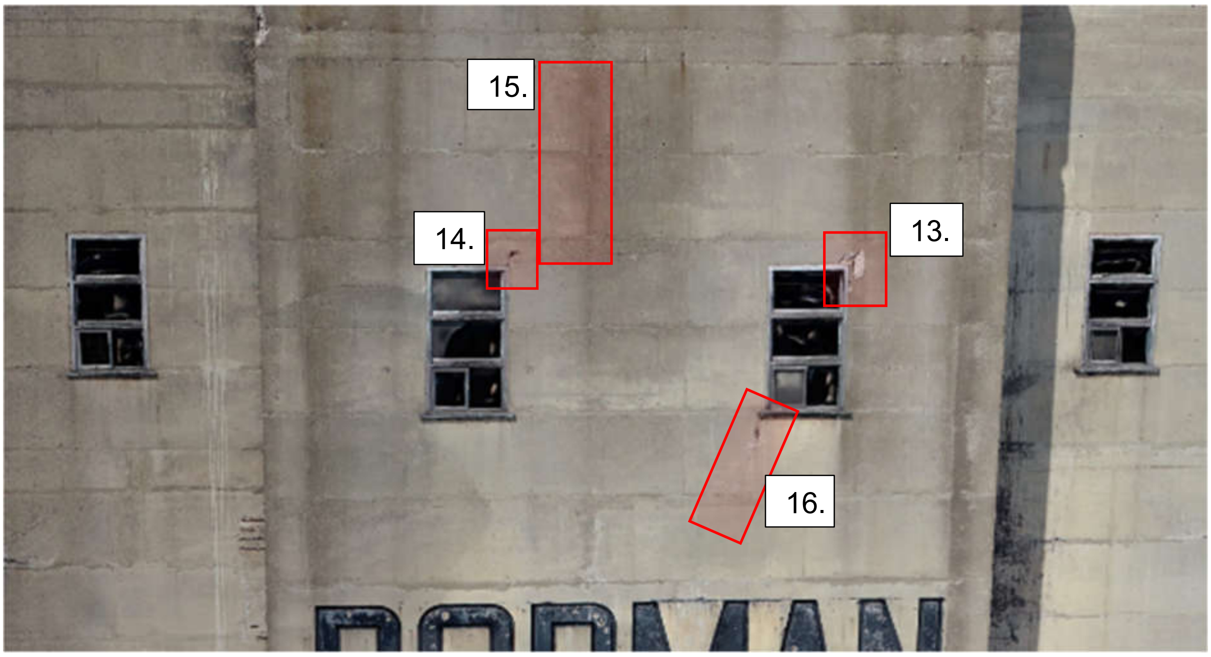


Figure 27: South Elevation - Defects 13-16

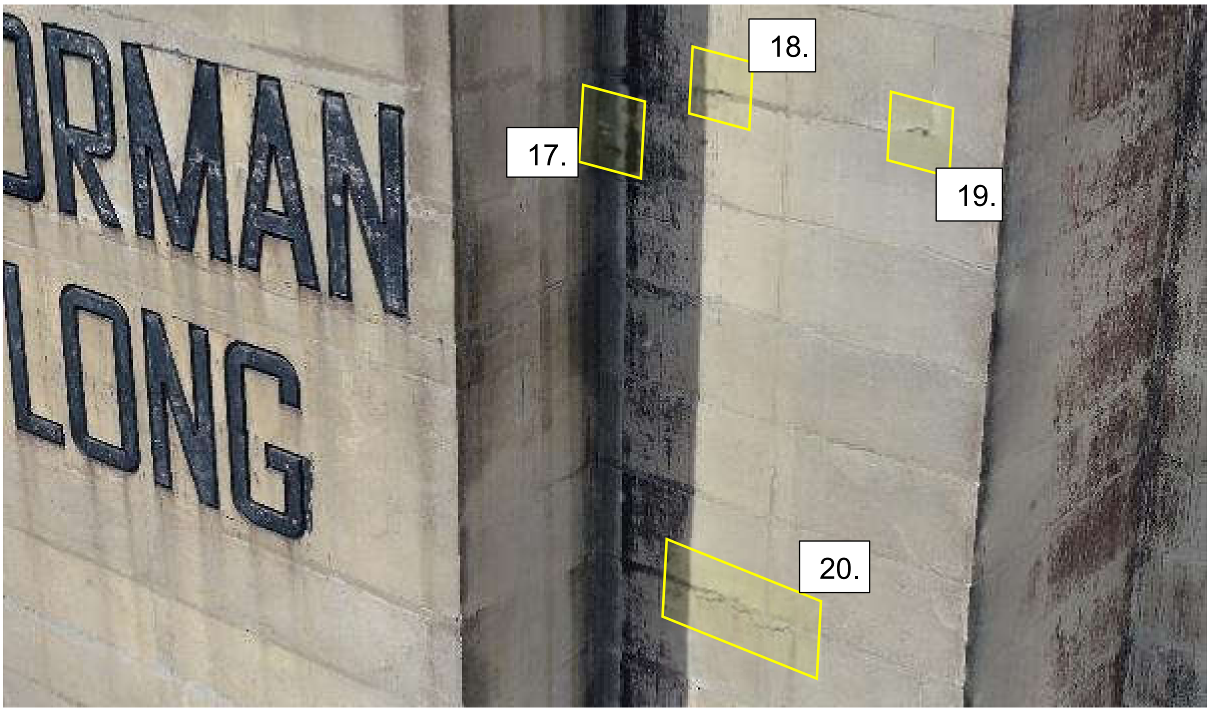


Figure 28: South Elevation - Defects 17-20

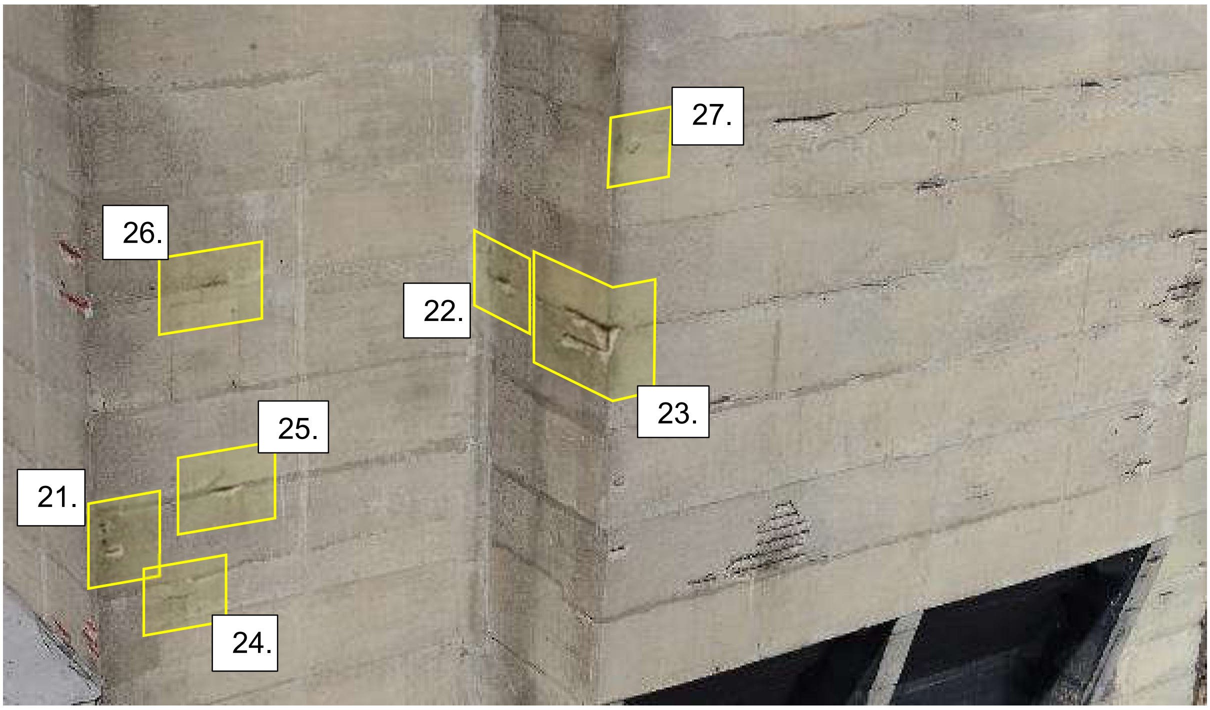


Figure 29: South Elevation - Defects 21-27

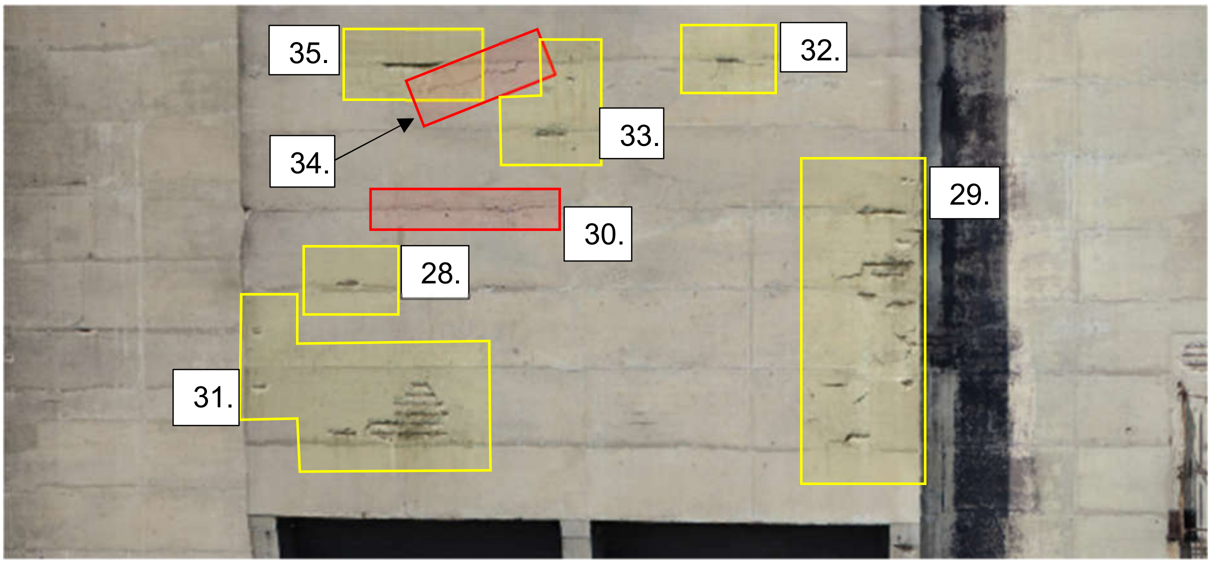


Figure 30: South Elevation - Defects 28-35

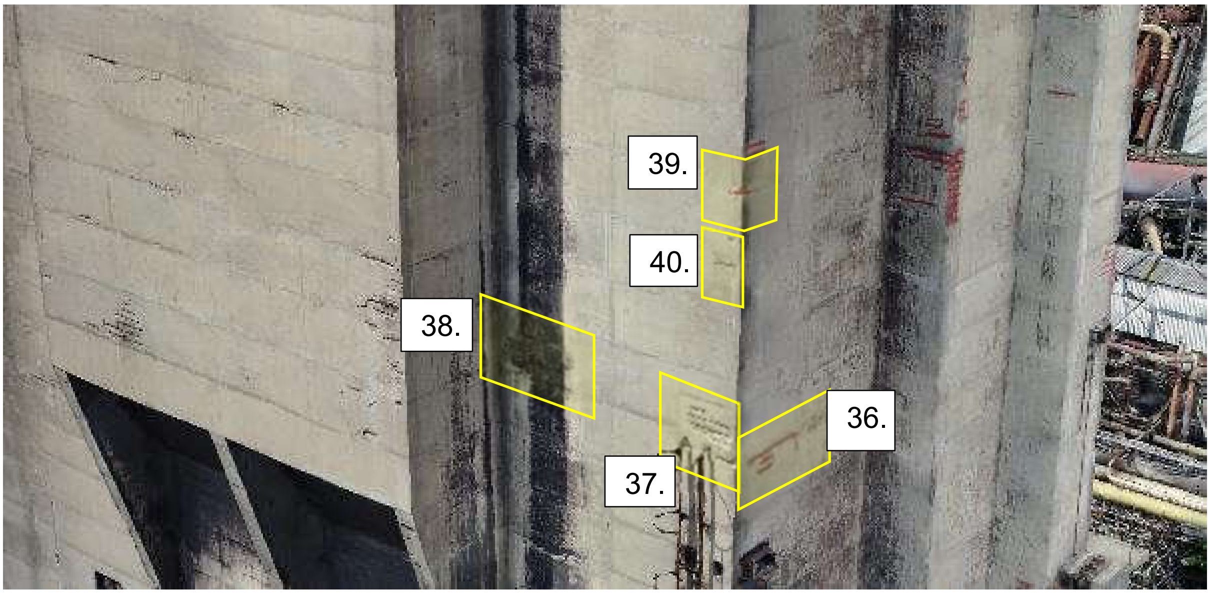


Figure 31: South Elevation - Defects 36-40

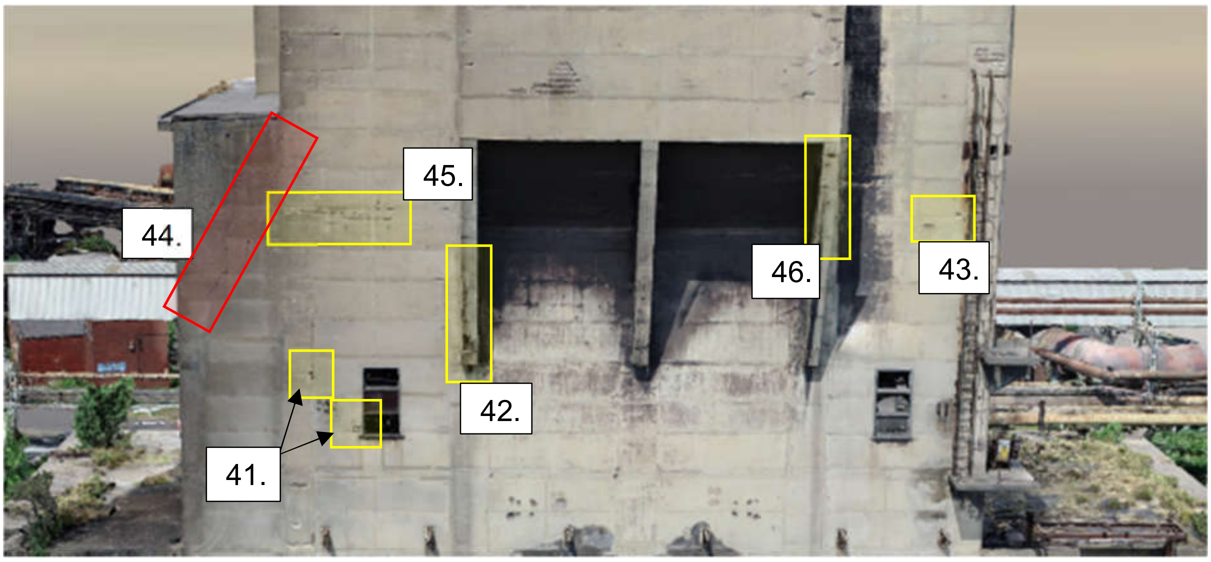


Figure 32: South Elevation - Defects 41-46

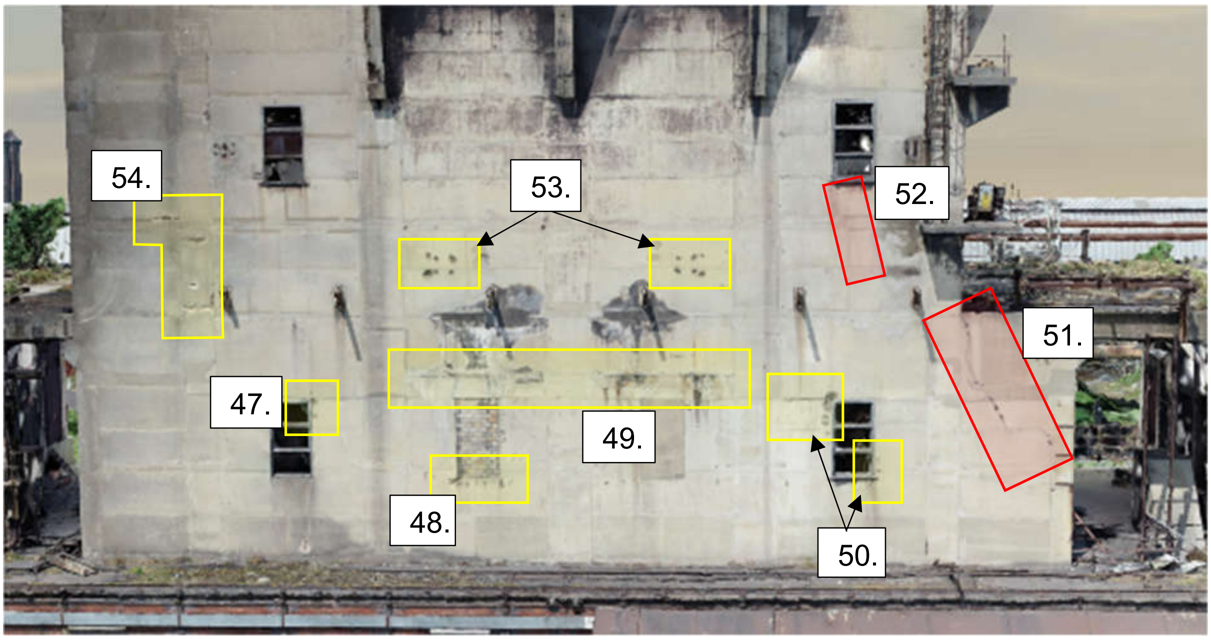


Figure 33: South Elevation - Defects 47-54

West Elevation

Figure 34: West Elevation

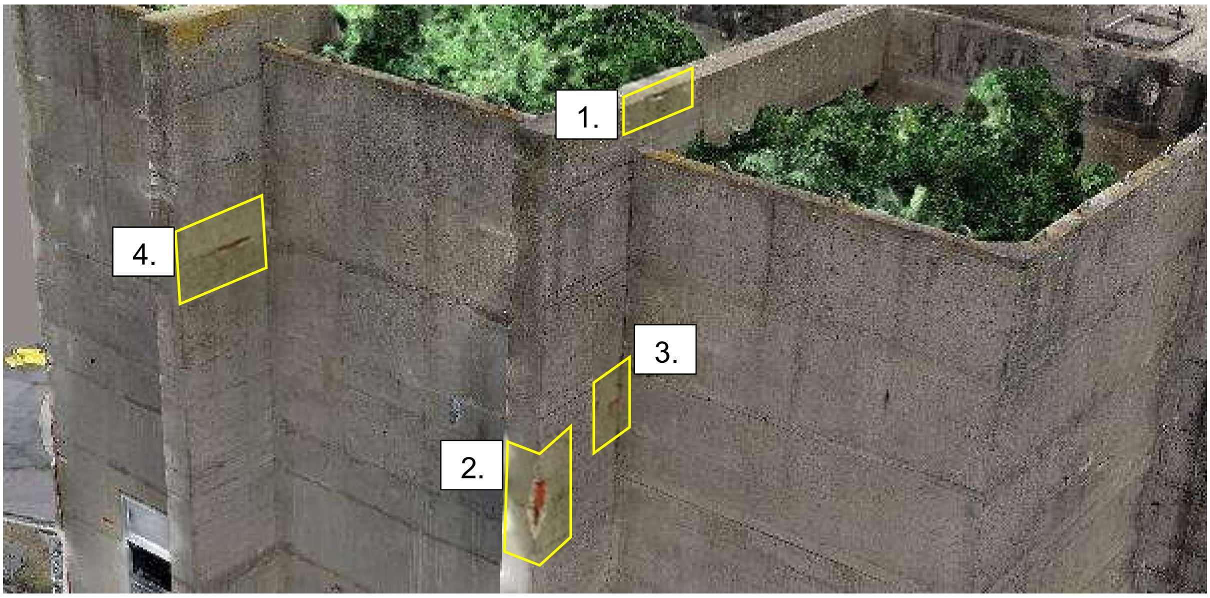


Figure 35: West Elevation - Defects 1-4

Figure 36: West Elevation - Defects 5-7

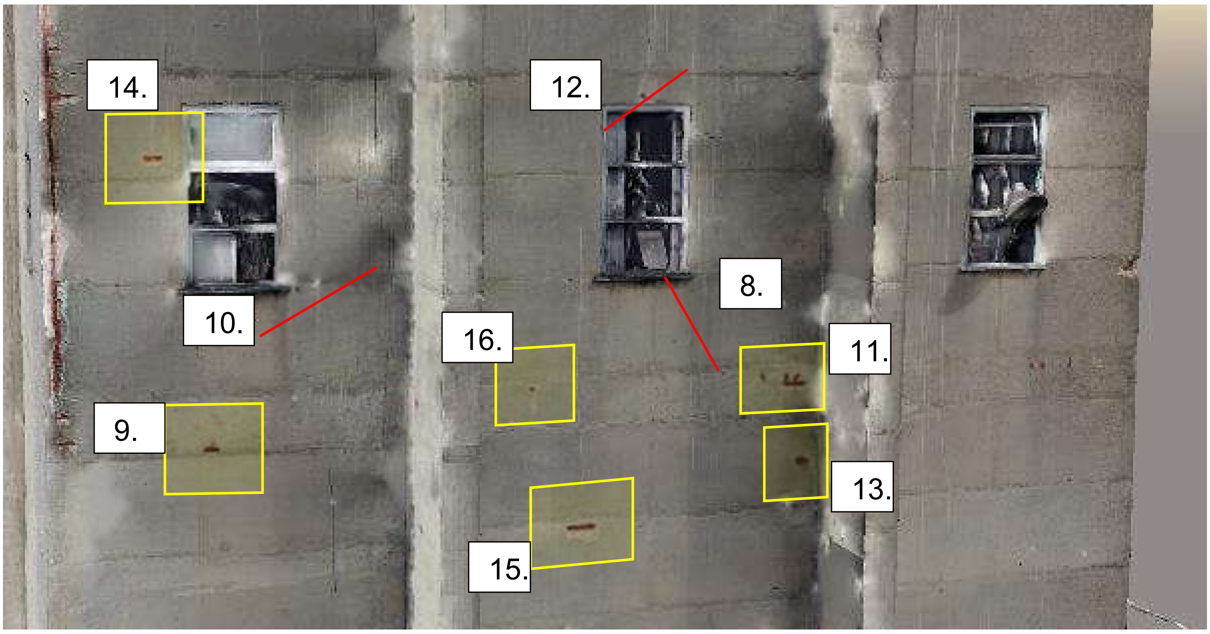


Figure 37: West Elevation - Defects 8-16

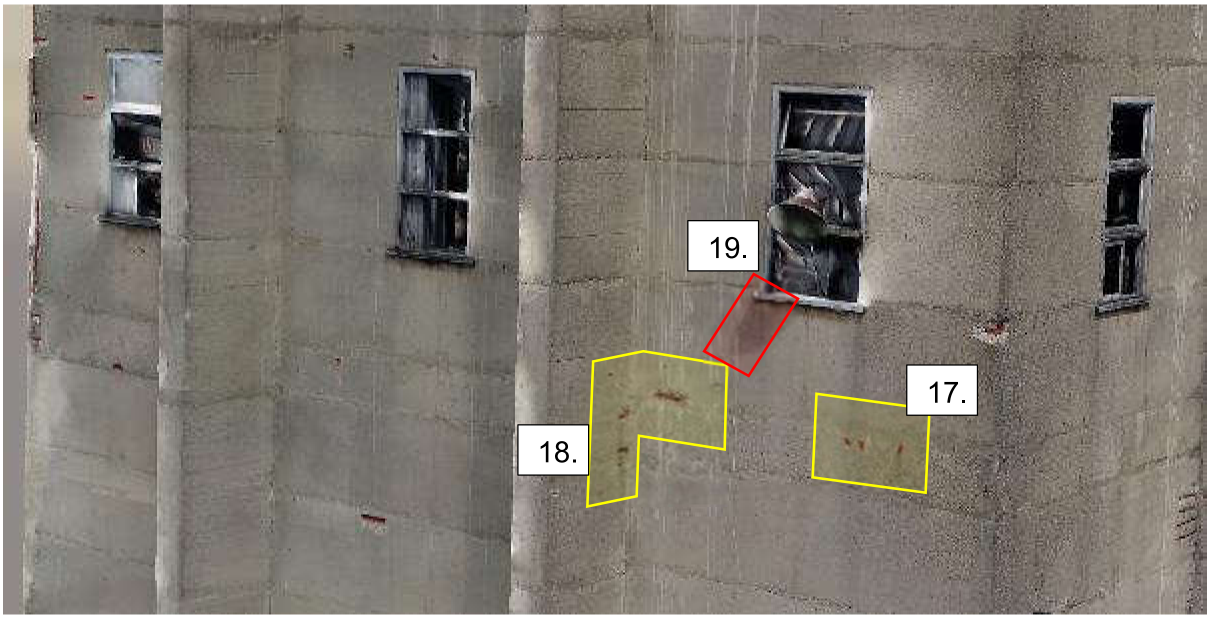


Figure 38: West Elevation - Defects 17-19

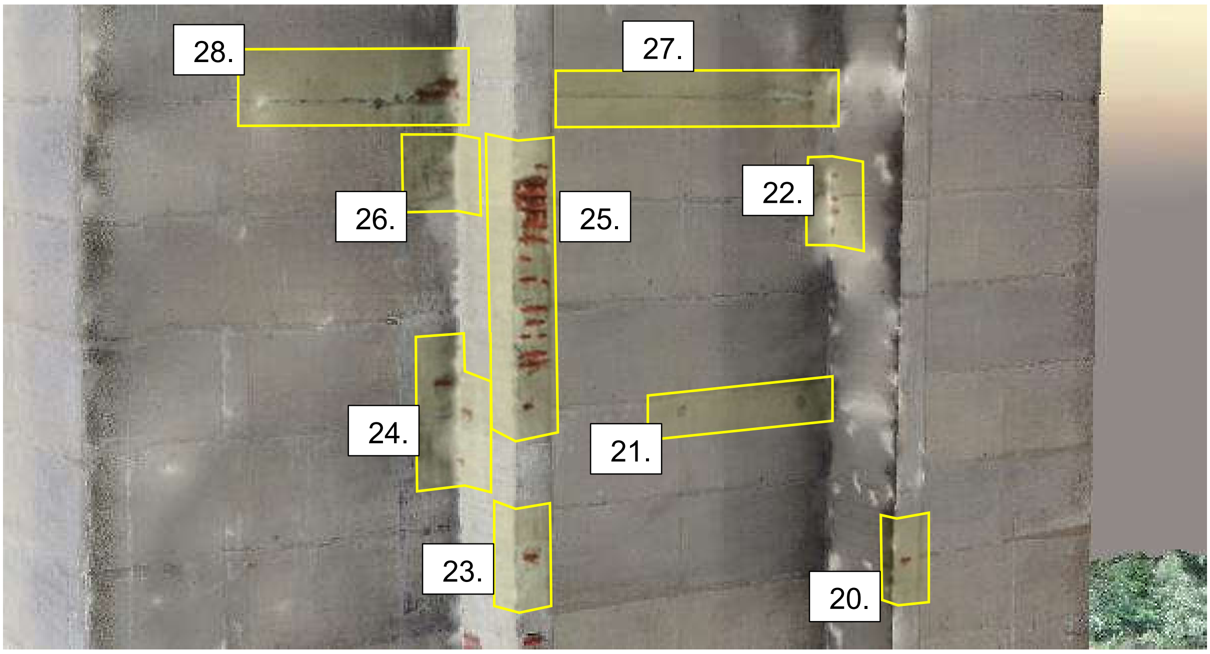


Figure 39: West Elevation - Defects 20-28

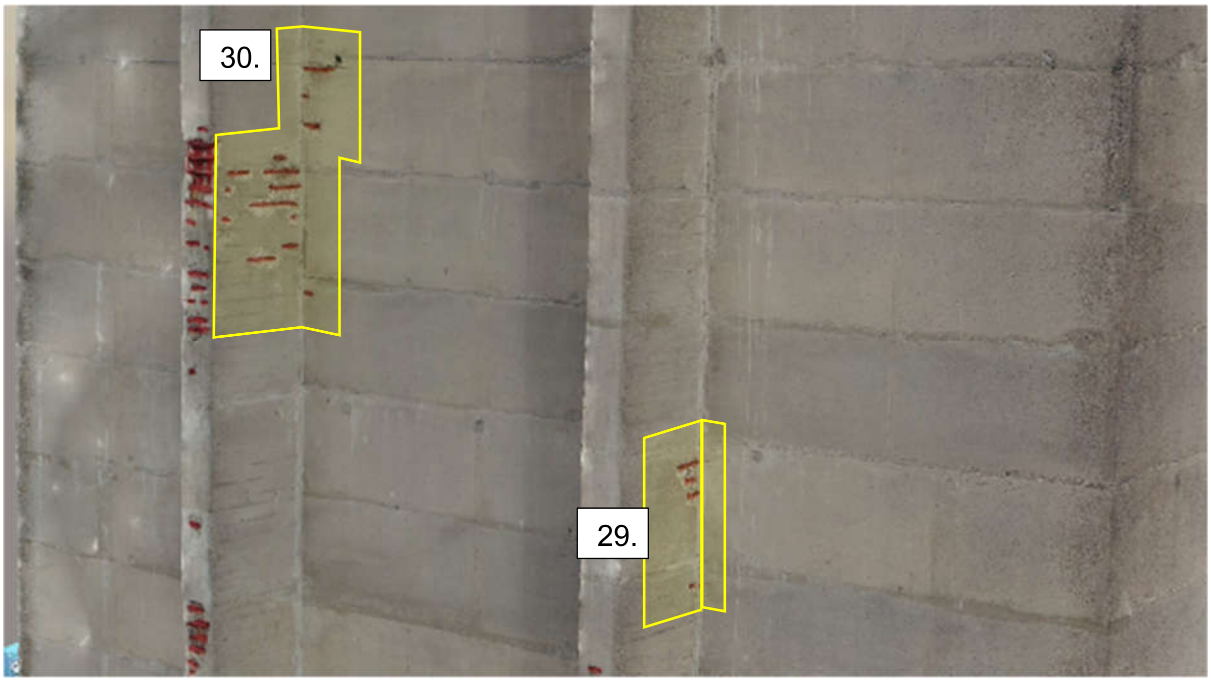


Figure 40: West Elevation - Defects 29-30

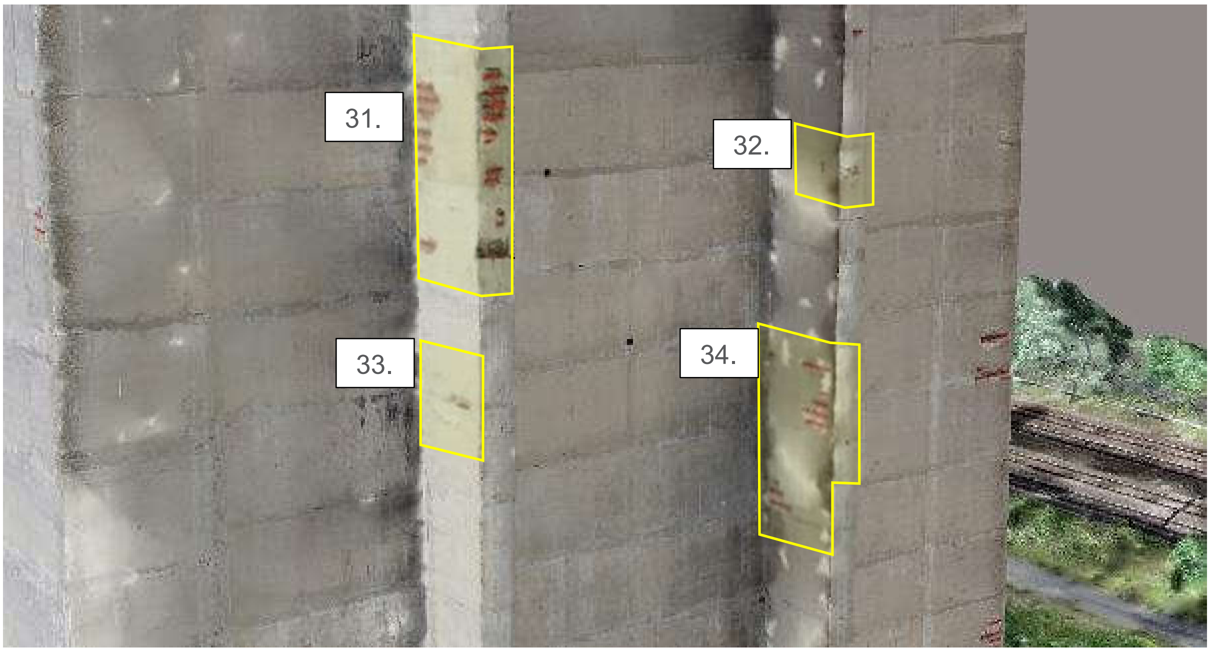


Figure 41: West Elevation - Defects 32-34

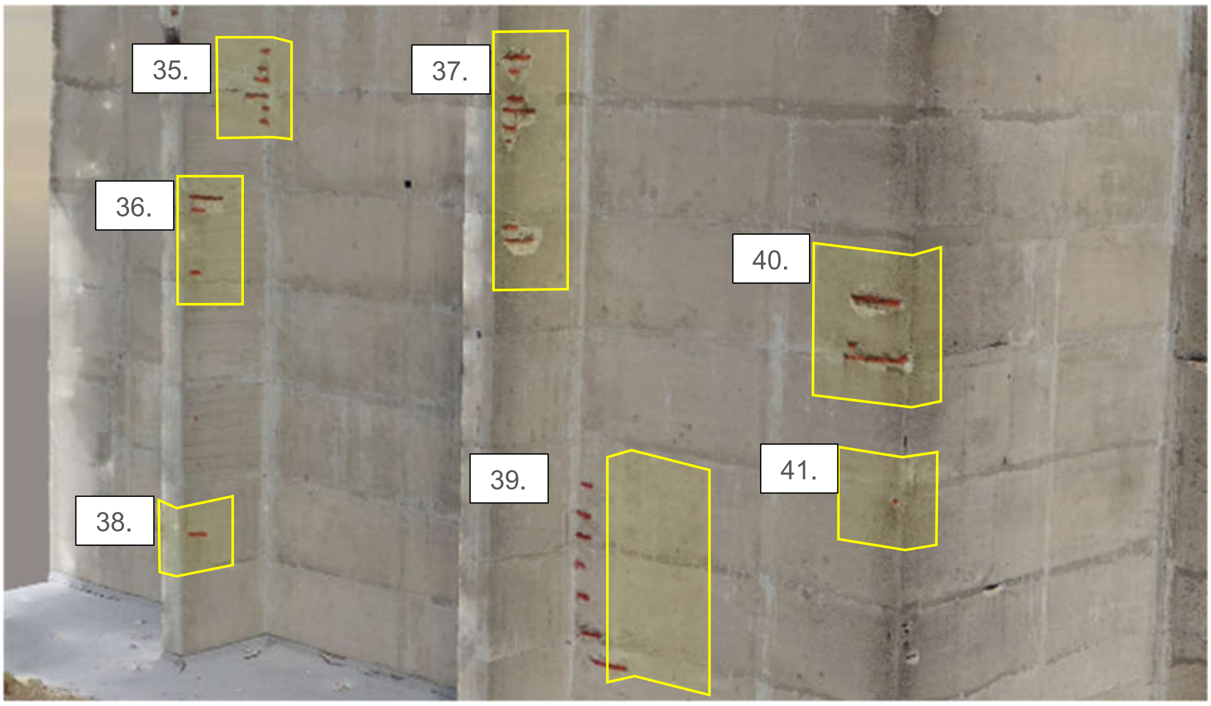


Figure 42: West Elevation - Defects 35-41

Figure 43: West Elevation - Defects 42-46

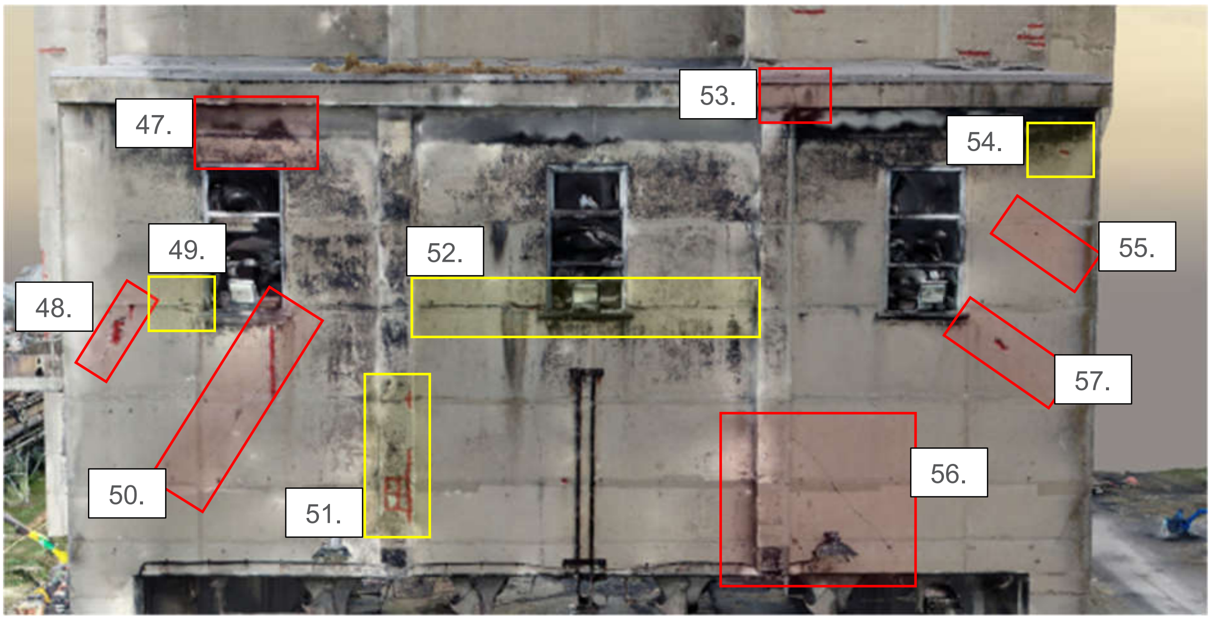


Figure 44: West Elevation - Defects 47-57

Figure 45: West Elevation - Defect 58

Appendix B. Defect Schedules

North Face

Elevation	Reference	Defect Type	Measurement	Units	Repair Area (m	Notes	Protective Coating
North Elevation	1	Concrete Spalling	1000mm	mm	3	1000mm length of concrete spalling with exposed rebar and another small patch.	Yes
North Elevation	2	Concrete Spalling	6000mm, approx 100mm deep	mm	6	Concrete spalled at edge of elevation with rebar exposed. Approximately 100-150mm of concrete depth has been eradicated	Yes
North Elevation	3	Concrete Spalling	700mm	mm	2.5	2 No. patches of concrete spalling with a length of 700mm and 200mm.	Yes
North Elevation	4	Concrete Spalling	300mm	mm	3.5	Several patches of concrete spalling with exposed rebar	Yes
North Elevation	5	Concrete Spalling	400mm	mm	1.4	Exposed rebar at edge of elevation, with a depth of around 100mm	Yes
North Elevation	6	Concrete Spalling	1000mm	mm	5	Area near edge 4000mm long with multiple layers of rebar exposed and a maximum width of 1000mm	Yes
North Elevation	7	Concrete Spalling	150mm	mm	2.5	3 No. patches of exposed rebar and concrete spalling originating from day joint	Yes
North Elevation	8	Concrete Spalling	500mm	mm	1.5	Concrete spalling over a length of 500mm exposing rebar	Yes
North Elevation	9	Concrete Spalling	500mm	mm	1.5	Concrete spalling over a length of 500mm exposing rebar at day joint	Yes
North Elevation	10	Concrete Spalling	200mm	mm	2	3 No. patches of concrete spalling and exposed rebar with maximum length of 200mm	Yes
North Elevation	11	Concrete Spalling	200mm	mm	4.5	3 No. patches of concrete spalling and exposed rebar. Maximum length of patch is approximately 200mm.	Yes
North Elevation	12	Concrete Spalling	300mm x 300mm	mm	1.8	Concrete spalled exposing rebar over area near edge of elevation	Yes
North Elevation	13	Concrete Spalling	200mm	mm	1.8	2 No. patches of concrete spalling with a length of 700mm and 200mm.	Yes
North Elevation	14	Concrete Spalling	150mm	mm	1.5	Small patch of spalled concrete at edge	Yes
North Elevation	15	Concrete Spalling	1200mm x 750mm	mm	4.4	Area of concrete spalling near edge exposing multiple layers of rebar	Yes
North Elevation	16	Concrete Spalling	600mm	mm	1.6	Concrete spalling at day joint exposing rebar	Yes
North Elevation	17	Concrete Spalling	300mm x 300mm, approx depth of 100mm	mm	1.8	Concrete spalling at edge with approximate depth of 100mm exposing rebar. Additional patch of of concrete spalling.	Yes
North Elevation	18	Concrete Spalling	500mm	mm	1.5	Patch of concrete spalling across from edge exposing rebar	Yes
North Elevation	19	Concrete Spalling	2600mm x 400mm	mm	4.2	Area of spalled concrete near edge of elevation exposing 2600mm length of multiple rebar layers on both axes	Yes
North Elevation	20	Concrete Spalling	5600mm x 1600mm	mm	9	5600mm long lengths of exposed rebar due to spalling along 4 No. layers	Yes
North Elevation	21	Concrete Spalling	650mm	mm	1.6	Area of spalled concrete below a walkway local to the edge exposing rebar	Yes
North Elevation	22	Concrete Spalling	250mm	mm	1.25	Patch of spalled concrete near window opening with some exposed rebar in the centre of the patch	Yes
North Elevation	23	Concrete Spalling	500mm x 500mm	mm	2.25	Spalled concrete close to eastern edge of structure exposing two layers of rebar	Yes
North Elevation	24	Concrete Spalling	2300mm x 1100mm	mm	7	Area of concrete spalling from edge onto north and east elevations. Depth of concrete broken approx 100mm	Yes
North Elevation	25	Concrete Spalling	700mm	mm	5	6 No. patches of spalled concrete wth maximum dimension 700mm. Other patches are smaller. All exposing rebar.	Yes
North Elevation	26	Concrete Spalling	1000mm x 400mm	mm	4.5	2 No. areas of spalled concrete. Severe area at edge with approximate depth of missing concrete of 150mm exposing area of rebar. Additional minor area below with spots of rebar visible	Yes
North Elevation	27	Concrete Cracking	800	mm		Fine crack originating from day joint on eastern side of north elevation	-
North Elevation	28	Concrete Spalling	1000mm	mm	8	Region of concrete spalling patches with exposed rebar over a width of around 5000mm	Yes
North Elevation	29	Concrete Spalling	3000mm	mm	3.5	Area of spalling along single rebar at underside of protruding face then up the elevation. Minor cracks emanating perpendicular to the spalling. Width across spalling approximately 70mm	Yes
North Elevation	30	Concrete Spalling	1550mm	mm	6.5	4 No. patches of concrete spalling in small area near underside of protruding face. 1550mm length of exposed rebar, aswell as 800mm x 800mm patch, and two smaller patches on the underside.	Yes
North Elevation	31	Concrete Spalling	250mm	mm	1.8	3 No. patches of spalled concrete exposing rebar for a length of 250mm each on underside of protruding elevation near main structure.	Yes
North Elevation	32	Concrete Spalling	1000mm x 850mm	mm	3.8	Area of concrete spalling resulting in rows of rebar being visible on underside of protruding elevation	Yes
North Elevation	33	Concrete Spalling	1100mm	mm	7	7 No. patches of rebar lengths exposed due to concrete spalling on north side of east wing structure. Lengths are up to 1100mm long	Yes
North Elevation	34	Concrete Cracking	750	mm		Crack across depth of floor roof slab of east wing structure spanning across opening. Crack in line with west support stub, adjacent to end of slab span.	-
North Elevation	35	Concrete Cracking	4800	mm		Diagonal crack between main central tower and east wing structure. Crack spans across two day joints and is close to reaching corner between main tower and wing.	-
North Elevation	36	Concrete Spalling	600mm	mm	1.6	Concrete spalling with exposed rebar below day joint in central region of tower	Yes
North Elevation	37	Concrete Spalling	600mm	mm	4	Area of multiple patches of concrete spalling along both axes of rebar near corner of window opening. Close to pipe/cable run across structure	Yes
North Elevation	38	Concrete Spalling	2250mm	mm	6.5	Concrete spalling local to upper end of opening for door exposing rebar. Rebar exposed for full width of door above opening.	Yes
North Elevation	39	Concrete Spalling	200mm	mm	1.2	Concrete spalling below day joint for 200mm length exposing rebar	Yes
North Elevation	40	Concrete Spalling	750mm	mm	1.75	2 No. patches of concrete spalling with exposed rebar. Larger patch with length of 750mm and other small patch approximately 150mm.	Yes
North Elevation	41	Concrete Spalling	200mm	mm	3	5 No. patches of concrete spalling across width of 1000mm. Near to opening for window.	Yes
North Elevation	42	Concrete Cracking	240	mm		Concrete cracking on lower level roof slab above opening. Some concrete appears to have broken off from the underside.	-
North Elevation	43	Concrete Spalling		mm			

Concrete Spalling		
Known	131	
Allowance for Areas not inspected (internal and basement) Say similar	135	
	266	
FOS 2 for unknowns	533	m2 of repairs
Concrete Cracking		
Known	6,590	mm
Allowance for Areas not	6,590	mm
	13,180	mm
FOS 3.0 for unknowns	39,540	mm of Cracks to be repaired

East Face

Elevation	Reference	Defect Type	Measurement	Unit	Repair Area (m2)	Notes	Protective Coating
East Elevation	1	Concrete Spalling	700mm	mm	1.7	Concrete spalling for length of 700mm exposing rebar on southern "fin"	Yes
East Elevation	2	Concrete Spalling	700mm	mm	2.6	Concrete spalling and broken from local step out of concrete fin above water tanks, exposing rebar and links	No
East Elevation	3	Concrete Spalling	250mm	mm	1.25	Concrete spalling towards edge of "fin" along day joint exposing rebar	Yes
East Elevation	4	Concrete Spalling	650mm	mm	2	2 No. patches of spalled concrete exposing rebar. For lengths of 650mm and 200mm.	Yes
East Elevation	5	Concrete Spalling	450mm	mm	2.25	2 No. patches of spalled concrete exposing rebar at day joint and below.	Yes
East Elevation	6	Concrete Cracking	1400	mm		Fine crack across fin structure in between any jointing in concrete	-
East Elevation	7	Concrete Spalling	750mm x 350mm	mm	2.5	Edge face of fin has concrete patch of concrete spalling exposing layers of rebar. Depth of approximately 150mm.	Yes
East Elevation	8	Concrete Spalling	400mm	mm	2.25	2 No. patches of spalled concrete exposing rebar, length of 400mm for one and other is short length in corner	Yes
East Elevation	9	Concrete Spalling	650mm	mm	2.8	Area on north side of fin with spalled concrete and exposed rebar for three layers	Yes
East Elevation	10	Concrete Spalling	350mm x 250mm	mm	1.5	Spalled concrete on corner of fin exposing rebar at day joint. Depth of approximately 100mm.	Yes
East Elevation	11	Concrete Spalling	70mm	mm	1.5	3 No. patches of spalled concrete with exposed rebar at edge. Patches are roughly 70mm in length	Yes
East Elevation	12	Concrete Spalling	250mm	mm	2	4 No. patches of spalled concrete with exposed rebar at edge. These patches are all approximately 250mm.	Yes
East Elevation	13	Concrete Spalling	4000mm x 1400mm	mm	10	Region on northern side of northern fin with numerous patches of spalled concrete over an area measuring 4000mm x 1400mm on the fin structure of the tower. Longest patch is 1000mm but the others are less than 500mm.	Yes
East Elevation	14	Concrete Spalling	7500mm x 1600mm	mm	20	Region on northern side of northern fin with an array of areas of concrete spalling with exposed rebar. Longest length is 2900mm on the edge and the depth of the spall is approximately 150mm. There is another area towards the top of the area with two layers of rebar exposed across the depth of the fin; this is also particularly deep.	Yes
East Elevation	15	Concrete Spalling	12500mm x 1600mm	mm	33	Reigion on the northern side of the southern fin is littered with patches of concrete spalling on this face, and some on the narrow face. Depth of some of the spalling is approximately 150mm on the edges.	Yes
East Elevation	16	Concrete Spalling	700mm x 300mm	mm	2.25	Patch of concrete spalling at southern edge exposing two layers of rebar	Yes
East Elevation	17	Concrete Spalling	1500mm	mm	3.75	Concrete spalling near edge of elevation exposing three layers of rebar with longest patch being 1500mm.	Yes
East Elevation	18	Concrete Spalling	600mm	mm	1.6	Concrete spalling with exposed rebar for a length of approximately 600mm	Yes
East Elevation	19	Concrete Spalling	1000mm	mm	5	Area on the south side of the southern fin with concrete spalling and exposed rebar, continuation of defect no. 15. Spalling works around the northern face of the fin and around the southern fin.	Yes
East Elevation	20	Concrete Spalling	1000mm x 250mm	mm	1.5	Area on the lower portion of the southern fin, just above the plinth support, concrete spalling with exposed rebar. Depth of penetration is significant at approximately 150mm. Defect wraps around the three faces of the fin.	Yes
East Elevation	21	Concrete Spalling	1400mm x 900mm	mm	7	3 No. patches of spalled concrete with exposed rebar. First patch is on the diagonal section of the fin and exposed nine layers of rebar and is the most significant patch. Another is a 600mm length of exposed rebar and the other is a 400mm x 400mm patch.	Yes
East Elevation	22	Concrete Spalling	1200mm x 900mm	mm	7.5	The northern side of the southern fin has areas of concrete spalling, one of which is a continuation of defect no. 20 which covers the southern side of the same fin. The maximum concrete spall length is approximately 1200mm. Similar to defect no. 21, there is an area on the diagonal support plinth with layers of rebar exposed due to spalling	Yes
East Elevation	23	Concrete Spalling	500mm x 300mm, approx depth of 100mm	mm	5	3 No. patches of concrete spalling with exposed rebar. One is just above plinth haunch support and it appears as though a depth of one of the corners has fallen.	Yes
East Elevation	24	Concrete Spalling	350mm	mm	1.4	Concrete spalled at midspan of support beam to tower structure near at opening on east elevation. Concrete chipped away at edge with an approximate depth of 70mm.	-
East Elevation	25	Concrete Cracking	300	mm	1.3	Fine crack across support beam to tower structure over opening on each elevation. Some concrete fallen, minor cracks present along the element	-
East Elevation	26	Concrete Spalling	13000mm x 7000mm	mm	91	East wall of east wing structure has patches of concrete spalling over the entire surface. Exposed rebar at each patch; larger areas of spalling at southern end.	Yes

Concrete Spalling		
Known	213	
Allowance for Areas not inspected (internal and basement) Say similar	213	
	426	
FOS 2 for unknowns	851	

Concrete Cracking		
Known	1,700	mm
Allowance for Areas	1,700	mm
	3,400	mm
FOS 3 for unknowns	10,200	mm of Cracks to be repaired

South Face

Defect Type	Measurement	Unit	Repair Area (m2	Notes	Protective Coating
Concrete Spalling	200mm-300mm in length	mm	9	4 No. patches of exposed rebar due to concrete spalling.	No
Concrete Spalling	750mm	mm	2.5	Edge concrete spalling exposing rebar.	No
Concrete Spalling	600mm	mm	1.5	Edge concrete spalling exposing rebar. Spalling towards upper corner. Merging with spalling at highest day joint level.	No
Concrete Spalling	10000mm	mm	14	Spalling along highest level day joint	-
Concrete Spalling	500mm long, 200mm widest point, approx. 150mm deep. Adjoining 1600mm long spall.	mm	3.5	Edge concrete spalling, deep recession into edge. Exposing two reinforcement bars. Edge spalling merges with spalling along day joints with exposed rebar.	No
Concrete Spalling	700mm long	mm	1.6	Concrete spalling exposing rebar.	No
Concrete Spalling	900mm long, 300mm widest point, approx. 50mm deep	mm	2.5	Edge concrete spalling, recession into the edge exposing rebar. Spalling in equal part on both faces	No
Concrete Spalling	200mm	mm	1	Patch of exposed rebar due to spalling	No
Concrete Cracking	500	mm	1.5	Crack appearing below day joint	-
Concrete Spalling	300mm	mm	1	Patch of spalling exposing rebar	No
Concrete Spalling	600mm x 600mm max	mm	13	Several patches of exposed rebar down an edge, with largest patch measuring approx 600mm squared	No
Concrete Cracking	750	mm	1.75	Crack appearing above day joint. Potentially exposing rebar	-
Concrete Cracking	250	mm	1.25	Cracking and fallen concrete at corner of opening for window	-
Concrete Cracking	2300	mm	2.6	Patch of broken concrete at corner of opening (700x500mm equivelant to 2300mm long crack)	-
Concrete Cracking	3000	mm		Fine crack spanning across two day joints	-
Concrete Cracking	1500	mm		Fine crack across single day joint originating from corner of opening	-
Concrete Spalling	160mm and 250mm	mm	1.8	2 No. patches of spalled concrete exposing rebar.	No
Concrete Spalling	250mm	mm	1.25	Concrete spalling along day joint area	-
Concrete Spalling	300mm	mm	1.3	Concrete spalling at day joint	-
Concrete Spalling	1300mm	mm	2.8	1.3m length of concrete spalling crack appearing below day joint	-
Concrete Spalling	350mm	mm	1.35	Short length of concrete spalling appearing at day joint	-
Concrete Spalling	300mm	mm	1.3	Concrete spalling at day joint exposing rebar	No
Concrete Spalling	300mm x 500mm	mm	1.9	No. of patches with exposed rebar at edge	No
Concrete Spalling	300mm	mm	1.3	Concrete spalling crack approx. 30cm in length	-
Concrete Spalling	400mm	mm	1.4	Concrete spalling exposing rebar on day joint	No
Concrete Spalling	800mm long, 600mm wide, approx. 120mm deep	mm	2.9	Large area of spalled concrete on edge exposing two layers of rebar for almost a metre.Max depth of spalled concrete is up to approx. 12cm	No
Concrete Spalling	200mm	mm	1.2	Concrete spalling crack near edge	-
Concrete Spalling	950mm	mm	2	Concrete spallling at day joint exposing rebar	No
Concrete Cracking	1000	mm		Crack originating at day joint, close to spalling defect (ref no. 28)	-
Concrete Spalling	500mm and 100mm	mm	2.4	Spalled concrete near day joint and above exposing rebar	No
Concrete Spalling	400mm	mm	1.4	Spalled concrete at day joint, rebar almost exposed	-
Concrete Spalling	900mm x 900mm	mm	7.7	Large patch of spalled concrete exposing rebar layers. Additional 3 No. smaller patches also exposing rebar.	No
Concrete Spalling	400mm	mm	1.4	Concrete spalling above day joint exposing rebar	No
Concrete Spalling	750mm	mm	10	Several patches close to the edge of elevation of exposed rebar, with lengths up to 750mm	No
Concrete Cracking	2500	mm		Fine crack on day joint possibly due to spalling	-
Concrete Spalling	500mm	mm	1.5	Concrete spalling at edge exposing rebar	Yes
Concrete Spalling	400mm	mm	1.2	Concrete spalling near edge and an additional small patch of spalling above	-
Concrete Spalling	1650mm x 650mm	mm	2.52	Area of concrete spalling leading to layers of exposed rebar. This area is within a black-stained patch of the concrete, most likely from the coal processes of the battery	No
Concrete Spalling	1000mm x 600mm	mm	3	Defects are local to what appears to be a small pour or patching. Area of concrete spalling leading to exposed rebar and another area of concrete spalling with a length of 400mm	No
Concrete Spalling	1400mm	mm	3.25	3 No. patches of concrete spalling and exposed rebar. Large patch is 1400mm long and two smaller ones are no longer than 500mm.	Yes
Concrete Cracking	7000	mm		Fine diagonal crack from corner of outstructure on west side.	-
Concrete Spalling	3000mm	mm	4	Concrete spalling for a length of 3000mm with exposed rebar.	No
Concrete Spalling	400mm	mm	2.6	2 No. patches of spalled concrete near external ladder.	-
Concrete Spalling	400mm	mm	3	2 No. patches of spalled concrete with exposed rebar. Both are small and one is breaking from the timber frame of a window opening	No
Concrete Spalling	3000mm long, 300mm wide and approx 200mm deep	mm	4	Area of damaged concrete at base of plinth support where structure haunches out for the external face. 3000mm length of rebar exposed at corner and base is deeply damaged exposing rebar	No
Concrete Spalling	300mm	mm	2.5	5 No. patches of spalled concrete on the plinth support haunch with some up to 300mm long with exposed rebar	No
Concrete Spalling	800mm	mm	6	4 No. patches of concrete spalling lengths with exposed rebar. Maximum length is approx 800mm.	No
Concrete Spalling	850mm x 700mm	mm	6	2 No. patches with spots of concrete spalling, exposing rebar ends in two layers	No
Concrete Cracking	2000	mm		Fine crack orginating from bottom edge of window opening towards corner of outstructure	-
Concrete Cracking	4500	mm		Diagonal crack splitting the outstructure on east side with largest widths at top and in the central area	-
Concrete Spalling	1000mm	mm	3.5	2 No. areas with several patches of concrete spalling and exposed rebar. 1000mm length spalling on day joint; other patches all local to window opening.	No
Concrete Spalling	3500mm	mm	9	2 No. lengths of concrete spalling along day joint. Both lengths are approximately 3500mm.	-
Concrete Spalling	300mm x 300mm	mm	3.5	300mm x 300mm area of spalled concrete and exposed rebar at corner of bricked up window opening. Other patches of concrete spalling surfacing below window opening.	No
Concrete Spalling	300mm x 200mm	mm	1.5	Concrete spalling around opening for window, focussed on the corner	-

	Concrete Spalling
Known	157
Allowance for Areas not inspected (internal and basement) Say similar	157
	314
FOS 2 for unknowns	628

	Concrete Cracking	
Known	25,300	mm
Allowance for Areas not inspected (internal and	25,300	mm
	50,600	mm
FOS 3 for unknowns	151,800	mm of Cracks to be repaired

West Face

Elevation	Reference	Defect Type	Measurement	Unit	Repair Area (m2)	Notes	Protective Coating
West Elevation	1	Concrete Spalling	600mm	mm	1.6	Concrete spalling for a length of 600mm exposing rebar on the northern "fin" along a day joint. Additional small spot below exposing rebar	Yes
West Elevation	2	Concrete Spalling	300mm	mm	1.3	Concrete spalling at top edge of one of the concrete walls for the water tanks. Exposing rebar and some materal has been lost.	No
West Elevation	3	Concrete Spalling	900mm	mm	2.5	Area of concrete spalling at the edge of the southern fin structure exposing rebar. An approximate depth of concrete which has fallen is 100mm.	Yes
West Elevation	4	Concrete Spalling	180mm	mm	1.2	Patch of spalled concrete exposing rebar originating from edge of fin	Yes
West Elevation	5	Concrete Spalling	50mm	mm	6	4 No. patches of concrete spalling over two day joints exposing ends of rebar	Yes
West Elevation	6	Concrete Spalling	450mm	mm	1.5	Area with concrete spalling off on the edge face of the fin. No exposed rebar	-
West Elevation	7	Concrete Spalling	500mm x 450mm	mm	2.5	Area of edge elevation of fin element with exposed rebar on both edges and across the face. Depth of penetration is approximately 100mm.	Yes
West Elevation	8	Concrete Spalling	220mm	mm	1.25	Spalled concrete exposing rebar near opening for window	Yes
West Elevation	9	Concrete Cracking	500	mm		Crack above opening for window with some concrete fallen at the centre	-
West Elevation	10	Concrete Cracking	1000	mm		Crack originating from corner of northern window opening on the elevation, edging towards the fin.	-
West Elevation	11	Concrete Spalling	200mm	mm	1.2	Concrete spalling at day joint exposing rebar	Yes
West Elevation	12	Concrete Spalling	60mm	mm	1	Spot of concrete spalling exposing rebar	Yes
West Elevation	13	Concrete Cracking	1200	mm		Crack spanning from corner of window opening to day joint below	-
West Elevation	14	Concrete Spalling	300mm x 150mm	mm	2	2 No. patches of spalled concrete exposing rebar. One large patch measuring 300mm x 150mm and another smaller spot of exposed rebar.	Yes
West Elevation	15	Concrete Spalling	180mm	mm	1.2	Concrete spalling near edge of fin with length of roughly 180mm exposing rebar	Yes
West Elevation	16	Concrete Spalling	400mm	mm	1.4	Patch of spalled concrete exposing rebar and more spalled concrete below visible rebar	Yes
West Elevation	17	Concrete Spalling	400mm	mm	3	3 No. patches of spalled concrete local to edge of fin. Exposed rebar for maximum length of 400mm	Yes
West Elevation	18	Concrete Cracking	900	mm		Fine crack originating from the corner of a window opening down towards a day joint, close to spalling in defect no. 17	-
West Elevation	19	Concrete Spalling	70mm	mm	1.7	3 No. patches of spalled concrete which are relatively small and expose a small area of rebar	Yes
West Elevation	20	Concrete Spalling	150mm	mm	1.2	Concrete spalled at edge face of southern fin exposing rebar	Yes
West Elevation	21	Concrete Spalling	150mm x 150mm	mm	2.8	2 No. patches of spalled concrete is circular areas. No exposed rebar at present	-
West Elevation	22	Concrete Spalling	160mm	mm	1.6	3 No. patches of spalled concrete originating from edge of fin element exposing rebar	Yes
West Elevation	23	Concrete Spalling	200mm	mm	1.2	Spalled concrete at edge face of northern fin exposing rebar. Spalling concrete forming above and below exposed rebar patch.	Yes
West Elevation	24	Concrete Spalling	200mm	mm	3.2	3 No. patches of spalled concrete close to the edge of the northern fin exposing rebar	Yes
West Elevation	25	Concrete Spalling	800mm x 400mm, approx depth of 60mm	mm	5.5	Area on edge face of northern fin with concrete spalling and layers of rebar exposed in both directions. Larger patch with numerous smaller patches local to it	Yes
West Elevation	26	Concrete Spalling	150mm	mm	1.2	Spalled concrete from edge of fin element exposing rebar	Yes
West Elevation	27	Concrete Spalling	4300mm	mm	4.3	Concrete beginning to spall along day joint, worse condition at southern end.	-
West Elevation	28	Concrete Spalling	600mm x 300mm	mm	3	Patch of concrete spalling on northern side of northern fin with two layers of exposed rebar. Concrete is also beginning to spall for a furrther 1.5m along the day joint northwards	Yes
West Elevation	29	Concrete Spalling	450mm x 450mm	mm	3.3	2 No. patches of spalled concrete. Larger one above exposed multiple layers of rebar and the other is just a small patch.	Yes
West Elevation	30	Concrete Spalling	800mm x 600mm	mm	4	Several patches of concrete spalling on northern fin, continuation of defect no. 25. Exposing layers of rebar in each patch of spalling.	Yes
West Elevation	31	Concrete Spalling	900mm x 480mm	mm	6	6 No. patches of concrete spalling with exposed rebar with fairly deep penetration. Three of the patches are large in size and expose multiple layers of rebar whilst the others are smaller in scale.	Yes
West Elevation	32	Concrete Spalling	120mm	mm	1.5	2 No. patches of spalled concrete with rebar exposed and surrounding concrete breaking away on the edge face of the southern fin	Yes
West Elevation	33	Concrete Spalling	250mm	mm	1.3	Spalled concrete exposing rebar on northern face of northern fin for a length fo 250mm and some spalling around it.	Yes
West Elevation	34	Concrete Spalling	500mm x 500mm	mm	4.5	4 No. patches of concrete spalling exposing multiple layers of rebar on northern face of southern fin	Yes
West Elevation	35	Concrete Spalling	900mm x 400mm	mm	2.8	Concrete spalling at edge of northern fin exposing 6 No. layers of rebar	Yes
West Elevation	36	Concrete Spalling	500mm	mm	5	Concrete spalling patches from edge of northern fin with maximum length of exposed rebar around 500mm	Yes
West Elevation	37	Concrete Spalling	600mm x 400mm	mm	4.5	3 No. patches of concrete spalling with multiple layers of rebar exposed. Depth of spalling is around 50mm on the southern face of the southern fin.	Yes
West Elevation	38	Concrete Spalling	280mm	mm	1.3	Concrete spalling on southern face of northern fin exposing rebar for a length of 280mm.	Yes
West Elevation	39	Concrete Spalling	600mm	mm	2.5	7 No. patches of spalled concrete originating from edge of southern fin with exposed rebar and maximum length of 600mm	Yes
West Elevation	40	Concrete Spalling	750mm	mm	2.8	2 No. patches of spalled concrete of lengths 750mm and 650mm with exposed rebar originating from the southern edge of the elevation	Yes
West Elevation	41	Concrete Spalling	70mm	mm	1	Small patch of localised concrete spalling close to southern edge of elevation with exposed rebar	Yes
West Elevation	42	Concrete Spalling	100mm	mm	1	Small patch of concrete spalling near northern side of southern fin with exposed rebar	Yes
West Elevation	43	Concrete Spalling	180mm x 160mm	mm	1.4	Area of spalled concrete and exposed rebar at centre. Rebar has not been coated with protective layer.	No
West Elevation	44	Concrete Spalling	430mm	mm	1.5	Interface between southern fin and roof felt sheeting has deep spalling with rebar across the fin exposed. Sheeting is also cracking in numerous places.	No
West Elevation	45	Concrete Spalling	450mm x 400mm	mm	3.5	2 No. patches of concrete spalling with exposed rebar. One is at the southern edge of the elevation and the other is closer to the level at which the wing structure begins.	Yes
West Elevation	46	Concrete Spalling	110mm	mm	1.1	Concrete spalling patch with exposed rebar at level of day joint towards the northern edge of elevation	Yes
West Elevation	47	Concrete Cracking	1000	mm		2 No. cracks from the corners of northern window opening towards the roof of the structure. Cracks are both approximately 1000mm long.	-
West Elevation	48	Concrete Cracking	1100	mm	1	Crack from day joint, spalling at crack and some rebar exposed for a length of roughly 300mm and 100mm.	Yes
West Elevation	49	Concrete Spalling	300mm	mm	1.2	Concrete spalling from edge of window opening along day joint towards crack no. 48.	-
West Elevation	50	Concrete Cracking	2500	mm	1	Cracking originating from corner of window opening down across two day joints. Length of rebar exposed for around 1000mm.	Yes
West Elevation	51	Concrete Spalling	1000mm x 300mm	mm	2	Concrete spalling patches on northern column structure at lower end exposing multiple layers of rebar	Yes
West Elevation	52	Concrete Spalling	4600mm	mm	5	Concrete spalling along day joint in line with bottom of window opening	-
West Elevation	53	Concrete Cracking	330	mm		Crack in roof level edge beam in line with edge of column support.	-
West Elevation	54	Concrete Spalling	160mm	mm	1.2	Patch of concrete spalling at southern end of elevation exposing rebar for a length of 160mm.	Yes
West Elevation	55	Concrete Cracking	1300	mm		Fine diagonal crack between day joint and southern edge of elevation	-
West Elevation	56	Concrete Cracking	2500	mm		Group of 3 No. cracks towards the southern column support of the structure from the large opening below	-
West Elevation	57	Concrete Cracking	1700	mm	1.3	Crack originating from the bottom of the southern window opening towards the day joint below. Some spalling has led to some exposed rebar for a length of around 300mm	Yes
West Elevation	58	Concrete Spalling	13000mm x 5000mm	mm	65	Region has numerous patches of concrete spalling with exposed rebar. More patches on the northern half of the elevation on the upper half.	Yes

	Concrete Spalling	
Known	180	
Allowance for Areas not inspected (internal and basement) Say similar	180	
	360	
FOS 2 for unknowns	720	

	Concrete Cracking	
Known	14,030	mm
Allowance for Areas	14,030	mm
	28,060	mm
FOS 3 for unknowns	84,180	mm of Cracks to be repaired

Appendix C. Teesworks Inspection Photos

Record Photo's from the last Asset Integrity Building Inspection Report (20/08/20) for areas not able to be inspected by Atkins in July 2021. With thanks to Stephen Wilson, Asset Inspection Engineer for sharing this report.

1 Internal Oven Cellars

2 Internal Oven Cellars

3 Internal Oven Cellar Roof

4 Chambers either side of Cellar

5 Internal Bunker Structure

6 First Floor Stair Stringer Baseplate

7 First Floor Corridor

8 Second Floor Level

9 3rd Floor Top Battery Level, below Bunker

10 3rd Floor Overhead Bunker Chutes

Appendix D. Preliminary Repairs

Summary of proposed repair details considered in cost appraisal.

Spalling Concrete Repairs

1 Hammer test concrete and identify delamination area.
2 Mark up rectangular area approx. 300mm beyond identified delamination area
3 Saw cut 25/30mm around repair area and chip away top surface 30mm of concrete surface
4 Break away concrete to expose rebar and at least 25mm behind reinforcement
5 Blast clean or wire brush rebar to white metal
6 Splice in new rebar 12mm min where reinforcement has lost more than 25% section. Splice shall overlap min 450mm beyond lost section.
7 Clean area, remove loose debris
8 Paint primer on steel reinforcement Sika® FerroGard®-901
9 Paint bonding primer/agent onto concrete surface
10 Apply epoxy mortar to rebuild to flat level surface

Surface Coatings

If Aesthetics important - use elastomeric paint coatings that can bridge cracks but give homogenous look - typically external facades

If Aesthetics NOT important use hydrophobic impregnation - typically internal facades

Typical External Coating Method

1 Surface cleaned as per Activity Schedule - light blast/high pressure water
2 Primer surface with Sikagard®-551 S Elastic Primer
3 Apply 2 coats of Sikagard®-550 W Elastic (by brush, roller or airless spray)

Typical Internal Coating Method

1 Surface cleaned as per Activity Schedule - light blast/high pressure water
2 Apply 3 coats of Sikagard®-740 W (by brush, roller or airless spray)

Typical Method of Repair

1 Concrete, mortar, stone should be thoroughly prepared by high pressure water jetting (150-200 bar) or by mechanical means such as grinding, and chiselling.
2 Cracks must be cleaned with compressed air to remove dust and loosely adhering materials
3 Inject Sikadur®-52 MY into cracks - mainly vertical with pumped injection system.

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