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Project Proposal

Locations: Central London

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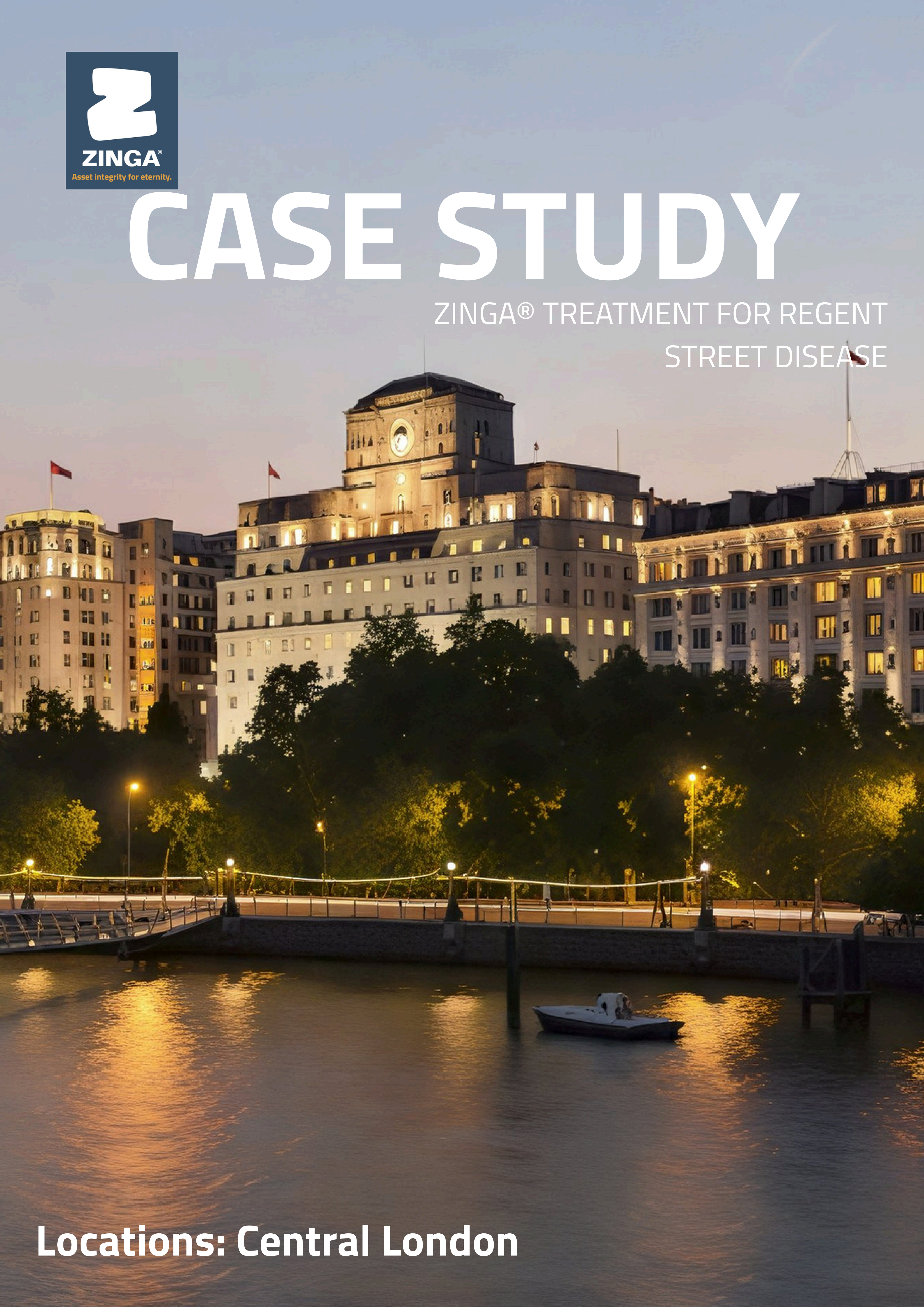
CASE STUDY

ZINGA® TREATMENT FOR REGENT STREET DISEASE



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Executive Summary

Since 2018, ZINGA® has been used to remedy this very unique kind of corrosion problem on five different steel-framed buildings across London. This damage could have led to a catastrophic failure of these buildings and posed a highly dangerous threat to the public if left unchecked.

The first building to be treated was the famous Shell Mex House, the official former headquarters of the merged Shell and British Petroleum companies in 1932.

For many years it was thought that this type of corrosion problem only affected these types of buildings that were erected between 1896 and 1921, but in recent years it has been established that it even affects steel-framed buildings that were erected during the 1950's.

Overview

Regent Street Disease (also known as Deansgate Disease in Manchester, UK) is a serious corrosion problem affecting numerous steel-framed buildings constructed between 1896 and the 1950s. It was first identified in the United Kingdom during the 1970s and was initially believed to affect only buildings erected between 1896 and 1921. In recent years, however, it has been established that buildings constructed up to the early 1950s are also vulnerable. The first buildings in London affected by this corrosion phenomenon were located on Regent Street, from which the name originates.

The steel frames of these early buildings were encased with brick infill between the steel members and clad with stone.

Construction practices varied slightly over the years. Some buildings were completed with cement-based mortars, while others used lime-based mortars. This variation is a major contributing factor to the onset of Regent Street Disease. When stonemasons or specialist contractors carried out repointing on these structures, they often applied cement-based pointing over original lime-based mortars. This was a critical but common error during a period when no strict regulations governed such specialist work.

Lime-based mortars are porous and allow moisture within the walls to evaporate externally. Cement-based renders, however, are impermeable and trap moisture within the structure. As moisture migrates towards warmer interior spaces, it may leads to blistering of internal paintwork, mould formation, and, more critically, the saturation of floor beams and ceiling joists, resulting in potential timber decay and structural weakening.

Corrosion damage:

It is very well-known that bricks and stone are all porous, as well as some unglazed tiles, and will allow the transmission of water vapor through the cladding and brickwork and onto the faces of the steelwork, where it is often present for weeks or months, and in the case of flat horizontal beams, it can pool in one area for years. This has been evidenced by the very heavy corrosion-pitting seen on these beams, and in some cases, heavy moisture has been held against vertical beams and has inflicted the same deep corrosion-pitting phenomena in these areas as well. The mortar was always applied tightly onto the steel/iron surfaces and did not allow any room for expansion from corrosion.

It is also well-known that iron and steel can corrode quite heavily under the correct circumstances, and the resultant corrosion products can expand the originally-installed volumes of iron and steel components by up to 200%. This causes a phenomenon known as "rust jacking" or "oxide jacking" because the expansive formation of corrosion products can push a heavy stone block (within the wall of a tall city building) out of alignment to the point at which it can come loose and fall. Such an occurrence would have catastrophic results in a busy city street, so tall buildings are monitored on a regular basis in order to prevent any such occurrences.

Definition of Regents Street Disease:

"The displacement of building elements due to the excessive and voluminous expansion of iron and steel components as the metal corrodes and forms iron oxide."

Alternative terms: Rust jacking or oxide jacking.

Discussion:

Although tall buildings may appear solid and stable, they are susceptible to ground movement (e.g., minor tectonic activity), thermal expansion caused by direct UV exposure, and daily temperature fluctuations.

These factors induce cracking in building joints, creating pathways for rainwater or condensation to reach the steel framework, initiating corrosion.

This movement is more pronounced in upper floors, which are less restrained than the lower levels.

High winds can cause tall buildings to sway, opening further cracks that allow increased moisture ingress. Corrosion rates are strongly influenced by the Time of Wetness (ToW) factor. Poorly maintained façades, particularly at upper levels, are highly susceptible to moisture accumulation from rain, condensation, airborne salts, sulfur emissions from traffic, and carbon dioxide, forming weak acids that accelerate corrosion.

Chemical degradation penetrates lime or cementitious renders, breaking down the high-pH protective barrier around the steel. Corrosion typically initiates when relative humidity reaches approximately 40% and accelerates above 70%. Where salts are present, the threshold is lower.

In the late nineteenth and early twentieth centuries, construction methods varied widely. Without uniform building regulations, some designers rendered lime or cement mortar directly against steel, which limited expansion but trapped moisture. Others introduced air gaps between steel and cladding, allowing expansion without accommodating section loss, but it did not prevent loss of section-thickness. Both approaches created long-term vulnerabilities.

Causes for Water Damage

Roof and Parapets

- Failed flashing around parapet walls, chimneys, or skylights.
- Aging or damaged membranes allowing water ingress.
- Cracked or missing mortar in parapet copings.

Masonry Walls

- Deteriorated mortar joints in brick or stone façades.
- Cracking due to thermal movement, settlement, or freeze–thaw cycles.
- Blocked or missing weep holes in cavity walls.

Windows and Doors

- Defective seals and degraded flashing.
- Cracked or unsealed sills.

Foundations and Below-Grade Areas

- Capillary rise of groundwater through porous materials.
- Inadequate drainage, basement leaks, or insufficient waterproofing.
- Unsealed service penetrations.

Expansion Joints

- Degraded sealants and movement creating water pathways.

Structural Connections

- Unsealed beam penetrations and bolted or riveted joints are vulnerable to water ingress.

Cornices and Decorative Features

- Cracks and blocked drainage are causing water pooling.

Gutters and Downpipes

- Blockages causing overflow and water penetration.

Drainage Issues

- Blocked or absent weep holes.
- Poor ground grading directs water toward foundations.

Once inside the wall cavity, water can:

- Accumulate in void spaces created by historic construction methods.
- Come into direct contact with unprotected steel, especially where original coatings have degraded.
- Promote electrochemical reactions between steel and adjacent metals, accelerating corrosion.

Preventive measures:

- Regular inspections of roofs, walls, and foundations.
- Prompt repair of cracks, failed seals, and flashing.
- Proper maintenance of drainage systems, including weep holes.
- Application of corrosion-resistant coatings.
- Installation of waterproofing membranes in vulnerable areas.

By identifying and addressing these points of entry, the risks of water ingress and subsequent steel corrosion can be minimized.

ZINGA® protection:

ZINGA® provides a galvanic protection system, similar in principle to sacrificial anodes and hot-dip galvanising (HDG). ZINGA® generates a high electrical potential (approximately 1120 mV), creating strong cathodic protection. This potential comfortably exceeds typical corrosion cell voltages, meaning that the ZINGA® coating dominates and acts as an anode layer on the steel surface, effectively preventing corrosion.

ZINGA® also provides a superior “throw”, approximately 15 mm, offering reliable protection to nearby uncoated areas in the event of localised damage. In normal use, however, the entire steel surface is fully coated, and the throw acts as a secondary line of defense.

Figure 01

EXAMPLES OF RUST JACKING

The building shown here on figure 01 has experienced a horizontal form of rust-jacking, which has actually lifted the steel lintel (plus the weight of the stonework above it) off the blockwork below it. This demonstrates the amazing pressures that can be built up over time when steel or iron corrodes

The moisture ingress on the lower front of the stonework shows what can happen when the moisture subsequently freezes in the winter months, with the expansion of the ice exfoliating the surface of the stonework.

Figure 02

CORRODED BEAM

The photograph on figure 02 was taken by Mr. David S. Petterson (AIA) who is senior principal from WJE Architects based in Princeton, New Jersey. He is a specialist in investigation and repairs of the building envelope.

His photograph clearly shows that a 9 mm beam flange (3/8 inch) has corroded very badly over time, with the steel striating into layers and expanding to 41 mm in thickness (1 $^{5}/_{8}$ inches).

This is further evidence of the incredible pressures and stresses induced by rusting steel or iron.

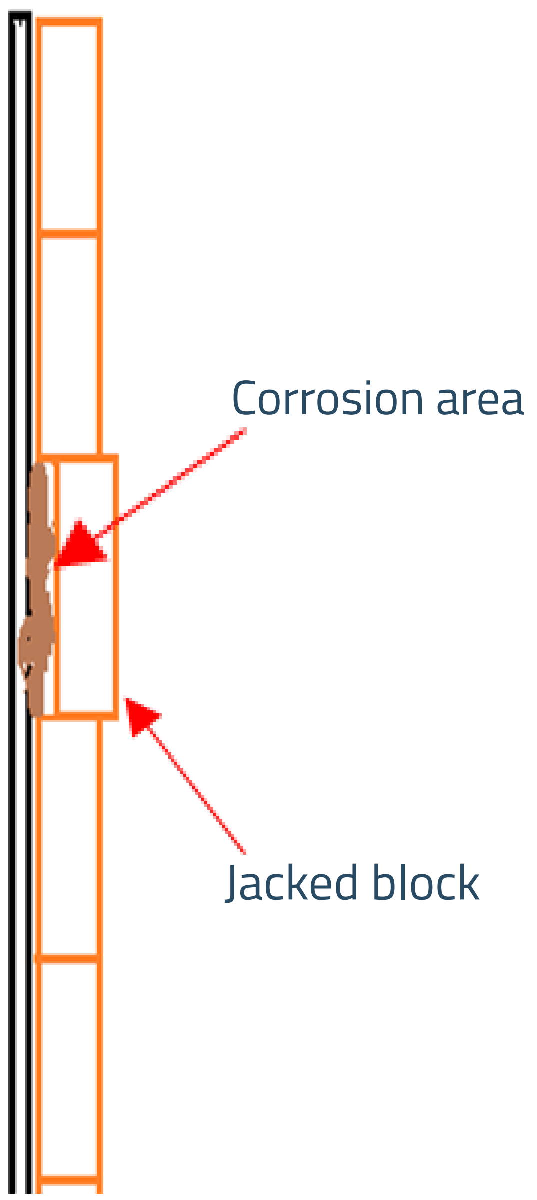
Figure 03

WOODEN WINDOW

In the photograph on figure 03, it can be seen that the steel lintel has corroded and expanded vertically, lifting the brickwork above the wooden window frame and also lifting the bricks within the supporting wall as well

This separation will weaken the structure quite severely, and it will require urgent remediation to prevent the damage from escalating any further to the point where structural failure will be taking place. There is, unfortunately, no short cuts or 'quick fix' methods to repair such damages.

BUILDING FACADE



On the left is a rough drawing giving a sectional view of a building façade, with a steel beam behind the stone blocks that has corroded half-way down its height. The corrosion taking place in that area has increased the original steel volume by up to 200% and the increasing rust-volume has 'jacked' the stone block out of place.

In a busy city street, a falling stone block would have catastrophic consequences, and so protecting the safety of buildings and consequently that of the public has become a large and highly specialized industry.

Surveyors who use laser-scanners will often scan from the building's roof-top in order to obtain the lowest possible angle of deflection from the front plane of the building, and in this manner a 3D scan will pick-up on the slightest out-of-alignment surfaces.

SURVEY

Figure 04

Modern façade inspection techniques play a vital role in the early detection of Regent Street Disease. High-resolution laser scanning is widely used to assess building façades with speed and precision. A full elevation can typically be scanned in under two hours. Surveyors usually position the scanner on the roof to achieve the lowest possible angle of deflection from the façade plane. This allows the 3D scanning system to detect even minute out-of-plane movements or displacements.

In practice, once a stone block has been displaced approximately 50 mm (2 inches) from the façade line, remedial action is generally initiated. This is because a displacement of this magnitude indicates that the steelwork behind the masonry has expanded significantly, most likely due to corrosion. he first operational step in any remediation program involves erecting scaffolding along the affected façade. In some cases, particularly on long street frontages, the scaffolding may extend across an entire city block.

This operation requires careful logistical planning, including partial road closures, traffic management, and delivery scheduling for scaffold materials.

Once the scaffolding is in place, stonemasons remove the displaced blocks to access the corroded steel behind them. In most instances, several adjacent stones must also be removed to give full exposure along the length of the affected beam. The removed stone blocks are placed on the scaffold decks and supported using protective measures to avoid any damage to their faces or edges.

Because many of these stone blocks form part of historic façades, they must be handled with extreme precision. Any damage to their surface or geometry would lead to additional fabrication and repair costs. This process also ensures that once the steel has been treated and protected, the original stones can be returned to their exact position, preserving the visual integrity of the building.

Figure 05

REMEDIATION METHOD

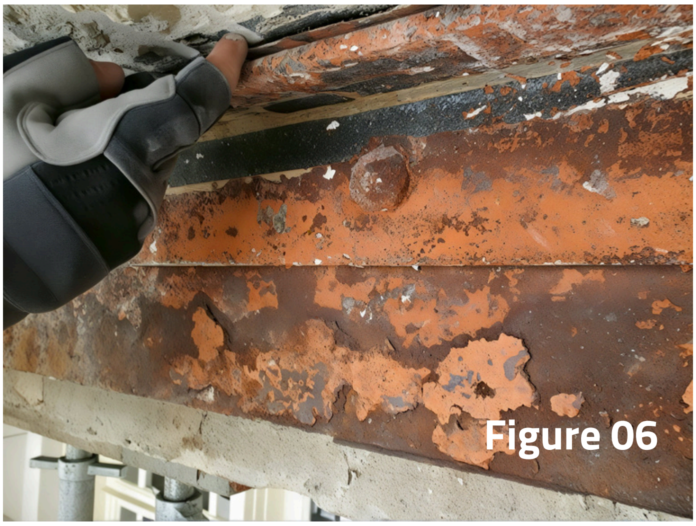


Figure 06

Due to the currently affected buildings always being in the center of London, the use of blast-cleaning equipment is forbidden unless it is inside the building. On building facades and roof-tops, the metal treatment process is normally carried out with the use of bristle-blasters and sharp needle-guns, and in some cases with wire cup brushes. As most power tools employ rotary discs or blasting belts, they are of no use to treat the inside surfaces of 90 ° corners and recessed surfaces, and so needle guns with very sharp needles can handle these awkward areas very well.

To gain access to the steel beams, hammer drills and chisels are used to remove the cement and concrete in which the beams have been embedded. The beam seen here on figure 07 is still partly coated with red lead primer, which was very popular back in the early 1900's right through to the 1970s.

Lead containing primers was only phased out in 1992 when it was replaced with red oxide pigment, but as far back as 1886 in Germany, a warning was given that such coatings were highly toxic. The steel surface underneath this coating has very little corrosion pitting to be seen, and this proves just how good this primer was in damp conditions.

Most of the beams in this condition can be treated on over 90% of their surface-area with a bristle-blaster and the 90° corners are treated with a needle gun with sharp needles. This usually gives excellent cleanliness, roughness and a very good adhesion value between the steel surface and the zinc, and guarantees a good electron-flow from the zinc coating into the steel surfaces, and subsequently with very good cathodic protection.

Figure 07

The concrete beam seen on figure 08 has had a slice removed from it using an angle grinder in order to inspect the integrity of the steel beam inside. It can be seen that the concrete was applied directly onto the surface of the steel, which had been coated with red lead.

The direct metal-to-concrete contact did not make any allowances for corrosion expansion of the steel beam's originally installed volume, so any expansion directly involved the concrete itself.

Figure 08

Where beams have had the concrete around them removed for an inspection, the concrete or stone above the beam is supported by machined bricks so that corroded beams can be treated and coated with ZINGA® before the concrete is replaced with fresh concrete or with a new layer of render. The one shown figure 08 is actually one of the areas within the walls of Shell Mex House.

Where an operator has glazed the surface of the corroded beam through being over-zealous in the cleaning phase, it is treated again with a bristle-blaster to produce the correct surface rugosity.

This photograph shown on figure 09 highlights the fact that volume expansion cracking can also induce lateral cracking across a beam, and not only longitudinal cracking that runs parallel to the steel beam.

This reveals the dangers of volume expansion cracking, because it can place dangerous loadings in unexpected places around a building.


Figure 09

This is a longitudinal crack running parallel to the hidden steel beam inside the concrete, and the damage done can be clearly seen below on figure 10.


Figure 10

Figure 11

Figure 11: This exposed section of a beam has been blast-cleaned, and the reverse face of the beam still has the original cement and brickwork in place. The beam continues to support all of the brickwork above it, and only the corroded faces of the beam were broken out to be treated,

Where a beam has long lengths of steel surfaces in tight contact with the cement or lime mortar, it is always a better option to use blast-cleaning where possible.

If sharp needle-guns are used, they can vibrate the steel beam and induce small air-gaps between the steel and mortar along the length of the beam. It is always better to maintain the intimate contact between these two surfaces in order to minimize the presence or free movement of moisture and oxygen. This removes two corners of the 'corrosion triangle'.

Figure 12

Well-trained technicians can access even some of the most awkward steel beams and successfully galvanise them before they are re-embedded in the concrete or lime render and then covered back in with stonework.

Figure 13


Figure 14

The broken-out beam on figure 14 shows a row of smaller stone blocks that have been returned to their original places, with the bedding cement being applied right up to the surface of the ZINGA® coating on the steel.

This type of refurbishment is completely acceptable in this environment, because the zinc coating will only ever expand to a maximum of 10% of its originally installed volume over 100 years.

Importantly, for this 10% extra volume to occur, the zinc layer would have to be kept wet over a long period of time, and with new cement or concrete being placed in these areas and subsequently covered with stone blocks, it would take many decades for enough moisture to accumulate to the point where the zinc would begin to produce such volumes of oxides.
With the rapidly decreasing sulphur levels in the air around London and other cities in the world, the potential for the production of zinc sulphates has also been vastly reduced, so the ZINGA® coating will automatically be covered in zinc oxides as per normal behaviour, and this can be clearly seen in the photograph at the top left.
During the days or weeks that the coated beam remains exposed to the atmosphere, the formation of zinc carbonates and simonkolleite takes place, and these cause the zinc to harden further whilst simultaneously increasing the adhesion values. They also seal any porosities within the zinc film, so if moisture was to reach the surface of the zinc coating after a few decades of service, it would normally not even produce the usual white oxides seen on zinc. In essence, this actually prevents the zinc corrosion products from even reaching the potential 10% volume excess and would keep it suppressed to less than half of that volume over a century.

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