Graeme Allen Consultancy Ltd

2023

Structural Report

Collapsed Balcony at

69 Albert Street

NW1 7LX

London

Prepared by

Dr. G. S Allen CEng MICE

For Client Susan Plowden

Dated September 2023

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1.0 Scope of Report

In September 2023 Graeme Allen Consultancy Ltd was asked to provide a structural report on the possible causes of collapse and remedies for a first floor front stone cantilever balcony of 69 Albert Street.

The balcony suddenly and unexpectedly collapsed at around midday on 1/9//23.

This is not a full structural survey and our report should not be used in the same way as a pre-purchase survey. It has been prepared specifically in connection with the instruction, noted above, and should not be relied on as a statement of structural adequacy. It does not deal with the general condition of the building, decorations, services, dampness, timber rot or infestation etc.

All directions are given relative to an observer facing the front of the property.

We have not commented on any part of the building that is covered or inaccessible.

The report is based upon a visible inspection of those areas freely accessible which by its very nature is limited.

An initial inspection took place on 8th September 2023 and a follow up inspection and investigation was carried out on 21st September 2023.

2.0 Description of Property and Balcony

The property comprises a Grade II listed four storey mid-terrace house built circa 1850 with solid external walls and a pitched roof.

There is a stone balcony at first floor level projecting 600mm.

The balcony, now collapsed, was original, constructed of stone possibly York stone.

The balcony had a cast-iron balustrade around its perimeter, connected to the main house, which fell with the stone balcony and fractured into multiple sections.

Many properties in the area benefit from similar balconies.

3.0 Investigations and Observations

3.1 Investigations

During our 2nd visit on 21/9/23 fragments of the balcony were re-assembled on the front patio for the purposes of measurement and closer inspection.

We were accompanied by labourer who were appointed directly by the owner to lift, move and re-assemble the debris into their original positions.

Two sections were too large to lift in one piece and these were broken at cellar level, lifted and re-assembled on the patio.

The balcony finishes of cement/mortar and bitumen were also collected and assembled however the majority of fractured sections were too small to replace as they were originally positioned.

One large piece of bitumen was located and re-assembled.

Sections of cast iron railing were also collected but not re-assembled.

3.2 Observations

We noted that the stone balcony failed at the abutment with the main house.

It was apparent that the embedded section of the balcony was intact.

It was also noted that the balcony had a surface bitumen cement coating of varying thickness 20-30mm overlying a cement/mortar bed of thickness 10-15mm.

The cement and bitumen layers had mostly de-bonded from the original stone, although some sections of cement mortar remained bonded to the stone.

We observed that the upper surface of the stone was noted to be uneven with signs of delamination.

The upper surface of the mortar bed was flat/level indicating that it may have been laid to level the surface of the deteriorated stone upper surface. Furthermore, the cement mortar bed was painted on its top surface indicating that it had been applied many years before the bitumen layer which we understand was in position in 1966 when the current owner moved into the property.

The bitumen layer was not well bonded to the cement mortar bed with no sections observed that were intact/joined.

The laid out sections of the stone balcony are shown in Figure 3.1 and Figure 3.2.

Figure 3.1 Balcony Sections

Figure 3.2 balcony Sections laid out

Regarding the condition of the stone, it was noted to be quite soft, fragments were quite easily broken with a hammer. The stone also appeared saturated, upper sections appeared de-laminated and these could be easily removed in places.

There was evidence to suggest that the bitumen layer had de-bonded from the cement mortar bed as there was localized dirt and debris on the lower surface of the bitumen and sections had warped.

We did not see any signs of weeds growing within the stone work or on the bitumen or within any of the cracked edges.

3.3 Images of balcony prior to collapse

We referred to google images (see Figure 3.3, below) which does not indicate any significant defects that would have alerted a layperson owner to likely collapse.

Figure 3.3 Google image prior to collapse

3.4 Collateral damage

Collateral damage occurred to the stone steps, railings and ground floor windows.

At ground floor there is damage to the timber window frame and surround, internally (see Figure 3.5) and the shutters now do not close properly.

As a result of the collapse the cast iron balcony railings were damaged as they were connected to the stone balcony, although the railings did not form an integral part of its structural purpose.

Figure 3.4 Balcony railing sections

Figure 3.5 Internal damage

In addition, damage occurred to the ground floor steps, ground floor railings and window.

4.0 Discussions

Balcony collapse is a rare occurrence as the current owner has lived at the property for circa 60 years and this is the first time a balcony has collapsed to their knowledge.

There are various reasons why a balcony's stability and condition may be compromised. Sometimes inherent weaknesses associated with the original design and construction are revealing themselves later in the life of the building, as for example poor structural properties of the materials, thin stone sections, or inadequate embedment of the stone slab into the masonry wall.

Two main failure mechanisms have been identified for the balcony element:-

- bending failure of the cantilever stone section or
- shear failure
- failure of the embedment into the building.

Inspection of the balcony revealed that the balcony failed at the junction with the house with the embedded stone still in place indicating that failure occurred at the junction with the house by bending or shear and not by inadequate embedment.

4.1 History

Based upon the examination we suggest that the original stone balcony showed signs of water ingress, delamination and unevenness prior to 1966.

At least 20 to 30 years prior to 1966 a cement mortar bed was applied to the top surface of the original uneven/delaminated stonework to level the surface and this was subsequently painted over.

In or around 1966 the bitumen layer was in place above the cement mortar.

Regarding bending, the stone balcony is of minimum thickness 60mm and allowing for 2N/mm2 tensile strength the balcony resists its own weight plus cement and bitumen finishes plus residential live loading. See calculations in Appendix.

Note variation in tensile strength depending on source of the stone, condition etc and could vary from assumed values.

See table in Appendix also indicating how strength of balcony reduces with effective depth and reduction in tensile strength.

Note that owner advises in June 2023 the window cleaner was standing on the balcony with no problem at the time.

4.3 Shear failure

Shear strength of stone estimated to be 0.1N/mm2 and in this case stone in good condition 60mm thickness would support self-weight plus live loading of 1.5kN/m2 with an overall safety factor of 2.22.

4.4 Embedment failure

The balcony did not fail by loss of embedment and the remaining sections connected to the main house were rigid without any undue movement.

4.5 Bitumen Finishes

Crucially the main difference between the neighboring intact balconies and the subject balcony, is the later applied finishes. It is alleged that the long term performance of the balcony was adversely affected by the finishes in particular comprising of bitumen layer.

As previously mentioned, the cement/bitumen finishes which had been applied to the balcony would not have significantly increased the loading and allowing for 2N/mm2 tensile strength the stone strength is adequate.

4.6 Cement/Bitumen obscuring Cracks

We now considered what effect the cement/bitumen finish would have had.on the balcony.

Firstly, the bitumen finish would have obscured any cracking to the underlying stone therefore signs of collapse would not have been readily apparent.

Figure 4.1 Larger section of intact bitumen finish

See Figure 4.1 showing the large section of bitumen that covered the left side stone surface within the window reveal. Crucially the bitumen section is intact and

this would have fully obscured cracking to the stone work below, at the junction, which would have ordinarily alerted a homeowner to a potential problem.

4.7 Thermal Stress Fracture

Another theory is that the thermal movement of the cement/bitumen finish differed from that of the underlying stone. Over time expansion and contraction of the cement/bitumen layer would have stressed the stone at the junction leading to cracking which could have progressed eventually reducing effective stone thickness at the junction, and reduced the effective safety factors for shear and bending.

4.8 Reduced stone thickness left side

Upon close inspection of the laid out sections we noted that the stone was only 40mm thick on the left-hand side, adjacent to a railing embedment.

Given the 40mm thickness it is possible that failure initiated on the left hand side and progressed to the reminder of the balcony.

Note calculations indicate that balcony stone of 40mm thickness would be liable to collapse in bending at the junction.

Most of the fragments were found in the cellar on the left side which would tend to support this theory, ie failure initiating on the left side..

Figure 4.2 Left corner of balcony thinning edge

Figure 4.3 top view

4.9 General

These balconies have stood the test of time however weathering on the surface can adversely affect strength and reduce resistance to shear and bending at the junction with the main house, where maximum bending and shear forces are concentrated.

4.10 Reinstatement

With regard to reinstatement this needs to be considered very carefully, and in particular

- need to check with listed building, planning whether the balcony can be re-placed with reinforced concrete or reconstituted stone to imitate the stonework,
- whether brackets can be used underneath and
- whether the existing stone needs to be removed that is embedded in the building and
- whether an alternative design can be adopted incorporating reinforcement or
- whether the balcony needs to be replaced exactly as it was originally constructed.

Reinstatement is not considered in detail within this report.

5.0 Summary and Conclusions

The damage was unexpected and occurred without warning.

Various causes have been considered however we are of the opinion that the collapse was related directly to the 20-30mm thick cement/bitumen finishes applied many years ago.

Firstly, the surface bitumen layer may have obscured cracks to the stone below or alternatively caused stress fractures over time as the thermal properties of the cement/bitumen and stone differed.

It would not have been reasonable to assume that an elderly property owner would have expected collapse to occur and there is no evidence that growing weeds or vegetation or poor maintenance by homeowner led to the collapse.

The collapse was an accident and not reasonably foreseeable in the circumstances.

Careful consideration to re-instatement should be given, complying with all relevant planning and listed building requirements.

Signed  Dated 28 September 2023

Dr. Graeme Allen CEng MICE

6.0 General Notes Concerning the Report

The report is concerned with the main structural components of the property (main house) which confer significant strength, stability, and integrity, such as main walls, beams and floors. Non-structural fabric such as timber partitions, non load bearing walls, plaster, render, windows and doors etc have not been considered. We have not commented on external features separate from the house such as garden sheds/summerhouses, retaining walls, pavings or swimming pools for example.

We have not checked fire resistance, means of escape, insulation, use of high alumina cement or calcium chloride, calcium silicate brickwork, calcium silicate reaction in concrete, cavity wall tie failure, contamination on the site, wood wool slab permanent shuttering, asbestos, radon gas seepage PBCB, alkali silicate reaction, party wall requirements, wall tie failure or concrete, timber or steel deterioration for example.

The report is not a guarantee that structural problems will not develop in the future and is an opinion of the damage at the time of the inspection.

We have not opened up the structure to inspect any beams or supports or inspected any structural drawings or checked calculations for any extensions or alterations and have assumed that they were constructed in accordance with building regulations and that satisfactory certificates/approvals were obtained. No measurements or calculations have been made of the load bearing capacity of the foundations, floors or other elements of the structure unless otherwise stated and they are therefore assumed to be suitable for the present or proposed use. Inspection covers have not been lifted. An additional instruction and separate fee would be charged where such checks are required to be carried out.

Any costing provided are approximate estimates only and the actual cost can only be ascertained once builder's quotes have been obtained.

Our report and damage description should not be used in the same way as a pre-purchase survey and should not be relied on as a statement of structural adequacy or general condition of the property.

Access was limited during the inspection and access to heights will be limited to the use of a 2m ladder. If access to higher areas is required, by prior agreement with the client a cherry picker will be used and the direct cost of the same will be added to the inspection fee. This will not be undertaken without the client's agreement.

The report should not be construed as an implied warranty in relation to the structure. Graeme Allen Consultancy will not be liable to any third parties for any loss, consequential or otherwise, as a result of the information given in the report.

Owners are advised to ensure that the property is fully insured for the normal perils including Subsidence heave and landslip.

The opinions in this report are based upon a visual inspection only to those areas that were freely accessible without opening up the building fabric and for the owners use. No inspection of the foundations or areas buried beneath the structure, behind cladding or obscured by furniture/carpets or fittings has been made. Where further investigations are required this will be noted within the report. However there is always the possibility that there are hidden defects which cannot reasonably be established from a standard structural engineer's inspection.

The report is prepared for the client i.e. the person who pays the invoice and Graeme Allen Consultancy Limited do not accept any liability to any third party. Accordingly, the client should not publish our report in any way (including extracts from it), without our prior written consent, and none of the terms of our engagement are enforceable pursuant to the Contracts (Rights of Third Parties) Act 1999 by anyone other than the parties to it.

Acceptance of the report implies acceptance of these conditions.

7.0 Additional Photos

Intact Balcony at Number 71

Cement mortar and bitumen pieces laid out on front patio

Cement mortar and bitumen pieces laid out on front patio

Stonework balcony sections laid out on front patio

Balcony debris in front cellar

Stone section note embedded railing shoe

Stone balcony section 60mm thickness


Stone balcony section-central joint

Stone sections being laid on front patio in original positions

Stone sections being laid on front patio in original positions

Bitumen 30mm thickness

Cement mortar bed 10mm thickness

Internal damage to frame at ground floor level

Stone sections

Left side window reveal, showing fracture at junction

Left side window reveal, showing fracture at junction and delamination of upper surface

Large bitumen section obscuring cracks and condition of underlying stone balcony

8.0 Appendix

Calculations

calculations for bending and shear of stone balcony, assuming 2N/mm2 tensile and 0.1N/mm2 shear with varying thicknesses of stonework and finishes. Can be modified if actual tensile and shear strength are established.

		70mm thickness stone			**40mm thickness stone**			reduced tensile strength	
shear strength		0.1	N/mm2		0.1	N/mm2		0.1	N/mm2
tensile strength		2	N/mm2		2	N/mm2		1	N/mm2
stone thickness		**70**	**mm**		**40**	**mm**		70	mm
cement/bitumen		30	mm		30	mm		30	mm
loading		1.5	kN/m2		1.5	kN/m2		1.5	kN/m2
length		0.6	m		0.6	m		0.6	m
applied load		2.9	kN		2.3	kN		2.9	kN
applied moment		0.87	kNm		0.69	kNm		0.87	kNm
z modulus		0.00081667	m3		0.00026667	m3		0.00081667	m3
applied bending stress		1065.30612	kN/m2		2587.5	kN/m2		1065.30612	kN/m2
applied bending stress		1.07	N/mm2		2.59	N/mm2		1.06530612	N/mm2
FOS bending		**1.88**			**0.77**			**0.94**	
applied shear stress		0.04142857	N/mm2		0.0575	N/mm2		0.04142857	N/mm2
FOS shear		**2.41**			**1.74**			**2.41**	