file note

Subject: Survey Summary
Project: 249 West George Street
Reference: FN 002 REV3
Author: PAH

1.0 Background

Woolgar Hunter have conducted and reviewed several historical drawing searches, surveys and inspections of the existing building since 2014. The following is an overall summary of the current status of the building for the current owner. It should be noted that the most recent survey works took place in 2019 and further deterioration of the façade is likely to have occurred.

A selection of the survey references has been included in the appendix.

The investigation confirmed that -

The breaking out confirmed that the sandstone facing had been "glued" to the concrete backing. The sandstone could not be easily removed from the concrete backing and could be considered to be "fully bonded".

Once the sandstone had been removed a pair of corroding reinforcing bars were observed. These bars had zero concrete cover. It is considered highly likely that expansive reinforcing bar corrosion of the bars within the backing concrete has been the cause of the historical detachment problems.

The façade has a malignancy in the form of Calcium Chloride contamination embedded within its build up.

We are of the opinion that the chloride contamination of the concrete backing is due to the incorporation of chloride containing admixtures at the time of production of the cladding panels. Calcium Chloride ($CaCl_2$) can be added to concrete at the time of production as a strength gain accelerator.

This chloride contamination is likely to have contributed to the observed corrosion of the reinforcing bars to the concrete backing to the sandstone.

Further that the cause of the cracking was likely

In summary, the detachment of the sandstone from the concrete backing is due to expansive corrosion of the reinforcing bars within the concrete backing.

The reinforcing bar corrosion is likely to be due to combination of contributing factors as follows:-

a) The fact that the sandstone facing to the panels is a porous material is likely to have allowed the ingress of moisture into the concrete.
b) The fact that the protective concrete cover to the reinforcing bars is zero.
c) The fact that the concrete backing is chloride contaminated.

2.0 Key Findings

There are several key findings that should be highlighted.

- The sandstone faced precast concrete cladding units will continue to be a maintenance liability and "inspect, repair and patch" is, in our opinion, no longer an appropriate approach or long-term solution.
- The original recommendation was that that the existing facings are stripped off; the reinforced concrete repaired and coated; and a new rainscreen cladding system installed. This is likely to result in the replacement of existing windows and will also require consent from the Planning Authority. The structural capacity of the reinforced concrete elements will require to be checked with respect to the installation of the rainscreen over cladding.

    - The original strategy was to remove the stonework and replace however the stone has been both mechanically fixed with reinforcement and chemically bonded to the concrete column. Therefore, the removal of the exiting sandstone facing, when trialed, proved a slow and difficult process, and inconsistent.

    - Unfortunately, investigations into historical drawings identified that the precast/sandstone cladding is load bearing above level 1; ie the elevational concrete panels support the floor slabs. As such removing and repairing localised precast/stonework sandwich would have significant structural works challenges which would involve temporary works and back propping and would have to be done on a sequential (slow) basis, which would be outwith the scale of any project and therefore not viable.

- Woolgar Hunter also carried out detailed investigations into the reinforcement cover of the existing structural elements and developed the attached report (Appendix 2) within the appendix. The results for the columns were positive, in that the cover would allow 60 minute fire protection to be achieved. However, the cover to the slabs is inadequate. As such any "change of use" for the existing building would require the team to enhance the fire protection to all slabs, through intumescent coating or fire boarding. The result of which could further reduce the available floor to ceiling and therefore the viability of alternative uses for the building.

3.0 Moving Forward

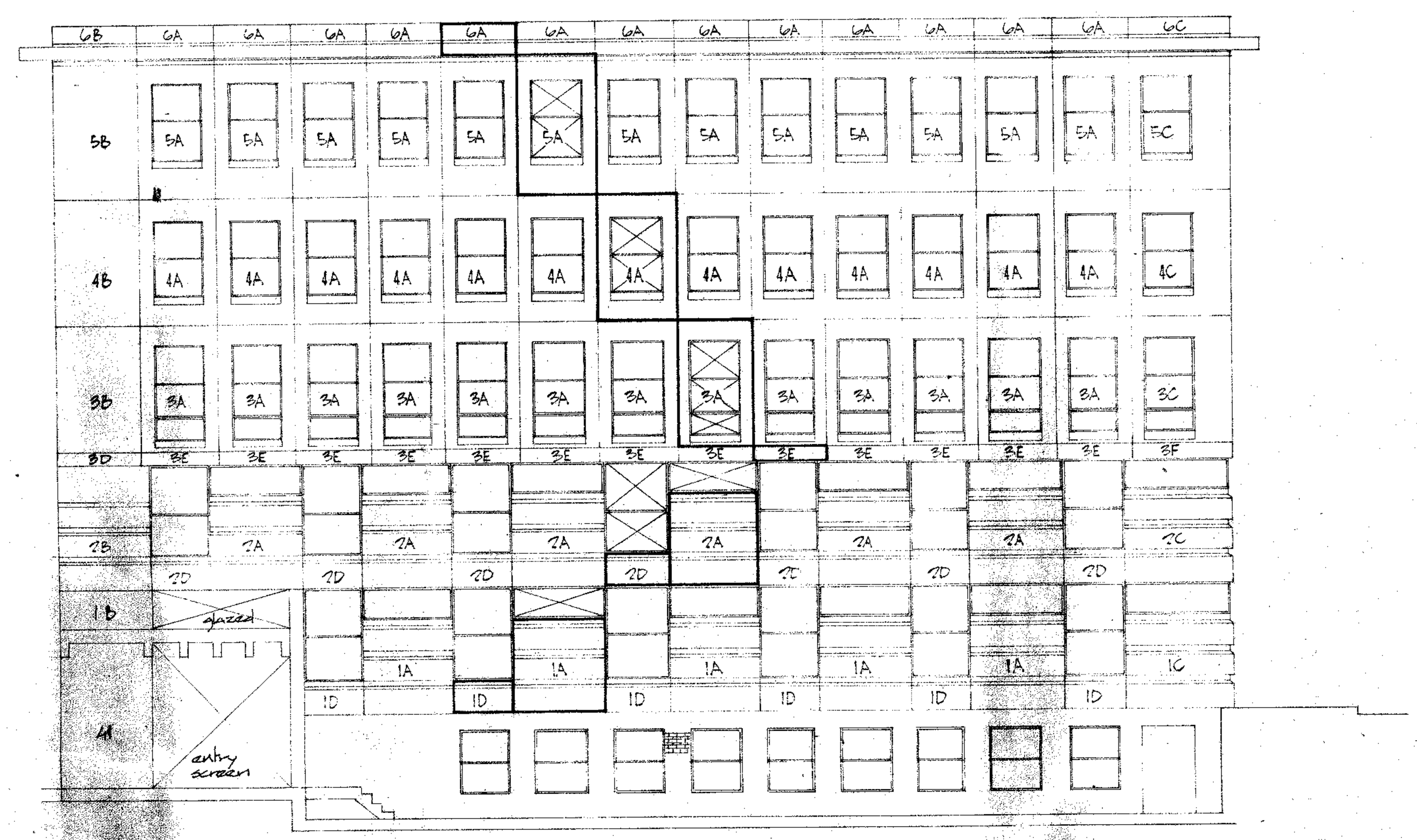
From the extensive investigation and research undertaken to date, it is our opinion that there are only two realistic and financially viable options are -

- Option 1; the building is reduced to ground level, where strengthening and fire protection works are carried out and the frame is reconstructed making use of the existing basement, and possibly the ground floor slab. This approach would allow a new constrained building to be constructed. The building would be limited by the existing foundation and the original column grid which may limit the viability and success of the new development, limiting the city's economic growth opportunities from the building.
- Option 2, the building is demolished, with site won material recycled and re-used where possible. A practical and sensible modern building could then be developed with the key focus on the whole life carbon and the importance of densification of the city centre and the resulting economic growth

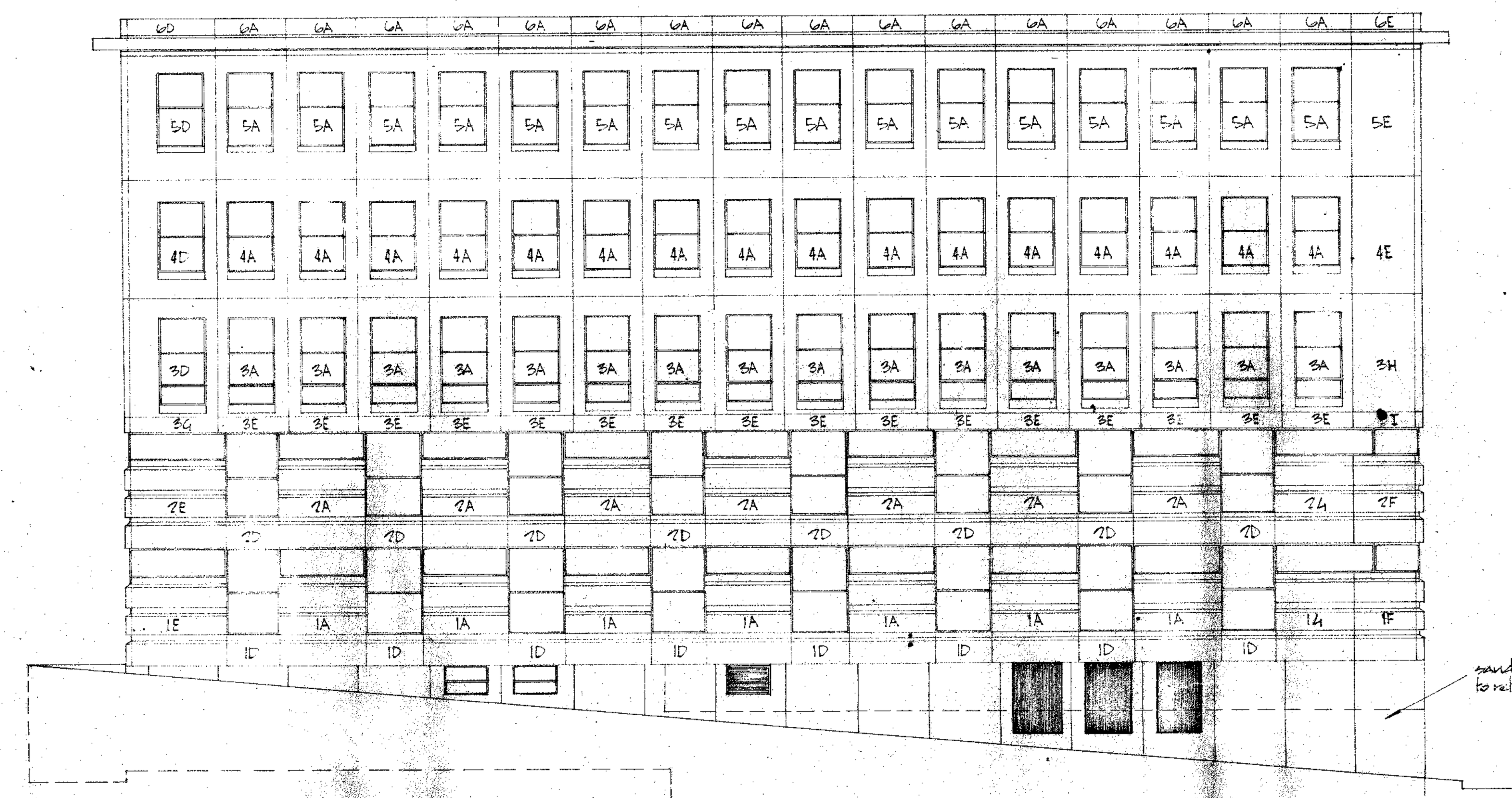
It should be noted that the façade in its current condition is a going concern and we re-iterate the importance of ongoing inspection surveys on a regular basis and continued patch repairs.

end

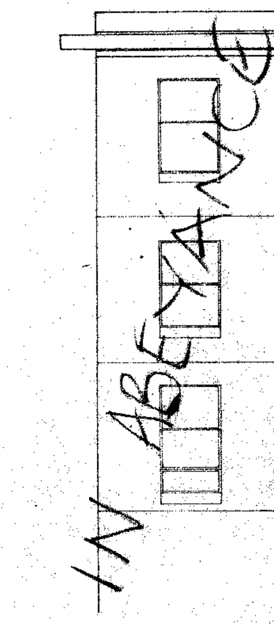
Ref : PAH/ file note re Survey Update / 131138/ prepared 180122



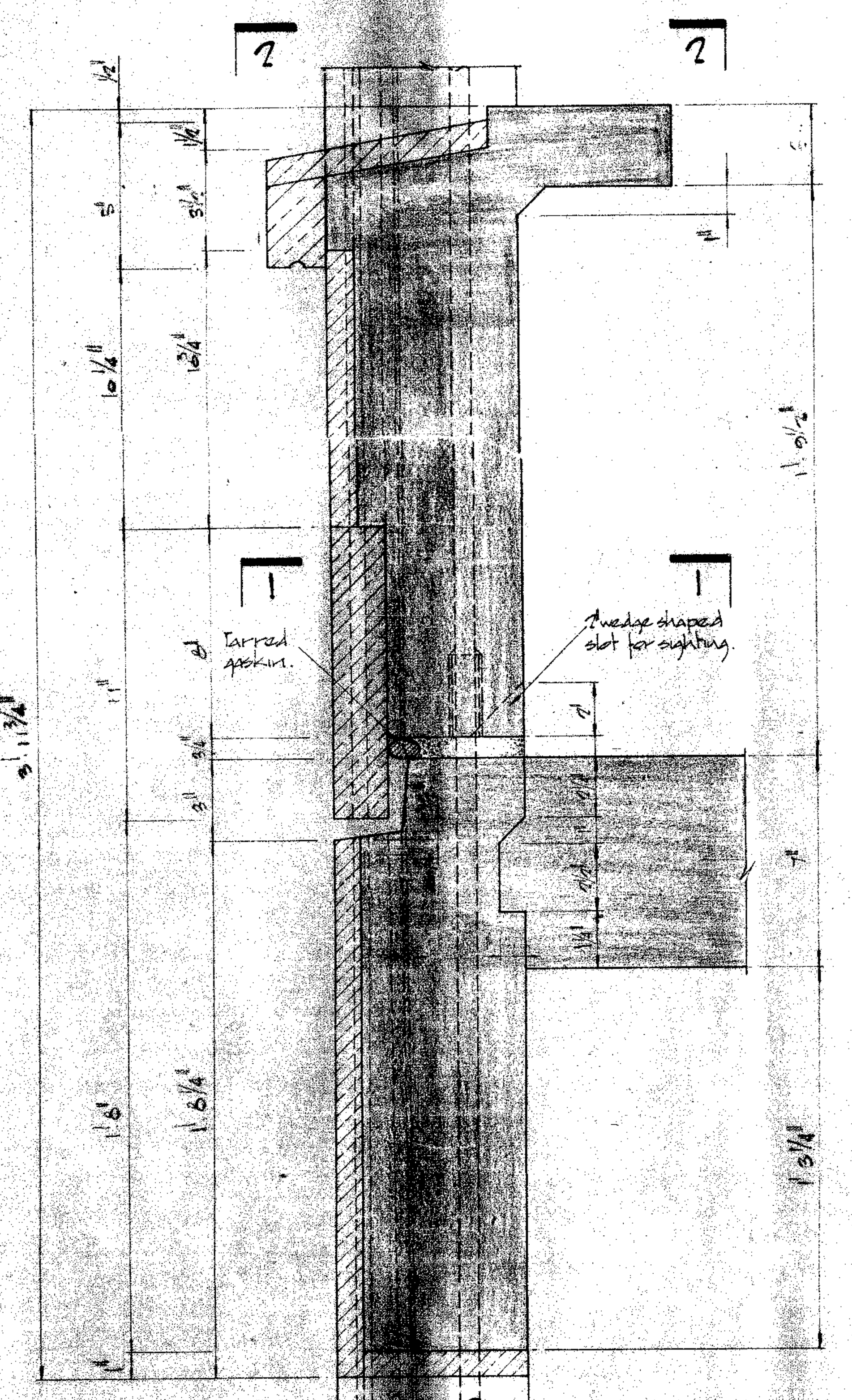
WEST GEORGE STREET ELEVATION



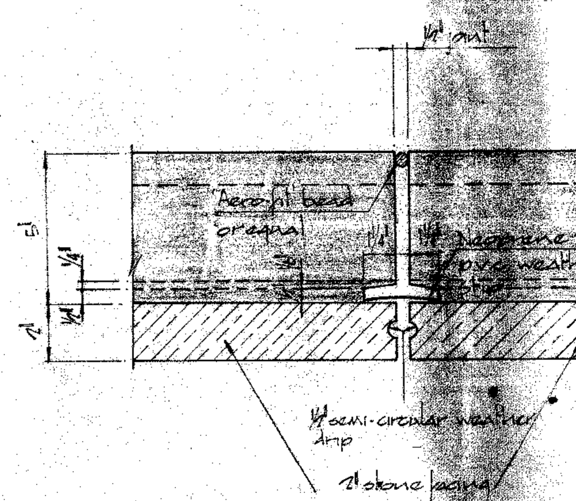
BLYTHSWOOD STREET ELEVATION



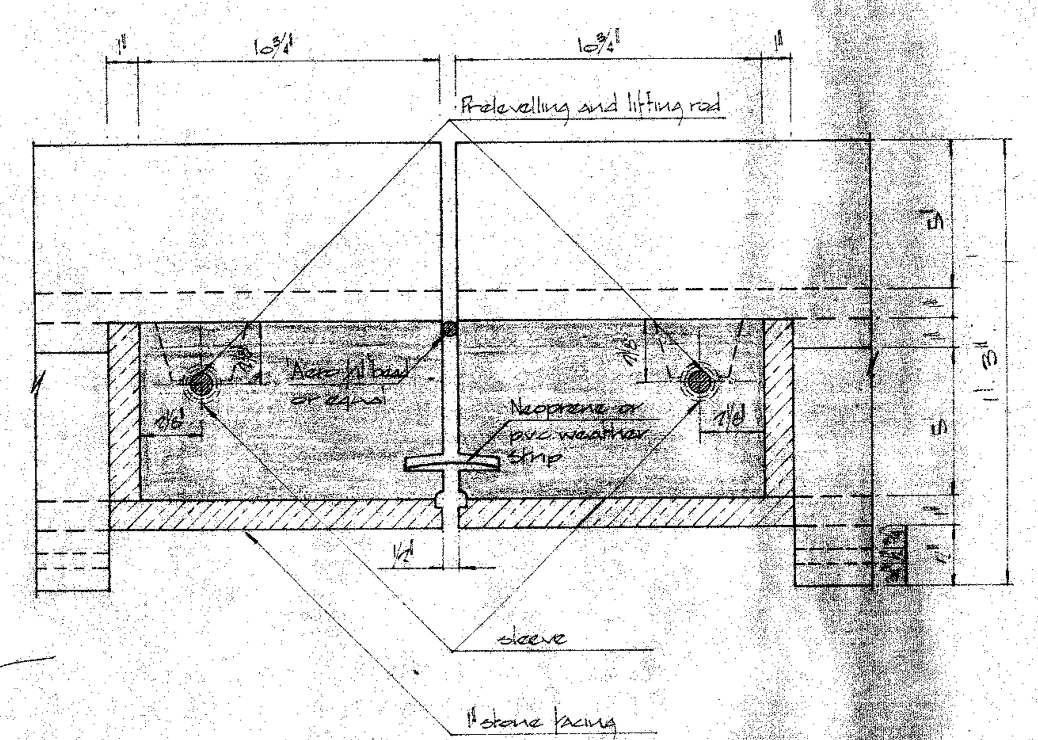
WEST GEORGE LANE ELEVATION



VERTICAL SECTION THROUGH FLOOR/PANEL JUNCTION
4TH & 5TH. FLOORS.



SECTION 1·1



SECTION 2·2

ACCOMPANYING APPROVED PLAN No. 16.
- 9 OCT 1970
Clerk of Court.
Dean of Guild Court (Buildings Authority) of the County of the City of Glasgow.

GLASCOW. 22 /7/70
Accompanying Sheet 16.
R. Seifert Co-Prtnrs.
Agent.

UNIT TYPE	Nº OFF	UNIT TYPE	Nº OFF
4A	29	1A	13
4B	1	1B	1
4C	1	1C	1
4D	1	1D	15
4E	1	1E	1
5A	29	1F	1
5B	1	2A	13
5C	1	2B	1
5D	1	2C	1
5E	1	2D	15
6A	29	2E	1
6B	1	2F	1
6C	1	3A	29
6D	1	3B	1
6E	1	3C	1
1G	1	3D	1
2G	1	3E	29
3G	1	3F	1
3H	1		
3I	1		

REVISION	DATE	REMARKS

OFFICE PREMISES
249 WEST GEORGE STREET

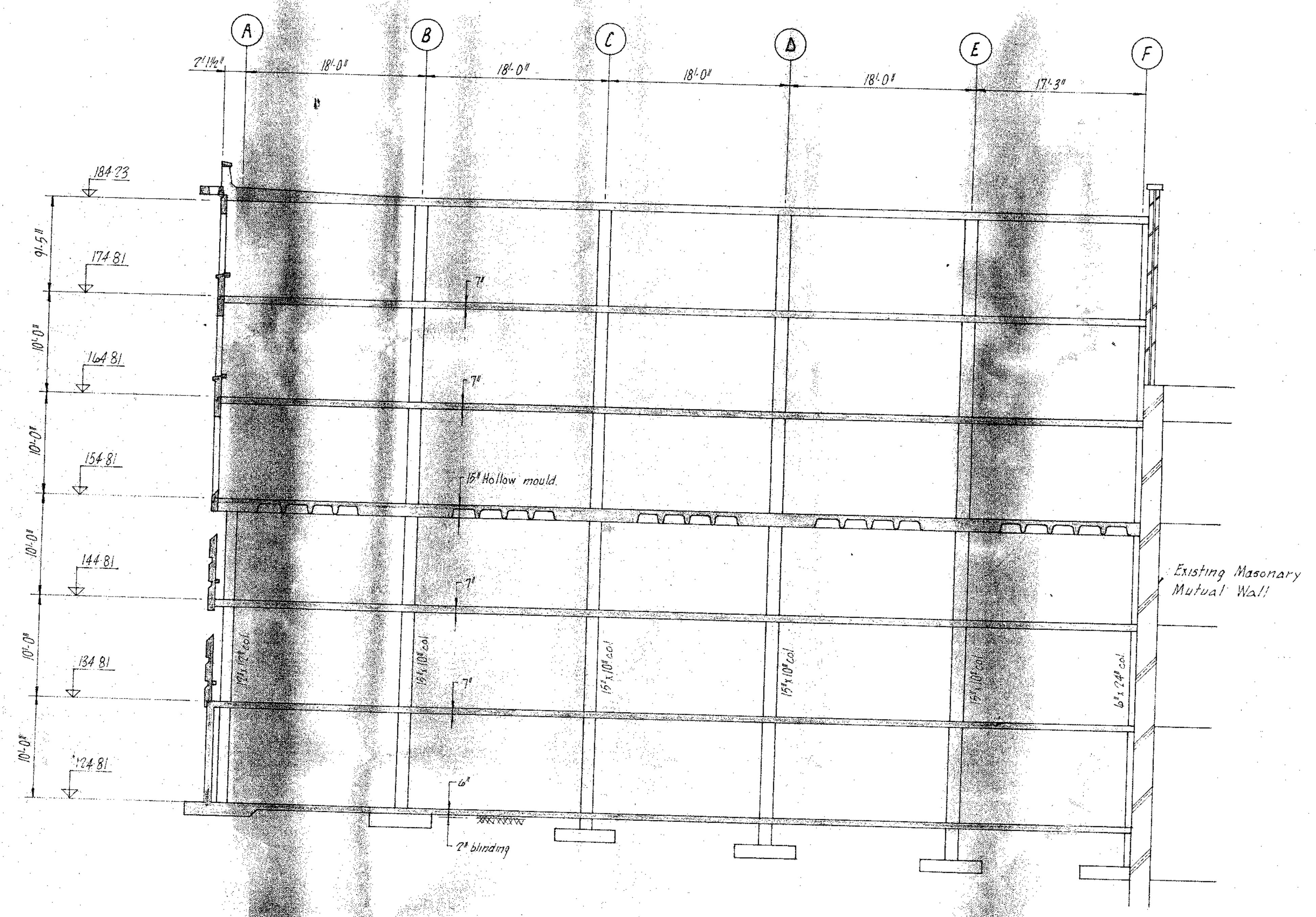
LAYOUT OF PRECAST CLADDING UNITS
AND JOINT DETAILS

R. SEIFERT CO-PARTNERSHIP
CHARTERED ARCHITECTS
TRAFALGAR HOUSE
HOPE ST. GLASGOW C.1.

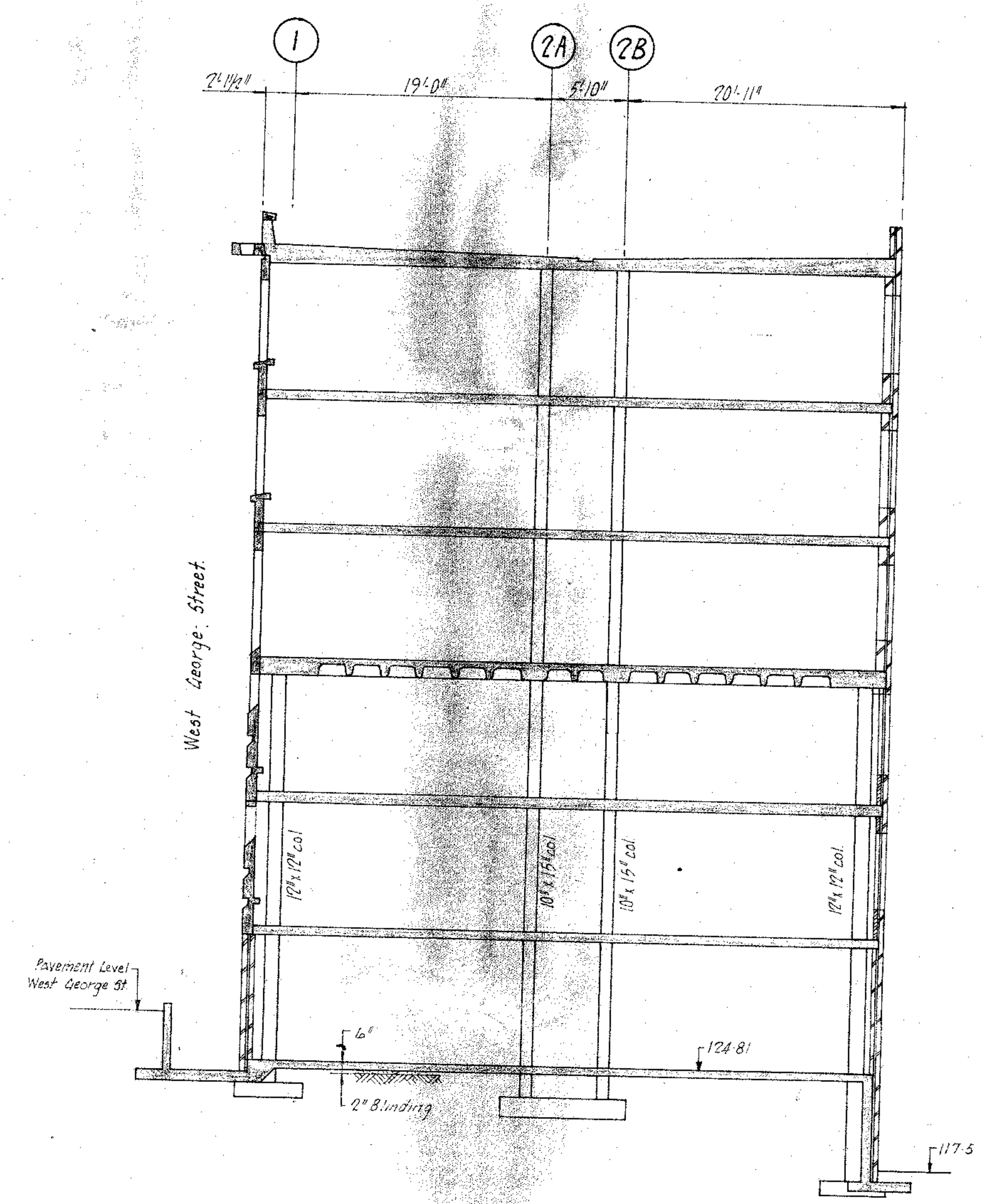
JOHN DEWAR & PARTNERS
CONSULTING STRUCTURAL ENGINEERS
154 WEST GEORGE STREET
GLASGOW C2 041 332 2571

SCALES 1/8" & 3" to 1'.0"
DATE 21·7·70
DRN. BY
DRAWING No. 537/8

(1970/86)

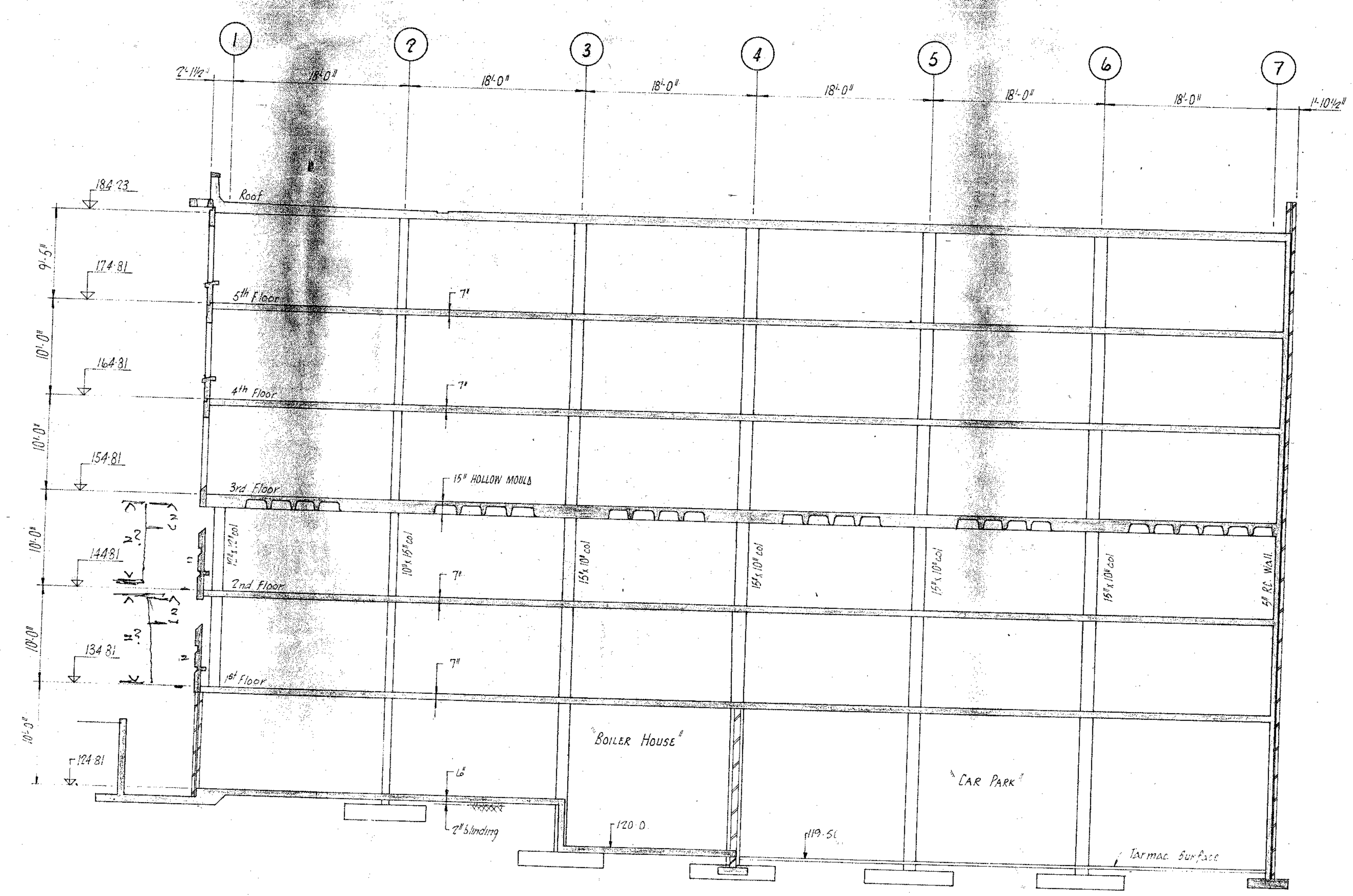


LONG SECTION - GRID LINE 2

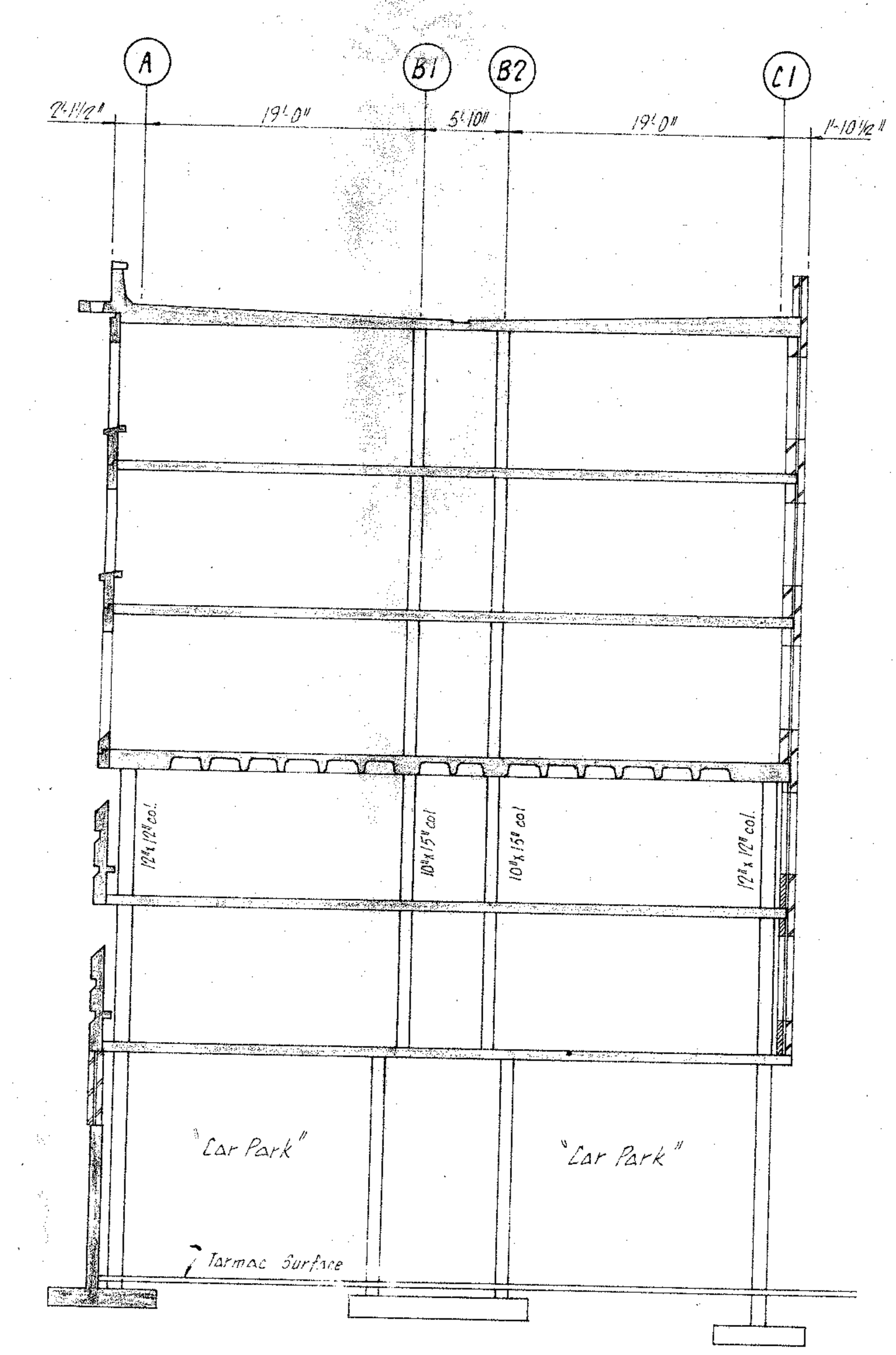


CROSS-SECTION - GRID LINE E

ACCOMPANYING APPROVED PLAN No. 164.
-9 OCT 1970
James Murray Clerk of Court.
Dean of Guild Court (Buildings Authority of the County of the City of Glasgow.)



LONG SECTION - GRID LINE B



CROSS-SECTION - GRID LINE 5

GLASCOW. 241/170
Accompanying. Sheet 14.
R. Seifert Co-Prtnrs.
Agent.

REVISION	DATE	REMARKS

OFFICE PREMISES
249, WEST GEORGE STREET.

SECTIONS THRO' BUILDING

R. SEIFERT CO-PARTNERSHIP
ARCHITECTS AND PLANNERS
TRAFALGAR HOUSE, HOPE STREET,
GLASGOW C.1.

SCALES 1/8" - 1'-0"
DATE 30·7·70
DRN. BY
DRAWING No. 537/3

JOHN DEWAR & PARTNERS
CONSULTING STRUCTURAL ENGINEERS
154 WEST GEORGE STREET
GLASGOW C2 041 332 2571

file note

From : Alex Paun
Date : 10/02/2017
Subject : 249 West George Street – Structural Element Cover for Fire Resistance & Removal of Sandstone Panels Timing
Reference : 131138

The purpose of this file note is twofold:

A) To inform about the cover findings of certain structural elements found during the structural investigation carried out by HTA on the 24&25th of January 2017.
B) To estimate the duration of sandstone façade panels removal both on West George Street & Blythswood street, based on site works timing during the same structural investigation.

A) Cover to Structural Elements

During the structural investigation carried out by HTA, the following covers have been found:

- 1st floor Internal Column -> B/01 -> 75 mm nominal cover of vertical bar
- 1st Floor External Column -> B/02 -> 65 mm nominal cover of vertical bar
- 2nd Floor Slab Soffit -> B/03 -> 15 mm nominal cover to face of main bars
- 3rd Floor Waffle Slab Rib -> B/05 -> 23 mm nominal cover to face of main bars (the 2 bars are not centred on rib – see Plate 20 picture) -> side cover is less than 23 mm from picture at this location.
- 5th floor Internal Column -> B/07 -> 40 mm nominal cover of vertical bar
- Roof Slab Soffit -> B/08 -> 11 mm nominal cover to face of main bars

From the structural investigation findings we can identify 2 structural elements:

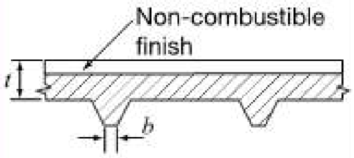
- Columns – min cover recorded = 40 mm
- Slabs (two-way span) – min cover recorded = 11 mm
- Waffle Slabs – min cover recorded = 23 mm

Cover Minimum Fire Resistance Requirements

1) Eurocode 2

By analysing the requirements for Fire Resistance recommended by IStructE based on Eurocode 2, we can see the following:

Table 5.1 Fire resistance requirements for slabs

Standard fire resistance (R) in minutes	Plain soffit solid slab (including joist + block) Minimum overall depth (mm)	Ribbed soffit (including T-section + channel section)  Minimum thickness/width, (mm/mm)		Flat slabs Minimum overall depth (mm)
		Simply Supported	Continuous	
		t/b	t/b	
R 60	80	80/120	80/100	180
R 90	100	100/160	100/120	200
R 120	120	120/190	120/160	200
R 180	150	150/260	150/310	200
R 240	175	175/350	175/450	200

	Axis distance to reinforcement, a (mm)				
	Simply supported	Continuous	Simply supported	Continuous	Flat slabs
R 60	20[a]	10[a]	25[a]	25[a]	15[a]
R 90	30[a]	15[a]	40	35[a]	25[a]
R 120	40	20[a]	55	45	35[a]
R 180	55	30[a]	70	60	45
R 240	65	40	75	70	50

Notes
- a For practical purposes the axis distance should be such that the minimum cover is 20mm.
- b The axis distance, a is measured from the surface of the concrete to the centre of the main reinforcing bars.
- c The axis distance, a should be increased by 10mm for prestressing bars and 15mm for prestressing wires or strands.
- d For other combinations of rib width and axis distance see EC2, Part 1-2[2].
- e Where a is 70mm or more refer to EC2, Part 1-2[2] for additional requirements.

<u>Note b</u> states that cover dimension a is measured from the centre of the bar to the face of the concrete. However, this depends on the dia. of the bar chosen. For safety it would be more conservative to take those figures to the face of the bar and not to the centre of it.

By comparing the figures above with the findings on site we can see that R60 fire resistance class will not be achieved for either of the two slab types.

Table 5.15 Fire resistance requirements for columns with rectangular or circular section

Standard fire resistance (R) in minutes	Minimum dimensions (mm) Column width b_{min}/axis distance, a, of the main bars			
	Column exposed on more than one side			Exposed on one side
	μ_{fi}[a] = 0.2	μ_{fi} = 0.5	μ_{fi} = 0.7	$\mu_{fi} \leqslant 0.7$
R 30	200/25	200/25	200/32 300/27	155/25
R 60	200/25	200/36 300/31	250/46 350/40	155/25
R 90	200/31 300/25	300/45 400/38	350/53 450/40[b]	155/25
R 120	250/40 350/35	350/45[b] 450/40[b]	350/57[b] 450/51[b]	175/35
R 180	350/45[b]	350/63[b]	450/70[b]	230/55
R 240	350/61[b]	450/75[b]	–	295/70

Notes

a μ_{fi} is the ratio of design axial load in the fire situation / the design resistance of the column at normal temperature conditions. It is unlikely to exceed 0.7.

b Minimum 8 bars with a bar at the centre of each face.

c The axis distance, a, is measured from the surface of the concrete to the centre of the main reinforcing bars.

d The axis distance, a, should be increased by 10mm for prestressing bars and 15mm for prestressing wires or strands.

For columns exposed to fire on more than one side, for a cover of 40 mm a fire resistance class of R60 can be achieved with less than 8 bars in the column.

2) BS8110:Part 1: 1997

By analysing the requirements for Fire Resistance based on BS8110, we can see the following:

Minimum dimensions and cover for fire resistance periods

Member	Requirements	Fire rating hours					
		0.5	1.0	1.5	2.0	3.0	4.0
Columns fully exposed to fire	Minimum column width Cover*	150 20	200 20	250 20	300 25	400 25	450 25
Walls (0.4 to 1% steel)	Minimum wall thickness Cover*	100 20	120 20	140 20	160 25	200 25	240 25
Beams	Minimum beam width Cover for simply supported* Cover for continuous*	200 20 20	200 20 20	200 20 20	200 30 40	240 40 60	280 50 70
Slabs with plain soffits	Minimum slab thickness Cover for simply supported* Cover for continuous*	75 20 20	95 20 20	110 25 20	125 35 25	150 45 35	170 55 45
Ribbed slabs (open soffit and no stirrups)	Minimum top slab thickness Minimum rib width Cover for simply supported* Cover for continuous*	75 125 20 20	95 125 20 20	110 125 35 20	125 125 45 35	150 150 55 45	170 175 65 55

* Cover required to all reinforcement including links. If cover >35 mm special detailing is required to reduce the risk of spalling.

Source: BS 8110: Part 1: 1997.

Comparing the survey finding with the BS Fire resistance requirements one can see that a 2h fire resistance for the columns can be achieved.

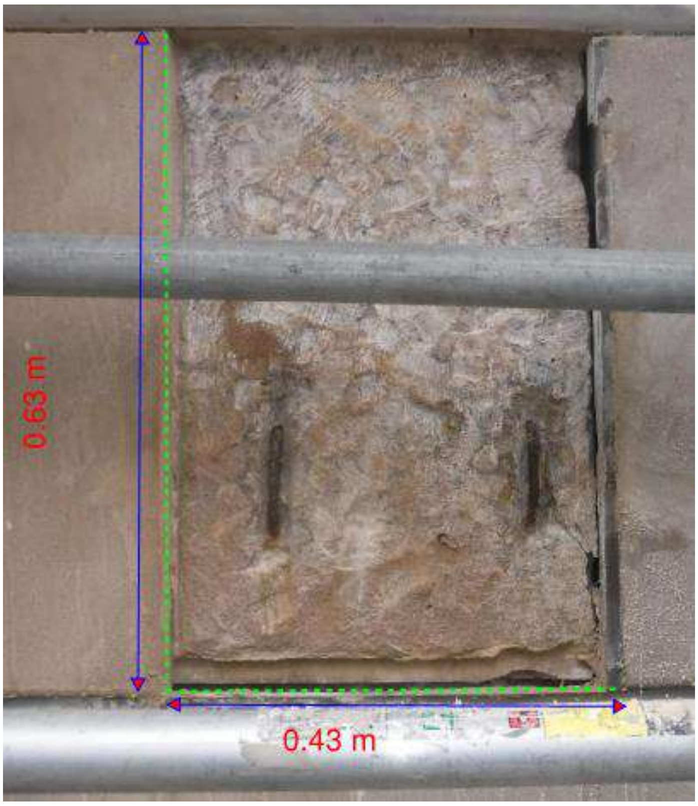
In addition, the minimum cover for slabs is 20 mm which is more than the 11 mm found on site, therefore the 30 min fire resistance will not be achieved.

B) Removal of Sandstone facings – Estimated duration

Based on site timings during the survey, it was observed that there were 2 types of panels depending on the time taken to remove them:

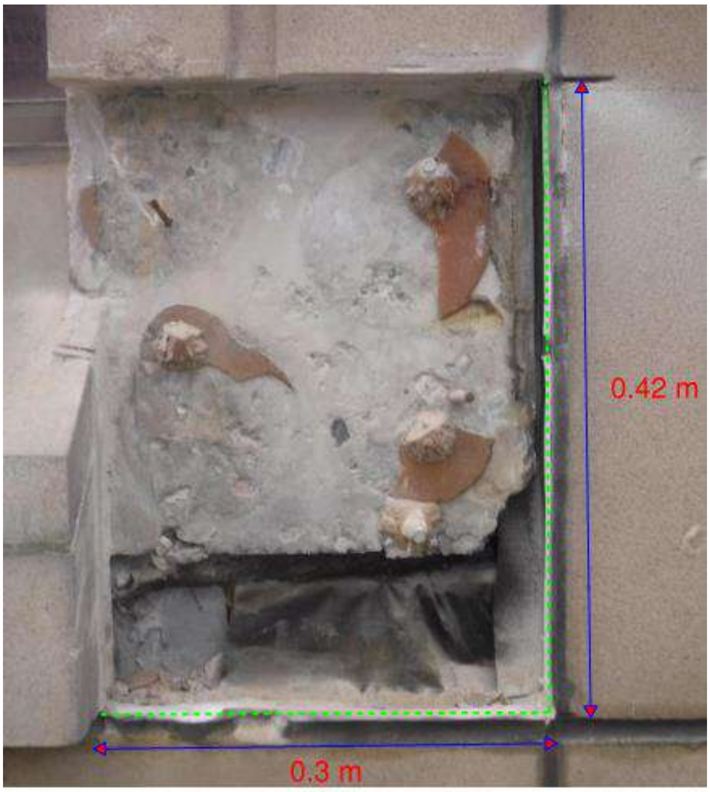
1) Fully bonded panels – 0.27m2 of sandstone facing took about 30 min to remove during the structural investigation.

Extrapolating, to remove 1 m2 of sandstone facing would therefore take approx.. 110 min.



2) Previously Pinned Panels – 0.126 m2 of sandstone facing took approx. 1 min to remove during the structural investigation.

Extrapolating, to remove 1 m2 of sandstone facing would therefore take approx.. 8 min.



From a raw estimation of the 2 types of sandstone panels, it was found that:

	Total Area (m^2)	Glazed Area (m^2)	Pinned Area (m^2)	Pinned Panels Duration of Removal (min.)	Fully bonded Area (m^2)	Fully bonded panels Duration of Removal (min.)
West George Street elevation	542	194	34.5	276	313.5	34485
Blythswood Street elevation	613.5	212.5	54	432	347	38170

Therefore, West George Street pinned area will take 276 min. (4.6 h) to be removed while the fully bonded area will take approx.. 34485 min. (575 h) to be removed.

Using the same method, the pinned area on Blythswood Street will take roughly 432 min. (7.2 h) to be removed, while the fully bonded area of the façade will need to take around 38170 min. (637 h) to be removed.

These numbers were obtained by extrapolating the timings identified during the site investigation works. Also, the pinned areas were determined using the mark-ups produced during a previous inspection carried out on the 13th of March and 3rd of April 2016. Mark-ups of these can be found attached at the end of this document.

West George Street Elevation - Pinned Area Mark-up

Blythswood Street Elevation - Pinned Area Mark-up

Report on Condition of Cladding on Main Elevations

249 West George Street

Carrigmay Glasgow (Jersey) Ltd

WoolgarHunter engineers

Document Information and History

Project Title: 249 West George Street
Client: Carrigmay Glasgow (Jersey) Ltd
Project No: 131138

version	date	description	author	reviewed by
V1.00	05.05.2016	First Issue	A.Porter	W.Neilson

Note: Version status
V1.00 series - draft issues
V1.10 series - formal issue

bsi. ISO 9001 Quality Management

Content

1.0 Introduction

1.01 Woolgar Hunter were instructed by Pick Everard, acting on behalf of Carrigmay Glasgow (Jersey) Ltd, to undertake an updated detailed close inspection of the cladding on the main street elevations of 249 West George Street, Glasgow.

Woolgar Hunter were requested to comment on any aspects of the main facades that could be an ongoing maintenance liability.

1.02 The property has previously been a subject to a close inspection by Woolgar Hunter on 1st February 2014 from a mobile access platform. This report should be viewed as a follow up report, to examine and comment on the ongoing condition of the façade and should be read in conjunction with the main report dated 1st of February 2014.

1.03 The close inspection on the West George street elevation was undertaken on 13th of March and an inspection of the Blythswood Street elevation was undertaken on the 3rd of April. Both inspections took place from a mobile access platform. The weather was dry during the inspection of the West George Street elevation but wet and windy during the inspection of the Blythswood Street elevation.

2.0 General Description

2.01 Existing Structure

The building dates from 1970 and essentially comprises a six storey insitu reinforced concrete frame, carried on 375mm and 450mm thick reinforced concrete pad footings. The building is “L” shaped on plan and has twin spine columns some 1770mm apart.

The superstructure is somewhat unconventional as there is a 380mm thick “waffle” transfer slab at third floor level. The perimeter columns stop at third floor level, with the perimeter structure above consisting of loadbearing PC Panels to the street elevations and a 225mm thick loadbearing inner leaf to the rear elevation.

Apart from the third floor slab, the suspended floor slabs are 178mm thick flat slab with the sixth floor slab surface being laid to fall towards the building spine. The floor panel size is 6m x 5.5m or thereby. The top (sixth floor) storey was originally two penthouses, and consists of loadbearing masonry walls with a timber roof structure: the elevations being set back from the main elevations. There is also a large tank room at sixth floor level.

Lateral stability appears to be provided by a mixture of masonry gable infill and RC shear walls at the main lift core.

2.02 Existing Elevations

The street elevations consist of 175mm thick, sandstone faced, precast concrete panels with the upper storeys, above third floor level, being loadbearing “window” panels. On the first and second storeys, the panels are non-loadbearing and are not full height due to the presence of an upper strip of ribbon window in each storey. The ground floor storey is conventional cavity masonry. The rear and gable elevations are cavity masonry with a facing brick external leaf. There is a 225mm thick loadbearing brickwork inner leaf above third floor level on the rear and gable elevations. The ground floor storey to Blytheswood Street is partly a reinforced concrete retaining wall with sandstone facings.

2.03 The precast cladding panels appear to have been formed by casting reinforced concrete onto 40mm thick sandstone facings. The thickness of the sandstone varies locally to suit the façade detailing.

2.04 The archive drawings show the "window" panels on the upper floor to have reinforcement located adjacent to the internal face of the panel, with the reinforcement being continuously coupled over the height of the façade above third floor level i.e. linking through the edges of the insitu floor slabs.

2.05 The connection of the panels on the first and second storeys is not clear from the archive drawings. However, as the panels have to cantilever from the edge of the supporting slabs, it is likely that a similar detail has been adopted albeit with the addition of a fixing bar on the outer edge to resist positive lateral wind pressures.

2.06 There is a projecting ladder feature at sixth floor level. This is formed in reinforced concrete with sandstone facings and copper capping.

2.07 There is a short sandstone faced return on the southern gable.

2.08 The panel joints are surface sealed and the archive drawings show a hidden sealing strip inserted into grooves in the panel edges.

3.0 Observations

3.01 It is apparent that some areas of the sandstone facings have been subject to remedial works consisting of the insertion of pins. There are two types. The first type would appear to be circular pin grouted into a 10mm diameter hole and the surface sealed with a sandstone plug. Some of these pins are difficult to see due to the weathering of the sandstone and are likely to have been in place for some time. The other type of pin consists of a square cut hole, possibly to accommodate a washer plate, with the holes filled with coloured mortar. A number of the pinned areas sound boss (hollow) when tapped.

3.02 There are a number of cracks in the sandstone facings, generally less than 1mm in width. Most of the cracks have been previously repaired but a number have re-cracked and some are recent.

There are a number of cracks which have either occurred in the period since the last inspection or have been repair but since deteriorated (see photographs 3,4,5)

3.03 As per point 3.02, there are a number of additional cracks in the cills which have either subsequently formed since the last inspection and have not been repaired, or have been repaired and increased in size.

3.04 There is some surface weathering of the sandstone facing at high level and, above the ladder feature, at pavement level on the Blytheswood Street elevation and on generally on the window cills.

Generally speaking, at the upper levels the facing sandstone is generally weathered directly above and below the windows. (See photographs 7,8 and 9)

3.05 The mastic pointing to the panel joints is in reasonable condition, with only one or two areas requiring attention (see photographs 6)

3.06 There is local circular discolouration of the surface of the sandstone (Photographs 1 and 2) Although there was no evidence of pinning at these locations, it is possible that a non-visible ferrous element could be corroding.

3.07 Panels were tapped to assess the fixity of the panel to the main load-bearing walls. Locally, where there was visible pinning, some of the panels sounded bossed (hollow). Panels with no visible pinning or remedial works were also tapped and generally appeared sound, however panel (6/6) on the Blythsewood Street elevation sounded boss, with no visible remedial pinning.

4.0 Discussion

4.01 The previous reports note's a number of defects in the cladding panels, with particular respect to the sandstone facings.

4.02 It is apparent from the previous reports that there has been an ongoing maintenance issue with the cladding panels for a number of years and that this is likely to continue. The reports make specific reference to annual inspections and recommend that these continue.

4.03 The reports offer no opinion as to the cause of the problem and offer no solutions other than periodic inspection and repair.

4.04 It is apparent that the sandstone faced precast cladding units will continue to be a maintenance liability. Historically there have been issues of lack of bonding of the sandstone facings to the reinforced concrete backing which have necessitated remedial pinning. The pinning appears to have been a reactive solution to identified problems. There remains a risk that further delamination may occur in the future to other areas, such as the areas referenced in point 3.07. The local cracking is probably due to corrosion of ferrous elements with minimal concrete cover as a result of the permeable nature of sandstone. The historic response to the cracking would appear to be to simply repair the crack rather than to investigate and rectify the cause.

4.05 The observations made in this report indicate that the condition of the sandstone facing has deteriorated further since the initial inspection.

5.0 Conclusions and recommendations

5.01 It is apparent that there has been some further deterioration of the sandstone facing since the last inspection. In the interim, new cracks and boss panels should be pinned.

5.02 The sandstone faced cladding units will continue to be a maintenance liability and "inspect, repair and patch" is, in our opinion, not an appropriate approach.

5.03 We recommend that the existing facings are stripped off; the reinforced concrete repaired and coated; and a new rainscreen cladding system installed. This is likely to result in the replacement of existing windows and will also require consent from the Planning Authority. The structural capacity of the reinforced concrete elements will require to be checked with respect to the installation of the rainscreen overcladding

5.04 The out-of-plumb panels on the first and second storeys should be dealt with in a similar manner as the upper storeys with the rainscreen being installed truly vertical.

5.05 In the absence of the remedial action noted in points 5.03 and 5.04, it is advised that further periodic inspections are carried to out in order to identify any potential safety issues as the condition of the faces continue to deteriorate.

LIMITATIONS AND CONSTRAINTS

a) This report is intended for the use of Carrigmay Glasgow (Jersey) Ltd. It is not intended for the use of third parties in terms upon which it can be relied.

b) No intrusive opening up of the building fabric has been undertaken in order to determine the nature or condition of structural elements.

Photographs

Photograph 1 Example of local discolouring

Photograph 2 Example of local discolouring

Photograph 3 - Instances of cracking worsening

Photograph 4 Example of crack worsening


Photograph 5 New Cracking, Blytheswood elevation panel 5/7

Photograph 6 - Mastic Seal Broken (Panel 4/7, Blytheswood Street elevation)

Photograph 7 - General Weathering Pattern

Photograph 8 - General Weathering – Ground level facing

Photograph 9 Cill Weathering and spalling


Photograph 10 Pointing on panel 3/9

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Date: 09th February 2017

For the attention of Mr. Alex Paun/ Mr Sandy Porter

FACTUAL REPORT ON THE STRUCTURAL INVESTIGATION TO 249 WEST GEORGE STREET, GLASGOW

File Number – L-1447-2017

Report prepared by:-

Drummond Henderson (Director)
For Henderson Thomas Associates, Ltd

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1.0 INTRODUCTION

Henderson Thomas Associates were instructed by Woolgar Hunter Consulting Engineers (Mr. Alex Paun) to carry out a structural investigation to 249 West George Street, Glasgow.

The purpose of the investigation was twofold: -

a) To determine the cause of the de-lamination of the buildings sandstone external cladding panels.
b) To determine certain as-built reinforcing bar details from the buildings internal floor slabs and columns.

The works were generally carried out in accordance with Woolgar Hunters 'Scope of Works' document.

The site works were carried out from Tuesday 24th January 2017 to Wednesday 25th January 2017 by a four-man team from Henderson Thomas Associates Ltd.

The works were carried out under the supervision of Woolgar Hunters engineers Mr. Alex Paun and Mr Sandy Porter.

The location of the areas under investigation was decided by Mr. Alex Paun.

Three samples (D1, D2, D3) were recovered as part of this investigation and were given our unique sample reference SSN 0455.

Structural and geotechnical matters are outside the scope of this report and all opinions expressed in this report are not covered by the scope of our UKAS accreditation.

2.0 BACKGROUND

HTA understand from Mr. Sandy Porter that there has been an ongoing problem of cracking and partial detachment of the buildings external sandstone cladding panels.

Because of this problem, it has been decided to remove and replace the entire population of sandstone panels. HTA were commissioned to determine the ease with which the panels could be removed and the likely cause of the detachment problem.

Prior to attending site RAMS were submitted and approved.

Access to the buildings external cladding panels was via an aluminium alloy access tower that was drilled and bolted to the building (see plates 1 and 2).

The location of the areas selected for sampling and investigation were chosen by Mr Sandy Porter.

3.0 SITE WORKS

The site works consisted of the following: -

a) The provision of an aluminium alloy access tower.
b) The taking of in-situ photographs (see appendix B).
c) The removal of three sandstone panels from the exterior of the building identifying fixing method.
d) The break out of 8 No. reinforced steel bars (B/01- B/08). Photographs of the breakouts are presented in appendix B and the breakout details are presented in appendix A.
e) The reinstating of all 8 No. breakouts and the dust drilling locations with repair mortar.

4.0 DISCUSSION OF SITE WORKS

4.1 INTERNAL CONCRETE BREKOUTS

Photographs of the concrete breakouts are presented in appendix B and the breakout logs are presented in appendix A.

4.2 CLADDING PANEL INVESTIGATION

Photographs of the three removed sandstone panels are presented in appendix B.

All three panels selected for investigation were accessed from an alloy tower.

The lower of the three panels was cut at a corner with a diamond tipped saw to allow access to attempt to breakout the sandstone facing from the concrete backing.

The breaking out confirmed that the sandstone facing had been "glued" to the concrete backing. The sandstone could not be easily removed from the concrete backing and could be considered to be "fully bonded".

Once the sandstone had been removed a pair of corroding reinforcing bars were observed. These bars had zero concrete cover. It is considered highly likely that expansive reinforcing bar corrosion of the bars within the backing concrete has been the cause of the historical detachment problems.

The sandstone facing could not be removed intact but broke into numerous small fragments (see plates 3 to 5). There was no evidence of bossing to the sandstone facing at this location.

Two further smaller sandstone panels were removed from a more elevated location, either side of a window cill. At both of these locations attempts had been made to affix the sandstone to the concrete backing by drilling holes through the sandstone into the concrete and inserting resin stainless steel rods.

Despite these attempts to "tie back" the sandstone to the concrete both panels were easily removed with only a few blows of the hammer action drill. At both of these locations the panels were debonded from the concrete substrate (see plates 6 to 9).

5.0 DISCUSSION OF LABORATORY TESTING

All three concrete dust drilling samples (D1 – D3) were analysed to determine the chloride ion content of the concrete. The samples were recovered from the concrete backing to the sandstone fronted precast cladding panel units.

The samples were analysed under sub-contract to Quartz Scientific Ltd. The certificate of analysis is presented in appendix A.

The limited testing undertaken has confirmed that the concrete backing to the pre-cast cladding panel units is chloride contaminated to a "Low/Medium" level.

Given the elevated location of the samples it is highly unlikely that the chlorides have insressed into the concrete since the time of construction due to the use of de-icing salts in the winter months.

We are of the opinion that the chloride contamination of the concrete backing is due to the incorporation of chloride containing admixtures at the time of production of the cladding panels. Calcium Chloride ($CaCl_2$) can be added to concrete at the time of production as a strength gain accelerator.

This chloride contamination is likely to have contributed to the observed corrosion of the reinforcing bars to the concrete backing to the sandstone.

6.0 SUMMARY

In summary, the detachment of the sandstone from the concrete backing is due to expansive corrosion of the reinforcing bars within the concrete backing.

The reinforcing bar corrosion is likely to be due to combination of contributing factors as follows:-

a) The fact that the sandstone facing to the panels is a porous material is likely to have allowed the ingress of moisture into the concrete.
b) The fact that the protective concrete cover to the reinforcing bars is zero.
c) The fact that the concrete backing is chloride contaminated.

7.0 QUALITY STATEMENT

HTA confirm that all reasonable skill and care has been exercised in the production of this report. We confirm that all comments and opinions expressed in this report are based solely on the locations at which data was acquired.

This report is for the sole use of the named client only (Woolgar Hunter) and this report should not be re-produced without the written permission of Henderson Thomas Associates Ltd.

Appendix A

REINFORCING BAR BREAKOUT LOGS
& LABORATORY TESTING RESULTS

INTERNAL BREAKOUT LOGS

Breakout B/O1:-
Location: Column base 1st floor (internal column)
Main (vertical) Reinforcement Exposed: 1 No. Square twisted bar, Section = 31mm
Main Reinforcement Cover = 75mm (excluding plaster)
Link Reinforcement – not exposed
Link bar spacings at 375, 260, 295 C/C
Slight surface corrosion, no loss in section

Breakout B/O2:-
Location: Column 1st floor level (external column)
Main (vertical) Reinforcement Exposed: 1 No. Square twisted bar, section = 25mm
Main Reinforcement Cover = 65mm (excluding plaster)
Link Reinforcement - not exposed
Link bar spacings at 300mm nominal C/C

Breakout B/O3:-
Location: 2nd floor slab underside
Reinforcement bars exposed in both directions: both 12mm dia. Knurled bars
Reinforcement Cover = 15mm
Bars @ 100 to 190mm C/C in both directions

Breakout B/O4:-
Concrete breakout B/O4 was not undertaken

Breakout B/O5:-
Location: 2nd floor waffle slab rib underside
Main Reinforcement Exposed: 2 No. square twisted bars, Section = 24mm
Main Reinforcement Cover = 23mm

Breakout B/O6:-
Location: 3rd floor top surface of cantilevered section of floor slab.
Floor coverings and topping screed were removed
Main Reinforcement Exposed: 1 No. knurled bar, Diameter = 15mm
Main Reinforcement Cover = 78mm (including topping screed)
Main bars @ 170, 140, 205, 185, 155, 155, 105mm C/C

Breakout B/O7:-
Location: 5th floor internal column
Main Reinforcement (vertical) Exposed: 1 No. Square twisted bar, Section = 24mm
Main Reinforcement Cover = 40mm (excluding plaster)
Link Reinforcement Exposed: 1 No. Plain round bar, Diameter = 8mm
Link bar spacings at 260 to 280mm C/C

Breakout B/O8:-
Location: underside of roof slab
Reinforcement Exposed: 2 No. square twisted bars, Section = 12mm
Cover = 11mm
Bars @ 170 to 270mm C/C in both directions

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CERTIFICATE of ANALYSIS

249 West George Street, Glasgow

Chloride content of concrete samples

Date received	:	3 February 2017
Mass received	:	31 to 46 g
Type of sample	:	concrete dust
Date of analysis	:	3 February 2017
Method of testing	:	B.S.1881:Part 124:1988.

Sample ref.	Client's ref.	Chloride content	
		% by mass of	
		sample	cement
726	D1	0.05	0.37
727	D2	0.03	0.21
728	D3	0.04	0.32

Note: 14 % cement content was assumed for the calculations.

End of report

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Appendix B

SITE PHOTOGRAPHS

Plate 1 – Showing a general view of Alloy Tower.

Plate 2 – Showing a general view of Alloy Tower.

Plate 3 – Showing a general view of Bottom Panel breakout.

Plate 4 – Showing a close up view of Bottom Panel Bar. Bottom Left Corner.

Plate 5 Showing a close up view of Bottom Panel Bar. Bottom Right Corner.

Plate 6 – General Shot of Top right-hand side panel breakout.

Plate 7 – General Shot of Top right-hand side panel breakout.

Plate 8 – General Shot of Top left-hand side panel breakout.

Plate 9 – Close up Shot of Top left-hand side panel breakout.

Plate 10 – Showing a close up shot of drill hole D1 on lower panel breakout

Plate 11 – Showing a close up shot of drill hole D2 on top left-hand side breakout

Plate 12 – Showing a close up shot of drill hole D3 on top right-hand side breakout.

Plate 13 – Showing a general view of breakout B/O1 (internal column 1st floor).

Plate 14 – Showing a close up view of breakout B/O1.

Plate 15 – Showing a general view of breakout B/O2 (perimeter column 1st floor).

Plate 16 – Showing a close up view of breakout B/O2.

Plate 17 – Showing a general view of breakout B/O3 (underside of 2nd floor slab).

Plate 18 – Showing a close up view of breakout B/O3.

Plate 19 – Showing a general view of breakout B/O5 (underside of 2nd floor waffle slab rib).

Plate 20 – Showing a close up view of breakout B/O5.

Plate 21 – Showing a general view of breakout B/O6 (top of 3rd floor slab).

Plate 22 – Showing a close up view of breakout B/O6.

Plate 23 – Showing a general view of breakout B/O7 (5th floor internal column).

Plate 24 – Showing a close up view of breakout B/O7.

Plate 25 – Showing a close up view of breakout B/O7. Note link.

Plate 26 – Showing a general view of breakout B/O8 (underside of roof slab).

Plate 27 – Showing a close up view of breakout B/O8.

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