Exchequer Court
25-51 St.Mary Axe and
9 St.Helen's Place
London EC3

Appraisal and Testing of Retained Elements

Library of Documents
Volume 12

Waterman Partnership
Supplementary Report

Waterman Partnership

EXCHEQUER COURT
25 - 51 ST. MARY AXE
AND
9 ST. HELEN'S PLACE
LONDON E.C.3

ASSESSMENT AND TESTING RETAINED STRUCTURES

SUPPLEMENTARY REPORT FOR PHASES 1 - 6 INCLUSIVE

DECEMBER 1994 (8859/A)

SUPPLEMENTARY REPORT
FOR
PHASES 1 - 6 INCLUSIVE

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SUPPLEMENTARY REPORT
FOR
PHASES 1 - 6 INCLUSIVE

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1.0 INTRODUCTION

1.1 On 10th April 1992 a terrorist bomb, estimated by Royal Ordnance as equivalent in size to 450 kg of high explosive exploded in the back of a van parked in St. Mary Axe, London E.C.3.

The approximate location of the bomb is shown on the accompanying Waterman Partnership drawing No. L/8859/A1.

1.2 In accordance with the investigation procedures outlined in the Waterman Partnership 'Strategy Document : December 1992' this Supplementary Report has been prepared following the staged completion of the associated assessment and testing operations undertaken during Phases 1, 2, 3, 4, 5 and 6 and the relevant covering Waterman Partnership Phase reports.

1.3 This Supplementary Report has been prepared to cover those aspects of the assessment and testing works which, because of the time scale or state of the site works could not be readily included in the main Waterman Partnership Phase reports.

The main items included in this Supplementary Report are:

i) Implications of the Bishopsgate explosion of 24.4.93.

ii) The supplementary work undertaken in Phases 1 to 6.

iii) Reports prepared to cover the completion of the remedial works as specified in Waterman Partnership Schedule of Remedial Works, Revision 'A' dated 4.11.93.

2.0 BISHOPSGATE EXPLOSION 24 APRIL 1993

2.1 During the course of the extensive programme of assessment and testing operations being undertaken following the first explosion in St. Mary Axe on 10.4.92 a second explosion occurred in Bishopsgate on 24.4.93, see Waterman Partnership Key Plan L/8859/H/1 accompanying this section of the report.

Although the charge was assessed as being considerably larger than that which caused the first explosion, it was some distance away from the Exchequer Court site and with a number of buildings suitably located between as to offer a degree of shielding. In addition to the shielding effects the alignment of Bishopsgate and the general open vertical aspect would have assisted the venting of the explosive pressures.

Nevertheless it was still necessary to interrupt the original assessment and testing operations to re-check and report on the condition of the retained structures following the Bishopsgate explosion.

2.2 This section of the Supplementary Report covers the various investigations undertaken, advises on the documentation prepared and summarises for record purposes the results and conclusions reached on the condition of the retained structures.

As for the original assessment and testing investigations those undertaken as a result of the Bishopsgate explosion were also reviewed and agreed by the Independent Structural Engineer.

2.3 Following initial site inspections by Waterman Partnership on 26.4.93 and also on 29.4.93 with the Independent Structural Engineers and having established that the retained structures were all structurally stable and apparently sound a detailed assessment and testing procedure was instigated to cover:

A) The Sub-Structure.
B) The Retained Facade.
C) The Site Cranes.

Apart from on site inspections and testing these investigations also included limited documentary support from Royal Ordnance and Soil Consultants Ltd on the airshock and groundshock implications.

2.3 : A) **Sub-Structure**

2.3 : A.1 On 27.4.93 Taywood Engineering Ltd were instructed to undertake initial visual inspections of the sub-structure and the retained facade areas see Item 2.3:B. The initial inspections to the retained facade area were also very restricted due to the special safety restrictions imposed on the access scaffolding following the explosion. All the site scaffolding had to be independently inspected and cleared for use.

Following these initial visual inspections Taywood Engineering reported in their letter to WP dated 30.4.94 on the results and in summary advised "there was no evidence of any damage or deterioration which could be attributed to the recent bomb. There is evidence of continuing movement of the concrete resulting in fine to very fine cracks. None of these observations give cause for concern".
See copy of TEL letter dated 30.4.93 in Appendix 'A' of this report.

The continuing movements of the concrete referred to in the TEL letter, were those due to thermal effects as the basement area had been opened up considerably due to the removal of the ground floor slab, together with the effects of load relaxation following the removal of the superstructure.
See Item 4.14 in the Waterman Partnership Phase 1 Report.

2.3 : A.2 In addition to the visual inspections and assessments of the retained sub-structures Waterman Partnership also instructed Royal Ordnance to advise on various aspects of the explosion and this was formally confirmed in a letter dated 4.5.93 as follows: R.O. to advise on;

1) The groundshock effects, if any, of the Bishopsgate explosion on the Exchequer Court sub-structure and foundations.

2) The airshock effects, if any, of the Bishopsgate explosion on the Exchequer Court retained facade at the east end of St. Helens Place and the two site cranes, approximate height to cabin say 50M, horizontal distance from the explosion say 120M.

In their letter to Waterman Partnership dated 29.4.93 Royal Ordnance advised on the results of their investigations as follows:

"Groundshock Pressures : The pressure that is delivered can be no more than 0.88KPa over-pressure with a duration of 980 m.sec at a distance of 95M (corresponding to the retained facade). This assumes no structure or foundations between the bomb and the point of incidence which is obviously wrong and will reduce the pressure further to an inestimable degree".

These low groundshock pressures were consistent with the sound condition of the retained sub-structures as revealed by the on site inspections and assessments.

Royal Ordnance also advised in their letter of 29.4.93 on the likely charge size as follows:

"The results indicate a crater of 10.7-12.0m diameter and between 4.5 and 2.5m deep. The charge required to cause this would have been between 650 and 800 kg of TNT. This (800) is the figure that has been used by the assessment". See copy of Royal Ordnance letter dated 29.4.93 in Appendix 'A' of this report.

2.3 : A.3 To complete the assessment of the likely groundshock effects on the retained sub-structures Messrs. Soils Consultants were requested by Waterman Partnership to advise on the geotechnical implications.

Following discussions and exchanges of documents Soils Consultants concluded in their letter to Waterman Partnership dated 7.5.93 "The effects of the explosion on the foundations and retaining walls can therefore be ignored". See copy of Soil Consultants letter dated 7.5.93 in Appendix 'A' of this report.

2.3 : A.4 As a result of these structural inspections and assessments Waterman Partnership concluded their initial assessment that the groundshock pressures, induced by the explosion in Bishopsgate, would have rapidly decayed over the distance between the charge and the site had been correct, and consequently the resulting induced groundshock pressures were not of structural significance.

2.3 : B) **Retained Facade**

2.3 : B.1 On 27.4.93 Taywood Engineering were instructed to undertake initial visual inspections of the retained facade supporting steelwork which, in due course, as full access became available, was to be extended to a full visual inspection of

the steelwork together with MPI's of all the assessable welds. This would effectively be re-checking all the steelwork elements previously inspected and tested during the Phase 3 assessment and testing investigations.
Following the initial visual inspections of the steelwork Taywood Engineering reported in their letter to WP dated 30.4.94 on the results and advised "The steelwork and floor slabs at each level were inspected from available access. There was no evidence of any gross damage or movement or any indication that the condition of the structure had changed in any way". This was in accord with the assessments made by Waterman Partnership. See copy of TEL letter dated 30.4.93 in Appendix 'A' of this report.

The detailed visual inspections and MPI's of the welding undertaken by Taywood Engineering were subsequently included in their Phase 3 Report, Assessment and Testing of Superstructure in Retained Facade Area, No. 1303/93/6583 : JULY 1993.

Items in the report which particularly refer to the implications of the Bishopsgate explosion are Item 1.1 page 4, Item 2/3 page 5, Item 3.1.4 page 8, Item 4.3 page 22 and Table 10. From Item 2/3 of the Summary on page 5, Taywood Engineering reported "Visual inspection and MPI carried out following the Bishopsgate explosion in April 1993 did not identify any additional damage to the steelwork".

2.3 : B.2 In addition to the inspections of the supporting steelwork undertaken by Taywood Engineering the airshock implications were also assessed by Royal Ordnance as previously noted in this report.

In their letter of 29.4.93 Royal Ordnance advised as follows.

"Airshock : The shock that is transmitted directly along Bishopsgate and into St. Helens Place should be no more than 9.0KPa (1.2psi) by the time it arrives at the facade.

"At this point it would have a duration of approximately 50m.sec.

"At the roof level, there will be transmission over the office block forming the wall of Bishopsgate. This should lead to pressures of approximately 10 KPa from the combined shock and gas phases".

These dynamic airshock pressures as derived by Royal Ordnance are considered very conservative. This is mainly because it appears that the areas between the explosion and the site of the retained facade at the east end of St. Helens Place could not be modelled in any detail in the time available.

Due to the height of the buildings fronting Bishopsgate, the narrow entrance into and the protected nature of St. Helens Place the retained facade would have been well shielded from excessively high airshock pressures.

It is our considered opinion that the average static pressure on the retained facade would have been more in the order of 4.0kN/m². In practice this assessment is consistent with the lack of significant structural damage to the supporting structure and also as many of the window panes in the building fronts adjoining the retained facade did not break.

In any event it was concluded in agreement with the Independent Structural Engineers that the effects of the airshock pressures on the retained facade supporting structure resulting from the Bishopsgate explosion would not have been any greater than from the original St. Mary Axe explosion in April 1992. The detailed assessment for the general airshock pressures on the retained facade are covered in Waterman Partnership Phase 2 Report : Volume Three.

2.3 : B.3 In addition to the inspections of the supporting steelwork to the retained facade areas the masonry facade was also visually inspected from the ground level during the first week after the Bishopsgate explosion. It was concluded that no major damage had been caused to the facade that would require emergency works or that would endanger the overall stability of the facade.

However, it was clear that further damage had occurred and more detailed inspects were recommended. Subsequently therefore a more detailed inspection of the facade was carried out from an aerial platform on 10.5.93 and the results of this are included in Waterman Partnership Phase 3 Report, Appendix 'C' : Report on Effects of Bomb 2 on Retained Facade : November 1993.

The remedial works noted in the facade report covered the general repairs required to cracked or spalled masonry elements and the fixing of loose stones and replacement of several items displaced as a result of the first explosion in St. Mary Axe. All this work was incorporated into the main reconstruction contract.

2.3 : C) **Site Cranes**

2.3 : C.1 At the time of the Bishopsgate explosion there were two tall cranes on site. Each of these comprised a tall lattice tower with a rigid stayed luffing jib.

Apart from general concern regarding possible damage to the cranes due to airshock effects, even though considered unlikely, it was also considered important to assess the damage if any to the crane bases which were anchored into the Level -2 R.C. slab construction.

2.3 : C.2 During the course of the general site inspections undertake on 29.4.93, as previously noted, the crane base areas at Level -2 were also carefully inspected by Waterman Partnership and the Independent Structural Engineers and no structural defects were found.
See Item 5.0 in Appendix 'A' of this report.

2.3 : C.3 In accordance with site safety procedures Messrs. AMEC also arranged for the two cranes to be inspected and load tested and this was satisfactorily undertaken and no movements were detected in the bolts or bases throughout the testing procedure.
See AMEC letter dated 19.5.93 in Item 9.0 of Appendix 'A' of this report.

2.3 : C.4 Following the receipt of design information from the crane manufacturers and using the airshock analysis data derived by Royal Ordnance Waterman Partnership checked the cranes for the effects of the assessed airshock loads resulting from the Bishopsgate explosion.

From these calculation assessments it was deduced that the tower cranes were designed for a static wind load of 1.1kN/m^2. The estimated equivalent dynamic load on the crane, due to the explosion, was 1.2kN/m^2 at mid-height of the crane, i.e. a difference of some 9%.
However when designing for dynamic loads the static strengths of normal construction materials can generally be increased by at least 10%. Therefore the effects of the loads due to the explosion can be considered to be no more than those due to the original crane design wind loadings.
See Waterman Partnership calculation package, Effect Of Bishopsgate Explosion Tower Cranes : JULY 1993, in Item 11.0 of Appendix 'A' of this report.

This assessment is consistent with the satisfactory results of the inspections and testing of the cranes as noted in Items 2.3 : C.2 and 2.3 : C.3 above.

2.3 : C.5 The various inspections and calculation assessments undertaken in connection with the Bishopsgate explosion were reviewed by the Independent Structural Engineers. This report has also been reviewed with them and they have confirmed their opinion on the validity of the conclusions reached as noted in their letter to Waterman Partnership dated 27.9.94 which accompanies this section.

Ove Arup & Partners
Consulting Engineers

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Direct Dialling
Telephone 0171 465 3648
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45668/MG/DH
27 September 1994

Mr A.W. Hurdle
Waterman Partnership
46-47 Blackfriars Road
London SE1 8PN

ARUP

Dear Mr Hurdle

EXCHEQUER COURT, 25-51 ST MARY AXE, LONDON EC3

Within the scope of our appointment as Independent Structural Engineers we have commented on draft copies of Section 2 of Waterman Partnership's Supplementary Report, which deals with the effects of the Bishopsgate explosion in April 1993, and discussed our observations with them.

Following the completion of this review process we confirm our opinion that valid conclusions have been drawn from the inspections, tests analyses carried out by Waterman Partnership.

Yours sincerely

Mike Glover.

Mike Glover
Director

cc Mr Peter Heritage - Buro 4

Registered in England
1312453 at
13 Fitzroy Street

3.0 SUPPLEMENTARY INVESTIGATION PHASES 1-6

3.1 This section of the Supplementary Report covers those aspects of the assessment and testing works which, because of the time or particularly the state if the site works could not be readily included in the main Waterman Partnership Phase reports.

3.2 After the preparation of the reports for Phases 1-6 it was found that there were in fact only two items which needed to be covered in this section of the Supplementary Report. These were areas of R.C. floor slabs which had been covered with temporary water-proofing to protect sensitive plant rooms under as noted in:

- Phase 4 : LEB Slab Area, Ground Floor
  (Items 4.5, 4.11 and 5.1 in the report refer).

- Phase 5 : Level -1 Slab.
  (Items 4.6, 4.8 and 5.2 in the report refer)

3.3 **Phase 4 : LEB Slab Area, Ground Floor.**

Following the careful removal of the temporary water-proofing this area of the ground floor slab was inspected on 7.12.94 and no defects were found.

The Waterman Partnership letter to AMEC dated 8.12.94 confirmed the site inspection of the exposed concrete slab and that no defects were found and the construction is therefore considered structurally sound.
See copy of Waterman Partnership letter dated 8.12.94 in Appendix 'B' of this report.

3.4 **Phase 5 : Level -1 Slab.**

The temporary water-proofing for the relevant areas was carefully removed as the main reconstruction works permitted. The surfaces of the Level -1 slab were inspected during the course of the contract and no defects were found.

The Waterman Partnership letter to AMEC dated 19.12.94 confirms the site inspection of the exposed concrete slab and that no defects were found and the construction is considered structurally sound.
In this regard, it should also be noted that any defects identified during the immediate post explosion inspections would have been made good prior to the installation of the temporary water-proofing. No such defects were recorded at that time in these relevant areas.

See copy of Waterman Partnership letter dated 19.12.94 and Figure 69 from Taywood Engineering's Phase 1 Report in Appendix 'B' of this report.

SUPPLEMENTARY INVESTIGATIONS, PHASES 1-6

APPENDIX B

SUPPORTING DOCUMENTATION

1.0 WATERMAN PARTNERSHIP PHASE 4 LETTER TO AMEC DATED 8.12.94.

2.0 WATERMAN PARTNERSHIP PHASE 5 LETTER TO AMEC DATED 19.12.94

3.0 TAYWOOD ENGINEERING LTD
FIGURE 69 FROM PHASE 1 REPORT

AWH/JS/8859/A

8th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 4 : LEB SLAB AREA GROUND FLOOR

Further to your letter dated 24.11.94 advising that the temporary asphalt water-proofing on the ground floor slab, above the LEB sub-station, had been removed we confirm that we carried out a final inspection on the 7.12.94 of the exposed concrete slab and that no defects were found and consider the construction structurally sound.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

b.c. S. Harden/C. Dicks

Waterman Partnership
CONSULTING ENGINEERS

46-47 Blackfriars Road
London SE1 8PN
Telephone: 0171-928 7888
Fax: 0171-928 3033

Our ref : AWH/JS/8859/A

Your ref :

Date : 19th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 5DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 5 : LEVEL -1 SLAB

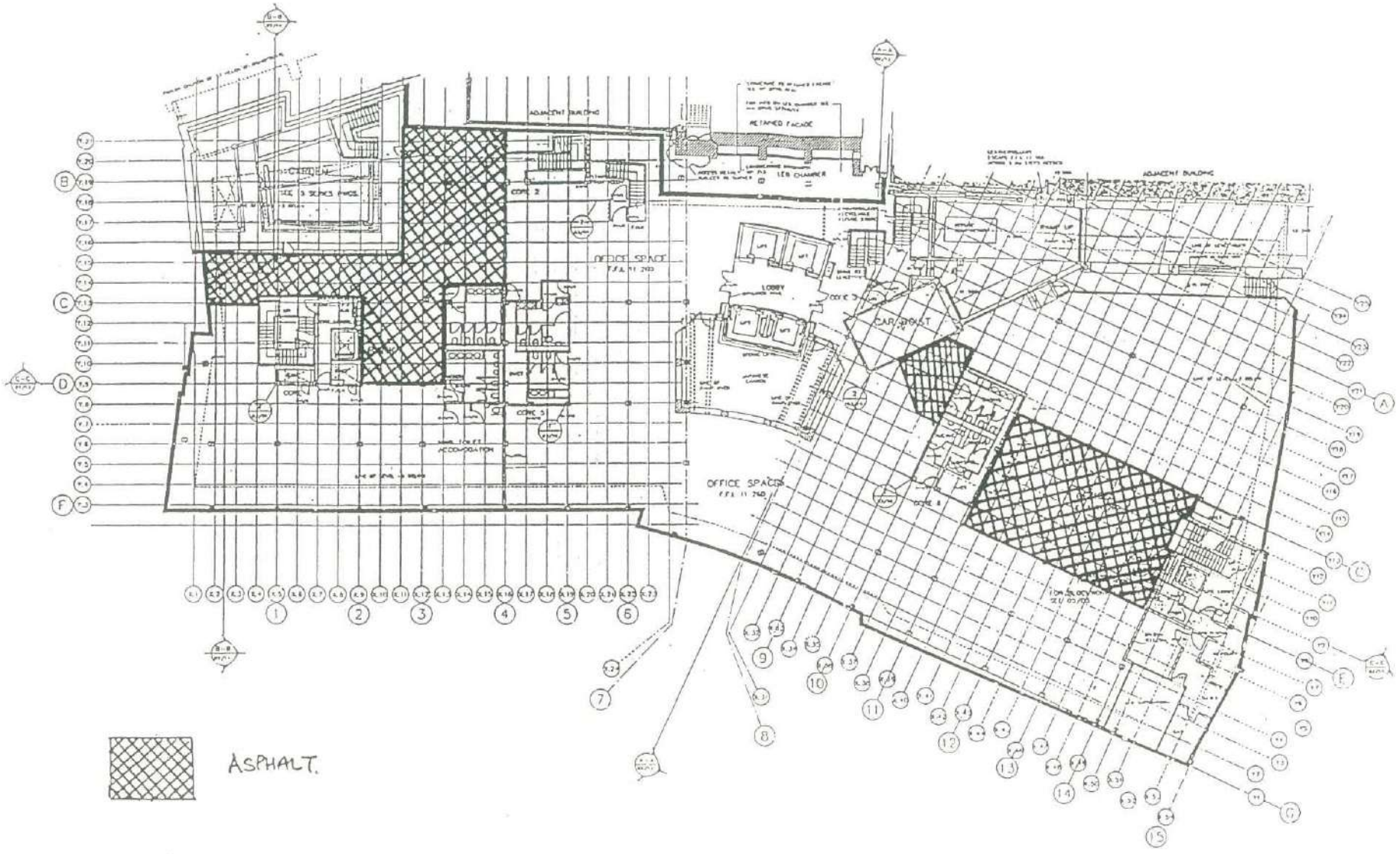
During the preparation of our Supplementary Report for document library purposes, it appears from our files that we have not formally confirmed our inspections of the areas of the Level -1 slab which were covered temporarily with asphalt.

We herewith confirm therefore that these areas have been inspected following the removal of the asphalt, during the course of our site visits to monitor the progress of the remedial works etc., and that no defects were found and consider the slab structurally sound.

Yours faithfully,

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden



NO OBSERVED CRACKING IN ASPHALTED AREAS

ASPHALTED AREAS OF LEVEL -1 SLAB

FIGURE 69

EXTRACT FROM TAYWOOD ENGINEERING PHASE 1 REPORT.

APPENDIX B : 3.0

4.0 SCHEDULE OF REMEDIAL WORKS PHASES 1-6 : COMPLETION REPORTS

4.1 This section of the Supplementary Report covers the inspections and records of completion prepared for the various items of remedial works recommended in the Waterman Partnership reports for Phases 1-6.

Due to the need for the building to be 'watertight' before the majority of the specified remedial works could be undertaken, the operations were undertaken some considerable time after the main assessment and testing reports had been prepared and generally during the later stages of the main reconstruction contract.

The remedial works are noted in Phase order with copies of supporting documents contained in Appendix 'C' at the rear of this Supplementary Report. In particular is a Check List which notes the specified works and relevant dates of the main inspections and AMEC and Waterman Partnership's letters.

4.2 Phase 1 : Concrete Below Ground

The various remedial works specified are noted in detail on Pages 2 and 3 of the WP Schedule of Remedial Works.

Waterman Partnership letter to AMEC dated 15.12.94 confirmed that the last inspection was undertaken on the 7.12.94 and that the works were considered complete and structurally acceptable.

Copy of Waterman Partnership letter dated 15.12.94 in Appendix 'C' of this report.

4.3 Phase 2 : Retaining Wall and Piled Foundations

The various remedial works specified are noted in detail on Page 3 of the WP Schedule of Remedial Works.

Waterman Partnership letter to AMEC dated 14.9.94 confirmed that a final inspection was carried out on 13.9.94 and that the works were considered structurally complete and acceptable.

Copy of Waterman Partnership letter dated 14.9.94 in Appendix 'C' of this report.

4.4 **Phase 3 : Retained Facade Area**

The various remedial works specified are noted in detail on Pages 4, 5 and 6 of the WP Schedule of Remedial Works.

Waterman Partnership letters to AMEC dated 14.9.94 and 15.12.94 confirmed that relevant inspections had been carried out by the WP resident engineer during the course of the steelwork erection contract and also by engineers visiting the site on the 13.9.94 and 25.10.94. The letters confirmed the remedial works were considered complete and structurally acceptable.

Copies of Waterman Partnership letters dated 14.9.94 and 15.12.94 in Appendix 'C' of this report.

4.5 **Phase 4 : L.E.B. Slab Area, Ground Floor**

The various remedial works specified are noted in detail on Page 6 of the WP Schedule of Remedial Works.

Waterman Partnership letter to AMEC dated 15.12.94 confirmed that an inspection had been undertaken on 25.10.94 and that the remedial works were considered complete and structurally acceptable.

Copy of Waterman Partnership letter dated 15.12.94 in Appendix 'C' of this report.

4.6 **Phase 5 : Level -1 Slab**

The various remedial works specified are noted in detail on Page 6 of the WP Schedule of Remedial Works.

However these comprise the application of emulsion paint to the slab soffits in accordance with the Architect's specification and the completion and inspection are covered within the main reconstruction works contract.

4.7 **Phase 6 : Garden Area**

The various remedial works specified are noted in detail on Pages 6 and 7 of the WP Schedule of Remedial Works.

Waterman Partnership's letter dated 15.12.94 confirmed that an inspection was undertaken on 17.11.94 and that the works were considered complete and acceptable.

Copy of Waterman Partnership's letter dated 15.12.94 in Appendix 'C' of this report.

A W HURDLE CENG. MISTRUCT E. C A DICKS CENG. FISTRUCT E. FFB. MCONS B.

SCHEDULE OF REMEDIAL WORKS PHASES 1-6 : COMPLETION REPORTS

APPENDIX C

SUPPORTING DOCUMENTATION

1.0 WATERMAN PARTNERSHIP SCHEDULE OF REMEDIAL WORK CHECK LIST.

2.0 WATERMAN PARTNERSHIP PHASE 1.
CONFIRMATORY LETTER TO AMEC DATED 15.12.94.

3.0 WATERMAN PARTNERSHIP PHASE 2.
CONFIRMATORY LETTER TO AMEC DATED 14.9.94.

4.0 WATERMAN PARTNERSHIP PHASE 3.
CONFIRMATORY LETTERS TO AMEC DATED 14.9.94 AND 15.12.94.

5.0 WATERMAN PARTNERSHIP PHASE 4.
CONFIRMATORY LETTER TO AMEC DATED 15.12.94.

6.0 WATERMAN PARTNERSHIP PHASE 6.
CONFIRMATORY LETTER TO AMEC DATED 15.12.94.

7.0 WATERMAN PARTNERSHIP FILE NOTE
ON SITE VISIT OF 25.10.94.

8.0 AMEC LETTER TO WATERMAN PARTNERSHIP
DATED 24.8.94.

9.0 AMEC LETTER TO WATERMAN PARTNERSHIP
DATED 16.11.94.

10.0 BOOTH STEELWORK DOCUMENT FOR AMEC
DATED 11.7.94 CONFIRMING BOLT REPLACEMENT.

WP PHASE FROM STRATEGY DOCUMENT	REMEDIAL WORKS SPECIFIED	PROGRESS IN HAND OR COMPLETE	AMEC LETTER FOR INSPECTION DATED	WP AGREEMENT DATED	WP MAIN SITE INSPECTIONS DATED
PHASE 1. CONCRETE BELOW GROUND. (SCHEDULE PAGES 1 & 2)	1). R/W HOLES FILL WITH SIKATOP 122. (SCH. 1.1). 2). R/W SURFACES BRUSH APPLY TWO COATS SIKATOP SEAL 107, OFF WHITE. (SCH. 1.2). 3). COLUMNS SIKATOP SEAL 107 AS WALLS. (SCH. 2.1). 4). SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 3.1).	COMPLETE COVERED BY MAIN	24.8.94 AND 16.11.94 RECONSTRUCTION WORKS	14.9.94 AND 15.12.94 N/A	16.8.94 31.8.94 13.9.94 25.10.94 11.11.94 7.12.94 N/A
PHASE 2. RETAINING WALL & PILED FOUNDATIONS. (SCHEDULE PAGE 3)	1). MAIN FOUNDATION PILES Nos.36 & 39 CORE HOLES FILL WITH CONBEXTRA HF. (SCH. 1.1).	COMPLETE	16.11.94	14.9.94	31.8.94 13.9.94
PHASE 3. RETAINED FACADE AREA. (SCHEDULE PAGES 4, 5 & 6)	1). STEELWORK MAKE GOOD WELD DEFECTS. (SCH. 2.1). 2). STEELWORK MAKE GOOD FLANGE BUCKLES. (SCH. 2.2). 3). FLOOR SLABS MAKE GOOD CRACKS WITH NITOKIT LV. (SCH. 3.1). 4). LEB PULLING CHAMBER COLUMN & BEAM CONCRETE ENCASURES APPLY TWO COATS SIKATOP SEAL 107, OFF WHITE. (SCH. 4.1). 5). LEB PULLING CHAMBER SOUTH & EAST WALLS APPLY SIKATOP SEAL 107, AS CONCRETE ENCASURES. (SCH. 4.2). 6). LEB PULLING CHAMBER NORTH WALL CONSTRUCTION JOINT MAKE GOOD WITH SIKATOP 122. (SCH. 4.2). NB. AS GENERAL RECONSTRUCTION WORKS ALL ACCESSIBLE BOLTS REPLACED IN STEELWORK.	COMPLETE COMPLETE COMPLETE COMPLETE COMPLETE	24.8.94 16.11.94 24.8.94	WP RESIDENT ENGINEER 14.9.94 15.12.94	WP RESIDENT ENGINEER 13.9.94 25.10.94
PHASE 4. LEB SLAB AREA GROUND FLOOR. (SCHEDULE PAGE 6)	1). LEB SWITCHROOM RECONSTRUCT SECTION OF HIGH LEVEL BRICKWORK SOUTH WALL. (SCH. 1.1).	COMPLETE	16.11.94	15.12.94	25.10.94 GRD. FL. SLABS OVER LEB SWITCHROOM 7.12.94
PHASE 5. LEVEL-1 SLAB. (SCHEDULE PAGE 6)	1). SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 1.1).	COVERED BY MAIN	RECONSTRUCTION WORKS	N/A	N/A ARCHITECTURAL
PHASE 6. GARDEN AREA. (SCHEDULE PAGES 6 & 7)	1). PLANTERS HYDROTECH WATERPROOF MEMBRANE OVERLAID WITH NEW AS PART OF GENERAL RECONSTRUCTION WORKS. (SCH. 1.0). 2). SLAB SOFFITS BRUSH APPLY TWO COATS SIKATOP SEAL 107, OFF WHITE. (SCH. 1.1) OR EMULSION AS ARCHITECTS SPECIFICATION. 3). SPALLING VOID MAKE GOOD WITH SIKATOP 122. (SCH. 1.2).	COMPLETE EMULSION TREATMENT ADOPTED COVERED BY MAIN COMPLETE	16/11/94 RECONSTRUCTION WORKS 16/11/94	15.12.94 N/A 15.12.94	17.11.94 N/A 17.11.94

SCHEDULE OF REMEDIAL WORK - CHECK LIST

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Telephone 071 928 7888 Fax. 071 928 3033

Title -

EXCHEQUER COURT

ASSESSMENT AND TESTING OF RETAINED STRUCTURE

APPENDIX C : 1.0

APPENDIX C : 2.0

Waterman Partnership
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Telephone: 0171-928 7888
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Our ref : AWH/JS/8859/A

Your ref :

Date : 15th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 1 : CONCRETE BELOW GROUND

Further to your letter of 16.11.94 advising on the progress of the Phase 1 remedial works, comprising the Sikatop Seal 107, we confirm that our last inspection was undertaken on 7.12.94 and that we consider these works were complete and structurally acceptable.

Yours faithfully,

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

AWH/JS/8859/A

14th September, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 2 REMEDIAL WORKS (LEVEL -2) : PILES No. 36 & 39

Further to your letter of 24.8.94, we confirm that we carried out a final inspection on the 13.9.94 of the filling of the inspection core holes in the above piles and consider these works structurally complete and acceptable.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

b.c. S. Harden/C. Dicks

AWH/JS/8859/A

14th September, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 3 REMEDIAL WORKS : FLOOR SLABS LEVELS +2, +3, +4 AND +5

Further to your letter of 24.8.94, we confirm that we carried out a final inspection on the 13.9.94 of the resin injection of cracks in the slabs at the above floor levels and consider these works structurally complete and acceptable.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

b.c. S. Harden/C. Dicks

Waterman Partnership
CONSULTING ENGINEERS

46-47 Blackfriars Road
London SE1 8PN
Telephone: 0171-928 7888
Fax: 0171-928 3033

Our ref : AWH/JS/8859/A

Your ref :

Date : 15th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 3 : RETAINED FACADE AREA

Further to your letter dated 16.11.94 advising on the progress of the Phase 3 remedial works, we confirm that inspections have been carried out by our resident engineer during the course of the steelwork erection contract and also by our engineers visiting the site on the 13.9.94 and 25.10.94 in particular. We confirm therefore that we consider these works complete and structurally acceptable.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

Waterman Partnership
CONSULTING ENGINEERS

46-47 Blackfriars Road
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Date : 15th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 4 : LEB SLAB AREA GROUND FLOOR

Further to your letter of 16.11.94 advising on the progress of the Phase 4 remedial works, comprising the reconstruction of a small section of high level brickwork in the LEB Switchroom, we confirm that an inspection was undertaken on 25.10.94 we consider these works complete and structurally acceptable.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

Waterman Partnership
CONSULTING ENGINEERS

46-47 Blackfriars Road
London SE1 8PN
Telephone: 0171-928 7888
Fax: 0171-928 3033

Our ref : AWH/JS/8859/A

Your ref :

Date : 15th December, 1994

Amec Design and Management Ltd.,
3rd Floor,
15, St. Helen's Place,
London, EC3A 6DE

F.A.O. MR. D. BUTCHER

Dear Sirs,

RE: EXCHEQUER COURT, 25 - 51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES
PHASE 6 : GARDEN AREA

Further to your letter of 16.11.94 advising on the progress of the Phase 6 remedial works, comprising the provision of a new Hydrotechnic waterproof membrane, etc., we confirm that an inspection was undertaken on 17.11.94 and that we consider these works complete and acceptable.

It is understood that the new membrane was installed on top of the existing membrane to avoid unnecessary disturbance of the existing construction.

Yours faithfully

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - P. Heritage
OAP - D. Hadden

EXCHEQUER COURT, 25 - 51 ST. MARY AXE, E.C.3.

FILE NOTE ON SITE VISIT TO EXCHEQUER COURT TO INSPECT AREAS OF THE RETAINED STRUCTURE LISTED IN THE SCHEDULE OF REPAIRS, AS NOTED IN WP SCHEDULE OF REMEDIAL WORKS CHECK LISTS.

Date: Tuesday, 25th October 1994.

Present: Karina Hall - WP
Burgess Pocock - AMEC

Weather report:

The weather as forecast and had been for several day was rain. This would help show up any defects in the retaining walls if any present.

Phase 1 Items 1, 2 and 3

a) The Level -1 retaining wall was inspected. The Sika render on the retaining walls was in accordance with the schedule of repairs and plan. The work has been carried out in the specified areas. The crack injection repairs have also been carried out. All retained columns have been Sika rendered.

b) Level -2 the Sika render has been applied to the retaining walls and the retained columns at this level in accordance with the schedule. However in the generator room Sika was applied to only the columns clear of the generator and to the retaining wall only where access was permitted due to the live equipment and its location against the west wall. This is considered structurally acceptable.

Phase 3 Items 5 and 6

Sika has been applied to the south and east walls and the construction joint has been repaired.

The beams are still exposed and the concrete encasing is not started yet.

Phase 4 Item 1

The LEB switchroom was also inspected and the brick repair has been carried out as specified.

The above items have been inspected by KH and considered as being satisfactorily completed.

AMEC Design and Management

AMEC Design and Management Limited
Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV37 9NJ
Telephone: (0789) 294288, Fax: (0789) 299135

DIR/ASSOC. | No. 21
ACTION BY | COMPLETED
25 AUG 1994
ACTION Reply to matters raised on site Insp.

209/WAT/DB/LAA

24th August 1994

Waterman Partnership
46/47 Blackfriars Road
London SE1. 8PN

FOR THE ATTENTION OF MR. A. HURDLE

Dear Sirs,

EXCHEQUER COURT - ST MARY AXE LONDON EC3

Further to your letter dated 26th July 1994, please find enclosed a marked up copy of your repair works schedule, indicating progress to date.

The completed works on the facade have already been inspected either by yourself or Mr. Prem Kumar your site representative, whilst the repairs to the piles are complete and ready for inspection.

The Sika works are currently in progress with the walls at -1 and the old car park level at 8.400, and some areas of -2 being treated. At the time of writing, these areas have been grit blasted and Sikatop applied to the -1 area. Sikatop is currently being applied at -2 and 8.400 level. We would record that you have inspected these works since they have begun, and that they are currently available for further inspections.

Yours faithfully,
for.AMEC DESIGN AND MANAGEMENT LIMITED

D Butcher

D.BUTCHER
PROJECT CONSTRUCTION MANAGER

encls.

c.c. B4/FRP/G&T)
PM/PAP/BP/File WAT)plus encls

(1) WP PHASE FROM STRATEGY DOCUM'T.	(2) REMEDIAL WORKS SPECIFIED.	(3) PROGRESS 1/11 COMPLETE	(4) AMEC LETTER FOR INSPECTION DATED.	(5) WP AGREEMENT DATED.
PHASE 1. CONCRETE BELOW GROUND. (SCHEDULE PAGES 1 & 2)	1) R/W HOLES FILL WITH SIKATOP 122. (SCH. 1.1) 2) R/W SURFACES BRUSH APPLY TWO COATS SIKATOP SEAL 107 OFF WHITE. (SCH. 1.2) 3) COLUMNS SIKATOP SEAL 107 AS WALLS. (SCH. 2.1) 4) SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 3.1)	IN PROGRESS	24/8/94	
PHASE 2. RETAINING WALL & PILED FOUNDATIONS. (SCHEDULE PAGE 3)	1) TAM FOUNDATION PILES Nº 36 & 39 CORE HOLES FILL WITH CONBEXTRA HF. (SCH. 1.1)	COMPLETE	24/8/94	
PHASE 3. RETAINED FACADE AREA. (SCHEDULE PAGES 4 & 5)	1) STEELWORK TAKE GOOD WELD DEFECTS. (SCH. 2.1) 2) STEELWORK TAKE GOOD FLG. BUCKLES. (SCH. 2.2) 3) FLOOR SLABS TAKE GOOD CRACKS WITH NITOKIT LV. (SCH. 3.1) 4) LEB PULLING CHAMBER COLUMN & BEAM CONCRETE ENCASURES APPLY TWO COATS SIKATOP SEAL 107 OFF WHITE. (SCH. 4.1) 5) LEB PULLING CHAMBER SOUTH & EAST WALLS SIKATOP SEAL 107 AS CONC. ENCASURES. (SCH. 4.2) 6) LEB PULLING CHAMBER NORTH WALL CONST. JOINT TAKE GOOD WITH SIKATOP 122. (SCH. 4.2) N/B. AS GENERAL RECONSTRUCTION WORKS ALL ACCESSIBLE BOLTS REPLACED IN STEELWORK.	COMPLETE COMPLETE COMPLETE COMPLETE	24/8/94 24/8/94	
PHASE 4. LEB SLAB AREA GROUND FLR. (SCHEDULE PAGE 6)	1) LEB SWITCHROOM RECONSTRUCT SECTION OF HIGH LEVEL BRICKWORK SOUTH WALL. (SCH. 1.1)			
PHASE 5. LEVEL -1 SLAB. (SCHEDULE PAGE 7)	1) SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 1.1)			
PHASE 6. GARDEN AREA. (SCHEDULE PAGE 8)	1) PLANTERS HYDROTECH WATERPROOF MEMBRANE OVERLAID WITH NEW AS PART OF GENERAL RECONSTRUCTION WORKS. (SCH. 1.0) 2) SLAB SOFFITS BRUSH APPLY TWO COATS SIKATOP SEAL 107 OFF WHITE. (SCH. 1.1) OR EMULSION AS ARCHITECTS SPEC. 3) SPALLING VOID TAKE GOOD WITH SIKATOP 122. (SCH. 1.2)			

Waterman Partnership
CONSULTING ENGINEERS

LONDON 071-928-7888
BIRMINGHAM 021-454-5858

L
B

LOCATION: SCHEDULED REMEDIAL WORKS CHECK LIST.

TITLE: COLCHESTER COURT, ASSESSMENT/TESTING.   NO 8859/A.

CALCULATIONS WORKS CHECK LIST.

SHEET NO SCR/1
BY [illegible]
DATE 25.7.94
ITEM REMEDIAL WORKS LIST.
DRAWING No: CHECK LIST.

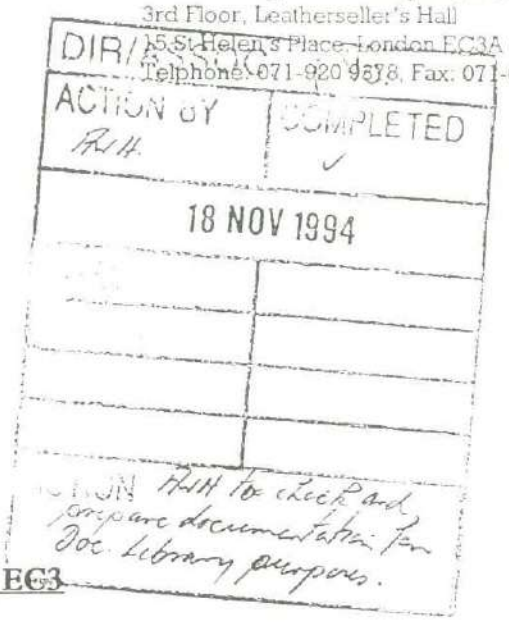
OUTPUT

APPENDIX C : 8.0

AMEC Design and Management

AMEC Design and Management Limited
Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV37 9NJ
Telephone: (0789) 204288, Fax: (0789) 299135

Please reply to:
Project Office
AMEC Design and Management Limited
3rd Floor, Leatherseller's Hall
45 St Helen's Place, London EC3A 6DE
Telephone: 071-920 9578, Fax: 071-628 7205



209/WAT/DB/LAA

16th November

Waterman Partnership
46/47 Blackfriars Road
London SE1. 8PN

FOR THE ATTENTION OF MR. A. HURDLE

Dear Sirs,

EXCHEQUER COURT - ST MARY AXE LONDON EC3

Further to our letter dated 24th August 1994, please find enclosed a marked up copy of your repair works schedule, indicating progress to date.

All areas are complete except the boarding to the beams in the L.E.B. pulling chamber and the painting to the -2 soffit, which is not a structural item and will be part of the decorating package works.

We would record that you have inspected the L.E.B. Switchroom (phase 4) and the Sikatop works.

Yours faithfully,
for.AMEC DESIGN AND MANAGEMENT LIMITED

D.Butcher

D.BUTCHER
PROJECT CONSTRUCTION MANAGER

encls.

c.c. B4/FRP/G&T)
PM/PAP/BP/File WAT)plus encls

Waterman Partnership
CONSULTING ENGINEERS

LONDON 071-928 7888 | L
BIRMINGHAM 021-454-5858 | B

TITLE: ELIZABETH COURT ASSESSMENT/TESTING. NO. 8859/A.
LOCATION: SCHEDULED REMEDIAL WORKS CHECK LIST.
CALCULATIONS

SHEET NO.
BY
DATE 25.7.94.
ITEM REMEDIAL WORKS CHECK LIST.
DRAWING Nos
OUTPUT

APPENDIX C : 9.0

(1) ...P PHASE FROM STRATEGY DOCUM'T.	(2) REMEDIAL WORKS SPECIFIED.	(3) PROGRESS 1/11 COMPLETE	(4) ATTEC LETTER FOR INSPECTION DATED.	(5) WP AGREEMENT DATED.
PHASE 1. CONCRETE BELOW GROUND. (SCHEDULE PAGES 1 & 2)	1) R/W HOLES FILL WITH SIKATOP 122. (SCH. 1.1) 2) R/W SURFACES BRUSH APPLY TWO COATS SIKATOP SEAL 107 OFF WHITE. (SCH. 1.2) 3) COLUMNS SIKATOP SEAL 107 AS WALLS. (SCH. 2.1)	IN ~~PROGRESS~~ COMPLETE	~~24/8/94~~ 16/11/94	
	4) SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 3.1)	NOT STRUCTURAL		
PHASE 2. RETAINING WALL & PILED FOUNDATIONS. (SCHEDULE PAGE 3)	1) TRIM FOUNDATION PILES Nº 36 & 39 CORE HOLES FILL WITH CONBEXTRA HF. (SCH. 1.1)	COMPLETE	24/8/94	
PHASE 3. RETAINED FACADE AREA. (SCHEDULE PAGES 4 & 5)	1) STEELWORK TAKE GOOD WELD DEFECTS. (SCH. 2.1) 2) STEELWORK TAKE GOOD FLG. BUCKLES. (SCH. 2.2) 3) FLOOR SLABS TAKE GOOD CRACKS WITH NITOKIT LV. (SCH. 3.1)	COMPLETE COMPLETE COMPLETE	24/8/94	
	4) LEB PULLING CHAMBER COLUMN & BEAM CONCRETE ENCASURES APPLY TWO COATS SIKATOP SEAL 107 OFF WHITE. (SCH. 4.1) 5) LEB PULLING CHAMBER SOUTH & EAST WALLS SIKATOP SEAL 107 AS CONC. ENCASURES. (SCH. 4.2) 6) LEB PULLING CHAMBER NORTH WALL CONST. JOINT TAKE GOOD WITH SIKATOP 122. (SCH. 4.2)	COMPLETE	16/11/94	
	N.B. AS GENERAL RECONSTRUCTION WORKS ALL ACCESSIBLE BOLTS REPLACED IN STEELWORK.	COMPLETE	24/8/94.	
PHASE 4. LEB SLAB AREA GROUND FLR (SCHEDULE PAGE 6)	1) LEB SWITCHROOM RECONSTRUCT SECTION OF HIGH LEVEL BRICKWORK SOUTH WALL. (SCH. 1.1)	COMPLETE	16/11/94	
PHASE 5. LEVEL -1 SLAB. (SCHEDULE PAGE 7)	1) SLAB SOFFITS EMULSION AS ARCHITECTS SPECIFICATION. (SCH. 1.1).	NOT STRUCTURAL		
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F.A.O. T. Hurdle.

APPENDIX C : 10.0
Ref. 41303/4

BOOTH

Booth Steelwork

Booth Steelwork Ltd.

PO Box 50
Hulton Steelworks
Bolton BL3 3ST

Telephone: 0204 61191.
Telex: 635679 FYRDOR G
Telefax: 0204 64646.

Rec'd 11th July 1994

ORIC- 265

cc N. TAYLOR LAT OFFICE
P. KUMAR LAT SITE
BP/DB

COMPLETION CERTIFICATE
FULL/PARTIAL

CONTRACT NO. ..0776.....

LOCATION. .EXCHEQUER COURT

CLIENT. ...AMEC.....

AREA TO BE HANDED OVER: REPLACEMENT OF BOLTS TO EXISTING STEELWORK AT LEVEL -1 AND RETAINED FACADE LEVELS TO 6

DATE 11-7-94

	CHECKED BY	COMMENTS
PLUMB		
LINE		
LEVEL		ALL BOLTS REPLACED EXCEPT WHERE BEAMS CASED OR WHERE ACCESS COULD NOT BE GAINED TO BOTH SIDES OF CONNECTIONS
GROUT		
SECTION		
BOLTS	IM HUGH / PREDWOOD	
PURLINS/SIDE RAILS		
PAINT		
DECKING		

FOR CLIENT. WE HAVE CHECKED THE AREA TO BE HANDED OVER AND IT HAS BEEN ACCEPTED ON BEHALF OF THE CLIENT.

CERTIFICATE ISSUED BY.....

FOR THE CLIENT.

BISHOPSGATE EXPLOSION 24 APRIL 1993.

APPENDIX A

SUPPORTING DOCUMENTATION

1.0 WATERMAN PARTNERSHIP DRAWING No. L/8859/A1 KEY PLAN

2.0 WATERMAN PARTNERSHIP DRAWING No. L/8859/H/1 KEY PLAN

3.0 ROYAL ORDNANCE LETTER 29.4.93.

4.0 TAYWOOD ENGINEERING LTD. LETTER 30.4.91.

5.0 WATERMAN PARTNERSHIP, OBSERVATIONS ON IMPLICATIONS OF BISHOPSGATE EXPLOSION ON RETAINED STRUCTURES 30.4.93.

6.0 WATERMAN PARTNERSHIP LETTER. 4.5.93 TO ROYAL ORDNANCE.

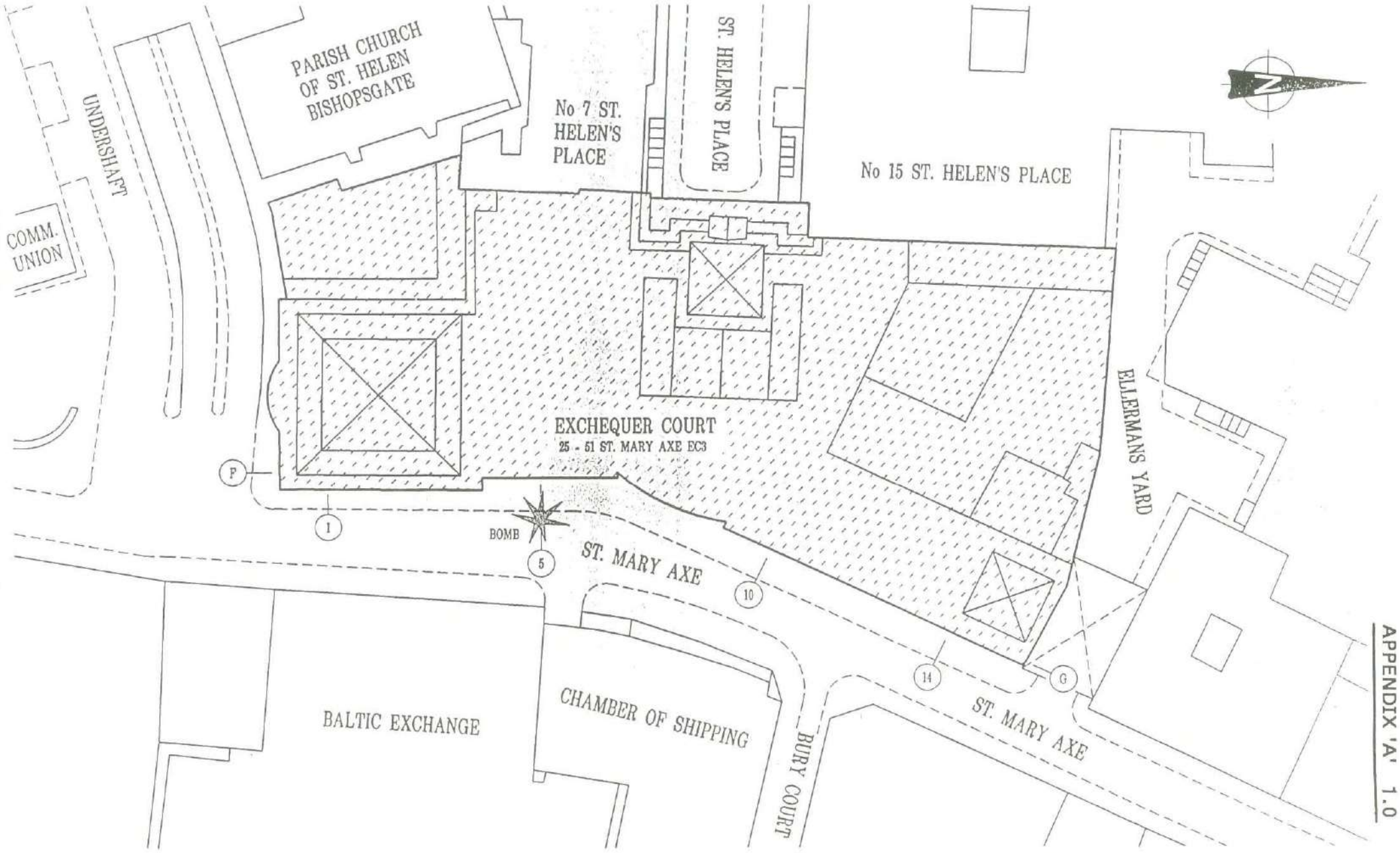
7.0 WATERMAN PARTNERSHIP LETTER 7.5.93 TO BURO FOUR.

8.0 SOIL CONSULTANTS LETTER 7.5.93.

9.0 AMEC DESIGN & MANAGEMENT LETTER 19.5.93.

10.0 WATERMAN PARTNERSHIP LETTER 11.6.93 TO BURO FOUR.

11.0 WATERMAN PARTNERSHIP CALCULATION PACKAGE : EFFECT OF BISHOPSGATE EXPLOSION TOWER CRANES : JULY 1993.



EXCHEQUER COURT ASSESSMENT & TESTING RETAINED STRUCTURES

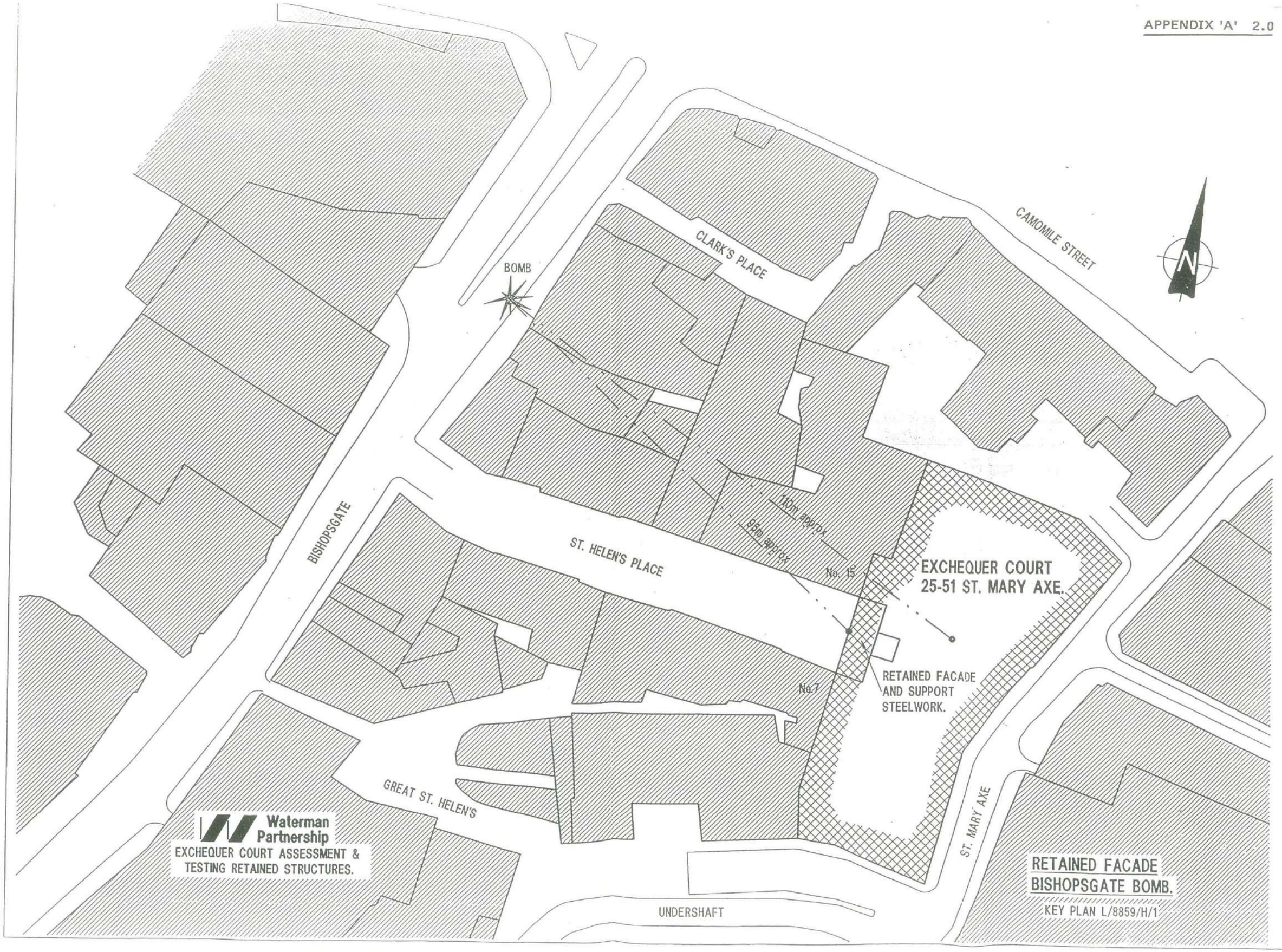
APPENDIX 'A' 1.0

WATERMAN PARTNERSHIP

KEY PLAN

L/8859/A1

APPENDIX 'A' 2.0



BRITISH AEROSPACE
DEFENCE
ROYAL ORDNANCE

British Aerospace Defence Limited
Royal Ordnance Division
Royal Ordnance Security Services
PO Box 243
Shrivenham, Swindon
SN6 8QD, England
Telephone (0793) 783610
Fax (0793) 783616

Reference: A 800 20/3

29 April 1993

Mr A Hurdle
Waterman Partnership
46/47 Blackfriars Road
London SE1 8PN

Dear Mr Hurdle,

25-51 St Mary Axe, London EC3. Assessment and testing of Retained Structures - Bishopsgate blast

We have completed an overview assessment of the groundshock and airshock experienced by the building, as a result of the terrorist bomb in Bishopsgate on 25th April 1993. As you requested a response in extremely short order we have made several assumptions about the blast.

The crater dimensions were taken from photographs taken by myself and Stephen Fuller at the site on the 27th April 1993. These dimensions were used to assess the charge weight for the event.

The results indicate a crater of 10.7-12.0m diameter and between 4.5 and 2.5m deep. The charge required to cause this would have been between 650 and 800Kg of TNT. This (800) is the figure that has been used by the assessment.

A selection of the bomb effect analysis computer models available to Royal Ordnance was used in the analysis with the bomb modelled as a point charge of 800 kg of TNT placed some 0.2m above the pavement surface, with no account being taken of the attenuating effect of the surrounding vehicle.

The dimensions of the streets and surrounding areas were taken from the street plans obtained by Royal Ordnance. The only groundshock point of interest was at ground level.

The other prime determinant of the groundshock conditions is the local geology and it has been assumed that the local conditions do not depart from the information supplied to Royal Ordnance by Waterman Partnership via STIL in your fax dated 1th August 1992 for St Mary Axe.

During the analysis several assumptions were made, namely:

a. The pavements does not decouple the explosion from the ground surface.

b. The interface between the two soil infill types is distinct and occurs at exactly 5.0m below the road surface.

c. The soil adjacent to the test point is of sandy loam and loess material, that contains a high proportion of fairly dry sand. This material was modelled as having a seismic velocity of 305 ms^{-1}.

d. The soil infill adjacent to test points T5, T6 and T7 is of much denser material containing gravels and shales in a substrate of sand. This material was modelled as having a seismic velocity of 488 ms^{-1}.

Results - Groundshock Pressures

The pressure that is delivered can be no more than 0.88 KiloPascals overpressure with a duration of 980 milliseconds at a distance of 95m (corresponding to the retained facade. This assumes no structure or foundations between the bomb and the point of incidence which is obviously wrong and will reduce the pressure further to an inestimable degree.

Note that all previous comments about groundshock calculations will hold although the degree of coupling will be greater since the charge is greater.

Airshock

The shock that is transmitted directly along Bishopsgate and into St Helens Place should be no more than 9.0 Kpa (1.2 psi) by the time it arrives at the facade. At this point it would have a duration of approximately 50 milliseconds.

At the roof level, there will be transmission over the office block forming the wall of Bishopsgate. This should lead to pressures of approximately 10 Kpa from the combined shock and gas phases.

I trust that this information is satisfactory to you.

Yours faithfully,

R W Ince
Technical Manager
Security Services
Royal Ordnance

TAYWOOD ENGINEERING LIMITED

CONSULTANTS IN DESIGN AND TECHNOLOGY

Taywood House
345 Ruislip Road Southall
Middlesex UB1 2QX
Tel 081-578 2366 Telex 24428 Fax 081-575 4044
Direct Tel: 081-575-4005 Direct Fax: 081-575-4318

Our Ref: KML8/KB

30 April 1993

Waterman Partnership
46-47 Blackfriars Road
LONDON
SE1 8PN

FAO Mr. A. Hurdle

Dear Sirs,

Exchequer Court, 25-51 St. Mary Axe
Assessment and Testing of Retained Structures (Bishopsgate)

As requested, we have carried out an initial visual inspection of the retained structures. Our findings are as follows:-

1. **Sub Structure**

1.2 Slab Tops -

Both slabs had sizeable areas of their upper surface obscured from view. The Level - 1 slab had various items of plant and materials on it whilst the Level - 2 slab had ponding water in several areas. This water was being removed at the time of inspection. As a result of the above, only gross defects would have been visible, however none were reported. The area around the crane bases was inspected and no damage was observed. Thorough cleaning of this critical area followed by closer inspection would be advisable.

Cont'd...../

1.2 Level - 1 Slab Soffit

The soffit was inspected from floor level only. There is evidence of a small (10%) increase in cracking in the South half of the slab and the effect is highlighted by general condensation, to the South, and dampness and encrustation where water is penetrating through the slab. These new cracks are similar in form to those already reported and they are thought to be due to continuing shrinkage of the concrete.
It would be prudent to carry out a closer inspection of these cracks particularly in areas to be load or water tested.

1.3 Retaining Walls

There is an increase (20%) in the incidence of fine cracking in the retaining walls at both levels. The pattern of the cracking is similar or that observed over six months earlier and a number of these cracks have extended. All cracks are very fine and range between 0.2mm to less than 0.1mm wide at their surface. These cracks are believed to be the result of shrinkage rather than bomb damage.
On Level - 2 adjacent to gridline 13 there is an area of cracking which has extended with time and there is slight water ingress at this point. This water path, and any others through the retaining wall should be sealed, preferably by injection.

1.4 Concrete Columns

Approximately 80% of all columns were inspected from floor level. The remaining columns were located within locked areas and there was insufficient time available to gain access.
There was no evidence of any significant change in the condition of the concrete from the previous inspections. In a small number of columns there was additional surface crazing with crack widths of less than 0.1mm. These do not give any cause for concern.

2. **Retained Facade Supporting Steelwork**

The steelwork and floor slabs at each level were inspected from available access. There was no evidence of any gross damage or movement or any indications that the condition of the structure had changed in any way.

Cont'd...../

In summary, there was no evidence of any damage or deterioration which could be attributed to the recent bomb. There is evidence of continuing movement of the concrete resulting in fine to very fine cracks. None of these observations give cause for concern.

I trust the enclosed meets your present requirements. I have some photographs of the additional cracking which I will copy to you.

Yours faithfully

K. McLernon

Waterman Partnership

EXCHEQUER COURT, 25-51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT AND TESTING RETAINED STRUCTURES (BISHOPSGATE)

OBSERVATIONS ON IMPLICATIONS OF BISHOPSGATE EXPLOSION ON RETAINED STRUCTURES

SUB-STRUCTURE

1.0 It is currently understood that the Bishopsgate bomb has been estimated as twice the size of that in St. Mary Axe.

2.0 From the groundshock analysis previously undertaken and the location of the Exchequer Court site relative to the explosion see WP sketch 8859/9/SK.1.0, we consider the groundshock pressures will have decayed sufficiently to have no affect on the sub-structure or piled foundations.

3.0 WP sketch 8859/G/SK.2.0 indicates in graph form of equivalent static load against distance the significance of distance and the associated decay using the existing groundshock analysis pressures as a basis.

4.0 This matter has been discussed with STIL/RO and Soil Consultants all of whom have confirmed verbally that due to the distance the explosion would have no effect on the sub-structure. RO have been requested to advise formally on this aspect, WP facsimile of 28.4.93 refers.

RETAINED FACADE

1.0 Initial visual inspections of this area were undertaken by WP on 26.4.93 and 29.4.93 and nothing of any structural significance resulting from the Bishopsgate explosion was found. Even though the charge was larger we consider the effects on the structure will have been no greater than for the previous incident, possibly even less due to the location within St. Helens Place and the shielding effects of the buildings. This is also borne out by the comparatively small number of window panes that were blown out by the airshock effects at the east end of St. Helens Place.

CRANES

1.0 The cranes are being inspected by the specialist sub-contractor as directed by AMEC. To enable WP/OAP to assess the airshock effects on the foundations we have requested relevant design data for the cranes.

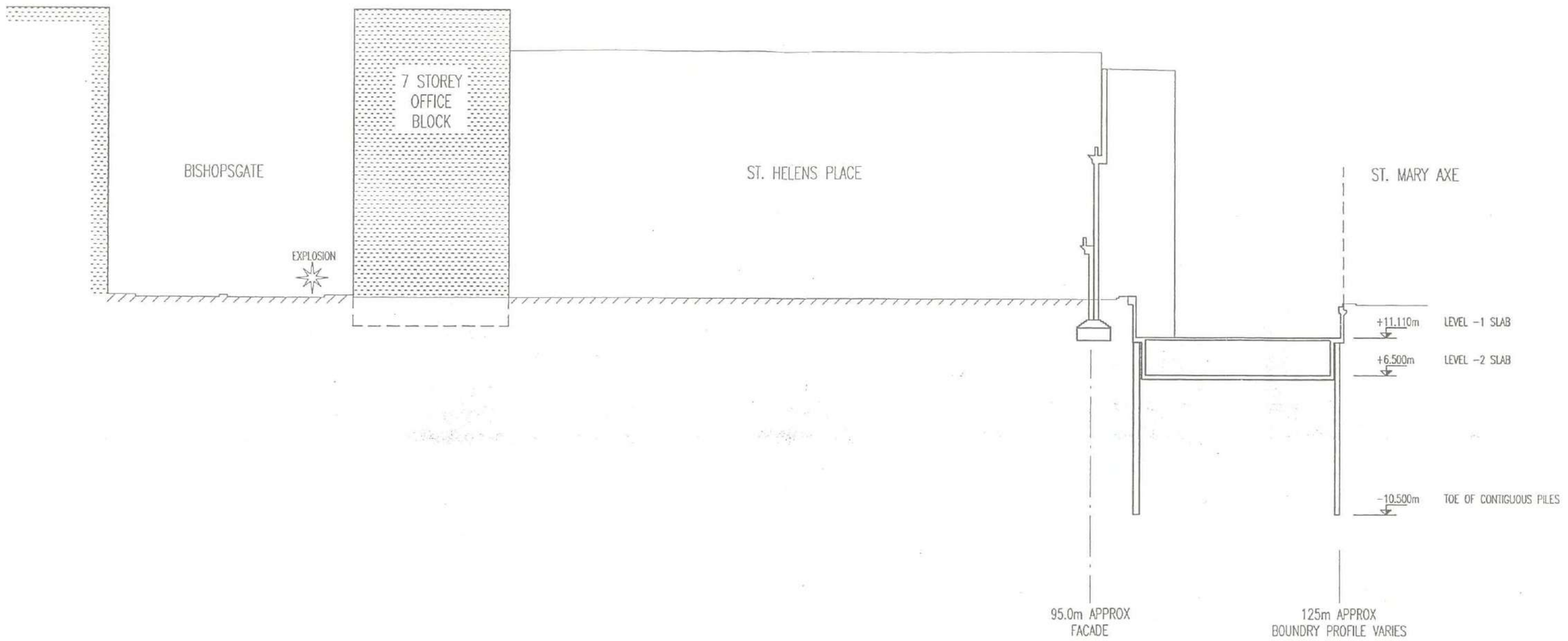
2.0 On 29.4.93 inspections of the crane base areas were undertaken by WP/OAP and nothing untoward noted.

3.0 In conjunction with STIL/RO we are assessing the airshock implications on the cranes. Due to the location of the charge in Bishopsgate and the shielding effect of the seven storey building immediately adjacent to the explosion plus the height of the buildings generally on the east side of Bishopsgate, including the entrance block to St. Helens Place, it is difficult to accurately assess the airshock pressures without detailed modelling analysis as previously undertaken by RO. In addition to the shielding effects the alignment of Bishopsgate and the general open vertical aspect would have assisted the venting of the explosion pressures.

4.0 Pending further information as requested from STIL/RO we consider the airshock pressures could have been in the order of 4.0 kN/m^2.

TAYWOOD ENGINEERING VISUAL INSPECTIONS

1.0 On 28 and 29.4.93 TEL undertook the initial visual inspections of the sub-structure i.e Retaining walls and columns Level 0 to -2 and the slabs at Level -1 and -2. Although some hairline cracks have been noted these are not of structural significance and are considered due to further shrinkage.



LONGITUDINAL SECTION

Waterman Partnership
CONSULTING ENGINEERS
46-47 BLACKFRIARS ROAD LONDON SE1 8PN
Telephone 071 928 7888 Fax. 071 928 3033

Title:-

EXCHEQUER COURT, 25 - 51 ST. MARY AXE, E.C.3.
ASSESSMENT & TESTING RETAINED STRUCTURES
(BISHOPSGATE)

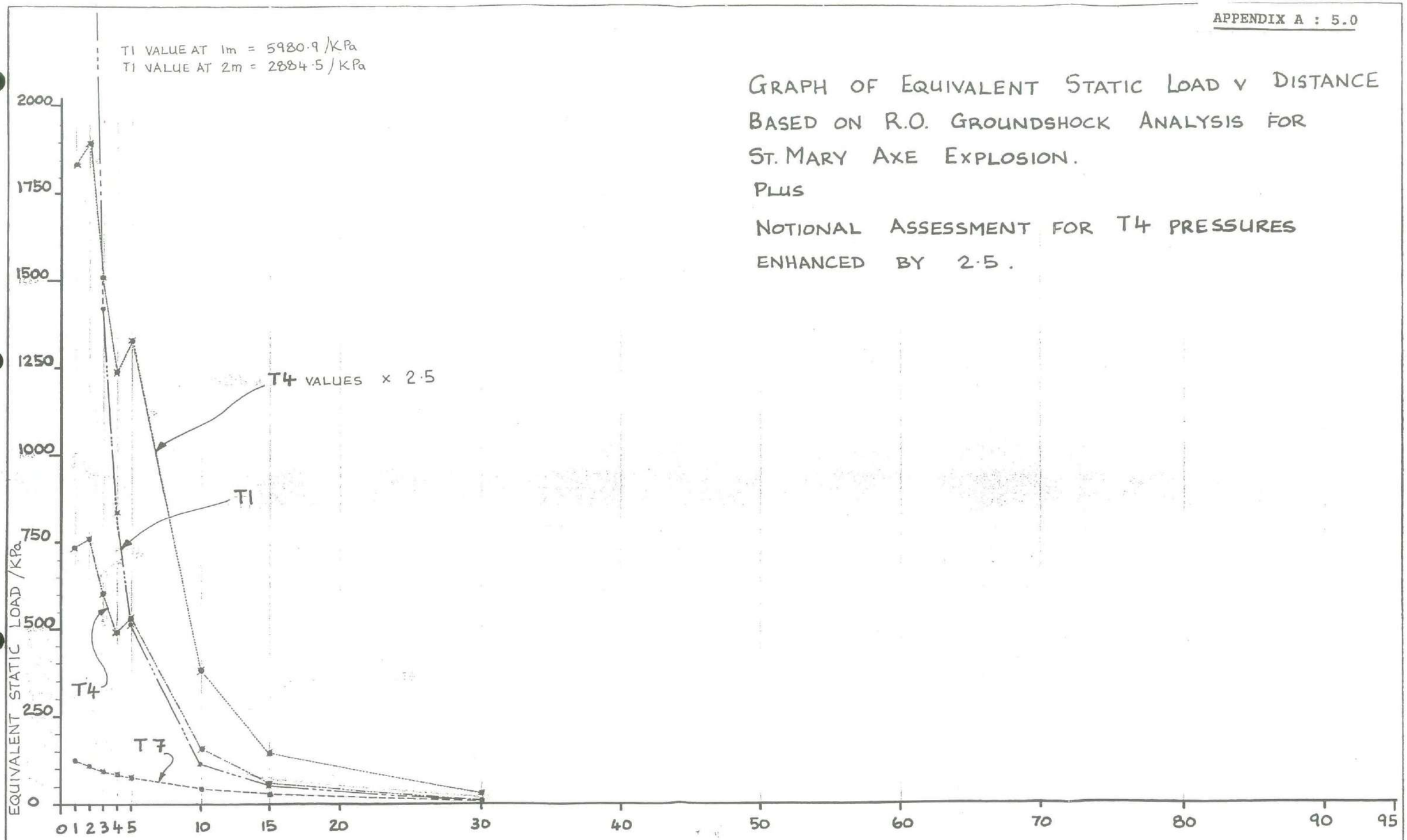
Ref.	Date	Amendments	By
Date APRIL 93		Scales:- 1:500	

Drawing No. 8859/G/SK.1.0

GRAPH OF EQUIVALENT STATIC LOAD v DISTANCE BASED ON R.O. GROUNDSHOCK ANALYSIS FOR ST. MARY AXE EXPLOSION.

PLUS

NOTIONAL ASSESSMENT FOR T4 PRESSURES ENHANCED BY 2·5.



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Title: EXCHEQUER COURT
25-51 ST. MARY AXE, EC.3.
ASSESSMENT & TESTING
RETAINED STRUCTURES
(BISHOPSGATE)

Rev.	Date	Amendments	By

Date: 28·4·93
Scale: VERTICAL 1:10, HORIZONTAL 1:250

Drawing No. L/8859/G / SK.2.0

AWH/JS/8859/A

4th May, 1993

Mr. R.W. Ince,
British Aerospace Defence Ltd.,
Royal Ordnance Division,
Royal Ordnance Security Services,
P.O. Box 243,
Shrivenham,
Swindon, SN6 8QD

Dear Sirs,

RE: EXCHEQUER COURT, 25-51 ST. MARY AXE, LONDON E.C.3
ASSESSMENT & TESTING RETAINED STRUCTURES (BISHOPSGATE)

Further to our facsimiles of 28.4.93 and 30.4.93 and discussions at Bishopsgate with our Mr. S. Fuller, we confirm requesting you for your formal advice on the following:

1.0) The groundshock effects, if any, of the Bishopsgate explosion on the Exchequer Court sub-structure and foundations.

2.0) The airshock effects, if any, of the Bishopsgate explosion on the Exchequer Court retained facade at the east end of St. Helens Place and the two site cranes, approximate height to cabin say 50M, horizontal distance from the explosion say 120M.

Enclosed for your information are single copies of a local site plan plus a longitudinal section showing the relationship of Bishopsgate and Exchequer Court.

We understand that your services associated in advising us on the above aspects will incur charges in addition to those previously agreed and confirm that these will need to be invoiced separately in due course under the above project title. In the meantime an estimate of your fees would be appreciated as soon as possible.

Yours faithfully,

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. Buro Four - N. Biscoe
G & T - J. Elliott
AMEC - P. Miles
Ove Arup & Partners - D. Hadden
encls.
b.c. S. Harden/C. Dicks

AWH/JS/8859/G

7 May 1993

N. Biscoe, Esq.,
Buro Four Project Services,
296-300, St. John Street,
London, EC1Y 4PP

Dear Mr. Biscoe,

RE: EXCHEQUER COURT, 25-51 ST. MARY AXE, E.C.3
ASSESSMENT AND TESTING RETAINED STRUCTURES (BISHOPSGATE)

With regard to the initial visual inspections undertaken last week by Taywood Engineering we enclose herewith a copy of their letter dated 30.4.93 reporting on the situation.

Although further fine cracks have been noted in a number of locations these are not considered due to the explosion but general shrinkage and elastic movements following the demolition and temperature changes now that the Level -1 slab and the retaining walls are exposed to the weather in the temporary condition.

On the 29.4.93 a closer inspection of the Level -2 slab in the crane base areas was also undertaken by ourselves and Ove Arup & Partners and no evidence of structural distress was found.

We propose to monitor the specific areas noted by TEL and prepare any necessary remedial works proposals in due course, although, as these are generally more of a 'cosmetic' nature they will need to be undertaken only after the basements are again fully enclosed.

Yours sincerely,

A.W. HURDLE

c.c. AMEC - P. Miles
G & T - J. Elliott
FRP - P. Freeman
OAP - D. Hadden
Davies & Co. - M. Lightbody

encls

b.c. S. Harden/C. Dicks/J.V. Lamb

SOIL CONSULTANTS LTD.

Site Investigation Specialists
and Geotechnical Consultants

Inkerman Farm
Amersham Road, Hazlemere
High Wycombe, Bucks HP15 7JH
Tel 0494 712494
Fax 0494 713922

A W Hurdle Esq.,
Waterman Partnership,
46-47 Blackfriars Road,
London SE1 8PN.

1215/JAD

7 May 1993.

Dear Mr Hurdle,

re : Exchequer Court, 25-51 St Mary Axe, London EC3.

ASSESSMENT AND TESTING RETAINED STRUCTURES (BISHOPSGATE)

Thank you for the information regarding the location and size of the recent explosion on Bishopsgate, together with the assessment by Royal Ordnance.

Our initial appraisal of the situation suggested that this recent incident was at a sufficient distance not to affect the foundations of Exchequer Court and this conclusion is supported by the subsequent assessment by Royal Ordnance. We agree that the ground conditions to the west of this building are likely to be similar to those used in the analysis of the 1992 incident. Royal Ordnance have calculated the overpressure to be less than 1 kN/m^2, acting for a period of about one second.

The effects of the explosion on the foundations and retaining walls can therefore be ignored.

Yours sincerely,

J A Dixon

AMEC Design and Management

AMEC Design and Management Limited
Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV37 9NJ
Telephone: (0789) 204288, Fax: (0789) 299135

Please reply to:
Project Office
AMEC Design and Management Limited
3rd Floor, Leatherseller's Hall
15 St Helen's Place, London EC3A 6DE
Telephone: 071-920 9378, Fax: 071-628 7205

DB/209/109/JMD

19th May 1993

Waterman Partnership
46 - 47 Blackfriars Road
London
SE1 8PN

Attention : S. Harden

Dear Sirs,

EXCHEQUER COURT, ST. MARY AXE, LONDON EC3

Further to the testing of the tower cranes following the Bishopsgate bomb, please find enclosed the following:-

i) Addendum Method Statement for load testing
ii) Report on testing procedures and conclusions
iii) Extracts from BS7121 Part 1 1989, supplied by Hewden Stuart Wolff on Testing and Examination of cranes.

Yours faithfully,

D. BUTCHER
CONSTRUCTION MANAGER

Encl.

c.c. B/4, FRP + Encl.
PM, PAP + copy of report only
File 109 + Encl.
File WAT + Encl.

ADDENDUM METHOD STATEMENT FOR TESTING

OF TOWER CRANES

Meeting on site, 4th May 1993, with following

V. Lamb - Waterman
P. Phillips - Hewden Stuart Wolff
D. Butcher - AMEC

The main topics discussed -

1. Effect of blast pressure on crane foundations on permanent structure (-2 slab).

2. Method Statement for load testing of crane.

1. EFFECT ON PERMANENT STRUCTURE

i) Hewden Stuart Wolff are to provide information to WAT on design elements of crane, namely.

   a) Design wind moment and the criteria used to arrive at that value.

   b) Is the figure factored or not?

   c) Stiffness of the crane.

   d) Pressure resistance of the windows in the cab.

ii) H.S.W. have contacted the manufacturers in Germany and they have confirmed that the weakest point of the cranes are the cab windows/seals. These have remained intact.

2. METHOD STATEMENT FOR LOAD TEST

i) Test loads will be brought to site by low loader which will park in loading bay in St. Mary Axe.

ii) Before any lifting of loads, the following will be carried out

a) Feeler gauges will be tried on all holding down bolts/nuts on the crane bases at -2 to assess if there is any gap between the nuts and the cross beams.

b) Physical examination of cranes by testing supervisor.

iii) Tower crane will pick up 50% of maximum S.W.L. at maximum radius (i.e. 3000kg for North Crane, 2250kg for South Crane) and slew at maximum radius allowed by confines of site boundary. At same time, the bolts at the base will be monitored throughout this exercise with the bolt inspector in radio contact with the crane driver.

iv) If the above proves to be satisfactory, the exercise will be repeated with the crane lifting 100% of S.W.L.

v) If item iv) proves to be satisfactory, the crane will then be subjected to a 25% overload test. This will be done by picking up the load at maximum radius in St. Mary Axe with the jib along the line of the cross frame. The load will then be trolleyed along St. Mary Axe until it is then at 90° to the first position. At all times the bolts will be monitored as before. The load will be kept at 200mm above road level during this test.

v) Following the 25% overload test the limits on the jib will be reset by picking up 100% S.W.L. at max radius and then travelling towards mast. This will be carried out within confines of site.

vi) Repeat for second crane.

ST. MARY AXE TOWER CRANE REPORT (POST BISHOPSGATE BOMB)

The following was executed to determine whether the Tower Cranes were in a safe condition for reuse:-

i) Initial Inspection with crane unloaded.
ii) Final Inspection with crane loaded.

i) INITIAL INSPECTION (Carried out 27th/28th April 1993

1. Bases/bolts visually inspected by AMEC/Plant Safety.
2. AMEC remained at crane base to monitor base continuously with radio contact with Driver/Plant Safety.
3. Plant Safety Inspector (PS) climbed and examined the towers visually checking for distribution, cracks to welds etc. and that all pins were in place and secure.
4. PS checked slewing ring and bolts.
5. PS checked 'A' frame/motors/pullies and jib pins and bolts.
6. Driver lowered the jib and PS visually inspected throughout.
7. Driver raised jib and PS checked Derrick ropes and supports.
8. Driver slewed jib and PS checked all mechanics.
9. Driver raised/lowered jib in 3 stages. AMEC monitored bases and bolts throughout.
10. Driver slewed 360° in 90° stages. AMEC monitored bases and bolts at each stage.
11. PS inspected ropes and hooks etc.
12. PS/AMEC inspected bases after operations complete. The conclusion from this inspection was that no damage had appeared to have been caused by the blast and that load testing of the cranes could be executed.

ii) FINAL INSPECTION - LOAD TESTING (Carried out 5th May 1993)

1. Test loads were brought to site by low loader parked in St. Mary Axe.

2. Before any lifting of loads the following was carried out:-

   a) A feeler gauge of 0.05mm was tried on all holding down bolts/nuts on the crane bases at L-2 to assess if there was any gap between the nuts and the cross beams. No gaps were found.

   b) A physical examination of the cranes by the Testing Supervisor (TS) was done.

3. The Tower Crane picked up 50% of the max. S.W.L. at maximum radius (i.e. 3000kg for North Crane, 2250 kg for South Crane) and slewed at maximum radius allowed within the confines of the site boundary. At the same time the bolts at the base were monitored throughout by AMEC, whilst in radio contact with the Crane driver.

4. The exercise was then repeated with the crane lifting 100% of S.W.L. and then again lifting 125% of S.W.L.
   (Note: the loads were kept 200mm above ground level at all times).

5. The load was slewed and trolleyed in several locations and monitoring was executed throughout.

6. The load of 100% S.W.L. at max radius was then lifted and trolleyed towards the mast to enable the limits to be reset. This was carried out on both cranes. No movement was detected in the bolts or bases throughout the testing procedure and the cranes were considered safe to use.

B. POCOCK

14.05.93

13 Testing and examination

13.1 General

Reference should be made to clause 13 of BS 7121: Part 1 for general particulars of testing and examination. 3.12 of BS 7121: Part 2, gives detailed particulars of the testing of tower cranes and this should be studied in detail before any attempt is made to test a tower crane.

13.2 Certification, etc. of cranes

See 13.12 of BS 7121: Part 1.

13.3 Personnel safety

Attention is drawn to 3.2.4 of BS 7121: Part 2, which points out that a test may fail and all personnel not essential for the test should be kept away from the area.

In this connection, it should be noted that if a crane is equipped with remote control, then this should be used for the purpose of carrying out the test with the driver at a safe position.

Attention is also drawn to 3.12.3.4 of BS 7121: Part 2, which suggests that a clamp or similar device should be attached to the jib to limit the radius of the trolley when carrying out a maximum load test. On tower cranes on which access along the jib is likely to be hazardous, it is suggested that other arrangements should be adopted to limit the radius of the trolley or the load.

14 Legal requirements

Reference should be made to clause 14 of BS 7121: Part 1.

15 Ropes

15.1 General

Reference should be made to BS 7121: Part 1, clause 15, for a comprehensive treatise on the subject of ropes. Items specific to tower crane ropes are given in 15.2 to 15.4.

15.2 Hoist ropes

15.2.1 *Construction*. Tower crane hoist ropes are invariably of a multi-strand construction having low rotational values. These ropes require very careful handling in order not to disturb the torque which is built into the rope.

The magnet should be marked with the safe working load as determined by tests using weights of the same characteristics as the load for which the device is intended to be used.

The power to the magnet should not be switched on until the magnet has been lowered on to the load to be lifted. The magnet should be carefully lowered on to the load and should not be allowed to strike a solid obstacle while in use. It should not be used on hot metal unless specifically designed for this duty.

When not in use, the power should be switched off to avoid the magnet becoming too hot and the magnet should not be deposited on the ground but should be rested on a wooden platform.

12.5.3 *Vacuum lifting devices*

12.5.3.1 Vacuum lifting attachments should be regularly inspected to ensure that adequate suction is maintained over the required period.

Every vacuum lifting device should be fitted with a device that gives a visual indication to the crane driver of the state of the vacuum at any time, and an audible warning to the driver and any person working in the vicinity at ground level when the vacuum is 80 % or less of the designed working vacuum and/or in the event of failure of the vacuum-inducing pump.

12.5.3.2 Every vacuum lifting device should have means that, in the event of failure of the vacuum-inducing pump, will maintain sufficient vacuum to continue to support the load suspended for a sufficient time (allowing a safety margin) for that load to be safely deposited from the maximum height of lift of the crane to ground level.

Every vacuum lifting device should be fitted with a suitable vacuum gauge that is of sufficient size and situated in a position where the gauge reading may be easily read at the attachment and release position of the load. The gauge should be distinctively marked in red to indicate the vacuum below which the appliance should not be used.

A vacuum lifting device should only be used to lift loads that have a surface suitable for vacuum lifting pads.

12.5.3.3 The vacuum device should be used as follows:

(a) so that each pad supports an equal part of the load, as far as is practicable;

(b) so that the contact surface of the load is suspended horizontally as far as is practicable;

(c) so that the surface of the load is clear of any loose material that would prevent any vacuum pad from making an effective contact with the surface.

12.5.3.4 Before being taken into use for the first time or after any substantial repair, the vacuum device should be tested by a competent person by application of a test load. The test load surface should, as far as is practicable, be similar to the worst type of surface on which the device is intended to be used.

The vacuum device, particularly the hoses and vacuum pads, should be inspected before use at the beginning of each shift or day, and the warning device should be tested at the beginning of each week.

12.6 Weather conditions

12.6.1 *General.* The operation of cranes in situations where they are likely to be affected by the weather should be given careful consideration. Certain weather conditions such as strong wind, heavy rain, ice or snow can impose loads on a crane and adversely affect the safety of crane operations.

12.6.2 *Wind.* The crane should not be operated in wind speeds that are in excess of those specified in the operating instructions for the crane. Gusting wind conditions may have an additional adverse effect on the safe handling of the load and the safety of a crane. Even in relatively light wind conditions, extra care should be taken when handling loads presenting large wind catching areas.

The limitations on wind speed for erecting, testing and dismantling the crane may be lower than the limitation for normal operation and in cases of doubt the designers' or another competent engineer's advice should be obtained. The testing of a crane should not be carried out in an area that is known to be subject to freak weather conditions.

Advice issued by the crane manufacturer regarding the out-of-service conditions should be strictly followed.

12.6.3 *Wind speed indication.* In the case of cranes in positions where they may be adversely affected by high winds, an anemometer should be mounted at a suitable high point, preferably on the crane structure.

12.6.4 *Visibility.* In poor visibility, suitable means of communication should be provided to ensure the safe operation of the crane. In extreme conditions, crane operations should be stopped until there is sufficient improvement in visibility to enable operations to be resumed safely.

12.6.5 *Rain, snow or ice.* During adverse weather conditions, the appointed person should ensure that adequate precautions are taken to avoid danger when the crane or the load is affected by rain, snow or ice.

13 Testing and examination

13.1 General

13.1.1 *Testing and examination.* Various tests and a thorough examination by a competent person are required to ensure that a crane is safe for use. Table 1 and clause 14 give the legal requirements for the testing and thorough examination of cranes. Additional tests and thorough examinations are usually necessary following any substantial alteration or repair to the crane. Any lifting gear to be used with the crane in normal duties or for the purpose of testing the crane should already have been tested separately from the crane.

13.1.2 *Test certificates and documentation.* Cranes are used under a wide variety of conditions, but the following recommendations generally apply.

(a) A crane should not be used unless it has the appropriate current test certificates. Tests will be required following substantial repairs or alteration, and/or periodically as prescribed by legislation.

(b) Periodic examination and inspections, systematic maintenance, repairs, renewals and any necessary heat treatment should be carried out and recorded.

(c) The safe working load should be clearly marked on the crane or the charts affixed to it.

(d) Any lifting attachments should be clearly marked with their safe working loads.

(e) A copy of the operating instructions should be with the crane.

(f) All test certificates and records related to items (a) to (e) should be available for inspection (see 8.8.4).

13.1.3 *Thorough examination.* A thorough examination should be understood to mean the following:

(a) a detailed examination by a competent person that is sufficient to ensure that the crane is safe for use;

NOTE. When considered necessary by the competent person, visual examination can be supplemented by methods of non-destructive testing that determine the condition of any part of the crane without causing any detrimental change to the materials.

(b) when considered necessary, dismantling of parts of the crane by a skilled person to the extent required by the competent person.

The examination should be carried out with the crane in operation and at rest.

13.1.4 *Test site.* Careful consideration should be given to the conditions of the test site. It should be remembered that the recommendations given in the operating instructions for the crane relate to operations within the safe working load. Requirements, which may in certain cases be statutory, apply when loads are being applied for testing.

The following general recommendations apply to all types of cranes.

(a) The ground should be well consolidated and capable of withstanding the loads that will be applied to it. Care should be taken to ensure that there are no hidden dangers such as cable ducts, drains, pipes, back-filled areas, cellars or other subterranean weaknesses.

(b) The ground should be level to within the limits appropriate for testing the particular crane.

(c) The site should be of sufficient area and have unrestricted overhead clearance to allow unobstructed movement of the crane and load throughout all its appropriate test movements, e.g. slewing, derricking and travelling.

(d) A test is designed to prove a crane and so it is essential to bear in mind that the crane might for some hidden reason not withstand the loading. It is therefore necessary to ensure that all personnel not essential to the test are kept away from the area. Test personnel should be so positioned that they are unlikely to be injured should there be any mishap. The test area should be roped off and notices posted prohibiting unauthorized entry. The test site should be well clear of public access areas such as roads and railways. For similar reasons the site should be clear of plant and property which, as well as inhibiting the test, could also be damaged.

13.1.5 *Weather conditions.* Apart from the obvious danger to personnel, it should be recognized that weather conditions such as wind, ice and snow can impose loads on the crane. For this reason test sites should preferably not be in areas that are known to be subject to freak weather conditions. The limitation on wind speed for testing of the crane may be lower than the limitation for normal operation and in cases of doubt the designer's or another competent engineer's advice should be obtained.

The competent person in charge of the tests should ensure that adequate precautions are taken when the wind speed exceeds the limit or the crane or load is heavily coated with ice or snow.

Tests should never be undertaken when the crane or load can not be clearly seen due to rain, snow, mist or fog, etc.

13.2 Conduct of tests

13.2.1 *General.* The tests should be carried out under the control of the competent person appointed for this purpose who should clearly indicate when the tests start and when they have been completed. During the tests the driver, signaller and/or slinger should accept instructions only from the competent person.

Immediately prior to the tests, the competent person should ensure by thorough examination (see 13.1.3) that the crane is as follows:

(a) free from any defect that would preclude it from safely handling the test load;

(b) in the correct configuration and condition according to the manufacturer's instructions;

(c) equipped with sufficient falls of rope for the load under consideration.

The competent person should also ensure that the site and weather conditions are suitable (see 13.1.4 and 13.1.5).

During the tests the load should be kept close to the ground. Shock loading, which may be caused by rapid acceleration of crane motions, sudden braking, erratic or sudden steering movements or movement of the crane controls, should be avoided.

At all times care should be exercised to avoid danger to personnel and damage to plant and surrounding property.

WARNING. At the completion of the test and thorough examination, all safety devices should be restored and checked to ensure that they function correctly.

13.2.2 *Overload testing.* The testing of the crane requires the application of loads in excess of the safe working load. Prior to the application of overloads, it should be established by reference to an authority on the design and construction of the crane, e.g. the manufacturer, that the design of the crane will permit the imposition of the overloads at the positions at which they will be applied. This is necessary because the overloads may be limited by the structural strength and not the stability of the crane. Under such circumstances the structure might buckle or collapse without warning before the crane gives any sign of tipping.

For statutory requirements relating to overload testing see table 1.

The crane should be operated through the motions for which it is designed to carry the load. These motions will include the following, where applicable:

(a) hoisting and lowering;

(b) derricking in and derricking out;

(c) trolleying in and out;

(d) telescoping through the permitted range of movement;

(e) slewing in both directions through the maximum arc for which load carrying is permitted;

(f) travelling and traversing in both directions.

NOTE. Precautions should be taken to limit swinging of the load.

The crane should show that it is capable of sustaining full control of the load throughout these tests.

There should be an adequate supply of known weights with means of handling them.

13.2.3 *Anchorage and ballasting test.* The security of the anchorage and/or adequacy of ballasting should be tested after erection or any alteration. The test requires the imposition of a 25 % overload above the appropriate maximum safe working load to be lifted by the crane at a position where there is a pull on each anchorage, or the imposition of a reduced load to be lifted at an increased radius to give an equivalent test of the anchorage or ballasting arrangements. Care should be taken to avoid overstressing the crane components (see 13.2.1).

Such testing does not apply to movement of a mobile crane about a site where it has been erected strictly in accordance with the manufacturer's instructions.

13.2.4 *Testing of automatic safe load indicator.* Automatic safe load indicators should be tested when testing the crane and it should be noted that in some circumstances testing is a statutory requirement.

The Construction (Lifting Operations) Regulations 1961 require automatic safe load indicators to be of a type approved by the Health and Safety Executive and for them to be inspected once a week.

NOTE. The test button provided on certain indicators only confirms that the electrical circuit and power supply are working. Such test buttons can not confirm the correct functioning of the indicator mechanism, which can only be effectively checked by lifting a known load at the appropriate radius.

13.3 Thorough examination after test

A thorough examination (see 13.1.3) should be carried out by a competent person to ensure that the crane has withstood the test loadings without signs of structural damage that will affect the safety of the crane, such as the following:

(a) cracking;

(b) permanent deformation;

(c) paint flaking;

(d) loosening of or damage to structural connections.

The examination should confirm that all mechanisms function correctly and are free from defect.

13.4 Records

After any test or examination the results should be recorded. If applicable statutory forms should be used.

If, for any reason, the competent person considers it necessary to restrict the use of a machine (e.g. site limitations prevent the testing of the full range of duties of the machine), the restrictions should be noted on the certificate and the use of the crane should be subject to these restrictions. The markings/tables of safe working loads on the machine should be amended to reflect these restrictions.

14 Legal requirements

14.1 General

The Health and Safety at Work etc. Act 1974 imposes duties on employers and the self-employed to ensure, so far as is reasonably practicable, the health and safety at work of all their employees and that undertakings are conducted in such a way as to ensure, so far as is reasonably practicable, that persons not in their employment who may be affected are not thereby exposed to risks to their health and safety.

This duty includes not only the provision and maintenance of plant that is, so far as is reasonably practicable, safe and without risks to health but also the provision and maintenance of such systems of work, information, instruction, training and supervision as are necessary to ensure, so far as is reasonably practicable, the health and safety at work of employees.

Employees have a duty to take reasonable care for the health and safety of themselves and of other persons who may be affected by their conduct at work. They also have the duty to co-operate with their employers so far as is necessary to enable the employers to meet their legal obligations.

14.2 Specific legislation

The following legislation current at the date of publication of this code contains provisions that apply to the provision, maintenance, examination and use of cranes.

(1) Health and Safety at Work etc. Act 1974

(2) The Mines and Quarries Act 1954

(3) The Factories Act 1961

(4) The Electricity (Factories Act) Special Regulations 1908 (S.R. and O. 1908 No. 1312 as amended by S.R. and O. 1944 No. 739)

(5) The Docks Regulations 1988 (S.I. 1988 No. 1655)

(6) The Quarries (General) Regulations 1956 (S.I. 1956 No. 1780)

(7) The Miscellaneous Mines (General) Regulations 1956 (S.I. 1956 No. 1778)

(8) The Shipbuilding and Ship Repairing Regulations 1960 (S.I. 1960 No. 1932)

(9) The Construction (General Provisions) Regulations 1961 (S.I. 1961 No. 1580)

(10) The Construction (Lifting Operations) Regulations 1961 (S.I. 1961 No. 1581)

Table 1 Legal requirements for the inspection, testing and thorough examination of cranes

Authority	Before erection and before being taken into use after each erection, adjustment, removal or exposure to weather conditions affecting anchorages or ballasting of cranes	Before first being taken into use	Before being taken into use for the first time after dismantling or being out of regular use for a period exceeding two months	Weekly	12-monthly	14-monthly	4-yearly	After substantial alteration or repair
The Docks Regulations 1988		Test and thorough examination Regulations 14(1)(a) and 15(1)(b)			Thorough examination Regulation 15(1)(a)			Test and thorough examination Regulations 14(1)(b) and 15(1)(b)
The Shipbuilding and Ship Repairing Regulations 1960		Test and thorough examination Regulation 34(1)			Thorough examination Regulation 34(2)			Test and thorough examination Regulation 34(1)
The Factories Act 1961		Test and thorough examination Section 27(6)				Thorough examination Section 27(2)		
The Construction (Lifting Operations) Regulations 1961	Examination of anchorages and/or ballasting Regulations 19(3) and 19(7)	Test and thorough examination Regulation 28(1)		Inspection Regulation 10(1)(c)		Thorough examination Regulation 28(3)	Test and thorough examination Regulation 28(1)	Test and thorough examination Regulations 28(2) and 28(3)
	Test of anchorages and ballasting Regulation 19(4)	Test of automatic safe load indicators Regulations 30(1) and 30(2)		Inspection of automatic safe load indicators Regulations 30(1) and 30(2)				
	Test of automatic safe load indicators Regulations 30(1) and 30(2)							
The Quarries (General) Regulations 1956			Thorough examination Regulation 13(2)			Thorough examination Regulation 13(1)		
The Miscellaneous Mines (General) Regulations 1956			Thorough examination Regulation 51(2)			Thorough examination Regulation 51(1)		

NOTE 1. The requirements given apply to all cranes unless otherwise stated.

NOTE 2. Reference should be made to the full text of the Act or Regulation indicated.

NOTE 3. Copies of the Statutory Instruments and the prescribed reports and certificates associated with the requirements given are obtainable from Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB.

4.2 If a crane is required to slew over a public highway the client should contact the appropriate Local Authorities to arrange convenient times and dates and, where necessary, diversion of traffic and pedestrians during the tests.

4.3 If a crane is required to slew over a railway or river the appropriate Authority should be asked to give permission and indicate the most suitable time for the tests to take place.

4.4 A test is designed to prove a crane and it should be borne in mind that the crane might not withstand the loading. It is therefore necessary to ensure that all personnel not essential to the test are kept away from the area. Test personnel should be positioned so that they are unlikely to be injured should there be a mishap. The test area should be roped off and notices posted prohibiting unauthorized entry. The site should be clear of plant and property which may inhibit the test.

5 Weather conditions

NOTE. See 12.6 of BS 7121 : Part 1 : 1989.

5.1 For cranes operating in situations where they are likely to be affected by the weather, careful attention should be given to this aspect. Certain weather conditions such as strong wind, heavy rains, ice or snow can impose loads on a crane or adversely affect the safety of crane operations.

For this reason test sites should not be in areas which are known to be subject to freak weather conditions. The limitations on wind speed for testing of the crane may be lower than the limitations for normal operation and in cases of doubt the designers' or other competent engineers' advice should be sought.

Tests should never be undertaken when the crane or load cannot easily be seen because of limitations on visibility or when heavily coated with ice or snow.

5.2 The crane should not be operated in wind speeds that are in excess of those specified in the operating instructions for the crane.

NOTE 1. Gusting wind conditions may have an additional adverse effect on the safe handling of the load and the safety of the crane.

NOTE 2. Long jib configurations present larger wind surface areas and in general should not be tested in wind speeds which exceed 8.0 m/s (18 miles/h) (Beaufort scale 4).

NOTE 3. Appendix A gives details of the Beaufort scale of wind force.

6 Test weights

The following test weights should be used.

(a) Weights of proven accuracy to within ± 1.0 %.

(b) Weights proven on a weighbridge, the weighbridge having been calibrated within the last 12 months.

(c) Weights suspended from a calibrated weighing device, the weighing device having been calibrated within the last 12 months.

NOTE. It is important that the weighing device is capable of weighing the test load to within ± 1.0 %.

7 Thorough examination

7.1 Prior to the tests the competent person should ensure by thorough examination with the crane in motion and at rest that it is:

(a) free from any defect that would preclude it from safely handling the test load;

(b) in the correct configuration and condition according to the manufacturer's instructions;

(c) equipped with sufficient falls of rope for the load under consideration.

7.2 Whenever considered necessary by the competent person the thorough examination should be supplemented by the following.

(a) Methods of non-destructive testing that determine the condition of any part of the crane without causing any detrimental change to the material.

(b) The opening up of concealed or encased parts by a skilled person to the extent required by the competent person.

7.3 The amount of ballast and its disposition should be checked and, where possible, reference should be made to the crane manufacturer's handbook for this information. It should be borne in mind that during the processes of erection and dismantling, ballast can be mislaid or lost.

7.4 The weight of all ballast should be known and, where not marked on the ballast, the weight should be confirmed.

Where loose ballast such as brick, gravel, punchings, pig iron, billets or similar material is used, it should be effectively contained.

7.5 The lifting gear should be thoroughly examined before the test and the competent person conducting the test should satisfy himself that the slinging arrangements are safe. Uncertified lifting gear should not be used.

0.3 All certificates should be endorsed with the information necessary to ensure there is no ambiguity as to crane rigging at the time of test. This applies to all possible variables, e.g. jib length, rope reeving, track width, short or long crawlers, counterweight, blocked, free on wheels, jib locking pins.

0.4 Where for any reason the competent person considers it necessary to restrict the use of a machine (e.g. site limitations prevent the testing of the full range of duties of the machine) then the restrictions should be noted on the certificate and the use of the crane should be subject to these restrictions. A notice of these restrictions should be posted in the cab. Where for any reason the competent person deems it necessary to change the safe working load, the markings and tables of safe working load on the machine should be amended to reflect these restrictions and recorded on the test certificate. The ASLI should be set to perform in accordance with the new safe working loads.

11 Overhead travelling cranes

11.1 For overhead travelling cranes it is necessary to ensure that the crane, gantry and supporting structure are thoroughly examined, tested and certified. However in some circumstances it may be necessary to treat them as separate entities, e.g. where a gantry supports more than one crane. The certificate should clearly identify the extent of such examination and testing.

11.2 A visual examination of the crane gantry and track within the test area should be made prior to commencing the test to ensure their suitability to withstand the test loads.

11.3 Before the application of any load, a thorough examination of the crane followed by a functional test with no load, to ensure the correct operation of controls, switches, contactors, relays and other devices, should be made. The operation and correct adjustments of the brakes and limit switches should be checked and tests carried out to ensure that primary safety and emergency systems are operating correctly.

11.4 At the start of the test the crane should be positioned over a supporting stanchion or column of the gantry with the crab positioned adjacent to the end carriage. With the crane in this position, provision should be made for measuring the deflection of the crane main girders at the centre span. The safe working load should now be raised to sufficient height to ensure that each tooth of the train of gears is subjected to the load, then the load should be lowered to 100 mm to 200 mm above the ground. The load should be held in this position for 10 min to check the brake. The load should then be raised from the suspended position by a further 200 mm and then lowered to 100 mm to 200 mm above the ground. The crab should then be traversed to mid span and the deflection measured. The load should be lowered to the ground to relieve the structure and then raised to ensure that the deflection remains constant.

The load should then be traversed to the opposite gantry, and the crane should be travelled along the track a sufficient distance to ensure that each tooth of the train of gears of the long travel motion is subjected to the load. The load should be traversed across the bridge to the opposite gantry and the crane should be returned to its original lift position.

11.5 The maximum deflection of the main bridge with the crab and safe working load at the centre of the bridge should not exceed $\frac{1}{750}$ of the span.

11.6 The safe working load should be increased by 25 % to form a test load and the test load should be hoisted sufficiently to ensure that each tooth of the train of gears is subjected to the overload then lowered to 100 mm to 200 mm and the procedure in 11.4 should be repeated.

11.7 During the overload test the crane should be capable of handling the overload and the brakes on each motion should be tested to ensure that they function effectively. The traverse and travel brakes should also function effectively with the overload.

11.8 During the overload test the cranes should only be operated at speeds appropriate to the safe control of the load.

11.9 For cranes with two or more hoists, separate tests should be carried out for each hoist. Where the use of more than one hoist is permitted, all tests including the measurement of deflection should be carried out with all these hoists loaded simultaneously.

11.10 On completion of the tests, a further thorough examination of the crane should be carried out in accordance with 7.7 and any overload protection devices should be reset and their correct operation verified.

11.11 When the procedures given in 11.2 to 11.10 have been satisfactorily completed, the competent person should issue the appropriate certificate.

The load should be slewed at the lowest possible speed in both directions through a small arc to determine the ability of the structure to withstand lateral loadings and then slewed through 360° where the design permits.

The maximum safe working load for the jib should be assembled at the minimum radius and raised to sufficient height to ensure that each tooth of the train of gears is subjected to the load. The crane should then be operated through its permitted motions at the lowest possible speeds including full circle slew.

The safe working load should be lowered off and increased by 25 % to form a test load which should be hoisted sufficiently to ensure that each tooth of the train of gears is subjected to the overload then lowered to 100 mm to 200 mm above the ground. The crane should be operated through its permitted motions at the lowest possible speeds.

NOTE 1. It is recognized that for certain types of crane the structure will not permit full slewing with the load just clear of the ground. In these cases it will be necessary to rest the test load and reposition the crane to ensure as much of the crane structure as possible is subjected to the test load.

NOTE 2. For lengths of jib (telescopic or strut) and fly jib, see table 2 or table 3, as appropriate.

13.6.5 It is important that the derrick brakes are tested with the 25 % overload suspended no more than 100 mm above the ground by derricking in from the maximum load radius a small distance and derricking out and applying the derrick brake immediately.

Extreme care should be taken during this test.

13.7 Indicator tests

13.7.1 During the testing of the indicator it is essential that the crane is never loaded beyond 110 % of its safe working load. The radius at which the test load corresponds to 110 % of the safe working load should be marked and the test load should never be taken beyond that point.

13.7.2 A known weight of between 80 % and 90 % of the maximum safe working load for that configuration should be suspended at the minimum radius of the crane. Keeping its load as close to the ground as possible the radius should be increased until the indicator gives the approach to safe load warning and indications. The radius should be measured and the load on the crane confirmed to be between 90 % and 97.5 % of the safe working load for that radius. The radius should be reduced slightly and the load increased by small amounts until the load required to cause an overload warning as it is carefully hoisted from the ground is found. The radius should be measured and the load on the crane confirmed to be between 102.5 % and 110 % of the safe working load.

13.7.3 The tests should be repeated using a known weight approximately twice the minimum safe working load for that configuration of the crane.

13.8 Post test examination and certification

13.8.1 On completion of the test a thorough examination of the crane should be carried out in accordance with 7.7.

13.8.2 When the procedures given in 13.1 to 13.7 have been satisfactorily completed, the competent person should issue the appropriate certificate.

14 Tower cranes

14.1 General

There are various types of tower cranes supported on the following types of bases.

(a) *Rail mounted*, supported on a carriage running on a parallel set of rails.

(b) *Outrigger mounted*.

(c) *On a fixed base*, securely supported on a concrete base.

(d) *Climbing type*, supported by floors during the construction of a multi-storied building.

(e) *On crawler tracks*. For the purpose of testing these cranes should be regarded as mobile cranes.

14.2 Visual examination

A visual examination of the crane and, as appropriate, associated rail track within the test area should be made prior to commencing the test. Before the application of the safe working load a thorough examination of the crane should be carried out including verification that ties, supports, anchorages, ballast, counterweight, and load radius configuration for the type of crane under test are in accordance with the manufacturer's manual. A functional test with no load to ensure the correct operation of controls, switches, contactors and other devices should be carried out. The operation and correct adjustments of the brakes and limit switches should be checked and tests carried out to ensure they are operating correctly.

14.3 Overload test

14.3.1 At the start of a test a rail-mounted crane should be positioned on a straight and level track with firm foundations and free from obstructions, and a rubber tyred crane should be used with jacks or outriggers. Its jacks or outriggers should be set to relieve completely the tyres of the load and set to manufacturer's instructions.

14.3.2 With the trolley or jib at maximum radius the safe working load should be raised a sufficient height to ensure that each tooth of the train of gears is subjected to the load then lowered to 100 mm to 200 mm above the ground and the crane operated through all its permitted motions.

14.3.3 The safe working load should then be increased by 25 % and this load hoisted sufficiently to ensure that each tooth of the train of gears is subjected to the overload then lowered to 100 mm to 200 mm just clear of the ground and the crane operated through its permitted motions.

14.3.4 For horizontal jib cranes with trolleys the trolley should be set at the maximum radius for the maximum safe working load. Suitable devices should be fitted to the jib, e.g. clamps to prevent the trolley from moving beyond this point.

For other cranes the load lifting attachments should be positioned at the maximum radius for the maximum safe working load. The appropriate safe working load should then be raised to a sufficient height to ensure that each tooth of the train of gears is subjected to the load then lowered to 100 mm to 200 mm above the ground and the crane operated throughout all its permitted motions subject to site limitations to ensure the crane is safe to proceed with the test.

NOTE. For most tower cranes it is possible to operate the maximum safe working load at a number of radii, so for these cranes the motions will include moving the load in towards the mast, stopping and moving the load back to the maximum radius position for that safe working load taking care to stop before the clamp is reached.

14.3.5 The load should then be increased by 25 %, which is hoisted sufficiently to ensure that each tooth of the train of hoist gears is subjected to the overload then lowered to 100 mm to 200 mm above the ground and the crane operated throughout its permitted motions to ensure the overload is applied to all parts.

Should tests be limited due to site conditions it may be necessary to dismantle and reassemble the test load at different positions throughout the arc of slew to enable the crane to be thoroughly tested over its working area. Otherwise duties should be restricted (See 10.4).

14.3.6 Where the loaded crane can travel on rail tracks the overload should be travelled the appropriate length of the track with the jib at right angles, at both sides and in line with it where such duties are permitted.

14.3.7 During the overload test the crane should be capable of handling the overload and the brakes on each motion should be proved to function effectively.

14.3.8 During the overload test the crane should be operated at speeds appropriate to the safe control of the load.

14.4 Indicator test

14.4.1 *General*

During the testing of the indicator it is essential that the crane is never loaded beyond 110 % of its safe working load. The radius at which the test load corresponds to 110 % of the safe working load should be marked and the test load should never be taken beyond that point.

14.4.2 *Horizontal jibs with trolleys*

Having proved the effectiveness of the trolley brake by the tests in 14.2 and 14.3 the clamps (see 14.3.4) should be removed and a known load not less than 80 % of the maximum safe working load should be lifted just clear of the ground at minimum radius and travelled very slowly out until the indicator gives the safe working load warning and indications. The radius should be measured and the load on the crane should be between 90 % and 97.5 % of the safe working load for that radius. The load should be increased by small amounts until the load required to cause an overload warning as it is carefully hoisted from the ground is found. This should be between 102.5 % and 110 % of the safe working load for that radius.

14.4.3 *Derricking jibs*

The procedure given in 13.7 should be followed.

14.4.4 *Repeat tests*

The tests should be repeated using a known weight approximately midway between the maximum and minimum safe working loads for that configuration of the crane.

14.5 Post test examination and certification

14.5.1 On completion of the test a thorough examination of the crane should be carried out in accordance with 7.7.

14.5.2 When the procedures given in 14.2 to 14.4 have been satisfactorily completed, the competent person should issue the appropriate certificate.

Table 1. Legal requirements for the inspection, testing and thorough examination of cranes

Authority	Before erection, before being taken into use after each erection, adjustment, removal or exposure to weather conditions affecting anchorages or ballasting of cranes	Before first being taken into use	Before being taken into use for the first time after dismantling or being out of regular use for a period exceeding two months	Weekly	Monthly	12-monthly	14-monthly	4-yearly	After substantial alteration or repair if likely to affect strength or stability
The Docks Regulations 1988	Test and thorough examination Regulations 14(1)(a) and 15(1)(b)	Test and thorough examination Regulations 14(1)(a) and 15(1)(b)				Max period between thorough examinations Regulation 15(1)(a)			Test and thorough examination Regulations 14(1)(b) and 15(1)(b)
The Loading and Unloading of Fishing Vessels Regulations 1988 - SEE Guide HS(R)2B	Test and inspection before use Regulation 6.2 Guide Clause 4 and 6	Test and inspection Regulation 6.2 Guide Clause 4 and 6	Test and inspection Regulation 6.2 Guide Clause 4 and 6		Thorough inspection Regulation 6.2 Guide Clause 6	Thorough examination Regulation 6.2 of lifting plant over 250 kg Guide Clause 6			Test plant over 250 kg Regulation 6.2 Guide Clause 6
The Shipbuilding and Ship Repairing Regulations 1960		Test and thorough examination Regulation 34(1)				Thorough examination Regulation 34(2)			Test and thorough examination Regulation 34(1)
The Factories Act 1961		Test and thorough examination Section 27(6)					Thorough examination Section 27(2)		

Table 1. Legal requirements for the inspection, testing and thorough examination of cranes (*concluded*)

Authority	Before erection, before being taken into use after each erection, adjustment, removal or exposure to weather conditions affecting anchorages or ballasting of cranes	Before first being taken into use	Before being taken into use for the first time after dismantling or being out of regular use for a period exceeding two months	Weekly	Monthly	12-monthly	14-monthly	4-yearly	After substantial alteration or repair if likely to affect strength or stability
The Construction (Lifting Operations) Regulations 1961	Examination of anchorages and/or ballasting Regulations 19(3) and (7)	Test and thorough examination Regulation 28(1)		Inspection Regulation 10(1)(c)			Thorough examination Regulation 28(3)	Test and thorough examination Regulation 28(1)	Test and thorough examination Regulations 28(2) and (3)
	Test of anchorages and ballasting Regulation 19(4)	Test of automatic safe load indicators Regulations 30(1) and 30(2)		Inspection of automatic safe load indicators Regulations 30(1) and (2)					
	Test automatic safe working load indicators Regulations 30(1) and (2)								
The Quarries (General) Regulations 1956			Thorough examination Regulation 13(2)				Thorough examination Regulation 13(1)		
Miscellaneous Mines (General) Regulations 1956			Thorough examination Regulation 51(2)				Thorough examination Regulation 51(1)		

NOTE 1. The requirements given apply to all cranes unless otherwise stated.

NOTE 2. Reference should be made to the full text of the Act or Regulation indicated.

NOTE 3. Copies of the Statutory Instruments and the prescribed reports and certificates associated with the requirements above are obtainable from Her Majesty's Stationery Office (HMSO), 49 High Holborn, WC1V 6HB for personal callers or by post from HMSO, P O Box 276, London SW2 5DT.

AWH/JS/8859/G

11 June 1993

N. Biscoe, Esq.,
Buro Four Project Services,
296-300, St. John Street,
London, EC1Y 4PP

Dear Mr. Biscoe,

RE: EXCHEQUER COURT, 25-51 ST. MARY AXE, E.C.3
ASSESSMENT AND TESTING RETAINED STRUCTURES (BISHOPSGATE)

Further to our letter of 22.4.93, advising on the situation regarding the proposed reconstruction works and the assessed condition of the retained structures following the explosion in St. Mary Axe, we confirm herewith our various observations following the Bishopsgate explosion.

Following the bomb explosion in Bishopsgate on 24.4.93 a programme of structural inspections and assessments has been undertaken to establish the condition of the retained structures.

These investigations have been systematically undertaken by ourselves in conjunction with AMEC, Taywood Engineering, Soil Consultants, Royal Ordnance and agreed with Ove Arup & Partners.

The various site inspections of the basement construction and the retained facade, including non-destructive testing of the welding on the supporting steelwork to the latter, has not revealed any significant structural damage as a result of the explosion.

Our initial assessment that the groundshock pressures induced by the explosion in Bishopsgate would have rapidly decayed over the distance between the charge and the site, so as not to be of any structural significance have been confirmed by the Royal Ordnance and Soils Consultants Ltd.

With regard to the retained facade although this was subjected to airshock pressures and our visual inspection of the masonry has revealed some additional spalling and crack defects these are not major problems and can be readily catered for during the general reconstruction works. From the local inspections it is clear that the location of the retained facade at the far end of St. Helens Place and the height of the adjoining buildings would have mitigated the airshock pressures.

As a consequence of the investigations to-date and although we await final reports from Taywood Engineering we are nevertheless satisfied that it is structurally acceptable for the structural steelwork erection and general reconstruction works to proceed as previously advised in our letter of 22.4.93.

Yours sincerely,

A.W. Hurdle,
WATERMAN PARTNERSHIP

c.c. OAP - D. Hadden
AMEC - P. Miles

b.c. SDH
C.Dicks

WATERMAN PARTNERSHIP
CONSULTING ENGINEERS

46/47 BLACKFRIARS ROAD,
LONDON SE1 8PN

01-928 7888

JOB: EXCHEQUER CT., ST. MARY AXE
BISHOPSGATE EXPLOSION

JOB REF. No. 8859/G

DATE: 22-7-93

TO: ATTN. MR. D. HADDEN
OVE ARUP & PARTNERS,
LONDON

Enclosures

Drawings No. (A)	Bending Schedules (B)	Calculation Sheets (C)
		ASE/1 → 9 ASE/A1 → A7

	Copy to	No. of encls. A	B	C
1 Local Authority				
2 District Surveyor				
3 Architect				
4 Quantity Surveyor				
5 Resident Engineer				
6 Clerk of Works				
7 Gen. Contractor H. O.				
8 Gen. Contractor Site				
9 Others:				
(a) OVE ARUP	✓	—	—	1
(b)				
(c)				
(d)				
(e)				

NOTE:

ENCLOSED REPORT ON EFFECT OF BISHOPSGATE EXPLOSION ON TOWER CRANES FOR YOUR INFORMATION / COMMENTS.

Signed A.S.Vidler

p.p. WATERMAN PARTNERSHIP

EFFECT OF BISHOPSGATE EXPLOSION TOWER CRANES

CONTENTS

LOCATION	CALCULATIONS	OUTPUT

EFFECT OF BISHOPSGATE EXPLOSION

INTRODUCTION

FOLLOWING THE TERRORIST BOMB ATTACK IN BISHOPSGATE ON 25TH APRIL 1993, ROYAL ORDNANCE WERE COMMISSIONED TO ASSESS THE GROUNDSHOCK AND AIRSHOCK EXPERIENCED BY THE BUILDING AT 25-51 ST. MARY AXE.

ROYAL ORDNANCE FINDINGS ARE INCLUDED IN THEIR LETTER DATED 29TH APRIL 1993. SEE APPENDIX 'A'

ACCORDING TO THE ROYAL ORDNANCE REPORT THE MAXIMUM GROUNDSHOCK PRESSURE EXPERIENCED BY THE FOUNDATIONS WAS 0.88 KN/M^2. THIS IS NEGLIGIBLE.

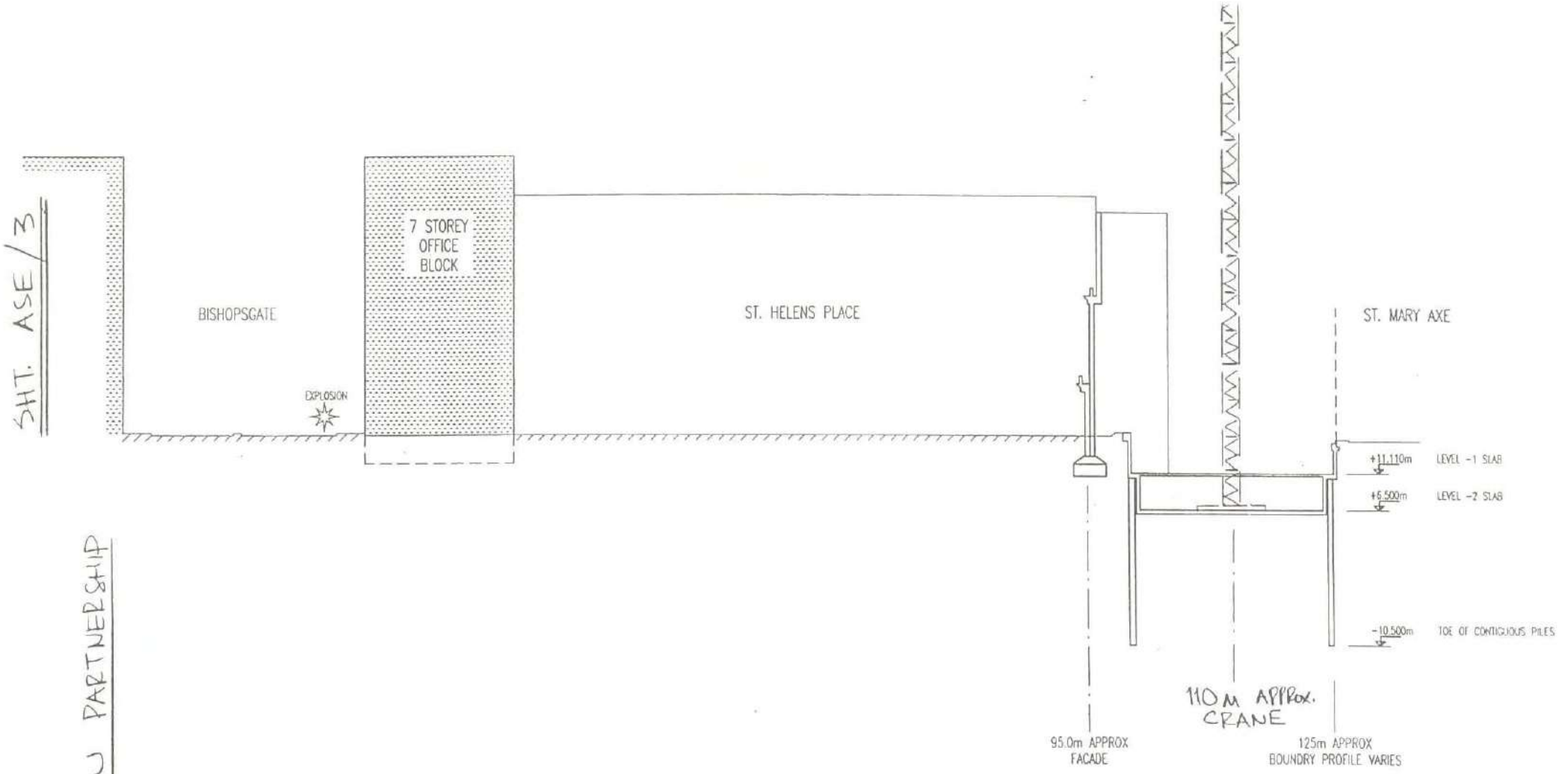
THE AIRSHOCK PRESSURES WERE EXPERIENCED BY THE RETAINED FACADE AND TOWER CRANES. AIRSHOCK EFFECTS ON THE FACADE WILL BE DEALT SEPARATELY.

THIS REPORT DEALS WITH AIRSHOCK EFFECTS ON THE TOWER CRANE ONLY

WATERMAN PARTNERSHIP

SHT. ASE/2

SHT. ASE/3



WATERMAN PARTNERSHIP

LONGITUDINAL SECTION

LOCATION	CALCULATIONS	OUTPUT

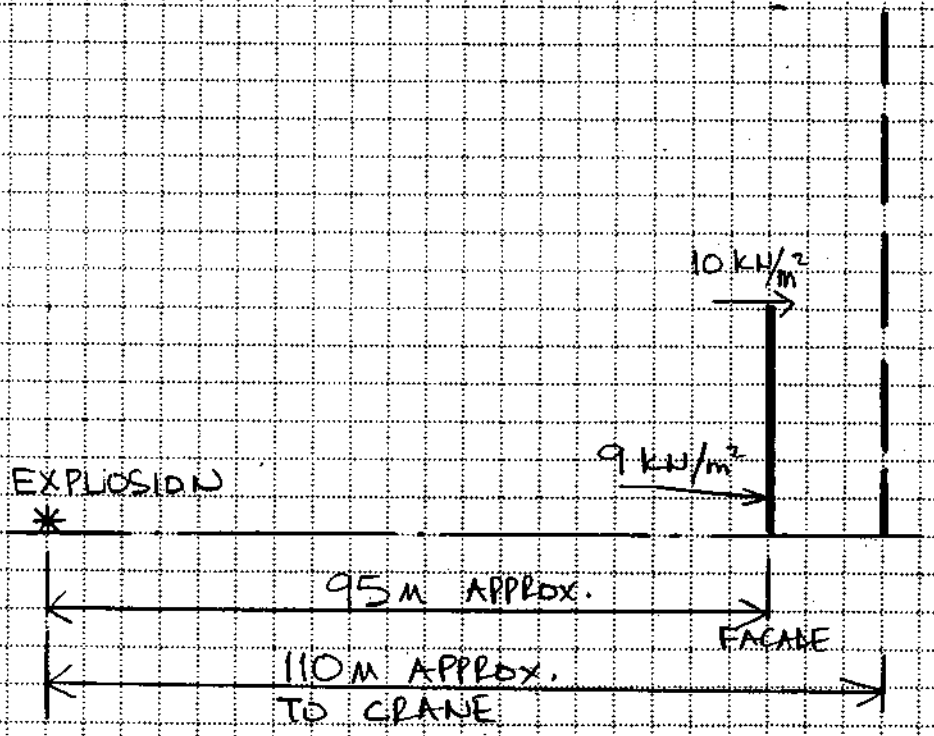
AIRSHOCK EFFECTS ~ TOWER CRANE

FROM ROYAL ORDNANCE LETTER DATED 29TH APRIL 1993, ~ SEE SHT. ASE/A1, A2;

PRESSURE AT FACADE = 9.0 kN/m²

PRESSURE AT ROOF OF FACADE } = 10.0 kN/m²

DURATION, t = 50 MSEC.



AS THE TOWER CRANE IS LOCATED 15M FURTHER AWAY FROM THE FACADE, CHECK FOR FOLLOWING:-

PRESSURE AT CRANE = 9.0 kN/m²
DURATION OF LOAD = 50+ MSEC.

NOTE
NATURAL PERIOD OF CRANE LIKELY TO BE 1 SEC. TO 2 SEC., i.e. >> 50 m SEC.
∴ IMPULSIVE LOADING CAN BE CONSIDERED

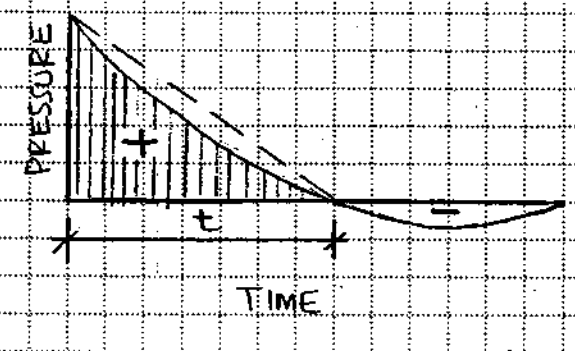
IMPULSIVE LOADING CONSIDERED

LOCATION	CALCULATIONS	OUTPUT

AIRSHOCK EFFECTS ~ TOWER CRANE

CONSIDER A SIMPLIFIED DYNAMIC ANALYSIS FOR RESPONSE IN THE ELASTIC RANGE. THE CRANE WILL BE CONSIDERED AS A CANTILEVER OF TOTAL MASS 'M' kg, STIFFNESS 'K', NATURAL FREQUENCY 'f' CYCLES PER SECOND, AND AN EFFECTIVE ELEVATIONAL AREA OF 'A' SQ. M.

ELASTIC RESPONSE CONSIDERED



Impulse, I = Area under the pressure/time curve

≈ 85% of triangular area.

$= 0.85 \times 9.0 \times 50 \times \frac{1}{2} \times 10^{-3}$

$= 0.191$ kN/m² . sec.

Maximum Velocity, $V = \frac{\text{Impulse}}{\text{Unit mass}} = I \times \frac{A}{m}$

$= \frac{0.191\,A}{m}$

Maximum acceleration, $a = \omega V$

where, $\omega = 2\pi f$ = Circular frequency

Also, Force = mass × acceleration

$= m \times \omega V = m \times 2\pi f \times 0.191 \frac{A}{m}$

$= \underline{1.20\,Af}$, kN

LOCATION	CALCULATIONS	OUTPUT

AIRSHOCK EFFECTS ~ TOWER CRANE

NATURAL FREQUENCY

FOR TOWER CRANES THIS IS A VARIABLE ENTITY, DEPENDING ON THE POSITIONS OF CABIN, JIB ETC.

EXPECTED RANGE, $f = 0.25 \rightarrow 1.0$

ASSUME $f = 1.0$ → VERY CONSERVATIVE

PERIOD, $T = \frac{1}{f} = 1$ sec.

∴ MAXIMUM FORCE = $1.2A$ KN

MAXIMUM EQUIVALENT DYNAMIC PRESSURE EXPERIENCED BY THE CRANE,

$$p_{max} = 1.2 \text{ kN/m}^2$$

DESIGN LOADS

FROM DETAILS OBTAINED FROM THE CRANE MANUFACTURER (SEE RPT. ASE/A3 TO A7) THE CRANE AND FOUNDATION WERE DESIGNED FOR TWO BASIC LOADING CASES, i.e. 'CRANE IN SERVICE' CASE AND 'CRANE OUT OF SERVICE' LOADING CASE. WHEN OUT OF SERVICE THE CRANE WAS DESIGNED FOR A STORM LOAD OF 1.1 kN/m².

DESIGN HORIZONTAL LOAD = 1.1 kN/m² (STATIC LOAD)

AIRSHOCK EFFECTS ~ TOWER CRANE

OVERTURNING MOMENT AT BASE (CHECK OF MANUFACTURER'S DATA)

THE CRANE IN PARKED POSITION IS SHOWN ON SHT. ASE/8

CRANE TOWER ~ 1.9m x 1.9m PLAN SIZE CONSISTS OF 4.5m HIGH TOWER SECTIONS

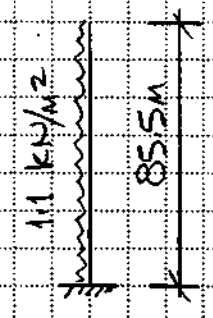
ELEVATION AREA = 1.9×4.5

$= 8.55\ m^2$ PER SECTION

WIND ATTACK AREA = $4.61\ m^2$ PER SECTION (SEE SHT. ASE/A)

$\therefore$ WIND ATTACK AREA = $\frac{4.61}{8.55} \times$ ELEVATION AREA

$= 54\% \times$ ELEVATION AREA



DUE TO WIND LOAD OF 1.1 kN/m^2,

MOMENT AT BASE = $0.54 \times 1.1 \times 1.9 \times \frac{8.55^2}{2}$

$= 4125$ kNm

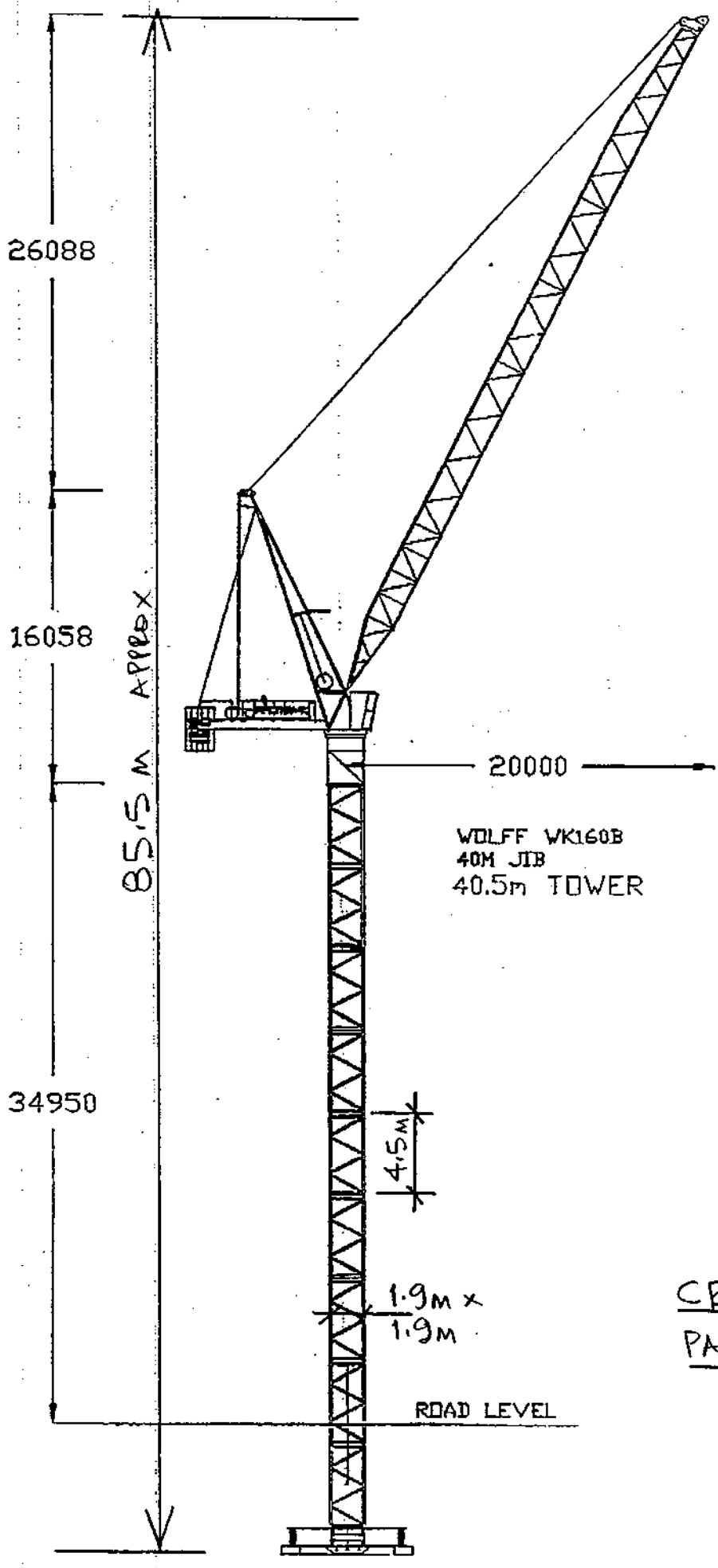
PERMANENT MOMENT = 425
(SHT ASE/A6)

TOTAL MOMENT (ESTIMATE) = 4550 kNm

MANUFACTURER'S DESIGN MOMENT FOR CRANE OUT OF SERVICE (SEE SHT. ASE/A6) = 4790 kNm

} THESE VALUES ARE IN CLOSE AGREEMENT

SHT. ASE/8



CRANE IN PARKED POSITION

AIRSHOCK EFFECTS ~ TOWER CRANE

CONCLUSIONS

1. THE TOWER CRANE WAS DESIGNED FOR A STATIC WIND LOAD OF 1·1 kN/m^2. IN COMPARISON, DUE TO THE EXPLOSION, THE EQUIVALENT DYNAMIC LOAD EXPERIENCED BY THE CRANE HAS BEEN ESTIMATED TO BE NOT MORE THAN 1·2 kN/m^2 AT MID-HEIGHT OF CRANE, i.e. A SHORTFALL OF ABOUT 9%. WHEN DESIGNING FOR DYNAMIC LOADS, THE STATIC STRENGTHS OF MATERIALS CAN BE INCREASED BY AT LEAST 10%. THEREFORE EFFECTS OF LOADS DUE TO EXPLOSION CAN BE CONSIDERED TO BE LESS THAN THOSE DUE TO DESIGN WIND LOADING.

2. INSPECTION OF THE CRANE BASE AREAS INCLUDING HOLDING DOWN BOLTS AND THE LEVEL-2 BASEMENT HAVE BEEN CARRIED OUT. NO DAMAGE HAS BEEN DISCOVERED.

3. FROM THE ABOVE WE CAN CONCLUDE THAT THE FOUNDATIONS TO THE TOWER CRANES INCLUDING THE BASEMENT SLAB WERE NOT OVERSTRESSED BY LOADS DUE TO THE BISHOPSGATE EXPLOSION.

SHT. ASE/A1

BRITISH AEROSPACE
DEFENCE
ROYAL ORDNANCE

British Aerospace Defence Limited
Royal Ordnance Division
Royal Ordnance Security Services
PO Box 243
Shrivenham, Swindon
SN6 8QD, England
Telephone (0793) 783610
Fax (0793) 783616

Reference: A 800 20/3

29 April 1993

Mr A Hurdle
Waterman Partnership
46/47 Blackfriars Road
London SE1 8PN

Dear Mr Hurdle,

25-51 St Mary Axe, London EC3. Assessment and testing of Retained Structures - Bishopsgate blast

We have completed an overview assessment of the groundshock and airshock experienced by the building, as a result of the terrorist bomb in Bishopsgate on 25th April 1993. As you requested a response in extremely short order we have made several assumptions about the blast.

The crater dimensions were taken from photographs taken by myself and Stephen Fuller at the site on the 27th April 1993. These dimensions were used to assess the charge weight for the event.

The results indicate a crater of 10.7-12.0m diameter and between 4.5 and 2.5m deep. The charge required to cause this would have been between 650 and 800Kg of TNT. This (800) is the figure that has been used by the assessment.

A selection of the bomb effect analysis computer models available to Royal Ordnance was used in the analysis with the bomb modelled as a point charge of 800 kg of TNT placed some 0.2m above the pavement surface, with no account being taken of the attenuating effect of the surrounding vehicle.

The dimensions of the streets and surrounding areas were taken from the street plans obtained by Royal Ordnance. The only groundshock point of interest was at ground level.

The other prime determinant of the groundshock conditions is the local geology and it has been assumed that the local conditions do not depart from the information supplied to Royal Ordnance by Waterman Partnership via STIL in your fax dated 1th August 1992 for St Mary Axe.

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Registered Office: Lancaster House, PO Box 87, Farnborough Aerospace Centre
Farnborough, Hampshire. GU14 6YU

During the analysis several assumptions were made, namely:

a. The pavements does not decouple the explosion from the ground surface,

b. The interface between the two soil infill types is distinct and occurs at exactly 5.0m below the road surface.

c. The soil adjacent to the test point is of sandy loam and loess material, that contains a high proportion of fairly dry sand. This material was modelled as having a seismic velocity of 305 ms^{-1}.

d. The soil infill adjacent to test points T5, T6 and T7 is of much denser material containing gravels and shales in a substrate of sand. This material was modelled as having a seismic velocity of 488 ms^{-1}.

Results - Groundshock Pressures

The pressure that is delivered can be no more than 0.88 KiloPascals overpressure with a duration of 980 milliseconds at a distance of 95m (corresponding to the retained facade. This assumes no structure or foundations between the bomb and the point of incidence which is obviously wrong and will reduce the pressure further to an inestimable degree.

Note that all previous comments about groundshock calculations will hold although the degree of coupling will be greater since the charge is greater.

Airshock

The shock that is transmitted directly along Bishopsgate and into St Helens Place should be no more than 9.0 Kpa (1.2 psi) by the time it arrives at the facade. At this point it would have a duration of approximately 50 milliseconds.

At the roof level, there will be transmission over the office block forming the wall of Bishopsgate. This should lead to pressures of approximately 10 Kpa from the combined shock and gas phases.

I trust that this information is satisfactory to you.

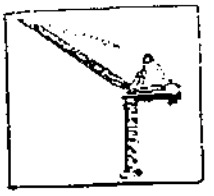
Yours faithfully,

R W Ince
Technical Manager
Security Services
Royal Ordnance

Hewden Stuart Wolff Ltd.

U.K. Agents for WOLFF TOWER CRANES

WILLOWBRIDGE LANE CASTLEFORD WEST YORKSHIRE WF10 5NJ
Telephone (0977) 558831 Fax (0977) 603046 London Office 071 370 0588



SHT. ASE/A3

F A C S I M I L E

To: David Butcher - AMEC, Exchequer Court

From: Paul Phillips

Date: 24 May 1993

No. of Pages: 4

Fax Ref: 1255

Fax No: 071 628 7205

Reference: Tower Cranes - Theoretical Stability Information

After the meeting on site between Mr Lamb of Waterman, yourself, and the writer, we received you meeting minutes. The information requested regarding design elements of the tower cranes was requested from the crane manufacturer's engineer, who quoted the following 3 DIN design standards as containing all the design criteria for this and the whole range of Wolff tower cranes.

They were DIN 15018, DIN 15019 and DIN 1055. To assist Mr Lamb with his considerations, I have requested our design engineer, Colin Beddow, to photocopy and highlight the areas of these standards that best answer the queries raised. His highlighted sheets are attached.

If you or Mr Lamb have further queries, please do not hesitate to contact Colin direct.

Best Regards

Paul Phillips
DIRECTOR

RECEIVED
24 MAY 1993
AMEC

427/1524/DB

In the example,

$\min\left(R_{Ka_1} + R_{Ka_2}\right)$ and $\min R_{Kr_1} + \min R_{Kr_2}$ } = the smallest wheel load total, and respectively, the sum of the smallest wheel load of the driven track wheels, excluding the useful load and the factors as per 4.1.4, as used in determining the drive forces on the basis of adhesion.

l_s = The distance, measured perpendicularly to the direction of motion, of the resultant of the drive forces from the centre of mass S of the crane bridge, trolley and hook load.

e = Centre distance of the wheels or guide roller or guide roller groups for absorbing the lateral forces; see fig. 4.

The mass forces during acceleration and retarding shall be calculated in each case with the trolley in the worst position for the component being analyzed (see Fig. 3).

Where lateral forces due to inertia effects act transversely to the runway they shall be transferred to the rails through positive and frictional contact in accordance with the structural and mechanical systems (running gear) and the type of guiding means used.

Unidirectional lateral forces, such as those due to inertia effects during the acceleration and retardation of trolleys (see Fig. 2), shall be uniformly distributed between all the track wheels or guiding means.

Lateral forces opposite in direction occur where there is a distance l_s between the centre of gravity of the masses to be moved and the resultant of the drive forces. Where they are transferred through the track wheels and where there are more than 2 track wheels per runway side, they shall be equally distributed between the outer wheels or wheel groups as shown in the examples illustrated in Fig. 4, namely

with not more than 4 track wheels per rail, to 1 outer wheel per corner,

with not more than 8 wheels per rail, to the 2 outer wheels per corner,

with more than 6 wheels per rail, to the 3 outer wheels per corner.

As far as the structural work is concerned, such as bridge, trolley or equalizer, the lateral forces shall be distributed between all the wheels of a corner even in the region of the inner track wheels that are non-loaded in accordance with fig. 4.

In the case of wide-span bridge and portal cranes having separate drives and whose structures are not designed to compensate for resistances to motion, drive and mass forces but only for a limited elastic load of one running gear side, special means shall be provided to assure that the assumptions on which the design calculations were based are not exceeded.

4.1.6 Centrifugal forces

The centrifugal forces acting on slewing cranes shall only be calculated from the dead load of the jib components, the counterweight, if used, and the hoist load without applying the factors mentioned in 4.1.4, and assuming the hoist load to be positioned at the tip of the jib.

4.1.7 Impact of bulk material

Impact effects on bins and transfer points due to dropping bulk material shall only be allowed for locally.

4.2 Additional loads

4.2.1 Wind load

In the case of cranes exposed to wind, wind load must be allowed for in accordance with DIN 1055, Sheet 4.

In the case cranes in service the wind load shall be allowed for by applying a velocity pressure of $q = 250 N/m^2$ ($25 kp/m^2$). Wind load on the useful load shall be taken to be 3 % of the useful load effects but not less than 500 N (50 kp), unless the surface area on which the wind acts is definitely known.

In the case of cranes out of service the velocity pressures given in DIN 1055, Sheet 4, shall be used to allow for wind load.

4.2.2 Forces due to skewing

If a crane bridge skews, that is, if it assumes a skew angle α relative to the runway, a positive contact force S is produced on the front guiding means or group of guiding means (wheel flange or guide roller) as seen in relation to the direction of movement, and consequently a group of positive contact forces X_{1i}, Y_{1i}, and X_{2i}, Y_{2i} acting in the contact areas of the track wheels.

The force S due to skewing of cranes with flanged track wheels shall be distributed in accordance with section 4.1.5 — Fig. 4.

For cranes with a total of n pairs of track wheels arranged each on an axis i, and of which m are synchronized, and whose wheel loads R_{1i} on side 1 and R_{2i} on side 2 are of

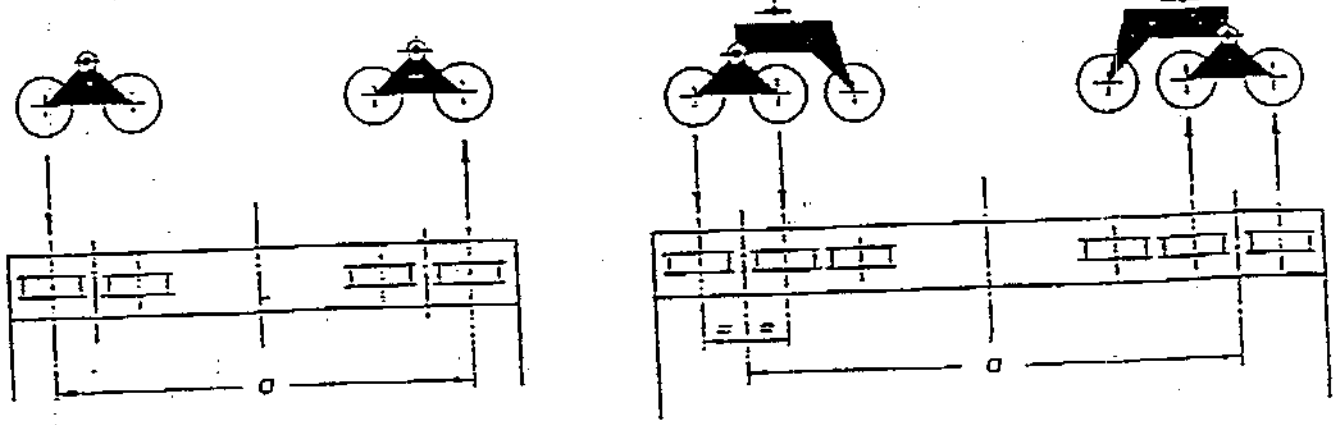


Figure 4 Distribution of lateral forces

Datei zur Windbelastung der Turmstuecke nach DIN (WITUD)

Stueck	Gewicht weight kN	Windfl. Wind area m**2	IwService q=0.25 Wind load/sect. kN/m**2	q=0.80 kN/m**2	Sturm q=1.10 Wind Load/Sect. kN/m**2	
12	25.03	12.00	3.00	9.60	13.20	
12	13.37	6.00	1.50	4.80	6.60	
12	17.07	6.00	1.50	4.80	6.60	
15	11.10	3.68	0.92	2.94	4.05	
15	12.75	3.90	0.98	3.12	4.29	
20	13.40	4.37	1.09	3.50	4.81	
25	27.50	6.76	1.69	5.41	7.44	
SA 15	13.35	4.17	1.04	3.34	4.59	
15	13.10	3.90	0.98	3.12	4.29	
S 20	14.00	4.37	1.09	3.50	4.81	
A 15	17.70	4.08	1.02	3.26	4.49	
A 20	19.70	4.61	1.15	3.69	5.07	
A 25	36.10	5.75	1.44	4.60	6.33	
T 15	17.10	4.08	1.02	3.26	4.49	
T 20 /UV20	18.20	4.61	1.15	3.69	5.07	*
T 25	36.40	6.16	1.54	4.93	6.78	
V 15	17.10	4.08	1.02	3.26	4.49	
V 20	18.20	4.61	1.15	3.69	5.07	
V 25	38.50	6.16	1.54	4.93	6.78	
VA 25	36.10	5.75	1.44	4.60	6.33	
TV 20	28.30	6.62	1.66	5.30	7.28	
TVA 20	28.30	6.62	1.66	5.30	7.28	
TV 25	31.00	7.20	1.80	5.76	7.92	
TUE 15	14.50	4.47	1.12	3.58	4.92	
UTUE 15	19.50	4.77	1.19	3.82	5.25	
UTUEN 20	23.00	5.96	1.49	4.77	6.56	
UVUE 15	19.5	4.77	1.19	3.82	5.25	

Derived from DIN 1055

SHT. ASE/A6

WOLFF

WK 160 B

Maximum Load Capacity 12 tonnes
Maximum Jib Radius 50 metres

STATIC DATA

Foundation loads

for a free-standing stationary crane without climbing equipment on a concrete foundation.

Permanent loads are:

Vertical forces of load case 2 as well as a permanently acting moment of 425 kNm.

The values given apply for the most unfavourable jib length i.e. if the crane is in service with another jib, lower foundation loads may result which have only a minor influence on the dimensioning of foundation.

tower height (m)	Crane in service (for loadcase 1 of DIN 1054) torquemoment: 250kNm			Crane out of service (for loadcase 2 of DIN 1054) torquemoment: 0kNm		
	M (kNm)	H (kN)	V (kN)	M (kNm)	H (kN)	V (kN)
9.0	3076	26	717	2097*	14	312
13.5	3297	27	737	2190*	15	331
18.0	3518	28	757	2288*	16	349
22.5	3737	29	777	2582	97	582
27.0	3952	31	802	3093	103	605
31.5	4167	32	834	3629	111	633
36.0	4385	34	865	4195	118	662
40.5	4603	36	896	* 4790	125	690
45.0	4822	37	927	5411	132	718
49.5	5039	39	960	6058	139	749
54.0	5257	41	995	6726	145	781
58.5	5477	43	1030	7414	151	813
63.0	5698	44	1066	8119	156	845
67.5						
72.0						
76.5						
81.0						

*Moments during crane erection
M = Moment
H = Horizontal forces
V = Vertical load

* WIND MOMENT.

SHT. ASE/A7

Hewden Stuart Wolff Ltd.

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FACSIMILE

FAX REFERENCE NO. 1481

TELEFAX NO. 071 401 3638

TO : AVTAR VIRDEE

FROM : COLIN BEDDOW

DATE : 25/Jun/1993 TOTAL NO. OF PAGES : 1
(including this cover sheet)

REFERENCE : 8859/A - WK160B TOWER CRANES, ST MARY'S AXE

MESSAGE :

1. APPLICABLE DESIGN DATA IS FOR TOWER SECTIONS UV20.

2. THE BASE MOMENT OF 4790KNM IS DUE TO WIND LOAD ON THE TOTAL AREA OF THE TOWER CRANE WITH THE CRANE IN FREE SLEW OFFERING THE SMALLEST WIND ATTACK AREA.

FURTHER TO OUR TELECON WIND LOADING IS STATIC LOADING. THE DESIGNERS CANNOT STATE A NATURAL FREQUENCY FOR THE CRANE. ALL THE RELEVANT DESIGN REGULATIONS, I.E., BS, DIN, FEM AND THE NEW EUROPEAN STANDARD HAVE NO REQUIREMENT AND GIVE NO GUIDANCE FOR NATURAL FREQUENCY.

BEST REGARDS

COLIN BEDDOW

IN THE EVENT OF ANY PROBLEMS ASSOCIATED WITH THIS MESSAGE PLEASE CONTACT THE SENDER ON (0977) 558831.

Ove Arup & Partners

13 Fitzroy Street
London W1P 6BQ
Telephone 071-636 1531
Telex 295341 OVARPT G

Direct Dialling:
Telephone 071-465 3319
Facsimile 071-465 3679

46570/DH/MB
7 October 1993

Mr A W Hurdle
Waterman Partnership
46/47 Blackfriars Road
LONDON
SE1 8PN

ARUP

Dear Tony

<u>Exchequer Court - Independent Structural Engineer</u>
<u>Bishopsgate Event</u>

Further to our discussions at recent Review Meetings I have no further comments on your calculations ASE/1-9, ASE/A1-A7 relating to the blast loads on the tower cranes.

Yours sincerely

David Hadden

Refers to calculation package submitted by WP on 22.7.93.

cc Mr P Heritage, Buro Four