UNISON HQ, EUSTON RD NORTH
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Report on Investigations and Required Remedial Works
To the Listed Buildings at the former Elizabeth Garrett Anderson Hospital

December 2006

Ref: L051036

Revision A

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APPENDICES

Revision	Amendments	By	Checked	Date
0	Draft Issue for comments.	PL	PL	15/12/06
A	Minor Amendments	PL	PL	01/02/07

1.0 Executive Summary

1.1 UNISON has purchased the former Elizabeth Garrett Anderson Hospital with the intention of re-developing the site as their main London offices.

1.2 It is proposed that the existing buildings will be demolished, with the exception of the L-shaped grade II listed building which will be renovated and incorporated into the development proposals.

1.3 This report discusses the condition of the existing listed building, describes the investigation works undertaken and provides outline recommendations for the required structural stability works.

1.4 The portion of the listed building fronting Churchway has subsided and has been subsiding for at least 10 years. The cause of the subsidence is the mature lime trees located on the corner of Euston Road and Churchway.

1.5 The subsidence has caused severe structural cracking to portions of the listed building.

1.6 The cracking is so severe in certain areas that, to prevent the imminent catastrophic collapse of parts of the listed building, areas have been propped both internally and externally.

1.7 The movement due to subsidence is so severe and has been occurring for such a long period that parts of the listed building cannot now be saved. The bay fronting Churchway must be demolished and re-built. The corridor linking the two halves of the listed building must be demolished and re-built.

1.8 The listed building is continuing to subside and further structural damage will occur progressively unless action is taken. The building fronting the Euston Road must be underpinned.

1.9 The ground floor slab to the building fronting Churchway should be removed and replaced with a suspended slab. A large amount of brickwork replacement will be required where masonry cracking is observed.

1.10 The floors of the listed building should be tied into the perimeter elevations.

1.11 The building can be saved, but works, specifically underpinning and re-building should be undertaken as soon as possible to prevent any further irreversible damage.

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2.0 Introduction

2.1 The former Elizabeth Garrett Anderson hospital located on the corner of Euston Road and Churchway has been purchased by our clients, Unison. The site is to be developed as their new head offices together with a residential block to the rear of the site.

2.2 The original part of the hospital, an L-shaped building fronting Churchway and Euston Road constructed circa 1890, is listed. The listed building has suffered serious damage due to subsidence and is currently propped internally and propped externally by raking shores.

2.3 In order to fully understand the extent of the damage, a soft strip of the internal finishes and some limited exploratory works have been undertaken to reveal some of the underlying structure. A geotechnical survey and floor level survey has also been undertaken local to the listed building.

2.4 Unison's project development team, including AKSWard, met with The London Borough of Camden's head of Conservation at the listed building on the 7th April 2006. The purpose of the meeting was to highlight the structural deterioration of the building and to discuss the proposed method of renovating the building. It was proposed that, due to the extent of the deterioration, the renovation would need to be undertaken in the following stages.

- Stage 1 Discuss soft strip/ exploratory works with London Borough of Camden and provide scope of works.
- Stage 2 Undertake soft strip, exploratory works and asbestos removal.
- Stage 3 Report upon findings with regard to stabilising the building and provide structural details for the necessary works.
- Stage 4 Undertake urgent building works to ensure the building is adequately stabilised.
- Stage 5 Undertake site wide development proposals including final renovation of listed building.

2.5 The scope of works for the exploratory investigations was submitted to the London Borough of Camden in April 2006. The proposals were deemed not to require listed building consent and approval to undertake the soft strip and exploratory works was received on the 12th May 2006. These works were undertaken between August and October 2006.

2.6 This document forms part of Stage 3 of the proposals to renovate the listed building and presents the results of the investigations.

2.7 Given the listed status of the building, full consultation with the London Borough of Camden will be undertaken at each stage.

2.8 This document only provides recommendations for the immediate stabilisation of the listed building, which will prevent further major structural deterioration, it does not provide details for the complete renovation of the building fabric; these works will be specified and undertaken as part of Stage 5 of the overall development proposals. It should be noted that this report is concerned with the load-bearing structure of the building only, it is not a detailed building survey, and does not provide recommendations for roof repairs, rainwater goods repairs, plaster repairs and window repairs etc.

2.9 AKSWard have also been monitoring the movement of the listed building through the use of suitably located 'tell-tales'. This monitoring has been continuous between May 2005 and March 2006. Data from this has indicated that the building is still subsiding. Given the size and location of the cracking, it is considered that parts of the building are now under threat of collapse and it is recommended that urgent remedial works are undertaken.

3.0 Listed Building – Present Condition

3.0.1 A typical floor plan of the listed building (fig 1) is shown in appendix A. The portion of the building fronting Churchway is labelled Block A, and the portion of the building fronting Euston Road is labelled block B.

3.0.2 The listed building, specifically Block B and the link corridor between blocks A and B, are in a very poor structural condition. The side bay to block B is currently propped externally by raking shores and propped internally by a series of back props. The link corridor between blocks A and B is currently propped internally. The structural cracking to these areas is so severe that, it is likely; these areas will collapse if the props are removed.

3.0.3 The areas of major structural concern are indicated below with corresponding photographs in appendix B.

3.1 Block B

3.1.1 The floors at each level show a noticeable fall to the south-west corner; the floor level survey indicates this fall to be up to 120mm (1 in 65) across block B. This is consistent at each floor level and is immediately noticeable by the observed fall of the window cills to the south and west elevation.

3.1.2 The ground floor slab, which is ground bearing, has also moved downwards and pulled away from the skirting creating a pathway for water penetration into the ground floor.

3.1.3 Many of the spandrel panels, beneath the windows to the south elevation at each floor level (215 solid brick), exhibit diagonal cracking. The cracks penetrate the brickwork. Above the windows a number of the arches have cracked.

3.1.4 Diagonal brickwork cracking is also recorded to the feature tower where it links to the main mass of block B.

3.1.5 Brickwork cracking, up to 20-25mm wide, is present to the western bay arch at each floor level. The arch has failed at ground, first and second floors. The arches support part of the floors; collapse of the floors is currently prevented by a system of back-props (installed in March 2005) to the arches. The back-props run from ground floor to the underside of the third floor.

3.1.6 The feature bay, located on the west of the building fronting Churchway, exhibits large diagonal cracking over its full height. The cracks are up to 30mm wide. The majority of the arches to the bay windows also exhibit major cracking, including loss of whole sections of brickwork which have fallen. The bay is no longer adequately tied into block B; it is currently prevented from collapsing into Churchway by raking shores (installed in March 2005). Although, loose brickwork is progressively falling from these areas.

3.1.7 The arch to the entrance to block B from the link corridor, exhibits brick cracking at ground and first floor level; this arch has failed.

3.1.8 The rainwater pipe located on the south-west corner is twisted and broken; it is likely to have been in this condition for some time. The brickwork walls to this area, at each level, are saturated. The damp has penetrated into the floor structure causing some of the supporting steel beams to rust.

3.1.9 The apparent movement of the building has caused many of the roof tiles and flashings to become broken. This together with the amount of brickwork cracking has allowed water to penetrate the building; large areas of the plaster work are saturated. Continued ingress of water will cause further damage.

3.1.10 Brickwork frost damage and spalling is evident around the base of the building.

3.1.11 The external steel escape stair, evidently a later addition erected to facilitate secondary means of escape from the former adjacent nurses residence, has rusted where it penetrates the masonry of block B. This, coupled with the apparent movement of block B, has caused the brickwork to crack and twist where the stair connects.

3.2 Link Corridor Between Blocks A and B

3.2.1 The floors to the link corridor have a noticeable fall from block A to block B

3.2.2 Major structural cracking to the floor slabs can be observed where the link corridor connects into either block A or block B. The crack width is of such magnitude (up to 40mm) that the underlying structural beams can be seen through the cracks. Under the recommendations of AKSWard, the entire link corridor was back-propped from basement to the underside of the third floor (the back-props were installed in August 2006). It is clear that the link corridor floor is in danger of slipping off its bearings. The back-propping was necessary to facilitate safe access to block B during the soft-strip and exploration works. The collapse of the link corridor floors is now prevented by the back-props.

3.2.3 The east and west flank walls to the link corridor also exhibit major structural cracking throughout their height. At third floor level the brickwork cracking is up to 60mm wide. The majority of the window arches, within these elevations, have failed. Loose brickwork is progressively falling from these areas.

3.2.4 The cracking extends up into the roof structure with many of the tiles and lead flashings fractured, allowing continuous water penetration into the buildings.

3.2.5 The observed cracks become progressively wider from basement up to third floor.

3.3 Block A

3.3.1 Block A exhibits no sign of major structural distress when compared to block B and the link corridor. Minor hairline cracking was observed to some masonry walls and to some window arches.

3.3.2 Hairline plaster cracking to both the walls and ceilings of block B were observed.

3.3.3 Brickwork frost damage and spalling is evident around the base of the building.

4.0 Investigation and Exploratory Works

4.0.1 In order to fully understand the movement of block B, the extent of damage, the structural load-paths and thereby specify any necessary structural remedial works, a series of investigation and exploratory works were specified.

4.0.2 These works were split into three categories.

- Geotechnical
- Intrusive exploratory
- Line and level survey

4.0.2 A summary of the results of these surveys is presented below.

4.1 Investigation and Exploratory Works; Geotechnical Survey

4.1.1 On the instructions of AKSWard, Soils Consultants Ltd were commissioned to undertake an external geotechnical survey local to blocks A and B. The works were undertaken in February 2006 and consisted of six window sample boreholes driven to a depth of 5.0m and seven trial pits. The trial pits were hand dug adjacent to the listed building with the purpose of revealing the profile of the building foundations.

4.1.2 The results of the survey are presented in detail in Soil Consultants Ltd's report titled, 'Report on Ground Investigation. Unison (formerly the EGA Hospital), Euston Road North, London', dated 1st March 2006 (Report No. 4097/OT/TSR). A summary of these results is discussed below.

4.1.3 Unsurprisingly, the listed buildings were discovered to be founded on London Clay. The foundations are traditional corbelled brickwork built off concrete strip footings. The foundations were found to vary in depth, depending upon the amount of man-made fill encountered. Each trial pit revealed the foundation to penetrate through the made-ground and bear upon the natural clay. The foundation depths varied from 1m below ground level to 2m below ground level; the shallower foundations being located in the south west corner of the listed building.

4.1.4 The six window samples were strategically located around the listed building and within close proximity. These samples provided a near-continuous soil profile, which was logged and sampled at regular intervals. Samples were tested in-situ and in the laboratory. Testing included penetrometer, hand vane and Atterburg's limits tests.

4.1.5 The tests proved that the underlying clay, which the listed building is founded on, to be desiccated. The depth of desiccation was found to be up to approximately 4.5m deep in the south west corner, adjacent to the lime trees on the corner of Euston Road and Churchway. The depth of desiccation reduced for the investigations undertaken further away from the lime trees.

4.1.6 Desiccation of clays is caused by the removal of moisture from clay; this can be caused by prolonged periods of drought coupled with the moisture demand from large trees. London clay is highly plastic and results in shrinkage of the clay at the point of desiccation.

4.1.7 Structural Soils Ltd confirmed in their report the following, *'...the tree growth in the vicinity of the listed building has caused extensive soil desiccation resulting in shrinkage of the high plasticity London Clay soil'*. They went on to note that, *'...dessication is the primary cause of the structural problems observed on this part of the site'*. They also concluded the following, *'Given the limited space available around the structure and depths of desiccation, this is highly likely to require underpinning by piles. In order to ensure that this is undertaken effectively the piles must be taken down below the depths of desiccation'*.

4.1.8 The geotechnical investigation proved AKSWard's hypothesis that the building has moved due to subsidence caused by the adjacent mature Lime Trees on the corner of Euston Road and Chruchway.

4.2 Investigation and Exploratory Works; Intrusive Exploratory Works

4.2.1 AKSWard specified a number of intrusive exploratory works to be undertaken within the listed building. These works were approved by The London Borough of Camden in May 2006. John F Hunts were appointed to undertake the exploratory works, along with the soft strip and asbestos removal works. The works were overseen by AKSWard and undertaken in September/ October 2006.

4.2.2 The works included the following.

- Ceiling removal to discrete areas of the listed building to reveal parts of the underlying structure.
- Small holes broken through the floor, in strategic locations, to enable inspection and measurement of the supporting floor joists.
- Plaster removal to areas of the walls to enable inspection of the brickwork cracking.
- Holes drilled within the load-bearing walls to enable their nature and thickness to be examined.
- An internal trial pit excavated within block B to enable the foundation profile to be recorded.
- Opening of the wall at two joist locations to enable the joist bearing to be inspected.

4.2.3 The listed buildings were found to be supported on load-bearing masonry; the perimeter walls to block B are load-bearing, and the perimeter, corridor and cross walls to block A are load-bearing. The walls are generally 2 bricks thick (approximately 440mm wide), the perimeter walls to block B reduce to 1 brick thick (approximately 215mm wide) at the windows. Chimneys are also built within the load bearing masonry walls.

4.2.4 The removal of the plaster to certain areas of the walls enabled the cracks to be examined; this revealed failure of many of the load-bearing arches (refer to comments in the previous chapter- 'Listed Building- Present Condition').

4.2.5 The floor structure to both blocks A and B was found to consist of a number of closely spaced steel joists spanning between the load-bearing walls. The space between the steel joists is filled with un-reinforced clinker concrete on clay pots which sit on inverted 'T-beams'.

4.2.6 The floor-finish through out the building varied, the finishes included; raised timber floor-boards on packing joists, 'modern' concrete up to 100mm thick with a floor screed, a floor screed, a floor screed with tiles, and concrete with screed with parquet flooring. All of these finishes were located on top of the original 'clinker' concrete structure.

4.2.7 It is apparent that the floor finishes have been altered since the construction of the building, certainly any part of the building with an additional 'modern' concrete or screed topping is not the original finish.

4.2.8 It is AKSWard's opinion that the original floor finish to the upper storeys would have been raised timber floor boards on packing joists, which is exhibited in areas of the building. Other finishes are not original.

4.2.9 'Building Construction' by Professor Henry Adams M.Inst.C.E., first issued in 1906, describes a number of floor constructions common within the building industry at that time; '*Howman's floor*' is described as *'rolled iron girders with joggled T-irons, upon which rest specially shaped hard burnt bricks with key grooves on underside for plaster, the whole covered with concrete.'* The accompanying diagram indicates the floor construction with a raised timber floor board on packing joists. It is concluded that the original floor construction for the first generation buildings at the Elizabeth Garrett Anderson Hospital was a form of 'Howman's floor', with a raised timber boarded floor as the finishes.

4.2.10 The alteration of the original finishes will have increased the dead load required to be supported by the underlying steel beams. This is discussed more fully in Chapter 7.0.

4.2.11 The steel beams exposed in the centres of the floors were found to be in good condition with very little or any rust. However, where water has penetrated within the building (specifically at the south west corner of block B) the steel beams were showing signs of rusting. This could also be observed to the steel beams at first floor level within the feature tower (over the entrance tunnel); the ceiling has collapsed in this area and the steels have been exposed to the atmosphere. The rusting to these areas, where visible, was not severe.

4.2.12 Of more concern is where water has penetrated the original clinker concrete infill. Clinker concrete was high in sulphates and damp clinker can form acid which will quickly cause steel to rust. It is recommended, during the remedial works, that areas of damp clinker are removed, the steel inspected and either replaced or painted; the clinker should be replaced, in these areas, with modern lightweight concrete.

4.2.13 Additionally, during the final redevelopment of the site (stage 5), areas of floors where toilets have been located should be opened up such that the steel can be inspected. A leaking toilet over a long period of time could have allowed water to penetrate the clinker concrete and thereby cause the steel to rust.

4.2.14 Where the beam bearings have been exposed (within the south west corner of block B at second and third floor level), the length of steel bearing was found to be acceptable; 170mm and 200mm bearing at second and third floor respectively.

5.0 Investigation and Exploratory Works; Line and Level Survey

5.1 In order to understand and confirm how block B has moved, AKSWard commissioned a line and level survey of various parts of the listed building. The survey was undertaken, to AKSWard's specification, by Glenn Surveys in September 2006.

5.2 A level survey was conducted across the ground, first, second and third floors of block B. The results of this survey are presented in figure 3 in Appendix A. It can be clearly seen that these levels indicate that the southern portion of the building fronting Euston Road has subsided with respect to the Northern portion. The worst movement is towards the south-west corner (closest to the lime trees and where the foundations are known to be the shallowest).

5.3 A 'plumb-bob' survey was undertaken to various points on the external elevations of the listed building. The purpose of the survey was to measure the line of the brickwork elevation and compare the building movement to the theoretical line of the building when first constructed (on the assumption that the building was originally built true). The line survey was undertaken with a theodolite rather than with a traditional 'plumb-bob'. The results of the survey are presented in figures 4 to 5. To visualise the wall movement, the horizontal and vertical dimensions are drawn at different scales.

5.4 The locations of each wall profile are indicated on figures 4 and 5 and the general direction of movement of the wall face is indicated within the table below. A dimension indicating the approximate 'out of plumb' of the wall is included; a negative dimension indicates the wall is moving into the building, whilst a positive dimension indicates the wall is moving away from the building. Walls with overall movement of less than ±10mm are described as 'plumb'.

Listed Building Location	Wall Profile No.	Approximate Out of Plumb (Between ground and third floor)	General Direction of Wall Movement
Fronting Euston Road	1	-60 mm	South
Fronting Euston Road	2	Plumb	None- Minor distortion
Fronting Euston Road	3	Plumb	Slightly south
Fronting Euston Road	4	-73 mm	West
Fronting Euston Road	5	+128mm (to top of chimney)	South
Fronting Euston Road	6	+143 mm	South
Fronting Euston Road	7	-35 mm	West
Fronting Euston Road	8	General distortion	General Distortion
Fronting Churchway	9	Plumb	None-very minor distortion
Fronting Churchway	10	Plumb	None-very minor distortion

Table Indicating General Direction of Wall Movement Within Listed Building

5.5 an clearly be seen from the table that the walls are generally leaning towards the south-west corner of the building, again towards the location of the lime trees on the corner of Euston Road/ Churchway; the closer the wall to the south-west corner, the more pronounced the movement.

5.6 wall profiles can be used to give an approximate understanding of the building stability. *CIRIA report No 111, 'Structural Renovation of Traditional Buildings'*, gives guidance upon the factors influencing the stability of walls. The report states that a loosely stacked and free-standing wall acted upon solely by gravity is *'found to retain a precarious equilibrium even when stacked to lean over by about 85% of its thickness'*.

5.7 The southern wall fronting Euston Road shows the highest degree of deformation being out of plumb by approximately 143mm; this equates to approximately 32% of the wall thickness (450mm). It should also be noted that the walls are not free-standing walls as described within the CIRIA report; the walls are restrained at each floor level by the positive bearing of the floor beams. Therefore, it is considered that the main load-bearing walls are stable in their present condition providing that the cause of the movement (subsidence) is eliminated and that the walls are adequately tied into the floors. To ensure that the floors are adequately tied into the walls, at all levels and locations, it is recommended that a new system of floor-to-wall ties is installed.

5.8 Wall Profile No 8 is located at the bay which is currently propped internally and externally. The profile has picked up some of the architectural features within the brickwork and therefore the profile cannot be compared to a theoretical straight wall. However, and as described previously, the main building has moved away from the bay, leaving the bay unrestrained. The raking shores are currently preventing the bay from collapsing into Churchway.

6.0 Structural Movement Mechanism

6.1 Given the amount of cracking and the size and location of the cracks outlined within the previous chapters, it is apparent that the structure has undergone a large degree of movement. All of this movement can be attributed to subsidence.

6.2 The majority of subsidence has occurred to the south west corner of block B, although subsidence has also occurred to the southern wall and western flank wall. The amount of subsidence is proportional to the depth of foundation and the distance to the lime trees on the corner of Churchway and Euston Road.

6.3 Due to the robust nature of the existing load-bearing masonry building, the walls being 2 bricks thick (approximately 450mm), absolutely no cracking is observed at the building corners and the floors have all moved as a whole. Consequently the floor beams have remained firmly embedded within the walls.

6.4 Block A has a basement and is founded at a much deeper level, and is further away from the mature trees, consequently its foundations have been unaffected by the clay movements which are constrained to the upper strata. The basement also extends under the link corridor and, critically, the northern part of block B is built off the basement walls. This has created a pivot point for the movement of block B and explains the crack patterns observed within the link corridor (cracks increasing in width up the building). This movement mechanism is described in figure 2 in Appendix A.

6.5 The cracking has occurred at all the weaker parts of the structure. Block B has ripped away from the link corridor, and the cracking to the southern elevation has occurred above and below windows where the brick is only one brick wide. Block B is also pulling away from the feature tower, causing cracks within the tower and the link bridges to the tower- although these cracks are minor when compared to the cracking within the link corridor between blocks A and B.

6.6 The bay structure is a weak point within block B, the bay creates a discontinuity within the western flank wall, and this weak part of the structure has fractured as the whole of block B pivots. This has caused all the arches above the bay to fail, and the main part of block B to rip away from the bay.

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7.0 History of Movement and Structural Cracking

7.1 AKSWard have copies of historical correspondence with regard to the movement of block B. The correspondence consisted of 7No letters from Nigel D. Courtnage, Chartered Structural Engineer, to the UCL Hospital. The correspondence is dated between the 17th November 1997 to the 7th June 2004.

7.2 From this correspondence, the following information can be acquired.

- The first visit to site by the previous engineer was undertaken on the 7th October 1997; internal and external cracking to the bay was recorded. It can be assumed that subsidence of block B commenced sometime prior to this inspection.
- On the 8th February 1998, following the excavation of trial pits adjacent to the bay, the following information was recorded. The foundations are founded upon clay, the window bay is founded at approximately 1.5 metres depth and the main block is founded slightly higher.
- On the 15th March 1999, the previous engineer's correspondence indicates that existing drain runs to the western frontage of block B have been re-built, although it is noted that the adjacent trees may affect the building to some degree.
- On the 29th September 1999, 'sudden and serious movement to the south entrance porch' was recorded, together with further internal cracking. Temporary propping of the ground floor arch and demolition of the entrance porch was recommended. Underpinning the perimeter walls of block B was also suggested.
- Correspondence dated the 27th January 2003 indicated that the front porch had been demolished. At this stage the internal cracking to block B and the link corridor had increased to such an extent that the engineer stated that these areas 'cannot be considered for use in their present condition'. A further recommendation for the underpinning of block B is given.

7.3 It is considered, from the above noted record information, that block B has been subsiding for a period of up to 10 years. It is now known that the buildings are founded upon clay with a high shrinkage potential and despite recommendations by the Hospital's appointed engineer, they were not underpinned

7.4 AKSWard first investigated the listed buildings in March 2005, prior to the purchase of the site by Unison. A series of 'tell-tale' crack width recorders were installed across some of the major cracks, with the purpose of understanding if the building was still moving. The movement of the cracks is summarised below.

Link Corridor Crack Location	Crack Width March 2005	Crack Width September 2006
Ground Floor Slab Crack	Up to 6mm	Up to 10mm
First Floor Slab Crack	Up to 35mm	Up to 50mm
Third Floor Wall Crack	Up to 40mm	Up to 60mm

7.5 It can be seen that the cracks are still opening and, therefore, that the ground is still subject to movement (ie. The building is continuing to subside).

8.0 Load Bearing Ability of Existing Floor Structure

8.1 As described previously, the original make-up of the floors consisted of raised timber boards on packing timbers, as the floor finish. These finishes were built off the structural slab; this consisted of 'clinker concrete' on clay pots. The clay pots sat between inverted steel 'T' sections, located at approximately 350mm centres, these steel 'T's' span between the main steel joists ('I' sections). This original structure is still present in many areas of the building a typical section is indicated in figure 6 in Appendix A.

8.2 Invariably, since construction of the building, the original timber board floor finish has been altered in many of the rooms. The timber boards and packers have been removed and replaced with a variety of finishes. In general, the timber boards and packers have been replaced with screed/ concrete. In some cases, parquet flooring is used as a finish. A typical section is indicated in figure 6, adjacent to how the structure would have appeared.

8.3 As part of the intrusive investigations, the underlying structure was exposed in 9 No locations. A small hole was broken out in the floor to expose the steel support joists and floor construction. This enabled the dimensions of the steel and floor construction to be recorded. In all cases, the floor consisted of steel joists spanning between the load-bearing walls, with steel 'T's' between the beams supporting clay pots and clinker concrete. The beam size varied with the beam span. The floor finishes differed through out the building.

8.4 *'Historical Structural Steelwork Handbook'*, by *'The British Constructional Steelwork Association Ltd.'* gives guidance on the design of historical steelwork. In 1879 the following average values for the ultimate strength of mild steel were quoted;

- Ultimate Strength in Tension 32 tons/sq.in.
- Ultimate Strength in Compession 32 tons/sq.in.
- Ultimate Strength in Shear 32 tons/sq.in.

A factor of safety (of up to 4) was adopted to obtain the safe working stresses.

8.5 the data attained through the exploratory investigations, and utilising an imposed loading of 2.5kN/m² (standard office loading), the actual factor of safety was calculated for each beam. The factor of safety was calculated for the structure with its current floor finishes, and the factor of safety was calculated for the structure as it was originally built. The calculations are not included within this report.

				Calculated Factor Of Safety	
Location	Beam Type	Beam Span	Beam Spacing	Original Finishes	Current Finishes
A	B1	3.6m	1.05m	3.0	3.0
B	B2	4.3m	1.05m	3.3	3.0
C	B3	7.9m	1.05m	3.7	2.9
D	B2	4.0m	1.05m	4.0	2.7
E	B1	3.0m	1.05m	4.1	3.7
F	B1	3.6m	0.9m	2.8	2.8
G	B3	7.9m	0.9m	3.8	3.3
H	B4	3.6m	1.05m	3.2	2.6
I	B5	7.9m	1.05m	3.2	3.2

Calculated Factors of Safety for Existing Floor Beams

8.6 It can be seen that the majority of factors of safety calculated for the support beams, with the original floor finishes, lie between the range 3 to 4; this approximately equates to the design recommendations of the period. The current heavier floor finishes have slightly reduced the factors of safety, they now lie within the range 2.6 to 3.3.

8.7 It should be noted that the calculations are based upon simply supported beams, it could be argued that, as the beams are well built within the walls, a degree of fixity is provided at the supports. This would have the effect of reducing the calculated bending moments and increasing the 'factors of safety'.

8.8 '*Building Construction'* by *Professor Henry Adams M.Inst.C.E.*, first issued in 1906, gives the following guidance on the preliminary design of joists....*'A rolled joist without concrete cannot be used over a longer span than twenty times the depth of the joist, but this ratio may be increased to twenty-four times when the concrete is the same depth as the joist, to thirty times when the concrete is 50 per cent deeper than the joist, and to thirty-six times when the concrete is twice the depth of joist.'* This design guidance is in fact an example of 'composite construction'. The wide use of composite construction techniques began in the 1960's; concrete floors are utilised to increase the strength of the underlying steel support (the natural compressive strength of the concrete floors being utilised with the natural tensile strength of the steel beams). In essence, this implies that, although the addition of further concrete to the original structure increases the dead load slightly, the additional concrete also has the effect of strengthening the overall floor system.

8.9 The strengthening of the overall floor system through the addition of concrete can be observed and simply demonstrated within the listed building fronting Churchway. The beams supporting these floors span clear between the perimeter walls; these beams are the longest spanning and the deepest. The first and second floors have had the original timber floor finishes removed and replaced with up to 50mm of concrete screed above the joists. The third floor remains with the original timber floor finishes (the clinker concrete not quite the full depth of the steel joist). The third floor is noticeably more 'bouncy' when compared to the first and second floors, when walked upon. This demonstrates the stiffening of the overall floor system by adding a small amount of additional concrete.

8.10 Therefore, a quantitative analysis of the load bearing capacity of the floors shows a slight reduction in factors of safety due to the addition of additional dead load in the form of new finishes. However, a qualitative analysis of the overall system quite clearly indicates that these calculated factors of safety can be significantly increased due to the nature of the beam end fixity and the composite nature of the floor systems.

8.11 A further qualitative source of reference is the design guide *'Office Floor Loading in Historic Buildings'* by *English Heritage*. The paper concludes by stating....*'The actual floor loading which the occupants of offices, their furniture, and storage put upon the floor will rarely exceed the loading from domestic occupation* (1.5kN/m²). *Proper examination and stiffening of the floor should be carefully considered rather than ensuring it can be justified by calculation to carry 2.5kN/m².'*

8.12 Actual floor loadings within offices have been studied in detail and very rarely do they approach the British Standard minimum floor loading of 2.5kN/m². *'An assessment of the imposed loading needs for current commercial office buildings in Great Britain'* by *Stanhope Properties Plc* also indicates that standard office loadings are significantly below 2.5kN/m².

8.13 To summarise, it is considered from the quantitative and qualitative evidence noted above that the upper floors to the listed buildings are capable for re-use as offices without undertaking further strengthening works. This excludes repair works to damaged areas of floors/ rusted beams or poor support conditions, which are described in this report or may be discovered during the renovation process. It should be noted that the upper floors of the listed buildings should not be used for storage, rolling filing systems, the support of new partitions or the support of plant without further investigations, and possible strengthening works being undertaken.

9.0 Conclusions and Recommendations

9.1 Parts of block B and the link corridor between blocks A and B have suffered severe structural damage. The reason for this damage is solely due to subsidence caused by the adjacent mature lime trees on the corner of Euston Road and Churchway. The subsidence has been on-going for a period of at least 10 years.

9.2 Evidence collected by AKSWard in the form of tell-tale monitoring over the previous eighteen months has indicated that the building is continuing to subside. The building in its present form will be difficult and costly to renovate and if nothing is undertaken; the continued movement could cause catastrophic collapse of parts of the building.

9.3 The cracking and movement of the structure relative to the bay has been so severe that AKSWard designed a system of internal propping and external raking shores, in March 2005, to prevent the bay collapsing into Churchway. It is highly likely that removal of this propping and shoring system will cause the collapse of the bay and part of the main block.

9.4 The cracking and movement of the link corridor between blocks A and B is so severe that AKSWard designed a series of internal back-props, in July 2006, to prevent the link corridor collapsing. It is highly likely that removal of this back propping system, combined with the continued subsidence of block B, will lead to the eventual collapse of the link corridor.

9.5 Despite the installed propping system, brickwork continues to fall from the bay and from the link corridor elevations, although this is constrained within the site which is securely fenced from the public. No person should enter these parts of the site without the correct personal protective equipment.

9.6 Given the extremes of movement and the size and location of cracks reported in this document. It is the considered opinion of AKSWard that the bay fronting Churchway, and the link corridor between blocks A and B, cannot be saved. These areas must be demolished and re-built. The required extent of demolition is indicated on drawing numbers L051036/ LB-02 and L051036/ LB-03 in Appendix C.

9.7 The bay will need to be re-built to the conservation architect's details and re-installed by specialist contractors. The internal bay arches at ground, first and second floor shall be repaired sequentially from second floor down to ground floor. The ground floor arch will need to be replaced with steel support beams. Refer to drawing numbers L051036/ LB-50, L051036/ LB-60, L051036/ LB-70 and L051036/ LB-71 in Appendix C.

9.8 The modern lean-to extension, indicated on figure 1, which does not form part of the first generation hospital buildings, has also subsided to an extent where it is required to be demolished with the link corridor.

9.9 The underlying clay beneath block B is desiccated to a depth of up to 4.5m, to prevent further subsidence, the whole of block B is required to be underpinned to beyond the zone of desiccation. This depth of underpinning within such a confined space is best achieved through underpinning with piles. The extent of underpinning and the outline method of underpinning are indicated on drawing numbers L051036/ LB10 to L051036/ LB12 in Appendix C. Alternatively, the building could be underpinned by the Pali Radice method, an example of this is indicated on drawing number L051036/ LB-13; this method requires the piling system to be designed by

a specialist piling sub-contractor (for example Fondedile Foundations Ltd.). Prior to underpinning, the site adjacent to the listed building will need to be cleared to allow access for the piling rig, refer to drawing number L051036/ LB-01.

9.10 The ground floor slab has subsided and will continue to subside; this movement has caused damp penetration into the building and will continue to cause further damage to the building fabric. The existing ground floor slab should be removed and replaced with a suspended ground floor slab supported on mini-piles. The outline scope for this work is presented on drawing numbers L051036/ LB-10 and L051036/ LB-11. A void is to be formed beneath the slab, by the use of a void-former, to prevent any future up lift of the slab, should the clay heave.

9.11 Block B has moved to such an extent that the perimeter walls may, with time, begin to move away from the floors. To ensure this does not occur and to provide added robustness to a seriously damaged building, it is recommended that each floor level be tied back into the walls. A possible method of re-tying the floors back to the walls is indicated upon drawing number L051036/ LB-20.; the final method will need to be co-ordinated with the site wide development proposals and the proposed end-use for the building.

9.12 All brickwork cracking observed within block B shall be repaired. Brickwork should be cut back around cracks, broken bricks replaced with similar bricks, whole bricks can be cleaned and re-used; a lime mortar should be used. A typical crack repair detail is indicated upon drawing number L051036/ LB-25. The location of each brickwork crack is indicated upon drawing numbers L051036/ LB-30 to L051036/ LB-36 (only major brickwork cracking is recorded). These works are not deemed critical with regard to stabilising the building against subsidence and may be undertaken as part of the site-wide development proposals

9.13 The emergency escape stair (later addition as a secondary means of escape to the nurse residence) should be demolished to facilitate the underpinning. Areas of brickwork damaged where the steel connects into the listed building should be replaced.

9.14 Upon completion of these elements of work, the listed building will have been stabilised and will not be subject to further movement due to subsidence. This will complete stage 4 of the remedial works to the listed building.

10.0 Further Investigation Works and Remedial Works

10.1 This document only includes recommendations for the immediate stability works required to save the listed building from further structural deterioration or collapse (stage 4 works).

10.2 Further works of a non-structural nature will need to be undertaken to the listed buildings (both blocks A and B) such that they are fully renovated. It is likely that these stage 5 works will be undertaken as part of the site wide proposals for the Elizabeth Garrett Anderson Hospital site.

10.3 A detailed building survey will need to be undertaken to report and recommend actions for the following items.

- Condition of roof, tiles and flashings and recommendations for replacement/ repair.
- Condition of windows and frames and recommendations for replacement/ repair.
- All walls and plasterwork to be inspected for damp and recommendations/ details for new damp proof courses/ replacement of plasterwork.
- Inspection of perimeter masonry and recommendations for replacement of frost damaged bricks etc.
- A detailed survey of all timberwork with recommendations for any required treatment against infestation and rot.
- A survey of all rainwater goods and recommendations for replacement and repair.

10.4 When the building is water tight, areas of clinker concrete noted as being saturated should be removed, the underlying beam painted or replaced and modern reinforced concrete inserted in place of the clinker (refer to drawing numbers L051036/ LB-20 and L051036/ LB 25 in Appendix C).

10.5 It was recommended, in the previous chapters, that the link corridor between units A and B should be demolished and re-built. However, this work may be undertaken as part of the site wide development works (stage 5). The works required to eliminate further movement of the listed building can be undertaken without the immediate demolition of the link corridor. However, the link corridor cannot be saved and must be demolished and re-built at some stage.

****

AKSWard
December 2006

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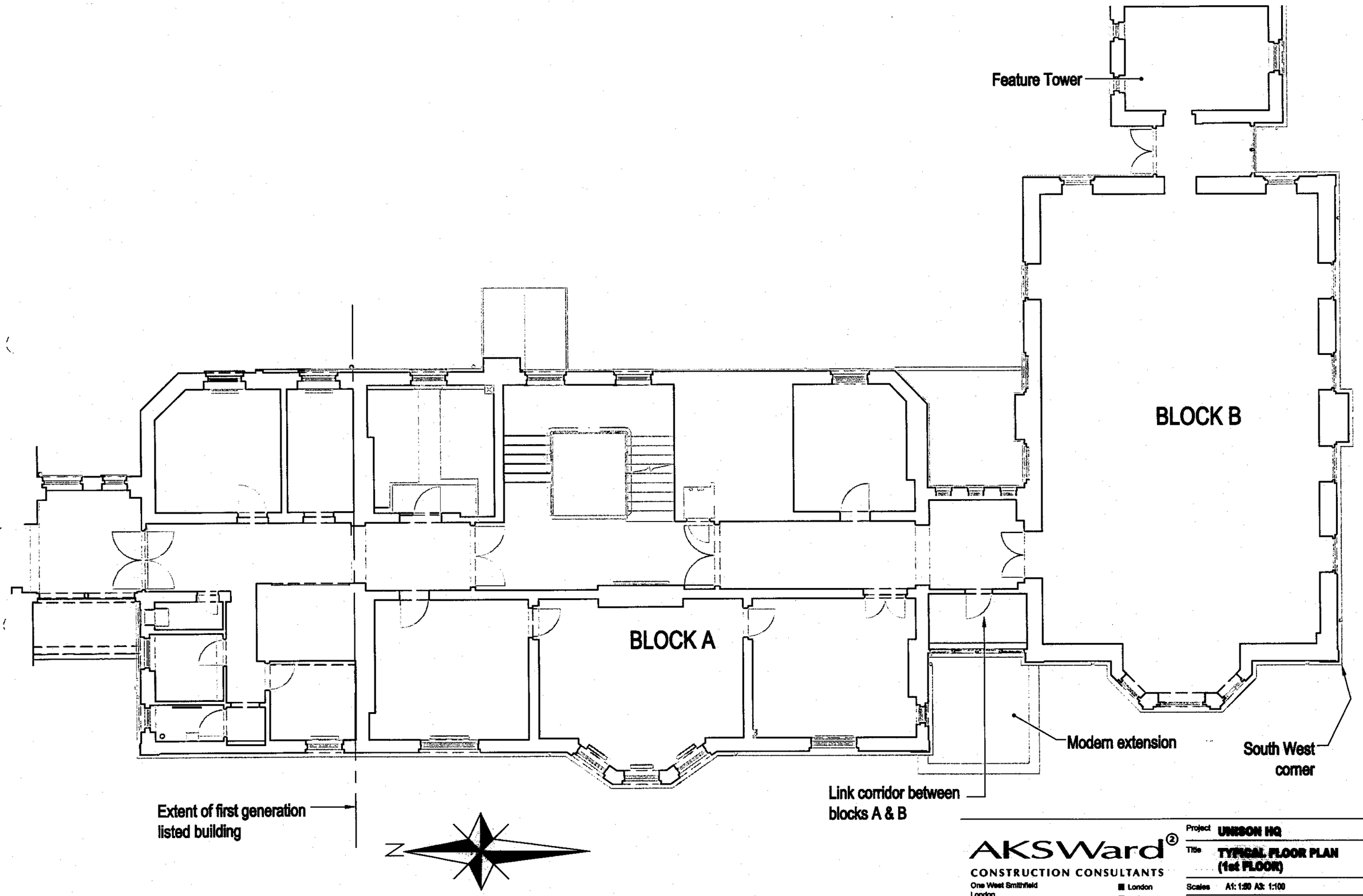
Appendix A

Figures



Rev.	Amendment	Drn	Chkd	Date

Drg Status Preliminary

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Project **UNISON HQ**

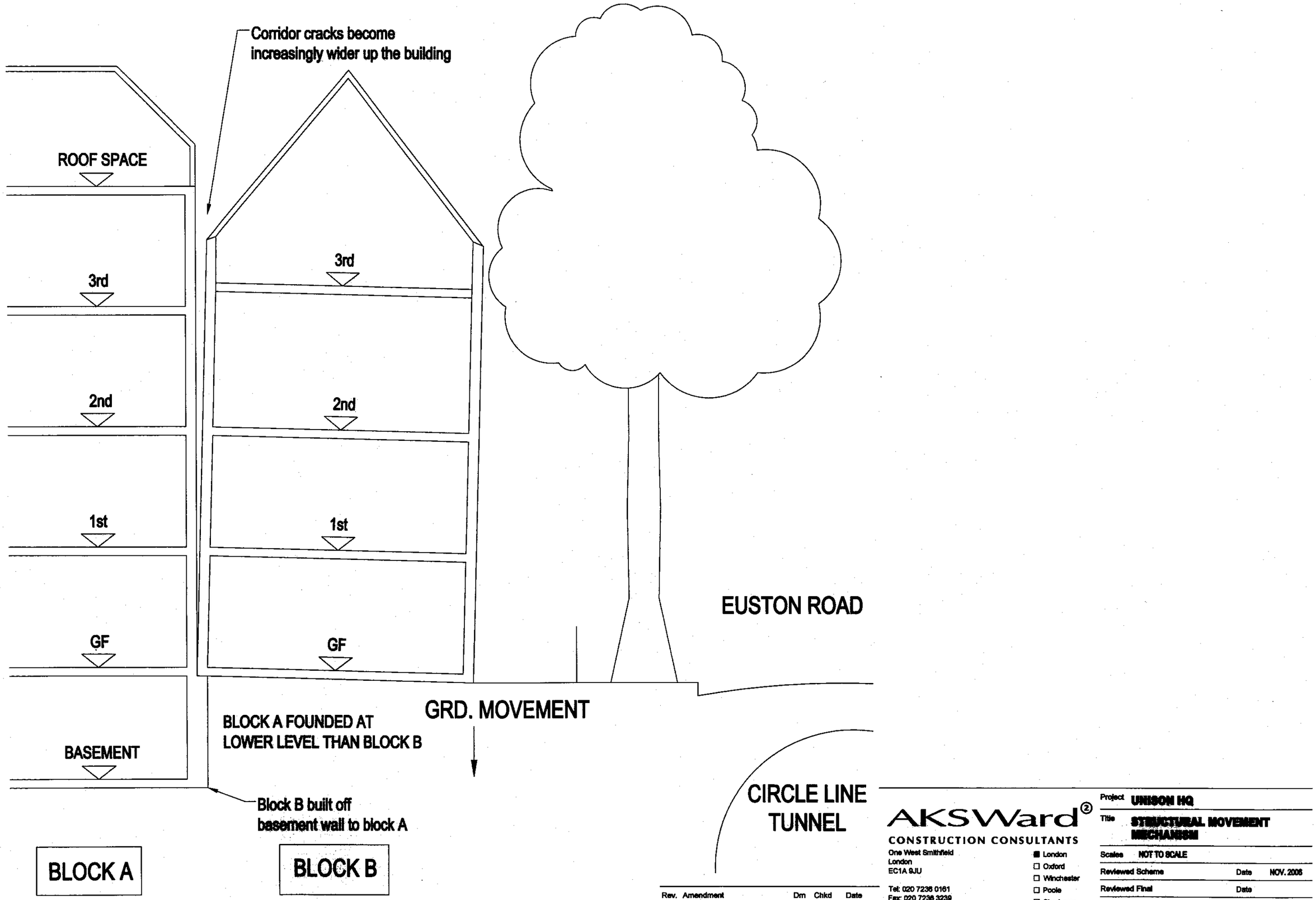
Title **TYPICAL FLOOR PLAN (1st FLOOR)**

Scales A1: 1:50 A3: 1:100

Reviewed Scheme Date NOV 2006

Reviewed Final Date

Project No.	Drg No.	Rev.
L051036	Fig. 1	P1



Rev.	Amendment	Drn	Chkd	Date
Drg Status	Preliminary			

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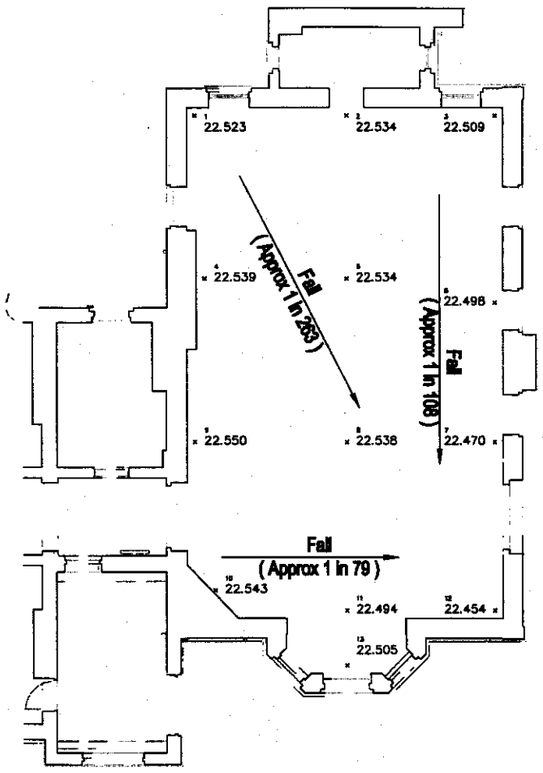
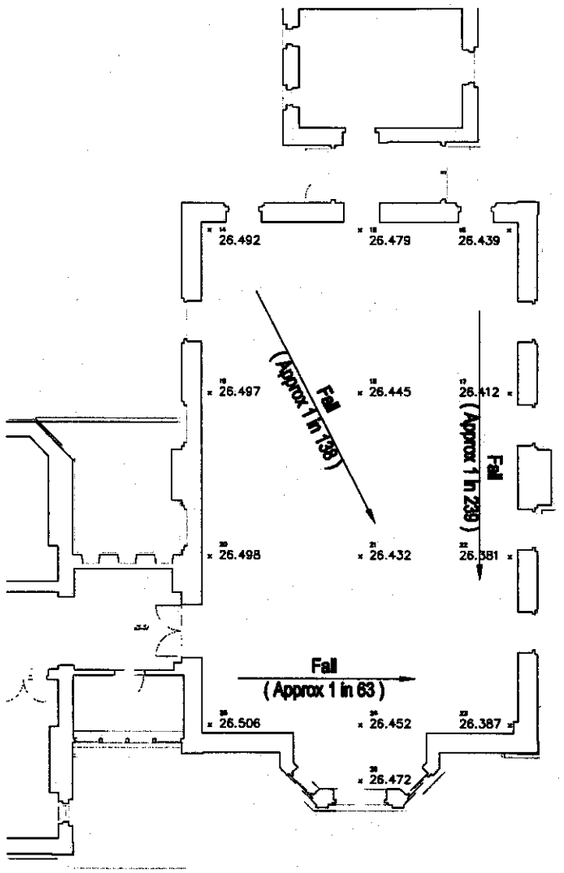
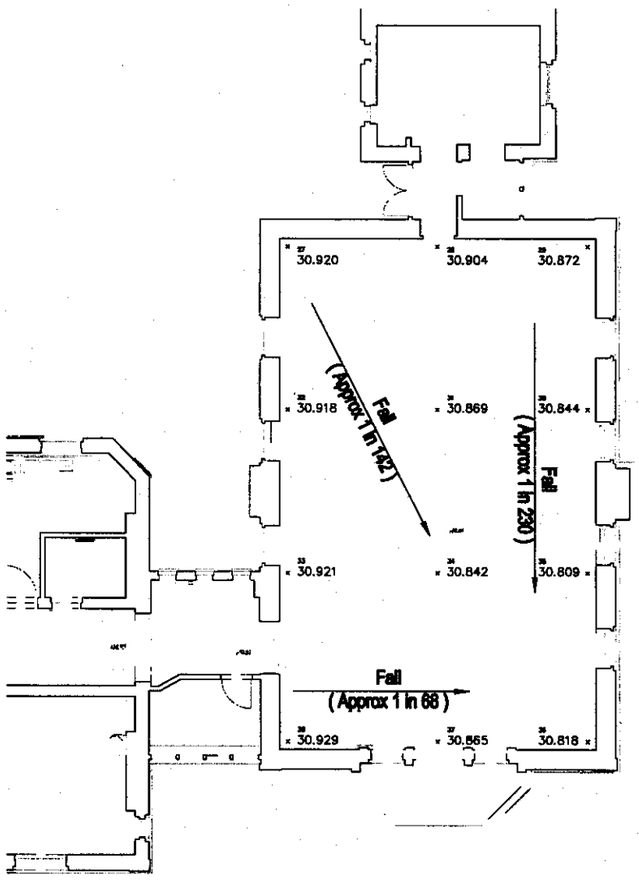
Project	UNISON HQ
Title	STRUCTURAL MOVEMENT MECHANISM
Scales	NOT TO SCALE
Reviewed Scheme	Date NOV. 2006
Reviewed Final	Date
Project No.	L051636
Drg No.	Fig. 2
Rev.	P1



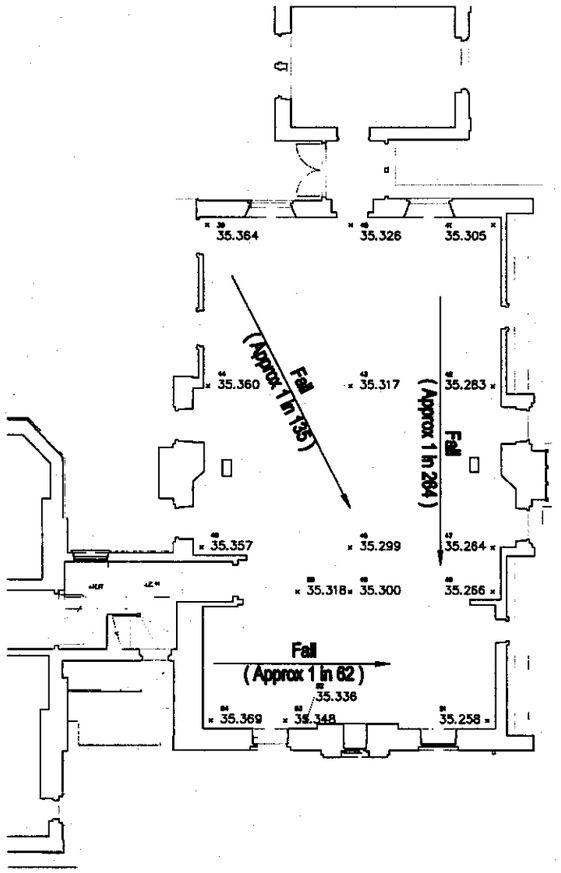
Ground Floor



1st Floor



2nd Floor



3rd Floor

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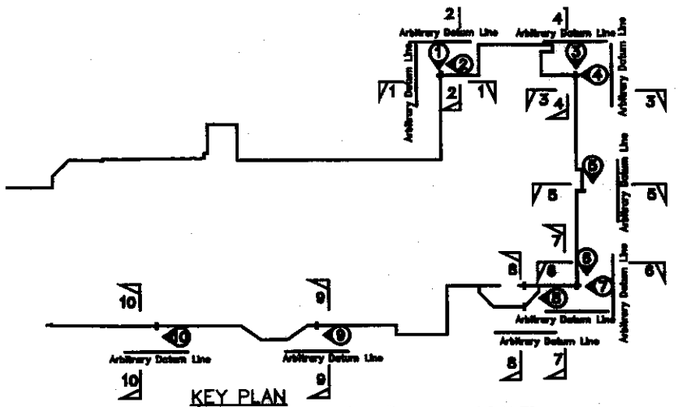
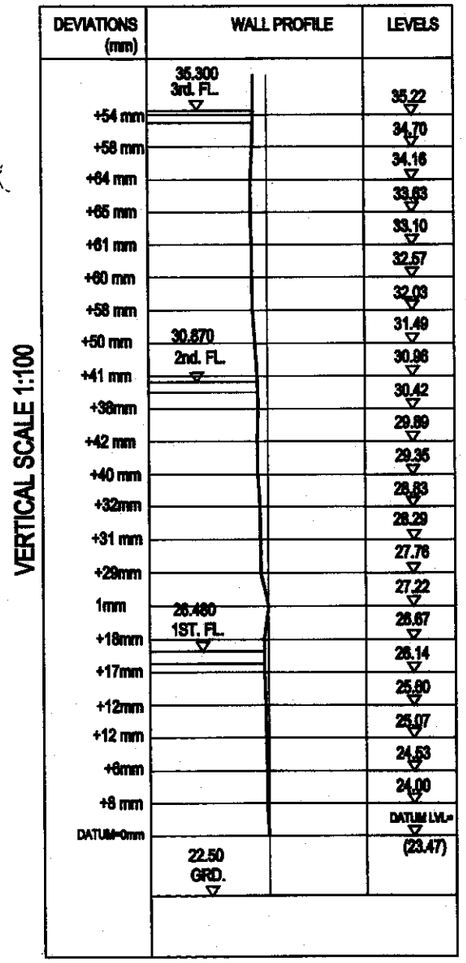
Project UNISON HQ
Title FLOOR LEVELS

Scales		
Reviewed Scheme	Date	NOV 2008
Reviewed Final	Date	
Project No.	Drg No.	Rev.
L051036	Fig. 3	P1



KEY PLAN
PROFILE POSITIONS (NOT TO SCALE)



PROFILE 1
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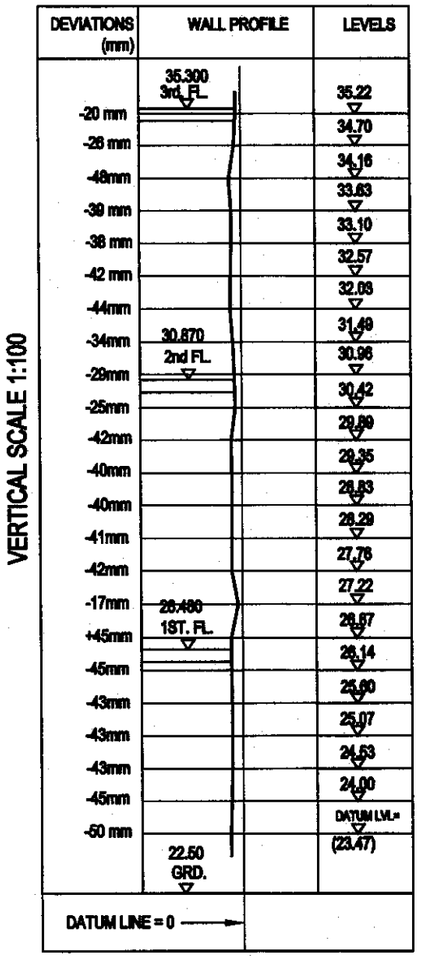

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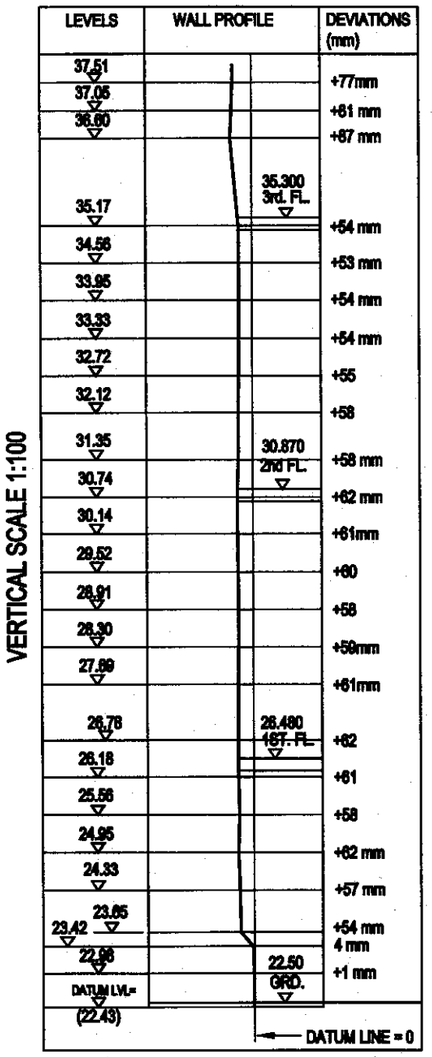
HORIZONTAL SCALE 1:25



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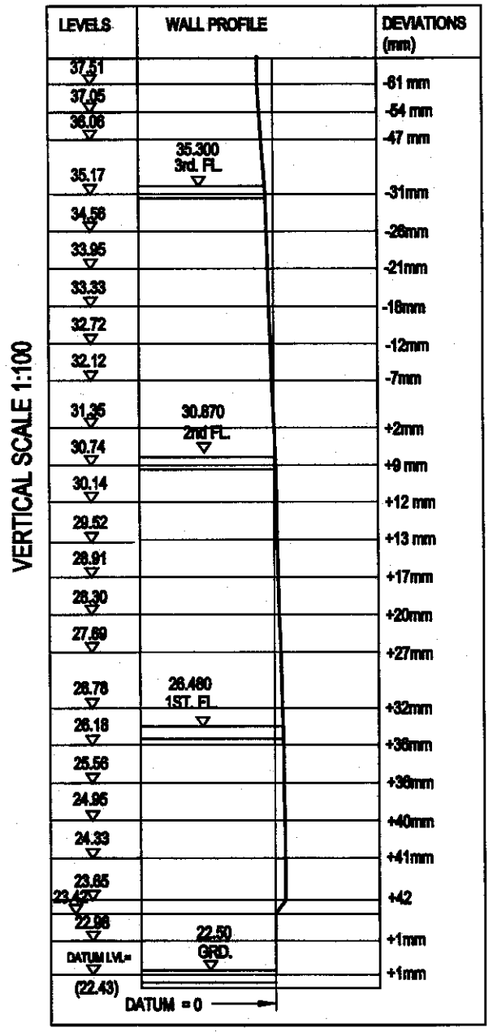
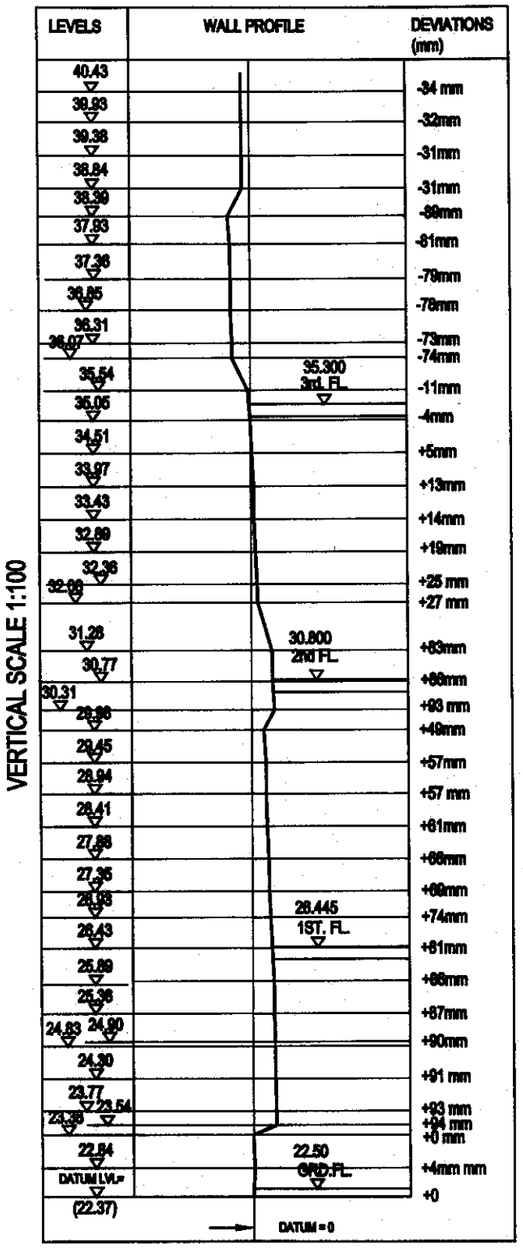
HORIZONTAL SCALE 1:25



PROFILE 4
HORIZONTAL SCALE 1:25



PROFILE 5

Rev.	Amendment	Drn	Chkd	Date
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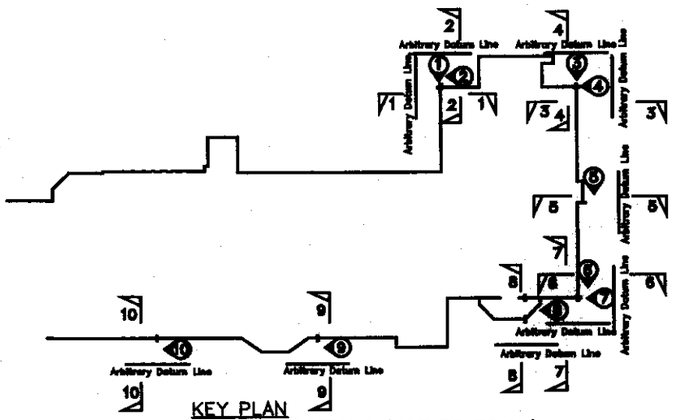
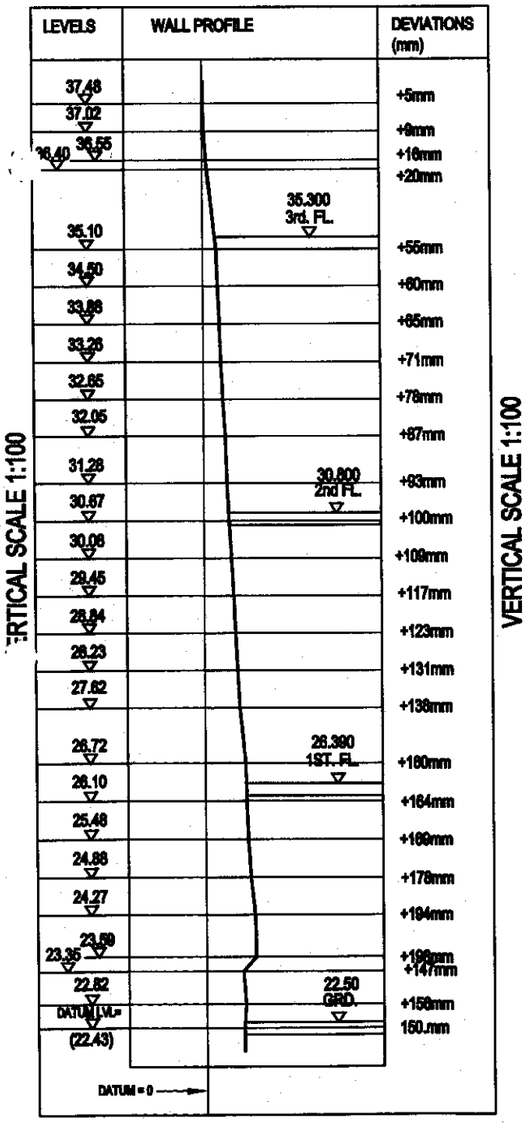
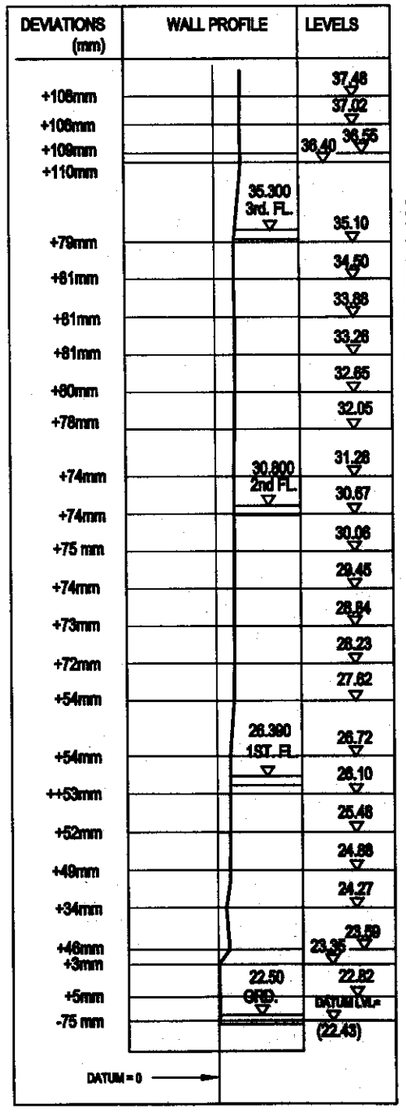
Project	UNISON HQ
Title	WALL PROFILE
Scales	AS SHOWN
Reviewed Scheme	Date OCTOBER 2006
Reviewed Final	Date
Project No.	L051036
Drg No.	FIG 4
Rev.	P1



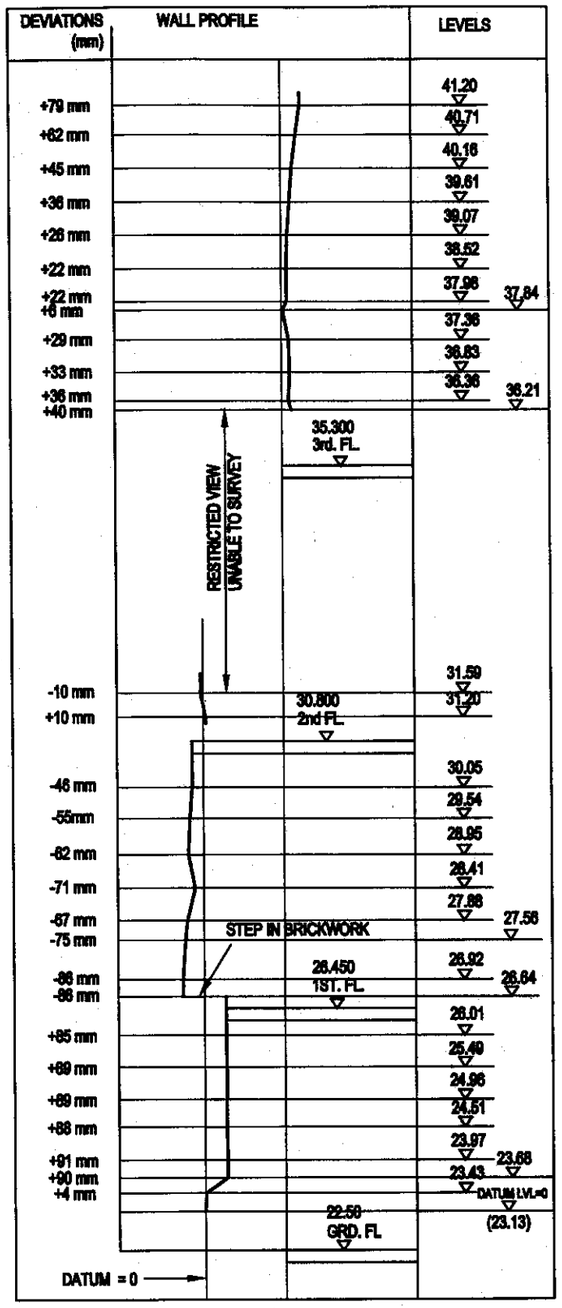
KEY PLAN
PROFILE POSITIONS (NOT TO SCALE)



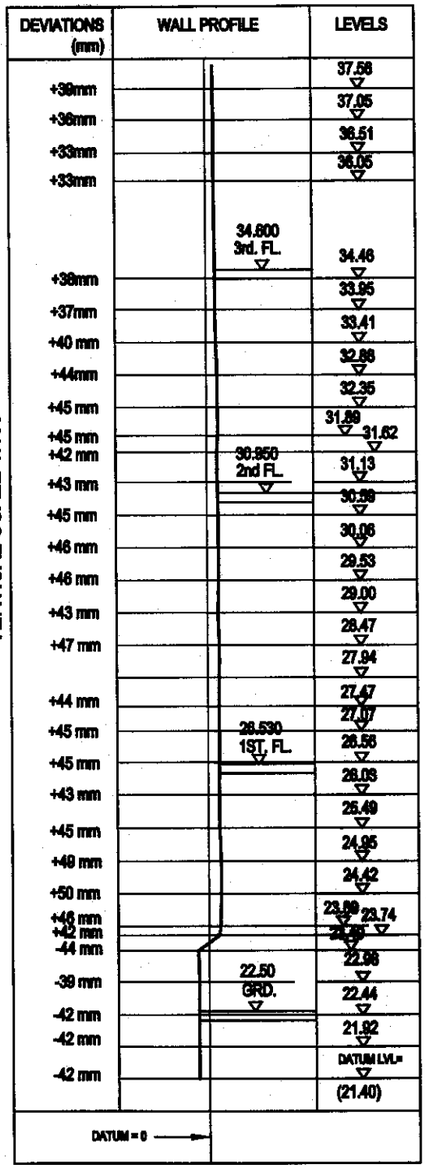
PROFILE 6
HORIZONTAL SCALE 1:25



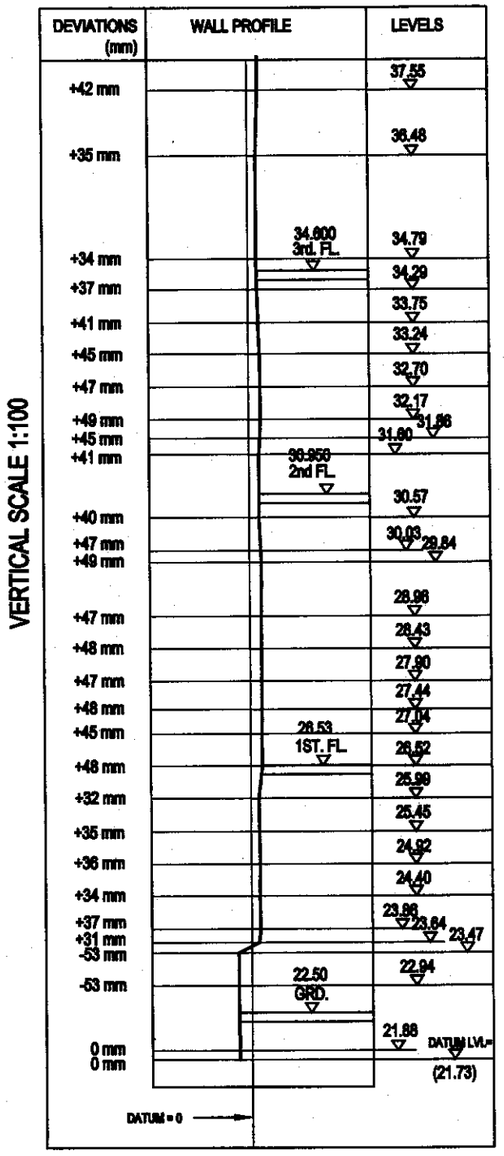
PROFILE 7
HORIZONTAL SCALE 1:25



PROFILE 8
HORIZONTAL SCALE 1:25



PROFILE 9
HORIZONTAL SCALE 1:25



PROFILE 10
HORIZONTAL SCALE 1:25

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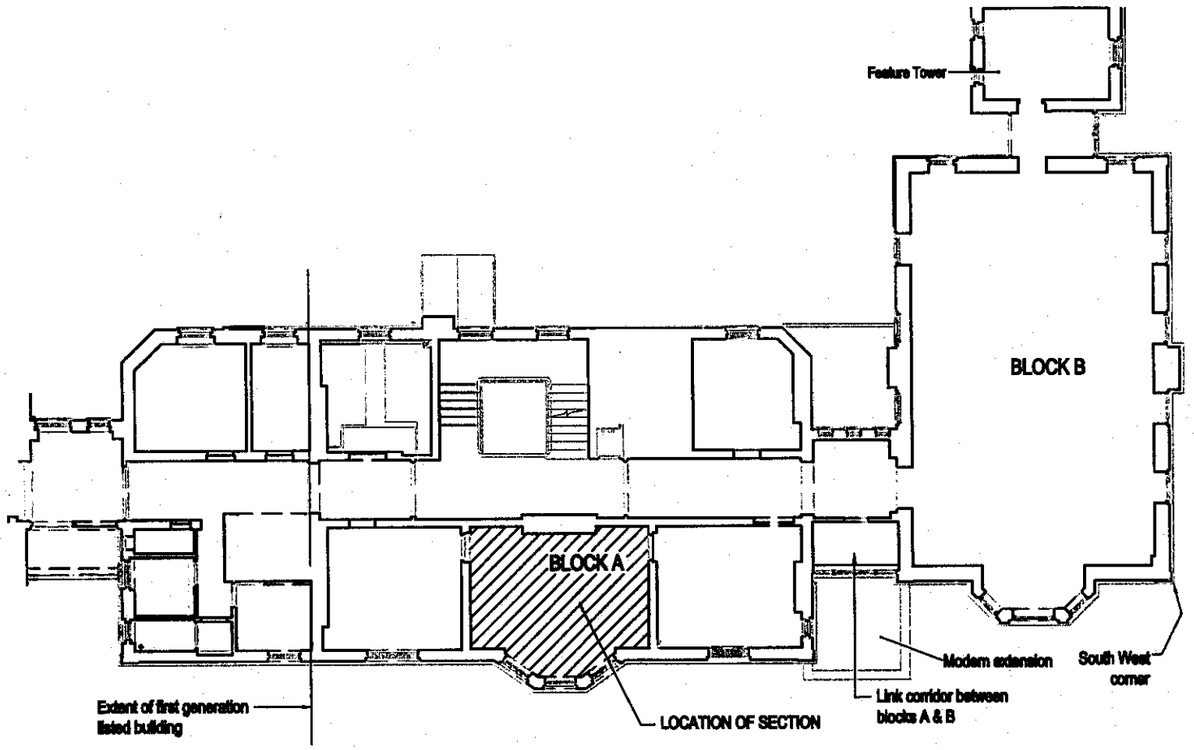
Project	UNISON HQ		
Title	WALL PROFILE		
Scales	AS SHOWN		
Reviewed Scheme		Date	OCTOBER 2006
Reviewed Final		Date	
Project No.	Drg No.	Rev.	
L051036	FIG 5	P1	



KEY PLAN AT FIRST FLOOR
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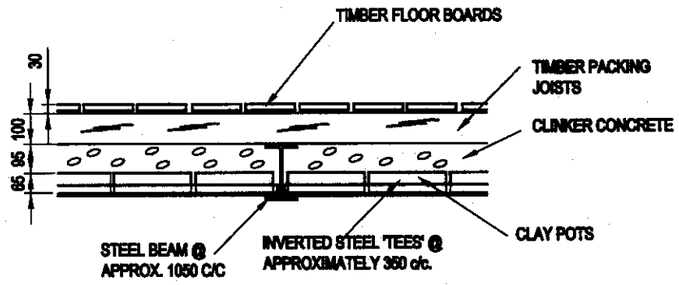
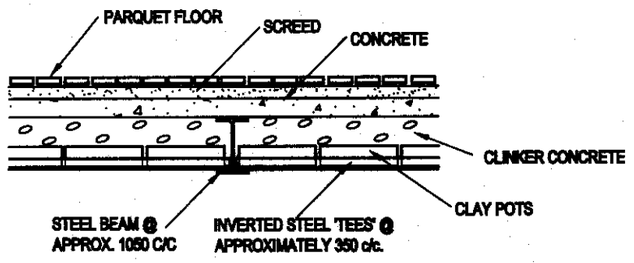


ORIGINAL FLOOR CONSTRUCTION
'HOWMAN'S FLOOR
1:20



CURRENT FLOOR CONSTRUCTION
1:20

NOTE:
FLOOR FINISHES VARY
FROM ROOM TO ROOM.

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Project	UNISON HQ
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Reviewed Scheme	Date NOV. 2008
Reviewed Final	Date
Project No.	Drg No. Fig. 6 Rev. P1
L051036	