STRUCTURAL INSPECTION
OF
SALEM MILL
HYDE BANK ROAD
NEW MILLS
FOR
AIM ENGINEERING LIMITED

Integra Consulting (Engineers) Ltd
Second Floor
Fountain House
Fountain Street
Manchester M2 2EE

Tel No: (0161) 237 3400
Fax No: (0161) 237 3635

Job No: RH/2142

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1.0 INTRODUCTION

The structural inspection and report has been prepared at the request of Mr. Jim Carter of Shaw Cavanagh Ltd on behalf of AIM Engineering Ltd.

Instructions to proceed were confirmed on 10 August 2009. An inspection was carried out on 12 and 13 August 2009 during generally sunny weather conditions. Intrusive investigations were conducted on 4th September 2009 during generally cloudy conditions with frequent heavy showers.

1.1 Third Parties

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2.0 BRIEF

Our brief was to carry out an investigation of the Mill to identify existing structural defects. The investigation was to include the following studies:

- Full inspection of the property incorporating an internal and external visual structural inspection.

- Estimation of out of plumb walls, floor levels and extent of any differential settlement.

- Full structural assessment of the existing building superstructure including roof, floors and walls.

- Intrusive investigation at strategic locations throughout the property to allow full structural assessment (e.g. foundations).

- Intrusive investigation and structural calculations to determine the condition and structural performance of the external retaining wall.

A report was to be provided to summarise the findings and define recommendations for the type and extent of structural remedial work required, demolition / rebuild and structural strengthening necessary to ensure the long term robustness and integrity of the development property. No specific details and / or drawings were to be provided as part of this appointment.

The report specifically excludes the existing low level properties attached to the Mill Building as it is understood that these will not be retained within the proposed development scheme.

3.0 SCOPE OF REPORT

This report is based upon a visual inspection of the Mill Building in order to assess the degree of structural defects evident in the property and the extent of remedial works necessary to correct such defects. The inspection extends to the structural performance of the roof, floor, columns and load bearing wall constructions. The inspection and conclusions reached do not include aspects of the buildings such as finishes, moisture barriers, services, damp, drainage, boundary walls, environmental aspects, valuation, disabled access, saleability and the like.

During the inspection, finishes were not removed to expose the structure beneath. The presence of internal finishes, external render, dense vegetation etc could conceal structural defects. During any remedial works we would be pleased to advise on any structural defects uncovered after removal of such finishes.

It should also be noted that, although comments may be made in relation to the general condition and structural performance of timberwork, timber decay may have taken place. Due to the age of the property, we recommend that a specialist contractor should be appointed to assess the condition of all structural timber work.

Please refer to Appendix H for a summary of other conditions on the use of this report.

4.0 SUMMARY OF VISUAL INSPECTION

The building was subject to an internal and external visual structural inspection and evidence of structural defects was noted. The following section summarises these findings in addition to providing a structural description of the building form at each level and a brief summary of the building history.

The building is a rectangular shaped three storey structure with a partial basement. Several additional structures of different ages directly abut the building. Evidence suggests that the building dates back to circa 1780 with a varied history of industrial uses including cotton spinning, chemical works and sheet metal fabrication. The west elevation, which forms the site boundary, abuts a structure which is also believed to date back to circa 1780. Although it is not possible to be categoric, it may be that this structure forms part of the original build (based on the continuous form of the stone cladding along the north elevation) which was divided into two buildings at a later date. The eastern and southern elevations abut single storey 'sheds' which are likely to date back to the mid 20th century when the building use was changed to sheet metal fabrication. The north elevation forms the northern site boundary and is located directly adjacent to the River Sett.

It is understood that the building replaced a 14th century cotton mill located on the same site. Site topography is generally level although retaining walls to the east and west perimeters of the site service yard retain higher ground and it is therefore likely that the pre-development site used to slope towards the river. Access to the adjacent site is at a significantly lower level with its ground floor broadly corresponding to the basement level in the Mill Building. This situation results in a variance in floor levels between the two buildings and hence stepped access would have been necessary between them.

Gated access to the external yard area of the property is from the south east corner of the site via a private road which serves the garages in the adjacent building.

The loadbearing external walls to the building are of solid gritstone construction with gritstone cills and lintels to all openings. Three of the elevations have been rendered leaving the stonework visible to the north elevation only. Various openings have been blocked up as the building use has changed over the years whilst other openings have been introduced. A brickwork chimney stack present in the south east corner of the building is considered to be a later addition.

The roof to the Mill Building is a duo-pitch construction with a slated covering. The adjacent existing industrial structures are of duo-pitch steel frame construction with corrugated sheet roofs.

Internal floors to the Mill Building are formed using timber joists spanning onto timber beams which in turn are supported on internal cast iron columns and external loadbearing gritstone walls.

4.1 External Visual Inspection

4.1.1 South Gable Elevation

Inspection of the south gable was restricted due to the presence of external render and the existing connected steel framed building. Inspection of the gable was therefore conducted externally and from within the steel framed link building. Findings and defects observed from the visual inspection are indicated in Appendix D of this report and are summarised in the following paragraphs.

The main gable wall was noted as fully rendered with general surface cracking noted throughout (refer to Plate 1 in Appendix E). Due to the presence of the rendered finish, the condition of the stonework could not be determined.

The verge detail to the top of the wall / edge of roof appears to be relatively recent construction and is in good condition. It is therefore likely that previous repair work has been carried out in this area of the building.

Organic growth was observed from the chimney at the south east corner of the building. A significant amount of render was noted to be absent from the chimney therefore exposing the brickwork construction.

Within the steel framed building, the lower level gable wall was inspected. This section of wall is again rendered and therefore the condition of the stonework could not be inspected. One crack was however noted to extend vertically from an electrical box in the lower section of the elevation.

4.1.2 West Elevation

A full inspection of the west elevation was not possible due to the presence of the attached building and external rendered finish. Findings and defects observed from the visual inspection are summarised as follows.

A significant area of the elevation is currently affected by damp and water ingress due to leaking rainwater pipes (refer to Plate 2). Accordingly, a large black stain is evident at the affected area and it is likely that the integrity of the render has been detrimentally affected.

Inspection of the roof indicates that there is a dip in the ridge line approximately 5m from the north gable.

A horizontal lean is visually apparent in both gable walls when viewed from the west with the north gable leaning inwards and the south gable leaning outwards. The lean of both gable walls is visible externally and hence the rotation of these walls is therefore likely to be considerable.

4.1.3 North Gable Elevation

Full unrestricted external assessment of the north gable was undertaken together with an assessment of the condition of stonework as there is no render present to this elevation. However, there were limited viewing angles due to the proximity of the river and the presence of heavy organic growth. Inspection was therefore conducted from a single location on the river bank opposite the development site.

External stonework was noted to be in a generally good condition with mortar joints intact. The condition of the mortar suggests that previous pointing works have been carried out. It is therefore possible that any structural defects / cracking have been re-pointed and hence are not visible.

Various stone lintels were found to be cracked across their full depth resulting in a loss of structural integrity with the window frames effectively supporting the load over the window head and preventing a localised masonry collapse.

Leaking gutters / drainage pipes are evidenced by the presence of a large dark green vertical staining of the wall in the location of the division between the two properties (refer to Plate 3). These leaks are almost certain to be causing problems with water ingress into mortar joints and therefore affecting the integrity of the stonework.

A significant inward bulge is noted to the entire gable elevation, particularly at first floor level.

Our inspection of the stonework across the north elevation and the adjacent property indicates it to be continuous and of matching construction. It is therefore believed that the two adjoining properties were constructed concurrently.

4.1.4 East Elevation

External inspection of the east elevation was limited due to the presence of the steel framed structures and external render. The inspection was therefore undertaken both externally and from within the steel framed link buildings.

A slight depression in the ridge line was noted as described in section 4.1.2.

Leaking gutters / rainwater pipes were observed between the steel framed building and the Mill (refer to Plate 4). This has resulted in a 'blackening' of the render surface together with a significant amount of surface spalling. Beneath the spalled surface, a regular pattern of cracking is noted along the lines of the mortar joints to the stonework beneath.

Inspection of the gutter line from the south east corner of the building indicates that the wall 'bows' outwards at approximately 4m from the north elevation.

Internal inspection of the southern side of the elevation was undertaken from within the steel framed buildings. The stonework walls were fully visible although coated with a thick dark green paint.

Stonework was generally considered to be in a poor condition with little mortar present within the bed and perpendicular joints. As a result, loose stonework is present with evidence of slight collapse of the outer skin in some areas (refer to Plate 5). Consequently, it is likely that some of these areas will need to be rebuilt.

Cracking was present at various locations, most notably between ground / first floor windows and above a first floor lintel as a result of lintel deflection / failure.

4.2 Internal Visual Inspection

4.2.1 Roof Structure

The roof structure was inspected from second floor level and the overall visible structural condition of the supporting timberwork identified. Localised leakages were identified and the overall performance of the roof assessed.

The roof consists of a slate covering supported on timber rafters and ridge members which are in turn supported on timber purlins. The purlins span between external gable walls and internal timber trusses which in turn are supported on the east and west elevation walls.

The roof covering appears to be in a satisfactory condition with no major leaking noted. In various locations however, daylight was visible through the roof and thus there may be some minor leaking through the roof covering.

The overall timber roof structure has tended to ‘rack’ over time which is also evidenced by the lean present to the gable walls as previously noted. The supporting trusses have rotated significantly out of plane from their bearings to the extent that the truss ridge is out of plane by between 200mm and 400mm relative to the bottom chord (refer to Plate 6). The timber roof structure currently relies on limited ‘diaphragm’ action of its structural and non-structural roof members to transfer lateral (wind) loading to the masonry walls below. However, the lack of roof bracing present means that the roof structure is not capable of acting as a ‘stiff’ diaphragm and hence the structure has tended to ‘rack’.

Inspection of the timber purlins, ridges and rafters suggests that they are structurally adequate although it should be noted that close inspection was not possible and therefore the extent of any timber decay could not be ascertained.

The truss assemblies were inspected and previous remedial work noted to the bearing of the northernmost truss in the form of a steel shoe seating bracket to the eastern end of the truss. The shoe has 'slipped' thus causing a reduction in the intended bearing area (refer to Plate 7) whilst a brick corbelled pier has previously been introduced at the western end of the truss to increase the bearing area. The bearings to the southernmost truss were found to have a significant level of rot with evidence of this also noticeable in the adjacent lintel (refer to Plate 8). The extent of timber rot is not quantifiable from a visual inspection although this constitutes a **major structural issue** that could lead to truss bearing instability and collapse of the roof structure which could in turn have a disproportionate 'knock on' effect onto the stability of the remainder of the building.

4.2.2 Second Floor Structure

The second floor, which also forms the roof void, consists of the trussed roof structure above which creates a floor plate clear of internal columns, load bearing walls or other supporting structure. The four external walls are therefore the sole supporting structure at this level.

The north gable elevation, as described in section 4.1.3, bulges inwards significantly (refer to Plate 9). In addition, considerable cracking is noted across the elevation, particularly around windows. The cracking generally extends across the weak points of the wall i.e. between adjacent openings and between lintels and purlins. The condition of the lintels to all visible window openings was generally considered to be poor.

The east elevation is also of solid gritstone construction with large window openings present across the elevation, some of which have been previously infilled. Visual inspection suggests that the wall is not plumb with various bulges both inwards and outwards evident along the wall. Lintels were generally in a poor condition and cracking was noted below the cills extending down to the lintels at the floor below.

The south gable elevation leans outwards significantly as described in section 4.1.1 above although the lean is less than that noted on the north elevation. Cracking was also noted on the elevation with the most severe cracking present at the south west corner where large vertical cracks were noted up to 10mm in width (refer to Plate 10). Other cracking was noted on the elevation above and below lintels and between openings. Lintels were also inspected and deemed to be in a poor structural condition.

The west elevation is of solid stone construction with all previous window openings having been stone infilled. Cracking was evident at various locations, in particular adjacent to the brickwork pier supporting the roof truss over whilst a large infilled crack was noted towards the north west corner of the wall. Lintels to the infilled openings were generally deemed to be in a poor condition with cracking noted above and below the openings.

The floor construction consists of timber floorboards on a supporting timber structure with significant deflections noted across the entire floor plate. The general fall of the floor appears to be towards the centre of the room with slopes evident towards the west elevation. Inspection of the timber beams and joists suggests that they have experienced heavy loading in the past resulting in large permanent deflection of the floor members although the current overall condition of the floor appears acceptable to transfer current loads from the floor above.

The position of the internal cast iron columns between first and second floor level suggests that previous structural modification work has been carried out with two of the columns having been repositioned to support a crane rail. This has resulted in one of the second floor beam spans increasing in length, with another beam span being split into three separate spans. The head plate bearings of these re-located columns were deemed to be inadequately connected in order to achieve a structurally satisfactory load transfer.

4.2.3 First Floor Structure

The first floor structure consists of external loadbearing solid stonework walls with central internal cast iron columns supporting timber beam and joist assemblies which form the second floor above.

Inspection of the first floor surface reveals a similar slope to the second floor suggesting that foundation settlement to the west elevation has occurred.

All visible first floor timberwork viewed from the lower ground floor area appears to be in a structurally acceptable condition to carry the current imposed loading although a significant floor deflection was apparent. It is however noted that the change in load path due to the removal of internal columns has resulted in the columns above applying load directly onto the mid span of the floor beams. On the basis that these columns support the second floor structure, these beam assemblies are resisting first and second floor loadings and any increase in either first or second floor loading could therefore cause these beam capacities to be exceeded, potentially causing serviceability issues and even structural failure.

With regard to the external solid stone walls, a visual inspection was carried out and the following defects recorded. Cracking was noted throughout various locations along the external walls with the positions of the cracks similar to those on the floor above i.e. above and below both current and infilled openings with previously filled, full height cracks also present in the north west corner of the west elevation wall.

4.2.4 Ground Floor Structure

The ground floor is constructed at two levels which vary in elevation due to the 'part basement' construction in the building. One level is formed using a suspended timber floor above the part basement whilst the other level is formed using a ground bearing floor slab set approximately 1.15m below the upper floor level. The ground floor level structure is believed to have been historically amended and this is evidenced internally at lower ground floor level through an absence of internal columns and the subsequent inclusion of two steel portal frames. The inclusion of the portal frames indicates that the internal columns were previously removed and the load path altered to allow a greater unobstructed working area.

The ground floor slab is of concrete construction. It is believed that this construction is not original and was introduced at a later date when alteration works were carried out within the building.

Walls are exposed stonework which is painted in a dark green colour. Generally, a lack of mortar was evident in the bed and perpendicular joints in various locations resulting in loose stonework (refer to Plate 11). In addition, cracking is also noted at various locations.

The thickness of the walls was measured at door / window reveals and found to be in the region of 500mm to 600mm, increasing to a thickness of between 650mm and 700mm over their lower 1.5m.

The upper ground floor level is set approximately 1.15m above the lower ground floor level. Inspection of this floor was not possible at the time of survey due to limited access and also due to the presence of false ceilings, new plasterwork and plasterboard finishes.

4.2.5 Basement

The part basement is accessed directly from the lower ground floor level and is located at the north end of the building. The level of the basement slab is understood to be close to the river water level directly adjacent to the north elevation although there is no current evidence of standing water.

All three external basement walls, particularly the north elevation wall, have evidence of rising damp at lower levels with mortar joints generally in a poor condition. There is also evidence of slight vertical cracking at the north west corner of the west elevation wall.

All door and window openings to the above three walls have previously been infilled although the original internal timber lintels are still in place. The condition of these lintels is considered to be very poor with a significant amount of wet rot and woodworm apparent within the timber (refer to Plate 12).

Timber beams and joists to the upper ground floor level were inspected from basement level. There is evidence of previous rot and general timber degradation in various locations although their structural performance is considered satisfactory under current loadings.

The basement slab is formed in concrete and is not considered to be original construction.

5.0 MEASURED SURVEY AND CONCLUSIONS

5.1 General

In addition to the visual survey, a measured survey was carried out to determine if the walls are plumb and floors level. A 1.8m spirit level was used to determine if the walls were plumb, whilst a tripod, dumpy level and graduated staff were used to determine the floor levels and any floor slopes / deflection present. Intrusive investigation was also carried out to the foundations of the building and the external retaining wall to the development site.

The following sections provide a summary of the results of the measured survey and intrusive works supplemented with our conclusions regarding the likely causes of any significant abnormal survey measurements. Conclusions are also formed with regard to the structural adequacy of the existing building elements following analysis of the visual and measured survey results.

5.2 Second Floor Level (including Roof)

The results of the wall measurements suggest that the north elevation wall leans inwards significantly by 500mm (1 in 12) over its total height whilst the south elevation leans outwards by 300mm (1 in 20) over its total height. The out of plumb walls have also resulted in the roof members 'racking' to the extent that the trusses have rotated out of plane on their bearings.

It is considered that a number of factors have contributed to the current wall alignments. Firstly, the size of the unrestrained wall panel between wall, floor and roof supports results in a significant lateral (wind) loading being applied to the wall panel. Although the wall thickness is substantial, the flexibility of the lime mortar joints and the lack of a regular coursing of the stone has resulted in a flexible panel that is susceptible to deflection over time due to wind loading. In addition, wind loads are then transferred through the stonework panel and into the supporting elements. Due to the lack of bracing present in the roof structure together with the significant nature of the applied wind load, the roof has been unable to resist the applied loadings without distortion and has consequently 'racked' causing the trusses to rotate out of plane and increasing the magnitude of horizontal movement of the supporting walls.

The west elevation external wall has a general lean outwards of up to 100mm over a 1.8m length (1 in 18 slope) whilst the east elevation leans inwards by up to 65mm (1 in 28 slope). Bulges in the wall are evident at some truss bearing positions where the bearings appear to be restricting local horizontal movement of the walls.

Floor level measurements indicate that the floor generally deflects significantly towards the internal column locations in the centre of the room below. Typical floor deflections are in the region of 90mm to 100mm across a floor span of 9.2m. This equates to a slope of approximately length/100 which is significantly outside all recommended British Standard serviceability limits. On the basis that the floor is not currently heavily loaded, it is unusual for such deflections to be experienced. Potential reasons for the high current deflections can be summarised as follows.

A proportion of the total deflection is due to the permanent timber deflection sustained from previous heavy loading of the timber over a long time period. Foundation settlement associated with the cast iron columns, which have since been removed at ground floor level, is also likely to have contributed to the deflection. Finally, previous removal of the columns in the lower ground floor area would have resulted in deflection of the first floor timber beams over and will therefore be contributing to the overall deflection. This is apparent when analysing deflections in the area above the lower ground floor area where internal columns have been removed in contrast to the area above the upper ground floor where internal columns remain. Where internal columns remain, the deflections above this area are less than that where columns have been removed by between 70mm and 90mm.

The perimeter floor levels indicate that there is a significant differential settlement between the east and west elevation walls. Floor levels across the east elevation vary from 0mm to approximately 80mm which is believed to be associated with floor imperfections and deflection of the joists below. The floor level measurements adjacent to the west elevation wall vary from 100mm to 150mm. Comparing the average floor level measurements between the walls suggests a differential settlement between the two walls of up to 85mm. This differential settlement is also likely to have contributed to the lean of the east and west walls due to a consequent minor rotation of the building.

5.3 First Floor Level

The results of the wall plumb measurements suggest a similar movement to the walls above. The north and south gable walls lean inwards and outwards respectively by 70mm over a 1.8m length (1 in 26). This would suggest that the lean experienced above continues over the full building height although it reduces in significance at lower level due to the presence of the floors acting as stiff lateral restraints. Rotation of the building due to differential settlement between the north and south elevation walls was considered as a potential reason for the excessive wall lean although this was eliminated on the basis that the floor measurements taken do not identify any significant differences in level and therefore any differential settlement is not of a substantial nature.

The east elevation wall leans inwards 25mm over a 1.8m length (1 in 72) although this is less significant than at the floor above which is likely to be due to the presence of the floor acting as a stiff lateral restraint and restricting the amount of horizontal movement.

The west elevation wall does not show marked evidence of any lean inwards and outwards with out of plumb measurements varying from 30mm outwards to 15mm inwards. This is probably because the first floor level restrains this wall together with the additional stability against horizontal movement provided by the original attached building.

The floor level measurements indicate that the floor has generally deflected significantly towards the centre of the room, i.e. towards the column positions. A typical floor deflection at column positions is in the region of 90mm to 110mm across a floor span of 9.2m, particularly in locations where the columns do not continue below. As per the floor above, this deflection is of a significant nature and outside British Standard serviceability recommendations. In addition, the floor slopes generally from east to west with differences in perimeter levels averaging 90mm. It is believed that the same reasons for differences in floor levels and perimeter levels as stipulated in section 5.2 above also apply to this floor i.e. permanent timber deflection, settlement of column foundations, removal of ground floor columns and differential settlement of east and west walls.

Levels were also taken on the underside of three of the first floor level beams as a check against the levels taken on the first floor surface. This verified the readings taken from above with all three of the beams showing evidence of significant mid span deflections together with two of the beams indicating a differential settlement between east and west walls of 90mm.

5.4 Ground Floor Level

Walls were measured at ground floor level, but due to the thickening of the walls over their lower 1.5m, measurements were taken on the upper section of the wall only. North and south elevation walls were measured at limited positions due to the restricted access to the north elevation and the large opening at the south elevation. It is evident however that the north elevation follows the same pattern as the walls above with an inwards lean of 70mm over 1.8m (1 in 26). The south elevation does not however appear to experience any significant lean inwards or outwards based on the three measurements taken suggesting that the wall is reasonably plumb.

The reason that the lean to the north elevation is more pronounced than the south elevation is due to the unrestrained nature of the north elevation in comparison to the south. It is believed that, due to the location of the staircase adjacent to the north elevation, minimal restraint is provided across all levels. Lateral (wind) loading has, over time, caused the entire elevation to deflect and lean inwards due to lack of restraint. This has resulted in horizontal loading being exerted on the roof structure which has not been able to stiffly transfer the loadings therefore leading to horizontal movement of the south elevation wall. The presence of floors being built into the south elevation wall has provided restraint to this wall in order to mitigate the further horizontal movement experienced in the north elevation.

Plumb measurement of the east and west walls suggests that there is a slight lean from east to west in a similar manner to the walls above. Although this lean is relatively shallow, the effect of the continued lean over the entire building height is likely to have an effect on the overall wall stability and it will therefore be necessary to rebuild the upper levels of stonework. Similarly, it will be necessary to rebuild the upper levels of stonework to the north and south walls as detailed in Appendix G.

The ground floor slab levels were measured and it was established that the slab slopes inwards significantly towards the centre of the room. Levels are also generally uneven across the slab and it is not certain whether this is due to settlement under previous heavy industrial loading or whether the slab was constructed in this manner.

5.5 Basement

Plumb measurements were not taken on the external basement walls due to the thickening of the wall at lower levels giving inaccurate readings. These thickenings would however suggest that the walls are robust and stable at the lower level and although there may be some slight lean present, it is unlikely that this has any effect on the wall stability.

The floor slab is of concrete construction and although levels were not taken across the floor slab due to the limited size of the floor plate, it appears relatively level.

5.6 Foundations

Intrusive work was carried out inside the building at 7 No locations. These locations are detailed in Appendix B whilst the investigation results are detailed in Appendix F. Excavations were carried out by a 3 tonne JCB excavator within the lower ground floor area (trial pits 1 to 3) whilst those in the basement were excavated by hand due to limited access (trial pits 4 to 7).

From the excavations in the lower ground floor area, the material removed was identified as loose, uncompacted made ground consisting generally of sand, bricks, gravel and topsoil. It is generally thought that this made ground does not date back to the original construction of the building in the 18th century due to the presence of bricks and the loose nature of the material. The nature of this shallow ground confirms that the deflections noted within the ground bearing floor slab are due to settlement of the made ground.

The trial pit excavations to the east and south walls exposed a similar foundation type i.e. stepped wall combined with a solid stone slab. The extent of the solid stone slab and also the depth could not be determined but it is believed that these are of a substantial nature. The top of the solid stone slabs were approximately 2m below the lower ground floor level (trial pits 2 and 3), and 630mm below basement slab level in trial pit 7 i.e. approx 2.2m below ground floor level. These top of stone slab levels approximately relate to a level of 141m AOD. Although ground water was not encountered in the excavations, it is believed that this lies at a level of between 140m and 141m AOD. It is therefore highly likely that the bases of the foundations to these walls are within the water table.

The trial pit excavations to the west wall exposed a different foundation arrangement to the other walls. The excavation in the ground floor area (trial pit 1) was terminated at 2.5m depth from ground floor level. There were no steps present in the wall and no solid base foundation slab. It could not be determined whether the foundation to this wall was deeper although, near the base of the pit, the ground appeared to change from made ground to clayey sandy gravel. Water was also encountered at the base of the excavation. Within the basement area (trial pit 4), the excavation was taken to a depth of 900mm below basement level (approximately 2.5m below ground floor level). It was terminated at this level as the ground became too difficult to penetrate due to the presence of large stone fragments. In addition, the water table was encountered at this level (approximately 140.5m AOD). It is therefore believed that the west elevation wall is built directly off the natural ground with formation below the water table.

The trial pit excavation to the north elevation wall (trial pit 5) was undertaken from basement level and revealed stepping in the lower level of stonework at approximately 600mm depth from basement slab level. Water was encountered at 900mm depth (approximately 140.5m AOD) with the ground conditions noted as clayey sand and gravel which is believed to be natural ground. A slight return under the stepped wall at approximately 1m depth suggests that the wall is constructed directly off the natural ground with the formation level being below the water level.

The excavation to the column base within the basement area (trial pit 6) revealed that the column is built directly off a solid stone slab at shallow depth. The excavation revealed that the ground 'returned' below the slab, with natural dense sand and gravel apparent below the footing. It is therefore believed that this is the original construction with the formation being above the ground water table.

The results from the trial pit excavations indicate that the loose made ground within the ground floor area demonstrates that, originally, the basement formed the extent of the building (which would have been the original ground floor level) and the upper ground floor level would have covered the entire floor plate. As a later alteration, possibly in the mid 20th century, part of the basement was infilled and ground floor level removed. Columns were removed and the lower ground floor level was thus formed, with a larger floor to ceiling height in this area to cater for the change in use. The infill material is likely to have been site won material from the demolition of adjacent buildings, cut & fill operations and previous site waste.

It is apparent from the excavations that the formations to the main walls are all present within the ground water table. Foundation arrangements also differ between walls. With the east wall being built off large stone slabs and the west wall being built directly off the ground, it is evident that this difference in allowable bearing pressures is responsible for the differential settlement experienced between the two walls. Possible reasons for the different foundation arrangements are that the east wall may have been built off the foundations to the original 14th century cotton mill which it replaced or alternatively weaker formation may have been present below the east wall and therefore more substantial foundations were accordingly adopted.

It is likely that, due to the thickness of the walls, the majority of the loading is dead load with only a small proportion being imposed load. Therefore the existing formations to all the walls have accommodated a sustained loading over the past 200 years and it is therefore believed that no further substantial settlement will occur.

5.7 External Retaining Wall

Exploratory work was carried out to the retaining wall forming the edge of the current service yard to the buildings. The aim of the intrusive works was to identify the type of retaining wall used and subsequently determine the existing structural adequacy of the wall. Intrusive work was carried out at two locations, one location where the wall was relatively low (trial pit 8) and one location where the wall was at its highest (trial pit 9).

Both wall profiles indicate a solid stone mass gravity retaining wall built off concrete foundations. Both walls have large weep holes present at the base of the wall with backfill directly behind the wall being of a granular nature to aid slope drainage and relieve pore pressure surcharge on the wall. Retained soil in both positions was noted as being of a cohesive nature. It was noted in trial pit 9 that the concrete foundation is of greater width in order to account for the larger overturning moment present as a result of higher retained ground. It was also noted that, at the rear of the wall, a thickness of approximately 350mm of weak mix concrete is present, presumably as a measure to increase the mass of the gravity wall and allow a consistent thickness of 480mm solid stone wall to be adopted across the entire extent of the wall.

As there is currently no site investigation report available for the site, geotechnical data such as material strengths, plasticity indices etc are undetermined and therefore an accurate structural analysis cannot be conducted on the retaining wall. We have however undertaken structural calculations using material assumptions based upon a visual inspection of the material in order to initially assess the stability of the wall with respect to overturning and bearing. The results indicate that the wall is currently structurally satisfactory in sustaining the existing applied loadings. Furthermore, the 'arc' plan profile of the wall tends to provide an increased stability to the entire construction.

Above the main retaining wall, it is noted that there is a secondary 'flag on edge' retaining wall further up the slope. Although this was not intrusively investigated, the condition of this construction is noted as being poor with a significant proportion of the 'flag' having undergone rotation and other areas having slipped / become dislodged from their original positions.

6.0 RECOMMENDATIONS

6.1 General

It is believed that the proposals for the current structure are to re-develop the Mill Building as a series of residential apartments. Section 5 highlights the current issues associated with the existing Mill Building and reports on areas which are of concern in addition to areas which are structurally unsafe and currently require attention. This section makes recommendations for the demolition / remedial work necessary in order to stabilise the building against further movement in addition to stabilising the out of plumb walls prior to conversion into a residential property. Recommendations are also made with regard to the roof, second floor, first floor, upper ground floor and ground bearing floor slabs, identifying any elements which may be retained for re-use. As there are no current comprehensive details of the re-development, this section focuses on the fundamentals of the existing structure rather than any structural issues which may arise as a result of the residential re-development plans. In addition, various other items such as insulation / tanking requirements, thermal issues etc have not been considered and it is assumed that these issues will be considered and reported on by others.

6.2 Roof

- Due to the previously described 'racking' of the roof, it will be necessary to remove and fully rebuild the entire roof structure.

- Rafters and purlins may be retained, if required, subject to a timber condition survey and grading by a specialist.

- Trusses may be re-used subject to a timber condition survey and grading by a specialist although some areas, in particular the bearings, will certainly require structural enhancement work due to the excessive degradation noted

- As a matter of urgency, it is recommended that the bearings to the southernmost truss are provided with an adequate temporary support system due to the excessive extent of rot which has occurred. Failure to undertake this remedial work could potentially result in collapse of the truss which would have a disproportionate ‘knock on’ effect on the collapse of walls, floors etc due to the unstable north and south walls taking support from the roof diaphragm.

- The new roof structure will require a bracing system to be introduced

6.3 External Walls

The following section outlines the minimum extent of demolition and re-building works necessary to the external wall construction. Elevation drawings indicating the approximate extent of works are contained in Appendix G. It is emphasised that this information is purely indicative and therefore for information purposes only. Following demolition of the existing link buildings and removal of render, the walls should be accurately plumb checked over the full external height of the building. Based on this information together with the proposed re-development scheme, it will be possible to detail a more accurate extent of areas requiring demolition.

- Remove and rebuild the entire north elevation from first floor level to ridge level.

- Remove and rebuild the entire east elevation from second floor level to eaves level together with other collapsed sections of the wall.

- Remove and rebuild the entire south elevation from second floor level to ridge level.

- Remove and rebuild parts of the west elevation from second floor level to eaves level.

- Remove the render from the east, south and west elevations to allow full structural assessment and subsequent recommendations for these areas.

- Rebuild sections of ground floor walls on the east elevation where partial collapse and bulging is present.

- Re-mortar and point all joints to exposed stonework on the east elevation where currently joints are generally not mortar filled.

- Clean north elevation stonework face where stained from residue from leaking gutters, rake out loose mortar from joints and repoint.

6.4 Timber Floors

- If the intention is to retain the existing floor joists, this is possible subject to a timber condition survey and grading by a specialist. Due to the permanent deflection however, it would be necessary to re-level the floor. In addition, extra support may be required depending upon the grading achieved.

- If the intention is to retain the existing floor beams, this is possible subject to a timber condition survey and grading by a specialist, in addition to a careful inspection of each beam by the engineer to determine notches present along the length of the beams and timber defects. Due to the permanent deflection however, it would be necessary to re-level the floor above. Also, it is likely that additional column supports, or beam strengthening would be required depending upon the grade achieved.

6.5 Ground Bearing Floor Slabs

- Existing ground bearing slabs may be utilized in the development scheme although these will require leveling, in addition to tanking, dpc, insulation measures etc (by others).

6.6 Lintels

- The majority of the internal lintels will need to be replaced due to significant deflection and timber degradation. These should be replaced with new steel or precast concrete lintels.

- The majority of the external lintels are cracked and have lost all structural capacity. These should be removed and either repaired / strengthened or replaced with new lintels.

6.7 Columns

- Existing columns may be utilized if required although attention should be paid to the head plate details for the two columns on the southernmost beam. In addition, new column supports must be introduced at ground floor level or new transfer beams incorporated in the locations where the columns are currently supported off the existing beams. Additional column supports may also be required to reduce the loading on the columns.

6.8 Foundations

- Existing foundations are adequate in resisting any applied loading and therefore no remedial measures are necessary.

- Any new internal foundations (potentially to support new internal columns) will need to be built off natural formation which is likely to be within the ground water table. It would therefore be prudent to design the proposed floor structures to span the full width of the building to avoid the temporary works associated with this construction.

6.9 Retaining Wall

- Existing site retaining wall may be reused subject to establishing satisfactory geotechnical data from a future Geotechnical Ground Investigation report.

- The existing secondary ‘flag on edge’ retaining wall situated within the slope should be replaced / strengthened.

APPENDIX A

EXISTING STRUCTURAL FLOOR PLANS & ELEVATIONS

APPENDIX B

PHOTOGRAPH & TRIAL PIT LOCATION PLANS

APPENDIX C

SCHEDULE OF MEASURED OUT OF PLUMB WALL LEVELS AND FLOOR LEVELS

APPENDIX D

DETAILS OF DEFECTS

APPENDIX E

PHOTOGRAPHS

APPENDIX F

TRIAL PITS

APPENDIX G

EXTENT OF WALL DEMOLITION

APPENDIX H

CONDITIONS ON USE OF THIS REPORT