
Job Title

Stonyhurst College – Old Infirmary

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Addendum to Preliminary Structural
Appraisal

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Addendum to Preliminary Structural Appraisal

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1. Introduction

In January 2019 Civic Engineers produced a Preliminary Structural Appraisal of the Old Infirmary building at Stonyhurst College in Lancashire, based on a non-intrusive visual site survey on 12th December 2018. The Old Infirmary is Grade II listed and is currently partly used for staff and pupil residential purposes and for teaching. The Preliminary Structural Appraisal report noted that cracking is present in walls across all floors of the building, appearing at the plaster surface as <5mm crack widths. Several floors have a significant slope and door frames have previously been distorted due to building movements. Doors have been reset to accommodate floor slopes, as there is no longer evidence of doors sticking in their frames. There were suggestions that the ground conditions of the site may consist of weak or variable material due to the settlement, and a quote for ground stabilisation works that had been produced in 2004.

This addendum report provides additional information gained from an intrusive ground investigation, CCTV drainage survey and minor opening-up works to examine the above mentioned defects in more detail. It also proposes remedial works for the building, to allow its proposed renovation into staff and pupil residences, with increased number of residences.

2. Surveys

The following surveys were carried out in February 2019, based on a scope of works produced by Civic Engineers.

2.1 Intrusive Ground Investigation

An intrusive ground investigation was carried out by Groundtech Consulting Ltd, consisting 4 No. window samples around the building perimeter and 5 No. trial pits; 3 of which were external and 2 of which were internal. The ground investigation recorded ground conditions, ground water level and existing foundation details as follows. Draft window sample logs and foundation sketches are included in Appendix 1. The full ground investigation report is awaited at the time of writing.

Ground Conditions

The ground conditions across the site were found to be variable, with generally fairly low capacity.

- Made ground was encountered in all investigations from ground level to a maximum depth of 3.5m BGL; this location was to the south-east elevation where the ground appears to have been built up between basement and ground floor level. The made ground generally consisted of natural material (clay/ sand) with brick and gravel.
- The natural strata were generally found to be loose to medium dense sand with varying proportions of organic material, clay, silt and gravel. Clay was encountered in an internal trial pit, and silt layers were encountered in an external window sample.

Groundwater

Groundwater was encountered in all window sample locations at between 2.0m and 2.5m BGL. The GWL in one window sample rose to 1.5m BGL in 20 minutes. Groundwater was also recorded at 2.0m BGL in the south-east side of the building which has a higher ground level, suggesting that there is perched groundwater present in this raised area.

Existing Foundations

Two trial pits were carried out to the perimeter walls on the south-west side of the building, to expose the foundations. These confirmed that the walls were founded on sandstone block foundations with a base depth of 1.0 – 1.3m BGL, founded in the sand. An internal trial pit in the basement corridor identified that the original stone walls are founded on a sandstone cobble foundation in clay, with a further wall lining built on a concrete slab; refer to Figure 1.

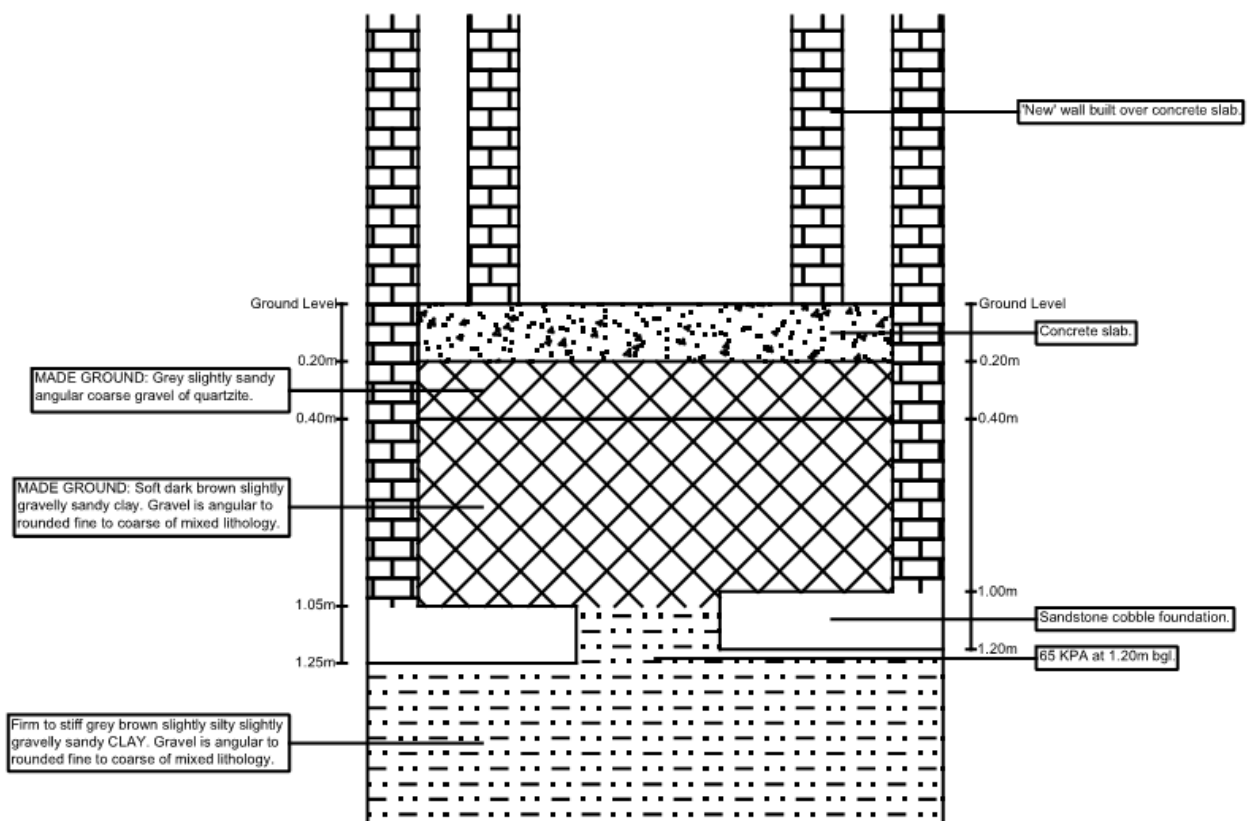


Figure 1: Internal Corridor Foundations (Groundtech sketch)

2.2 Opening-Up Works

As part of the Preliminary Structural Appraisal report, Civic Engineers identified areas to be opened up to allow further inspection of the cracking. In general, this included stripping back plaster finishes to identify the actual crack widths within the wall substrata. This information has been added to revised Site Observations Sketches (SK-001 to SK-004), included in Appendix 2. Photos are included in Appendix 3. The following provides an overview of the observations made by Civic Engineers during a site visit on 21st February 2019 to view the opening-up works.

Basement

The Key Plan in Figure 2 shows the locations of observations made by Civic Engineers of the basement. Items in red refer to observations made in the Preliminary Structural Appraisal report; refer to separate report for descriptions. Items in blue refer to observations made in the opening up works. Refer to Table 1 for descriptions of opening up works observations and photo references.

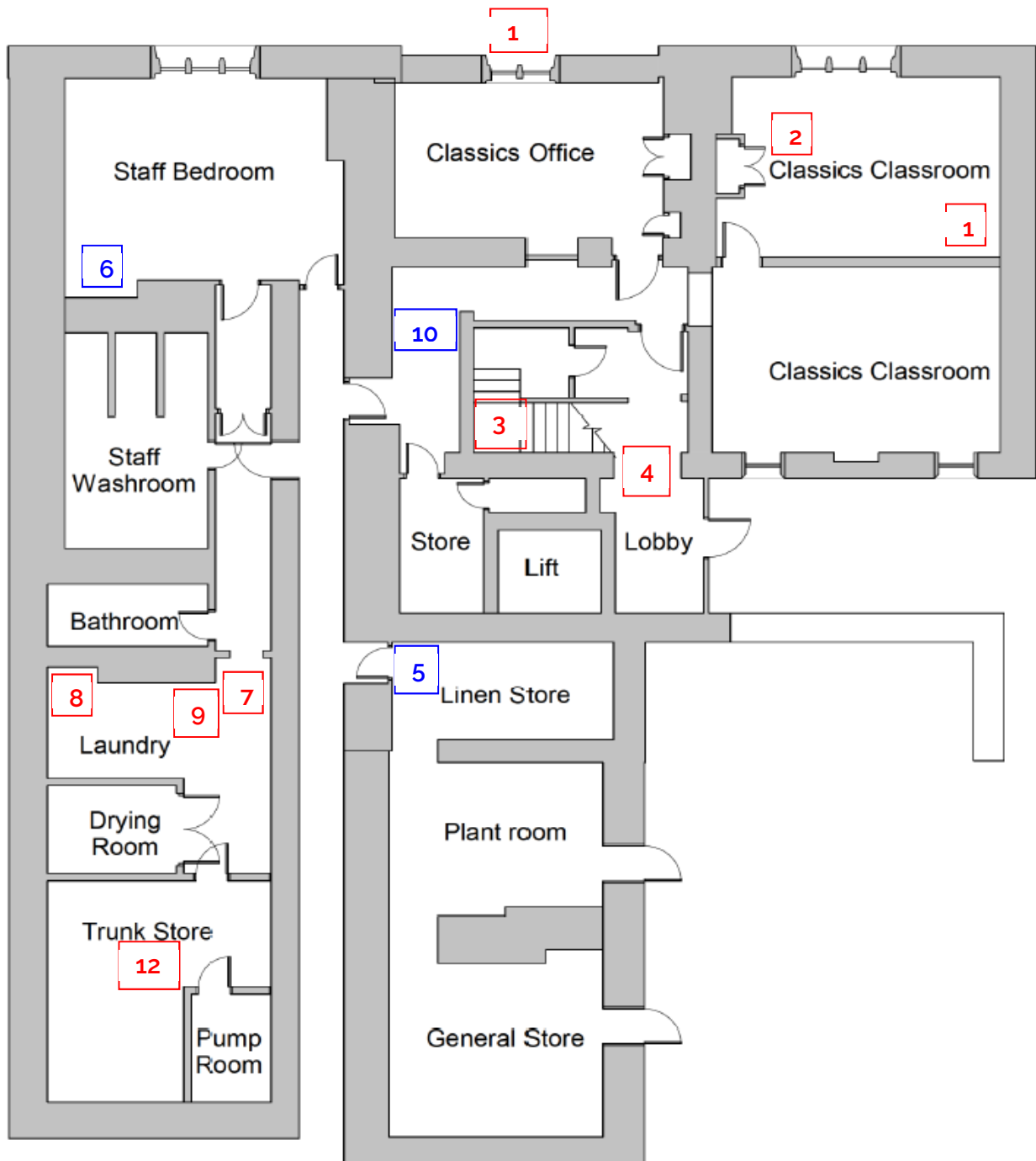


Figure 2: Site Observations - Basement Key Plan

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The site observations described in Table 1 relate to the opening up works at the Old Infirmary. Refer to Figure 2 for the location of each item.

Item	Description	Photo References
5	Plaster stripped out around crack; severe crack in stone wall with maximum 50mm horizontal crack and maximum 20mm vertical crack. Wall above crack is stepped into the room by maximum 25mm.	21-02-19, 14.18.34 21-02-19, 14.18.38
6	Plaster stripped out around crack, blockwork liner wall identified below. Crack identified in blockwork wall below corbel beam support. Beam above identified as timber.	21-02-19, 13.59.36 21-02-19, 14.04.48 21-02-19, 14.05.14
10	Plaster stripped out around crack; wall covering is new lathe and plaster over blockwork lining wall. No structural cracking evident in substrate.	21-02-19, 14.12.44

Table 1: Site Observations – Basement

Ground Floor

The Key Plan in Figure 3 shows the locations of observations made by Civic Engineers of the Ground Floor. Items in red refer to observations made in the Preliminary Structural Appraisal report; refer to separate report for descriptions. Items in blue refer to observations made in the opening up works. Refer to Table 2 for descriptions of opening up works observations and photo references.



Figure 3: Site Observations - Ground Floor Key Plan

The site observations described in Table 2 relate to the ground floor of the Old Infirmary. Refer to Figure 3 for the location of each item.

Item	Description	Photo References
1	Plaster stripped back over cracking; timber beam identified in wall in the area of cracking. No structural cracks noted in wall.	21-02-19, 11.22.16
5	Crack to the RHS of fireplace has been stripped out below plaster. Long crack in stone wall below, with maximum 20mm vertical crack width and minimal horizontal crack width. Plaster over crack on LHS of fireplace (above door has been stripped back). No structural cracking noted in the stone wall. A precast lintel is identified over the door.	21-02-19, 11.15.23 21-02-19, 11.17.36 21-02-19, 11.17.21
6	Wallpaper and plaster have been stripped off over crack. Long diagonal crack noted in stone wall, maximum 20mm wide.	21-02-19, 13.47.54 21-02-19, 13.48.08
7	Steel beam lintels identified over timber panelling (305mm deep longer beam and 180mm deep shorter beam). Plaster stripped back around crack above door; no structural cracking noted in the stone wall.	21-02-19, 11.18.38 21-02-19, 11.20.20
9	Plaster stripped back around crack extending from lintel. Crack identified in stone wall, around 25mm width. Timber lintel over door.	21-02-19, 13.46.28
13	Wall adjacent to staircase bows inward between basement and ground floor.	N/A

Table 2: Site Observations - Ground Floor

First Floor

The Key Plan in Figure 4 shows the locations of observations made by Civic Engineers of the First Floor. Items in red refer to observations made in the Preliminary Structural Appraisal report; refer to separate report for descriptions. Items in blue refer to observations made in the opening up works. Refer to Table 3 for descriptions of opening up works observations and photo references.

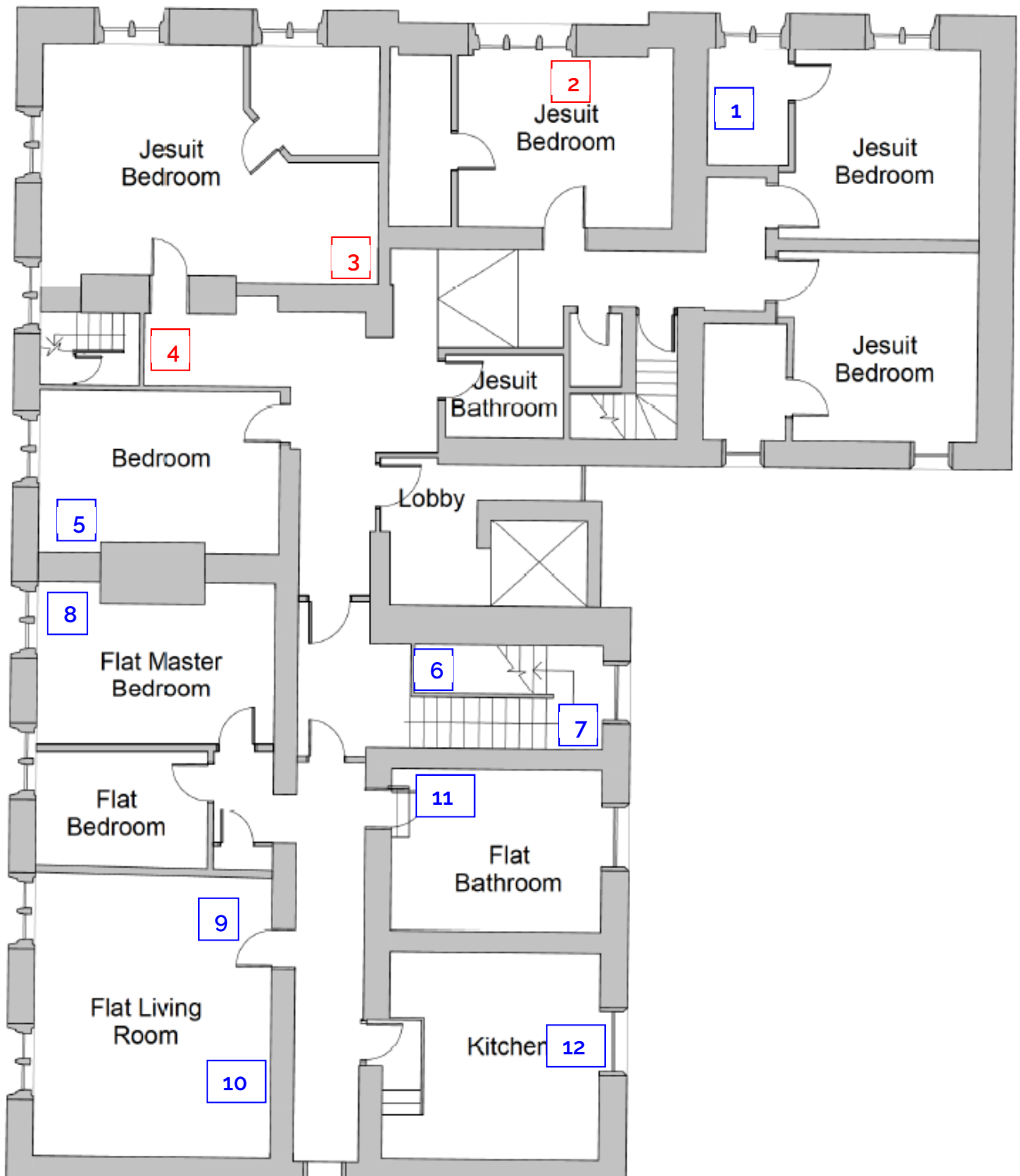


Figure 4: Site Observations - First Floor Key Plan

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The site observations described in Table 3 **Error! Reference source not found.** relate to the first floor of the Old Infirmary. Refer to Figure 4 for the location of each item.

Item	Description	Photo References
1	Plaster stripped back around crack. The stone substrate general contains loose material, with maximum 15mm crack width.	21-02-19, 11.55.39
5	Plaster stripped back over crack; crack in stone wall below. Maximum 20mm wide vertical crack and minimal width horizontal crack.	21-02-19, 11.48.19
6	Plaster stripped back over crack; crack in wall does not appear to be structural.	21-02-19, 11.40.06
7	Plaster stripped back over crack; crack in stone wall below, maximum 10mm crack width.	21-02-19, 11.39.40
8	Bumps in plaster suggest crack below, following the same line as crack on the other side of the wall (plaster has not yet been stripped back to expose crack).	15-01-19, 13.13.43
9	Crack in plaster above door (appears minor at surface, but plaster has not yet been stripped out to expose full extent of crack).	15-01-19, 13.21.14
10	Cracks in coving between wall and ceiling, appear to be superficial.	15-01-19, 13.19.14
11	Bumps in plaster indicate diagonal crack below in stone wall. Plaster has not yet been stripped back to identify the extent of cracking.	15-01-19, 13.17.15
12	Cracks in plaster above window; plaster has not yet been stripped back to identify extent of cracking.	15-01-19, 13.23.28

Table 3: Site Observations - First Floor

Second Floor (Attic)

The Key Plan in Figure 5 shows the locations of observations made by Civic Engineers of the Second Floor. Items in red refer to observations made in the Preliminary Structural Appraisal report; refer to separate report for descriptions. Items in blue refer to observations made in the opening up works. Refer to Table 4 for descriptions of opening up works observations and photo references.

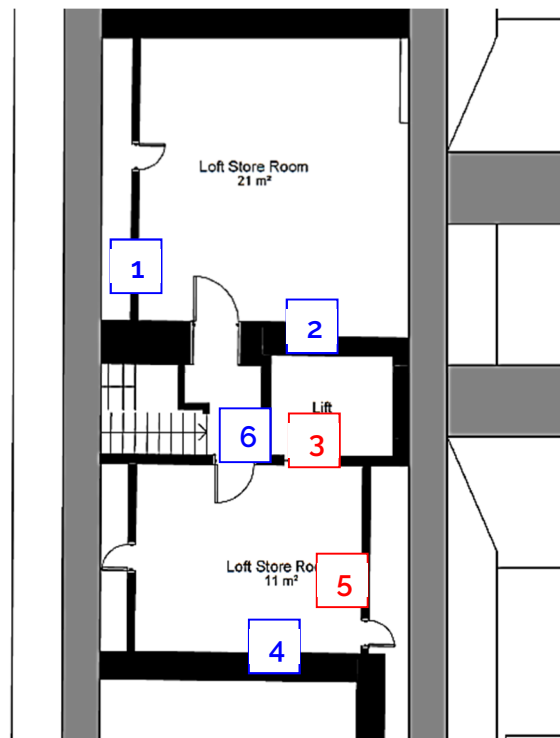


Figure 5: Site Observations - Second Floor

The site observations described in Table 4 **Error! Reference source not found.** relate to the second floor of the Old Infirmary. Refer to Figure 5 for the location of each item.

Item	Description	Photo References
1	Plaster stripped back over crack in corner of door; stone lintel identified. No structural cracks noted in this area, however there may be further cracking lower down wall (cracks in plaster noted).	21-02-19, 13.31.47
2	Plaster stripped back over crack. The wall is stone to mid-level and a timber stud wall above (timbers have warped). The line of the stone wall may follow an old pitched roof line, which reflects the line of the crack. Structural crack carries on around step in wall, maximum around 30mm crack width.	21-02-19, 13.29.53 21-02-19, 13.29.55 21-02-19, 13.30.05 21-02-19, 13.30.11
4	Plaster stripped back over crack. Long diagonal crack noted, maximum around 40mm width.	21-02-19, 13.26.14 21-02-19, 13.26.58

Item	Description	Photo References
6	Cracks noted in plaster on wall. Plaster has not yet been stripped back to inspect extend of cracks, however pattern suggests that they follow line of cracks on other side of wall.	21-02-19, 13.36.05

Table 4: Site Observations - Second Floor

3. Conclusions

The surveys carried out suggest that settlement has occurred at the Old Infirmary, generally due to poor and variable ground conditions. The intrusive ground investigation encountered foundations generally founded on loose to medium dense sand. The foundations to the internal corridor walls are founded on clay, which has an allowable ground bearing capacity of 65 KPA at 1.20m BGL. By comparison, Civic Engineers have carried out an estimated load check at the base of the foundations along the corridor and found that around 185 KPA would be required, based on existing foundation geometry exposed by ground investigation. This indicates that settlement has occurred because the ground does not have sufficient capacity to resist the applied building loads.

The intrusive ground investigation also confirmed that the ground water level across the site was approximately 2-2.5m BGL and rose to 1.5m in some investigations. The rising and falling of ground water level may have caused shrinking and swelling in the clay natural strata and weakening of the sand natural strata by washing away material. The Old Infirmary site is situated close to a lake and there is evidence of a historic culvert running through the site, so there may have been a stream or river bed in the location of the site prior to its development.

The pattern of structural cracking in the building shows that differential settlement has occurred; refer to Figure 6 for specific areas. This may be due to a combination of weaker spots in the ground and concentrated areas of the building loads. For example, the walls to either side of the staff washroom (locations 1 and 2 shown in Figure 6) include heavy chimney stacks, and are below the second floor (attic) area which is likely to have been a later conversion so has added to the building weight.

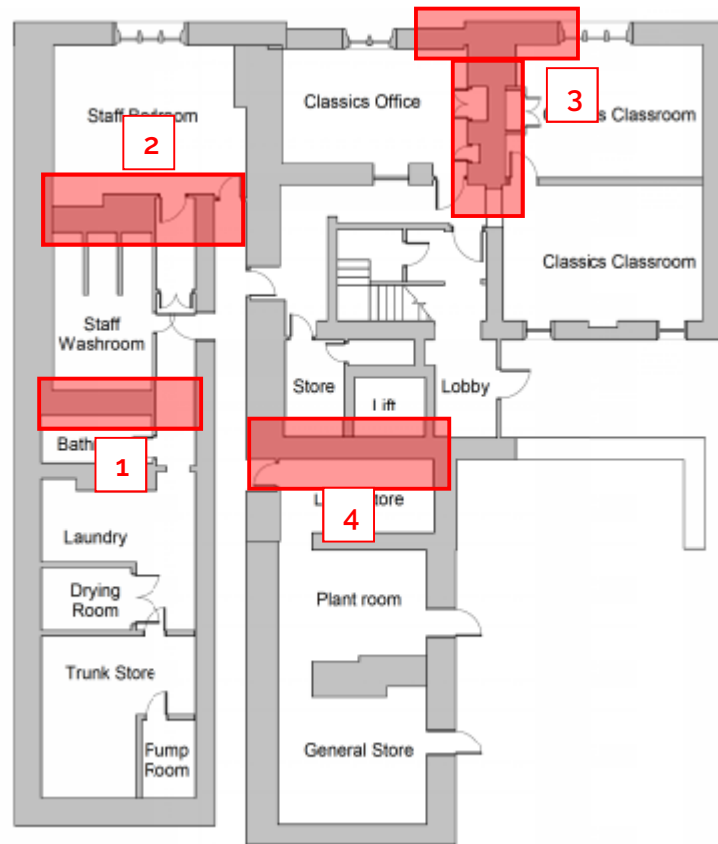


Figure 6: Areas of highest settlement

The highlighted walls around the classics office and classics classroom (location 3) appear to support relatively high line loads as the internal wall between the classics classrooms is not load bearing, therefore the supported area is relatively high compared to the rest of the building. An estimated load check at the base of the perimeter wall to the classics classroom found that approximately 225 KPA ground capacity would be required to support this wall load, based on existing foundation geometry exposed by ground investigation.

The pattern of cracking in the wall to the linen store (location 4) suggests that the building has dropped towards the corner with the lift. The lift appears to be a later addition due to the different stone, and the stairs above the linen store appear to have been reconfigured as they do not coordinate with the window level. These renovations may be resulting in the ground in this area having become overloaded.

4. Recommendations

Civic Engineers would recommend that the structural cracks noted are crack stitched with HeliBar crack stitching bars, in the specified locations and to the proposed detail shown on Civic Engineers' Tender drawings. This will provide continuity across the crack joint and restraint against further opening up of the cracks.

To arrest any further settlement of the Old Infirmary building, Civic Engineers propose to use ground stabilisation to improve the bearing capacity of the ground below the critical

areas highlighted in Figure 6. The technique proposed is a geopolymer injection below the affected walls, to a depth of 4.0m BGL. The geopolymer expands to fill any voids in the subsoil and binds with the soil to improve the bearing capacity of the ground. This method has the benefit that it can be injected without any temporary propping or restraint of the existing structure over, and only requires small holes to be drilled for the injections rather than large excavations. There is documentary evidence that this technique may have already been carried out along the main internal corridor wall foundations and appears to have stopped previous settlement in these locations as previous cracks have not continued to widen or propagate through the reinstated plaster finishes over them. The geopolymer injection is proposed to a depth of 4.0m BGL because the draft window sample logs received from the ground investigation suggest that the bearing capacity of the ground improves at this level to a suitable capacity.



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