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Engineering

CONSERVATION ACCREDITED ENGINEER STRUCTURAL ENGINEERING CONSULTANCY

Structural Engineering Stage 3 Report

on

St Lawrence Church, Lechlade – Project Inspire

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Structural Engineering Stage 3 Report

on

St Lawrence Church, Lechlade – Project Inspire

For

The PCC of St Lawrence church, Lechlade-on-Thames

Client:	The PCC of St Lawrence Church Parish Office, Church Cottage, Market Place Lechlade on Thames, GL7 3AB
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Contents

1.0 Introduction

2.0 The site

3.0 Description of the existing structure

4.0 Later surveys and investigations

5.0 The Proposals

6.0 Proposed strategy for structural engineering works

Appendix A *Listing description*

Appendix B *Structural engineering drawings*

1.0 Introduction

This Structural Engineering Report has been prepared for the PCC of St Lawrence Church, Lechlade. The purpose of the report is to summarise the RIBA Stage 3 structural engineering design for Project Inspire, which involves the restoration and reordering of the existing church, for which Chedburn Codd is acting as Architect.

The church is listed Grade I. A copy of the listing description is enclosed within Appendix A.

The Stage 3 design has been based on a close collaboration between the design disciplines from mid-August 2022, site inspections made during a site visit on 25 August 2022, and with reference to the documents noted below.

Observations on the existing structure to date are based on a walk around the church both externally and internally. At this stage, no physical opening-up works, surveys or investigations have been carried out and no samples of materials forming the structure have been taken or analysed during the design. Earlier investigation reports arranged by the PCC have however been reviewed.

By its nature, this report provides structural engineering advice on the Stage 3 design. Where comments are provided on the structural condition of the church, they are related to the structural appraisal that has been carried out to inform the structural engineering strategy. As such, it should not be interpreted as a detailed building condition survey. The report only considers non-structural elements, fittings, and fixtures where they raise structural implications. It also does not consider every opened-up joint or crack in the fabric, as these are often non-structural in nature.

The following key documents have been reviewed as part of the structural engineering design:

- Project Inspire – Structural Engineering Services: Brief for detailed design, dated July 2022, Version 3.
- Project Inspire – Statement of Need.
- Project Inspire – Statement of Significance Part 1 (Overview of the significance of the Church) and Part 2 (The significance of the area affected by the proposal).
- A Report on a Ground Penetration Radar Survey, prepared by Archaeological Surveys Ltd., ref J760, dated September 2018.
- An Archaeological Watching Brief Report, prepared by Urban Archaeology, ref UA201_WB_report_v2, dated 29 February 2020.
- Existing survey plans of the church, set out on Chedburn Codd drawings numbered 1922/002 to 006, originally dated November 2019.
- Transcript from an original Specification in the Gloucestershire Archives (ref D2593/2/431 and D/2593 /1/12/6) related to Lechlade St Lawrence Church: “Alterations and fittings of the Church 1881 to 1882 including plans, elevations and sections”, prepared by the PCC of St Lawrence Church, undated.

2.0 The site

2.1 Location and Topography

St Lawrence Church is located within the centre on Lechlade-on-Thames, close to the north bank of the river Thames. It is within the Diocese of Gloucestershire and the local planning authority is Cotswold District Council.

The measured survey indicates the church is set on ground at a level of roughly 77m above Ordnance Datum (AOD) on raised ground above the river.

2.2 Geology

The local geology map published by the British Geological Survey (BGS) indicates the natural ground conditions on the site consist of the Oxford Clay Formation (Bedrock geology) overlain by the Summertown-radley Sand and Gravel Member (Superficial Deposits). The latter formation is generally described by the BGS as sands and gravel.

2.3 Historic Development – key points

Whilst there has been a parish church on the site since the 13th century, the fabric of the church today mainly dates from the late 15th and early-16th centuries when it was reconstructed.

There have been two main phases of reordering works that have been subsequently carried out. They cover works by architect Richard Price in 1828, in the late-Georgian Period, and by architect FS Waller and Son in the early 1880's.

Image 2.1: *The nave and side aisles with the chancel beyond, viewed from the west end of the church*

3.0 Description of the existing structure

3.1 The Medieval Church

Whilst the parish church has a 13th century foundation, it was reconstructed from the mid-to-late 15th century in the Perpendicular style.

It has a traditional layout with the main axis running east-to-west, and contains a central nave, two side aisles to the north and south, an eastern chancel and sanctuary, two chantries and a western tower. A porch to the north of the north aisle and a vestry to the north of the sanctuary completes the layout of the church.

The initial building work is believed to date from the 1470's when the central nave and the two side aisles, were constructed. The chantries are understood to have been added shortly afterwards, with the chancel, sanctuary, north porch, and vestry completed in the early 16th century.

The nave contains markings high on the west wall that suggest it originally contained a pitched roof. This is understood to have been damaged by fire and was replaced with a clerestory and a new flatter roof. The clerestory is in the late-Perpendicular style, suggesting this work was carried out in the early 16th century. The western tower and spire are believed to be 16th century additions too.

Below the south aisle there is a small basement boiler room.

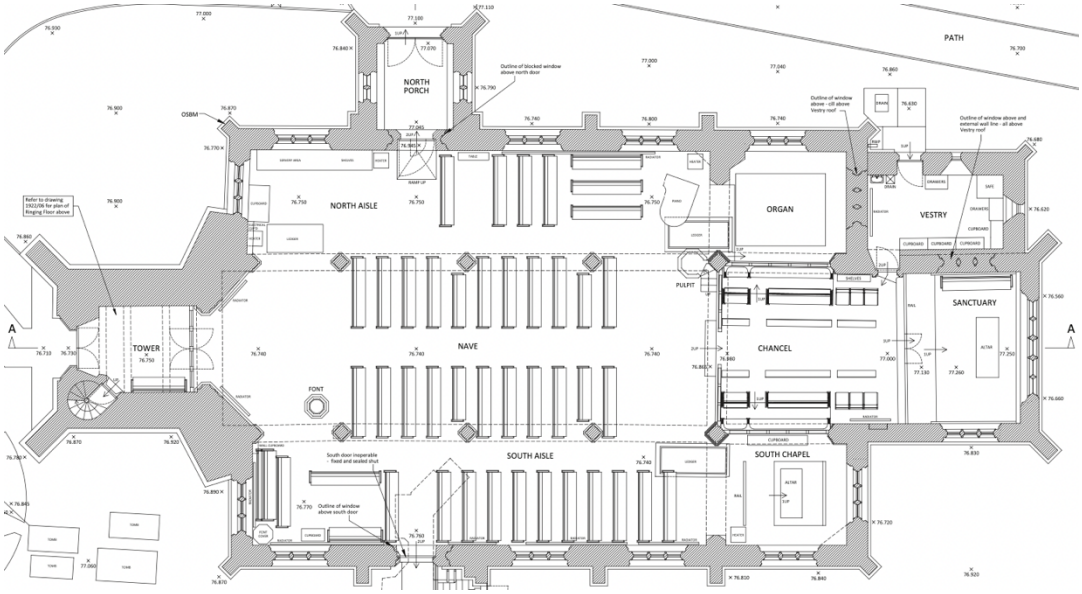


Figure 3.1: *Plan of church (part copy of Chedburn Codd drawing 1922/002)*

The structure of the church contains load bearing stone masonry walls supporting timber carpentered roofs. The elevations are faced with coursed and dressed Taynton stone, with carved stone dressings forming the window frames and door frames. Buttresses occur along the north and south elevations and diagonally on the corners of the west tower, the aisles, and the sanctuary. Taynton stone is an oolitic limestone quarried around the village of Taynton, near Burford, roughly 8 miles from Lechlade. Historically, it was recognised as a good quality building stone.

Image 3.2: *External view from the east*

Image 3.3: *View from the nave looking west*

Generally, medieval wall construction was generous in thickness and often consists of two outer skins of good quality coursed ashlar with random rubble and mortar fill contained between these two skins. Masonry walls from earlier Norman and Early English times tended to be more massive and of a poorer quality, compared to later work. Walls of the Decorated and Perpendicular Periods were often more slender in comparison, aided by prominent buttresses on the elevations. The walls at St Lawrence are roughly 750mm wide, with regularly spaced piers and corner buttresses, and so could contain two ashlar faces of between 200 and 300mm with a rubble core of between 150 and 350mm thick.

The arcades dividing the nave from the side aisles have four bays. They contain dressed stone pillars that rise to support pointed dressed stone arches and the clerestory structure above. The clerestory level is set back slightly and contains side walls penetrated by prominent rectangular windows. Timber shafts are located between the window openings rise to support the nave roof beams above.

Image 3.4: *The arcade between nave and north aisle*

Image 3.5: *Roof above the nave*

The roof over the nave is a form a beamed roof, with cambered principal beams supporting a ridge beam, that in turn supports common rafters that span from the ridge to the clerestory walls. This form of roof structure is commonly found above clerestories since the roof does not impose horizontal thrusting on to the slender side walls at high level.

The structure of the roofs over the side aisles are arranged in a similar fashion, although set at a lower level.

A prominent chancel arch divides the nave from the chancel. Similar – although smaller – arches divide the side aisles from the chantries.

The west tower is square on plan and has massive stone walls. This is set out in three stages over a height of roughly 20m and supports an eight-sided stone spire that rises to a height of 35m above ground level. The tower contains three principal floor levels – forming the ringing chamber, clock chamber, and belfry.

Regarding the original foundations, whilst Medieval builders did not have the same appreciation of foundation design and sensible bearing pressures as structural engineers have today, there would have been some recognition that walls on buildings of this importance needed to sit on reasonable ground. The existing walls are therefore expected to bear on to the natural ground either with a slight corbelling out of the width of the walls or directly with no increased width.

The small basement / cellar below the south aisle is a localised feature which is capped with stone pavers with brick side walls. Whilst the cellar may have links back to an earlier building, the use of bricks to the side walls of this space suggests it is later work.

Image 3.6: *The south arcade, looking east*

Image 3.7: *The west tower*

3.2 Late Georgian Period: 1828 Re-ordering Works

Architect Richard Price carried out numerous alterations to the church fabric in 1828. Of relevance to this project included the introduction of two new galleries – one at the western end of the nave and two side aisles, and a second gallery positioned within the north aisle.

Historic photographs show these galleries. They suggest the two galleries were separate from one another and were set at slightly different levels (see images 3.8 and 3.9 below). These same images show the western gallery was supported on slender posts. This view is consistent with a historic drawing, dated 1829, by Richard Price (see image 3.10). This shows the bases of the columns to the galleries (marked in red). The western gallery contained four columns placed to suit the arrangement of new box pews which were added at the same time. Given the age of this construction, it is expected the galleries were constructed using an arrangement of timber joists and beams supported on cast iron columns. These columns are expected to have had foundation bases of masonry construction bearing on to the natural ground.

Image 3.8: *Historic view (between 1823 & 1882)*

Image 3.9: *Historic view (date not known – pre-1881)*

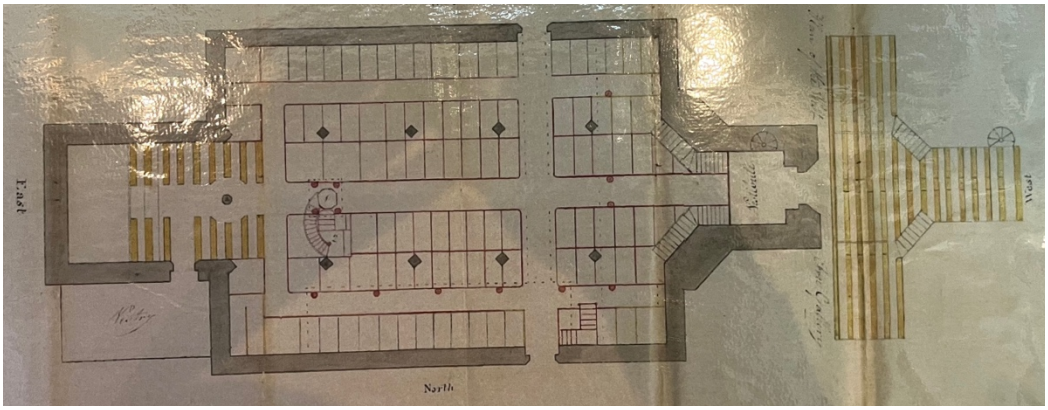


Image 3.10: *Part copy of drawing by R Pace, dated 1829*

3.3 Mid-Victorian Period: 1881-82 Alterations and Refitting Works

Further re-ordering work was carried out by architect FS Waller and Son in the early 1880's. The galleries were removed as they are reported to have been considered unsafe. The box pews and the stone floors were also removed. The floor was replaced with a new concrete floor that was finished using plain clay tiles. The chancel was also raised by two steps.

The PCC have provided notes from a review of the Specification for these works, which were dated January 1881. Of note, they show the following points which are relevant to the proposed scheme now being developed:

- The floor levels were to remain as existing, except for the chancel. (See comment below).
- Human remains disturbed by the laying of the new floors and foundations were to be removed. Where open graves were found, once the bodies were removed, the voids were to be filled with "soil and well rammed".
- The stonework to the interior of the church was to be repaired and reinstated, as necessary.
- Excavations required to remove foundations etc. were to be backfilled and rammed, although there are no notes provided as to whether the material used had to be of a certain quality.
- The new concrete floor was to be 6 inches thick (150mm). This was to be formed using one part of fresh lime to six parts of stone and gravel.
- The tile paving was to be laid on a screed of cement on the concrete slab.

The Statement of Significant highlights a design change was initiated during these re-ordering works such that the floor levels were lowered, rather than retained as existing.

Image 3.11: *Victorian tiled floor to the nave*

Image 3.12: *Victorian tiled floor - rear of the nave*

4.0 Later Surveys and Investigations

Two surveys and investigation reports into the existing floor of the nave and side aisles were initiated and instructed by the PCC prior to the Stage 3 design commencing. These reports have been reviewed. The key points from these reports that raise structural engineering implications for the emerging design are highlighted briefly in this section.

4.1 Ground Penetration Radar Survey Report

Report reference: A Report on a Ground Penetrating Radar Survey for St Lawrence Church PCC by Archaeological Surveys Ltd. dated September 2018, ref J760.

This survey has highlighted there appear to be several unmarked graves or vaults. Some of these features may occur below the floor within the north and south aisles where the new gallery is proposed. The report indicates there could be subsurface disturbance to a depth of 1.5m.

4.2 Archaeological Watching Brief Report

Report reference: An Archaeological Watching Brief Report for St Lawrence Church PCC by Urban Archaeology dated 29 February 2020, ref UA201_WB_v2.

This archaeological watching brief report discusses the excavation of six test pits adjacent to three ledgers set in the floor of the church aisles. The test pits were numbered 1 to 6.

Test pits 1 and 6 were located at the western end of the north aisle, and revealed:

- Part of the base of the stone pillar was noted between 150mm and 300mm below the floor level of the nave. The base is shown projecting slightly from the face of the pillar.
- The concrete slab was recorded to be between 140 and 150mm thick.
- Below the concrete slab, the material was described as “loosely compacted yellow-orange dirty sandy gravel”.

Test pits 2, 3, 4, and 5 were located at the eastern end of the north and south aisles by the junctions with the adjacent chantries and revealed:

- The concrete slab was recorded to be between 100 and 110mm thick.
- Below the concrete slab, the material was described as “loosely compacted yellow-orange dirty sandy gravel”.
- Part of the base of the stone pillar was exposed and is shown slightly projecting out slightly from the face of the pillar.

5.0 The Proposals

The proposed restoration and reordering works include the following works that have structural engineering implications:

- The provision of a new gallery at the western end of the church similar to that in place prior to 1881.
- The provision of a new kitchen in the southwest corner and two toilets in the northwest corner of the church below the new gallery.
- The construction of a new raised limestone floor, incorporating underfloor heating, within the nave and the two side aisles so that the floor levels match that of the chancel.
- Reordering the vestry for shared use as an office and incorporating new rooflights into the space.
- New services and associated plant to serve the church.

The structural engineering aspects that need to be considered as part of these works are set out below:

- The new gallery structure.
- A review of the structural implications of laying the new raised floor on the suspended floor over the basement boiler room.
- Structural alterations to accommodate the new rooflights within the vestry roof.
- A review of the structural implications of integrating new mechanical and electrical services and plant into the building structure.

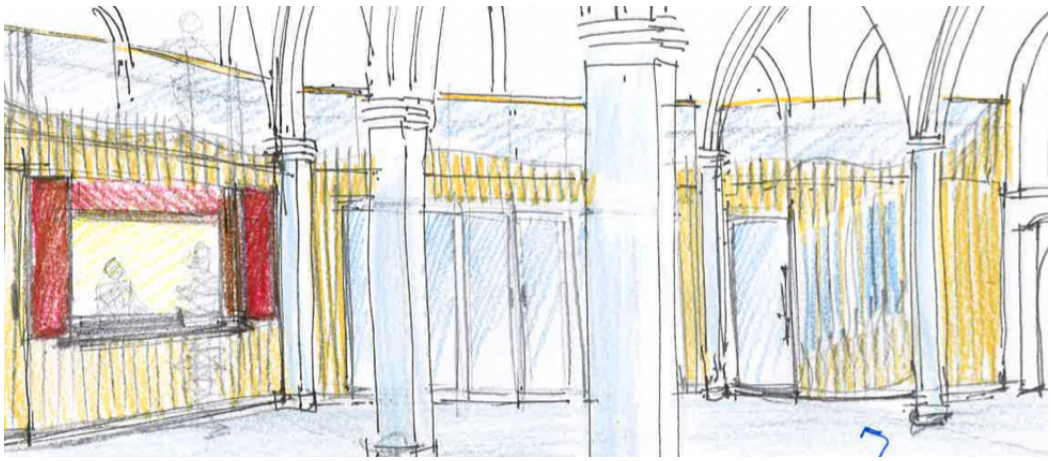


Image 5.1:

Proposed internal view of gallery and new ground floor facilities (part copy of Chedburn Codd sketch reference 1922-SKG-1 dated 22 September 2022.

6.0 Proposed Strategy for the Structural Engineering Works

6.1 A Conservation Engineering Approach

St Lawrence Church is listed Grade I. This reflects the exceptional historic and architectural interest of the building. Of all buildings that are listed in England, only 2.5% are listed Grade I – which represents under 10,000 buildings in the country.

Much of the importance of the building lies in its Medieval architecture. Although it was built in more than one phase, these phases were close together to reflect a church that was built within a relatively short period of time in the late 15th and early 16th centuries – providing a very fine example of late-Perpendicular architecture. The listing description focuses mainly on the aesthetics and detailing of the elevations, but other commentors had highlighted the importance of the bosses and corbels within the roofs.

The later reordering works of late-Georgian and mid-Victorian times naturally impacted on the original Medieval construction. The introduction and later removal of galleries may have caused pockets to be formed in the external walls to support the gallery floors, and the columns would probably have been constructed on localised pad footings, disturbing the archaeology below floor level. The floor to the nave and side aisles, formed as a lime concrete slab in the 1880's, caused further archaeological disturbance. It is not a unique structural feature and is considered to be of less architectural and historic importance than the original Medieval fabric.

Overall, the proposed structural works will have a limited impact on the historic fabric of the church. The main area of potential intervention is with the design of the new gallery structure. The integration of new building services into the church is another area of impact.

Given the building appears to be in a reasonable structural condition for its age and type in the areas where works are proposed, it should respond well to the proposed structural works provided they are carried out in a sympathetic manner by a builder experienced in dealing with existing buildings of this nature.

Given the importance of the church, the engineering strategy for the structural design will therefore aim to limit the impact of the structural works on the historic fabric. The existing structure will be retained where possible and new structural elements – whether related to alterations or repairs – will be designed to be compatible with the historic fabric. Where practicable, they will also be designed to be reversible and interpretable for what they are as part of a proposed 21st Century refurbishment. This approach is good in conservation terms, but also provides a sensible and economic engineering approach for the works.

6.2 Building Regulations

In accordance with the Building Regulations, St Lawrence Church will not undergo a material change of use. As such, the Building Regulations do not specify structural engineering requirements that the existing structure needs to comply with under Part A of the Building Regulations.

The approach with the existing structure however will be to appraise it using appropriate assumptions about its strength and condition, and to design any structural repairs that are found to be necessary in a sympathetic manner, in line with the principals set out above. Where necessary the approach

aims to mitigate some of the defects in the existing structure with a view to extending its life expectancy. This is particularly relevant with the suspended floor over the basement boiler room – which is discussed in more detail below.

Where structural alterations and the new gallery are proposed, new structural elements will be designed in accordance with current Eurocodes or British Standards as appropriate.

6.3 The New Gallery Structure

The proposed structural design for the gallery reflects the following aspects:

i. Given the church is Grade I listed, the impact on the original Medieval fabric will be limited. Where alterations are required – such as the formation of pockets into the existing masonry structure, these will be restricted to the more general masonry construction of the walls. The stone dressings and features within the wall and pillar construction have greater importance in defining the architecture and character of the building and will not be disturbed.

ii. The lime concrete floor is Victorian. The works carried out in 1882 replaced an earlier stone floor and disturbed the archaeology below. The Specification for the 1882 works describes how the floor level of the nave and aisles was to remain as it was but included the removal of human remains and old drains and other features, where disturbed. Given the new floor was specified as a 6-inch thick slab and supported a tiled floor finish on a bed of mortar, excavations at the time would have disturbed at least 175mm of the earlier floor construction. The archaeological report on the recent trial holes describes the material beneath the slab as a loose material.

Two issues arise these observations:

- The Victorian floor does not have the same architectural and historic importance as the Medieval fabric of the church.
  and
- The existing concrete floor construction is not considered suitable to form a new foundation for the new gallery structure. It would also create a significant challenge to demonstrate the slab could be used as a foundation under Part A of the Building Regulations.

To comply with the Building Regulations, the new gallery floor needs to be designed to reflect the proposed use. The PCC have confirmed that the gallery will have flexible seating and will support some storage for choir vestments and music. Given flexible seating could create situations where crowd loading could occur, the new gallery floor will be designed as follows:

Table 6.1: New floor loads on gallery (1)

Type of use	Uniform load	Point load
Areas susceptible to overcrowding - places of worship	5.0 kN/m^2	3.6 kN

Reference (1): BS 6399-1 1996: Code of Practice for dead and imposed loads

The design therefore naturally lends itself to a timber joisted floor supported on a grillage of steel beams. These beams will be supported off discrete steel posts located within the new partitions at ground floor level and in pockets on the external walls. These pockets will be limited in number but

are necessary to provide overall stability to the gallery structure without it becoming heavy and cumbersome. Stability of the gallery also relies on ply sheeting being fixed to the floor joists to provide diaphragm plate action.

Given the curved profile of the front edge of the gallery, this can be awkward to form using straight sections of beam and joist. The design currently shows a greater concentration of steel beams running through to the curved edge of the gallery than is strictly necessary to support the design loads but are anticipated from a buildability point of view. This aspect will be reviewed in more detail as part of the Stage 4 design.

The pockets in the existing walls will involve the localised removal of the inner skin of stonework, without disturbing the rubble core in the centre of the wall. Investigations are required to assess the condition of the inner skin of stonework to establish whether the new beams can be supported directly off the stonework or whether a local padstone is required. These investigations are discussed further in section 6.8 below.

The new columns will require new localised foundations to support them. Provided the natural ground conditions are reasonable and not too deep below the floor level of the church, these are expected to be mass concrete pad foundations.

The aim will be to keep these separated from the existing historic fabric. However, where the architecture requires columns to be positioned close to existing stone pillars, the new footings will probably clash with the existing foundations below ground level. In this instance, and provided the ground conditions are good, the design can probably explore an approach which forms the new footing against the existing stone corbelled foundation, possibly with stainless steel dowel rods tying the two foundations together. However, if the ground conditions are more susceptible to settlement occurring, this approach is not recommended as it could trigger settlements within the historic church fabric.

A geotechnical site investigation is required to inform the design – both to allow the new foundations to be designed and to inform how the columns adjacent to the stone pillars are placed. It is therefore recommended these column positions are kept under review, and they may need to be moved as the design develops. These investigations are discussed in section 6.8 below.

6.4 The new raised floor across the nave and side aisles

The new raised floor will extend across the nave and both side aisles, and will raise the floor level by roughly 250mm, to match the floor level of the chancel.

The build-up of the new floor will consist of a new limestone floor finish on a bedding, over underfloor heating and rigid insulation. This will be laid on a levelling screed over the existing tiled floor finish, with a separating membrane to protect the tiles from future damage if the new raised floor was to be removed in the future.

This new raised floor will apply an imposed load of roughly 2.5kN/m^2 to the existing floor.

Across much of the existing floor, this new load will be transferred into the ground via the existing late-19th century lime concrete slab. The archaeological watching brief report suggests the thickness of this slab is variable and sits on a “loosely compacted yellow-orange dirty sandy gravel”. This description is not consistent with the 1881 Specification and suggests the workmanship associated with the construction of the lime concrete floor was not of the standard required. The floor however has since been used continuously as a place of worship, which should have helped consolidate the

sandy gravel sub-base to some degree. The description in the archaeological report that it remains a "loosely compacted" material however does suggest the slab is potentially vulnerable to settling under concentrated loads.

Whilst this is a non-structural issue, new limestone floors often require a very stiff substrate to support them. If they are laid on floors which then deflect, this can cause the joints between the limestone pavers to open-up slightly. If thin pavers are used, it can also cause pavers to fracture. It is recommended the limestone floor supplier is made aware of the existing floor build-ups so they can advise whether additional measures should be implemented – such as introducing some reinforcement into the new raised floor.

6.5 The suspended floor over the basement boiler room

Viewed from below, the floor over the narrow basement is formed of stone pavers that span across the space on to the brick walls. There are metal – probably wrought iron or steel – plates sitting below which appear to have been added to provide the pavers with additional support. The overall thickness of this floor is about 120mm according to the measured survey. The existing details are shown on drawing 0117/20.

In many cases there is a gap between the metal plate and the underside of the stone pavers. The metal plates also exhibit surface corrosion. In one corner, the brickwork off which the metal straps are supported forms a brick corbel – which is not considered very robust. There could be other defects with the floor which are not obvious. This could be assessed in more detail by lifting the tiled floor finishes to expose the pavers from above.

The existing floor finishes above are showing no obvious signs of distress. This suggests the stone pavers are performing adequately to support the use of the floor above. This however has probably been restricted to people walking about or sitting on pews – which generate relatively limited imposed loads. The existing floor is unlikely to be able to support heavy concentrated loads – such as those set out in table 6.1 above.

Image 6.2

Image 6.3

If a new raised floor was not to be introduced, simple repair measures could be carried out by introducing a mortar bedding to fill the gaps between the pavers and metal plates, plus cleaning and protecting the metal plates with a corrosion protection paint. This is shown as option 1 on drawing 0117/20. Such an approach would still mean the floor has a restricted use - similar to how it has been used before - but the measures would improve the overall robustness of the floor.

As noted in section 6.3 above, introducing a new raised floor will apply an additional uniform load of about 2.5kN/m^2 to the stone paved floor. To justify whether the stone pavers could support the additional loads would probably require material testing and the lifting of the tiled floor to allow the stone pavers to be thoroughly inspected. This is both disruptive and costly.

One alternative approach would therefore be to introduce new steel plates on top of the existing floor – which are designed to carry the weight of the new raised floor. This is shown as option 2 on drawing 0117/20. This strategy is consistent with a conservation-based approach of giving the existing historic fabric a "helping hand" and would be combined with the repairs required in option 1. Given there would still be question marks over the condition of the stone pavers, and how they are supported, there would remain a very slight risk that the new stone floor could deflect above the basement boiler room with this approach.

An alternative – but similar - approach would be to introduce a reinforced concrete slab over the tiled floor finish. This however does not remove the risks noted above with the steel plate approach. In addition, such a slab would prevent the underfloor heating being placed where the slab is located – creating a 'cold spot'. Removing such a slab at a later date would also be far more awkward than a steel plate approach and could potentially cause damage to the historic fabric.

To remove these risks and provide a floor that can support imposed loads consistent with contemporary codes of practice (as table 6.1) would require the stone pavers to be replaced by a new permanent reinforced concrete floor slab. This would need to sit at the same level as the existing lime concrete floor slab and is shown as option 3 on drawing 0117/20.

6.6 New rooflights within vestry roof

Given the vestry appears to date from the early-16th century, the roof structure is expected to be formed using hardwood timber joists of a generous size at regular centres spanning between the north elevation and the north wall of the chancel / sanctuary.

Two rooflights are proposed. Structurally, it is recommended the width of these new openings is defined by the spacing of the timber joists so that the disruption to the existing historic fabric is restricted. Based on assumptions about the size and spacing of the joists, one strategy is shown on drawing 0117/30. This shows – for each opening – one joist is trimmed and re-supported off the roof joists either side. If two or more joists need to be trimmed, there may be a requirement to strengthen the joists that support the trimmers.

Investigations are required to confirm the arrangement and sizes of the roof structure. It is recommended this is done by removing the timber panelled ceiling entirely within the vestry. This will limit any damage to the ceiling fabric and enable the proposed sizes and locations of the rooflights to be confirmed. Such an approach would allow the rooflights to be procured in a timely fashion. These investigations are discussed in section 6.8 below.

6.7 Integration of new services into the structure

In summary, the proposed building services will impact the existing structure as follows:

- New services need to penetrate the existing elevations.
- A new internal manhole is proposed.
- A new buffer tank needs to be introduced into the basement boiler room.

The new services that will penetrate the elevations include an underground drainage pipe and mechanical extract on the west wall of the North Aisle, together with a soil vent pipe and mechanical extract on the southwest corner of the South Aisle. Given the thickness and anticipated construction of the elevations, it is proposed these penetrations are formed using core-drilling holes through the elevations and sleeving them with stainless steel hollow sections grouted in position. This will maintain the structural integrity of the structure throughout its depth, and stainless steel will prevent corrosion being an issue, thus protecting the historic stonework in future. The core-drilled holes ideally should be formed perpendicular to the face of the wall to aide buildability and to limit the extent of the historic fabric that is damaged by the works.

The new internal manhole will be positioned in the North Aisle adjacent to the west elevation. If the foundations to the elevation are shallow, there is a possibility that the construction of the new manhole could undermine the foundations of the elevation. To manage this risk, the manhole has been orientated such that its short side is positioned against the elevation and below a window opening where the magnitude of loads within the wall are likely to be less. As such, if the footing is at a shallower depth than the excavation for the manhole, the length of the elevation undermined in the temporary condition should be kept short and so will not be of structural significance.

A new access opening is required to allow the buffer tank to be accommodated within the basement boiler room. Discussions within the design team concluded this should be a permanent opening to aide future maintenance and to assist with the removal of the buffer tank if it needs to be replaced in future. From a health and safety perspective, the new opening should also be placed directly above the location where the buffer tank will sit, to limit the need for having to manoeuvre the tank by hand. As the tank is to be located within the area of the basement boiler room that sits outside the footprint of the church, it is proposed this opening is formed as an access hatch within a new reinforced concrete slab. This proposal is shown on drawing 0117/21 in appendix B. It is recognised this solution is disruptive to the historic fabric and a further review of the options can be explored during the Stage 4 design stage.

In addition to these issues, the potential for introducing PV (photovoltaic) panels on the roofs of the nave and chancel have been explored. From a structural engineering perspective, the weight of the panels and their fixings (assuming a non-ballasted system) could add between 10-15% to the dead weight of the roof structures in these areas. This is not insignificant. In order to assess the structural implications more fully and advise whether the existing roofs can support this increase in load would require a structural appraisal of the affected roofs to be carried out. This appraisal would require high level access to be provided so that the roofs can be inspected more closely and would probably require sections of the roof to be opened-up and investigated.

6.8 Summary of Investigations to inform the Stage 4 Structural Engineering Design

<u>For the new gallery design:</u>

1. A geotechnical site investigation is required to confirm the depth of the existing foundations to the stone pillars along the arcade, the depth of the natural ground conditions, and geotechnical parameters on the natural ground to inform a foundation design. This work will consist of three trial pits: two to be placed against each of the stone pillars by the front of the gallery and a third to be placed where the new manhole is to be positioned by the west elevation of the north aisle. Allowance should be made for each trial pit to be roughly 900mm square and up to 1.0m deep. These works need to be carried out by a geotechnical

specialist so that an interpretative ground investigation can be prepared. This work may also require an archaeological watching brief during the excavations.

2. The internal face of the elevations needs to be investigated to establish the detailing required to support new steel beams off them at the new gallery level. Three locations should be investigated – one in each corner of the north and south aisles, and a third on the diagonal wall line on the eastern side of the tower. All three locations should be in positions where beams are proposed to be supported. In each instance the render / plaster should be removed from a small area (say 600mm square) to reveal the stone face of the wall. A small diameter core-drilled hole is then proposed in each location to establish the quality and depth of the stone inner face. Material testing of the stone is not anticipated at this stage, but this will be reviewed once the investigations have progressed.

<u>For the alterations to the vestry roof to accommodate new roof lights:</u>

1. It is proposed that the timber panelling across the vestry is removed to expose the roof structure above. Whilst local removal of panelling could be carried out, such an approach is more likely to damage the existing panelling and could leave some question marks over the arrangement and condition of certain structural elements and how the roof lights are positioned and sized. This work could be delayed until a builder is ready to commence work as it is appreciated it is disruptive to the use of the vestry.

At the commencement of Stage 4, these works will be identified on engineering drawings together with a specification. This can then be priced, and the works procured. Separate costs need to be budgeted for the geotechnical specialist, archaeological watching brief, and a builder to do the other investigations and provide high level access.

Appendix A: Listing Building Description from Historic England Website

Official list entry	Heritage Category:	Listed Building
	Grade:	I
	List Entry Number:	1155874
	Date first listed:	26-Nov-1958
	Statutory Address:	CHURCH OF ST LAWRENCE, MARKET PLACE
Location	Statutory Address:	CHURCH OF ST LAWRENCE, MARKET PLACE
	The building or site itself may lie within the boundary of more than one authority.	
	County:	Gloucestershire
	District:	Cotswold (District Authority)
	Parish	Lechlade
	National Grid Ref:	SU 21494 99503

Details

SU 2199 LECHLADE MARKET PLACE (east side)

10/180 Church of St. Lawrence 26.11.58

GV I Anglican parish church. C13 foundation, completely rebuilt mid/late C15, with clerestorey and north porch of early C16, restored 1882 by Waller. Coursed and dressed Taynton stone, roofs not visible. West tower with spire, nave with clerestorey and 4- bay aisles, north porch, north and south chancel chapels of one bay at end of aisles, chancel with north vestry. Tower of 3 stages with offsets, large stepped diagonal buttresses with angle pinnacles, embattled parapet, 8-sided spire with roll mouldings at edges and gilt weathervane. Top stage has 2-light belfry openings with continuous hood and dripmould and stringcourse over with carved heads. Clockface to west with 3-light Perpendicular window below with angel and shield at top of hoodmould over arched splayed doorway with roll mouldings. Embattled nave parapet with straight headed 4-light cusped clerestorey windows and sanctus bellcote to east gable. Aisles and chancel chapels have plain parapets and 3- light windows with 2 vertical drops over. North porch has embattled parapet with pinnacles and carved figures along base, square-headed doorway with carved stops, flat stone ceiling with star rib pattern. South doorway in similar style with square hoodmould with carved square stops and foliage spandrels. Chancel has pierced quatrefoil parapet in 2 rows set in lozenges and circles, and 5-light east window in 2 tiers with flattened cusped ogees with mouchettes to each light, in overall flattened arch shape. Single storey north vestry has similar pierced parapet to east. Interior: Nave rafter roof of early C16 on central ridge, of 4 bays with braced cross beams carried on wooden shafts to base of clerestorey windows. Five-bay arcade including chancel chapels with piers of 4 shafts and diagonally set square capitals. Chancel roof similar structure to nave, in 3 main bays each sub-divided into 3 with gilded and painted bosses in easternmost bay, Vestry door on north side is original with carved decoration. Piscina and credence shelf in south east corner, rest of wall panelled in style of reredos of 1897. C15 octagonal font at west end with canopied niche over in pier of arcade. Several fine medieval brasses at east end and also marble monuments including one by Nicholas Read to Mrs Anne Simmons (died 1769) on south side of chancel. (David Verey, Buildings of England - Gloucestershire: the Cotswolds, 1979.)

Listing NGR: SU2149399507

Appendix B: Sketches showing structural engineering strategy

0117 / 10	New Gallery Proposed Ground Floor plan
0117 / 11	New Gallery Proposed First Floor plan
0117 / 20	Basement Ceiling Repairs Options
0117 / 21	Basement Access Hatch Proposals
0117 / 30	Vestry Roof Proposals

COLUMNS C1 TO C7 SUPPORT GALLERY STRUCTURE OVER. PLACED TO FIT WITHIN WALLS BELOW GALLERY. ALLOW FOR COLUMNS TO BE 100 x 100 x 8 STEEL HOLLOW SECTIONS (M.S. SHS), WITH 300 x 300 x 12 M.S. BASE PLATES, AND HOLDING DOWN ANCHORS.

NEW STEEL COLUMNS TO BE SUPPORTED OFF CONCRETE PAD FOOTINGS BEARING ON TO NATURAL GROUND. TRIAL PIT INVESTIGATION REQUIRED TO CONFIRM DEPTH OF NATURAL GROUND AND ALLOWABLE BEARING PRESSURE. PROVISIONALLY ALLOW FOR FOOTINGS TO BE 750mm SQ, 1.0m DEEP, WITH SOME VARIATION REQUIRED ADJACENT TO EXISTING STONE PILLARS.

APPROXIMATE LINE OF IRON GRILL IN EXISTING FLOOR.

C1 C2 C3 C4 C5 C6 C7

REFER TO DRAWING 0117/20 FOR OPTIONS TO REPAIR FLOOR OVER BASEMENT.

REFER TO DRAWING 0117/21 FOR ACCESS HATCH PROPOSALS IN THIS AREA.

This drawing is to be read in conjunction with all relevant architect's and engineer's drawings and the specification.

Refer to Engineering Schedule of Structural Elements for sizes of structural elements.

Rev	Date	Amendment
	14.10.22	ISSUED FOR STAGE 3

Project:	St Lawrence Lechlade – Project Inspire		Andrew Turner Engineering
Drawing:	New Gallery – Proposed Ground Floor Plan	Date:	September 2022
Sketch No:	0117 / 10 Rev:	Scale:	~1:50 at A3 Size

KEY

——— DENOTES STEEL BEAM. ALLOW FOR BEAMS TO BE 203mm DEEP - FORMED USING 'UC', 'UB' or 'PFC' SECTION SIZES. ALLOW 30kg/m AVERAGE.

PRIMARY / SECONDARY — DENOTES FULLY FABRICATED CONNECTION OF SECONDARY TO PRIMARY BEAMS, TO ALLOW SECONDARY TO CANTILEVER.

— — — DENOTES COLUMN UNDER.

EXISTING BEAMED TIMBER FLOOR TO BELL RINGING CHAMBER.

CHANNEL (PFC) SECTION COACH-SCREWED TO EXISTING TIMBER BEAM

STEEL BEAM AND COLUMNS ON EDGE OF GALLERY TO HAVE MOMENT CONNECTIONS AT COLUMN HEADS TO PROVIDE SWAY ACTION FOR OVERALL STABILITY

STEEL BEAM TO BE CRANKED TO SUIT PROFILE OF STAIRCASE

STEEL BEAMS SUPPORTED OFF INTERNAL STONE FACE OF EXTERNAL WALLS. EXISTING STONEWORK TO BE ASSESSED TO ESTABLISH IF NEW PADSTONES ARE NEEDED.

STAIRWELL FOR STAIRCASE - ASSUMED TO BE BY OTHERS.

B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15 B16 B17 B18 B19 B20 B21 B22 B23 B24 B25 B26 B27 B28 B29 B30 B31 B32

T

DETAILING OF HOW BALUSTRADING IS SUPPORTED MAY ALLOW FREQUENCY OF STEEL BEAMS TO BE REDUCED ON CURVED EDGES OF GALLERY.

DENOTES SPAN OF NEW TIMBER JOISTED FLOOR: 47 × 220 DEEP SOFTWOOD JOISTS AT 400c/c WITH BLOCKING, TO BE DECKED WITH 18mm PLY SHEETING FOR DIAPHRAGM ACTION.

BALUSTRADE TO BE DESIGNED FOR POTENTIAL AFFECTS OF CROWD LOADING. DESIGN PROCUREMENT TO BE CONFIRMED.

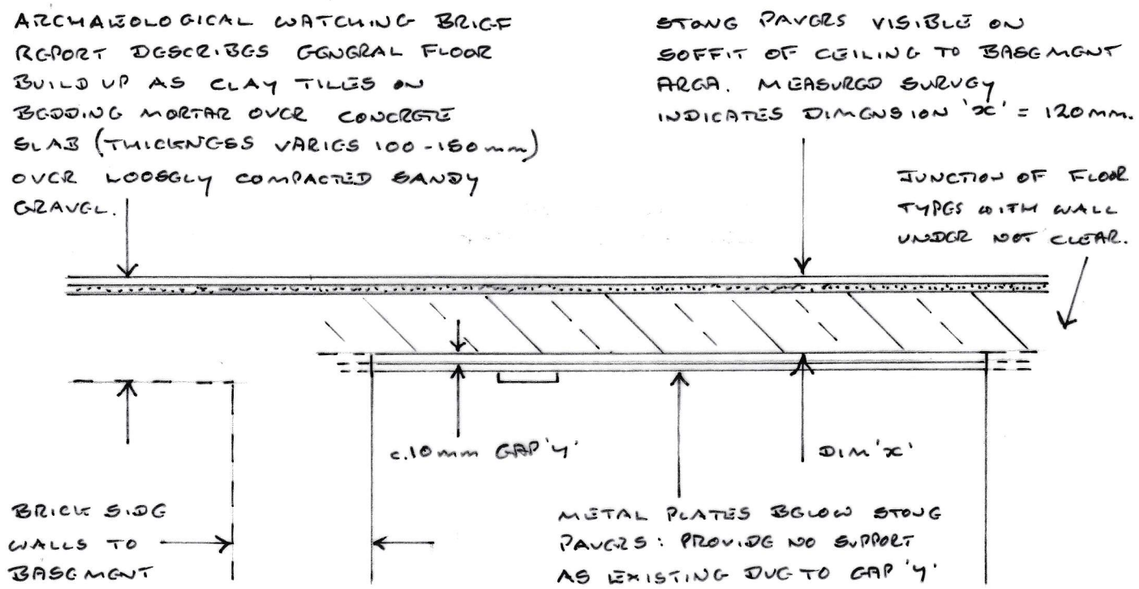
This drawing is to be read in conjunction with all relevant architect's and engineer's drawings and the specification.

Refer to Engineering Schedule of Structural Elements for sizes of structural elements.

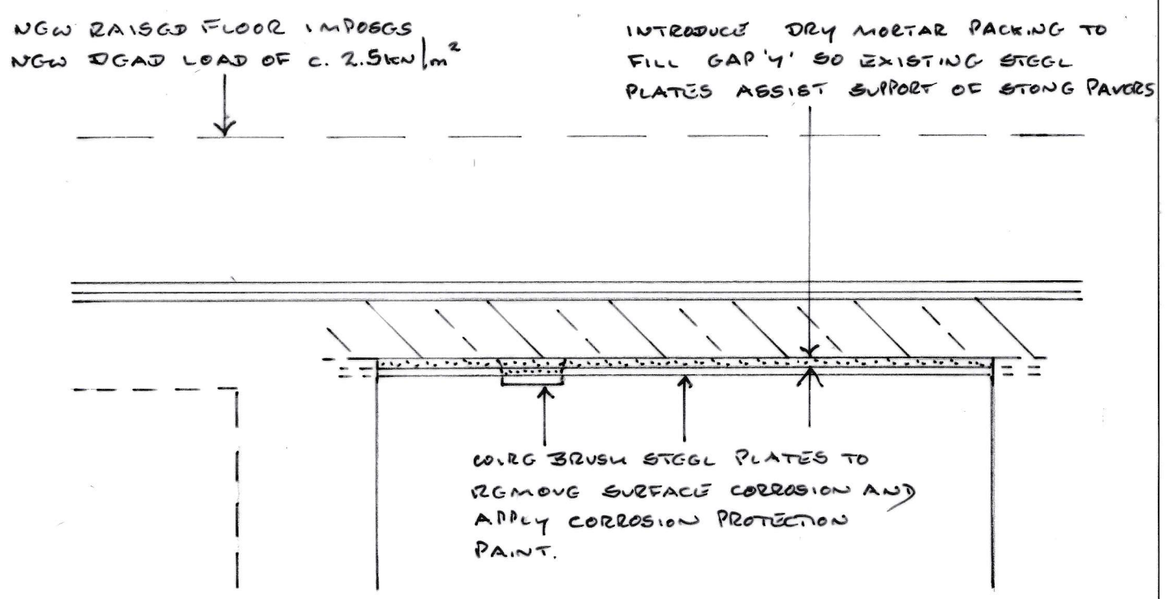
Rev	Date	Amendment
A		STEELWORK WEIGHT ADDED.
	14.10.22	ISSUED FOR STAGE 3.

Project:	St Lawrence Lechlade – Project Inspire
Drawing:	New Gallery – Proposed First Floor Plan
Sketch No:	0117 / 11
Rev:	A
Date:	September 2022
Scale:	~1:50 at A3 Size

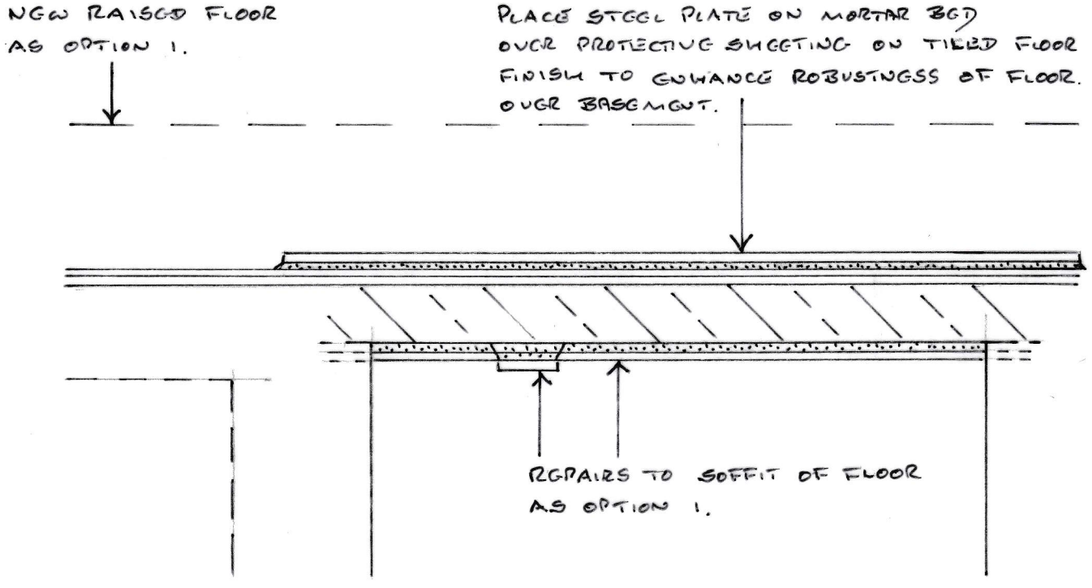
Andrew Turner Engineering



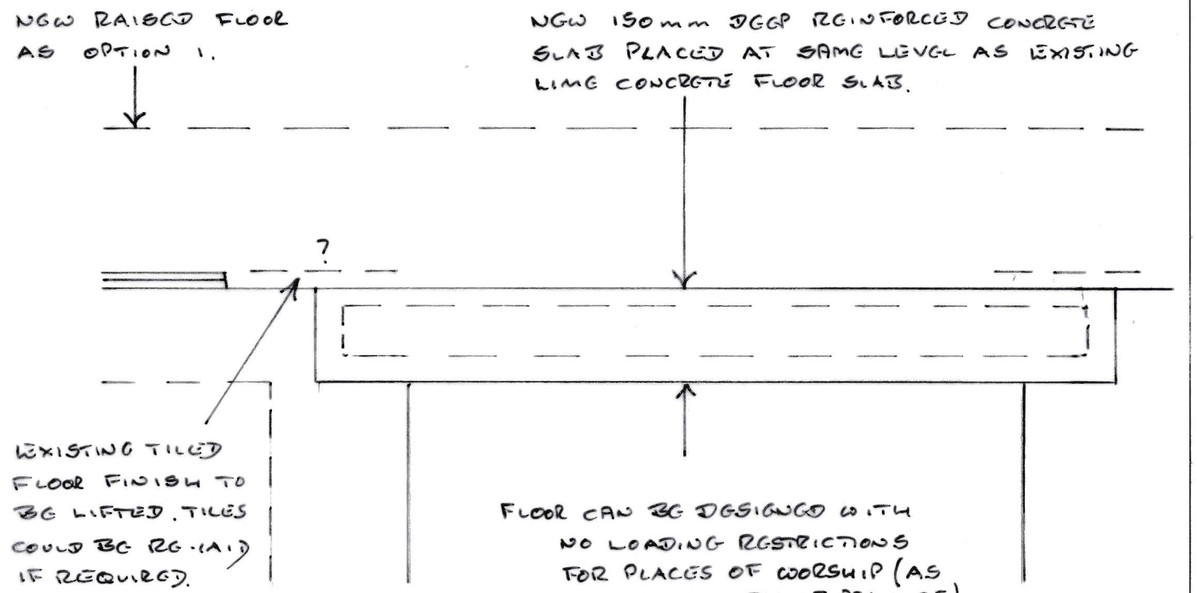
EXISTING FLOOR DETAIL OVER BASEMENT



REPAIR OPTION 1: REPAIR EXISTING FLOOR



REPAIR OPTION 2: REINFORCE WITH STEEL PLATE



REPAIR OPTION 3: REPLACE WITH CONCRETE SLAB

This drawing is to be read in conjunction with all relevant architect's and engineer's drawings and the specification.

Refer to Engineering Schedule of Structural Elements for sizes of structural elements.

REFER TO STAGE 3 ENGINEERING REPORT FOR DISCUSSION ON STRUCTURAL IMPLICATIONS OF EACH OPTION.

Rev	Date	Amendment

Project: St Lawrence Lechlade – Project Inspire

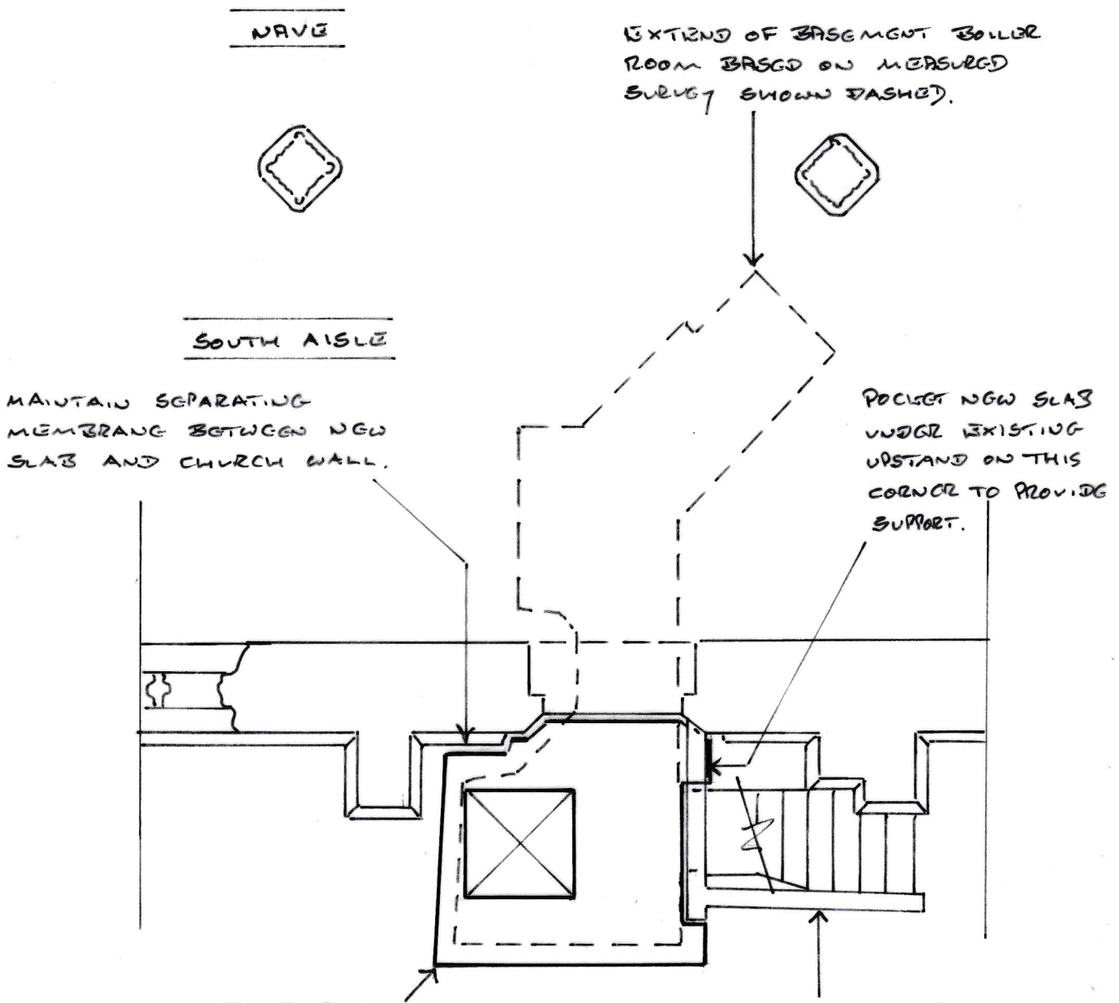
Drawing: Basement Ceiling Repair Options

Sketch No: 0117 / 20 *Rev:*

Andrew Turner Engineering

Date: September 2022

Scale: ~1:10 at A3 Size



PART GROUND FLOOR PLAN.

This drawing is to be read in conjunction with all relevant architect's and engineer's drawings and the specification.

Refer to Engineering Schedule of Structural Elements for sizes of structural elements.

Rev	Date	Amendment

Project: St Lawrence Lechlade – Project Inspire

Drawing: Basement Access Hatch Proposals

Sketch No: 0117 / 21 Rev:

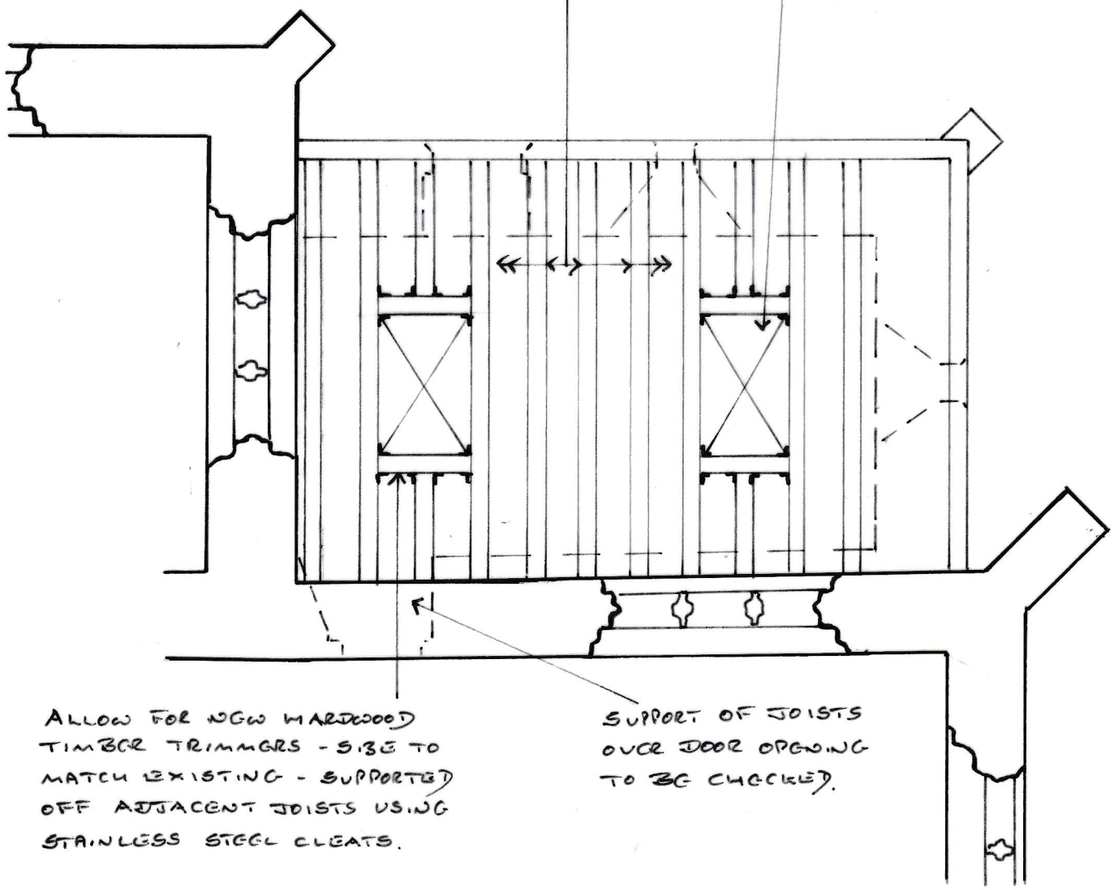
Andrew Turner Engineering

Date: September 2022

Scale: 1:50 (A3 Size)

LAYOUT OF EXISTING ROOF STRUCTURE IS CONJECTURAL AT THIS STAGE AND IS ASSUMED TO CONSIST OF HARDWOOD TIMBER ROOF JOISTS SPANNING NORTH-TO-SOUTH. DESIGN ASSUMES EXISTING JOISTS ARE 125 - 150mm SQ. AT 450 c/c.

NEW ROOFLIGHTS : POSITIONS TO BE DETERMINED TO SUIT LAYOUT OF ROOF JOISTS TO LIMIT IMPACT ON HISTORIC FABRIC.



ALLOW FOR NEW HARDWOOD TIMBER TRIMMERS - SIZE TO MATCH EXISTING - SUPPORTED OFF ADJACENT JOISTS USING STAINLESS STEEL CLEATS.

SUPPORT OF JOISTS OVER DOOR OPENING TO BE CHECKED.

VESTRY ROOF PLAN - AS PROPOSED

EXISTING CEILING TO VESTRY IS TIMBER - PANELLED. TO LIMIT DAMAGE TO PANELLING, IT IS RECOMMENDED THIS IS ENTIRELY REMOVED TO ALLOW ROOF STRUCTURE TO BE INSPECTED. ROOFLIGHT POSITIONS AND SIZES CAN THEN BE CONFIRMED. INVESTIGATIONS TO BE CARRIED OUT DURING STAGE 4 DESIGN.

This drawing is to be read in conjunction with all relevant architect's and engineer's drawings and the specification.

Refer to Engineering Schedule of Structural Elements for sizes of structural elements.

Rev	Date	Amendment

Andrew Turner Engineering

Project:	St Lawrence Lechlade – Project Inspire		
Drawing:	Vestry Roof Proposals	Date:	September 2022
Sketch No:	0117 / 30 Rev:	Scale:	~1:50 at A3 Size

Andrew Turner

Engineering

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