



Booker Hall, Oakhurst Gardens, Littlehampton
Structural Engineer's Feasibility Study

May 2021

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Revision	Status	Date	By	Checked
-	For Information	12/05/21	CS	

1.0 Introduction

1.1 Appointment and brief

EngineersHRW have been appointed by Littlehampton & Rustington Housing Society to provide a preliminary structural engineering appraisal of architectural proposals by Studio Scott Taylor for the site at Oakhurst Gardens, Rustington, Littlehampton. The project comprises the demolition of an existing resident's hall at Rustington Hall Care Home and construction of a replacement facility that will better meet the needs of the residents. Our current appointment covers a desktop study of site conditions and constraints and preliminary advice on the structural design of the scheme to support the planning application.

It is not in our scope as Structural Engineers to make observations on issues relating to:

- MEP services
- Drainage
- Damp
- Deleterious materials such as asbestos that may exist in the existing buildings to be demolished.

Refer to information by other consultants' information and/ or Building Surveyor reports relating to the existing building to be demolished.

1.2 The aims of the report

This report describes the findings of the visual survey and lists defects identified.

The aims of the report are to:

- Comment on structural implications of site conditions and constraints as far as discernible from a desktop survey of available information.
- Identity structural issues that will require further investigation and assessment.

This report is for the sole use of the client and the client's professional advisors. It should not be relied upon by any other party without the written approval of engineersHRW.

The desktop study was carried out by Chris Stobbart CEng MStructE on behalf of engineersHRW in May 2021. It was outside of our preliminary scope to carry out a site visit, or to arrange for any structural investigations to be carried out in time to inform this report.

Architectural proposals considered are those described on the preliminary drawings produced by Studio Scott Taylor dated March 2021. It is proposed to build a tall dual-pitched roof, single-storey, hall with associated utilities over two storeys in one volume, and a smaller connected annex with office and ancillary accommodation on two-storeys as a second volume.

2.0 Site Information

2.1 Ground Conditions

2.1.1 Site Geology Description from Desktop Study

We have received a copy of the Factual Site Investigation Report (April 2021), by Constructive Evaluation Ltd. (CEL) describing findings from geotechnical site investigation works at Oakhurst Gardens, Rustington. The purpose of the investigation was to provide winter groundwater monitoring data. Due to the timing of the site works, a further round of monitoring will be required in winter 2021. No geotechnical testing was carried out to confirm structural design parameters of the soil underlying the site, but the windowless sample boreholes carried out to provide groundwater monitoring points provide some information.

The CEL borehole WLS2 is within 'development area 2', which includes the existing resident's hall. The borehole log in this location (refer to Appendix A.1) shows only 200mm of top soil over firm, sandy, gravelly clay to 2.4m below existing ground level (bgl), gravelly sand to 3.55m bgl, soft becoming firm slightly sandy clay to 5m bgl and gravelly sand to 6m where the borehole was terminated. No evidence of ground contamination was observed during the site investigation and ground water was found between 4.55-5.55m bgl. The findings were similar in the other two samples taken across the wider site, although depths and layering vary.

This samples can be compared to the available geological maps and borehole logs available on the British Geological Survey (BGS) online viewer. The maps show the site to be located within the New Pit Chalk formation, of chalk bedrock with flint and marl seams. Overlying superficial deposits for the area are recorded as River Terrace Deposits which comprise sands and gravels with local lenses of clay, silt or peat.

Borehole logs show sands and gravels to 7m bgl, where groundwater is found sitting above marl/ clay which is only a few metres deep over the chalk bedrock.

2.1.2 Recommended Geotechnical Site Investigation Post-Planning

Based on the above findings it is considered feasible for the new 1-2 storey structures to be founded on conventional mass concrete shallow strip or pad footings. However, it is recommended that a full geotechnical site investigation is carried out to confirm suitable foundation design parameters to enable foundations to be sized and a specification to be developed for concrete in the ground.

We have not received any structural details relating to the existing buildings on the site, although they are known to be of a similar scale and footprint to the proposed buildings. From photographs, the existing building appears to consist of an asymmetrical timber roof supported on loadbearing masonry or timber frame walls with external render. We would recommend carrying out trial pits to inspect the existing footings to understand the depth of excavations that will be required, which impacts on the cost of works. Following this we could also review whether it was feasible to re-use existing footings for the new building.

Due to the clay content of the soils encountered, we would recommend that testing is carried out to find the plasticity of the soil to determine the volume change potential. This may impact on required foundation depths to reduce the impact of ground movements due to changing groundwater levels. Soft clay, peat and silt lenses should be removed locally where encountered at formation level.

We would recommend that commentary is provided by the geotechnical engineer with regards to the risk and implications of possible sinkholes occurring in the chalk overlain with granular material. These are known to have occurred locally, and consideration by the geotechnical engineer would be recommended to mitigate potential associated risks.

Site conditions can vary locally and where existing buildings are to be demolished to clear the site, we would expect an increased depth of made ground over the sands, gravels and clay. Related to this and to ensure safe working conditions of site operatives, we recommend that some contamination testing is carried out.

We do not currently have a record of buried services beneath the site. These would typically be included in a geotechnical site investigation report to identify possible hazards and mitigate the risk of undetected obstructions impacting on ground works.

2.1.3 Environmental Exposure and Durability of Proposed Materials

The site is relatively close to the sea, so the structure may need to be designed to resist relatively high wind pressures and external exposed materials specified to allow for corrosion resistance to environmental conditions with a relatively high salinity. External steelwork, or that integrated within the external wall build-up should be considered to be within corrosive category C3 'medium' as defined in BS EN ISO 12944-2. The corrosion class dictates a certain preparation and finish, such as hot-dip galvanising. The required finish of any such elements is determined by consideration of the environmental conditions and design life to first service, which should be agreed with the client before finalising details.

Reinforced concrete elements should be considered within BS EN 206 exposure class XS1, which will need to be considered when finalising the concrete mix specification and depth of cover to reinforcing bars.

Exposed external timber will need to be similarly specified to select suitable species and preservative treatments, and any masonry units and associated mortar considered in the same regard. Input will be required from material suppliers to advise on suitable material specifications.

2.2 Flood Risk

From a preliminary review of information freely available from online resources we can see that the site is in flood zone 1 on the Environment Agency's maps and as such a Flood Risk Assessment should not be required to support the Planning application.

As noted above, a groundwater monitoring regime has been established and further results are awaited following further monitoring of winter groundwater levels.

Engineers HRW are not appointed to advise on below ground drainage, but it is noted from review of the drawings that there is approximately a 30% increase in hard standing proposed in this area of the site and some compensation measures may be required to attenuate surface water run-off.

3.0 Proposed Design

Refer to annotated key plans in the appendix. Preliminary architectural proposals have been reviewed through exchange of drawings and through design meetings with Studio Scott Taylor. Due to the residential setting, to minimise disruption to residents it is proposed to investigate modular/prefabricated solutions that could be installed relatively quickly on site. Substructure works causing significant ground vibration such as driven piles are not thought to be necessary based on current understanding of site ground conditions.

3.1 Main Hall

3.1.1 Architectural Proposal

Preliminary structural appraisal of the main resident's hall has been carried out to test the feasibility of the proposals. The architectural proposal is to provide a tall single-storey and column-free space approximately 9.6x9.6m (to centre of structural elements) on plan, connected to office and ancillary accommodation at ground level on the north and south ends, fully glazed on the east side, with a solid wall against the party wall to the neighbouring garages to the west. The hall sits within a larger building, with supporting facilities to the south including storage, kitchen, bathrooms at ground floor and offices at first floor. This rectangular block has a dual pitched roof. On the south-eastern corner of the building, the main entrance is set-back at ground floor level, so the first floor and roof need to span over.

3.1.2 Preliminary Structural Scheme

It is proposed to design the hall as a load-bearing timber frame structure, with cross laminated timber shear walls and roof deck. The more cellular office and ancillary accommodation could be formed as a frame or load-bearing wall construction. This is discussed in section 3.2. This feasibility study has focussed on the hall structure, due to the preference for a visually expressed structure with no internal columns, or tie elements across the hall.

Due to the length of elements, high visual aspirations and importance of controlling movements in the timber frame, it is initially proposed to build the frame with engineered, glue-laminated timber (glulam). From our review, it may be feasible to build the frame in solid timber although it is noted that larger size solid timber elements are more difficult and expensive to procure, and current market shortages in supply are being experienced on other projects.

The structural proposal for the hall roof is to form a deep truss in the roof plane either side of the ridge. Glulam rafters zig-zag across the length of the hall to provide out-of-plane stiffness and act as the

bracing of the deep truss. Glulam ridge and eaves elements form continuous lines of compression and tension respectively to distribute lateral loads to gable ties and stability walls, as the pitched roof tends towards flattening at the ridge and pushing the eaves in an outward direction. Refer to the plan mark-up in Appendix A.2 (SK02).

3.1.3 Analysis Model

An initial 3D analysis model was assembled to review the proposed roof geometry and assess likely structural element sizes, deflections to be considered and loads to foundations. Refer to the below image from the analysis model showing these key structural elements.

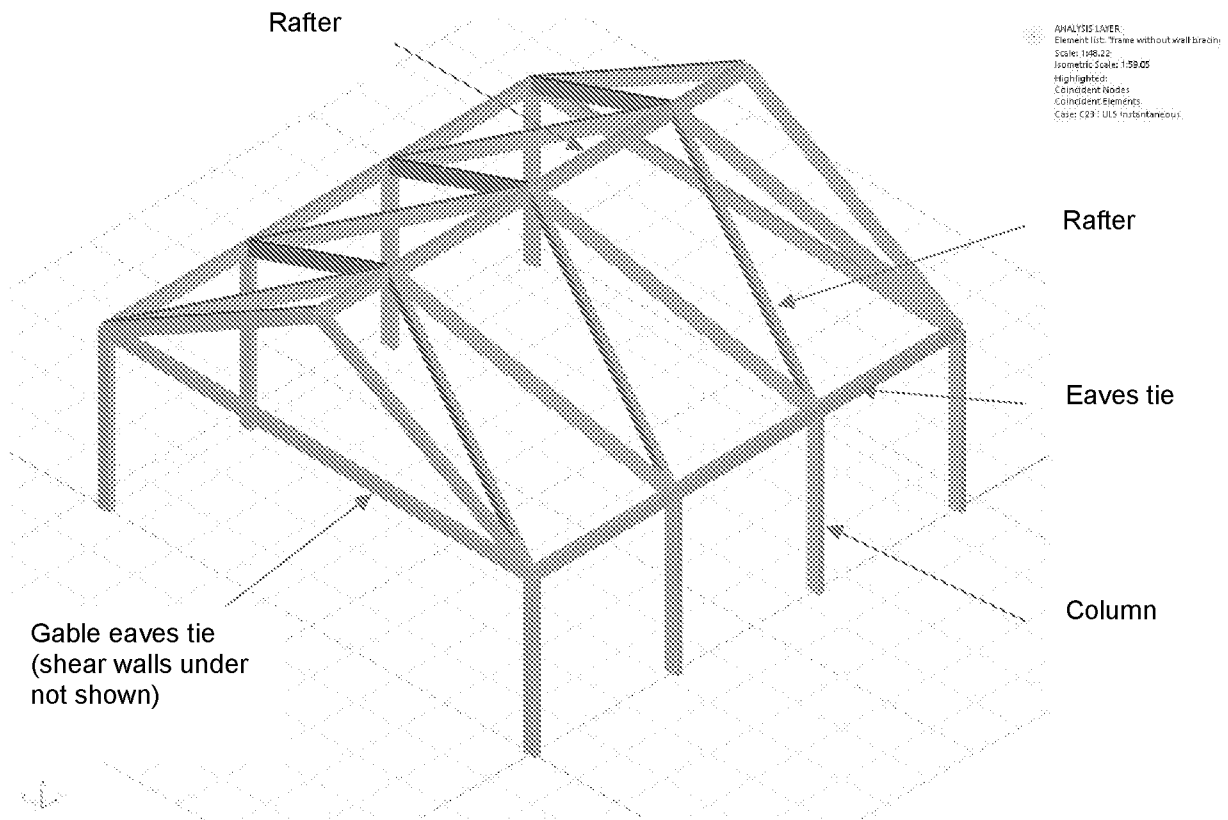


Fig.1 Analysis Model - Primary Elements Only

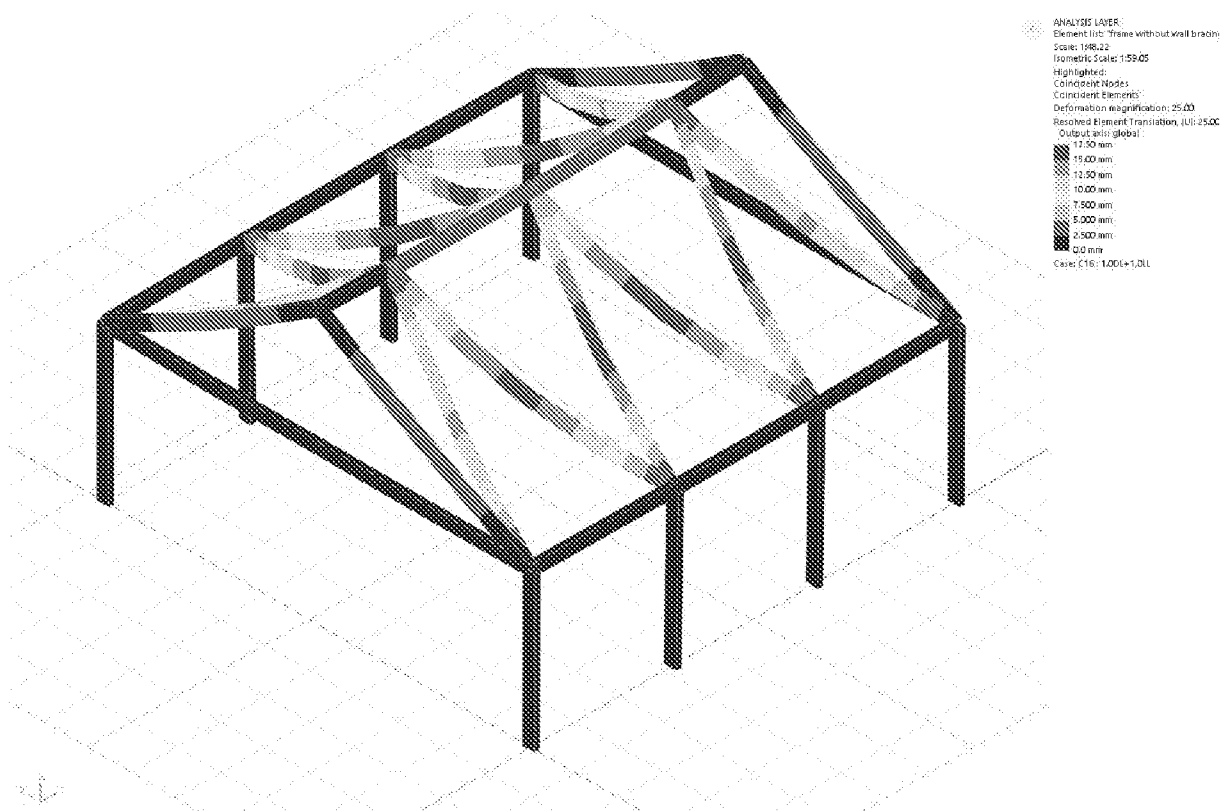


Fig.2 Analysis Model - Deflection Plot

3.1.4 Discussion

The analysis showed that glulam elements of approximately 140mm width by 280mm depth would support the anticipated roof loads with deflections within typical acceptable limits. Due to the extent of rooflights proposed, it may be necessary to increase the depth of elements to further reduce elements, and this should be discussed with a rooflight supplier once loadings are confirmed.

Connections and detailing often govern the sizing of elements. For the basis of this appraisal we have considered bolted connections with steel flitch plates cut into the glulam elements and countersunk bolt heads with timber plugs. Due to the geometry of the frame, consideration will need to be made to the orientation of the glulam rafters (orientated vertically or rotated to the roof pitch) which may require one edge to be tapered to meet the roof deck. The relationship between the column and rafters will also need to be reviewed. For this appraisal, it was assumed that all primary elements are set out so that their centrelines are aligned. This is the most structurally efficient arrangement as it allows elements to be primarily loaded axially, and prevents connections needing to transfer bending moments, which can increase their size. If for construction, or architectural purposes, it is preferred to

have eccentric connection, we will need to review how to best minimise the impact of this eccentricity on connections and putting additional bending into frame elements.

Sizes of glulam elements vary by supplier but typical available sizes for glulam graded at GL24h have been assumed. This would be achievable in European Spruce which is generally the most readily available and cost-effective species, although relatively low durability and only suitable for use internally in a conditioned environment. Alternative species that could be considered European Redwood, Siberian Larch (UK Larch available at lower strength grades), Douglas Fir, Ash, Oak and Sweet Chestnut with varying costs and associated lead-in times. It is advised that this is discussed with possible suppliers at the earliest opportunity post-planning.

Lateral stability to resist wind loads and out-of-balance vertical loads would be resisted by cross laminated timber (CLT) walls. Alternative solutions could be solid timber/ glulam/ steel braced bays, or timber stud walls with plywood racking boards. By review of the architectural layouts there are currently sufficient a sufficient length of shear walls in each direction.

It would be advised to keep all structural timber elements above external ground level, and this is typically achieved with concrete or blockwork upstand and steel baseplates. As noted above, it is assumed that conventional shallow footings would be suitable on the site, although this is subject to confirmation of local ground conditions. Depending on the volume change potential of the ground or any impact from the removal of the existing hall, the ground floor may be formed as a suspended slab over heave protection on strip footings, or if possible as a ground bearing slab on compacted, well graded fill.

The timber frame should only need to be fire-rated if there is no separation to the first-floor office accommodation. Any structure supporting a suspended floor would need to be fire-rated to the required minimum fire period.

For the overhang at the south-eastern corner, it has been discussed that the external structure could comprise a pre-cast concrete frame, or pre-cast concrete beams at first floor level, supported on load-bearing masonry. Pre-cast concrete would better facilitate faster on-site construction.

In terms of site operations, from the available drawings it is assumed that access via Station Road would not obstruct delivery of a crane, or concrete trucks. It also appears that it should be relatively straight forward to install a crane on site to lift large glulam elements and CLT panels. It is noted that the CLT walls may need to be propped in the temporary case until floors and roofs are installed. All timber frames need to be weather protected in the temporary condition until the proposed long-term protection is in place. Advice should be sought regarding any temporary fire protection measures that might be required to control the spread of flame during the construction stage.

3.2 Offices

Three different options have been considered for the two-storey office and ancillary accommodation:

- 1) Cellular arrangement of loadbearing CLT walls at ground and first floor, simply supporting roof

and floor decks in CLT.

- 2) Installation of a ridge beam at roof level, spanning between the end walls and an internal column from roof to ground floor level to support CLT roof deck; transfer beam at first floor level, supported on external walls and the internal column to support CLT floor deck.
- 3) CLT pitched roof with raised steel ties above first floor. Below first floor, the arrangement described in either option 1) or 2) could be adopted.

All of these options are feasible with the complexity of the structural solution increasing (from 1-3) with the degree of flexibility of end use of the space. The thickness of the CLT roof slab would also be expected to increase from options 1-3, although full structural analysis of these different options was not within the scope of this study. Mark-ups prepared for options 2-3 are included in Appendix A.2 to this report (SK01).

As an office, horizontal ties would be incorporated into connections between suspended floors and roof to prevent disproportionate collapse in accordance with the Building Regulations.

Fire protection requirements are to be confirmed, but as a minimum it should be considered that fire protection is required to any structure supporting the first-floor accommodation. In accordance with the Building Regulations Approved Document B, the minimum period of fire resistance for structural elements should be 30 minutes, increasing to 60 minutes for compartment walls. Fire protection to timber walls and floors could be achieved by lining with fire-rated plasterboard, or where exposed, panels would need to be oversized to allow for charring and associated loss of panel section.

4.0 Conclusions and Next Steps

From our review of available site information and the architectural proposals, the proposed buildings could suitably be framed in engineered timber, with several variations available. Conventional mass concrete shallow strip or pad foundations are expected to be suitable. Other more conventional forms of construction could be considered, but a CLT/ glulam solution would be expected to offer a more favourable solution in terms of embodied carbon while also facilitating relatively quick construction on site. The relative light weight of CLT should also permit the use of smaller foundations, requiring less concrete.

To develop the structural scheme, it is advised to carry out further investigations on site:

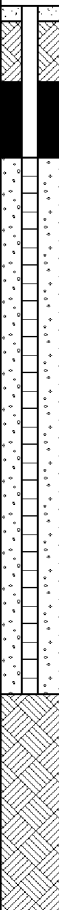
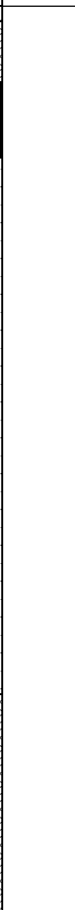
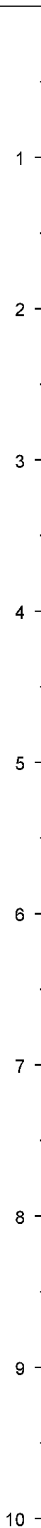
- Below ground services investigation as part of a desktop phase 1 site investigation. The below ground drainage engineer might require a CCTV survey of existing drainage features;
- Trial pits to inspect footings to the existing buildings;
- Further windowless sample boreholes with material testing to confirm allowable bearing pressures for new foundations and required depth, soil plasticity to confirm the volume change potential of soil, chemical testing and contamination testing to inform groundworks and concrete specification;
- Asbestos survey of the buildings to be demolished.

If appointed post-planning, we would provide a specification for site investigation works relating to structural works and attend site as required to view the findings.

The design would then be developed with Studio Scott Taylor and other consultants. As noted above, we would recommend that specialist suppliers for engineered timber are consulted once the scheme is progressed to ensure that a suitable specification and supply can be determined.

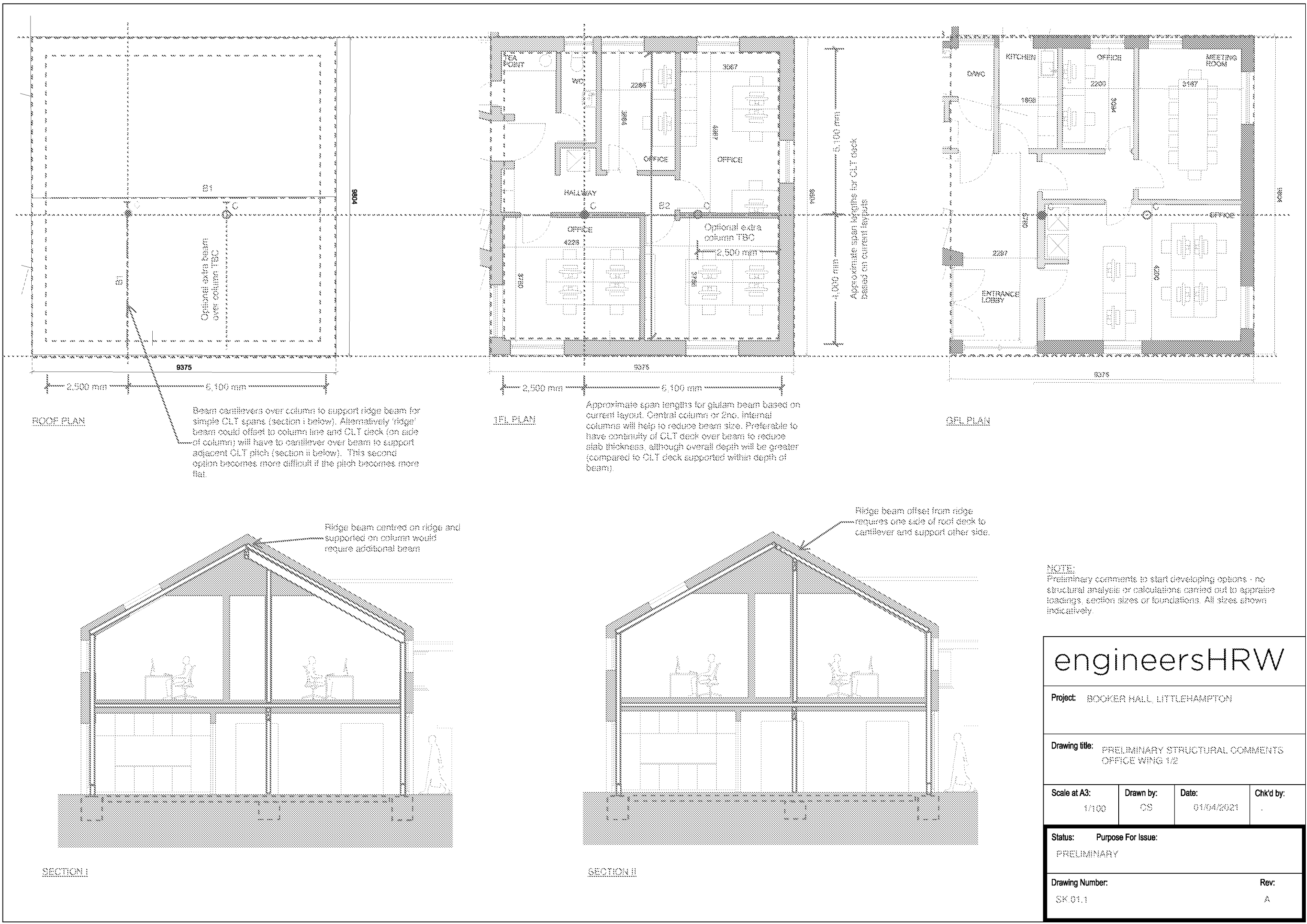
Appendix

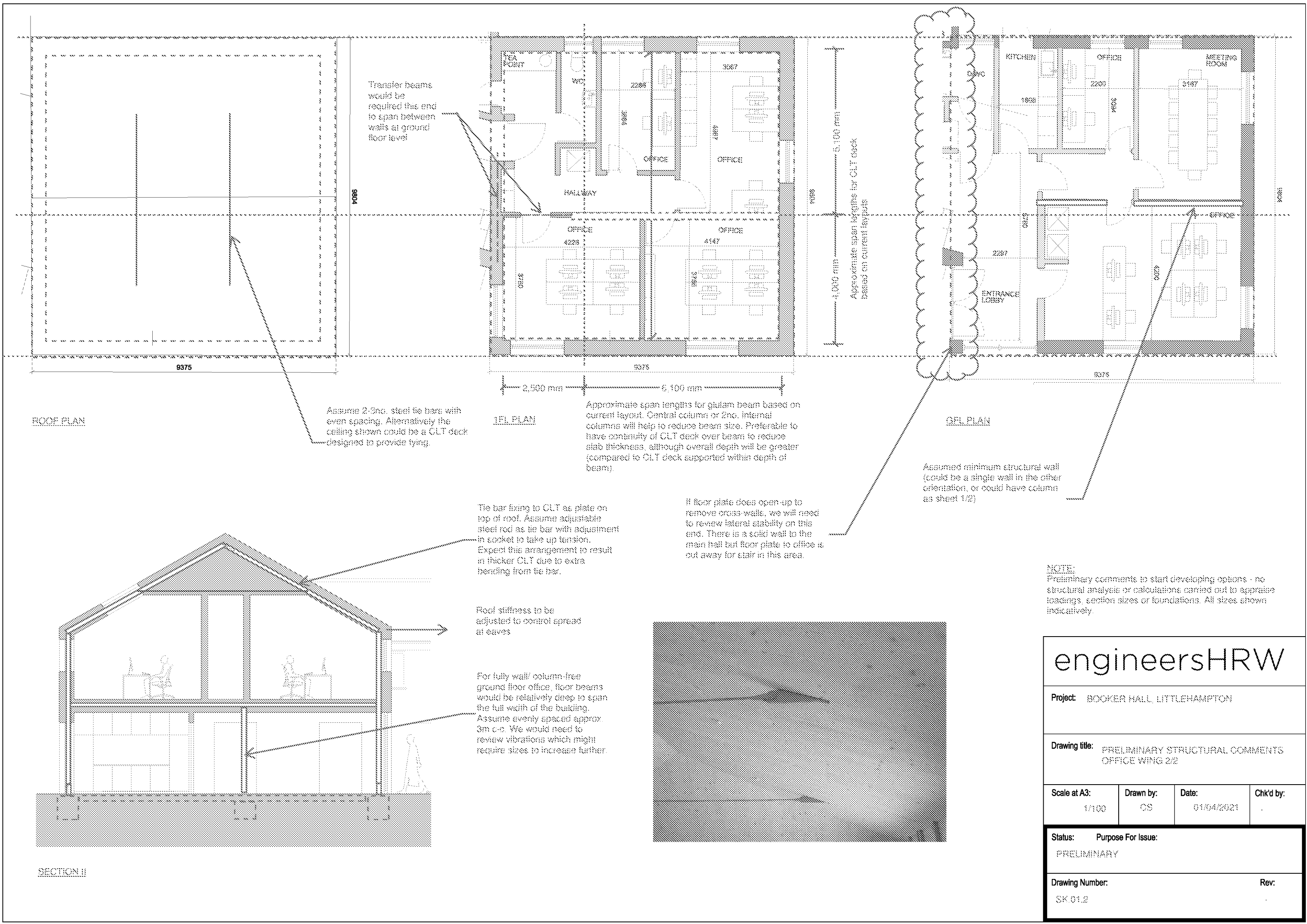
A.1 Sample Borehole Log

 constructiveevaluation site investigation • building pathology				Borehole Log			Borehole No. WLS2 Sheet 1 of 1		
Project Name: Oakhurst Gardens				Project No. 21.1045		Co-ords: 506187E - 102604N		Hole Type WLS	
Location: Rustington				Level:		Scale 1:50			
Client: Studio Scott Taylor				Dates: 26/03/2021		Logged By IB			
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.20		 Grass over soft dark brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is sub-angular to rounded fine to coarse of flint. (TOPSOIL)		
							 Firm orangish brown mottled grey slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is sub-angular to rounded fine and medium of flint.		
					1.90		 Firm grey mottled orangish grey slightly sandy slightly gravelly CLAY.		
					2.10		 Brown clayey sandy GRAVEL. Sand is fine to coarse. Gravel is angular to sub-rounded fine to coarse of flint.		
					2.40		 Brown gravelly SAND. Sand is fine to coarse. Gravel is angular to rounded fine and medium of flint.		
					2.95		 <i>Band of firm grey sandy CLAY. Sand is fine to coarse.</i>		
							 Grey slightly gravelly SAND. Sand is fine to coarse. Gravel is sub-angular to rounded fine and medium of flint.		
					3.55		 Soft becoming firm with depth orangish brown mottled grey slightly sandy CLAY. Sand is fine and medium.		
							 <i>Firm dark grey slightly sandy CLAY. Sand is fine and medium.</i>		
					5.00		 Yellowish brown gravelly SAND. Sand is fine to coarse. Gravel is sub-angular to rounded fine to coarse of flint and occasional weak low density white chalk.		
			6.00		End of Borehole at 6.000m				
Remarks 1. Excavation area scanned using CAT and Genny prior to any excavation, repeated every 300mm in service pit to 1.2mbgl. 2. Borehole installed with 19mm groundwater monitoring standpipe to a depth of 4.55mbgl. 3. Borehole collapsed at the base on installation of monitoring well.									



A.2 Structural Mark-ups



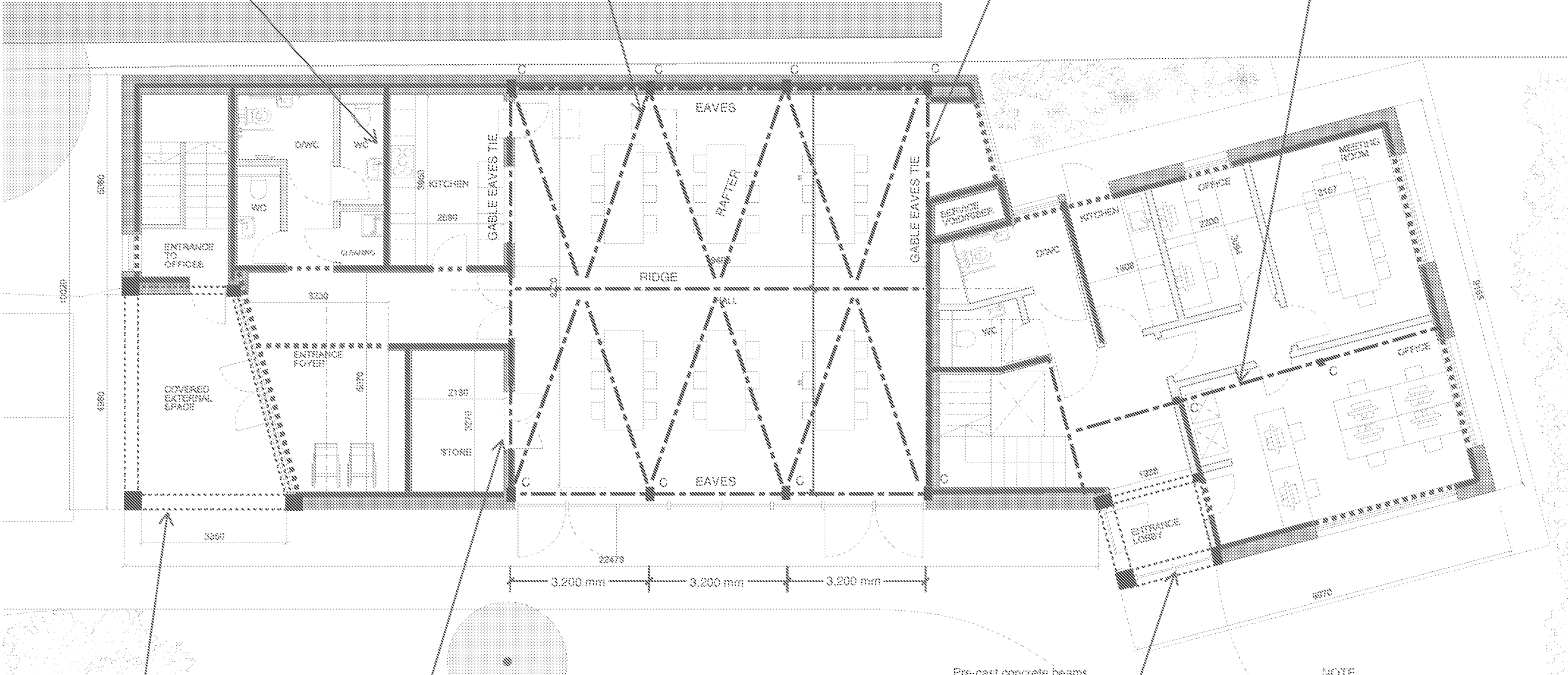


Office variation with cellular CLT wall layout shown this end. Refer to SK01 for further options and roof proposals considered at this stage.

Glulam roof frame elements over all checked as 140 x 280mm GL24h, subject to confirmation of roof loadings and design development. This size applies to rafters, eaves and ridge beams, and columns. It is assumed that all elements are aligned with coincident centrelines.

Eaves ties continuous over recessed bay at ground floor level.

Office variation with internal load-bearing columns and transfer beams supporting the first floor CLT deck. Refer to SK01 for further options and roof proposals considered at this stage.



GROUND FLOOR PLAN
WITH STRUCTURE OVER SHOWN DASHED

Pre-cast concrete beams over supported on pre-cast concrete columns. Thermal breaking details to be developed for support of floor structure over.

Gable level tie beams continuous between corner columns on either end of the hall with shear walls beneath. It would be preferable structurally to move the position of this door to get one longer length of wall along this line.

Pre-cast concrete beams over supported on pre-cast concrete columns. Thermal breaking details to be developed for support of floor structure over.

NOTE:
Refer to Structural Engineer's Feasibility Study report for further description of the proposed structure and options considered.

engineersHRW

Project: BOOKER HALL, LITTLEHAMPTON

Drawing title: PRELIMINARY STRUCTURAL COMMENTS
RESIDENT'S HALL

Scale at A3: 1/100	Drawn by: CS	Date: 12/05/2021	Chk'd by: .
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Status: Purpose For Issue:
PRELIMINARY

Drawing Number: SK.02	Rev: A
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