

Case study:

The GSK Carbon Neutral Laboratories for Sustainable Chemistry, University of Nottingham

Modern and Traditional Construction. Managing the Design and Construction Process / Civil Engineering Technology



Glaxo Smith Kline Carbon Neutral Laboratory Nottingham University (Wikipedia, 2016)

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INTRODUCTION

The GlaxoSmithKline Carbon Neutral Laboratory of Sustainable Chemistry was under construction and due to be complete in 2015, at the University of Nottingham's Innovation Park, construction started in September 2013 and a fire broke out at 20:35 on Friday 12th September 2014. Firefighters stopped the fire spreading further but not before the building was destroyed. Fortunately, there were no casualties. (The Construction Index, 2015)

It was reported by the fire service that the Fire that destroyed the unfinished Nottingham Laboratory was most likely caused by an electrical fault, with the temporary power supply to the building. Due to there not being fire doors and windows installed yet caused the fire to spread with "ferocity". The building was 70% complete when the fire destroyed it. (BBC, 2015)

The contract was for £16m awarded to Morgan Sindall, partly funded by GlaxoSmithKline the building will occupy 4500 square meters over two floors at Nottingham University's Innovation Park. The architects that worked on the project were Fairhursts Design Group reaching a BREEAM rating of 'Outstanding' as well as reaching a carbon neutral status after 25 years. The laboratory will be built using natural and sustainable materials also using renewable energy sources like solar power and biomass. (The Construction Index, 2013)

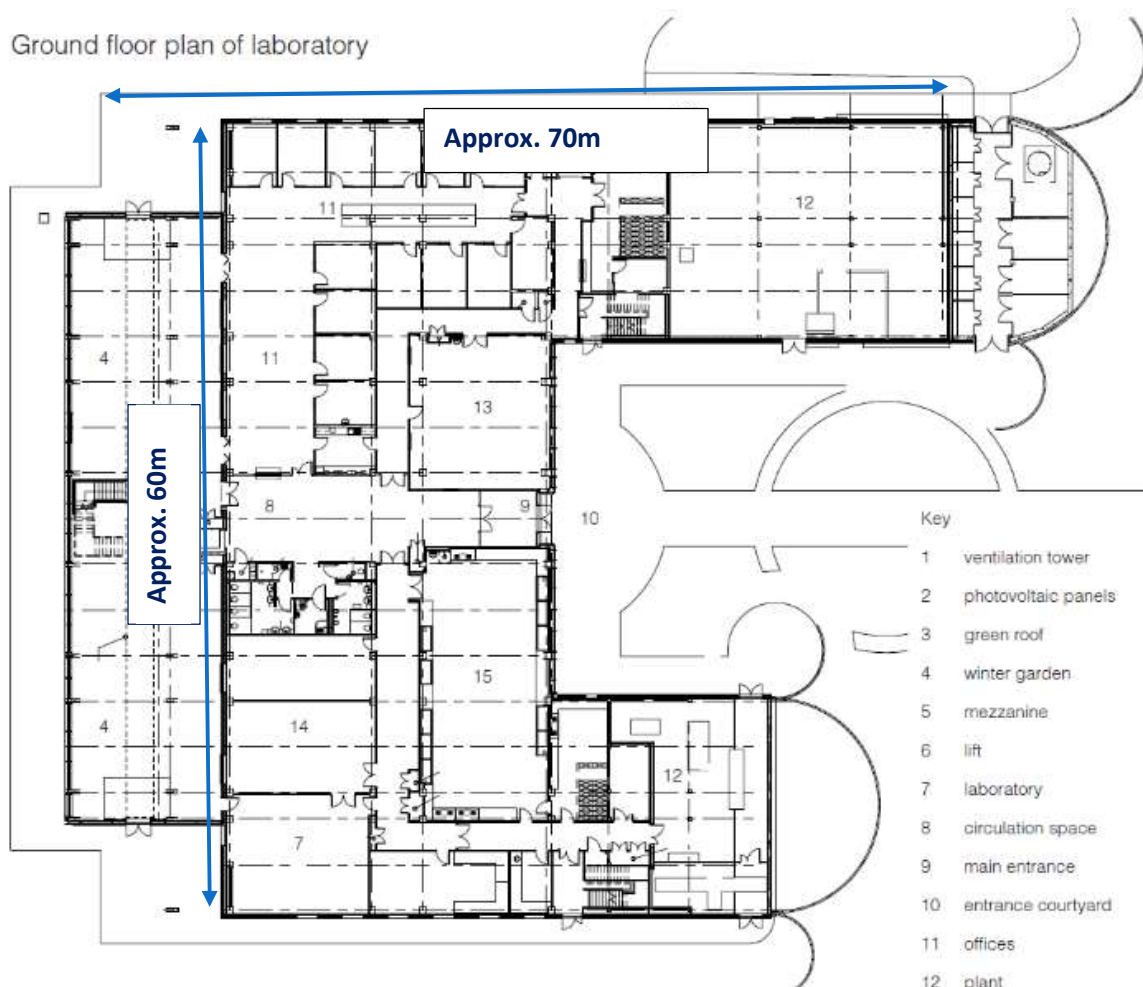


Figure 1 Plan View of Carbon Neutral Laboratory Nottingham with approximate dimensions (BM Trada, 2019)

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FOUNDATION RECOMMENDATIONS

Soil Reports and borehole information Nottingham Local area

Below is a Bing Maps satellite image of the location of the GlaxoSmithKline Carbon Neutral Laboratory.



Figure 2 Bing Maps satellite image of the location of the GlaxoSmithKline Carbon Neutral Laboratory. <https://www.bing.com/maps/>

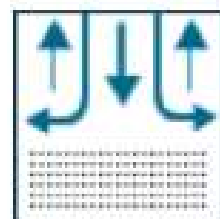
The soil quality across Nottingham varies which ranges from grade 1, being excellent quality to grade 4 poor quality. Nottingham is mainly urban land with small areas of non-agricultural land. (Gedling Borough Council, 2016)

The location of Nottingham University has slow permeable soil with clay, with impeded drainage this can cause more waterlogging during winter months and create very wet ground conditions.

Soilscape 18:
Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils

Texture:
Loamy and clayey

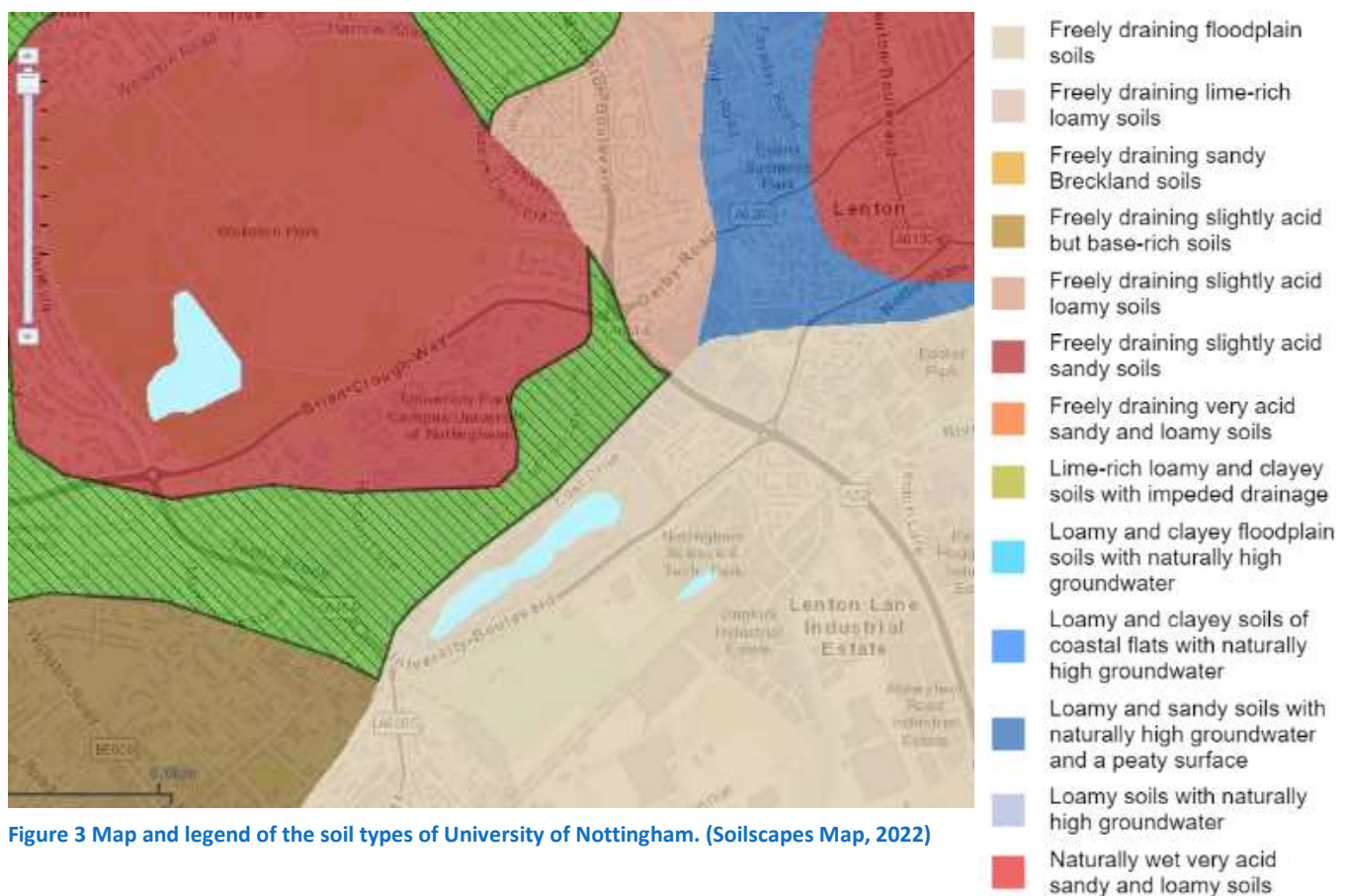
Drainage:
Impeded drainage



(Soilscales Map, 2022)

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With data extracted from the British Geological Survey website for boreholes at Cavendish Hall Nottingham University, Beeston NG7 2QL the below information could be extracted with regards to soil and ground investigations.

The data shows firm, brown slightly sandy clay at depths of 0.6m – 2m, and then stiff grey clay reaching depths of 4m – 7m, and compact brown fine sand with stone and fine gravel at depths of 7m – 9m, compact brown fine sand with thin sandstone at depths of 7m – 12m, and weakly cemented grey, brown sandstone at 12m depths with very compact grey and brown fine sand with sandstone bands reaching 17m. This is susceptible to consolidation settlement, which is stress on the clay layer that will cause settlement over time.

It is recommended to follow *BS 8004:2015+A1:2020* setting out all standards for structural and geotechnical engineers for shallow and deep foundations for low rise and high-rise buildings.

Another important consideration for clay soils and foundations is desiccation in clay soils, this is shrinkage of the soil and then expansion due to the soil rehydrating. In clay soils minimum foundation depth should be at a depth that would not affect seasonal moisture content, (not less than 1m deep) (BRE, 2016)

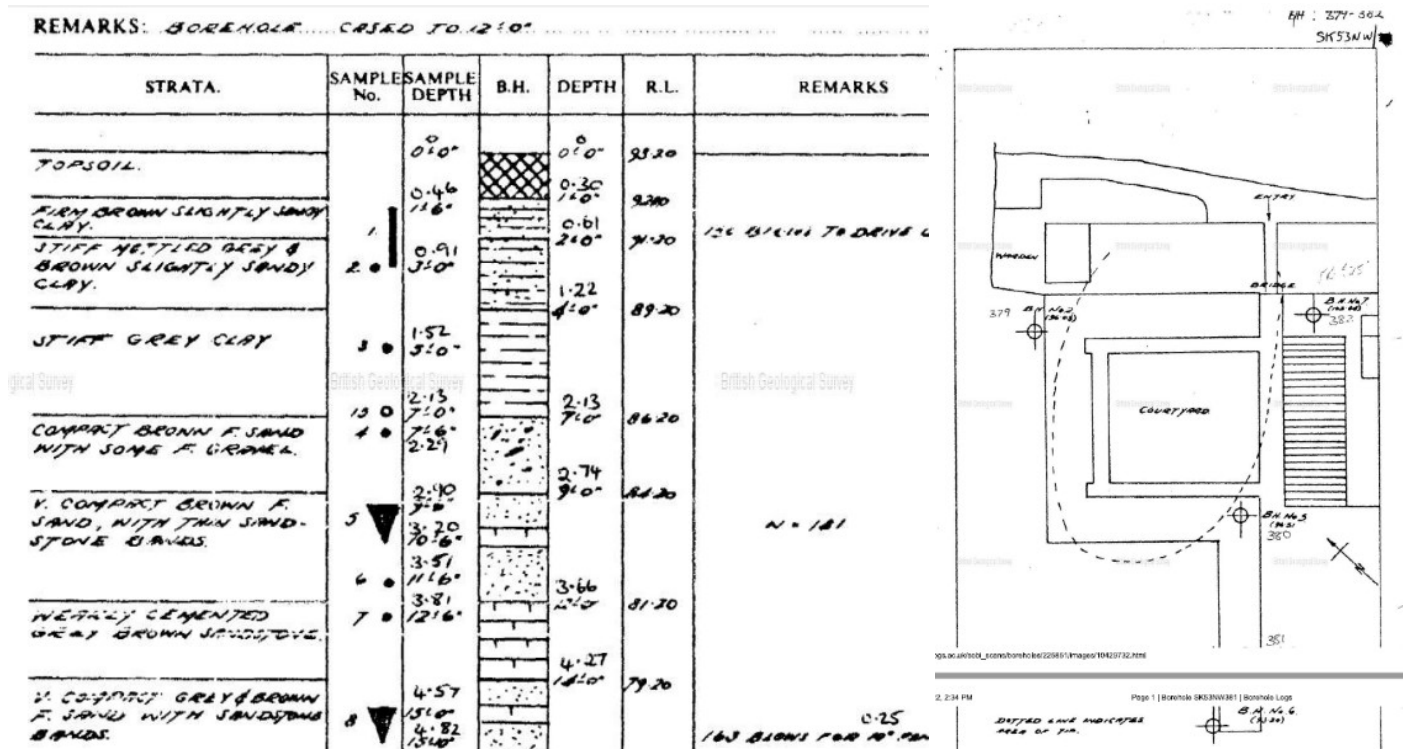


Figure 4 Borehole report from BGS website Cavendish Hall Nottingham. (British Geological Survey, n.d)

Foundation recommendations

With increased development on sustainability in the construction industry to aim for a 'zero-carbon' building making use of local and renewable materials, which can be recycled. Foundation choice is often decided on two main factors, cost, and ease of construction, this does not tend to be the most sustainable choice. There is no specific Green Guide or any other assessment of environmental performance and impact on foundations under BREEAM therefor the only guidance on foundations according to BREEAM is the responsible sourcing of materials (BRE, n.d)

Due to the given ground conditions in the location of the GSK Carbon Neutral Laboratory, taking into account the use of the building, ground conditions, soil bearing capacity, the load of the structure, and ease of construction, and sustainability the suggested foundation, would be driven pile foundations at a depth of at least 15m to reach the very compact grey and brown fine sand strata, this type of foundation will help increase the lateral pressure and consolidates the soil. This higher strength concrete pile also counteracts the CO2 footprint, but with driven piles there may be soil to dispose of therefor an increase in transportation costs. (BRE, n.d)

Advantages of using driven pile foundations is the use of less materials, this in return provides cost and time savings, therefor becomes more sustainable within the project. The use of pile driven foundations also results in less excavation works required. This means less disruption to the ground which means less risk of ground contamination on brownfield sites, due to the shallow excavations there is less chance of contaminated ground water permeating through, creating less of an environmental risk. (Ground Sun, n.d)

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The foundation will be finished off with caps on the top of each pile with reinforced concrete and then tied together with ring beams and finished with conventional reinforced concrete slab.

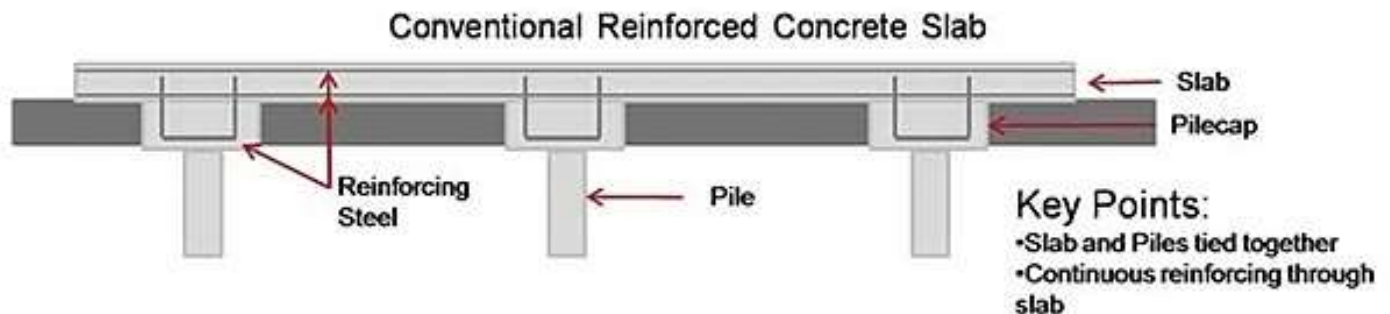


Figure 5 Example of pile driven foundations with caps, including the reinforced concrete slab as a complete foundation. (CoGriPedia, n.d)

SUPERSTRUCTURE

The objective of the GSK Carbon Neutral Laboratory for Sustainable Chemistry was to create a carbon neutral building, over its 25-year lifetime. The laboratory has achieved a sustainable building certification from BREEAM of 'Outstanding' this means the GSK Laboratory reached a 70 percent reduction in carbon than conventional buildings. Timber is used throughout the building, it has a timber structure, timber walls, floors, and timber cladding. (BM Trada, 2019)

The choice of structural material was Timber Glulam, this is a natural choice when compared to steel or concrete. Glulam is strong, sustainable, and economical. Laminates of timber are glued together under pressure and heat; this forms a strong and durable alternative to steel and timber. Glulam is also manufactured from the sustainable forests in Scandinavia.

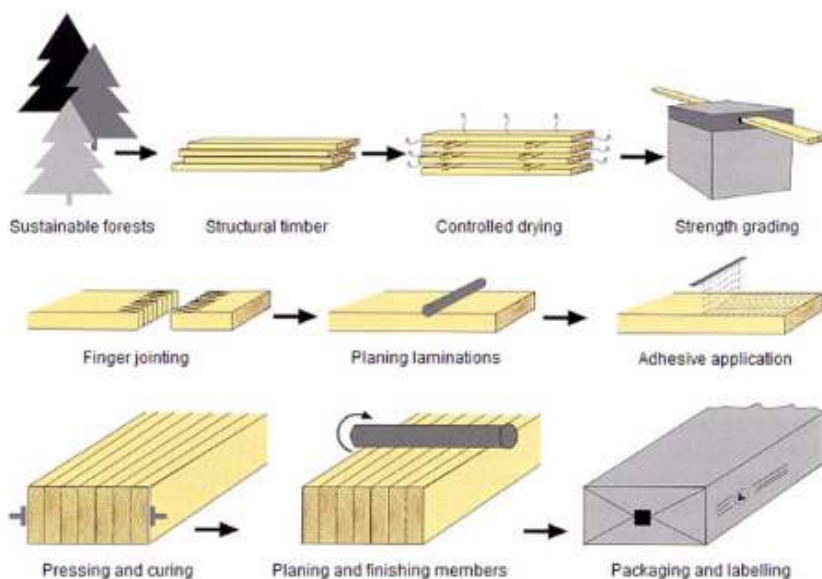


Figure 6 Image above shows the process of Glulam from the sustainable forest to packing and labelling.

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Glulam is much lighter than the alternative being concrete or steel for the structure. Glulam is versatile, for use in any structure, Glulam can be more expensive as a product, but the savings can be made up in transport and construction. Glulam must follow the approved British standards BS EN 386. (Glulam Ltd, n.d)



Figure 7 Image above showing the timber structure (Robru Steel Erection, n.d)

Design & sustainability

Glulam is one of the most versatile engineered wood products, it can be used as the structural material for many forms of buildings. It is carbon neutral and a renewable resource. The biggest advantage of Glulam is the wide variety of shapes, size, and configurations it can be used in. Various types of curves can be used in the design, from simple curves to complex arch curves, curved Glulam is manufactured by bending laminates on forms prior to them being glued and clamped for curing. (Structural Timber Association, n.d)

The design of the laboratory consists of a braced Glulam frame, using cross laminated timber panels for the flooring, which is PEFC certified. The ground floor is fitted with lightweight partitions, in an open plan design. The first floor is fitted with cross laminated timber structural walls which is exposed in some areas. The Glulam beams have a maximum span of 10 meters, this structure traps approximately 1600 tonnes of carbon. Traditional timber to timber connections were used to reduce the amount of steel in the building, these connections used dowelled fixings with oak plugs while providing aesthetically pleasing and protection to the steel dowels in a fire. Solar energy and sustainable biofuel are only two examples of the renewable energy sources that are used to power

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the laboratory. The entire building goes into 'dormancy' when not in use, utilising the least amount of energy while storing heat. (Programme for the Endorsement of Forest Certification, n.d)

The important design features of the laboratory consist of four timber-clad ventilation towers that are situated on the pitched roof, this roof is lined with photovoltaic panels facing the south side and a green roof system is situated on the north side of the laboratory. These timber towers are naturally ventilated, the pitch of the roof has large rooflights which increase the intake of natural light into the laboratory. The pitch on the south is ideal for the photovoltaic panels, while the north has a green roof system which aid in rainwater attenuation. The building then has a deep overhang on the roof to control the internal environment with inset windows. Many of the components were prefabricated off site this allowed a reduction on construction time, which in turn assisted with less dependency on the weather to meet production deadlines and planning.

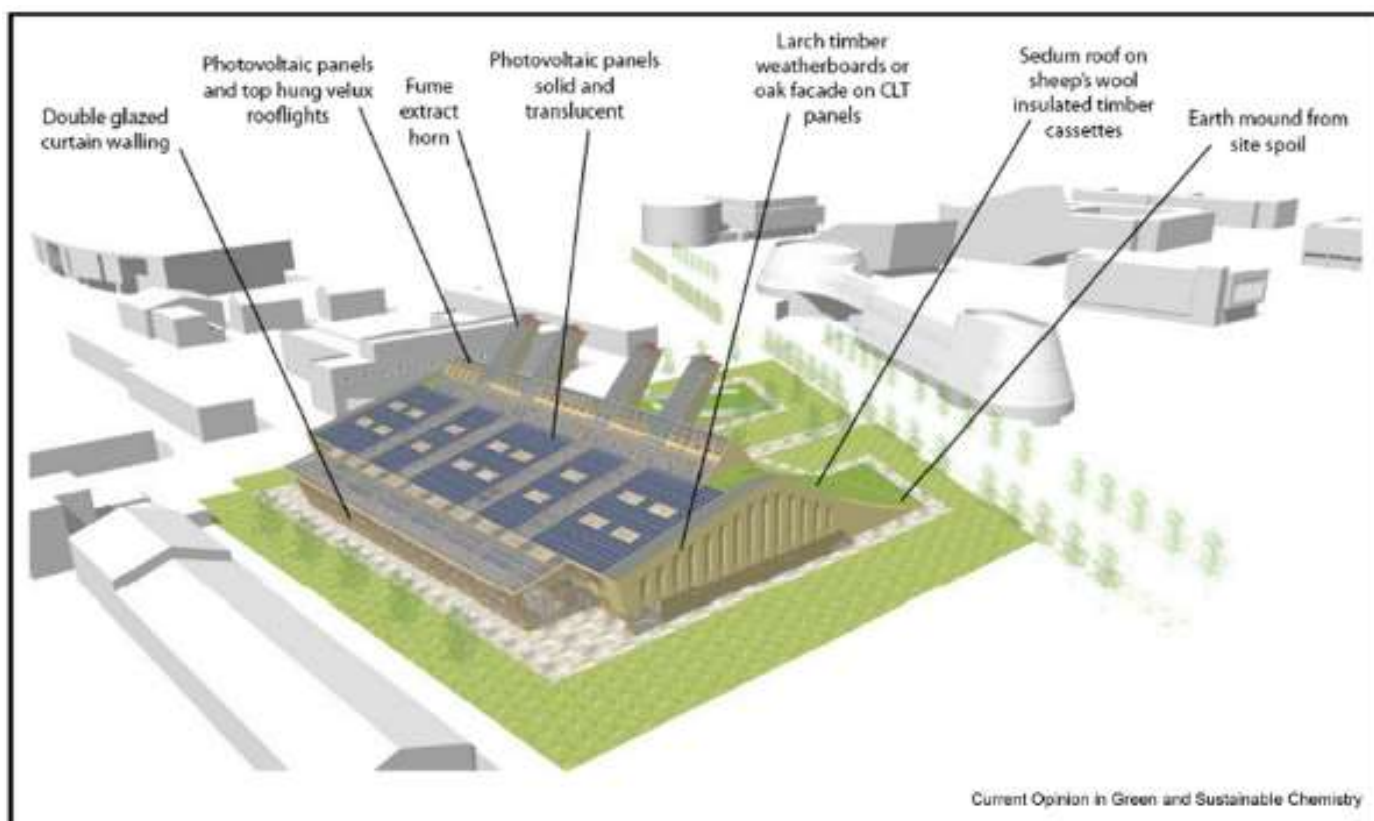


Figure 8 GSK Carbon Neutral Laboratory for Sustainable Chemistry (Poliakoff, et al., 2018)

Four large, prefabricated ventilation towers were lifted into place, the shape of the building allows these towers to direct air into the laboratories, these also create a heat recovery with the aid of heat exchangers. By assembling these towers on the ground, and fitting them out with services, and then craning them into position also reduced working at height. The towers are made from Glulam and cross laminated timber. (BM Trada, 2019)

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Figure 9 GSK Carbon Neutral Laboratory for Sustainable Chemistry craning ventilation towers into position. (Lowry, 2015)

Structural strength, stability, and aesthetics

The use of cross laminated timber panels and Glulam, make for an easy structural connection between the panels and Glulam, cross laminated timber can carry imposed axial loads as well as handle shear wind loads. Where there is a need for large floor spans, a combination of cross laminated panels with Glulam can be used to increase strength without increasing the thickness of the panels. Due to the nature of a solid wood construction internal and external surface mounted equipment can easily be attached. This also means that any internal or external cladding or insulation can be easily fixed to the panels. (BM Trada, 2017)

With the goals, in mind for GSK Carbon Neutral Laboratory, and the requirements that needed to be met, using a material like steel or concrete, would have met the structural requirements but would not have met the design and carbon neutral footprint or design aesthetics. Glulam is a favourite choice of designers when it comes to specialist buildings, it is a high-performance product produced in factories with high quality control systems. It can be used for most load bearing structures specially where aesthetics is key to the design. The standard Glulam needs to adhere to regarding structural performance is set out in BS EN 14080 and Eurocode 5 is the

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preferred design codes standard. According to BS EN 1912 the quality of the timber needs to meet a C24 strength class.

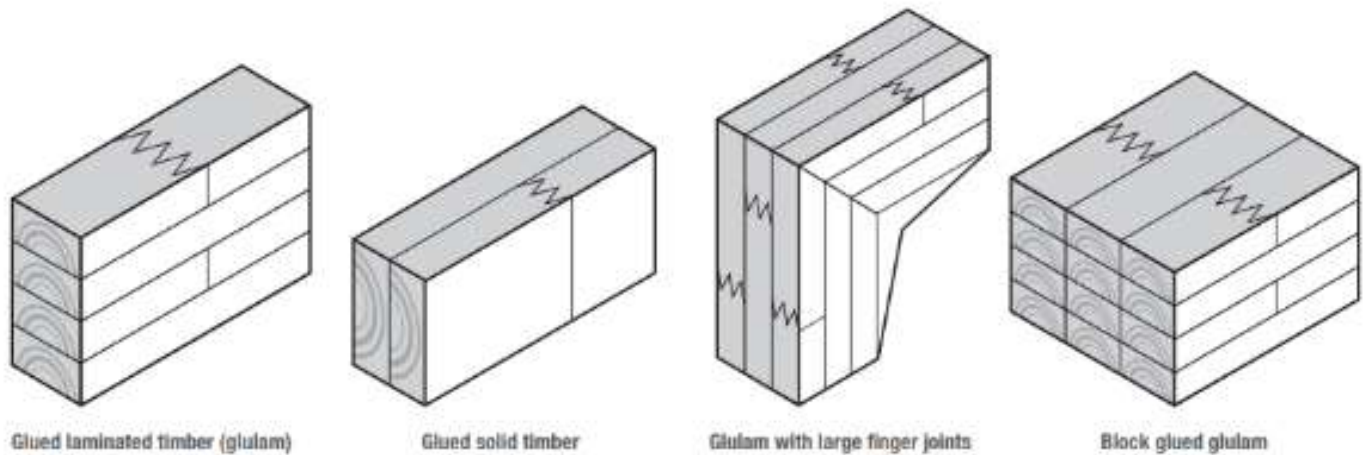


Figure 10 Four product types in BS EN 14080

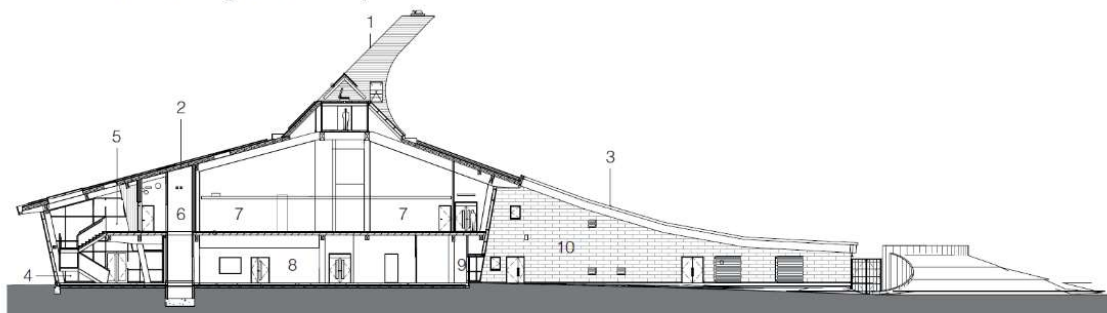
Glulam is ideal for higher loads, long spans and curved members. Glulam can be used in many structural forms for construction of a building. Examples of the structural uses of Glulam are;

- Purlins, beams and lintels
- Arches and domes
- Frames, and trusses
- Pyramids, and cones

(BM Trada, 2019)

The flexibility in design and structural form of Glulam meant that the designers could meet the performance requirements of the carbon neutral laboratory, with regards to the design shape and function of the ventilation towers, high ceilings (for natural ventilation rather than mechanical), entrance into the circulation area which enters into the winter garden, and shallow pitch roof with a green roof system. This also meant the use of the cross laminated panels with Glulam also allows flexibility in any changes to the building for future uses.

Cross section through laboratory



(BM Trada, 2019)

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Glulam compared to steel and concrete has a higher strength to weight ratio, with its lower weight it makes it easier to handle and assemble on site. The Glulam structure will produce good heat and sound insulation along with its structural strength makes it a great choice for nonstandard applications and design requirements.

Glulam strength is stronger than the timber from which it is manufactured, timber strength is based on the weakest pieces that are specified. Whereas the weaknesses from the timber that is manufactured to fabricate Glulam is distributed throughout the section of Glulam, therefore the strength variation of Glulam is less than timber. BS EN 14080 and the design code need to be followed with regards to the tensile strength of the outer laminates, for high grades this would be the strength of the finger joints but in lower grades of Glulam this would just be the value of the strength class.

Due to the moisture content of Glulam being lower than that of other timber for construction, Glulam has less shrinkage and the dimensional stability of Glulam is better. Change in the ambient humidity can cause movement, this means it is better for designers to keep the components of the Glulam in the same environment.

Timber has a low coefficient of thermal expansion in comparison to steel and concrete, therefore expansion joints are not required in most Glulam structures, or they are simplified. (BM Trada, 2019)

Fire safety



Figure 11 Carbon Neutral Laboratory Nottingham Fire September 2014 (The Guardian, 2014)

The laboratory burned down in September 2014, the reason the fire spread so fiercely was due to the fact no windows and fire doors were yet installed. (BBC, 2015) With regards to the actual fire safety of a completed structure out of Glulam and cross laminated timber, it is like that of solid wood, the structure and components will be slow to char, and any uncharred sections of beam would still retain its strength, this compares well to that of steel or concrete. The calculations needed for a section to reach the necessary fire resistance is calculated under Eurocode 5. (BM Trada, 2019)

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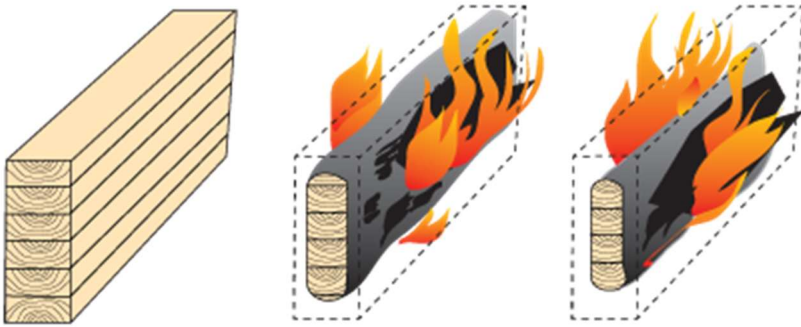


Figure 12 Cross section of Glulam retaining load capacity in fire, far left prior to fire, middle 30minutes of fire and right after 60min of fire

The fire rate for penetration of burning Glulam is slow with a 0.5-1mm per minute rating. The connections used in the Carbon Neutral Laboratory in Nottingham are specified for public buildings with high standards of fire safety. (Swedish Wood, n.d)

CONCLUSION

With most of the structure prefabricated off site, the construction program was not weather permitting, and most of the Glulam was prefabricated off site, it made for quicker on-site construction, the choice of construction material and type of construction played an important role with the programme of construction, especially considering the fire that occurred in 2014 and construction had to start from scratch again. The use of all timber (structure, walls, and floors) is a huge offset to carbon footprint of the building during its lifetime, it is almost entirely made from renewable resources, this helped achieve the highest green building awards and accolades. The life cycle of the building itself also works to offset the carbon footprint. Glulam and cross laminated timber, looks to be the future product of sustainable and carbon neutral construction, ease of build and time saving construction methods, adds more value to the structure material chosen. However, a lesson is learnt during the construction process, with the fire that occurred, more consideration needs to be taken into account with fire safety regulations and fire safety controls during the construction processes with timber and Glulam.

REFERENCES

- BBC, 2015. *University of Nottingham laboratory fire caused by electrical fault, says report*. [Online] Available at: <https://www.bbc.co.uk/news/uk-england-nottinghamshire-30751431> [Accessed 28 November 2022].
- BM Trada, 2017. *Cross Laminated Timber Design and Performance*, s.l.: BM Trada.
- BM Trada, 2019. *Glued Laminated Timber: Structural Uses*, s.l.: BM Trada.
- BM Trada, 2019. *GSK Carbon Neutral Laboratory for Sustainable Chemistry - Case Study*, s.l.: BM Trada.
- BRE, 2016. *Soils, ground investigation*, s.l.: IHS BRE Press.
- BRE, n.d. *Sustainability In Foundations A Review*, s.l.: S&P Global.
- British Geological Survey, n.d. *BGS*. [Online] Available at: https://mapapps2.bgs.ac.uk/geoindex/home.html?layer=BGSBoreholes&_ga=2.93377117.1515661793.1669985077-1695621846.1669985077 [Accessed 28 November 2022].
- CoGriPedia, n.d. *Pile Supported Slab*. [Online] Available at: <https://cogripedia.com/pile-supported-slab/> [Accessed 3 December 2022].
- Gedling Borough Council, 2016. *Extract of Greater Nottingham Landscape Character*, s.l.: s.n.
- Glulam Ltd, n.d. *Glulam Beams*. [Online] Available at: <https://glulambeams.co.uk/about-glulam/what-is-glulam/> [Accessed 3 December 2022].
- Ground Sun, n.d. *Ground Sun*. [Online] Available at: <https://groundsun.co.uk/pile-foundations-and-their-suitability-within-construction/> [Accessed 3 December 2022].
- Lowry, E., 2015. *Blog Nottingham University UK*. [Online] Available at: <https://blogs.nottingham.ac.uk/newsroom/2015/09/07/rising-from-the-ashes-glaxosmithkline-carbon-neutral-laboratory-one-year-on/> [Accessed 3 December 2022].
- Poliakoff, M., Licence, P. & George, M. W., 2018. *Science Direct*. [Online] Available at: <https://www.sciencedirect.com/science/article/abs/pii/S2452223617301189> [Accessed 3 December 2022].

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Programme for the Endorsement of Forest Certification, n.d. *PEFC*. [Online]

Available at: <https://www.pefc.co.uk/case-studies/glaxosmithkline-carbon-neutral-laboratory/>
[Accessed 3 December 2022].

Robru Steel Erection, n.d. *Robru*. [Online]

Available at: <https://www.robru.co.uk/case-studies/csc-nottingham-university/>
[Accessed 3 December 2022].

Soilscapes Map, 2022. *Landis*. [Online]

Available at: <https://www.landis.org.uk/soilscapes/#>
[Accessed 28 November 2022].

Structural Timber Association, n.d. *Glued laminated timber structures*, s.l.: s.n.

Swedish Wood, n.d. *Swedish Wood*. [Online]

Available at: <https://www.swedishwood.com/building-with-wood/about-glulam/choosing-glulam/technical-properties/#:~:text=Fire%20stability,the%20surface%20of%20glulam%20products.>
[Accessed 5 December 2022].

The Construction Index, 2013. *Morgan Sindall to build Nottingham Uni's sustainable lab*. [Online]

Available at: <https://www.theconstructionindex.co.uk/news/view/morgan-sindall-to-build-nottingham-unis-sustainable-lab>
[Accessed 28 November 2022].

The Construction Index, 2015. *Morgan Sindall to rebuild Nottingham lab destroyed by fire*. [Online]

Available at: <https://www.theconstructionindex.co.uk/news/view/morgan-sindall-to-rebuild-nottingham-lab-destroyed-by-fire>
[Accessed 28 November 2022].

The Guardian, 2014. *The Guardian*. [Online]

Available at: <https://www.theguardian.com/uk-news/video/2014/sep/13/nottingham-university-chemistry-building-destroyed-fire-video>
[Accessed 05 December 2022].

Wikipedia, 2016. *Glaxo Smith Kline Carbon Neutral Laboratory Nottingham University*. s.l.:s.n.