

SUSTAINABLE STUDENT ACCOMMODATION IN SA1 SWANSEA.

LOUIS KING (2320088)
CONSTRUCTION TECHNOLOGY 2-
LECTURER: HANNAH WILLIAMS
09/05/25



Table of Contents

Introduction	1
Environmental Impact	2
Façade Greening and SUDS	4
Flexibility in Design and Use.....	8

Introduction

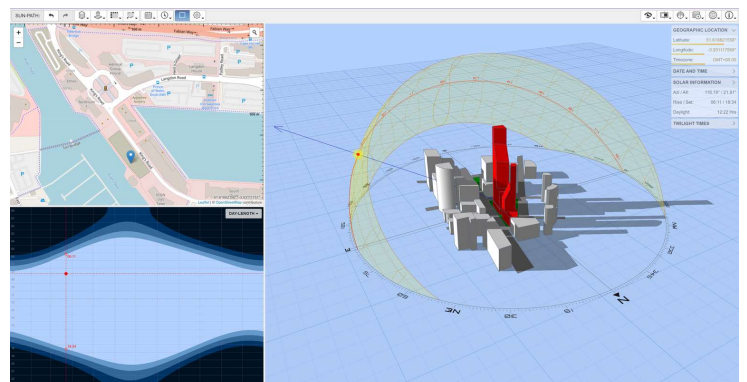
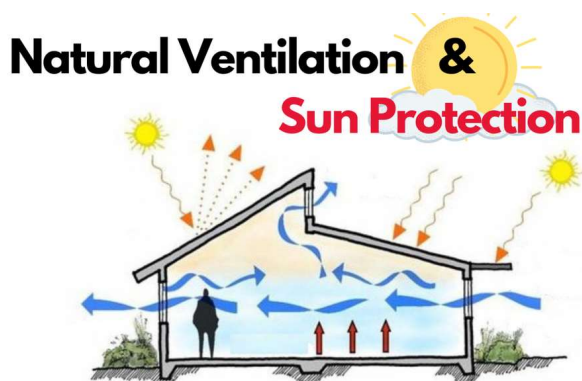
The proposed design is a medium-rise development for student accommodation and is at the SA1 waterfront site adjacent to King’s Road, Swansea Bay. The development is being designed to respond to an increasing demand for student accommodation in the area to serve the University of Wales Trinity Saint David, which is located near the site. The site and surrounding area lie within an urban neighbourhood and a desirably well-connected locality in terms of public transport, good cycling infrastructure, and good serviceability in terms of utilities, as demonstrated, in part, in the initial design. The design seeks to embrace sustainability through an engineered structural frame based on glue-laminated timber (glulam), selected for its strength, life cycle, and environmental performance. The building envelope will use triple-glazed composite windows, mineral wool, insulation, and metal cladding, each offering thermal performance with limited maintenance. The overall aesthetic is influenced by the site's location, incorporating references to the area's coastal industrial history, and using some elements of biomimicry, emulating the gentle roll of the sea waves and shape of a ship hull in the surrounding environment. (King *et al.*, 2024)

Within this report, the preliminary design proposal will be used to look into sustainability on the project, focusing on 4 main areas: Enviromental Impact, Façade Greening and SUDS, Flexibility in Design and Use and Additional Considerations for Sustainability.

Environmental Impact

Orientation

The building orientation has been selected with the front elevation facing south-west, not only for views of the harbour, but to optimise passive solar gain and natural ventilation. This orientation is aimed at maximising the exposure of the communal and study lounge, areas of the building in daylight, especially during the cooler months when solar heating is the most advantageous. The north and east façades have high-performance glazing and thoughtfully placed shading devices to ensure a balance between solar gain and thermal comfort(BRE, 2015). Natural ventilation is facilitated with operable windows and passive window openers, and sustainable internal planning to enable cross-ventilation. These passive concepts are essential for reducing reliance on mechanical systems and reducing energy use. Furthermore, the SA1 site is open on all sides, and relatively level terrain allows wind to flow unobstructed on most occasions, which will assist natural cooling strategies (Onsharp.Admin, 2019) during the warmer months of the year. The shape of the building should allow winds to flow around it rather than lightly hitting it head-on. To reinforce this, orientation studies and sun-path studies (Dr.A.J.Marsh, no date) were undertaken as part of its design development to ensure that everything adheres to low-energy design principles. All these loose concepts relate to the aims of Part L of the Building Regulations (Building Regulations 2010, 2021) and will contribute towards BREEAM Passive Design credits(Ve-Admin, 2023). (Dr.A.J.Marsh, no date)(Tank, 2023).

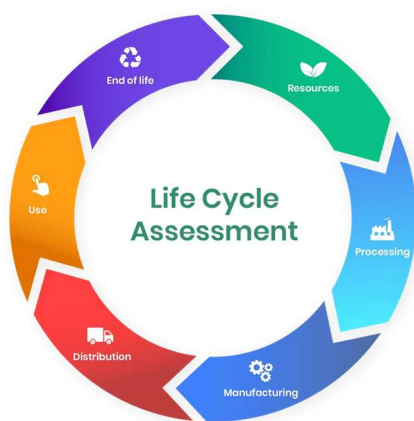


Life Cycle

The building employs durable and sustainable materials of glulam beams, triple-glazed composite windows, mineral wool insulation, and low-carbon concrete. Glulam is engineered timber that has a life expectancy of more than 50 years. It is made of layers of bonded-sized lumber and arguably provides greater structural stability and a great resistance (to both decay and fire)(King *et al.*, 2024b). 'Glulam is often used because of its sustainability. The timber is sourced from independently certified sustainably managed forests' (Bekin, 2023) and is generally lower in embodied carbon than traditional materials like steel or concrete; it also better supports biophilic design concepts (Ashton, 2025) by bringing people closer to natural materials. While triple-glazed units are usually more expensive than double-glazed units, their thermal performance is excellent, with U-values $< 0.8 \text{ W/m}^2\text{K}$ (*Why use triple glazed windows & doors?*, no date), which greatly assists in the long-term energy sustainable performance of the building, and lessens heating costs. They will also provide enhanced acoustic insulation, which is crucial in a city such as Swansea, as urban transmission, both from internal and outside, could greatly diminish the quality of life.

Mineral wool insulation is used for the wall and roof build-up. The insulation will also be non-combustible, having a small R value, which contributes to the construction's fire protective barrier and the energy performance of the building. Mineral wool insulation can also provide acoustic insulation in between units and shared areas.

Low carbon concrete is only used where there is weight bearing (heavy loads) required of the building, the pile foundation system, for example. The low-carbon concrete policy outlined in the previous report is undertaken through the project limiting Portland cement whilst using other materials that blend well with concrete, such as fly ash or GGBS, Collins (no date), which are very helpful in reducing the total carbon footprint of the building.



Many pre-fabricated materials, such as the curtain wall panels, floor slab, and glulam frame, have all been fabricated off-site, in controlled environments. This contributes to the level of precision quality of construction, and reduction in on-site material waste and disturbance. A full life cycle assessment (LCA)(Ramachandran, 2025) in compliance with BS EN 15978 (*BS EN 15978-1*, no date) will be undertaken to ensure an estimated whole building life to around >70+ years while

needing little maintenance. Like many other significant elements of design, there are considerable numbers of components, these have all been designed with disassembly and reuse

or recycling, and designed for minimum wastage and promote circular economy practices and long-term adaptability. (UK Green Building Council, no date)(Ramachandran, 2025b).



Aesthetics

The building is cohesive with the industrial nature of the SA1 area, utilising corrugated metal cladding, grey aluminium window frames, and biomimicry-oriented curves that reference a ships hull(King, 2024). The decisions have been made to complement the ports/industrial era, whilst offering a modern, environmentally responsible architectural triumph. The tones of the dark grey metal cladding tie in nicely with the urban developments nearby, and the aluminium frames and large sidelights provide a clean contemporary aesthetic to help maximise daylight and perspectives toward the bay.

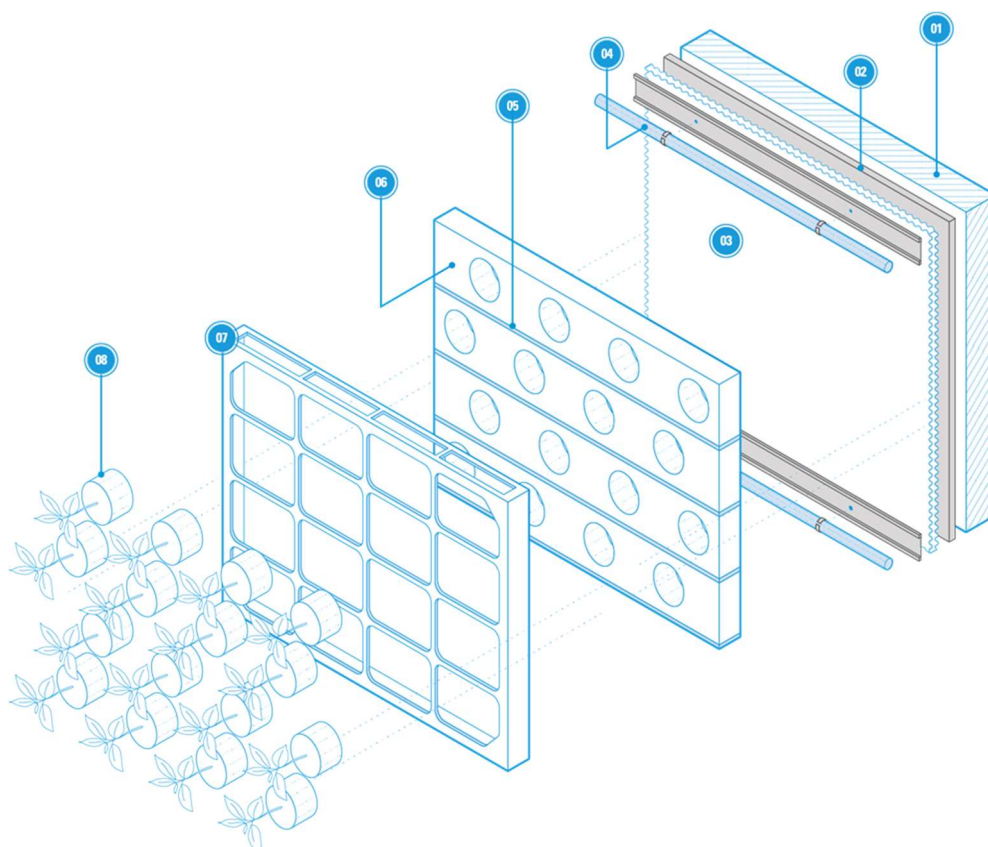
Biomimicry in form for the curved façades is not only a representation of the ship hull shape, but also creates useful functions to help with wind deflection (GmbH, 2022) and areas of low pressure around the structure with the shape of a ship hull. The inclusion of natural materials in the form of glulam for interior finishes maintains a visual connection to nature and the principles of biophilic design. Public green open spaces, landscaped communal courtyards, provide outdoor social spaces for interaction and well-being Ashton (2025b), reinforcing the building's role as a dynamic, student-focused place to gather.

Façade Greening and SUDS

Green Façades

In terms of facade greening, the possibility is high due to the modular design and exposed beams, which provide a fixing point for most types of vegetation systems. Green façades or modular green wall systems can greatly reduce urban heat buildup by shading the external façade and absorbing the solar radiation, *“In order to reduce the energy demands of the cooling systems, to mitigate the urban heat island and to improve the thermal energy performance of buildings. Green façades can allow the physical shading of the building and promote evapotranspiration in summer, and increase the thermal insulation in winter”*Vox, Blanco and Schettini (2018). This additional insulation layer helps moderate indoor temperatures and reduces energy consumption in cooling demand during the warmer months. In addition to providing thermal comfort and utilizing passive cooling, green façades remove ambient air pollutants and improve the local microclimate. The acoustic properties of living systems provide some noise dampening effect against exterior sound, which is important in a high density urban environment like Swansea. Green façades provide a visually softer building, whilst adding natural vibrancy and creating possible positive psychological impacts for building residents and the surrounding community. Two systems could be implemented in conjunction: Hydroponic green walls (with water and nutrients circulating directly to plants with no soil present) and trellis-based systems (where native or adaptive climbing species will be allowed to grow vertically with minimal maintenance).

Hydroponic Green Wall System-



Biotope Hydroponic green walls are vertical designs where soil is not used and plants achieve nutrients through a water based solution. The key components of the hydroponic green wall are as follows: Structural Support: A framework set up to but attach to the building facade.

Waterproof Backing Board: Stay vast to keep moisture away from building wall. Hydroponic

Substrate: Base where plants grow to anchor and grow. Irrigation System: Drips water into plant roots with the nutrient water provided. Drainage Layer: Allow excess water to be drained off.

Benefits:

- ☐ Thermal Regulation: Provides insulation and lowers energy consumption.
- ☐ Air Quality Improvement: The plants filter pollutants out of the air providing better air quality.
- ☐ Aesthetic Appeal: Provide a lush green look to urban buildings.
- ☐ Biodiversity Encouragement: Support variety of plant species and their animal life.

(Green Wall specification and drawings - Biotope, 2024)

Trellis-Based Green Façade System-



Jakob UK Trellis-based systems limits plant growth to direction upward along a framework. The main components of the trellis-based green façade systems are: Support Structure: Stainless steel cables, rods, or meshes to attach to the building. Anchoring System: Fixings in place to firmly secure the trellis to the façade. Planting Beds: Planters at ground level or an elevated where climbers will be inserted to grow.

Benefits:

- ☐ Cost Saving- Generally cost less than a Hydroponic Green Wall arrangements (installation and maintenance).
- ☐ Lightweight- Lesser weight than a Hydroponic Green Wall, and less weight on the building.
- ☐ Natural Cooling- Provides a cooling shade to the façade which aids in reduction of heat gain.

- ❑ Less Maintenance- Green walls require a greater amount of on-going maintenance, once established, trellis-based systems require less maintenance.

(Green Walls - Jakob Green Wall Solution from MMA, 2022)

Sustainable Urban Drainage Systems (SUDS)

Because the site is urban and flat, surface water will need to be managed to mitigate flood risk, increase water quality, and protect nearby urban infrastructure. As such, the Sustainable Urban Drainage Systems (SuDS) had been proposed as a multi-faceted approach using both engineered and nature-based drainage systems, with the goal of emulating the natural drainage process. The integrated SuDS system will include porous paving such as Resin-Bound Paving in outdoor communal areas and pedestrian routes to allow stormwater infiltration, rather than overland flow into drains. *(Why is permeable resin bound important? - ClearStone, 2019)*



The flat-roof portions of the buildings will have green roofs to accept additional surface water and improve thermal performance, and enhance biodiversity within the urban environment. Vegetated raingardens (shallow basins that fill with vegetated material)(*Rain gardens / RHS*, no date), located adjacent to building edges and in open spaces, will slow down surface water runoff by collecting and filtering the water thereby providing habitat for pollinators and native plant life. Furthermore, from an aesthetic aspect these offer visual green components to normally grey urban hardscapes. No maintenance is required on the littoral or littoral-like biodiverse flood management systems.(*SUDS Planters: London's residential flood Solution - Meristem Design*, no date)

Flexibility for Changing Needs

The modular internal design and easy removal, relocation, and alteration of partitions will allow adaptable layouts to meet changing functional demands. Flexibility is important in a student housing scenario as uses may diverge from single living units, shared accommodation, and study spaces. Community spaces, such as lounges, cafés or study areas, were specifically designed to be an open plan that could be subdivided or expanded.

The service routes (i.e. Electrical, plumbing, HVAC, and data) are configured in service voids and risers that can allow for future upgrades or reconfigurations without the need for major structural work. Where applicable, raised access flooring in common utility areas further enhances flexibility of the internal layout. The use of prefabricated components simplifies disassembly and reassembly of parts of the building allowing internal spaces to react to user needs.

Alternative Future Uses

Although the building will be constructed in the first instance as student accommodation, the building has also been developed with future alternative use in mind. The dimensions of the structural grid, floor heights, and M&E solutions were all designed to allow for possible alternate functions without extensive retrofitting.

Possible future uses include:

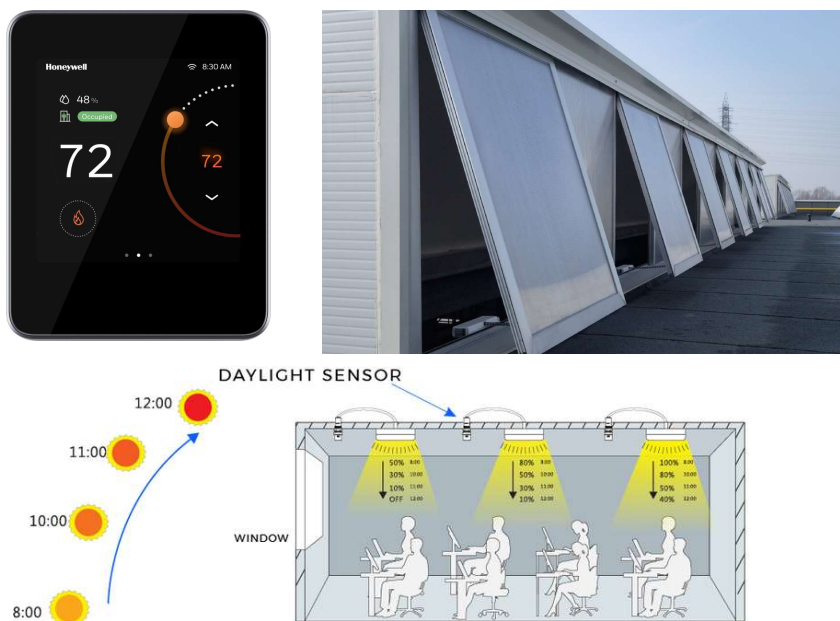
- ☐ Co-living apartments for young professionals
- ☐ Affordable housing
- ☐ Temporary lodging as a city hotel or hostel
- ☐ Community centre involving education, health, or social provision
- ☐ Co-working & office space for start-up businesses and small enterprises

The neutrality of the internal finishes of the building, the robust servicing strategy, and the modularity of internal layouts make these varied uses possible. The multiple accessibility features in accordance with Approved Document M (Building Regulations 2010, 2015), such as lift access, wide corridors and doors, WCs with adaptability, also ensure that future uses can still accommodate a diverse range of users.

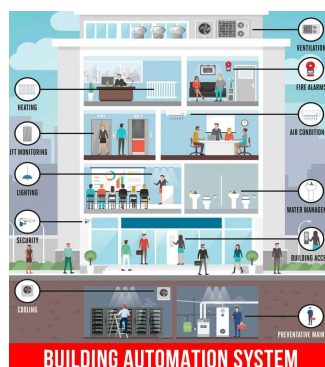
Additional Considerations for Sustainability

Smart Building Technologies

To further promote energy efficiency, comfort and enhanced user experience, it is proposed to incorporate smart building technology. This includes motion and daylight sensors for lighting control, smart thermostats, smart window openers and HVAC systems with zoning that can respond dynamically to use. An energy meter dashboard could also be integrated into the building management system where energy consumption can be monitored to maximise opportunities for its optimisation.(Nurmi, 2022)(*TC500A Commercial Thermostat*, no date)(Window Openers - Rocburn Limited, 2025)



Smart metering and app controlled room heating or lighting would give students the control over their energy use whilst aiding building automation systems (BAS) by supporting maintenance and fault detection. (Damia Global Services, 2024)



Renewable Energy Systems

Photovoltaic (PV) panels will be mounted on the roof which will allow the generation of clean electricity. They can also be integrated with battery storage to develop an energy resilience strategy where surplus electricity from the PV system can be stored and brought on to balance peak demand. Solar thermal collectors could also be added to the system to produce hot water reducing boiler load and lowering carbon emissions in the operational phase of the development. These renewable energy systems move towards progress for a future goal of net-zero operational energy.(ARKA360, no date)



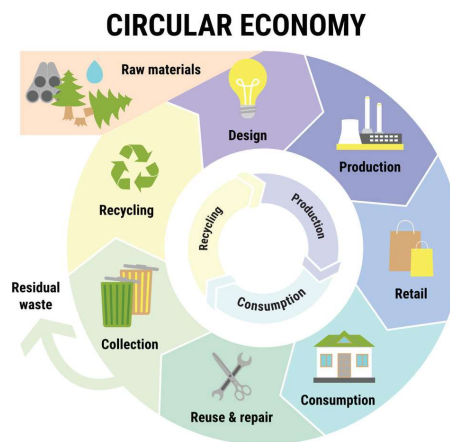
Social Sustainability

Social sustainability has been approached with design strategies that can improve wellbeing, inclusivity and social interaction for users. Communal lounges, shared kitchens, study pods, and an outdoor landscaped courtyard are designed to support interactions and building community. Inclusive design concepts, such as tactile signage(Signs, 2023), visual contrast, and zones of relative quiet support neurodiverse users (Jason Slocombe, Senior Inclusive Design Consultant and Neurodiversity Design Specialist , Motionspot, 2023) and users with varying degrees of sensory impairment. The design approach establishes the foundation for an environment that could improve mental health and socialisation/harmony for residents.

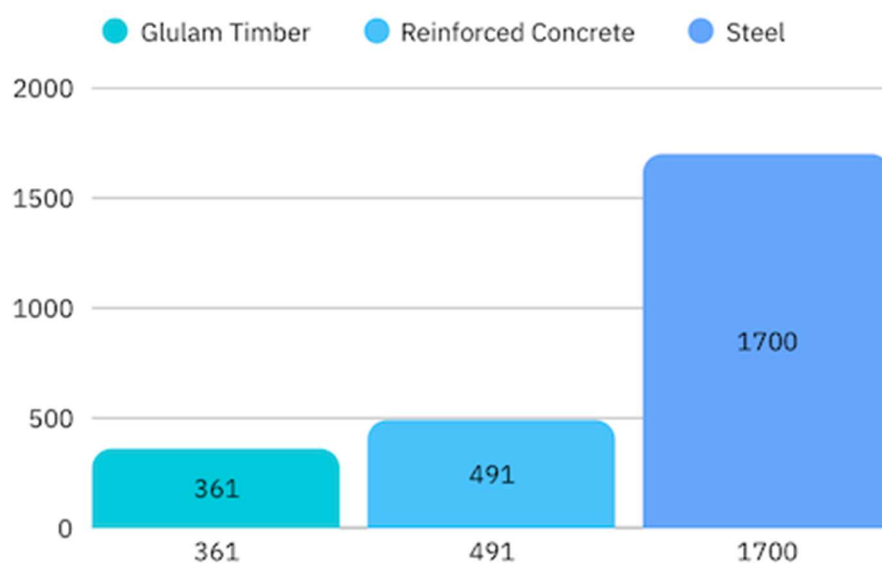


Sustainable Sourcing and Embodied Carbon

If possible, all modules will be locally sourced to minimise transportation emissions. A significant amount of the timber used for the glulam elements is a certified sustainable forest scheme (e.g. FSC or PEFC) (Graham, 2024) and materials that could be cradle-to-gate assessed (Arbor, no date) Glulam has significantly lower embodied carbon than steel or reinforced concrete(Rs, 2024). Aluminium frames have recycled content and mineral wool insulation has some post-consumer recycled content, both of which are valuable for a circular economy. (*What a circular economy means for businesses*, 2025)



A table was created to show the difference in embodied carbon of a material comparison between glulam, concrete, and steel, using statistics from Buckland Timber, NSC, and ARUP.



(*Environmental Benefits*, no date)(Nsc, 2021)(Ove Arup & Partners Limited, 2023) .

Designing for disassembly has been considered, with prefabricated items facilitating deconstruction with minimal damage and/or reuse or recycling. Modular partitions, and finishes can be deconstructed and separated in a relatively easy manner; so little to no waste is generated by demolition. Leveraging cradle-to-cradle thinking with disassembly capability exemplifies long-term sustainability. (Wikipedia contributors, 2025)



- Arbor (no date) *What is Cradle-to-Gate in Carbon Calculations? | Carbon 101*. ACESSED ON-
<https://www.arbor.eco/blog/what-is-cradle-to-gate-in-carbon-calculations-carbon-101#:~:text=Grave%20Carbon%20Calculations-,What%20is%20the%20difference%20between%20gate%2Dto%2Dgate%20and%20cradle,environmental%20impacts%20of%20their%20products.>
- ARKA360 (no date). Arbor (no date) accessed on *What is Cradle-to-Gate in Carbon Calculations? | Carbon 101*. <https://www.arbor.eco/blog/what-is-cradle-to-gate-in-carbon-calculations-carbon-101#:~:text=Grave%20Carbon%20Calculations->

,What%20is%20the%20difference%20between%20gate%2Dto%2Dgate%20and%20cradle
,environmental%20impacts%20of%20their%20products.

- ARKA360 (no date). accessed on <https://arka360.com/ros/basic-components-of-photovoltaic-system>.
- Ashton, D. (2025a) accessed on *What is biophilic architecture? 15 real-world examples in the built environment*. <https://www.ucem.ac.uk/whats-happening/articles/biophilia-examples-built-environment/>.
- Ashton, D. (2025b) accessed on *What is biophilic architecture? 15 real-world examples in the built environment*. <https://www.ucem.ac.uk/whats-happening/articles/biophilia-examples-built-environment/>.
- Bekin, M. (2023) accessed on *All you need to know about Glulam*. <https://ecochoice.co.uk/all-about-glulam/#:~:text=Why%20is%20Glulam%20a%20Sustainable,Green%20points%20all%20around!&text=Above%20table%20based%20on%20the,is%20assumed%20to%20be%20re-cycled>.
- BRE (2015) accessed on *Daylight and shading, BRE Expert Collection 6*. IHS BRE Press. <https://www.brebookshop.com>.
- BRE Bookshop (no date). accessed on <https://www.brebookshop.com/details.jsp?id=905>.
- BREEAM | Sustainable Building Certification (no date). accessed on <https://breeam.com/>.
- BS EN 15978-1 (no date). accessed on https://www.designingbuildings.co.uk/wiki/BS_EN_15978-1.
- Building Regulations 2010 (2015) *Building Regulations 2010 Approved Document M Volume 1, 2015 edition, Building Regulations 2010*. accessed on https://assets.publishing.service.gov.uk/media/5a7f8a82ed915d74e622b17b/BR_PDF_AD_M1_2015_with_2016_amendments_V3.pdf.
- Building Regulations 2010 (2021) *Building Regulations 2010 Approved Document L Volume 1, 2021 edition, Building Regulations 2010*. 2021 edition. accessed on https://assets.publishing.service.gov.uk/media/662a2e3e55e1582b6ca7e592/Approved_Document_L__Conservation_of_fuel_and_power__Volume_1_Dwellings__2021_edition_incorporating_2023_amendments.pdf.
- CIBSE - Chartered Institution of Building Services Engineers (no date). accessed on <https://www.cibse.org/>.
- Collins, M. (no date) *Combination cements and environment*. accessed on <https://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=194>.

- Damia Global Services (2024) 'New Smart Building Automation System Integration 2024,' *Damia Global Services Private Limited*, 4 May. accessed on <https://dgsfire.com/building-automation-system/>.
- Dr.A.J.Marsh (no date) *PD*: accessed on *3D Sun-Path*.
<https://andrewmarsh.com/apps/staging/sunpath3d.html>.
- *Environmental Benefits* (no date). accessed on
<https://www.bucklandtimber.co.uk/environmental-benefits/>.
- *Fire and soundproofing insulation | ROCKWOOL* (no date). accessed on
<https://www.rockwool.com/>.
- GmbH, R. (2022) 'Wind Assessment for Urban Planning and architecture,' *Rheologic*, 8 September. accessed on <https://rheologic.net/articles/urban-wind-assessment/>.
- Graham, K. (2024) *Is FSC or PEFC the better option? - Hazel 4D*. accessed on
[https://www.hazel4d.com/articles/fsc-or-pefc/#:~:text=FSC%20is%20a%20global%20standard,criteria%20\(third%2Dparty\)](https://www.hazel4d.com/articles/fsc-or-pefc/#:~:text=FSC%20is%20a%20global%20standard,criteria%20(third%2Dparty)).
- *Green Wall specification and drawings - Biotecture* (2024). accessed on
<https://www.biotecture.uk.com/design-and-specify/specifications-and-compliance/specifications-and-drawings/>.
- *Green Walls - Jakob Green Wall Solution from MMA* (2022). accessed on
<https://jakob.co.uk/solutions/view/green-walls/>.
- *Home* (no date). accessed on <https://www.passivhaustrust.org.uk/>.
- Jason Slocombe, Senior Inclusive Design Consultant and Neurodiversity Design Specialist ,
Motionspot (2023) 'How to design spaces to better meet the needs of neurodivergent groups,' *How to design spaces to better meet the needs of neurodivergent groups*, 9 May.
<https://hdsunflower.com/au/insights/post/design-accessible-spaces>.
- King, L. *et al.* (2024a) *Building Evaluation – Design proposal for medium to high rise student accommodation*.
- King, L. *et al.* (2024b) *Building Evaluation – Design proposal for medium to high rise student accommodation*.
- King, L., 2320088 (2024) *SUSTAINABLE STUDENT ACCOMMODATION IN SA1 SWANSEA*.
- Nsc (2021) *UK average embodied carbon of structural steel*. accessed on
<https://www.newsteelconstruction.com/wp/uk-average-embodied-carbon-of-structural-steel-2/>.
- Nurmi, T. (2022) *Microwave sensors: How to utilize them in lighting?* accessed on
<https://light.fi/microwave-sensors-utilize-lighting/>.

- Onsharp.Admin (2019) *Natural cooling strategies*. accessed on <https://cppwind.com/natural-cooling-strategies/>.
- Ove Arup & Partners Limited (2023) *Buildings & Infrastructure Priority Actions for Sustainability*, Ove Arup & Partners Limited.accessed on https://www.istructe.org/IStructE/media/Public/Resources/ARUP-Embodied-carbon-concrete_1.pdf.
- *Rain gardens / RHS* (no date). accessed on <https://www.rhs.org.uk/garden-features/rain-gardens>.
- Ramachandran, A. (2025a) 'Life-cycle assessment for green building experts explained,' *Asha Ramachandran*, 10 February. accessed on <https://oneclicklca.com/en/resources/articles/life-cycle-assessment-for-green-building-experts>.
- Ramachandran, A. (2025b) 'Life-cycle assessment for green building experts explained,' *Asha Ramachandran*, 10 February. accessed on <https://oneclicklca.com/en/resources/articles/life-cycle-assessment-for-green-building-experts>.
- Rs (2024) *Steel vs Timber vs Concrete – which is best for your project? - Tate + Co*. accessed on <https://tateandco.com/answers/steel-vs-timber-vs-concrete/>.
- Signs, D. (2023) *NHS Braille & Tactile Signs - Display Signs*. accessed on <https://www.displaysigns.net/nhs-braille-tactile-signs/>.
- *SUDS Planters: London's residential flood Solution - Meristem Design* (no date). accessed on <https://www.meristemdesign.co.uk/blog/suds-planters-londons-residential-flood-solution/>.
- Tank, N.V. (2023) *The benefits of natural ventilation and sun protection in hot climates for your home*. accessed on <https://www.linkedin.com/pulse/benefits-natural-ventilation-sun-protection-hot-climates-nitesh-tank/>.
- *TC500A Commercial Thermostat* (no date). accessed on https://buildings.honeywell.com/us/en/brands/our-brands/bms/what-we-do/field-devices/commercial-thermostats/tc500a_commercial_thermostat.
- *The SUDS manual* (no date). accessed on https://www.designingbuildings.co.uk/wiki/The_SUDS_manual.
- UK Green Building Council (no date) *Circular Economy | UKGBC*, *UKGBC*.accessed on <https://ukgbc.org/our-work/topics/circular-economy/>.
- Ve-Admin (2023) 'BREEAM ENE04 - Low Carbon Design explained,' *Vision Energy*, 22 February. accessed on <https://vision-energy.co.uk/breeam-ene04-low-carbon-design-explained/>.

- Vox, G., Blanco, I. and Schettini, E. (2018) *Building and environment*. accessed on <https://www.sciencedirect.com/science/article/abs/pii/S0360132317305607#:~:text=Gree+n%20fa%C3%A7ades%20can%20represent%20a%20sustainable%20solution,and%20increase%20the%20thermal%20insulation%20in%20winter.>
- *What a circular economy means for businesses* (2025). accessed on <https://amtivo.com/ie/resources/insights/what-is-the-circular-economy-and-what-does-it-mean-for-businesses/>.
- *Why choose Composite Windows?* (no date). accessed on <https://www.norrskan.co.uk/newsitem/why-choose-composite-windows.>
- *Why is permeable resin bound important? - ClearStone* (2019). accessed on <https://www.clearstonepaving.co.uk/resin-bound-gravel/why-is-permeable-resin-bound-important/#:~:text=Permeable%20resin%20bound%20paving%20allows,actively%20contributes%20to%20flood%20prevention.>
- *Why use triple glazed windows & doors?* (no date). accessed on <https://www.norrskan.co.uk/sustainability/why-triple-glazing#:~:text=Are%20triple%20glazed%20windows%20better,additional%20layer%20of%20argon%20gas.>
- Wikipedia contributors (2025) *Cradle-to-cradle design*. accessed on https://en.wikipedia.org/wiki/Cradle-to-cradle_design.
- Window Openers - Rocburn Limited (2025) *The leading window openers & ventilation specialists | Rocburn*. accessed on <https://www.window-openers.com/>.
- accessed on <https://arka360.com/ros/basic-components-of-photovoltaic-system.>
- Ashton, D. (2025a) *What is biophilic architecture? 15 real-world examples in the built environment*. accessed on <https://www.ucem.ac.uk/whats-happening/articles/biophilia-examples-built-environment/>.
- Ashton, D. (2025b) *What is biophilic architecture? 15 real-world examples in the built environment*. accessed on <https://www.ucem.ac.uk/whats-happening/articles/biophilia-examples-built-environment/>.
- Bekin, M. (2023) *All you need to know about Glulam*. accessed on <https://ecochoice.co.uk/all-about-glulam/#:~:text=Why%20is%20Glulam%20a%20Sustainable,Green%20points%20all%20around!&text=Above%20table%20based%20on%20the,is%20assumed%20to%20be%20recycled.>
- BRE (2015) *Daylight and shading, BRE Expert Collection 6*. IHS BRE Press. accessed on <https://www.brebookshop.com.>

- *BRE Bookshop* (no date). accessed on <https://www.brebookshop.com/details.jsp?id=905>.
- *BREEAM | Sustainable Building Certification* (no date). accessed on <https://breeam.com/>.
- *BS EN 15978-1* (no date). accessed on https://www.designingbuildings.co.uk/wiki/BS_EN_15978-1.
- Building Regulations 2010 (2015) *Building Regulations 2010 Approved Document M Volume 1, 2015 edition, Building Regulations 2010*. accessed on https://assets.publishing.service.gov.uk/media/5a7f8a82ed915d74e622b17b/BR_PDF_AD_M1_2015_with_2016_amendments_V3.pdf.
- Building Regulations 2010 (2021) *Building Regulations 2010 Approved Document L Volume 1, 2021 edition, Building Regulations 2010*. 2021 edition. accessed on https://assets.publishing.service.gov.uk/media/662a2e3e55e1582b6ca7e592/Approved_Document_L__Conservation_of_fuel_and_power__Volume_1_Dwellings__2021_edition_incorporating_2023_amendments.pdf.
- *CIBSE - Chartered Institution of Building Services Engineers* (no date). accessed on <https://www.cibse.org/>.
- Collins, M. (no date) *Combination cements and environment*. accessed on <https://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=194>.
- Damia Global Services (2024) 'New Smart Building Automation System Integration 2024,' *Damia Global Services Private Limited*, 4 May. accessed on <https://dgsfire.com/building-automation-system/>.
- Dr.A.J.Marsh (no date) *PD: 3D Sun-Path*. accessed on <https://andrewmarsh.com/apps/staging/sunpath3d.html>.
- *Environmental Benefits* (no date). accessed on <https://www.bucklandtimber.co.uk/environmental-benefits/>.
- *Fire and soundproofing insulation | ROCKWOOL* (no date). accessed on <https://www.rockwool.com/>.
- GmbH, R. (2022) 'Wind Assessment for Urban Planning and architecture,' *Rheologic*, 8 September. accessed on <https://rheologic.net/articles/urban-wind-assessment/>.
- Graham, K. (2024) *Is FSC or PEFC the better option? - Hazel 4D*. accessed on [https://www.hazel4d.com/articles/fsc-or-pefc/#:~:text=FSC%20is%20a%20global%20standard,criteria%20\(third%2Dparty\)](https://www.hazel4d.com/articles/fsc-or-pefc/#:~:text=FSC%20is%20a%20global%20standard,criteria%20(third%2Dparty)).
- *Green Wall specification and drawings - Biotecture* (2024). accessed on <https://www.biotecture.uk.com/design-and-specify/specifications-and-compliance/specifications-and-drawings/>.

- *Green Walls - Jakob Green Wall Solution from MMA* (2022). accessed on <https://jakob.co.uk/solutions/view/green-walls/>.
- *Home* (no date). accessed on <https://www.passivhaustrust.org.uk/>.
- Jason Slocombe, Senior Inclusive Design Consultant and Neurodiversity Design Specialist , Motionspot (2023) 'How to design spaces to better meet the needs of neurodivergent groups,' *How to design spaces to better meet the needs of neurodivergent groups*, 9 May. accessed on <https://hdsunflower.com/au/insights/post/design-accessible-spaces>.
- King, L. *et al.* (2024a) *Building Evaluation – Design proposal for medium to high rise student accommodation*.
- King, L. *et al.* (2024b) *Building Evaluation – Design proposal for medium to high rise student accommodation*.
- King, L., 2320088 (2024) *SUSTAINABLE STUDENT ACCOMMODATION IN SA1 SWANSEA*.
- Nsc (2021) *UK average embodied carbon of structural steel*. accessed on <https://www.newsteelconstruction.com/wp/uk-average-embodied-carbon-of-structural-steel-2/>.
- Nurmi, T. (2022) *Microwave sensors: How to utilize them in lighting?* accessed on <https://light.fi/microwave-sensors-utilize-lighting/>.
- Onsharp.Admin (2019) *Natural cooling strategies*. accessed on <https://cppwind.com/natural-cooling-strategies/>.
- Ove Arup & Partners Limited (2023) *Buildings & Infrastructure Priority Actions for Sustainability, Ove Arup & Partners Limited*. accessed on https://www.istructe.org/IStructE/media/Public/Resources/ARUP-Embodied-carbon-concrete_1.pdf.
- *Rain gardens / RHS* (no date). accessed on <https://www.rhs.org.uk/garden-features/rain-gardens>.
- Ramachandran, A. (2025a) 'Life-cycle assessment for green building experts explained,' *Asha Ramachandran*, 10 February. accessed on <https://oneclicklca.com/en/resources/articles/life-cycle-assessment-for-green-building-experts>.
- Ramachandran, A. (2025b) 'Life-cycle assessment for green building experts explained,' *Asha Ramachandran*, 10 February. accessed on <https://oneclicklca.com/en/resources/articles/life-cycle-assessment-for-green-building-experts>.
- Rs (2024) *Steel vs Timber vs Concrete – which is best for your project? - Tate + Co*. accessed on <https://tateandco.com/answers/steel-vs-timber-vs-concrete/>.

- Signs, D. (2023) *NHS Braille & Tactile Signs - Display Signs*. accessed on <https://www.displaysigns.net/nhs-braille-tactile-signs/>.
- *SUDS Planters: London's residential flood Solution - Meristem Design* (no date). accessed on <https://www.meristemdesign.co.uk/blog/suds-planters-londons-residential-flood-solution/>.
- Tank, N.V. (2023) *The benefits of natural ventilation and sun protection in hot climates for your home*. accessed on <https://www.linkedin.com/pulse/benefits-natural-ventilation-sun-protection-hot-climates-nitesh-tank/>.
- *TC500A Commercial Thermostat* (no date).accessed on https://buildings.honeywell.com/us/en/brands/our-brands/bms/what-we-do/field-devices/commercial-thermostats/tc500a_commercial_thermostat.
- *The SUDS manual* (no date). accessed on https://www.designingbuildings.co.uk/wiki/The_SUDS_manual.
- UK Green Building Council (no date) *Circular Economy | UKGBC, UKGBC*. accessed on <https://ukgbc.org/our-work/topics/circular-economy/>.
- Ve-Admin (2023) 'BREEAM ENE04 - Low Carbon Design explained,' *Vision Energy*, 22 February. accessed on <https://vision-energy.co.uk/breeam-ene04-low-carbon-design-explained/>.
- Vox, G., Blanco, I. and Schettini, E. (2018) *Building and environment*. accessed on <https://www.sciencedirect.com/science/article/abs/pii/S0360132317305607#:~:text=Gree+n%20fa%C3%A7ades%20can%20represent%20a%20sustainable%20solution,and%20increase%20the%20thermal%20insulation%20in%20winter>.
- *What a circular economy means for businesses* (2025). accessed on <https://amtivo.com/ie/resources/insights/what-is-the-circular-economy-and-what-does-it-mean-for-businesses/>.
- *Why choose Composite Windows?* (no date). accessed on <https://www.norrskan.co.uk/newsitem/why-choose-composite-windows>.
- *Why is permeable resin bound important? - ClearStone* (2019). accessed on <https://www.clearstonepaving.co.uk/resin-bound-gravel/why-is-permeable-resin-bound-important/#:~:text=Permeable%20resin%20bound%20paving%20allows,actively%20contributes%20to%20flood%20prevention>.
- *Why use triple glazed windows & doors?* (no date). accessed on <https://www.norrskan.co.uk/sustainability/why-triple-glazing#:~:text=Are%20triple%20glazed%20windows%20better,additional%20layer%20of%20argon%20gas>.

- Wikipedia contributors (2025) *Cradle-to-cradle design*. accessed on https://en.wikipedia.org/wiki/Cradle-to-cradle_design.
- Window Openers - Rocburn Limited (2025) *The leading window openers & ventilation specialists / Rocburn*. accessed on <https://www.window-openers.com/>.