CONSTRUCTION TECHNOLOGY 2

Proposed satiability plan



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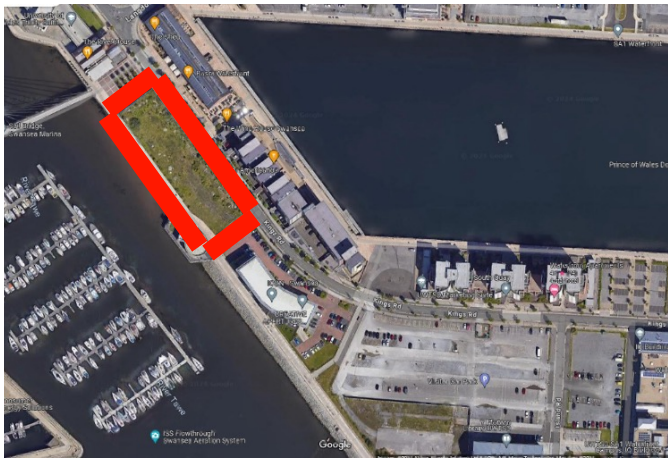
Introduction

This report builds upon the technical design for a high-rise student accommodation located in Swansea Waterfront (SA1). The project is designed to meet the housing needs of students attending the University of Wales Trinity Saint David. In this phase, the focus is on assessing the sustainability of the building, examining its environmental impact, integration of green technologies, and flexibility for future use. The structure is supported by a combined pile and raft foundation, addressing the poor soil conditions at the site. The superstructure features an outrigger frame, a triple-glazed curtain wall façade, and high-performance rigid foam insulation. This report evaluates the environmental performance of these elements and proposes enhancements through strategies such as façade greening and Sustainable Urban Drainage Systems (SUDS).

Environmental Impact

Building Orientation

The building is oriented to maximise natural light and ventilation, with the primary façade facing south to capture sunlight. This orientation reduces the need for artificial lighting and heating, thereby enhancing energy efficiency. Additionally, the use of a triple-glazed curtain wall with a low U-value further improves the thermal performance of the building, reducing the need for additional heating during colder months. Proper building orientation not only maximises natural light but also ensures efficient ventilation and reduces reliance on energy-consuming mechanical systems. According to the **Essex Design Guide**, a building's orientation significantly influences solar gain, allowing the structure to benefit from passive solar heating while preventing overheating during the warmer summer months. The guide stresses that buildings should be aligned to take advantage of both solar exposure and prevailing winds, which can aid natural cooling (Essex Design Guide, 2025). Similarly, **Venturewell Sustainability Workshop** emphasises that thoughtful site orientation can enhance energy efficiency by reducing reliance on artificial systems and promoting the building's sustainability over time (Sustainability Workshop, 2025).



Developing plot of land (SA1)

To manage solar gain and prevent overheating during the summer months, a range of shading devices will be incorporated, including external adjustable louvers, which will provide flexibility in blocking direct sunlight while still allowing natural light to penetrate. Green walls with climbing plants will be used on the north-west façade to

provide additional shading and enhance the building's aesthetic appeal, while also improving air quality and promoting biodiversity. Retractable solar canopies on terraces and roofs could further optimise shading, and dynamic shading systems such as electrochromic glass will offer adjustable levels of solar gain based on external conditions. These strategies will ensure that the building maintains optimal energy efficiency throughout the year while preventing excessive heat gain in the summer periods.

Life Cycle Assessment

The design considers a 50-year lifespan, during which durable materials have been chosen for long-term stability and minimal maintenance. Reinforced concrete is used for the structural components, ensuring the building's resilience over time. The triple-glazed curtain wall and rigid foam insulation are selected for their high performance in thermal regulation, contributing to the building's energy efficiency. Furthermore, regular maintenance protocols will be in place to ensure the longevity of these materials, reducing the need for costly replacements or repairs.

Whole Life Carbon Assessment

Embodied carbon and operational carbon are key considerations in the building's life cycle. Strategies to minimise embodied carbon are implimented by selecting durable, low-carbon materials. The operational carbon is mitigated by employing energy-efficient systems, such as high-performance insulation and the building's passive design features that enhance natural heating and cooling.

Aesthetics

The building features a modern aesthetic with a glass curtain wall that contributes to its visual appeal while maintaining functionality and energy efficiency. The transparency of the façade enables natural light to penetrate deep into the building, enhancing the living environment. This design fits well within the SA1 waterfront's urban environment, offering a contemporary structure that balances aesthetics with environmental responsibility. The choice of materials and the building's proportions are carefully considered to ensure that the structure is visually appealing while also being highly functional.



Wind Loading Analysis

Wind Load Principles

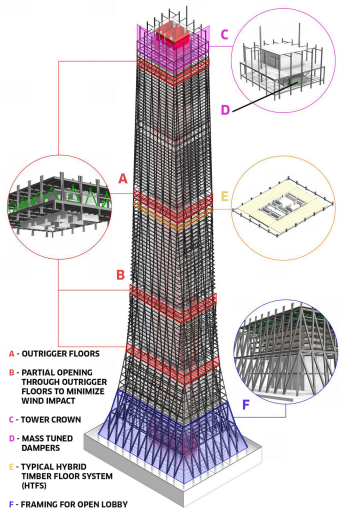
Wind loading is a critical consideration in the structural stability of high-rise buildings, particularly in coastal areas. The proposed building in SA1 will be exposed to high wind speeds due to its location near the waterfront. As such, wind loading has been factored into the design to ensure the building's structural integrity and occupant safety.

Wind Load Calculation

Wind loads on the building are calculated using the principles of BS EN 1991-1-4. The basic wind speed for the Swansea region is 23 m/s, and the design pressure has been determined as 0.33 kN/m². This calculation is adjusted for factors like building height, exposure, and terrain. The wind load model ensures that the building is able to withstand the expected wind forces, particularly in the coastal setting.

Wind Management Strategies

The outrigger structural system plays a key role in enhancing lateral stability against wind loads. This system, coupled with aerodynamic modifications such as rounded corners, reduces wind pressure on the building. Additionally, tuned mass dampers are incorporated to control building sway and resonance, ensuring that the building remains stable even under high wind conditions. Canopies and podiums are also included in the design to deflect downwash, preventing disruption in pedestrian areas.



Buildability Analysis

Buildability

Buildability refers to the ease and efficiency with which a building can be constructed, focusing on streamlining the process and minimising delays or complications. In the design of this project, several principles have been carefully integrated to enhance constructability. By adopting a simple and straightforward design approach, complexity is kept to a minimum, allowing for faster decision-making and fewer potential problems during construction. This principle ensures that the construction process remains as efficient as possible, with clear instructions and fewer unexpected hurdles. Additionally, the use of **standard prefabricated components**—such as modular structural elements, pre-formed wall panels, and pre-assembled plumbing or electrical units—further contributes to reducing construction time and ensuring consistent quality control. Prefabrication allows many of the components to be built off-site under controlled factory conditions, where precision and quality can be better ensured. This not only reduces the risk of errors on-site but also makes the overall construction process faster, more predictable, and cost-effective. Prefabrication also allows for better planning and coordination of construction activities, which reduces the impact of weather delays and ensures a smoother workflow during the build.

Material Selection

The selection of materials is crucial to ensuring both the sustainability and efficiency of the construction process. In this project, durability and sustainability are prioritised to create a building that performs well over its lifecycle while minimising environmental impact. The structure uses **reinforced concrete** for the foundation and structural components, which provides strength, stability, and longevity. Concrete is known for its durability and resistance to wear, and its thermal mass properties help regulate indoor temperatures by absorbing heat during the day and releasing it at night, reducing the need for mechanical heating or cooling. The **triple-glazed curtain wall** is another key material in the design, selected for its energy-efficient properties. The glazing reduces heat loss in colder months while minimising heat gain in warmer months, improving thermal comfort and energy efficiency. The use of **high-performance rigid foam insulation** further enhances the building's energy performance by providing excellent thermal resistance, which reduces the need for artificial heating and cooling. To minimise environmental impact, materials that are readily available and locally sourced have been prioritised. This approach not only reduces transportation emissions but also supports the local economy. Additionally, the use of **prefabricated elements**, such as modular structural components and pre-assembled wall panels, reduces the amount of on-site construction, which streamlines the build process and minimises waste. The precision of prefabricated components helps ensure higher quality and efficiency during construction, while reducing overall material waste. These material choices align with the project's goals of creating a sustainable, durable, and energy-efficient building that has minimal impact on the environment throughout its lifecycle.



Integration of Trades

The design has been carefully coordinated to avoid conflicts during the construction process. This ensures that all trades can work seamlessly, leading to reduced delays and increased safety.

Compliance with CDM Regulations

The design complies with Regulation 9 of the Construction (Design and Management) Regulations (CDM), ensuring that risks are identified and controlled from the design stage. The construction sequence has been carefully planned, with a storyboard to guide safe and efficient work practices.

Construction Methods

To enhance efficiency and quality control, modular construction and prefabrication are employed. Prefabricated façade panels and structural components reduce on-site construction time and ensure that all elements meet stringent quality standards.

Health and Safety Considerations

Health and safety during construction are prioritised by incorporating measures such as fall protection, clear access routes, and emergency response plans. The design also integrates CDM principles to prevent accidents and ensure a safe working environment.

Façade Greening and SUDS

Green Facades

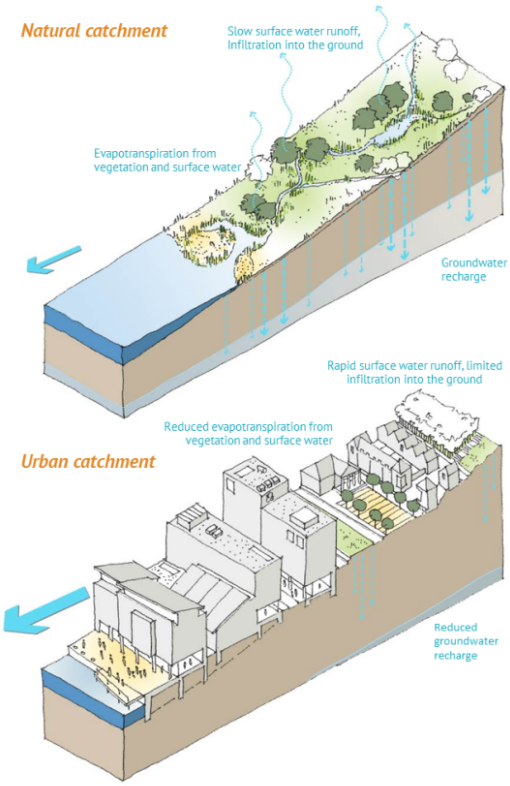
Façade greening, through the use of climbing plants or green walls, is proposed on the north-west façades of the building. This approach offers several environmental benefits. Green facades help to improve air quality by absorbing CO2 and producing oxygen. They also contribute to the building's thermal regulation, reducing the need for mechanical cooling in the summer months. The addition of vegetation also enhances the aesthetic appeal of the building, providing a natural contrast to the urban environment. Furthermore, green facades promote biodiversity by offering habitats for insects and birds.

Sustainable Urban Drainage Systems (SUDS)

To manage surface water runoff sustainably, the site will integrate a range of **Sustainable Urban Drainage Systems (SUDS)** methods designed to mimic natural water management processes. These systems are essential for reducing the burden on local drainage infrastructure, mitigating flood risks, and improving the environmental quality of the surrounding area. According to the **British Geological Survey (BGS)**, SUDS are effective in mimicking natural drainage regimes, which help to reduce the impact of urbanisation on water environments and control water pollution by filtering out contaminants (BGS, 2025). Additionally, **Susdrain** highlights that SUDS offer significant benefits by providing not only flood risk reduction but also improving water quality, supporting biodiversity, and enhancing the aesthetic value of urban spaces (Susdrain, 2025). A notable example of SUDS implementation is the Queen Mary's Walk scheme in Llanelli, which involved the construction of a 100-metre-long planted swale and a planted basin on Regalia Terrace. This project successfully reduced peak flow rates entering the combined sewer network by approximately 77%, demonstrating the effectiveness of SUDS in managing urban runoff (Susdrain, 2025).

Permeable paving will be implemented across walkways, parking areas, and other hard surfaces, allowing rainwater to filter through the material, reducing surface runoff and

promoting **groundwater recharge**. This method helps mitigate the ‘urban heat island effect’ and enhances water retention in the local environment.



Rain gardens will be strategically placed across the site to filter rainwater before it enters the drainage system. These gardens, featuring water-tolerant plants, will capture pollutants and slow the flow of stormwater, preventing erosion and reducing the load on downstream infrastructure.

Retention basins will be used to store excess water during periods of heavy rainfall, helping to prevent flooding by regulating the rate at which water is released into the drainage system. These basins will also contribute to improving water quality by allowing water to settle before being discharged.

Swales, vegetated channels designed to direct and filter water, will help manage surface water flow and promote infiltration. These swales will be placed in areas where stormwater flow is expected to be greatest, slowing down the movement of water and allowing it to be absorbed into the ground. Additionally, a **rainwater harvesting system** will collect runoff from the roof and other impermeable surfaces. This harvested water will be stored for **non-potable uses** such as irrigation, toilet flushing, and cooling, thus reducing the building's demand for potable water. Collectively, these SUDS solutions will not only mitigate surface water runoff but also improve resilience to extreme weather events, enhance local biodiversity, and contribute to a more sustainable urban environment.

SUDS Design Calculations

To design an effective **Sustainable Urban Drainage System (SUDS)**, it's essential to calculate both the **peak runoff rate** and the **storage volume** to ensure the system can handle stormwater runoff during heavy rainfall events. Below is an explanation of the key calculations involved in the SUDS design process for the proposed site.

Peak Runoff Rate Calculation

The **peak runoff rate** is the maximum rate at which water will flow from a catchment area during a rainfall event. This is an important calculation for sizing drainage components such

as retention basins, swales, and permeable paving systems. The formula used for calculating the peak runoff rate is:

$Q = 2.78 \times C \times I \times A$ *(See appendix for formula breakdown)*

$Q = 2.78 \times 0.75 \times 17 \times 1.01$

$Q = 2.78 \times 0.75 \times 17 \times 1.01 = 49.0 l/s$

The **peak runoff rate** for this catchment area is **49.0 liters per second (l/s)**.

This value helps determine the sizing of the drainage systems (such as retention basins, swales, and permeable paving) to ensure they can handle the stormwater during the peak runoff event.

Storage Volume Calculation

Next, the **storage volume** needs to be calculated to ensure that the drainage system can temporarily store excess water during peak rainfall events and release it slowly to prevent flooding. The storage volume can be calculated using the formula:

$V = (I_{inflow} - I_{outflow}) \times Duration$ *(See appendix for formula breakdown)*

$V = (0.049 - 0.0051) \times 3600$

$V = (0.049 - 0.0051) \times 3600 = 0.0439 \times 3600 = 158.0 m^3$

The **storage volume required** to manage the runoff during peak rainfall events is **158.0 cubic meters (m^3)**. This volume of water will need to be temporarily stored in the retention basins and slowly released into the drainage system to prevent flooding.

Importance of Sizing for Flood Mitigation

The calculations for peak runoff and storage volume are crucial for sizing the drainage infrastructure, ensuring that the systems can manage stormwater efficiently during heavy rainfall events. Without sufficient storage capacity, there could be a risk of flooding, damage to property, and strain on local drainage networks. These calculations help ensure that SUDS systems are properly sized to handle typical and extreme weather conditions, contributing to flood resilience and sustainable water management practices.

Flexibility in Design and Use

Incorporating Flexibility for Changing User Needs

The building's design is developed with flexibility in mind, anticipating potential changes in user needs over its lifetime. The student accommodation is designed with modular layouts that can be easily adapted to suit varying numbers of occupants or different types of living arrangements. The internal spaces are open and flexible, with partition walls that can be relocated or removed as needed, providing the possibility of converting rooms into larger or smaller units depending on future demand. Additionally, the building's electrical and plumbing systems are designed to allow easy reconfiguration of internal layouts without extensive renovation work, ensuring minimal disruption and cost-effective adjustments. The ground floor is designed with larger, open communal areas that can be repurposed for different uses, such as social spaces, study areas, or retail outlets, depending on the changing needs of future users. By incorporating these flexible elements into the design, the building can adapt to various changing requirements, whether related to the user demographic or to societal shifts in how spaces are used.

Potential Alternative Future Uses

While initially intended for student accommodation, the design of the building allows for potential alternative future uses. The building's structural flexibility and adaptable internal layouts make it suitable for conversion into other types of residential accommodation, such as apartments or mixed-use housing. In the event that student housing demand decreases, the building could be easily converted into workforce housing or short-term accommodation for tourists or professionals. The integration of SUDS and green facades will continue to offer environmental benefits regardless of the building's use, contributing to sustainable development even if the buildings primary function changes. Furthermore, the ground-floor commercial space could be repurposed for retail, cafes, or office spaces, enhancing its potential for mixed-use development. These alternative uses reflect the building's long-term sustainability, as its design ensures it can evolve with future needs while maintaining functionality and energy efficiency.



Conclusion

This report has detailed the design and implementation of a robust foundation system, an efficient structural system, an advanced building envelope, and compliance with fire safety regulations. The sustainable approach to surface water management through SUDS, along with the integration of green technologies like façade greening, ensures that the building is not only environmentally responsible but adaptable for future uses. The design focuses on creating a safe, sustainable, and flexible living environment for students at SA1 Swansea Waterfront, balancing the demands of modern architecture with the principles of sustainability and long-term usability.

Appendix

Formulas

Peak Runoff Rate

$$Q=2.78\times C\times i\times A$$

- **Q** = Peak runoff rate (m^3/s)
- **C** = Runoff coefficient (dimensionless), which represents the fraction of rainfall that becomes surface runoff. It varies depending on the land use, vegetation, and the type of surface in the catchment area. For urban areas with impervious surfaces, a typical value for C is 0.75.
- **i** = Rainfall intensity (mm/h), which is the rate of rainfall for the area in millimetres per hour. In this case, the assumed rainfall intensity is 17 mm/h, based on local climate data for a typical storm event.
- **A** = Catchment area (ha), which is the total area from which rainfall will runoff. For this design, the catchment area is 1.01 hectares (1.01 ha), equivalent to 10,100 m^2.

Storage Formula

$$V=(I_{inflow}-I_{outflow})\times Duration$$

- **V** = Storage volume required (m^3)

- **i inflow** = Inflow rate (m^3/s), which is the peak runoff rate calculated earlier (49.0 l/s or 0.049 m^3/s).
- **i outflow** = Outflow rate (m^3/s), which is the rate at which water can be released from the system. For this example, we will assume that the outflow rate is 5.11 l/s (0.0051 m^3/s).
- **Duration** = The time over which the storage is required, typically measured in seconds or hours. For the purposes of this calculation, we will assume a 1-hour (3600 seconds) duration of peak rainfall.

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