



Case Study Report with Drawings

ADVANCED CONSTRUCTION TECHNOLOGY

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INTRODUCTION

BRIEF DESCRIPTION OF THE ALEX BUILDING

The Alexandra Road Building in Swansea is a prominent Grade 2 listed structure with significant architectural, educational, and cultural importance. Originally constructed in 1887 as the Swansea Public Library and Art School, the building was designed by architect Henry Holtom in the Italian Classical style. Which over the years, it has evolved to meet the changing needs of the city, serving a variety of educational and community functions while retaining many of its historic features.

During the 1930s and again in the 1960s, the building was extended to accommodate a wider range of educational activities. It continued to serve as Swansea's central library until its relocation in 2007, at which point the site became available for redevelopment.

Later that year, Swansea Metropolitan University, now part of the University of Wales Trinity Saint David (UWTSD), undertook a major refurbishment and extension project. This transformation converted the historic building into a modern educational facility, providing specialist teaching spaces for disciplines such as Glass, Digital Media, Automotive Engineering, and Product Design, while also promoting collaboration between academia and industry.

One of the building's most distinctive features is the circular reading room located at its centre. Originally serving as the main library reading room, this impressive domed space remained in use until the library's closure in November 2007. The building has also gained wider recognition through its cultural associations, as a filming location for the BBC television series Doctor Who, appearing in the episodes Silence in the Library and Forest of the Dead. Furthermore, it was known to be a favourite place of the renowned Welsh poet Dylan Thomas, adding to its historical and cultural significance.



Figure 1 – Site Visit, 15 June 2026 - main library reading room

The building also played a role in Swansea's wartime history. During the Three Nights Blitz between 19 and 21 February 1941, extensive bombing raids which devastated much of Swansea city centre. The Alexandra Building, then operating as Swansea Central Library, suffered significant damage, particularly to its cupola, the small tower. In which the building survived the attacks, the damaged cupola remained unrepaired and largely concealed for more than seventy years.

As part of a £9.69 million redevelopment project completed in 2015, the building was transformed into the Alex Design Exchange. Which a key element of this restoration was the reconstruction of the historic cupola, returning a prominent architectural feature that had been lost since the wartime bombing. The project successfully restored the building closer to its original 1887 appearance while ensuring its continued use as a modern educational and creative hub.

(Peters, K. (2021). *Swansea Bay News*. [online])

(Wikipedia Contributors (2026). *Old Swansea Central Library*. Wikipedia.)

THE ROLE OF BUILDING INFORMATION MODELLING (BIM) AND DIGITAL TECHNOLOGIES IN PLANNING, RISK MITIGATION, MAINTENANCE, RETROFIT, REPAIR AND REFURBISHMENT

BIM can be implemented in the Alex building, which can improve collaboration, efficiency and decision-making throughout the asset lifecycle. BIM also provides a central source of accurate information that can be shared between designers, contractors and facilities managers, reducing errors and improving coordination. Which, BIM can also support building maintenance by storing asset data, operation manuals and maintenance records in one accessible location. Moreover, BIM assists retrofit and refurbishment projects by providing accurate building information, enabling better planning and more sustainable asset management.

(BSI (2022). *ISO 19650 - Building Information Modelling (BIM)*. [online])

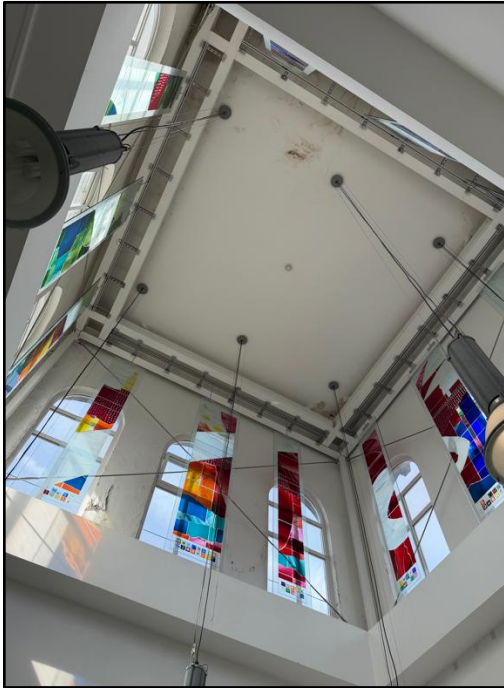
With BIM technology implemented in the Alex Building, planned and unplanned maintenance can be managed through a single platform. In which maintenance schedules, asset information and service histories can be stored within the BIM model, allowing staff to quickly access information and respond to faults. This would improve efficiency, reduce time and support a better lifecycle management for the building.

How can maintenance be classified as?

- Planned Maintenance: Regular servicing and inspections to meet legal requirements (e.g. boiler servicing).
- Preventative Maintenance: Work carried out to prevent failures and extend asset life (e.g. replacing damaged roof tiles).
- Corrective Maintenance: Repairs undertaken after a fault or failure has occurred (e.g. fixing broken windows or guttering).

- Front-Line Maintenance: Maintenance completed while the building remains occupied and operational (e.g. decorating occupied areas).
- PPM (Planned Preventative Maintenance): Scheduled maintenance activities recorded on a maintenance programme to reduce unexpected breakdowns.

(Thomas, R. (2026) Building Maintenance. PowerPoint presentation. UWTSD University of Wales, Trinity St Davids)



During the site visit, evidence of water ingress damage was observed within the cupola. If BIM technologies had been implemented, routine inspections and condition assessments could have been scheduled and monitored digitally. Which this proactive approach may have identified defects at an earlier stage, allowing preventative maintenance to be undertaken and reducing the risk of water penetration and subsequent damage to the building.

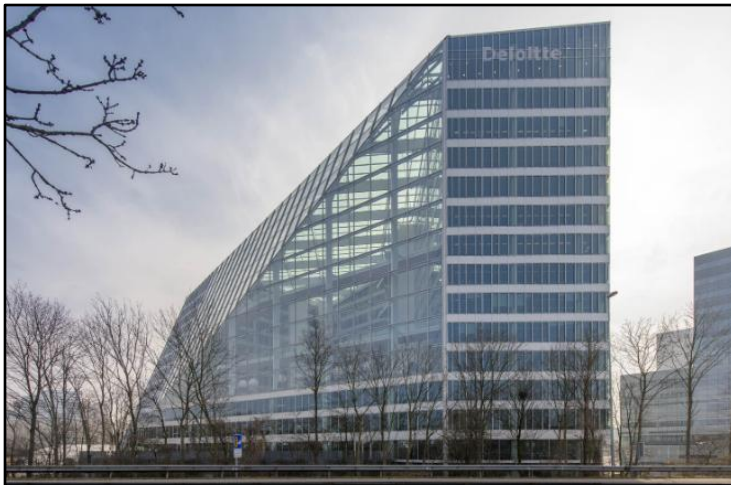
External drone surveys can also be used to assess the external areas of the building. Which, external drone surveys provide a safe and efficient method of inspecting hard to reach areas of a building, such as roofs, cupolas, and high-level façades. Which by integrating a drone survey the data can be added to BIM technology, building conditions can be monitored regularly, enabling early detection of defects, supporting preventative maintenance, and reducing the risk of costly repairs. (francois.pierrel (2026). *Seamless Synergy: Integrating Drone Inspection Data With BIM Models* | AAI-Drones)

*Figure 2 - Site Visit, 15 June 2026
Cupola, the small tower – Water
Ingress*

BIM - CASE STUDY

The Edge in Amsterdam is widely recognised as a leading example of how BIM can support the development and operation of a smart building.

From a BIM perspective, The Edge demonstrates how a digital model can be used beyond the design. In which the construction stages support facility management and building operation.



Information from thousands of sensors throughout the building can be linked to building management systems, providing data on occupancy, energy consumption, temperature, lighting, and maintenance requirements.

Figure 3 - Peng, S. (2025). The Edge, Amsterdam: The World's Greenest and Smartest Office Building - Welcome.

Key BIM-related features include:

- Digital asset management through a centralised building information model.
- Integration with smart sensors, allowing building performance to be monitored in real time.
- Data driven facilities management, enabling proactive maintenance and operational decision-making.
- Energy performance monitoring, supporting sustainability objectives and reducing operational costs.
- Occupancy analysis and space utilisation, helping optimise workplace efficiency.

(The Edge | Projects. (2026). [online] *Plparchitecture.com*)

Which these smart BIM features could be implemented within the Alex Building. By monitoring classroom occupancy, lighting, temperature, and energy use, the system could optimise space utilisation and automatically adjust building services to improve comfort, reduce energy consumption, and enhance overall operational efficiency.

INSULATION UPGRADES:

As the building is Grade 2 listed, there are restrictions on the type of alterations that can be undertaken to ensure its historic and architectural significance is preserved. Which as a result, measures such as External Wall Insulation (EWI) will not be appropriate, as they would alter the external appearance and character of the building.

However, Internal Wall Insulation (IWI) can be installed within a Grade II listed building where it can demonstrate that the works will not affect the building's historic character or significance.

As IWI is installed internally, it is often considered a more appropriate solution than EWI, which can alter the external appearance of the building.

(Listed building consent | Cadw. (2023).
[online] *Gov.wales*. Cadw)

The InteriA - A2 Internal Wall Insulation (IWI) System would be proposed to be installed by Wetherby.

InteriA is Wetherby Wall Systems Internal Wall Insulation (IWI) system, designed to improve the thermal performance of solid wall buildings while maintaining high standards of fire safety and moisture management. The system uses non-combustible stone wool insulation and a vapour-open design to help reduce the risk of condensation, damp, and mould.

It is particularly suitable for:

- Grade 2 listed and heritage buildings.
- Properties where external insulation is not permitted.
- Solid wall construction.

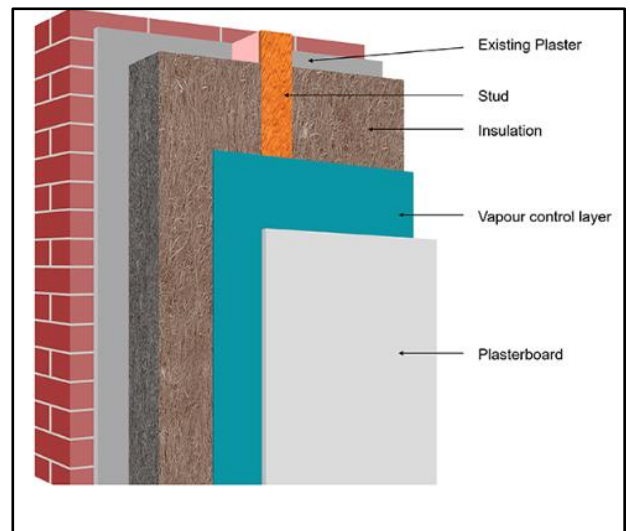


Figure 4: Energy Efficiency Matters - Internal Wall Insulation. (2021).



- Refurbishment and energy efficiency improvement projects.
- BS EN 13501-1 - European standard used to classify the reaction to fire performance of construction products and building materials. (BS EN 13501 - Fire classification (2025). [online])

With InteriA installed to the Alex Building it will provide improved thermal efficiency whilst preserving the building's historic external appearance, subject to conservation requirements and any necessary listed building consent.

(InteriA Internal Wall Insulation | Wetherby Wall Systems. (2026). [online])

Figure 5 - Site Visit, 15 June 2026 – Classroom – Proposed IWI installation to rooms

RETRO FITTING METHODS:

Methods of retro fitting which could be proposed to be installed into the Alex building:

- Upgrade existing windows to high-performance double or triple glazing, where permitted, to improve airtightness, thermal efficiency, and occupant comfort.
- Install Air Source Heat Pump (ASHP) to provide a low-carbon heating solution and reduce long-term energy and operating costs.
- Introduce modern photovoltaic (PV) panels and battery storage systems to generate renewable energy and improve energy resilience.
- Replace existing lighting with energy-efficient LED fittings to lower electricity consumption and reduce maintenance requirements.
- Implement cool roof or green roof systems, where feasible, to minimise heat gain, reduce the urban heat island effect, and improve summer cooling performance.
- Carry out draught-proofing measures around doors, windows, and other openings to reduce heat loss and improve building efficiency.
- Upgrade or install a modern HVAC system to provide effective heating, ventilation, and cooling, improving indoor comfort, air quality, and energy performance throughout the building.

THE APPLICATION OF SMART BUILDINGS, DIGITAL TWINS, ARTIFICIAL INTELLIGENCE AND ADVANCED SCANNING TECHNOLOGIES TO IMPROVE ENERGY EFFICIENCY, WHOLE-LIFE PERFORMANCE, AND FACILITIES MANAGEMENT

SMART TECHNOLOGIES

Smart buildings use IoT (Internet of Things) sensors, connected systems, and AI to monitor, control, and optimise operations. Key features include automated lighting and HVAC, energy management, predictive maintenance, security and access control, real-time data analytics, occupant comfort monitoring, and improved sustainability.

IoT:

The IoT is a network of physical devices connected to the internet through sensors, software, and communication technologies. Which these devices collect and exchange data, enabling real-time monitoring, automation, and improved decision-making. IoT devices include smart thermostats, lighting systems, wearable technology, vehicles, and industrial equipment.

By communicating with each other and with cloud-based platforms, they can perform tasks automatically with minimal human intervention. IoT is widely used in homes, businesses, and cities to improve efficiency, reduce energy consumption, enhance security, and support predictive maintenance, creating smarter and more connected environments.

(IoT Solutions | IBM. (2025). [online] *Ibm.com*)

Within the building automated systems can be integrated into the building to allow for the performance and efficiency of the building to be improved. Will be proposed for a HVAC system to be installed.

“A Heating, Ventilation, and Air Conditioning (HVAC) system provides year-round environmental control by integrating heating, cooling, and ventilation into a single system. It helps maintain comfortable indoor temperatures, improves air quality through continuous fresh air circulation, and reduces humidity levels that can contribute to dampness and mould growth. Modern HVAC systems also enhance energy efficiency by automatically regulating building conditions, reducing energy waste and operating costs while improving occupant comfort, health, and overall building performance” (Intersam (2024). *HVAC System: How It Works and Benefits.*)

Which integrating this technology will ensure that all areas of the building remain comfortable, functional, and suitable for all year-round use. During the site visit, it was noted that the basement experiences excessive heat due to the plant room and machinery. An HVAC system would help reduce temperatures in these areas, improving comfort and

working conditions. In addition, the system would provide effective heating during the winter months, helping to maintain a consistent internal temperature and reducing the risk of damp and moisture penetration, which can lead to deterioration of the building fabric over time.

Other Smart Systems such as:

- Building Management System (BMS) - Central control of building services and performance.
- Smart Lighting Systems - Occupancy and daylight sensors adjust lighting levels automatically.
- Energy Management Systems - Monitor and optimise energy consumption.
- Access Control Systems - Automated entry using key cards, fobs, biometrics, or mobile devices.
- CCTV and Security Monitoring – Intelligent surveillance and threat detection.
- Fire Detection and Alarm Systems - Automatic detection, notification, and emergency response.
- Smart Metering Systems - Real-time monitoring of electricity, gas, and water usage.
- Predictive Maintenance Systems - Sensors identify equipment faults before failure occurs.
- Automated Blinds and Shading - Adjust according to sunlight and occupancy.
- Lift Control Systems - Optimise lift operations and reduce waiting times.
- Environmental Monitoring Systems - Track temperature, humidity, air quality, and CO₂ levels.
- Leak Detection Systems - Automatically identify water leaks and trigger alerts.
- Parking Management Systems - Monitor space availability and control access.
- Occupancy Monitoring Systems - Track building usage to optimise space and services.

(Furnival, J. (2025). *Smart Building Technology in Commercial Property*)

Augmented Reality (AR) in construction enhances the physical environment by overlaying digital information, such as 3D models and BIM data, onto real-world building elements. This technology allows engineers, contractors, and construction teams to visualise project designs in real time and at a high level of accuracy directly on site. By comparing digital models with physical construction work, AR can help reduce errors, minimise material waste, and prevent costly rework, resulting in improved project efficiency and quality.

Key Applications and Benefits of AR in Construction:

- **On-Site Verification and Quality Assurance (QA):** AR enables construction teams to overlay digital plans onto completed work, allowing them to verify that installations have been carried out correctly and within specified tolerances before progressing to the next stage.
- **Clash Detection:** Using tablets, smartphones, or smart glasses, workers can visualise future installations and identify potential conflicts between building services, such as HVAC systems, electrical conduits, and plumbing networks, before construction is completed.
- **Safety Training and Site Planning:** AR provides interactive and immersive training experiences by simulating hazardous situations within a controlled environment. This helps workers understand potential risks and improves preparedness for real-world construction site conditions.
- **Improved Communication and Collaboration:** AR allows project stakeholders to better understand design intent, reducing misunderstandings between designers, contractors, and clients.
- **Enhanced Maintenance and Facility Management:** Following project completion, AR can be used alongside BIM models to assist facilities management teams in locating building services, planning maintenance activities, and managing assets throughout the building's lifecycle.

(Anon, (2023). [online] *Rics.org*)

Drones and scanning technologies are transforming the construction industry by improving the efficiency of surveying, progress monitoring, and site inspections. Using advanced reality-capture technologies such as aerial photogrammetry and LiDAR scanning, construction teams can quickly produce accurate topographical surveys, detailed 3D models, and digital twins of existing assets. These technologies reduce the need for manual surveying, improve data accuracy, and enable more effective comparison between the constructed asset and the original design.

Core Technologies:

- **Photogrammetry** - Drones capture a series of overlapping photographs that are processed to create accurate 2D Ortho mosaic maps and detailed 3D models of buildings, landscapes, and construction sites.
- **LiDAR (Light Detection and Ranging)** - Utilises laser pulses to measure distances and elevations with a high degree of accuracy. LiDAR is particularly effective for surveying complex structures, mapping heavily vegetated areas, and producing detailed 3D representations of buildings and infrastructure.

- Thermal Imaging and Multispectral Sensors - These technologies enable drones to detect heat loss, moisture ingress, electrical faults, and hidden defects within building roofs, façades, and other structural elements, supporting preventative maintenance and building performance assessments.

Benefits in Construction

- Improved surveying accuracy and data collection.
- Reduced time and costs associated with traditional inspections.
- Enhanced health and safety by minimising work at height.
- Early identification of defects and maintenance requirements.
- Creation of digital twins for Building Information Modelling (BIM) integration and asset management.
- Improved monitoring of construction progress and quality assurance throughout the project lifecycle.

Joos Vermolen (2026). *Drone mapping for construction*. [online]

DroneDeploy (2025). *The rise of drone mapping in construction: speed, accuracy and efficiency from the sky*. [online]

SMART BUILDINGS – CASE STUDIES



Figure 6 - GLUMAC: SHANGHAI HQ - Glumac. (2016). Johnson Controls - Glumac.

Glumac's Shanghai Headquarters is a 6,450 sqft. sustainable retrofit project located within a 100-year-old historic mansion in Shanghai's Chang Ning District. Designed by Gensler.

The office operates as a living laboratory for sustainable design, demonstrating how historic buildings can be adapted.

Key features include biophilic design principles, incorporating a living green wall and extensive natural daylight to enhance occupant wellbeing. Rooftop solar panels enable the office to generate more energy than it consumes, while innovative water systems and composting toilets support net-positive water performance. Additionally, the project prioritised sustainable material selection, utilising salvaged, recycled, and locally sourced materials while avoiding products containing harmful chemicals. In which overall, the headquarters showcases how innovative retrofit strategies can transform historic buildings into highly sustainable, energy-efficient workplaces.

(Glumac. (2016). Johnson Controls - Glumac.)

CONCLUSION – HOW TO INTERGRATE EMERGING TECHNOLOGY WITHIN THE ALEX BUILDING

With the points outlined above, there are a range of emerging technologies available that can enhance the performance, efficiency, and sustainability of older buildings.



With PV panels already been installed on the building. However, the visible build-up of dirt and debris suggests that the panels may not be included within a planned maintenance schedule. A lack of regular cleaning can reduce the efficiency and energy output of the system. The introduction of BIM would enable maintenance activities to be recorded and monitored digitally, allowing facilities management staff to track when inspections, cleaning, and servicing tasks were last completed and when future maintenance is required.

Figure 7 - Site Visit, 15 June 2026 – Elevator room top floor

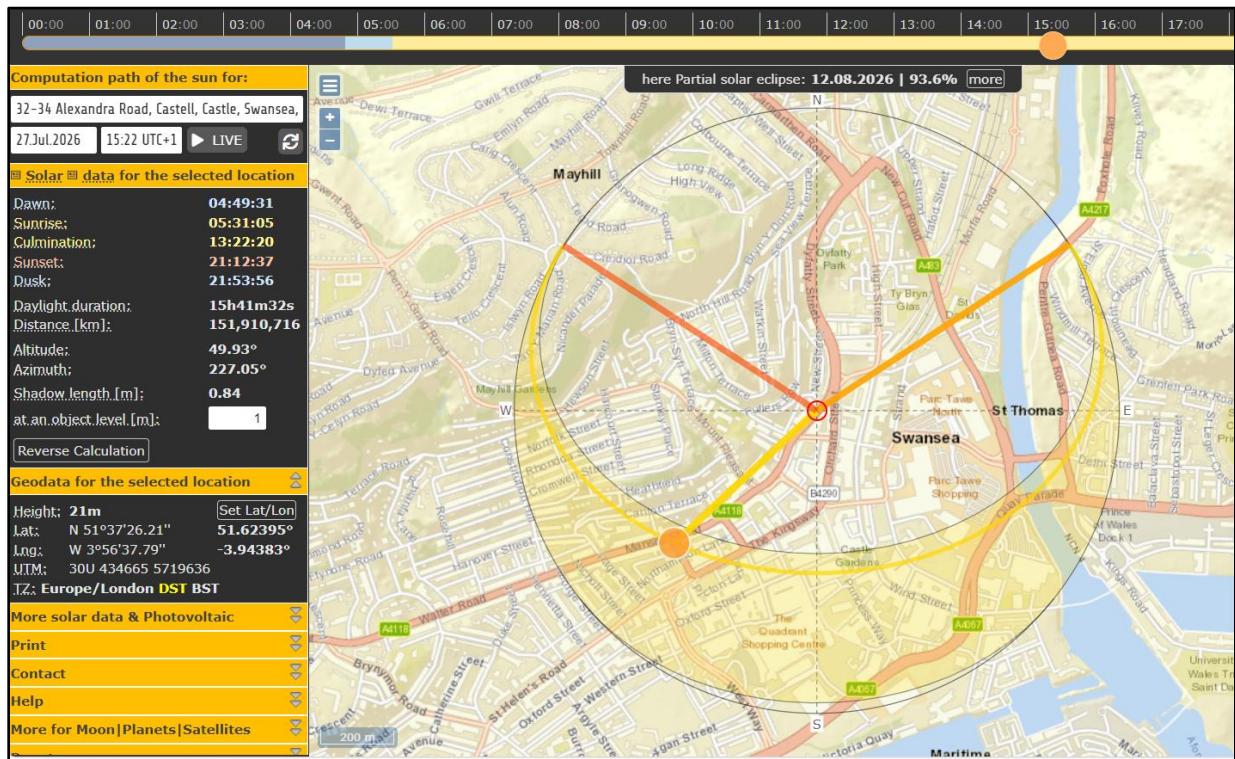


Figure 8 - Suncalc.org. (2026). SunCalc sun position- und sun phases calculator.



Figure 9 - Site Visit, 15 June 2026 – Lobby Room Office spaces

Due to the building's south-facing orientation, significant passive solar heat gain is likely to occur, particularly during the summer months. This can lead to elevated indoor temperatures, resulting in uncomfortable conditions for occupants and potentially reducing productivity. In which to address this, automated window actuators could be installed to provide natural ventilation by releasing excess heat when internal temperatures rise above predetermined levels. These actuators can be linked to temperature and occupancy sensors, allowing windows to open and close automatically in response to environmental conditions. This smart building solution would improve occupant comfort, reduce overheating, and minimise reliance on mechanical cooling systems, thereby improving the building's overall energy efficiency.

By incorporating technologies such as BIM, IoT sensors, Smart Building Management Systems (BMS), automated ventilation controls, drone surveys, and PV monitoring systems, the building can be significantly improved by its facilities management. These technologies can enable real time monitoring of building performance, allowing facilities managers to identify issues quickly and respond proactively, rather than relying on reactive maintenance. In which this will improve the building life cycle and use of the building.

Additionally, by using smart building technologies it can help ensure students, staff, and facilities management teams can use the building to its full potential. Which occupancy sensors can monitor room usage and integrate online booking systems, allowing spaces to be reserved efficiently. This approach, is like technology used in The Edge, which helps maximise space utilisation, improve user experience, reduce energy consumption, and support more effective facilities management.

Also, by introducing Retro fit technologies, such as window upgrades, insulation upgrades, ASHPs and PV panels this would support Wales's Net Zero objectives. These improvements would enhance the building's energy performance, lower operating costs, reduce reliance on fossil fuels, and be more sustainable.

(Welsh Government (2022). Net Zero Strategic Plan.)

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Wikipedia Contributors (2026) Old Swansea Central Library. Wikipedia.

Appendix

Figure 1 – Site Visit, 15 June 2026 - main library reading room

Figure 2 - Site Visit, 15 June 2026 Cupola, the small tower – Water Ingress

Figure 3 - Peng, S. (2025). The Edge, Amsterdam: The World's Greenest and Smartest Office Building - Welcome. [online] Welcome -. Available at: <https://architalks.org/the-edge-amsterdam-the-worlds-greenest-and-smartest-office-building/> [Accessed 27 July 2026].

Figure 4 - Energy Efficiency Matters - Internal Wall Insulation. (2021). [online] Energy Efficiency Matters. Available at:
<https://energyefficiencymatters.co.uk/measures/insulation/internal-wall-insulation/> [Accessed 27 July 2026].

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