

University of Wales Trinity St. David



Sustainable Architecture

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“Lampeter University Sustainability Cold Bridge Upgrades”

By

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(Author, 2017)

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1.1 Introduction

As political agendas are revised to cater for increased greenhouse gas emissions, architecture is at the forefront of advances in energy efficiency and sustainable design. With the construction industry contributing an estimated 47% of total UK CO₂ emissions (Gieseckam et al. 2014), routes have been made into the holistic outlook on building design and form over its lifecycle. Often referred to as the cradle to grave approach.

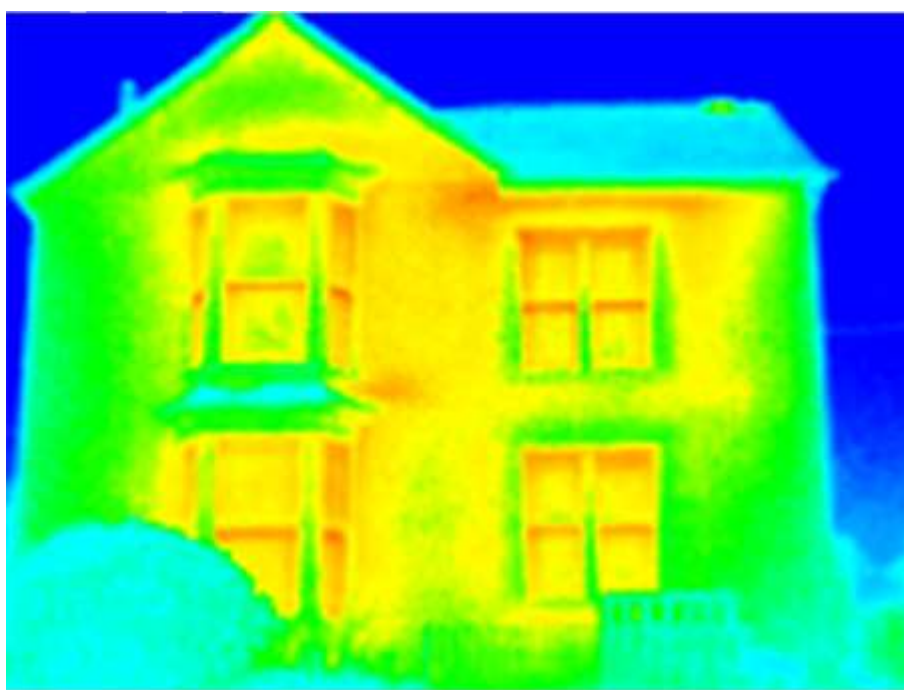


Figure 1.1.1: A traditional Buildings Heat Loss via a Thermal Camera (Author, 2017)

The leads to the effect of unsustainable harvest of natural resources for energy provisions and the during the construction/retrofit process, which is predicted to reach 100 billion tonnes per year by 2030 (Sayigh, 2014), Older buildings which account for 35% of the UK housing stock (Ghosh et al. 2017) are often highly inefficient in terms of sustainability, therefore, energy efficiency measures can be procured to bring these structures to 21st century standards of operational efficiency.

2.1 Case Introduction

The proposal for the research is to research and suggest sustainability measures for UWTSD Lampeter Campus. The campus was erected in 1822 under the name of St. David's college, whereby education was provided to the clergy. The university was renowned for its undergraduate and post graduate programmes, which extended to English, Archaeology, Chinese, Classics, History, Theology, as well as introducing new areas such as Philosophy, Anthropology, Ancient Civilisations and Creative Writing (Uwtsd.ac.uk. 2018). Since then, the institute has merged with the UWTSD central body and continues to provide higher education courses.



Figure 2.1.1: Case Study – A View of St David's College (Mackenzie et al, 1787)

2.2 Site Study

The main Lampeter University Campus is situated at grid reference SN 57917 48222, which consists of a rectangular form with each façade fronting the four poles. The structure allows a central courtyard to be created, thus sheltering occupants from weather conditions by inducing a micro-climate. This works in favour of its usage as

the site sits on a fairly-exposed elevated location, as prevailing south westerly winds that the site experiences are dampened by its form.



Figure 2.2.1: Aerial Photograph of the site (*Map.coflein.gov.uk, 2004*)

The site is also subject to historical importance, such as the proposed siting of an historic moat, referred to as Stephen's Castle. This is located on the northern side of the main building. The main building is also listed, however for the purposes of this research, we are to assume that the listed status does not have an overbearing effect on the energy efficiency proposals but it is considered for real life scenario.

2.3 Building Composition

The areas subject to thermal upgrade include the student accommodation on the South and West elevations – referred to as Block C. The structure of the building consists of a solid stone wall with a render external finish; this wall varies in thickness from 400 to 600mm thick in areas. This composition is said to have a breathable quality, whereby the fabric is permitted to breathe using vapour permeability,

hygroscopic and capillarity of fabric in combination with controlled and uncontrolled ventilation to create a safe [internal] environment. (English Heritage, 2014). Therefore, it is imperative to understand the logistics of vapour movement through the fabric prior to the specification of insulative measures. If ignored, this may jeopardise the fabric and allow interstitial condensation to occur where the vapour reaches an impermeable component – such as the specified insulation method.

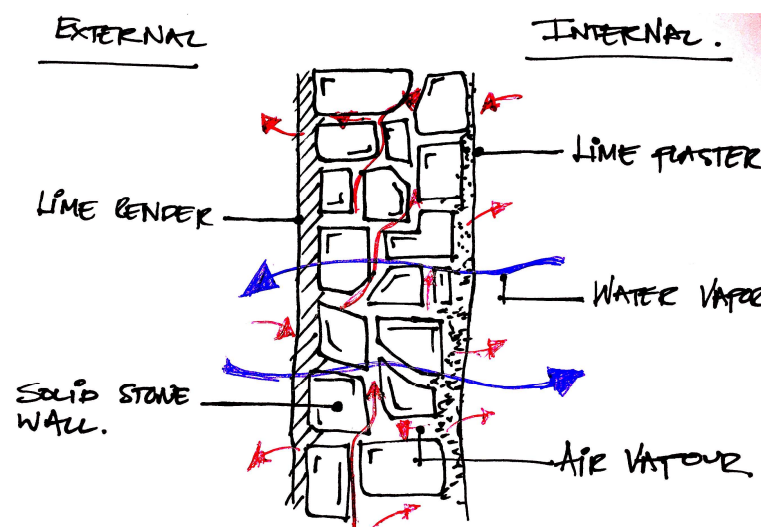


Figure 2.3.1: Cross Sectional Sketch of vapours through a traditional solid Wall
(Author, 2018)

A solid stone wall is assumed by rdSAP software that this building is categorised by age band A (before 1900), whereby the U-value is assumed at $2.0 \text{ W/m}^2\text{K}$ and is of a 500mm thick sandstone composition. (BRE.co.uk, 2012)

This offers a medium to which the calculations will be based. However, some research has suggested that rdSAP overestimates U values by 77% - whereby the actual measured reading is $1.5 \text{ W/m}^2\text{K}$ (Rye, 2014)

The article will examine existing sites of where thermal bridging is currently occurring and propose remedial works to minimise the effects of thermal bridging and reduce heat loss through elements. The thermal survey was carried out on the 3rd of December 2017 by the UWTSD Built Environment students using the Testo thermal

camera with supervision from lecturer Juan-Ferriz Papi. The external ambient temperature was measured at 5 degrees Celsius and the internal ambient temperature measured an average of 23 degrees Celsius. This variance may be due to external variables such as solar heat gain, which would have also affected the readings on the image due to emissivity.

Thermal Bridges & Measures

3.1 Windows and Reveals

The existing windows are traditional timber double side hung windows with mullions between the single paned glazing panels. These units are typical of the buildings' era and have an estimated U value of $5.4 \text{ W/m}^2\text{K}$. (Curtis and Jenkins, 2014) Traditionally, these windows would often have a thick fabric curtain which would've reduced the U value to $3.2 \text{ W/m}^2\text{K}$, an equivalent reduction of 14% (Curtis and Jenkins, 2014).

However, an installation of a thermal blind would still not meet the required standards to meet Part L1A of the building regulations 2010, *Conservation of fuel and power*, whereby the proposed window's U value is to achieve $1.4 \text{ W/m}^2\text{K}$. (HM Government, 2010) Therefore a proposal will be made, within reason, to meet this benchmark.



Figure 3.1.1: Internal image of existing timber window (Author, 2018)

The thermal image below dictates the points of heat loss, a pattern of proportional heat loss is evident. Whereby more heat is lost, the closer to the window frame. This is mainly due to the distance to the external environment though the wall structure.

Excessive localities of heat conduction include the glazing units themselves, which is exacerbated by the dividing mullions in the windows. The timber frame offers an effective buffer between the stone wall and the glazing itself.

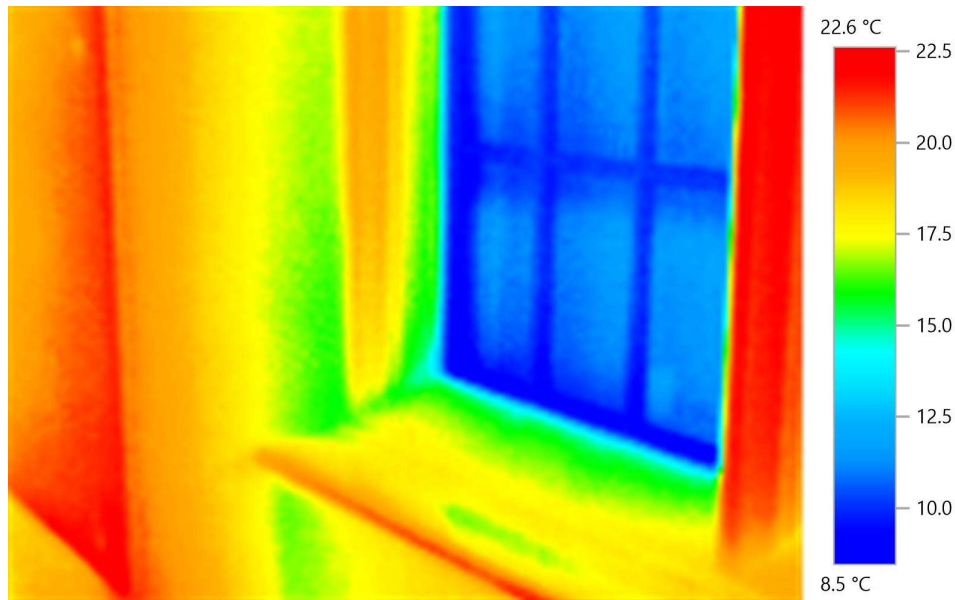


Figure 3.1.2: *Internal Thermal image of existing timber window (Author, 2018)*

Proposed Measures

To meet the energy targets, a proposal of secondary glazing seems to be most sympathetic to the existing structure and give drastic improvements to the thermal efficiency of the opening. The installation would include a renovation and making good of the existing timber windows which reduces the heritage impact from thermal improvements; ensuring all glazing panes are sealed, wood jambs, heads and mullions are structurally sound and shows no signs of pest infestation or rot. Defects in the unit will allow water ingress and saturate reveals and inner wall structure, this dampness of material induces further heat loss. For example, saturated bricks convey heat 2.5 times faster than dry bricks (Rennergysolutions.co.uk, 2018). Therefore, insuring the inner fabric is dry, reduces heat loss. The reveals are also to be lined with 25mm of expanded cork boards to further decrease heat loss by reducing linear heat transfer through the wall structure via convection. The specification is as follows in the

table

below:

Location	Measures
Opening - Existing	Timber frame window to be made good
Opening - Proposed	Timber framed secondary glazing fitted to internal
Reveal - Existing	350-500mm Solid Wall Structure 25-40mm Lime Plaster to be inspected to ensure flat finish
Reveal - Proposed	10mm AdhereVit Cork Adhesive 40mm Cork Board Insulation 6mm Lime Hemp Plaster Mesh Reinforcement 6mm Lime Hemp Plaster 3mm Lime Top Coat Lime Wash Paint

For Installation Detail, refer to *Appendix A – Drawing 001*

3.2 External Walls

The existing external walls are consisted of a solid stone construction with a rendered outer and painted thistle skim internal finish. The internal partition walls are composed of a single brickwork skin with modern type F plasterboard facing either side. Traditionally this wall would've been rendered in breathable lime plaster, which is stated by rdSAP to have an estimated U value of 2.0 W/m²K. (BRE.co.uk, 2012) Laths would form the supports for the lime plasterwork – forming the internal finish. Current standards set by Part L1A of the building regulations 2010, *Conservation of fuel and*

power, state a proposed external wall U value is to achieve 0.18 W/m²K. (HM Government, 2010)



Figure 3.2.1: Internal image external Wall Corner (Author, 2018)

The thermal image below shows that the very corner of the wall is the point of excessive heat loss, at its lowest point measuring 13.9 degrees Celsius surface wall temperature. A temperature difference range of 8 degrees Celsius across the internal wall surface. A thermal measure will not only require tackling heat loss through the wall face but more importantly the corner of the room.

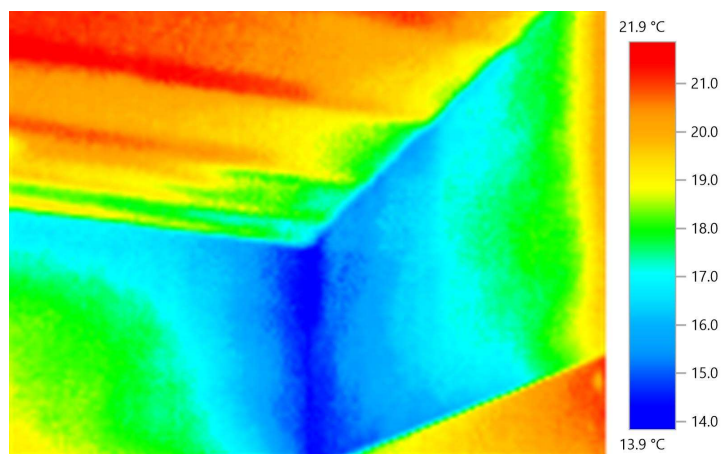


Figure 3.2.2: Internal Thermal image of external Wall corner (Author, 2018)

Proposed Measures

To reduce heat loss through internal walls and meet a figure that meets modern standards, the Ty-Mawr internal wall insulation is to be applied. The proposal includes 40mm expanded cork boards, a LEED - rapidly renewable material (Green Building Team, 2016), to be fitted to the internal face of external walls with a lime finish. The calculated U value for this wall construction has been in-house electronically calculated by the manufacturers, T-Mawr, at 0.67 W/m²K. Although this does not meet modern standards set by Approved Document Part L1A of 0.18 W/m²K, the thermal measure still induces a 66.5% decrease in heat loss through the external wall. To further reduce heat transfer, there is scope to install thicker expanded cork boards. However, there is a downside to thicker insulation measures as space is lost to the internal of the rooms. The specification is as follows:

Location	Measures
Wall - Existing	350-400mm Solid stone wall 25-40mm existing lime plaster internal
Wall - Proposed	10mm AdhereVit Cork Adhesive 40mm Cork Board Insulation 6mm Lime Hemp Plaster Mesh Reinforcement 6mm Lime Hemp Plaster 3mm Lime Top Coat Lime Wash Paint

For Installation Detail, refer to *Appendix B – Drawing 002*

3.3 Roof Space

The existing roof space of the university harvests a typical apex roof construction forming of rafters with spanning purlins for further strength and stability through both live and dead loads. The roof is finished in a layer of slates, which would have traditionally sat on battens nailed directly onto the diagonal rafters. However, at some point during repair works, a modern vapor control membrane has been applied below the horizontal battens for insurance against water ingress as slates can sometimes suffer nail sickness which leads to slipping. Current standards set by Part L1A of the building regulations 2010, *Conservation of fuel and power*, state the proposed roof structure complies to a U value of 0.13 W/m²K (HM Government, 2010).



Figure 3.3.1: *Internal image between rafters (Author, 2018)*

The existing thermal image shows excessive heat lost between the spanning diagonal rafters, with a surface temperature on the rafters at 13.2 degrees Celsius and 27.3 degrees Celsius on the inner of the vapour membrane. However external factors may

be of influence on the membrane temperature, such as solar conduction as heat transfers through the slates to the membrane – exacerbated on the south façade.

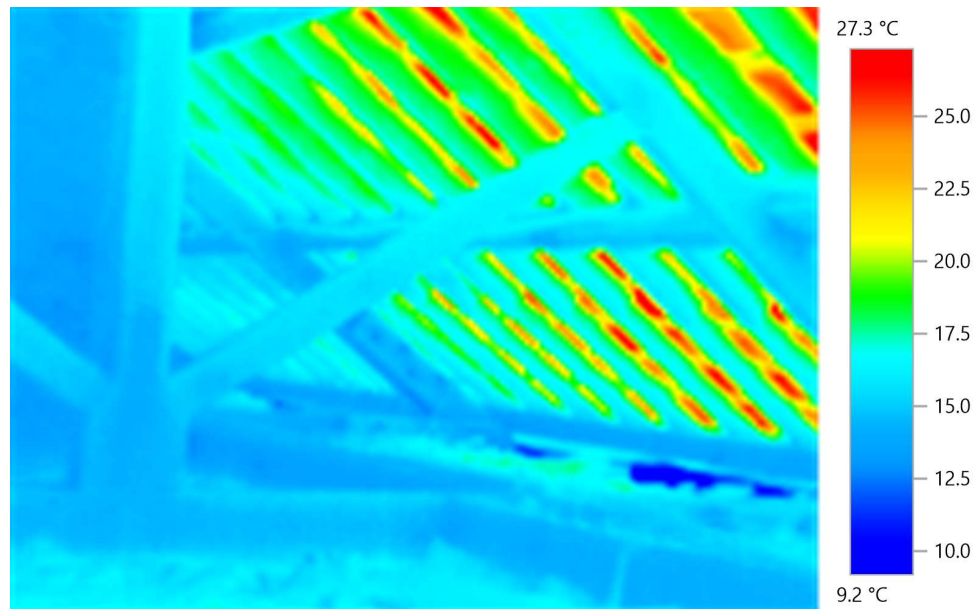


Figure 3.3.2: *Internal Thermal image between rafters (Author, 2018)*

Proposed Measures

To reduce heat loss through the uninsulated roof, the measures to be installed include 225mm of sheep's wool installed between the roof rafters. Sheep's wool is a highly breathable, sustainable material which is considered more renewable and recyclable (Saxena. et al. 2011). In sustainability terms, 1m³ of sheep wool hosts 5.4kg of embodied CO₂, whereas a close comparative, Mineral wool, retains 135kg of CO₂ (Korjenic et al., 2015). Sheep's wool also offers the ability to regulate temperature and harvest a natural resistance to fire due its hydrophilic composition. However, Borax, a non-volatile salt, is added to give greater repellence against pest infestations (Balson, 2013). To retain this wool in place, a polymer netting is to be fitted and fixed to the rafters. The roof structure as outlined below should achieve a calculated U value of 0.17 W/m²K, a large reduction from the 6.75 W/m²K of the existing rafter structure.

Location	Measures
Roof - Existing	8mm Slate 0.5mm Felt Vapour Membrane 225mm deep timber rafter
Roof - Proposed	225mm Sheep's wool insulation Polymer Mesh fixed to rafters

For Installation Detail, refer to *Appendix C – Drawing 003*

3.4 Ceilings

The student rooms in Block C are spread mainly over the ground floor and first floor, with some rooms utilising the apex roof space. The floor joists form a ceiling that separates the floors, which reached circa 3000mm. The construction operates on a spanning timber joist, supported at a load bearing, brick internal wall. The joists ends to each external wall would subsequently be set into a notch in the stone wall.



Figure 3.4.1: Internal image of Existing Block C Ceilings (Author, 2018)

The thermal image shows excessive heat transfer through the voids between the spanning timber floor joists. The joists form a liner 23.5 degrees Celsius thermal

bridge, originating from the external wall, without removing the joist ends to insert a structurally bearing thermal break, the heat will always conduct through the wall and into the joist. A more invasive measure would involve installing a joist hanger which provides the separation between the timber and the external wall/ However, measures can be specified to reduce heat transfer through the voids between the joists.

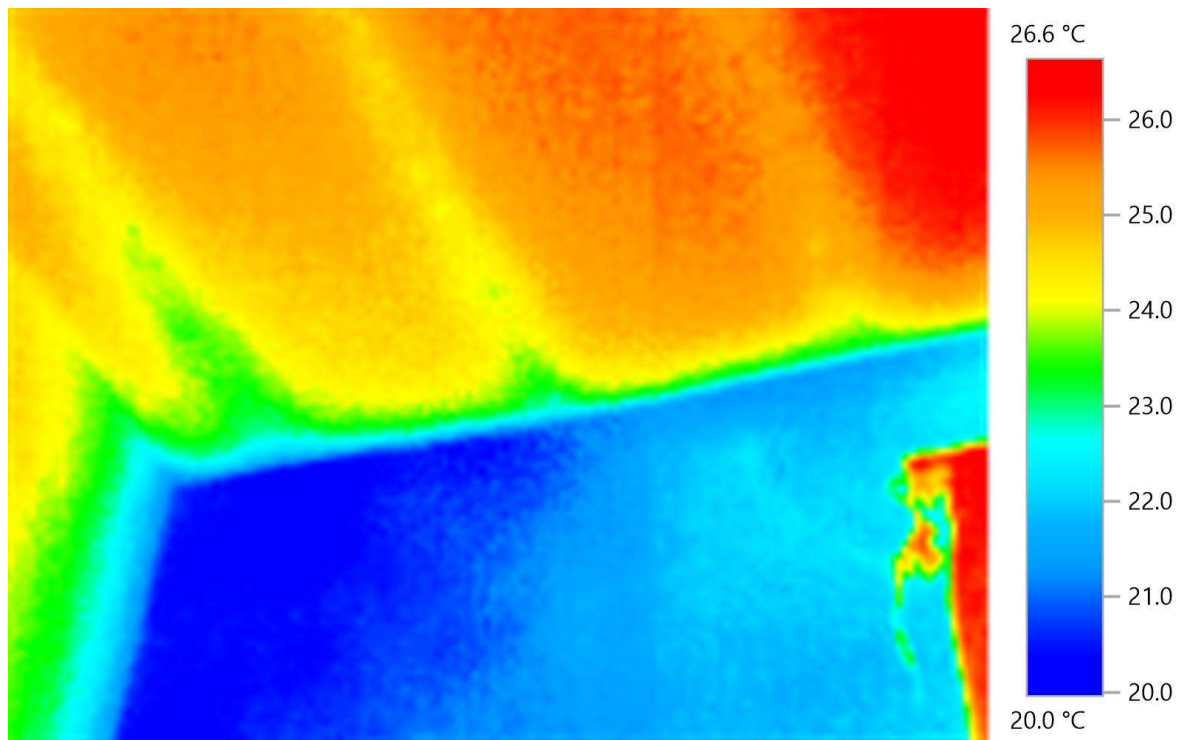


Figure 3.4.2: *Internal Thermal of Block C Ceiling/Floor Joists (Author, 2018)*

The proposal harvests a similar remedy to that of the roof rafters, whereby 225mm of Thermafleece sheep's wool is to be laid between the spanning joists and held in place with a polymer netting below, which will be fixed to the joists. Threaded bar is to be fixed to the spanning timber joists and OSB3 board is to be installed with a counter sunk nut to form a ceiling void. This void can further be filled with sheep's wool for greater insulative effect.

For Installation Detail, refer to *Appendix D – Drawing 004*

Conclusion

Heat loss in older buildings has always been an ever-pressing issue in an era of extensive fossil fuel reliance and the inducement of climate change contributing global temperature rise. However, it has proven that small, sustainable thermal measures may be introduced to the building fabric without compromising structural stability and cultural heritage impacts. Although it has been established previously that the standard rdSAP calculations have the attribute to overestimate the heat loss calculations.

The report has utilised the relatively new method of thermal upgrades retailed by Ty-Mawr. Although some of products specified are manufactured overseas with a large embodied carbon emission through their transportation – particularly the expanded cork boards from Portugal, the lime and sheep's wool are readily available and UK sourced. As Ty-Mawr is a Brecon based supplier, transport from their warehouse is minimised and investment in local economy all contributes to an overall sustainable retrofitting process.

Although Ty-Mawr retail many other products to improve heat retention, the measures specified above are less invasive. These natural, breathable materials offer characteristics that conform with the envelope's equilibrium of vapour transfer through the fabric. As the measures specified are internally applied, no external factors in a real-life scenario may apply – such as delays from bad weather conditions or the costs associated with scaffolding for external measures. The measures are also more sympathetic to the buildings heritage and listed status, as the proposals offer similar techniques which would have been used at the time.

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