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Industry CPD

Structural thermal breaks: design considerations and certification

This CPD module, sponsored by Farrat, examines the realities of designing for the competing requirements of structural, thermal and fire performance through the lens of structural thermal breaks.

Continuing professional development (CPD) ensures you remain competent in your profession. Chartered, Associate and Technician members of the Institution must complete a specified amount each year. All CPD undertaken must be reported to the Institution annually. Reading and reflecting on this article by correctly answering the questions at the end is advocated to be:

1 hour of verifiable CPD

Introduction

In construction, thermal breaks prevent or reduce the flow of thermal energy between elements of a building. Structural thermal breaks help prevent thermal bridges in structurally loaded building details that pass between spaces of differential temperature. The two primary reasons for avoiding thermal bridges are to reduce energy loss and mitigate risk of condensation. The choice of thermal break material can significantly affect a building's overall performance.

This CPD will examine the realities of designing for the competing requirements of structural, thermal and fire performance and meeting the ever-increasing demand for construction product safety and certification through the lens of structural thermal breaks.

Why use thermal breaks?

Modern building design and regulation recognise the importance of energy conservation and occupier comfort in all aspects of construction detailing. Developments in material science and advanced manufacturing techniques have led to the use of structural thermal breaks. Structural thermal breaks are a solution to avoid thermal bridges in building details that pass between spaces of differential temperature, specifically where the thermal break material needs to perform both in transmitting structural loads as well as preventing thermal movement across the connection.

The impact of poor detailing resulting in thermal bridges occurring in building envelopes is well documented. The resultant energy loss can impact severely on the overall performance of a building in respect of the amount of energy required to heat or cool a space and the cost of that energy both monetarily and environmentally. Building regulations typically guide the designer in understanding the minimum requirements in thermal performance of building elements to achieve satisfactory thermal performance in respect of energy loss or gain. In England and Wales, approved Document L gives detailed guidelines for calculating Target Emissions Rates and Target Fabric Energy Efficiency and minimum values to satisfy these requirements.

Alongside energy loss, thermal bridges in a building fabric can result in condensation and mould growth. This is where the temperature of a room's internal surfaces is sufficiently low for moisture laden air to reach a dew point temperature and condensate and, in some cases, for the propagation of mould spores to occur.

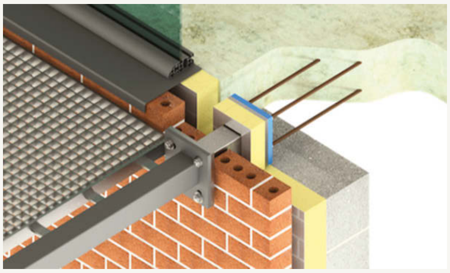
Applications

Structural thermal breaks can be incorporated into any detail where there is a calculated or perceived risk of a thermal bridge occurring. This is typically in details that occur in building envelopes **(Figures 1 and 2)** or where significant temperature difference is likely to occur between compartments, such as highly controlled atmospheric environments (plant or server rooms) or warm high humidity environments, such a brewery or swimming pool.

Examples are:

- facade system connections to the primary frame
- brise solei and canopies
- roof plant room columns

↓FIGURE 1: Farrat structural thermal break in typical concrete-to-steel connection



↓FIGURE 2: Paddington Square development, incorporating Farrat TBF structural thermal breaks to isolate feature lift shafts and canopies in fire-protected facade zones

- balustrading
- external balconies
- external staircases
- man-safe systems
- substructure and basement structure elements
- external-to-internal primary building element connections.

Design – structural performance

As with all construction components, correct handling and installation are a critical part of the performance. Attention should be paid to any specific manufacturer's requirements for handling; this should also include connection-specific labelling, material conformity certification and batch traceability to ensure avoidance of site and design validation issues.

Particular attention should be paid to materials specified and that their performance is independently verified specifically for structural use with all appropriate certifications.

As well as the simple evaluation of a compressive strength figure, account should also be taken of the material's ability to disperse loads from highly loaded points of a connection. This factor and a selected material's ability to deal with these loads should be addressed by the material manufacturer.

All material-to-material connections have the potential to rotate under load. Note that care should always be taken to a) ensure that the chosen structural thermal break can resist these loads and b) to avoid compromising the short- and long-term performance of a connection with undue flexibility or excessive creep **(Figure 3)**.

Structural thermal breaks typically limit the extent of their load transmittance for design purposes to the transferal of compression loads. The main connection elements typically deal with shear loads. Notice should be taken of the effective connection lengths in relation to the thickness of structural break specified. A thickness of 25mm would typically be the optimum without having to consider increasing the size of the bolt.

Table 1: Critical temperature factors

Type of building	Critical temperature factor
Storage buildings	0.30
Offices, retail premises	0.50
Dwellings, residential buildings, schools	0.75
Sports halls, kitchens, canteens	0.80
Swimming pools, laundries, breweries	0.90

Structural design summary (steel connections)

Connections that include thermal break plates should be designed in accordance with the relevant design standards (e.g. BS EN 1993-1-8) or industry guidance (e.g. SCI publications).

Additionally, the engineer should check that:

- the thermal break plate can resist the applied compression forces
- any additional rotation due to the compression of the thermal break plate (including allowance for long-term creep) is acceptable
- the shear resistance of the bolts is acceptable given that there may be a reduction in resistance due to:
  - packs – cl. 6.3.2.2 of BS 5950-1 or cl. 3.6.1(12) of BS EN 1993-1-8
  - large grip lengths – cl. 6.3.2.3 of BS 5950-1 or BS EN 1993-1-8.

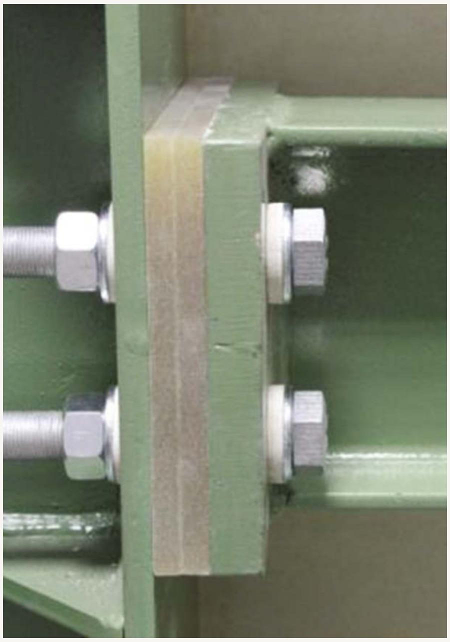
For connections involving concrete and masonry, the material principles detailed above should be considered in conjunction with the relevant Eurocodes. All connections involving proprietary fixing systems (non-standard) may require consultation with the product supplier.

This is the checklist for thermal breaks that require a HSFG bolt. This is predominantly a requirement in the USA or UAE following US design principles, but becoming more relevant in buildings with external skeleton structures.

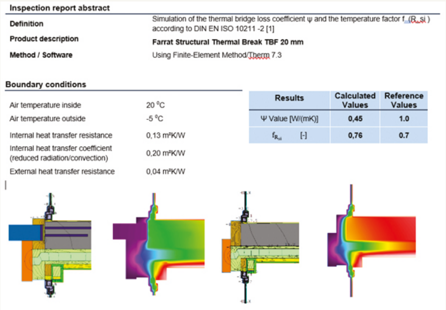
Thermal performance – typical details

In the absence of a full thermal model of the actual detail being used, typical details can be modelled and used as indicators of likely performance and

↓FIGURE 3: Farrat structural thermal break plate, independently tested for long-term creep in moment connection



↓FIGURE 4: Typical project-specific thermal detail analysis by Farrat



used to specify materials that will meet design requirements.

The Building Research Establishment (BRE) has produced indicative details available online to assist in the specification of solid-state thermal breaks, which can be relied upon in the absence of a full 3D model analysis.

The scheme database includes both BRE Certified Thermal Details and Products and Government Accredited Details and this provides a freely accessible and independently assessed and certified resource for users. The third-party BRE global certification can distinguish products and services from their competitors and give customers confidence about the thermal performance of the products. The database has been developed to enable details to be linked directly into SAP 2016 and is also featured within the BRE Home Quality Mark standard.

A number of typical connection details have been analysed under the scheme to assist designers when specific modelling of their details is not undertaken. All details assessed (Ref 600063 to 600068) had a temperature factor above 0.80, meaning mitigation against risk of surface condensation **(Table 1)**.

After determining the thermal performance of the construction detail, either through modelling or using exemplar details for the smallest cross-sectional area of penetration/connection, the thickest thermal break plate able to be accommodated with the lowest thermal conductivity must be selected to ensure optimum performance.

Recommendations

Carry out a full analysis of the cold bridge – heat loss/condensation risk in conjunction with codified methodology to determine the thermal break requirements **(Figure 4)**.

The best thermal performance will be obtained by:

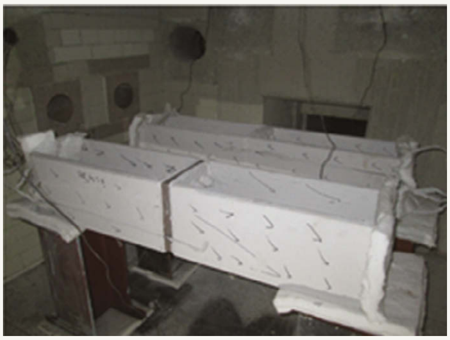
1) developing the smallest cross-sectional area of penetration/end connections using the smallest cross-sectional area of bolts through the connection
2) using the thickest thermal break plate
3) using materials with a low thermal conductivity value, *k*
4) locating the thermal break connection within the insulated layer of the building facade/roof construction.

Design – fire performance

In the majority of applications, there are no requirements to meet any fire regulations (outside the fire compartmentation). High-rise buildings (over 18m/six storeys) now have stricter requirements for building envelopes following the Grenfell Tower fire. Structural thermal breaks are excluded from the new Document B requirements but are a key component in high-rise building facades.

↓FIGURE 5: TBF thermal break connected between sections

↓FIGURE 6: TBF sections before fire test



However, while strengthened regulations are evolving to ensure that disasters such as the Grenfell fire cannot happen in the future, some designers are already recognising the direction of travel and choosing to go beyond the regulations. Driven by several factors, particularly client and insurance insistence on future-proofing, they are pushing up the minimum standard when it comes to fire performance.

Structural thermal breaks, like most building materials, can be produced with different grades of flammability and performance under fire loading. Where fire sits high up the order of risk, alongside structural and thermal performance, designers should look to choose a certified fire-resistant material.

The decision on specification of structural thermal breaks, by nature of their dual role, can come from a number of sources. It is crucial that the essential criteria for performance are understood by all parties and that the final product supplied is correct by specifically naming manufacturers by name and product.

Generally, thermal breaks are used in locations that do not require fire protection. Where the connection requires a fire rating:

- →| a board fire protection system can be applied
- →| sprayed fire protection can be applied. The compatibility of the applied fire protection material should be checked with the thermal break material
- →| the connection may be designed on the assumption of complete loss of the thermal break material in the accidental condition. For accidental conditions, excessive deformations are acceptable provided that the stability of the structure is maintained.

Rules for fire protection are formulated in relation to time and the safety afforded to persons exiting the building and firefighters attending the blaze. A large part of this is the propensity of materials used to either contribute to the fire load and ease of ignition or continue to burn, causing the fire to spread.

Fire testing

Investigation and analysis of events such as the Grenfell fire has revealed that failure of even the smallest simple detail in a safety critical area of a facade can lead to catastrophic failure, resulting in uncontrolled failure of systems designed to prevent loss of life in the event of fire. To limit the possibility of these types of failures, specification of the correctly tested and certified materials is critical.

Components such as structural thermal breaks can play a pivotal role in maintaining structural integrity in the event of a fire. Testing of these components in realistic details in combination with other safety critical components is essential to fully understand the implications of specification choice **(Figures 5 and 6)**.

Full-scale fire testing and post-test analysis allow the correct specification choices to be made and give the designer the confidence to create details without fear of unforeseen failure.

Clear, transparent publishing of test results allows others to question and assess performance in new and amended details, as well as direct unambiguous questioning of manufacturers and suppliers as to the probity of results.

Supplementary and complementary testing of material designed to continue to perform in the event of prolonged exposure to fire also serves to reassure owners and occupants alike that their safety has been forefront in the mind of the building designers.

Ultimately, peer-reviewed and independently tested construction products give building designers the confidence to propose fully safe working details.

In the case of structural thermal breaks, there are some simple checks that can be carried out to ensure that the best product choices are made where fire performance is a key component of the design process.

- →| Ensure materials are independently certified to EN 13501-1 – A2,s1,d0 as a minimum.
- →| Choose a material with independent verification of performance at high temperatures, up to 700°C to EN 604.
- →| Choose a material that is compatible and

performs with any fire protection system likely to be used (intumescent coatings or boards).
→| Ensure materials have been subject to prolonged fire testing (120 minutes) with temperatures exceeding 1000°C.

Materials testing

The provision of manufacturing standards allows specifiers to compare performance of different materials as well as warranting product performance via independent testing. As with all construction products, physical properties and levels of performance can be verified by testing against relevant standards for specific product groups. As new products are developed, standards are created to assess them. In the case of solid-state structural thermal break plates, it is now possible to hold a European Technical Assessment (ETA) based on European Assessment Document 041877-00-0301 certified by the European Organisation for Technical Assessment (EOTA). Therefore, it is crucial with these critical components that independent verification of figures and performance is sought via accreditations such as ETAs or BBA certification.

Materials testing takes many forms and is often tailored towards a specific end use. Where there are multiple ways of testing similar physical properties, it is important that the right test is carried out to suit the situation in which the material is used. To this end, material properties that can vary depending on variable use factors – such as compressive strength and thermal transmittance in relation to temperature – need to be assessed correctly. Materials which appear to have similar values can ultimately perform very differently in real-life conditions.

CCPI

One way is to look to the new Code for Construction Product Information (CCPI). The CCPI was created to promote an urgent and positive behaviour change in the way the construction product manufacturing industry manages and provides information on their products. The CCPI was initiated by the Construction Products Association (CPA) as a direct response to Dame Judith Hackitt's review of building regulations and fire safety set up in the wake of the Grenfell Tower tragedy.

Continuing the direction of travel in the development of design frameworks that guide positive use of proven materials and set the standard for good building design, the rise of environmental performance awards such BREEAM, LEED and Passive House gives a pathway for designers to use that means that buildings can be measured against a common standard and independently assessed to assure best practice and performance.

To claim your CPD certificate, complete the module online by 31 August 2022 at: **www.istructe.org/industry-cpd**

Questions

1) What are the two primary reasons for avoiding thermal bridges?
☐ Reducing energy loss
☐ Mitigating risk of condensation
☐ Enhancing aesthetic quality
☐ Improving connection strength

2) What thickness of Farrat structural thermal break would typically be the optimum without having to consider increasing the size of the bolt?
☐ 20mm
☐ 25mm
☐ 30mm
☐ 35mm

3) Which two items should be considered when assessing bolt shear resistance when incorporating a structural thermal break?
☐ Thread direction
☐ Packs
☐ Large grip lengths
☐ Bolt head type

4) What is the minimum reaction to fire rating to EN 13501-1 that can be considered where use of non-combustible materials is required?
☐ A2-s1,d1
☐ A2-s3,d0
☐ A2-s1,d0
☐ A2-s2,d0

5) Which two of the following are independent sources for product certification of structural thermal breaks?
☐ BBA
☐ BRE
☐ SCI
☐ EOTA

6) Which three of the following design frameworks can be used to exhibit consideration for environmental performance of chosen construction products?
☐ BREEAM
☐ CCPI
☐ LEED
☐ Passive House

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