BEAM ENCASEMENT & SFS HEAD FIXING

Technical Guidance Note - MET-TGD-01

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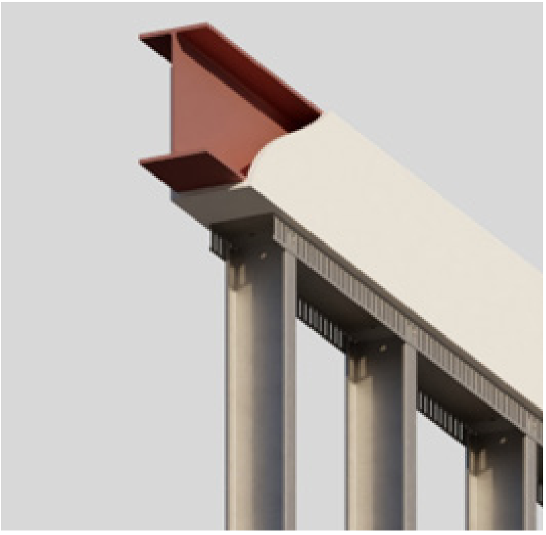
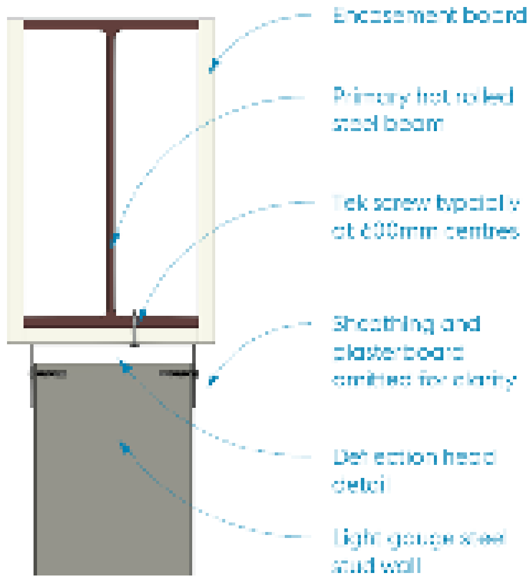
When designing both hot rolled and cold rolled steel frames, it's essential to account for structural performance under fire conditions. Elevated temperatures cause a reduction in the strength of steel, underscoring the need for fire protection measures. Advancements in fire protection materials have yielded effective solutions, however there remains a requirement for additional research to better understand the performance of these materials at junctions and interfaces between different structural systems.

Fire Protection

One method of providing fire resistance for a primary steel frame is to encase the steel beams and columns with a fire-resistant board. Boarding systems are tested to ensure that the hot rolled steel they encase is kept below the critical temperature to ensure sufficient strength remains. This boarding is however located at the same position as the structural connection for a secondary framing system, such as a light gauge steel SFS system. A proposed detail, which has been adopted by some SFS suppliers, involves fixing the SFS head track through this boarding and effectively sandwiching it between the head track and primary hot rolled steel (Figure 1: Connection through encasement board). While this detail is regularly used for internal drylining walls, several unknowns exist around the long-term suitability of this detail for external walling applications, due to the higher horizontal forces exerted by an external wind load. voestalpine Metsec have maintained that a direct steel-to-steel connection is the preferred fixing method for a SFS system, due to a number of concerns around the suitability of this detail.



» Figure 1: Connection through encasement board



» Figure 2: Typical section detail

The primary concerns with this detail are:

- » Cyclic wind loading can lead to fatigue failure of fixings due to bending, potentially causing dislodging and falling of SFS panel and cladding. Fatigue is a sudden and catastrophic failure which can be impossible to inspect for when built into a wall.
- » Increased horizontal wind loads may cause greater head/base track movement, resulting in board compression and damage.
- » Placing a compressible board between SFS and primary steel can lead to board degradation over the structure's lifespan.
- » Damaged board may lose its original fire protection capabilities and allow excessive SFS track movement, risking finish cracking.

Industry Response

Currently boarding providers will offer a warranty on the performance of the boarding, a small number of SFS suppliers were providing a warranty on the SFS but no-one is covering the long-term performance of the fixing screws or any linked interface which would result in a gap in cover for the end client. To address this ambiguity, just under a year ago the FIS and SCI formed a working group consisting of leading SFS manufacturers (including voestalpine Metsec), several large main contractors, major fixing manufacturers, the largest boarding manufacturers, SFS installers, and several technical groups and consultants. This group agreed that a full-scale system test was needed including the cyclic effects of the wind loading to establish a fully tested detail which everyone could have confidence in. Before the full test could be conducted the group agreed that the starting point would be a simple shear test on the fixings with the board to establish the affect the board layers would have compared with a direct steel to steel connection. This would form the basis of how the full-scale test would be done or if the idea was a non-starter.

The testing was undertaken at an independent laboratory with the results written into a report by the SCI. Due to the testing and report being co-sponsored by a number of companies, it is not possible to release the full contents of this report, however below is a summary of the testing and results obtained.

Testing & Results

In order to examine a wide array of variables, 22 shear tests were carried out to model a single fixing point (Figure 3: Simple shear test) using:

- » 2 different size screws (5.5mm and 6.3mm)
- » The 4 leading encasement board types
- » 2 different encasement board depths

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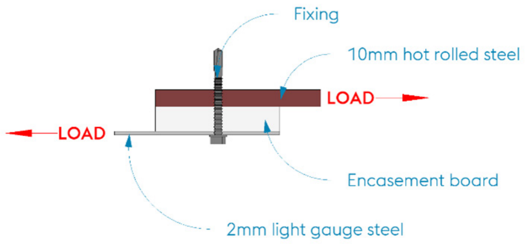

» Figure 3: Simple shear test

These tests provided a failure capacity for the screws, as well as the deflection that occurred under load. The 5.5mm screw saw a significant reduction in capacity when compared to a direct steel-to-steel connection. This was in the region of 50% lower than the published capacity of the screws. The 6.3mm screw performed better in terms of capacity, however deflection became a concern.

As anticipated, the movement with the 5.5mm screw through encasement board was greater than that for a direct steel-to-steel connection. This movement of around 3.0mm occurred before failure of the screw. The 6.3mm screw however saw considerable movement 15mm+, which would be deemed to be unacceptable.

The board type had little effect on the performance of the screw, with all boards showing similar movements and fixing capacities.

Summary

While this initial testing helps the construction industry to better understand the behaviour of the fixings when through an encasement board and gives an indication as to what movement might be expected from a full-scale construction, the testing was intended to cover one aspect of the connection detail under review.

There is wide agreement within the construction industry that further testing to establish design limitations of the detail is required. Of particular concern is the risk of fatigue failure of the fixings, and the long-term durability of the encasement board. While the SCI report provides a recommended fixing capacity, thus making it possible to design the head track fixings with a reduced capacity, this does raise questions over whether projects with this detail currently installed need to be design reviewed.

This next stage of testing will need to focus on the movement of the head track under load, and whether this could have a long-term impact on the performance of the fire protection board, rotation of the SFS head track, or lead to fatigue failure of the fixings.

voestalpine Metsec take our position as market leader seriously, and are aware that our endorsement of a detail will see it become the industry standard. It is important that designers responsible for junctions consider the impact of the encasement board on the fixity of the SFS head track. We will continue to support industry with further testing to ensure designers have factual data to enable the design of beam encasement details with full confidence. We are committed to continued testing of this detail, as well as exploring alternative solutions to offer the construction industry a robust and efficient solution for SFS head fixing junctions.

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To summarise the voestalpine Metsec position on the testing, the issues in the results of the testing are:

1. The capacity of the screws is less than 50% of the steel-to-steel values used in the design.
2. The movement of the screws shows that the screws cut into the board.

When designing beam encasement details for use on a project, there are a number of key issues which should be considered and that we believe should be addressed with further testing:

1. Fatigue failure of the screws. The long-term bending action on the fixings may cause failure of the screws in fatigue. No data is currently available to support this type of action.
2. Jamb studs – for typical buildings with a hot rolled steel primary structure, the loads at the jambs may generally require 2-3 fixings. Given the reduced capacity recommended via testing, 4-6 fixings may now be required. See point 3 below.
3. Where there is a cluster of fixings, there is no guidance available on how close these can be together to avoid propagation of cracks through the boarding.
4. Where the SFS doesn't achieve 2/3 bearing on the beam there would still be a requirement for additional support steel, such as zed bars. These support elements would have at least 2 fixings in a line, which could propagate cracks through the board as per point 3 above.
5. Movement of the fixings, and subsequently the head track, leading to damage and degradation of the encasement board over the life of the building.
6. Where zed bars are used the thinner bearing area on the board and the offset of the loading is going to further increase stress into the fixings and board, beyond that of the tested scenario.
7. Similar issues with clustered fixings and high loads occur when cleats and posts are used to support larger openings.
8. How the boarding detail can be applied close to hot rolled steel connections.

Bibliography

Association for Specialist Fire Protection. 2018. Fire protection for structural steel in buildings 5th Edition.

Collaborative Reporting for Safer Structures UK (CROSS-UK). 2021. "Safety Report 1030: Fire protection of light gauge steel frames."

Collaborative Reporting for Safer Structures UK (CROSS-UK). 2020. "Safety Report 921: Fire protection of mixed hot/cold rolled steel structure."

Finishes and Interiors Sector (FIS). 2019. Technical Report ED017: Design and installation of light steel external wall systems.

Steel Construction Institute (SCI). 2021. P424: Fire Resistance of Light Steel Framing.

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