

Masonry support system at Big Wood School

Big Wood Secondary School in Nottingham is situated on the edge of Bestwood Country Park, with approximately 750 pupils aged between 11 and 16 currently on the roll. As part of the UK Government’s *Building Schools for the Future* initiative, the school is being completely rebuilt and the first phase of the £18 million development, the construction of three two-storey rectangular teaching blocks (about 40 m x 20 m in plan), was opened in the autumn of 2009. The buildings are brick-clad, structural steelwork frames, with composite floors. The brickwork is supported by a stainless steel masonry support system over the windows (some are in excess of 9 m wide). The support system provides a horizontal ledge for the masonry and is fixed to rectangular hollow edge beams.

Material Selection

The masonry support system is made from grade 1.4301 (S30400) austenitic stainless steel, which is the grade used for most support systems. It complies with material reference 3 in EN 845-1 [1], the European specification for ancillary components for masonry. The material was specified with a 1D standard mill finish (hot rolled, heat treated and pickled) in accordance with EN 10088-2 [2]. (This is equivalent to a No. 1 finish to ASTM A480.)

A stainless steel support system was preferred to a carbon steel system because the latter is likely to corrode in the damp environment encountered in a cavity wall, which might lead to cracking of masonry along mortar joints as well as bulging brickwork. Once a building has been erected, the masonry support system is inaccessible; no cleaning, inspection or maintenance is possible to ensure its structural integrity. Stainless steel has a proven track record of adequate durability in cavity wall environments for the design life of the structure.

Another reason that stainless steel was chosen is that if the surface is damaged on site, the transparent ‘passive layer’, which seals the stainless steel from the environment, will instantaneously reform and the lifespan of the component will be unaffected.

Stainless steel has a significantly lower thermal conductivity than carbon steel (see Table 1). As masonry support systems are attached to the main structure and pass through the insulated cavity to the outer leaf, the lower thermal conductivity minimises the effect of cold bridging, leading to a more thermally efficient building.



Figure 1: General view of Big Wood School

Table 1: Typical values for thermal conductivity of building materials

Metal	Thermal conductivity [W/(m·K)]
Aluminium	160
Carbon steel	50
Austenitic stainless steel	17
Brick	0.7
Plastic	0.2

Design

The masonry support system consists of a continuous angle, with brackets welded to the vertical leg of the angle at regular intervals. The brackets are fixed to the structural steel frame. This system is more economical for wider cavities than a conventional continuous angle system (where the angle has to span the full width of the cavity) and hence the thickness of the angle can be reduced, leading to a lighter solution. The precise dimensions of the bracket and angle are determined by the cavity and loading for each specific project. In Big Wood School, the bracket angle support system was designed to support 4.5 kN/m^2 load with a 170 mm cavity and the bracket projects below the supporting structural member. Figures 2 and 3 show two of the arrangements adopted on the first floor of the Maths and Design block. The majority of the angles and brackets were manufactured from 4 mm thick plate. Several special corner pieces were fabricated from 6 mm thick plate.

The design of the system involves modelling the angle as a cantilever while taking into account the behaviour of the angle between the brackets. It is carried out in accordance with steel design standards, backed up by extensive physical testing and industry experience. The vertical deflection at the toe of the angle relative to the structural steelwork is limited to 1.5 mm.

The supporting steelwork was designed to BS 5950-1 [3] using RAM structural system software. To avoid excessive movement of the support system, the structural edge member was designed to minimise deflections and accommodate torsional forces created by the eccentric load from the brickwork in accordance with Reference [4].

The brickwork cladding is tied to the inner leaf wall at a maximum horizontal spacing of 450 mm and within 300 mm above the support angle. The tie details were checked to BS 5628: Part 1 [5] using wind loadings to BS 6399-2 [6].

Pre-cast panels comprising blockwork with slip bricks were tied back to the secondary steelwork and cold rolled steel framing to achieve the desired vertically stack-bonded brickwork effect.

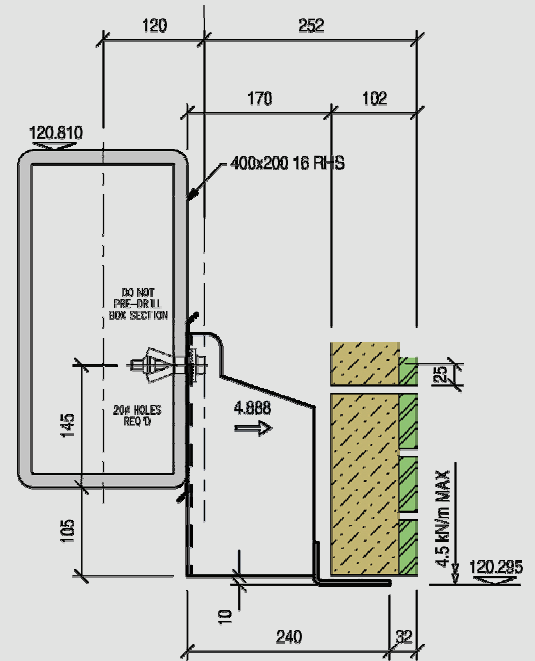


Figure 2: Bracket directly connected to rectangular hollow edge beam

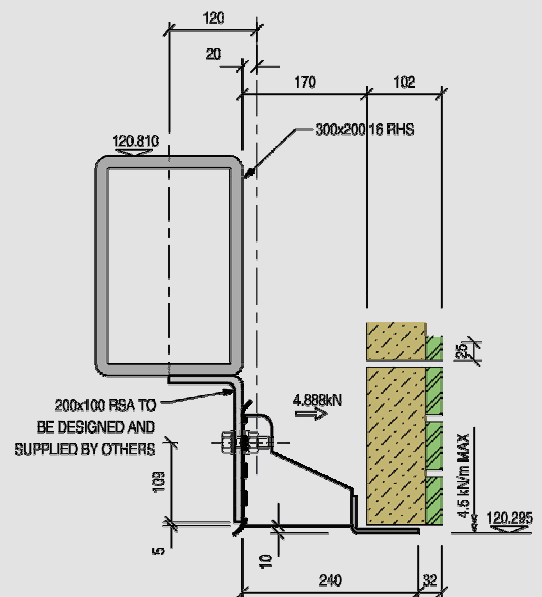


Figure 3: Bracket connected to angle beneath rectangular hollow edge beam



Figure 4: Construction of support system shown in Figure 2

Where the stainless steel support system is bolted to the structural carbon steel frame, there is a slight risk of bimetallic corrosion if the environment were to become damp. This would not affect the stainless steel but might lead to increased corrosion of the carbon steel. To prevent this, the two metals are isolated from each other by inserting short strips of hi-load DPC (damp proof course), cut down from rolls, between the back face of the bracket and the supporting carbon steel rectangular hollow section.

In order to support Nottingham City's aim to become a zero carbon local authority within 10 years, Big Wood School incorporates a number of innovative schemes to reduce carbon emissions and water use. The school has a renewably fuelled combined heat and power (CHP) plant which substantially offsets the demand for grid energy, leading to 60 % reduction in carbon emissions against current UK Building Regulations. (It is the first education building in the UK to have a pure plant oil CHP plant.) It can sell electricity to the grid and create revenue through green certificates; energy consumption and production is displayed in the entrance of the school. The demand for water from the mains supply is reduced by features such as low-volume, dual-flush cisterns, automated spray taps and low-flow shower taps and a rainwater harvesting system collects rainwater from building roofs to be used to flush toilets.

Fabrication and Installation

The masonry support system was fabricated from plate and cold formed into shape.

The loading on the support system is vertical and static and the angle is permanently subjected to its full design loading. Tight tolerances have to be observed because slight deviations in bracket dimensions and installed position of the brickwork cause relatively large effects on the position of the loading, on the associated deflections and stresses.

The as-built position of the structural frame was checked for its line and level before the support system design was finalised and manufacture commenced. Facility was provided for small adjustments in the vertical and horizontal directions during installation (Figure 6).

To permit horizontal adjustment along the length of the angle, the system was designed with 10 mm nominal gaps between individual angles and pre-drilled horizontal slots in the steelwork to facilitate adjustment of the angle position.



Figure 5: Construction of vertically stack bonded brickwork held up by masonry support system

To cater for minor deviations in the cavity width, the bearing width of the masonry wall on the support angle was adjustable. Where the cavity width was smaller than expected, this necessitated cutting the brick to clear the angle radius. Ideally the design bearing width of the masonry wall on the angle is at least two thirds of the width of the wall. To cater for a wider cavity than expected, full height stainless steel shims were provided, to be inserted between the face of the structural steelwork and the back of the bracket. The maximum thickness of the shims is the smaller of the outside diameter of the fixing bolt or 16 mm, so in Big Wood School the maximum shim thickness is 12 mm. The shims had to be of sufficient length to extend to the bottom of the bracket; individual shims were as thick as possible.

To permit vertical adjustment, the bracket has a vertical slot which allowed ± 30 mm vertical adjustment in either direction. To ensure no slip occurs in the fixings, the slotted holes in the brackets have a serrated surface and are secured into the steel frame with stainless steel serrated washers (at the correct orientation) and stainless steel set fasteners.

Where access was possible on both sides of the structural steelwork, M12 set screws were used to fix the bracket to the supporting steelwork, installed in a 14 mm wide horizontal slot (see Figure 3).

M12 Steelgrip™ fasteners in 20 mm diameter fixing holes were specified for fixing the bracket directly to the hollow steel section where access is only available from one side (see Figure 2). They feature a serrated washer that corresponds with the serrations on the bracket. The serrated surfaces interlock, and as the head is tightened to the correct torque the sleeve expands. The fastener consists of a zinc plated sleeve and cone, and a stainless steel screw and serrated washer (Figure 7).

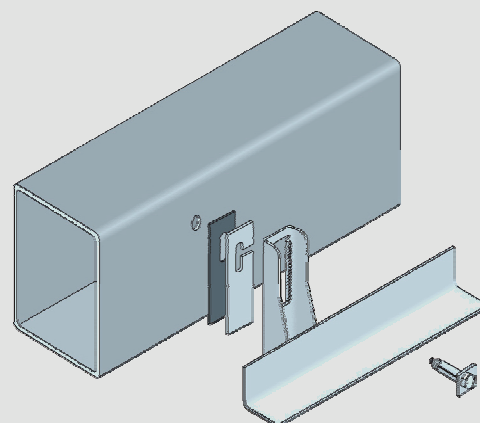


Figure 6: Accommodation of vertical and horizontal tolerances

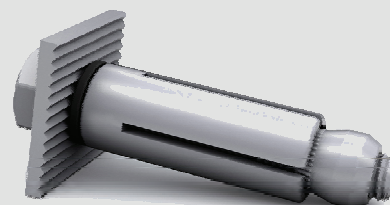


Figure 7: Steelgrip™ (Patent no. 241 0307)
Image courtesy of Ancon Building Products

Information for this case study was kindly provided by Capita Symonds and Ancon Building Products.

References and Bibliography

- [1] EN 845-1: 2003 Specification for ancillary components for masonry - Part 1: Ties, tension straps, hangers and brackets
- [2] EN 10088-2:2005 Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.
- [3] BS 5950-1:2000 Structural use of steelwork in building. Code of practice for design - Rolled and welded sections
- [4] Design of members subject to combined bending and torsion, SCI, 1989
- [5] BS 5628: Part 1:2000 Code of practice for use of masonry. Structural use of unreinforced masonry
- [6] BS 6399-2: 1997 Loading for buildings. Code of practice for wind loads

Online Information Centre for Stainless Steel in Construction:
www.stainlessconstruction.com

Procurement Details

Client:	Inspiredspaces (Nottingham) Ltd/ Nottingham City Council
Architect:	Capita Architecture
Civil & Structural Engineer:	Capita Symonds
Main contractor:	Carillion Building
Design and manufacture of masonry support system:	Ancon Building Products

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