MULTI-STOREY TIMBER-FRAME

Brick Clad Timber Frame at BRE Cardington

Brick-clad timber-framed building construction has been around for a long time, but its applicability has remained in the low-rise housing market. Recent prototype research and development work, along with the construction of actual commercial buildings, has demonstrated the potential for extending the method beyond its historical height limitations into medium-rise uses. The following article first appeared in the summer 1999 edition of BDA's Brick Bulletin and it is reproduced here in an updated format.

In the context of building land scarcity and forecast household growth, timber- framed construction is very likely to make an important contribution in meeting new housing needs. The method scores highly in tight access locations with poor ground conditions, underlining its future potential for housing and related uses in urban brown field sites. The factory-made lightweight frames can reduce foundation requirements, are less dependent upon site working practices and can cut on-site build time significantly.

Four Storey Brick Clad Timber Frame

But how high can you go? Every further storey added takes off some of the pressure and housing providers are understandably keen to build higher. Until the introduction of amended fire provisions in the 1991 England and Wales Building Regulations, timber-framed construction had been mainly limited to a maximum of three storeys. Guidance for brickwork cladding - by far the most popular elevational treatment - for up to three-storey construction, is given by NHBC and also in BDA Design Note 15. This is based on a 102.5mm outer leaf of off-the-frame brickwork secured by ties across the cavity, with differential movement joints under window cills, producing the marriage of a brittle wall to a relatively flexible frame.

But what are the implications for brickwork design with floor-by-floor increments to the height of timber-framed buildings? As BDA Senior Structural Engineer Peter Watt wrote in Brick Bulletin Autumn 1994, extending to four story timber-frame offers no substantial obstacles to brick cladding and associated tying requirements, beyond increased provision for vertical differential movement in the uppermost storey and the need for structurally independent lintel systems for support at openings.

And higher than four storeys? Structural engineers know how to resolve the issues, such as the potential for vertical differential movement that is accentuated with each additional storey height. In the early 1990's BDA advised on the use of sliding anchor ties to the top two storeys of Mannheim Quay, Swansea, the first five storey example. Despite that successful precedent, the widespread adoption of medium-rise brick-clad timber-frame has been inhibited by the lack of research and the trend to conservatism in specification. But that may very well change with the results of a major research project, TF2000.

TF2000 - the test-bed

At six storeys, TF2000, the timber-frame building at BRE Cardington, is the tallest structure of its kind in the world. It has acted as a test-bed for the Timber Frame 2000 Consortium's own research and development programme, aimed at verifying performance to support medium-rise brick-clad timber-framed construction. The project has been a collaboration between government, BRE, TRADA Technology Limited and the timber industry.

The BDA, as an associate partner, has provided materials, design and construction know-how for the brickwork cladding elements to explore the relationship between superstructure and cladding. Are we over-specifying for lack of scientific evidence as to how medium-rise brick-clad timber-frame behaves? This test-bed is providing the answers.

The external cladding was of single leaf brickwork 102.5mm thick for the full height of the building, without intermediate horizontal supports. Proprietary BS DD140 type wall ties were used for the whole six storeys to accommodate an estimated 40mm maximum vertical differential movement of the timber-frame and brickwork elements combined.

Detailing at Openings for Movement

Heads, cills and reveals required allowance for projected movement too, and at the heads of window in storeys five and six, bed joint reinforced brick lintels have been used. For spans of up to about 2.1m these are easy to design and construct and give complete independence between brickwork and timber-frame at the upper storeys.

The external cladding envelope in TF2000 used three different brick types to represent low to high movement clay brick unit alternatives.

At each storey height at floor level two layers of prefabricated austenitic stainless steel bed joint reinforcement, one layer in adjacent brickwork bed joints, was used to provide a ductile reinforced ribbon all around the building. This was provided to give enhanced performance of the brickwork in the case of accident/misuse and associated disproportionate collapse considerations.

Cladding passes disproportionate collapse test

Disproportionate collapse has been one of the principal research areas for TF2000. The advent of brick-clad timber-framed buildings of five storeys and more means that, like any other five storey plus building, they must be designed for the disproportionate collapse requirement of Building Regulations.

Building Passes Progressive Collapse Requirements.

Completed tests included the removal of an internal timber-frame load-bearing wall, and separate removal of a 4 m+ length of brickwork and timber framing in the external wall. The external wall was breached near the corner of the structure at ground level, reducing the corner buttressing effect. This test - the equivalent of a major accident - was completely successful, with no collapse, excessive deflection or even minor cracking of the brickwork resulting.

Vertical differential movement

Medium term measurements have been made to determine the levels of vertical differential movement of the wall constructions. This will ultimately assist user design guidance, not least in the specification of wall ties for the brick-clad outer walling.

Building stiffness

With TF2000 has come the opportunity to measure building stiffness on a complete structure. Separate tests carried out on the timber-frame shell and again with the brick cladding in place indicate that the brickwork significantly enhances stiffness performance of the overall building. Ultimately such information is likely to feed into improved and more competitive design procedures for brick-clad timber-frame, and particularly with respect to stability shear (racking).

Wind shielding

In March 1999 it was announced that BDA, with research partners Ceram Building Technology and BRE, had been granted a Partners in Innovation award from the then DETR. This has enabled investigations into the composite action and hence the shielding effect of brickwork to lateral (predominantly wind) loading to timber-framed structures. Design for brick shielding has to-date been mainly semi-empirical and somewhat conservative. The research, based partly on TF2000 and partly at Ceram’s Stoke-on-Trent facility, has shown that significant design economies for wind shielding effects are possible.

The future

Though the findings of much of the innovation programme will emerge over the next few years, tangible commercial results have already been reported. A case in point is the five storey timber-frame Crown House in Manchester for student accommodation specialist Zonan. This was designed by Colin Farmer Architects with technical assistance

from AJ Lang Architectural and Surveying Services and in close dialogue with Manchester Building Control. By using medium-rise brick-clad timber-frame, with brickwork off the critical construction path, build time was almost halved.

Crown House, Manchester Five Storey Brick Clad Timber Frame.

When BDA was consulted the disproportionate collapse outcomes from TF2000 were known and guidance was given along the lines of the Cardington building prototype. Citing the example of the five storey Mannheim Quay building, the use of sliding anchor type ties was advocated to accommodate differential movement to the top two storeys. These were used for greater robustness and until such times as standard timber-framed wall ties can be justified by fuller analysis of the results from TF2000.

Will more medium-rise brick-clad timber-framed buildings be seen on site if research findings from TF2000 justify liberating this type of construction from traditionally based design constraints? It is an exciting prospect, with major implications for housing providers.

Typical Brickwork Movement Joint Provision