EDUCATION AND SKILLS COMMITTEE: SCHOOL BUILDINGS – WALL TIES AND FIRE STOPPING

Submission by the Building Research Establishment Ltd (BRE)

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BRE has undertaken substantial research over many years on the performance of masonry buildings and fire stopping relevant to the subject matter of the Cole Repoert, including the individual materials and the completed wall elements. Much of the research was undertaken up to year 2000; however, BRE continues to address the performance of masonry often being requested to investigate failures of buildings. BRE has not to date undertaken any investigations or reports related to wall tie performance in PFI/PPP schools in Scotland following the failure at Oxgangs School. This submission is therefore based on prior knowledge and experience of wall ties and related matters.

Good Practice

BRE produces guidance through a series of publications that is widely used by the construction industry, including consultants and contractors as well as in education of professionals and trades. In 2000 BRE published Good Building Guide 41, Installing Wall Ties. The abstract of which states the following:

> "Ties are essential in cavity walls to ensure that the wall is structurally sound and stable. A cavity wall is as strong as a solid wall only if the two slender leaves are securely tied together. Lack of skill or care in installing ties can lead to distortion, cracking, or – in extreme cases — collapse of the outer leaf. The outside leaf is also the vital rain shield for the building. If ties are badly installed, this can lead to rain penetration and dampness in the inner leaf."

The Guide advises on the purpose of wall ties and the implications should ties not be correctly installed and/or an insufficient density of ties is provided. The guide states that ties which are too widely spaced, especially at openings, ties which are not long enough to bed into both leaves by at least 50 mm, or ties which are not correctly bedded can result in collapse of a cavity wall.

In addition a number of Defects Action Sheets have been published on the impact of incorrect wall ties installation on walls, as follows:

- DAS 19 External masonry walls: wall ties – selection and specification [February 1983] - The failure – instability of external cavity walls. - The defect – incorrect specification of type, size and frequency of wall ties.
- DAS 20 External masonry walls: wall ties – selection and specification [February 1983] - The failure – instability and rain penetration of external cavity walls - The defect – insufficient ties to comply with Standards both generally and at openings: insufficient embedment; ties pushed into 'green' mortar; ties sloping the wrong way; drips not in the centre of the cavity, mortar snots on ties.
- DAS 115 External masonry walls: wall ties – selection and specification [June 1988] - The failure – instability of external cavity walls. - The defect – incorrect specification of type, size and frequency of wall ties.
- DAS116 External masonry walls: wall ties – selection and specification [February 1988] - The failure – instability and rain penetration of external cavity walls - The defect – insufficient ties to comply with Standards both generally and at openings: insufficient embedment; ties pushed

into 'green' mortar; ties sloping the wrong way; drips not in the centre of the cavity, mortar snots on ties.

BRE Information Paper IP4/84 'Performance specification for wall ties' [1984] covers the overall performance requirements for masonry cavity walls and masonry cladding are discussed in the context of the current and future design environment. A technical basis for the quantification of the structural requirements is suggested which, together with an appropriate schedule of type tests and materials and dimensional specification, could form the skeleton for a future performance standard. IP6/86 [1986] 'Spacing or wall ties in cavity walls' reviews the results of load tests. IP16/88 'Ties for cavity walls – new developments' [1988] covers the durability of galvanised mild-steel ties made before 1981 has been shown to be insufficient, and also the types of tie used and the quality of workmanship have often been inappropriate, necessitating expensive remedial works. In this paper the history of the development of cavity wall ties is reviewed and recent improvements in both materials specifications and performance are covered. Newer forms of tie which are suitable for the same applications as the ties to British Standard BS 1243 are described and illustrated. IP11/00 'Ties for masonry walls: a decade of development' covered the further development over the last decade and anticipated the future CEN (European) standard, the draft EN845-1.

BRE Report BR45 'Performance specification for wall ties' [1984] covers the performance requirements for ties intended to connect two leaves of masonry together or the leaves of masonry cladding onto structural frames, are discussed. Many of the requirements, particularly those affecting the structural behaviour, are quantified in the context of existing Codes and Standards and data from recent programmes of research. Performance specifications are given for a range of ties to cover most normal masonry/masonry and masonry/timber wall applications in all geographical situations (exposure levels) in the UK and tests are proposed by which compliance may be judged.

Experience

BRE has been called upon to investigate and report on instances of masonry wall failure over decades. This includes the collapse of walls, materials failure and rain ingress. An example of a recent project is from the south of England. In this case detachment of the outer leaf to an end terrace property located in the south of England occurred during strong winds even although remedial wall ties were understood to have been previously installed. An examination suggested that the remedial ties were introduced into defective mortar bed joints within the inner leaf or were ineffectively installed in holes drilled into the body of bricks forming the inner leaf.

At the PPP schools there were issues with the way the wall ties were installed but there could also be a problem with mortar. Factory made mortars are proprietary so the testing is undertaken on the ingredients (cement, lime, plasticiser, air entertainer, sand). There is also regular factory testing of the mix. The product should carry a CE mark. The huge increase in the use of proprietary mortars which offers the client, main contractor and sub-contractor confidence in the product also has a down side. Although test laboratories still offer mix proportion analysis and chemical testing as out lined in BS 4551. The results are ambiguous and often appear to indicate that mix is incorrectly formulated. The principal requirement of the mortar as out lined in British Standards is its compressive strength (mortar class M1 to M10). When there is a question about performance it is now challenging as there is no British Standard test method for assessing the properties of hardened proprietary mortars. There is the screw pull-out test (BRE Digest 421), which does give compressive strength by testing and calculation. The in-situ bond strength can also be determined by the brick to mortar bond strength as outlined in BRE Digest 360. However, none of these tests are recognised by British Standards.

The air content of fresh mortar is determined according to BSEN 998-2. There is no agreed test method for assessing the permitted void content of hardened mortar. BRE has been using petrography, water absorption and density to assist in understanding local variations within mortar on brick and blockwork facade.

Building Standards and Reasonable Inquiry

BRE has undertaken research in recent years for Scottish Government related to 'Reasonable Inquiry', the initial research project undertaken in association with Optimal Economics ultimately resulted in the introduction of Construction Compliance and Notification Plans (CCNPs). Further research over 2015/16 itself addressed the introduction of CCNPs, where they had now become a significant part of

the reasonable inquiry process (the report is on the Scottish Government website). However, some of the key findings were as follows:

- "The case studies (of local authority verifiers) demonstrated that although the CCNP approach across eight local authorities was similar that there were differences. The differences manifested themselves in different inspection stages, number of stages and how applicants could notify the Verifier that a stage was ready for inspection. There was most notably differences in inspection by the verifier, for example some verifiers did not inspect at initial notification at all, whilst others did when they were notified.
- The verifiers all use a risk based approach to Reasonable Inquiry, but how to implement the findings vary by local authority.
- Issues that need further consideration within existing guidance include how Verifiers deal with staged warrants; some local authorities use a CCNP by warrant stage, but for others one CCNP covers all warrant stages. For some straightforward projects, e.g. a domestic alteration all Verifiers should adopt the same CCNP and only change if project circumstances dictate such a requirement."

This research addressed CCNPs mainly by process, it was also clear that the methods by which building stages were inspected or alternative evidence was provided was variable. There was an apparent increase in the reliance on photographs or other evidence being supplied by others to the Verifier in order to assess that the construction meets the building regulations. There is little in the way of technical guidance for local authority Verifiers in assessing compliance of wall tie installation, or appropriate inspection processes. It is clear that the risk based approach for wall tie installation on large stretches of masonry should involve significant inspection by Verifiers (building standards surveyors). The guidance should be tightened to ensure that such higher risk practices receive more attention.

Passive fire protection

The Cole report also discussed the issue of passive fire protection. BRE broadly agrees with the recommendations made in respect of fire-stopping in the report. BRE have been aware of defects with passive fire protection in buildings due to poor workmanship and poor fire safety management for some time now. This issue has been the subject of a number of reports one of which was referred to by Prof. Coles. The most recent report "Life safety and Regulation 7" outlines these issues. BRE suggest that there are two potential approaches to the issue of assuring quality of passive fire protection installation. Regardless of the approach used BRE note that it is not possible (or desirable) to inspect 100% of installations.

Inspection and certification of installations

Regarding Recommendation 5.8, BRE agrees that those carrying out inspections and certification of building work ought to specifically consider passive fire protection. With regards the Independent Inspector/Certifier (IIC), the specific remit of the IIC should be clarified as well as the extent of inspection and the level of training/knowledge the IIC has regarding adequacy of passive fire protection.

Approval of contractors

The use of third-party approved installers for passive fire protection is recommended by industry and provides assurance to clients regarding quality of work and these involve regular audits of installations by the approved installer and their third party approval body.

Relevant guidance

Holland, C; Shipp, M and Crowder, D. (2017) Life safety and Regulation 7. First published Building Engineer January 2017.
BRE IP 6/12 Passive and reactive fire protection to structural steel, 2012.
BRE Digest DG524 Fire doors, 2013.
BRE GBG 81 Installing fire-resisting ductwork and dampers,
Association for Specialist Fire Protection, 'Fire stopping and penetration seals for the construction industry' (Red Book).