DISCUSSION

Bracing of timber roofs

This technical paper by Walter Burdzik and Nick Dekker was originally published in J SA Inst Civil Eng, 41(3), 1999.

Problems attributed to the bracing of timber roofs have necessitated a fresh look at the bracing criterion given in the timber design code, SABS 0163 (1994). The difference between bracing provided for stability of the overall structure and bracing that is used to reduce the effective length of compression members was discussed. The differences between bracing at discrete intervals and bracing by means of a continuous elastic diaphragm were shown. Revised design rules were proposed, which, if, implemented, should solve the problems being experienced with timber roofs.

R B Hutton

Firstly, let me say how pleased I am to see much needed attention being paid to one of the more important problems in the timber roof industry.

Accepting the theoretical content of the above paper I however question whether the authors' proposals will alone solve the bracing problems associated with timber roofs. The paper fails to address important aspects such as:

- Connection details and stiffness thereof.
- Bow girder effect of the continuous bracing system and associated torsion.
- Connection of continuous bracing system along the length of the rafters and the importance of such connections.
- Effective length of rafters braced at discrete intervals. Buckling length of rafters about minor axis should be increased from the batten spacing to the truss centres along the slope of the rafter.
- Eccentricity at connections and the associated secondary effects at these connections.
- Braced bay centres and the effectivness of spliced connections in bracing runners.
- Poor workmanship.
- Bracing of multiple ply girders and the connection of battens to girder top chords.

The above represent just a few aspects which, I believe, play an important role in the effectiveness of the bracing in timber roofs.

In my opinion the authors' emphasis on the bracing stiffness is theoretical and a more practical approach to bracing details and the supervisions thereof on site will produce more stable and safer timber roof structures.

In conclusion I strongly support the need to improve the bracing specifications but would like to see a more practical approach adopted in the engineering specifications proposed.

Authors' response

It is our opinion that code requirements should be based on an acceptable theory that has been backed up by test results, and not some rule of thumb.
Requirements that are properly applied will lead to more robust bracing systems that will be more forgiving of bad workmanship.

In his letter the correspondent states that the paper fails to address some important aspects. We repeat his concerns (in italics), followed by our response.

- *Connection detail and stiffness thereof.* This is discussed in a following paper and some of the dangers inher ent in the bracing systems are high lighted.
- *Bow girder effect of the continuous bracing system and associated torsion.* We must assume that the correspondent is referring to the three-dimensional frame that is formed when prefabricated bracing frames are attached to the top and bottom chords to form a closed box. Any structural analysis package that analyses three-dimensional frames may be used to solve this problem. We cannot see that it is possible to give rules that will apply to all possible permutations. If the apex of the roof is held in position, as we suggest, the analysis may be reduced to plane frame analysis.
- *Connection of continuous bracing system along the length of the rafters and the importance of such connections.* If one remembers what is being braced and how the forces are being transferred, it becomes obvious that the battens or purlin should be nailed to the bracing frame. The bracing frame should in turn be connected to the members that are used to hold the apex in position and to the wall plates. The connection to the rafters of the two adjacent trusses is not that important.
- *Effective length of rafters braced at discrete intervals. Buckling length of rafters about minor axis should be increased from batten spacing to truss centres along the slope of the rafter.* The distance between braced points determines the effective length of a compression member. We would advise designers to determine where the rafter is braced and not rely on some arbitrary rule as is being suggested by the correspondent. Nowhere in the paper do we suggest that the effective length is the distance between battens. Figure 4 of the paper clearly shows the possible buckling of the top chord of a truss that is braced at discrete intervals. The buckled shape will then determine the effective length.
- *Eccentricity at connections and associated secondary effects at these connections.* It is not clear whether the correspondent is referring to the eccentricity of the connection to the bracing, or whether he refers to eccentricity of joints in general. It is our experience that the eccentricity of bracing connections is not that important in trusses with fairly shallow top and bottom chords. If the correspondent is referring to the eccentricity of connections where trusses are connected to multiple ply girder trusses, this is a separate issue and can be solved theoretically.
- *Braced bay centres and the effectiveness of spliced connections in bracing runners.* We discuss the effect of the number of nails between a rafter that is being braced and the bracing frame in a following paper. It is obvious that if the connection is not done properly, the bracing resistance will fall away and that the buckling length will be adversely affected.
- *Poor workmanship.* Poor workmanship can be countered by having a robust bracing system that allows for minor errors in the construction. It is only possible to design a robust bracing system if one understands how the bracing works.
- *Bracing of multiple ply girders.* A well-defined set of bracing rules and an understanding of these rules will make it possible to theoretically determine the bracing system and the required frequency of fixing to the bracing system.

We believe that the correspondent is not aware of the importance of stiffness in a bracing system. For too long designers have been mislead by simplified bracing rules that are based on a strength criterion. We would also like to point out that steel design codes will in future have a stiffness as well as a strength criterion, and that the timber design code will not be unique in its approach. It is not in the interests of designers to include practical solutions, based on experience, in design codes. Practical solutions can be found in design manuals and handbooks.

The use of clay hollow-ware for wall construction: a Western Cape case study

This technical paper by K S Cattell & G N Ramsay was originally published in J SA Inst Civil Eng, 41(4), 1999. The paper reported on commissioned research into the technical and cost aspects of using hollow clay 'maxi' bricks in Western Cape house construction. Specifically, sample bricks were evaluated in terms of the National Building Regulations, a technical analysis was conducted of energy savings, dimensional co-ordination, structural strength, structural stability and rain penetration, and a framework for a comparison between the effect on house costs of the use of hollow clay and solid cement 'maxi' bricks was established.

J W Lane

Of concern is that 'this paper was submitted in March 1996', and that the text refers to October 1998 prices (table 3). This is confusing.

The opening sentence in the Introduction states: 'The use of clay hollow-ware for general purposes is covered by SABS 589.' Please note that this SABS standard specification was withdrawn many years ago. Also, some of the terminology, units of measurement and spelling used are incorrect and is not as in SABS and ISO documents. There are also technical errors.

My concern is how this paper could be accepted in its present form with the numerous errors, which should have been corrected before publication.

Discussion

For a better appreciation of the contents of the paper, could the authors elaborate on the following points?

1 Figure 1. In the testing of the masonry units were they capped?

2 What is meant by a 1:1:6 mortar mix?
If by mass: 50 kg cement (1 bag): 50 kg lime (2 bags of 25 kg giving a loose bulk volume of 80 ℓ): 300 kg sand.
If by volume, it does depend on the volume of the particular type of cement used where the volume of paper bag may vary between 33 ℓ (CEM I – 32,5) to over 40 ℓ (CEM II – B – V 32,5). Thus, mixes could be 33 ℓ cement: 33 ℓ lime: 198 ℓ sand, or 40 ℓ cement: 40 ℓ lime: 240 ℓ sand.
Of course, if the cement is volume batched by pouring into a container, a 50 kg bag of cement may have a loose bulk volume of 50 ℓ.

3 In the measurement of initial rate of absorption of the bedding face of the burnt clay bricks, what was the range of depths of water on the serrated face?

4 What was the density of the concrete used in the concrete 'maxis' 290 x 90 x 140? Productivity of laying is related to the mass of the masonry unit, and where low-density aggregates are used in the concrete high rates of laying are experienced.

5 In the water penetration tests on a window housed in a cavity wall, one end of the wall being plastered externally and the other end painted, was any observed difference in water penetration of the two sections of wall noted? Is it necessary to plaster or to paint the external surface of a cavity wall to resist water penetration in the Western Cape?

Authors' response

The paper was submitted to the journal in March 1996. For reasons unknown to and beyond the control of the authors, it was only returned with referees' comments in May 1998. These comments included the suggestion that table 3 (cost data) should be updated. This was duly done, using October 1998 prices.

The reference in the first sentence of the paper to SABS 589 was erroneously couched in the present tense. By way of clarification we note that SABS 589, which dealt with the use of clay hollow-ware, was withdrawn in 1992, due to amendments made to SABS 227 in the same year. The amendments included: the addition of the term 'hollow masonry units' (ie units with voids exceeding 25% and not exceeding 60% of volume) to the definitions; and the stipulation of performance requirements, rather than dimensional properties of masonry units, as had been the case prior to 1992. The important point, however, is that our reference to SABS 589 was intended as background information. The evaluation of the hollow-clay unit described in the paper was conducted in terms of the currently applicable SABS Specifications and Codes of Practice (ie SABS 227, SABS 0164 and SABS 0400) and was not in any way based on SABS 589.

We now address the five points raised under 'discussion'.

1 In the section of the paper entitled 'Evaluation', we noted that all of the tests were conducted by the SABS in accordance with the various requirements of SABS 227, SABS 0164, SABS 0400, and the Agrément Board. Among these is the SABS 227 requirement that units be capped for the compressive strength test – this was duly done.

2 All three references to the mortar mix refer to 1:1:6 (Class II) mortar. Class II mortar consists of 50 kg cement, 0–40 litres of lime and a maximum of 200 litres of sand. Verbal confirmation was obtained from the SABS that the mix used for the wallettes constructed for the tests consisted of 1 part cement (33 litres), 1 part lime (33 litres) and 6 parts sand (198 litres).

3 As noted in point 1 above, tests were conducted in accordance with stipulated procedures. In the case of the initial rate of absorption of the bed face, SABS 0164: Part 1-1980 requires specimens to be placed on 6 mm thick rests in a tray of water. Prior to testing the first specimen, a thoroughly saturated 'reference test specimen' is placed on the rests and water is added to the tray until the total depth is 9 mm (± 0,25 mm), ie 3 mm above the top of the supports. Specimens are then placed, in turn, on the rests for a period of one minute, then removed and weighed. The initial rate of absorption is expressed in kg/m^2, being the gain in mass expressed over the area of the bed face. Six specimens were tested and the SABS test report indicates the initial rate of absorption for each, namely 0,70; 0,65; 0,85; 0,85; 0,65; and 0,60 kg/m^2. The report does not, however, stipulate the depth of the water after each immersion. We have confirmed verbally with the SABS that a 500 mm x 300 mm tray was used and that there was 'no appreciable drop in the water level' as a result of the immersion of the six specimens.

4 It is unclear to us why reference is made to *'concrete "maxis" 290 x 90 x 140'*. As clearly stated in the Introduction, the evaluation concerned a masonry unit that 'has the same external dimensions as the cement and clay "maxi" brick (222 x 114 x 90 mm)'. The cost comparison in the section entitled 'Cost' compares the perforated clay unit to what is commonly known in the Western Cape as a cement *maxi brick* (222 mm long x 90 mm wide x 114 mm high). However, the purpose of the comment was clearly to note that the mass of the unit affects laying productivity. We agree, and noted this in the paper, where we pointed out that 'outputs for the two types of bricks were held constant at 720 bricks per day, notwithstanding the fact that the perforated clay "maxi" is lighter that the solid cement "maxi"'. The average mass of the perforated clay maxis tested by the SABS was 2,9905 kg and, according to INCA, the average mass of the cement maxi is 3,5 kg. The reason for holding outputs constant in the cost comparison was that we obtained as many estimates of laying productivity as opinions we canvassed. When the costing model was first developed, three large

housing contracting firms were consulted and all agreed that 720 cement maxi bricks per day was a reasonable average output to use for comparative purposes, for both clay and cement maxis.

5 As noted in the section entitled 'Evaluation', there was no evidence whatsoever of water penetration after 24 hours of exposure to continuously sprayed water at a rate of 50 litres/hour/square metre. This applies to both the plastered side and the side treated with Premier Cote self-cure textured coating. Thus, there was no observed difference between the two sections. It should be noted that SABS 0400 stipulates that, in the Cape Town area, the test should be conducted for 15 hours. However, given that no penetration occurred during this period, the test was continued for a further 9 hours (24 hours is the maximum period stipulated by the SABS 0400). The SABS does not undertake a post-demolition analysis of masonry wallettes, which would be the only way of determining the relative degree of protection afforded by each finish.

Is it necessary to plaster or paint cavity walls in the Western Cape to resist water penetration? Our view is that it is, for the following reasons:

First, let us consider this question in the context of single-skin walls. Water penetrates through the mortar joints much more rapidly than through the masonry unit itself. For example, the SABS have conducted tests on solid 230 mm walls of calcium silicate bricks built to fair face with tooled mortar joints, which indicated a significant penetration of water to the inner face through the mortar joints within one hour. There have been attempts to combat this problem, and it has been shown that under test conditions a mortar additive can effectively make the joints impervious. However, we believe that one must take a realistic view of what standards of workmanship can be expected regarding the degree of control over the mortar mixing process. Given the context of large-scale housing delivery, it is unlikely that effective controls would be exercised over whether or not the correct amount of additive is used and therefore, mortar joints are likely to remain a problem. This problem would obviously also apply in the case of external skins of cavity walls. A further problem with cavity walls is that bridging of the cavity by pieces of broken brick and/or mortar droppings on wall ties, etc, is likely to occur, thereby permitting moisture to travel across the cavity to the inner skin. In addition, once moisture penetrates the external skin of the cavity wall, if evaporates into the cavity and condensation forms on the surface of both the inner and outer skins. The only way to prevent this problem is to effectively waterproof the exterior of the wall with a coat of plaster or an appropriate wall coating such as the self-cure textured coating described in our paper.