

AD 489: Height of shear studs

AD 380 entitled “What height of shear stud should be used in Eurocode 4?” provided interim advice on the height/length of shear studs to be used in design calculations and referred to a programme of tests/analysis that was in progress. On completion, the programme of tests provided the input to SCI publication P405¹ but AD380 was not subsequently updated. This AD note now supersedes AD380 and reconfirms and supplements the guidance it contained.

BS EN 1994-1-1² defines h_{sc} as the ‘overall nominal height’ of a stud connector in the list of notation, but elsewhere the same variable is defined as simply ‘the overall height’. Moreover, a stud that is for example 105 mm long when manufactured would typically have “length after welding” (LAW) of 100 mm when welded directly to a beam flange, or 95 mm when welded through decking. It would generally be described as a nominal 100 mm stud.

Resistances

Stud resistance values are a function of h_{sc} , because the solid slab resistance P_{Rd} (clause 6.6.3.1(1)) may be reduced using the factors k_1 (clause 6.6.4.1(2)) and k_t (clause 6.6.4.2(1)) used to allow for the presence of decking. SCI’s advice in P380 was that LAW should be used when determining reduction factors, not least because although the code itself is not clear, the ICE Designers’ Guide to Eurocode 4 by Prof. Roger Johnson used the LAW in the examples.

In addition, BS EN 1994-1-1, clause 6.6.5.8(1) suggests that the minimum embedment length, i.e. length of stud extending above the top of the decking, should be $2d$ (where d is the stud diameter). Although considering the LAW when verifying this would be consistent, it would also suggest that a nominal 100 mm stud of 19 mm diameter could not be used with 60 mm decking.

Experience and tests have shown that such a conclusion would be incorrect. It is therefore reconfirmed that, although apparently inconsistent, the nominal stud length may be used when establishing this lower bound length.

Results of test programme and analysis

As well as considering what values to use for the variables in code rules, the test programme referred to was undertaken to confirm what resistances and slip capacities, can be achieved when studs are used with modern forms of profiled decking. The tests also investigated the justification for the detailing requirement given in BS EN 1994-1-1 that any mesh local to the studs should be placed at least 30 mm below the head of the studs. Note that this criterion is not satisfied with the very common situation in the UK of a 60 mm trapezoidal deck used with nominal 100 mm studs.

The conclusions from this test programme are provided in reference 1, and guidance given therein confirms the recommendation that the as-welded height (LAW) is used in the BS EN 1994-1-1 reduction formulae.

More significantly, the results also show that when the decking is transverse to the beam the rules given in BS EN 1994-1-1 may be unconservative. To allow for this, additional reduction factors to those given in BS EN 1994-1-1 associated with the decking geometry are required as described:

- when double studs are present additional reduction factors are introduced as follows:
 - When mesh is placed below the heads of the studs an additional multiplication factor k_{mod} of 0.9 should be applied. The mesh does not need to be 30 mm below the head, merely underneath it.
 - When mesh is placed at nominal cover

(assumed to mean above the head given typical slab geometries) the values derived from EN 1994 should be reduced using an additional multiplication factor k_{mod} of 0.7.

For studs with transverse decking:

$$P_{Rd} = k_{mod}k_t \text{MIN}[P_{Rd} \text{solid slab}]$$

- no further reduction is necessary when single studs are used, even if mesh is placed at nominal cover.

In addition, much research has been carried out in continental Europe as part of the background to new rules that will be presented in the so-called Generation 2 EN 1994-1-1. These suggest that some current UK practice may be unconservative, although this may simply be because of conservatism of the mechanical models that have been developed to predict resistance. The Generation 2 document will also allow the use of test derived values.

One final point for designers to be aware of is that studs come in standard lengths (of which 100 and 125 mm are the most common). A designer may consider increasing the length of a stud to (potentially) increase resistance, but only standard lengths should be specified.

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References

- 1 Couchman G C, *Minimum degree of shear connection rules for UK construction to Eurocode 4*, SCI P405, 2015
- 2 BS EN 1994-1-1:2004 *Eurocode 4 Design of composite steel and concrete structures. General rules and rules for buildings (incorporating corrigendum April 2009)*

All-steel operating theatre

FROM

**Building
with Steel**

November 1971

The theatre installed at the Mile End hospital



This theatre was constructed by the medical equipment division of Calmic Ltd in association with T. P. Bennett & Son at a cost of £68,000. It is designed in metric dimensions and built to the Wellcome industrialised modular theatre system.

Sterility, temperature, humidity and light are all controlled in this theatre. The structure is self-supporting and comes as a complete package only requiring erection by Calmic engineers and connection to water, steam and electric supplies. The all-steel construction makes it ideal for the tropics. The standard units provide six sizes of theatre and all steel is galvanized while the wall panels are additionally protected with a 1mm PVC coating.

It is claimed that the total departmental cost can be 30 per cent lower than with traditional methods since the building required to house the theatre is much less complex.