Design requirement

$$\phi M_{bt} \geq M^* + M^*_{axial}$$

where: M^* = design bending moment at connection (defined in Section 7)

$\phi M_{bt} = 2\phi N_{tf} \sum d_i$

ϕN_{tf} = design capacity of bolt in tension

= 163 kN   M20 bolt, 8.8/TB

= 234 kN   M24 bolt, 8.8/TB

$M^*_{axial} = N^*_{fr}(d_b - t_{fb}) \leq 0.25M^*$

N^*_{fr} = flange force due to tension/shear (defined in Section 7, see Table 2 for relevant equation)

= 0 if resultant causes compression

$\sum d_i = d_{10} + d_{11}$ 4 bolt connection (see Figures 16,17)

$= d_{10} + d_{11} + d_{12} + d_{13}$ 8 bolt connection (see Figures 18, 20)

$= d_{10} + d_{11} + d_{12}$ 6 bolt connection (see Figure19)

This DESIGN CHECK is based on Reference 6, but reformulated as Reference 6 has an equation that determines bolt diameter rather than the design moment capacity of the bolt group, as given above. Reference 6 also makes no provision for axial force or shear force components causing tension on the bolt group, which are allowed for here in N^*_{fr}, via the equations derived in Section 7.

The bolt force model is discussed extensively in Reference 6 and will not be repeated here in detail. The model:

- considers two stages of plate behaviour, thick plate behaviour with no prying forces and thin plate behaviour with maximum prying forces. The threshold between the two behaviours is considered to be the point where bolt prying forces are negligible, and is taken to be when ninety percent of the end plate strength is achieved, based on test results. The recommended design model is based on thick plate behaviour.
- for thick plate behaviour, the bolt forces are determined by taking the static moment of the bolt forces about the centreline of the compression flange;
- each bolt is assumed to reach its design capacity in tension at the same time and because thick plate behaviour is assumed, no prying is required to be considered. Hence, the design moment capacity then becomes the bolt strength at each bolt row multiplied by the lever arm between the bolt centreline and the centreline of the compression flange;
- the underlying assumption is that the outer bolts will yield and deform sufficiently to allow the inner bolts to also develop their full design capacity in tension. The weld to the web is designed to be strong enough for this to occur (refer to DESIGN CHECK NO. 2);
- to ensure thick plate behaviour, there is a requirement that the end plate design capacity in bending be at least 1/0.9 = 1.11 times the design capacity of the bolts in tension (see DESIGN CHECK NO. 6). The difference between thick and thin plate behaviour and the modifications to this DESIGN CHECK for thin plate behaviour are discussed in Appendix A.

- M^*_{axial} allows for the fact that design axial tension present (N^*_{fr}) reduces the capacity of the bolts at the tension flange to resist the tension due to the design bending moment (M^*). The method of allowing for this is to convert the design axial tension component (N^*_{fr}) into an equivalent design moment (M^*_{axial}) which the bolt group must also resist. This is the method proposed in Reference 18. The limit on M^*_{axial} is intended to ensure that the yield line solutions in DESIGN CHECK NO. 6 remain valid. There is no published justification for this limit at this time.

The modifications to this DESIGN CHECK for thin plate behaviour are discussed in Appendix A.

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