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A Note on the Buckling of a Plate Girder Web due to Partial Edge Loadings

Bemerkung über das Ausbeulen hoher Blechträger unter Streckenlast

Remarques relative au voilement de poutres à âmes minces dues à des charges partielles agressants sur le bord

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1. INTRODUCTION

Professor Massonnet (1), in the excellent paper he has presented in the 'Preliminary Publication', has drawn attention to the need for further research into the buckling of a web under the action of a concentrated load applied to the compression flange. Subsequently, at the Conference, Beedle and his colleagues (2), have reported on experimental work they have conducted on this problem. This note briefly reports on a theoretical study which the present authors have made and which is reported in full in Reference (3).

2. THEORETICAL RESULTS

Relatively little research has been conducted into the behaviour of the buckling of the webs of plate girders when subjected to in-plane concentrated loads applied to an edge, the notable exceptions being the research of Zetlin (3) and White and Cottingham (4). However, both of these studies only involved the buckling of an isolated plate, i.e., the interaction between flange and web was not considered.

The writers have employed a finite element method of solution which is ideally suited to deal with such problems. Present space does not permit a presentation of the theoretical solutions which are given in Reports (5,6).

Figure 1 gives details of the problem considered. The applied load, which is symmetrically distributed about the central line of the panel, is supported along the vertical edges of the panel by uniform shear stresses as shown. The vertical edges are assumed to be simply supported, that is, there is no out-of-plane deflection along their lengths. It was assumed, however, that these vertical edges can rotate about the neutral axis of the section in a manner similar to that which occurs in an actual plate girder.

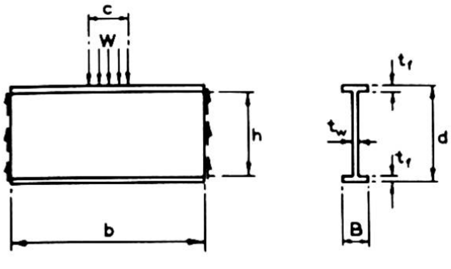

Figure 1.

The theoretical study has shown that the relationship between the applied load P_{cr}, which will cause the plate to buckle and the physical and material properties of the plate, is given by Equation (1), in which K' is a non-dimensional coefficient.

$$P_{cr} / bt = K' \pi^2 D / d^2 t \quad .. \quad .. \quad (1)$$

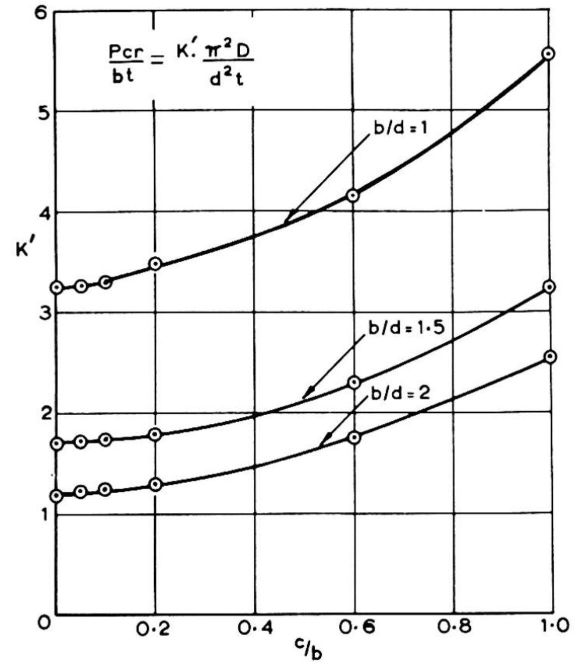

FIGURE 2
VARIATION OF BUCKLING COEFFICIENT K' WITH c/b RATIO FOR A PLATE

Where b = width of plate
d = depth of plate
t = thickness of web plate
$D = Et^3/12(1-u^2)$
E = Young's Modulus of plate
μ = Poisson's Ratio

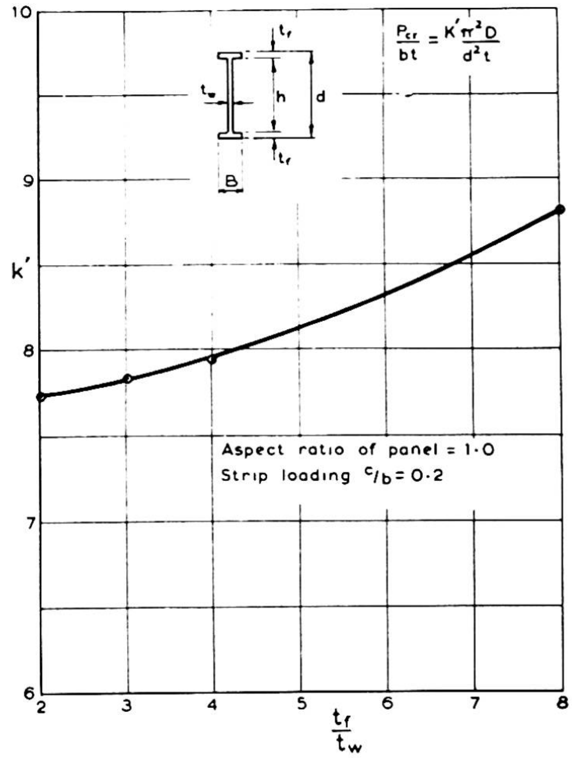

FIGURE 3
RELATIONSHIP BETWEEN K' AND RATIO OF FLANGE THICKNESS TO WEB THICKNESS

Figure 2 shows how, for a plate which is assumed to be supported against deflection along all edges, K' varies with the loading parameter c/b.

From this diagram it will be seen that as the length of application of the load is increased so a larger load is needed to buckle the web plate. In a practical girder the flange members will assist in distributing the load and will also provide additional restraint to the web plate. Figure 3 shows how for a square panel, K' varies with the ratio of flange thickness/web plate thickness. It will be noted that with a flange plate of only twice the web thickness, the value of K' is 2.3 times as great as the corresponding value given in Figure 2 for an isolated plate. The influence of the flanges upon the buckling stress is therefore seen to be most significant. In forthcoming reports the authors will be providing curves giving the relationships between buckling coefficient K', the ratios c/b and b/d where the web plate is subjected to the combined action of bending, shear and a concentrated load applied to the upper flange.

3. CONCLUSION

This note deals with the buckling of the web plate of a plate girder when it is subjected to a concentrated vertical load applied to the flanges and shows how this critical load varies with the physical properties of the flange members.

4. ACKNOWLEDGEMENT

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