The statistical variation of the buckling strengths of columns

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The Authors have presented a lucid description of buckling tests on nominally identical specimens at four different slenderness ratios. With the current move towards semi-probabilistic methods for assessing safety¹⁷ it will become necessary to conduct series of tests of this nature where the maximum control is kept on some of the more obvious objective variables involved in order to assess the subjective uncertainties which reflect man's imperfect knowledge.¹⁸ Only then will designers have the best bases for choosing characteristic values and partial safety factors for strength.

46. It can be seen from Fig. 6(c) that the buckling strength coefficients of variation from the Author's tests (Fig. 5) and those of the European group⁸ show a peak close to 10% at $l/r = 78$ which is the slenderness value closest to $(l/r)_T$. However, it seems that it is at this slenderness value that the minimum value of $\bar{\alpha}_0$ occurred. It would therefore appear that most of the variation in strength must be due to something other than geometrical imperfections which are known to exert their greatest effect in the $(l/r)_T$ region. Likewise the excellence of the test arrangements would seem to discount the possibility that end constraints or eccentricities have any significant influence. If this is true then the uncertainties illustrated by Fig. 6(c) (which average about 4%) are more likely to be subjective than objective. Can the Authors confirm these inferences and explain this scatter?

47. In the same vein Fig. 11 may be of interest. It shows the result of compression tests on thirteen nominally identical uniaxially tee bar stiffened plate panels designed in the buckling-yield transition.¹⁹ The experimental conditions were carefully controlled to minimize their uncertainties. The panels were made from mild steel selected and constructed under normal shipyard conditions. The effect of stiffener shape imperfections was negligible but the effects of residual welding stresses and plate deflexions were apparent but moderate. The objective random uncertainties, which were dominated by variations in yield stress, had a coefficient of variation of about 6%. Subtracting this from the experimentally found total uncertainty of 10.9%, and assuming statistical independence, suggested a typical subjective random uncertainty for such structures of 9-10%. This is similar to that obtained by the Authors, although somewhat greater overall as one would expect for a more complex fabricated structure.

48. I am surprised at the cusped nature of some of the figures at the transition slenderness. Of course many theoretical approaches show greatest sensitivity to shape and material imperfections at this transition, but it is my experience and belief that such discontinuities seldom appear in practical structures during test.

Panel details: $\beta = 2.11$, $\lambda_s = 0.94$, $\gamma = 0.49$, $i = 6.1$ (tee), $\eta = 40.45$

Fig. 11. Strut-panel strength distribution¹⁸

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Professor Faulkner has raised several points of interest. In conducting the tests, we were anxious to test 'real' columns, and made no attempt at selection. Ideally, we would have hoped for broadly the same distribution and mean value, $\bar{a}_0$, of the geometrical imperfection at each of the slenderness ratios studied. Perhaps fortunately, the minimum value of $\bar{a}_0$ (the mean of all values of a_0 for one slenderness ratio) occurred at $l/r=78$ (Fig. 7), i.e. at the experimental slenderness ratio closest to $(l/r)_T$. It was at $l/r=78$ that we found the largest variation of maximum strength. Fig. 8 shows that this can be predicted from consideration of solely the geometrical imperfection. Thus, other than in the transitional region, essentially

$$\sigma_{\max} = (E \text{ or } \sigma_y, a_0)$$

50. The results presented in Fig. 11 are not only similar to our results, but also to those obtained by the European Convention⁹ for tubes, double angle, I, T and square box sections. However, this behaviour does not necessarily apply to other structural forms. Work done on simply-supported mild steel plates subject to end compression^{20, 21} shows, for these members, the scatter of maximum strengths to be a minimum in the region of elastic-plastic failure.

51. We agree that sharp discontinuities, such as those shown in Fig. 6(c), should be regarded with caution. In this case, both experimental results (curves A and D) and the theoretical ones (curves B and C) indicate that a sharp discontinuity in the coefficient of variation does indeed exist.

References

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Corrigendum

The horizontal axis of Fig. 4 should be labelled a_0/r .