The workability of steel-fibre-reinforced concrete*

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Professor Hughes and Dr Fattuhi must be commended for presenting valuable experimental data in an area of great topical interest. Though work on the strength of fibre-reinforced concrete is not new, very little research has been reported on the workability of steel-fibre-reinforced concrete[1]. The slump and Vebe test results presented in the paper give enough information for some definite conclusions to be drawn regarding steel-fibre-reinforced concretes in the green state. However, I wish to add a few supplementary observations in this regard.

A plot between the slump and the aspect ratio (Figure 3 of the paper) indicated that the slump is affected by a shape factor, z, as in the case of crimped fibres. A very similar observation was made with regard to the Vebe time (Figure 6). However, from what has been plotted in these two Figures, the other forms (even the hooked) do not seem to have influenced the behaviour. It might be expected that the crimped and the hooked fibres would behave quite differently from the other forms of fibrous reinforcement in the hardened state because of their increased bond capacity. However, this need not affect their behaviour in the green state. When viewed against this background, the behaviour of crimped fibres in the green concrete looks odd.

Having in my possession a few crimped fibres obtained some time ago from the UK, I examined these carefully and found, logically enough, that the length of the fibres effective for their behaviour in the green state of concrete is not the total length but only the projected length. From the fibres available, it was found that the crimp was of the order of 30° from the straight in both ways, and thus the projected length of fibres participating in the workability of the fibrous mix was considerably less than the assumed values.

Figures 3 and 6 are re-plotted here as Figures I and II with this modified definition of the fibre length. The new Figures indicate that the points due to crimped fibres are now much closer to the points obtained

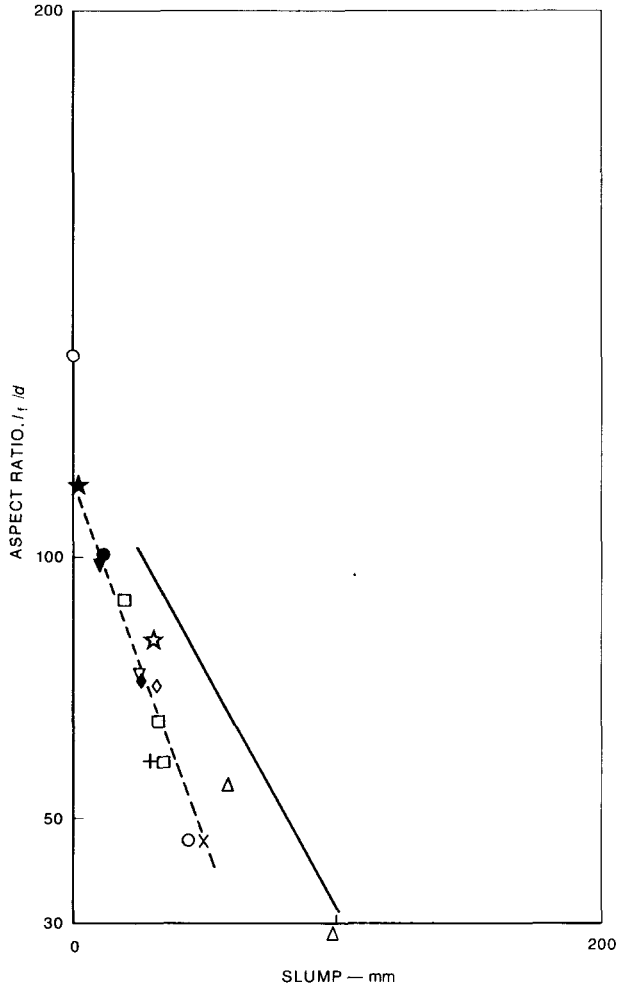

Figure I: Figure 3 of the paper corrected for the modified definition of the length of crimped fibres.

*Pages 157 to 161 of *MCR* 96.

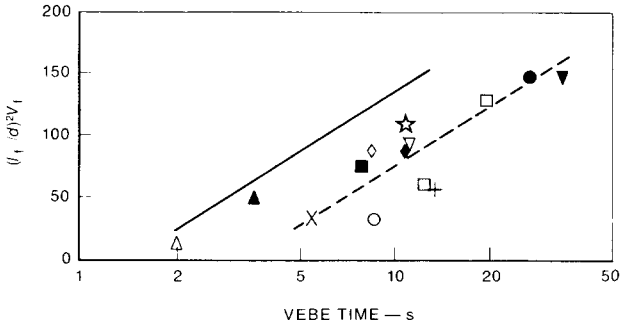

Figure II: Figure 6 of the paper corrected for the modified definition of the length of crimped fibres.

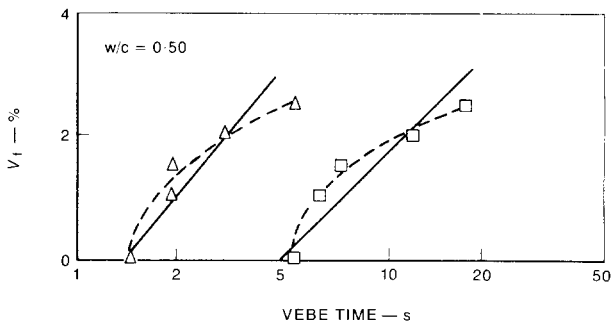

Figure III: Figure 8a of the paper corrected to show the curvilinear relationship.

from other types of steel-fibre reinforcement. However, if the crimps of the fibres used by the author were to be inclined at 45°, the points would practically merge with the average theoretical curves due to fibres other than crimped fibres. So effectively, if we consider the projected lengths for the behaviour of steel-fibre-reinforced concretes in the green state, their workability is affected only by the aspect ratio and volume fraction and not by the shape factor.

Furthermore, if a typical example from the array of plots in Figure 8 (Figure 8a, w/c = 0·50) is considered, it can be seen that the plots remain closer to a parabolic curve than to a straight line in spite of the log scale used for Vebe time, especially in the case of lower water/cement ratios. Further thought might be given to this aspect of the behaviour also.

Reply by the authors

We wish to thank Dr Babu for his contribution. However, as a point of information, it should be confirmed that the aspect ratios as given in the paper are based on fibre lengths (l_f) given by what Dr Babu refers to as the projected lengths. If l_f values based on the original (uncrimped) lengths of the fibres had been used, the differences between the straight and crimped fibres in Figures 3 and 6 would have been even greater. The shape factor for workability for crimped fibres is therefore very significant, even though the angle of crimp from the straight was only of the order of 30%.

The shape factor for hooked fibres can be expected to be relatively small and intermediate between the values for straight and crimped, since the projected length is only slightly less than the original (undeformed) length (see, for example, the photograph in reference 2). The result in Figure 3 need not therefore be regarded as so surprising.

We agree that, for water/cement ratio = 0·40, Figure 8a could be drawn as shown in Figure III. Any limitations of the linear relationship as apparent in Figure 8 would need to be resolved by further work.

REFERENCES

1. RITCHIE, A. G. B. and RAHMAN, T. A. The effect of fiber reinforcements on the rheological properties of concrete mixes. *Fiber-reinforced concrete.* Detroit, American Concrete Institute, 1974. Publication SP-44. pp. 29–44.

2. HUGHES, B. P. and FATTUHI, N. I. Fibre reinforced concrete in direct tension. *Conference on fibre reinforced materials* London, Institution of Civil Engineers, March 1977. p. 129.