

# Discussion on an article published in the

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## Some fatigue tests on reinforced concrete beams\*

by R. Taylor, B.Sc., D.I.C., A.M.I.C.E.

### Contribution by N. Falcini

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Mr Taylor has no doubt attempted to present his results without giving the customary mass of figures that is common in complicated tests of this kind. However, there are some basic facts which it is important to know but which were omitted.

Firstly, there was no mention of the properties of the steels used. The relative strengths and ductilities are critical when examining test results of this nature.

Secondly, and perhaps equally important, is the type of cold-worked bar used. Clearly from the photograph of beam F6 (Figure 3 of the paper), the bars were of the ribbed type where the transverse ribs join the longitudinal ribs at some acute angle. The rolling process of forming the bar produces high stresses at the root of the ribs, particularly at the junction of the transverse and longitudinal ribs, and is thus a main cause for concern in premature fatigue failures. To use this type of bar under the general label of "cold-worked bars" is grossly misleading. These bars cannot be taken as wholly representative of all cold-worked bars in such tests but may represent the behaviour of similarly ribbed bars of other steel qualities.

The writer has been associated with repeated loading tests purposely identical with those reported by Dr Bate<sup>(1)</sup>. These tests were performed on beams reinforced with mild steel and with Square Grip.

The cold-worked mild-steel bars used by Dr Bate are identical with those used by Mr Taylor and a comparison of the load factors obtained is given in Table I.

Under repeated loading at a load corresponding to failure of the beam reinforced with cold-worked mild steel, the maximum crack width in the beam with Square Grip reinforcement was  $8 \times 10^{-3}$  in.

TABLE I: Experimental load factors

	Cold-worked mild steel	Square Grip
Static loading	2.40	2.70
Repeated loading	1.80	2.10
Number of cycles to failure	$3.02 \times 10^6$	$4.27 \times 10^6$
Range of steel stress at failure (lb/in <sup>2</sup> $\times 10^3$ )	15-48	15-57

As regards Dr Bate's tests, Dr Abeles agreed with him that for very narrow crack widths, say 0.005 in. or less, there was very little danger that fatigue loading would cause a very large increase in crack width. However, Mr Taylor has shown that beam F2 had a crack width of 0.004 in. which increased to four times that amount after  $\frac{1}{3}$  million load repetitions. The writer thinks that this is due to the different shear reinforcements and load range adopted and would like to have Mr Taylor's views.

Perhaps Mr Taylor would also explain his reasons for choosing this particular bar to represent "cold-worked mild steel".

### REFERENCE

1. BATE, S. C. C. A comparison between prestressed concrete and reinforced concrete beams under repeated loading. *Proceedings of the Institution of Civil Engineers*. Vol. 24. March 1963. pp. 331-358.

### Reply by the author

I am grateful to Mr Falcini for his comments and for his additional experimental data. With regard to the strengths of the materials used in my tests, these were given in the fuller experimental report in reference 2.

It should be noted that the tests were aimed at clarifying the behaviour of reinforced concrete beams

\*Pages 31 to 38 of *Magazine* No. 46

under repeated loading when the amount of shear reinforcement was reduced from that normally used. The ribbed type of deformed cold-worked bar was adopted simply because it had been used in the previous static loading tests and not because it possibly had better or worse fatigue characteristics than other types. For the type of test carried out, where the dowelling effect of the longitudinal reinforcing bars was most important, the behaviour of the different cold-worked bars remains in doubt. It would be interesting if Mr Falcini could extend his comparative tests to include this effect.

With regard to the effect of repeated loading on crack widths, it is necessary to point out an essential

difference between the tests of Dr Bate and those of the author. Whereas in the former the shear reinforcement in the beams was deliberately proportioned to preclude the possibility of a shear failure and any possible effect of inclined cracking, the latter tests were designed to indicate the effect of inclined cracking on behaviour. Thus Dr Bate's measured crack widths, and Dr Abeles' remark, relate essentially to regions of constant bending moment whereas my data on crack widths were pertinent to regions of high shear. As the tests indicated, repeated loading may have considerable effect on inclined cracks which may be quite fine under static loading. This in turn affects the behaviour of the longitudinal reinforcement.