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An appreciation of the work carried out on fatigue in prestressed concrete structures*

by R. E. Rowe, M.A.

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It is to be regretted that Mr Rowe, in his appreciation of published work on the fatigue strength of prestressed concrete members, has made no mention of the admirable review presented by Dr S. C. C. Bate as Paper 2 at Session D of the Symposium on the Strength of Concrete Structures, London 1956. Even apart from the summary itself, Mr Bate's impressive bibliography makes his paper one which should be known to all workers interested in this particular field of study.

It seems to be generally agreed that fatigue failure of pre-tensioned members does not occur, provided that tensile stresses are not developed during the loading cycle. Tests carried out at Nottingham on a number of beams have verified this fact, and have shown no evidence of a significant change in flexural rigidity during the course of a test up to 4×10^6 cycles. Recently published work by Ozell and Ardaman⁽¹⁾, however, shows that changes in flexural rigidity do occur in a beam subject to loads greater than the design load, and that these changes become marked immediately prior to failure. This loss of bending stiffness is used as a criterion to define incipient failure.

When tensile stresses are developed under load in the extreme fibres of the beam, and cracking of the concrete occurs, failure is caused by fracture of the prestressing wires themselves. Some discretion should be used when assessing the force in the wires before failure, since an estimate can only be reached after certain assumptions regarding the stress distribution in the remaining concrete have been made, and, at best, the estimate can only be as accurate as the assumptions on which it is based.

The fatigue life, in the working stress range, of pre-tensioned beams previously cracked by an unforeseen overload has still not been determined beyond question, although the British Transport Commission's test (reference (7), as reported by Mr Rowe) will remove many doubts. The existence of cracks may possibly prevent the

use of resonant type fatigue machines (as used at present in Nottingham), and it may be necessary to work with fixed displacement or hydraulic pulsator machines.

The fundamental definitions which require careful study before further experiment are, firstly the range and frequency of applied loading which may be anticipated in practice and, secondly, the meaning to be given to the use of the word failure. On the first point, it should be said that only in very broad terms are working rules available for metal specimens subjected to cumulative damage, with varying loading histories, despite the vast amount of experimental work already carried out on the subject. Failure of a beam has been variously used by earlier investigators to mean either decrease of flexural rigidity or increase of permanent set, both within certain limits, or the development of cracks visible to the naked eye, or catastrophic fracture. Considerable care must be exercised, therefore, when comparing results from various experiments.

REFERENCE

1. OZELL, A. M. and ARDAMAN, E. Fatigue tests of pre-tensioned prestressed beams. *Journal of the American Concrete Institute*. Vol. 28, No. 4. October 1956. pp. 413-424.

Reply by the author

I should like to thank Mr Coates for his contribution to the discussion on my paper and I agree with him that Dr Bate's paper is one that should be widely known. The omission of a reference to it is due to the fact that it was not available for general distribution when I prepared my paper.

I agree with Mr Coates that the fundamental definitions of the range and frequency of the applied loading and the meaning given to the word failure need careful study. Until these particular definitions can be given in a much more precise manner, the interpretation of test results and the application of such results to actual structures subjected to fatigue loading will remain a very difficult problem.