

Discussion

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A quantitative assessment of damage sustained in concrete during compressive loading*

D. C. Spooner and J. W. Dougill

Contribution by A. G. Young

University of Leicester, Department of Engineering

By coincidence, the work on damage during compressive loading by Dr Spooner and Dr Dougill appeared in the same issue as work on failure of concrete under sustained tension in which I was involved⁽¹⁾. I was impressed by the results of their cyclic loading technique and took the opportunity to

apply it to the case of tensile loading, using the specimen design and loading and measuring techniques described in reference 1. Test results are presented in Figures I and II. Figure I shows the stress – strain curves obtained by subjecting a specimen to cyclic loading in tension, the peak stress in each cycle being

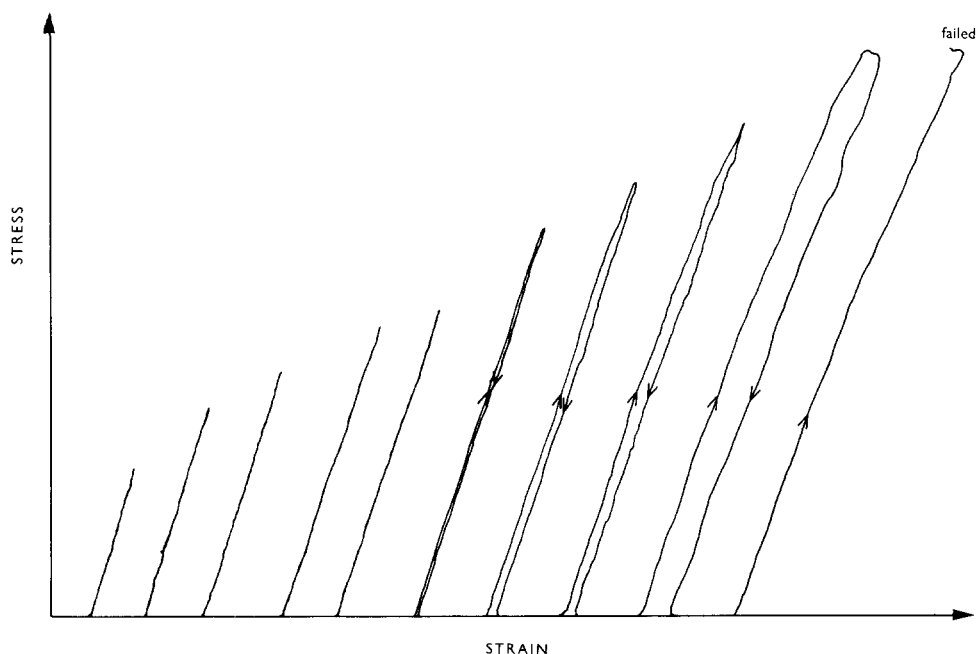


Figure I

*Pages 151 to 160 of MCR 92.

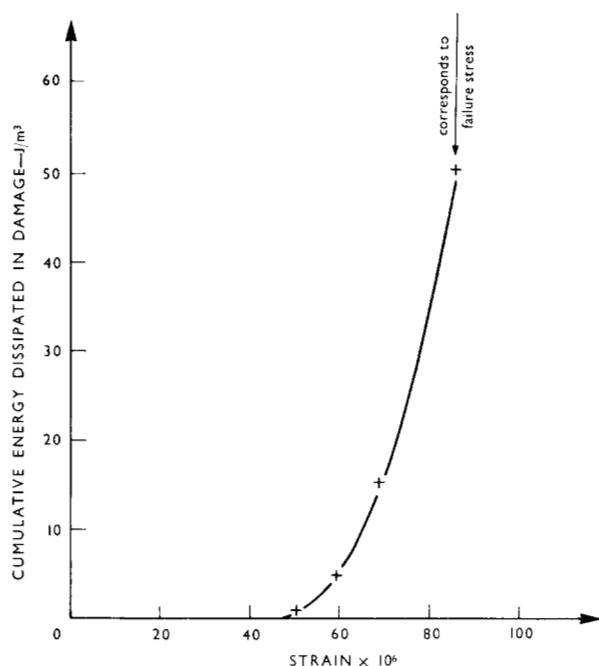


Figure II

steadily increased until failure occurred. The individual cycles were recorded separately for clarity. Figure II shows the values of cumulative energy dissipated in damage obtained from Figure I plotted against the peak strain applied in the cycle. These results suggest that, contrary to the authors' findings with compressive loading, there is a certain level of tensile stress below which the damage suffered by the concrete is so small as to be deemed negligible. The threshold value of stress is, in this instance, about 0.65 times the short-term strength, a value which corresponds closely with the 'discontinuity' point found previously from stress/transit-time curves obtained by using ultrasonic equipment.

The concept of a threshold stress, below which no damage of any significance occurs, is supported by the results we have obtained to date from long-term tests of concrete specimens under sustained tension. Although the Kachanov model, based on progressive damage, predicts a time to rupture at 0.65 times the short-term strength of 33 days (see reference 1), specimens loaded to this value survived 7 months without failure.

Reply by the authors

We wish to thank Dr Young for his contribution and for his interest in our work. It is particularly gratifying when a technique is taken up quickly and applied to different situations.

Dr Young's data on energy dissipation in damage in concrete in direct tension are most useful and we note that the energy required to break the specimen is some 50 J/m³. If we calculate the work of fracture from the data, assuming a diametral fracture plane, a value of 19 J/m² is obtained. This figure is of the same order as those obtained by workers in the fracture mechanics field. It is also interesting that the total energy to break the specimen in tension is nearly two orders of magnitude less than that dissipated in damage in a

compression specimen taken to maximum stress. This energy difference presumably reflects the relative areas of crack surface created in the two test methods.

We are hesitant to accept Dr Young's definition of a 'threshold value of stress' based upon a 'deemed to be negligible' value of energy dissipation in damage. In this, we are particularly conscious of the manner in which the resolving power of different measuring techniques has affected the definition of 'discontinuity' in recent years. Thus we feel it may be premature for concrete in tension to postulate the existence of 'threshold' stress levels until more data are available. We hope that we may look forward to more work by Dr Young in this field.

REFERENCE

1. AL-KUBAISY, M.A. and YOUNG, A. G. Failure of concrete under sustained tension. *Magazine of Concrete Research*. Vol. 27, No. 92. September 1975. pp. 171-178.