The creep of sealed concrete under multiaxial compressive stresses*

by I. J. Jordaan and J. M. Illston

CORRIGENDA

The key of Figure 7 should read:

- biaxial
- uniaxial

The right-hand side of equation 4d should read:

$$= \frac{1 + \nu}{1 - 2\nu}$$

The caption to the Figure on page 202 should read:

Figure 8: The effective Poisson's ratio of (sealed) concrete under uni-, bi- and triaxial systems of stress, both during the period under load and after the load has been removed.

Contribution by G. S. Pandit, BE(Hons), MSc, PhD(Alberta)

Considerable work has been done in recent years on the strength and deformation, both instantaneous and deferred, of concrete subjected to multiaxial stress systems. The apparent conflicts and contradictions in the conclusions drawn by different investigators seem to be mainly due to the differences in the manner of testing, the sequence of loading and the restraint exerted by the loading platens. The sequence of loading is important because the creep strains are functions of the relative magnitudes of the principal stresses and the principle of superposition is not valid⁽¹⁾. Similarly the importance of the platen restraint is evident from its significant influence upon the observed stresses and strains⁽²⁾.

Dr Jordaan and Dr Illston have hinted at the possibility that the volumetric recovery may change sign before the deviatoric recovery is complete. It is interesting to note that Gopalkrishnan et al.⁽¹⁾ found that, under multiaxial compression, the direction of creep recovery need not necessarily be the same as that of the elastic recovery. Even under uniaxial compression,

the lateral creep recovery changed from contraction to extension after a few days. The phenomenon of the creep and elastic recoveries being of opposite sign has been explained by analysing the overlapping influences under multiaxial stresses⁽³⁾.

The authors found the average value of elastic Poisson's ratio to vary within the narrow range from 0.15 to 0.17 under uni-, bi- and triaxial states of stress. The effective Poisson's ratio was also found to vary in the same range. It is interesting to compare these observations with those of Gopalkrishnan et al.⁽¹⁾, who found that the effective creep Poisson's ratio under multiaxial compression was lower than under uniaxial compression, the ranges of the two values being 0.09 to 0.17 and 0.17 to 0.20 respectively.

I wish to conclude by commending Dr Jordaan and Dr Illston for their interesting paper. The concept of separating the total creep into volumetric and deviatoric components helps towards a better understanding of the mechanism of creep and the failure of concrete under multiaxial stress systems.

Reply by the authors

Dr Pandit draws attention to the diversity of conclusions on Poisson's ratio that have accumulated over the years. The problem certainly has considerable experimental difficulties and there is no doubt that what he calls 'the manner of testing' is an important factor. We were fortunate enough to start our project when the reports of a number of other investigations

were available (references 1 to 9 of the paper) and we were well aware of the challenge. We went to some trouble to test our apparatus, including the important effects of platen restraint. The results of the proving tests have been reported in some detail (reference 11), and we consider that our conclusions are justified for the particular materials and conditions that we have described.

Dr Pandit also mentions the possible influence of

*Pages 195 to 204 of Magazine No. 69.

the sequence of loading. In the tests we have presented here, the specimens were not subjected to any variation of load with time; in these circumstances, it is our view that, provided the principal stresses are applied with reasonable expedition, there will be no significant effect upon the creep strains. We consider that our system of loading satisfies this condition of expeditiousness since the loads were applied simultaneously and proportionately, and the first strains were recorded within 2 to 3 minutes of the start of loading.

If there is a history of variable stress (and it may be that this is what Dr Pandit has in mind), the question deserves further consideration, and we have to be clear about what we mean by the validity of the principle of superposition. Under uniaxial variable stress, what may be called the Boltzmann principle of superposition has been used with success in engineering problems. However, it is not by any means exact and it is not, strictly speaking, valid. Perhaps we should say that it has engineering validity. We consider that much

the same situation exists in relation to creep under constant multiaxial states of stress. It is true that the creep Poisson's ratio differs slightly with the system of stress, but the volumetric and deviatoric components of the creep strains are reasonably in agreement and there is a basis for accepting a common value of creep Poisson's ratio for engineering purposes. This, of course, is only the first stage of the treatment of multiaxial variable stress and consideration has to be given to the possibility of using the Boltzmann principle under multiaxial conditions.

The change of sign of creep recovery is intriguing and, in addition to the instances noted by Dr Pandit, it has been reported by Buettner and Hollrah⁽⁴⁾ in relation to the longitudinal recovery of uniaxially loaded specimens. The three observations refer to very different circumstances and it would seem to be wise to await more experimental evidence before attempting an explanation.

REFERENCES

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