Geotechnical Aspects of Underground Construction in Soft Ground, Mair & Taylor (eds)
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Discussion: Reply to discussion by M.P.O'Reilly

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Dr O'Reilly questions why we have stated in Section 4.3 of our paper that the average horizontal ground strain is more appropriate than maximum horizontal ground strain in the context of assessment of potential damage. The methodology we outline involves partitioning the building into a sagging portion and a hogging portion. The maximum bending and diagonal strains are then calculated from simple expressions involving the deflection ratio Δ/L (equations 7 and 8 in our paper). The precise locations of these strains are not defined, and will depend on the deformed profile of the idealized 'beam' representing the building. Burland et al (1977) have demonstrated that this approach gives very satisfactory results when assessing the risk of damage for buildings undergoing differential settlements.

The superposition of horizontal ground strain on the calculated maximum bending and diagonal strains is intended to account for the contribution of horizontal ground movements to potential damage. Strictly the derivation of an absolute maximum resultant tensile strain would require a knowledge of the distribution of bending and diagonal strains throughout the 'beam' onto which the horizontal strains would be superimposed, and a search would have to be carried out to find the resultant maximum. In our view this approach would not be appropriate to the simplifications that Burland et al adopted, nor would it be practical. We believe that it is more appropriate to take the average horizontal strain over a partitioned portion of the building and superimpose this on the maximum bending strain and the diagonal strain as given in equations 9 and 10 of our paper. It would also be unduly conservative to attempt to superimpose the maximum horizontal ground strain, particularly in view of the horizontal strain induced in the building in many cases being considerably less than the horizontal strain in the ground, as stated in our paper.

Dr O'Reilly argues that the limiting tensile strain values given in Table 2 for each damage category would be effectively halved if it were assumed that visible cracking in concrete occurs at a strain of 0.04% compared with 0.075% for brickwork, as originally assumed by Burland and Wroth (1974). We disagree with this argument. Table 2 indicates that 'Negligible' damage could be expected if the strain is between 0 and 0.05%. Table 1 defines 'Negligible' as "hairline cracks less than about 0.1mm". This is consistent with Dr O'Reilly's point that visible cracking in concrete occurs at 0.04%; Table 2 is not based on the limiting tensile strain of 0.075% originally assumed by Burland and Wroth.

It should be emphasized that the damage classification in Table 1 is based on 'ease of repair', as stated in our paper. Dr O'Reilly expresses concern about the durability of concrete beams with cracks up to 1mm in width, but in terms of 'ease of repair' it is reasonable to classify such damage as "Very slight" in that such cracks can be easily treated.

Finally Dr O'Reilly expresses concern about geotechnical (and tunnelling) engineers "deciding what is appropriate and acceptable for buildings", and he argues that any damage assessment techniques will lack credibility with building owners unless structural engineers are involved in their formulation. It is significant to note that the pioneering work on damage criteria for buildings due to differential movement was undertaken by geotechnical engineers (e.g. Skempton and MacDonald, 1956) and not by structural engineers. Moreover, the system of classification of damage on which our paper is based is widely recognized in the construction industry both in the UK and in

other countries, and it has been adopted by the Institution of Structural Engineers (1978, 1989 and 1994), as well as by the Institution of Civil Engineers (Freeman et al, 1994) and the BRE (1981, 1990).

Additional reference

Skempton, A.W. and MacDonald, D.H. (1956). Allowable settlement of buildings. Proc. Institution of Civil Engineers, part. 3, vol.5, pp. 727-768.