SCALING LAWS APPLIED TO IMPACT TESTING AND COMPUTER ASSESSMENTS MADE TO COMPARE TESTS AT TWO SCALES

I. LI. DAVIES, D. CARLTON

Taylor Woodrow Construction Ltd.,
345 Ruislip Road, Southall, Middlesex UB1 2QX, United Kingdom

T. P. O'BRIEN

Atomic Weapons Research Establishment, Foulness, Essex, United Kingdom

SUMMARY

The response of structures to missile impact loads is being studied in the U.K. in a co-ordinated programme of experiments and computer assessments to improve fundamental understanding of the problem and to develop mathematical techniques with which the behaviour of a wide variety of structures may be analysed when subjected to a broad spectrum of missile parameters. Based on previous experience with the response of structures to dynamic and static load situations, and following a detailed dimensional analysis of the scaling relationships which applied in the impact load case, a series of tests at 1/25th scale was initiated; this scale was fixed by the size of the missile launcher available.

The dimensional analysis described in this paper considered the various scaling laws that could be applied in the experimental work and the relationships between the various material and loading parameters that had to be maintained to enable experimental results obtained with a model system to be suitably extrapolated to indicate full scale behaviour. This analysis indicated that it would be most appropriate to apply 'replica' scaling since this would give the most readily interpreted information. This 'scaling law' requires that:-

i velocity is an invariant parameter between model and prototype.
ii geometrical dimensions scale linearly.
iii identical (or 'replica') materials be used at all sizes.
iv times scale as the linear dimensions.
v loads scale as the square of the linear dimensions.

Most of these requirements may be readily achieved by very careful attention to detail in the experimental preparations however, because of the large scale factor proposed for the U.K. work, strain rates are 25 times greater in the model than in the prototype and rate effects on materials need to be carefully assessed.

Similar studies are under way in both Germany and France with the former having built a missile launcher approximately five times bigger than that available in the U.K. and an ideal opportunity presented itself to check the validity of the 'scaling law' adopted. Tests performed in Germany on targets with normal concrete and a heavy steel tube missile were duplicated in the U.K. on targets of 1/5.6 scale made with scaled concrete and a scaled tubular missile. In the first tests, apparent differences in behaviour caused some alarm, but some assessments made upon the computer indicated that lack of similtude between material properties and differences between impact velocities could, to a large extent, account for these differences. Later tests, in which material properties were nearly identical and in which impact conditions were duplicated at both scales, resolved these differences and produced similar response at both sizes.

The results indicated that although scale models could be used for impact studies great care is needed to duplicate all material parameters and to match identically the experimental conditions.