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# Concrete Research



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# Editorial comment

WHEN THE HELP of mathematical theory is enlisted in the solution of a structural problem the steps taken are: (*a*) theory, (*b*) experiment, (*c*) full-scale application; or (*a*) experiment, (*b*) theory, (*c*) full-scale application.

The first two steps go hand-in-hand and are the subject of scientific work in the laboratory. The transition to the third stage is often difficult, and may take place many years after the first stages are complete. One reason for this delay is that a fully developed theory, taking into account all possible variables and conditions, is frequently so complex that its application in practice is impossible. A search then begins for a simpler procedure which can be applied without much loss of accuracy. The development of a less rigorous theory usually requires the adoption of a wide range of assumptions of conditions which, it is recognized, may not be reproduced in practice. The gain in simplicity over the full mathematical solution is, however, so important that some deviation may be allowed.

Very few structural problems are capable of being solved by "exact" mathematical methods. It is, however, possible to analyse a number of structures by methods that, while not being exact, are so complicated as to convey a sometimes unjustified impression of accuracy and authority, while at the same time making it desirable to find a simpler solution.

Reinforced concrete shell roof design is in some respects in this position. Complicated but not necessarily "exact" theories are at present used to solve the problems of design and some attempts at simplification are being made. A theory for the strength of thin shells was first put forward by Lamé and Clapeyron in 1831, almost 100 years before it was put to practical use in reinforced concrete shell design. A. E. H. Love, in his *Treatise on the mathematical theory of elasticity* (1892), gave the general equations of thin shells, taking into account bending and twisting. This work was of an academic nature, and not specifically developed for application to reinforced concrete shells. It was not until about 1925 that the practical application of the theory to reinforced concrete was considered. The first so-called Zeiss-Dywidag shell was a semi-elliptical barrel; it was calculated by the membrane theory and the bending moments were estimated from the results of experiments on models of sheet metal and reinforced concrete. In 1932 Finsterwalder published an approximate solution to the bending problem and his equations were simplified by Schorer in 1936. Dischinger investigated this approximate method and gave limits for its applicability, suggesting modifications. In 1935, Dischinger gave a more complete solution which was necessarily complicated. The position was simplified slightly by Jakobsen and by Lundgren and later Jenkins was able to eliminate some of the negligibles and simplify the solution considerably as well as making progress in solving the problem of the interaction of the shell and the edge beams.

Two of the papers included in the present issue of this Magazine present methods of approach to the problem of simplification of reinforced concrete shell design. Mr. Silvera suggests a method using prestressed edge beams to give the edges of the shell known conditions of stress, provided by suitable prestressing arrangements, while Professor Baker considers the strength of the shell in the range of plastic deformation. In shell design theories it is usual to assume the material to be purely elastic and isotropic and with zero value for Poisson's ratio. These assumptions are known to be inaccurate and however thoroughly the mathematical analysis is made, errors due to the basic assumptions persist throughout the development of the solution. Plastic theory applied to the beam method of calculating shells, although giving only an approximate method of design, also gives a truer picture of the behaviour of a concrete shell, especially near its ultimate load. The experiments being carried out at Imperial College will, it is hoped, either provide confirmation of the theory or enable modifications to be made to it.

There is much of fashion in research as in many other human activities. All research workers wish to break new ground and rightly feel that a new topic gives greater scope for novelty than one that has long been studied. The fashionable subjects in concrete research at the moment are shell roof design and prestressed concrete. They are both comparatively new forms of construction and engineers frequently require answers to many problems that arise in connexion with their use. There are thus obvious reasons why research in these fields may be regarded as important.

In America during the last five years the fashionable subject for concrete research has been air-entrainment. American interest in this subject arose from the difficulties that American road engineers had with the scaling of concrete roads when salt was used for ice removal. Again, there was an urgent practical need for research and work was done on the same subject in many research laboratories until it became hackneyed and lost its interest.

It is clear that a concentration of attention on one subject at a time is bound to occur. Such a concentration has, in fact, a number of advantages in that research workers can study the problem from a number of different aspects at the same time, and gain from the mutual interest aroused from the different methods of approach. Fashion in research has its disadvantages on the other hand in that subjects of fundamental importance are often passed over, or work on them allowed to lapse because of a desire to study something new and of immediate interest to practising engineers. It is possible that the results of much careful research are lost because the work has been stopped before really useful conclusions could be drawn. It is, on the other hand, just possible that to break off a train of research for a time may make success more easily attainable when work is resumed. For example, during the period from 1928 to 1938 a considerable volume of research was carried out on the workability of concrete, and results were published, but since then very little work has been done in this field. Now, however, interest in the subject appears to be reviving in certain quarters and the problems which were far from being solved by the earlier research are now being approached on new lines.

As a general rule, however, it is a great mistake to allow too much attention to be diverted from research on the fundamental properties of concrete to the more fashionable subjects of study, and it should be the duty of the larger research institutions to make sure that a fair proportion of work is still devoted to the everyday problems.