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Theme II.

Stresses and the degree of safety in reinforced Concrete from the designer's point of view.

1) In the *calculation of reinforced concrete sections subjected to bending* a distinction should be drawn between the first case, corresponding to a lightly reinforced section wherein failure is governed by the yield point of the steel, and the second case in which it is governed by the compressive strength of the concrete. As regards the first case it is possible to calculate the lever arm of the internal forces, and hence the resisting moment, by reference either to Navier's theory of bending as applied to the compound section when cracking is about to take place, or by reference solely to conditions of equilibrium at the moment when failure is imminent. The two methods of calculation give values of resisting moments which differ little from one another, so that no occasion arises to modify the methods of calculation hitherto in use.

In the second case, where failure is determined by the compressive strength of the concrete, it is not possible to calculate the resisting moments by reference to the conditions of equilibrium alone. Here the usual method of calculation does not give the correct factor of safety, and it would be desirable to adopt a new method of calculation ensuring better utilisation of the material and, at the same time, enabling the limiting amount of reinforcement which separates the two cases from one another to be calculated. This will as far as possible avoid the need for compression steel and for haunching under the ends of the beam, and will thus improve the design.

In the case of bending combined with axial loading the present usual method of calculation does not give a correct idea of the conditions in regard to the factor of safety; it is proposed that the best method of calculation should be worked out on the basis of experiments and on the lines of the Norwegian draft regulations for reinforced concrete.

At the Congress expression was given to the view that the usual methods of calculation for bending fail to afford a correct indication of the factor of safety, and that it would be a problem of the future to develop a new method, with a view to more complete utilisation of material, taking account of the plastic behaviour of the concrete and of shrinkage.

2) *The resistance of unreinforced concrete against frequently repeated loading* (varying between zero and a fixed upper limit) in compression, tension and bending may be taken as equal to approximately half the strength as ascertained in the static test. In the case of reinforced concrete members exposed to frequently repeated loads attention must be given to the perfect anchorage of the reinforcing bars, and to the ample curvature of these bars at the places where they are bent up.

3) *The tensile strength of concrete* is the second most important characteristic of the material, the first being the cube compressive strength. Like the tensile strength it depends primarily on the cement content, the granulation and the water-cement ratio. Tensile tests of concrete members afford no satisfactory criterion, but bending tests on concrete beams have given good results.

4) It is recommended that the views and suggestions put forward by M. *Freyssinet on improvements in concrete* should be examined from their physical aspects with a view to their utilisation in practice. The basic principle of the method consists in reducing or completely eliminating the tensile stresses in the concrete not only for bending but also for shear, as may be done by pre-stressing the reinforcement to a sufficiently high degree. By compressing and heating the concrete it is possible to give it a high strength in a few hours. It is recommended that the properties possessed by a concrete made in this way should be studied.

5) The use of *high tensile structural steel* in reinforced concrete work has fulfilled all expectations. The advantages consist in the permissible stress for the steel being increased up to 1800 kg/cm^2 = 25,602 lbs./sq. in. (or in exceptional cases to as much as 2200 kg/cm^2 = 31,291 lbs./sq. in. according to the elastic limit of the steel and the quality of the concrete. T-beams subject mainly to stationary loads, reinforced with St. 52 with a permissible steel stress of 1800 kg/cm^2 = 26,000 lbs./sq. in. and having a correspondingly increased cube strength in the concrete, exhibit the same degree of safety against cracking as if reinforced with St. 37 at 1200 kg/cm^2 = 17,068 lbs./sq. in. Under moving loads slabs of rectangular cross section are to be preferred to T-beams, on account of their greater safety against cracking.

6) It is recommended that in the construction of floors, water tanks and similar building structures, *temporary expansion joints* should be provided and left open during the period of construction for at least several weeks, and subsequently concreted in. Apart from these it is desirable to provide permanent expansion joints for the purpose of permanently separating the constituent parts of the structure and allowing freedom of relative movement of the latter.