# Theme I.

## Importance of the Ductiliy of Steel for Calculating and Dimensioning Steel Structural Work, especially when Statically Indeterminate.

1) In order to assess the safety of a structure or structural member of steel it is necessary to take into account the conditions of equilibrium and strain under increasing load after the plastic state has already partly been attained. The shapes of cross section of bars and girders have an effect on the occurrence of this plastic state and, therefore, on the carrying capacity and safety. The usual hypothesis of uniform transference of stress through the constituent parts of a steel structure (whether riveted or welded) is fulfilled by reason of the ductility of the steel.

The classical theory of plasticity, when applied to investigations of stable and unstable equilibrium in steel structures, assumes that the occurrence of the plastic condition (flow) depends on local conditions of stress. A newer hypothesis rests on the view that the phenomenon of flow depends on the configuration of the field of stress and is, therefore, manifested in a series of discontinuous jumps. Experiments recently carried out on bending specimens and on eyebars indicate that the large increase in the yield point — previously noted in cases where the stresses are not uniform — is to be attributed to differences in the interpretation of the experimental results. It has been found that the upper yield point of the steel is an important property of the material and one which cannot be accurately ascertained in the tensile test. In bending, an upper yield point always occurs quite independently of the cross section. The occurrence of the flow by a series of jumps is attributed to the effect of this upper yield point. Future developments of the theory of plasticity must take account of the conditions of stress and strain in a member within the plastic range, and supporters of the new conception of the condition of flow no longer look upon the maximum stress as being a decisive criterion. Further experiments are contemplated with a view to clearing up the uncertainties which remain.

2) Both the classical theory of plasticity and the new condition of flow have been adopted as a basis for the solution of problems of stability (under eccentric pressure). It is found that about equally simple results are obtained whichever of these methods is applied. The new criterion of flow leads to results which agree very well with those obtained in experiments.

3) The case of a load increasing from zero to a maximum value appears to have been cleared up so far as continuous girders of uniform cross section are concerned. The principles deduced from the experiments are to be further investigated by reference to the two alternative criteria of flow. For practical purposes a simple method of arriving at the effective carrying capacity is desi-

rable. Here, however, it is necessary to take account of the final upper limit to which plastic strain extends.

4) As yet no experiments have been carried out under varying loads. The theoretical principles still require to be checked by reference to the new knowledge acquired.

5) In plate web girders free from large notches, it has been shown by fatigue tests that the permanent deformations arising where the girder is continuous over a number of equal spans tend towards a fixed limit, even when the number of repetitions of load is made very large (700,000). Further experiments are in hand, and until these are completed the application of the "equilibrium load method" to the design of dynamically stressed structures (subject to fatigue failure) cannot be recommended.

6) The investigations already carried out make it possible to ascertain the effect of sinking of the supports, which in most cases appears to be inconsiderable.

7) In the case hitherto examined of statically indeterminate framed structures, the method of calculation is subject to a qualification when it is applied to the dimensioning of compression bars which cannot be utilised for equalising the moments. In more general cases, however, the assumptions that may properly be made on this point call for further careful examination.

8) It may be stated, in summary, that in many cases the ductility of the steel results in an increase in the safety of statically indeterminate structures by comparison with those that are statically determinate. The increased carrying capacity which theory justifies and experiment confirms can be turned to account economically by means of the methods of calculation now available for application to building frames. In a few cases the equalisation of moment brought about by the automatic "cold working" effect has been reflected in official regulations. The economic advantages are most apparent in the case of structures of uniform cross section throughout their legth, and less so in structures where the cross section has been adapted according to the variation in forces (such as moments).