THE PROPERTIES AND DESIGN OF REINFORCED CONCRETE: INSTRUCTIONS, AUTHORISED METHODS OF CALCULATION, EXPERIMENTAL RESULTS AND REPORTS BY THE FRENCH GOVERNMENT COMMISSIONS ON REINFORCED CONCRETE

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REINFORCED CONCRETE

INSTRUCTIONS, AUTHORISED METHODS OF CALCULATION, EXPERIMENTAL RESULTS AND REPORTS BY THE FRENCH GOVERNMENT COMMISSIONS ON REINFORCED CONCRETE

TRANSLATED AND ABRIDGED

BY

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AUTHOR'S PREFACE

In setting out to study the properties and the applications of such a comparatively new material as Reinforced Concrete, one is led to consider the possible sources of information and their nature. The fact should be kept in mind that, from certain points of view, the study of much successful practice is frequently not so fruitful as the study of some examples where failure took place or of full-sized structures tested to destruction.

A considerable amount of experimental work has been done and a vast number of reinforced concrete structures successfully carried out in America, of which the records are in English. In Germany, Italy, and Austria a considerable amount of both experimental and practical work has been done. In Great Britain the volume of reinforced concrete construction is steadily growing, but very little experimental research on the properties of the material has been made in this country. It is undoubtedly to France and to French literature that a student must turn for the most concise and authoritative information on the subject.

Reinforced Concrete had its origin in France. French constructors were accumulating experience of its properties, and research was being carried on by French engineers very many years before the material came to be regarded as a practical proposition in other countries. Consequently, the Commission appointed in December, 1900, by the French Minister of Public Works embraced a group of engineers whose experience in this material was unrivalled. The work of this Commission, extending over the succeeding six years, included a series of experiments, simple in detail and comprehensive in range, and directed not to the solution of academical minutiæ, but to the obtaining of results immediately applicable to practice. The report of the Commission contains the results of the tests on experimental structures and of the tests to destruction of several of the structures of the Paris Exhibition of 1900. It is unique in the literature of Reinforced Concrete, containing as it does all the necessary scientific data, based on first-hand observations, for the design of reinforced concrete structures, with the observations thereon of a group of engineers of the widest and most mature experience obtainable. The instructions are characteristically French in their clearness and boldness—a boldness derived from intimate knowledge, and entirely justified by results.

The report has been much quoted and extracts have appeared from time to time in various English books and periodicals, but a complete survey of the work of the Commission was to be obtained only from the French edition. The translator has thought that a useful purpose might be served by an abridged English edition which would enable professional men with limited time to acquaint themselves with the scope of the work of the Commission and to have the results at hand in readily accessible form. It will also guide the research student to the detailed records of methods and results to be found in the French edition, and at the same time form one of the easiest avenues of approach for those who wish to make a systematic study of the properties and applications of Reinforced Concrete.

NATHANIEL MARTIN.

Glasgow,
December, 1911.

PREFACE

The rapidity of the development of reinforced concrete structures, the principle of which was indicated by Monier in 1877, is well known. Thanks to the initiative of some bold and skilful constructors, a considerable number of applications of Reinforced Concrete had already been made when on December 19, 1900, the French Minister of Public Works instituted a Commission to study the question from the point of view of his Administration.

Notwithstanding the already numerous experiments, the properties of the new material were still imperfectly known, and the methods of calculation followed by different constructors presented essential differences and even absolute contradictions.

The elementary properties of Reinforced Concrete were incompletely investigated, and it was unknown in what measure these properties permitted application to the new material of the principles and the results which had been laboriously acquired for metallic structures, and which constituted the classic science of the Resistance of Materials.

The Commission decided that they ought first to study the elementary properties of Reinforced Concrete, reserving for later research, in the light of these properties, the interpretation of the complex phenomena arising in structures.

The following are some of the facts established and results obtained by the Commission :—

Experiments of several months' duration have shown the importance of the contraction, denied by certain constructors, which occurs in concrete, not only at the end of the period of setting but also during a long period of hardening, and which influences the distribution of the stresses between the concrete and the metal. The constructor ought to make the necessary arrangements to avoid the undesirable consequences this contraction may produce.

The study of elasticity is the basis of that of stress. The Commission made an important contribution to the former, and verified for the first time the exactitude of the law announced by one of its members concerning concrete under tension. The modulus of elasticity of concrete under tension varies according to a straight line law up to a certain limit, and afterwards becomes almost rigorously constant till rupture. The stronger the reinforcement with bars well distributed in the tension areas, the longer is rupture postponed.

The laws of elasticity of concrete in compression had already been the object of numerous experiments. The Commission made additional experiments without revealing any new facts.

Attention has been drawn to the fact that in compression members, the longitudinal bars necessarily produce resistances proportional to the shortenings which the concrete with which they are associated supports without crushing. Thus arises the idea of the importance of the ductility of the concrete.

By varied experiments, which have confirmed the results announced by one of its members, the Commission has definitely proved that for equal weights transverse reinforcements and especially spirals increase the resistance to compression of the concrete much more than longitudinal bars of the same weight. In preparing the regulations for the employment of transverse reinforcements the French Minister of Public Works may, at first sight, have appeared rather daring, but the expediency of his initiative is now demonstrated by the almost identical regulations on this matter which have been issued in Germany, and particularly in Austria, after the repetition of the experiments inaugurated in France.

The tests by the Commission have given useful but too scanty information on the resistance of Reinforced Concrete to shear and to torsion.

The study of flexion is of prime importance. The Commission has given to it a rational basis by proving by numerous experiments that the conservation of plane sections, which is the foundation of the classic theory of bending, is realised almost as exactly in Reinforced Concrete as in metallic members.

The application to Reinforced Concrete of the exact ideas of the science of flexure, and particularly of those of the neutral axis and of the moment of inertia, has thus been sanctioned. Together with the laws of elasticity, they permit of the determination of the stresses which are developed in statically indeterminate structures. These stresses depend not only on the laws of statics, as in members statically determinate, but also on the deformations.

Light has been thrown by some interesting experiments on the question of the extent to which, from the point of view of resistance to compression, slabs assist the ribs with which they are continuous and form part.

Structures in Reinforced Concrete—slab, floor, footbridge and retaining wall—which were erected for the Exhibition of 1900, were tested to destruction. Made with care and method these tests have given useful information.

Finally, the theoretical studies of the Commission following on its experiments cleared up several questions until then obscure, and have thus given a new impulse to the researches of engineers.

A. CONSIDÈRE.

PARIS,
June 11, 1912.

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