thereby to direct into the ranks of science the ablest of their young graduates desirous of qualifying for a career, whether in pure science or in science applied to Canadian industry. It would place at the service of Canadian industry a factor which would insure its success in the strenuous international trade competition which is near at hand. It would, above all, enable the nation to direct its energy towards the economic and right utilization of its untouched stores of national wealth, in order that it may bear, with some degree of ease, in this and the next generation, the almost Atlantean financial burden it is assuming as a result of its playing its part in the present world struggle."

EXPERIMENTAL STUDIES OF CONCRETE*

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TO the engineer of a generation ago, concrete was known as a substitute for stone masonry in the construction of massive works, such as foundations, bridge piers, abutments and arches, retaining walls, dams, breakwaters, fortifications, etc. Concrete offers a high resistance to compressive stresses but is somewhat deficient in tensile reisistance. Reinforced concrete is a combination of concrete with steel in such a manner that the steel members take the tensile stresses and thus form a structural unit of a new type. In certain members, such as columns, the steel assists in taking the compressive stresses.

Reinforced concrete as an important structural material is a development of the past twenty years. From a small beginning reinforced concrete has come to be one of the most important materials of construction. At the present time it is widely used for buildings, roads, pressure pipes, ships, and almost an infinite variety of other purposes which touch every phase of modern life.

May Design With Confidence

Exhaustive experimental studies of reinforced concrete have been carried out by many investigators in the United States and Europe. These researches have developed a large fund of information, so that well-informed engineers are now able to design and build reinforced-concrete structures with the same confidence that has characterized the use of other structural materials.

Concrete is a combination in suitable proportions of three entirely different materials: cement, water and aggregate. It is notable that our knowledge of the properties of concrete and concrete materials has not kept pace with the developments in the field of reinforced-concrete construction. It may seem somewhat anomalous to say that at the present time we know a great deal more of the properties of reinforced concrete than of concrete. If we make certain assumptions as to the properties of the concrete to be used, we can design reinforced members and structures which will perform their proper functions. However, it is impossible for the engineer to estimate in advance with any degree of certainty the strength and other properties of the concrete made from definite proportions of given materials which are mixed and placed in a given manner. This condition has resulted from a lack of a complete analysis of the principles of concrete mixtures and has led to rule-of-thumb methods of selecting materials and proportioning.

The problems which generally confront the engineer in designing and estimating the cost of concrete structures are as follows:—

1. What quality of concrete is most economical?
2. Are the aggregates near at hand suitable?
3. Of several aggregates, all of good grade, which is the best for the purpose?
4. What tests shall be made to determine the suitability of aggregates?
5. How shall the materials be proportioned, mixed and placed in order that concrete of the highest quality may be produced at lowest cost.
6. What is the effect of certain changes in the proportions of the materials?
7. What is the effect of exposures or service conditions on the permanency of the concrete?

The aggregate constitutes 75 to 90 per cent. of the weight of the material in concrete; this makes it important that aggregates which are found near at hand be used if they can be shown to be suitable.

Present Knowledge is Incomplete

Our present knowledge as to the fundamental properties of concrete and the exact manner in which the character and the proportions of the constituent materials influence the strength and other properties is by no means complete. When we consider the almost endless variety of materials available for concrete aggregate and the numberless combinations which may be made in the size of aggregate and the relative proportions of cement, water and aggregate, it is not surprising that many divergent opinions are now current as to the influence of these factors.

Lack of definite information on many of the questions raised above has led to a demand for a more comprehensive study of the properties of concrete and concrete materials. In an effort to supply this information, the Structural Materials Research Laboratory was organized in 1914. This laboratory is located at Lewis Institute, an educational institution in Chicago. The work of the laboratory is carried out through the co-operation of the Institute and the Portland Cement Association. The Portland Cement Association includes practically all of the manufacturers of Portland cement in the United States, Canada and Cuba. The work of this laboratory is an example of the co-operation, not only of the manufacturers in an effort to solve the problems arising in the use of their product, but also a striking example of the successful co-operation of an engineering college with a manufacturing industry of international scope.

Advisory Committee Controls Laboratory

The control of the policies of the laboratory is vested in an advisory committee consisting of representatives of Lewis Institute and the Portland Cement Association. The association is represented through its committee on technical problems, of which F. W. Kelley, Albany, N.Y., is chairman.

The laboratory is supplied with all necessary equipment for both physical and chemical experiments. There is now a permanent staff of 23 employees engaged in this experimental work. Tests are now being made at the rate of about 50,000 per year.

Experiments already carried out have shown that the most elemental principles of concrete mixtures have escaped notice in the practical use of the material and in

*Address to the American Society for Testing Materials.