REINFORCED CONCRETE AND ITS PRACTICAL APPLICATION.

By Mr. Moritz Kahn.

Various engineers in Great Britain have already used reinforced concrete to so great an extent that it would seem unnecessary to dwell upon any lengthy argument advising the use of this material in buildings and other constructions.

Its efficiency has been thoroughly demonstrated, and it is now recognized as a permanent method of construction, proof against the deteriorations to which other materials are subject. The fire at Baltimore gave evidence of its being fireproof; the earthquake at San Francisco showed it, to a great extent, to be proof against earthquake; innumerable instances have convinced users that it is rust-proof; and the Pantheon at Rome proves it practically everlasting.

A reinforced concrete structure, cast as a monolith, is more rigid than steel, where rigid connections can only be secured at great cost. The corresponding strength obtained from this cause is one of the reasons for the economy secured in its use, and in the hands of capable designers, girders and other structures can be made as strong in reinforced concrete as in structural steel. Finally, what is most advantageous about it is that its strength continually increases with age.

An engineer, in deciding upon the use of any building material, after satisfying himself as to its suitability and efficiency, inquires as to its probable cost. In all important structures, and in all buildings where steel framing might be used, reinforced concrete will prove an economical structural material. In this country, however, there are many places where it would be of no advantage whatever to have a steel or concrete frame building, so far as the external walls are concerned, on account of the thickness of the walls required by the building by-laws. If the external walls of the building are to be built in a structural frame, the filling-in should be made of thin panels, and where reinforced concrete is used, these panels need not be more than five inches thick. If, on the other hand, brick panels are used, a nine-inch thickness will suffice. As a rule, it is necessary to secure permission from the local authorities whenever it is desired to erect a construction as outlined.

It is erroneous to say that reinforced concrete will always prove the cheapest method of construction. As already stated, there are instances where it is not so cheap, and engineers soon recognize such cases. Middle-sized and small residential buildings, small manufacturing buildings, and the ordinary one-storey type of building, will show very little saving when reinforced concrete is used in their construction. A low retaining wall six feet high would be cheaper in brick than in reinforced concrete, inasmuch as it would require a comparatively thin brick wall to withstand the strain, but a retaining wall over ten feet high could easily be constructed in reinforced concrete cheaper than in brick. Isolated girders and roof trusses high in the air will invariably prove cheaper in steel than in reinforced concrete; but a steel structure, after having been built, will always require a certain amount of upkeep, and the maintenance charges thus entailed will have considerable influence on the total cost. In brief, though the material under discussion may not always be the cheapest form of construction, it is generally the most economical when all things are taken into consideration, such as the additional safeguard against fires, with a corresponding efficiency in one's plant, the reduction in fire insurance premiums, and also the reduction in maintenance charges.

One of the reasons for the popularity of reinforced concrete lies in the fact that the constituents from which it is made can easily be obtained in almost any locality. In every part of England there are cement mills, and it is never necessary to look far for sand and crushed stone or ballast. These materials being found near the site produce a considerable decrease in the freight charges of building materials. The only remaining constituent which need be brought any distance is the reinforcing steel, but such steel will only be about 20 per cent. of the weight of the material which would be used in an ordinary steel structure, and consequently the freight is reduced in accordance therewith.

In the selection of materials, the question is often asked whether preference should be given to either crushed stone or ballast. Engineers are wont to object to the use of the latter, on the ground that the surfaces are generally round and too smooth. It has often been demonstrated that round, smooth ballast gives just as strong a concrete as crushed stone. This statement might be limited by the fact that in the early stages, say, at the end of two weeks, crushed stone concrete will be found to be a little stronger than ballast concrete, but at the end of thirty days ballast concrete is just as strong as stone concrete, and from that time on its strength begins to surpass it.

Ballast is often considered unsatisfactory as a fire-resisting material. At a fire test made recently, it was found that ballast concrete would not go through the ordeal. The ballast used in that test was uncrushed, and portions of it were of considerable size. Large stones when heated to a certain temperature will fly apart, owing to the internal strains existing therein, but small stones heated to the same degree will not disintegrate. If the ballast used in that test had either been crushed, or screened to pass a ¾-inch mesh, the floor slab in question would have successfully withstood the test. A similar test was made by myself for the New York City Fire Department, in 1904, using crushed ballast concrete, with satisfactory results.

With reference to sand used in concrete, some engineers specify that it shall be sharp and coarse. It is, however, very probable that these specifications will soon be eliminated. It has been recently proved that a moderately fine sand will give a stronger concrete than sharp, coarse sand. In the selection of this material, however, it is necessary to discover whether it contains chemicals which might act on the cement. Sand taken from beds in contact with impure water kills the action of the cement, and should be condemned. Pit or bank sand is a very satisfactory kind to use. The cement should be of the very best grade, and should be subjected to many mechanical tests during the progress of the work. There is no necessity to dwell upon this material, as the products now being turned out by the various leading English mills are of such excellent grades that very little difficulty should be experienced in securing a proper quality. In this respect English cements are probably the best in the world.

The handling and mixing of concrete is a feature which to a great extent, governs its cost. Many engineers object to the use of machine mixers. The use of a good batch machine mixer is advisable, however, on every large construction. When the concrete is mixed by hand it is turned from six to eight times, but when a machine mixer is used the concrete is turned at least twenty times in a much shorter period, and at a considerable saving in expense. In truth, a good machine mixer should actually be specified, provided the size of the construction and the amount of concrete to be mixed warrant the expense of installing such a plant. In general, it will be found that in all constructions involving a quantity less than 400 or 500 yards the concrete will be more economically mixed by hand than by machine, but in larger constructions the reverse is true.

One of the most important matters in connection with reinforced concrete is that concerning its inspection or supervision. An inspector who is too fastidious can do quite as much harm by over-inspection as one who

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