

TIME TESTS OF CONCRETE.*

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IT is the purpose of this paper to present a summary of data collected during the past three years at the Experimental Engineering Laboratory of the University of Minnesota concerning the behavior of concrete when subjected to long time tests. The results of these investigations should be of interest to engineers in regard to the character and amount of the time changes as well as their relation to the theory and practice of reinforced concrete design. Naturally the question arises as to the cause of these time changes and the possibility of their elimination. This, however, must be left to future investigations for no attempt was made in these tests to discover the reasons for this behavior, it being desired first to know something of the movements themselves and how generally they may be expected in ordinary practice.

The tests have been conducted largely on laboratory specimens, because of the greater facility and accuracy

a discussion of the important features as they are brought out. Only such description as is necessary to a proper understanding of the results will be indulged in.

These studies resulted from an effort to explain the continued sag in a floor panel of a reinforced concrete building under a test load held in place for several weeks. In the very earliest work done it was recognized that the continued movement arose from two sources, one a direct result of the loading and the other entirely independent of it. That movement due to the load has been termed in former publications the time yield to distinguish it from the other movement which is purely shrinkage or volumetric change. Both of these act to produce a shortening of the compression fibres of a beam or slab, which of itself would account for a very large part of the progressive sag frequently noted. This action is probably accompanied by a gradual extension or breaking of those fibres in tension which have not already broken; but as this effect is one contemplated in our usual assumptions, and one that probably is accomplished, if at all, much sooner than that due to time yield and shrinkage, it need not be considered in these discussions.

The term "time yield" has been used in preference to

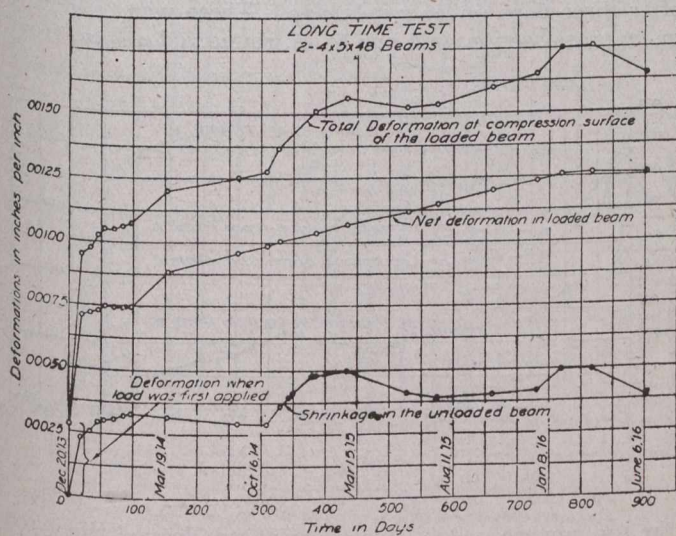


Plate 1.

with which the results may be obtained, but such observations as have been made on a few buildings in service warrant the conclusion that the results from the laboratory specimens are applicable to the ordinary reinforced concrete building construction. The laboratory specimens, which include small beams, as well as large-sized slabs, have all been made and treated with perhaps somewhat greater care than the average building receives, but no greater than should be had nor than would be possible with little or no change in the customary specifications.

The measurements of deformation have been made by the Berry Strain Gauge in the hands of skilled observers. The experimental details, such as selection of standards of reference, elimination of temperature and instrumental errors, etc., which in tests extending over a period of years are troublesome features, have been given careful consideration and it is believed that, especially in the later tests, the results leave little to be desired in these particulars.

In presenting these results, it will be better, except for a brief statement as to the character of the changes observed, to consider the individual tests separately with

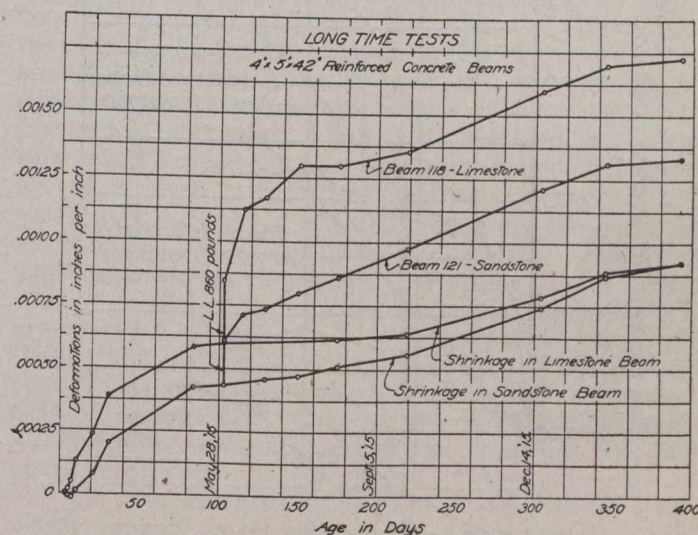


Plate 2.

the term "flow," used by other writers, as it has not been shown that the movement is a flow in the strict meaning of the word. It is of no significance structurally, at least for the purpose of this discussion, whether the movement be a flow or a gradual yielding accompanied by no increase in dimensions laterally, for this paper is concerned only with deformation in the direction of stress.

Test of Two 4-in. x 5-in. x 48-in. Beams.—One of the earliest tests made in the prosecution of these studies will be given first as it shows very clearly the relative effect of the two elements of this time deformation of beams and slabs under load. In Plate 1 are given the results of measurements extending over a period of two and one-half years of the deformations in two small reinforced concrete beams.

In the test of these beams, one was allowed to remain flat on a platform, while the other was tested on a 42-inch span with a centre load of 860 pounds. Since the beams were of the same make-up and kept side by side during the entire period of curing and test, the shrinkage of the loaded beam may be taken the same as that shown for the unloaded beam. This has been done in drawing the curve marked *net deformation* for the loaded beam, which is

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