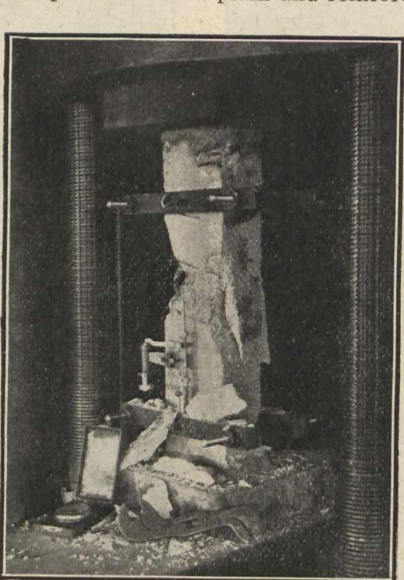
the properties revealed in some six individual tests is given below:—

Commercial Tests of Steel Reinforcement.

Number of Specimen	Elastic Limit Strength (Pds.per sq.in.)	Ultimate Strength (Pds. per sq. in.)	% Elongation in 8 ins.	% Contraction in Area
1	43,100	66,600	25	57
2	41,900	64,800	26	59
3	43,000	64,600	25	56
4	43,100	67,400	27	55
5	43,100	67,600	27	53
6	42,900	67,500	26	54
Average	42,800	66,400	26	56

Figures 1, 2, 3, 4, 5, 6, 7, and 8 are the stress-strain diagrams for the eight different columns described above. The ordinates represent stress, that is, the quotient of the total load on the column divided by the total area of the cross-section; and the abscissal represent the strains or the deformation per unit of column intercepted between the collars of the compressometer device. The absence of a constant ratio between stress and strain is apparent in every case, the curves deflecting downward in most cases almost from the start. This is in general agreement with what is frequently called the parabolic stress-strain relation and is in accord with the findings of all experimenters in plain and reinforced concrete.

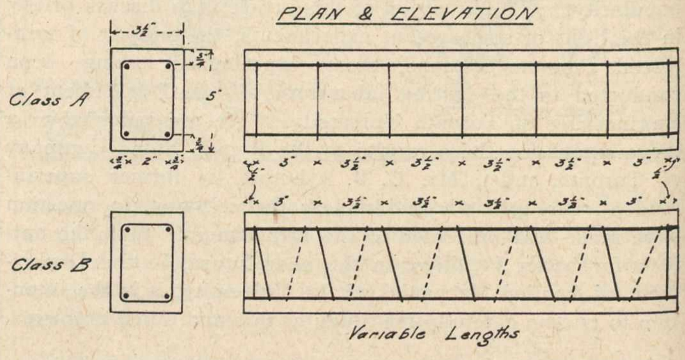


Column 1-B, Showing Mode of Failure.

In order to find what portion of any stress was carried by the concrete and what portion by the steel, a method adopted by Talbot was employed. It was assumed that the steel and the concrete deformed together. If the elastic limit of the steel be not exceeded, the stress therein will be proportional to the strain. For a strain of .0014 say, the stress in the steel, taking Es, Young's Modulus, to be 30,000,000, would be f = .0014 × 30,000,000 = 42,000 pounds per square inch. This, it will be observed, is a stress slightly below the average elastic limit of the steel as given in the table of results of tests thereon. Let A denote the total area of the column cross-section and p the ratio between the steel and the concrete. Then the total load carried by the steel, corresponding to the stress assumed, will be 42,000 p A pounds. If this quantity be divided by the total area of the cross-section, A, we have as quotient, the number of pounds per square inch of total area which the reinforcement carries. The numerical value of this will be $42,000\ p = 42,000 \times \frac{2\frac{1}{2}}{100} = 1,050$ pounds per square inch. Through a point in the diagram whose co-ordinates are 1,050, and .0014, a straight line was drawn to the origin. This will be subsequently referred to as the line for steel. From what has been said, it is apparent that the portion of any ordinate below this line will give the stress in pounds per square inch, based on total area of cross-section which the steel supports. In consequence, therefore, that portion of the total ordinate intercepted between the line for steel drawn as described, and the curve as plotted, will be the stress in the concrete for the corresponding strain. Referring to figure 3, we see that the stress, 1,620 pounds per square inch corresponds to a strain of .001. The line for steel shows that 750 pounds per square inch of this is supported by the reinforcement. From this it follows that the accompanying stress in the concrete is the difference or 870 pounds per square inch. The line for steel has been drawn, it will be noticed, in each case to the ordinate through .0014 as this corresponds to a stress of 42,000 pounds per square inch, substantially equal to the elastic limit of the steel.

REINFORCED TEST COLUMNS

PLAN & ELEVATION



In order to find the maximum stress in the concrete occuring either prior to or in coincidence with the elastic limit of the steel, a tangent to the curve parallel to the line for steel was drawn. The point of tangency on the diagrams is denoted in each case by the letter T. Singularly enough, this point corresponds in every case very nearly to the elastic strain of the steel, viz., .0014. The values of the simultaneous stresses are given in the subjoined table. The stress in all cases were scaled from the plot and the tangent was drawn by the usual geometrical method.

Stresses Corresponding to Point T.

Column.	Stress in Concrete.	Stress in Steel.	Strain.
1 B	890	37,500	.00125
2 A	1,320	42,000	.00140
3 B	1,650	43,500	.00145
2 B	1,050	33,000	.00110
4 A	1,380	37,500	.00125
Average—	1,260	39,000	.00130

As to the manner of the distribution of the total stress between steel and concrete, after the deformation .0014 is passed, little can be said with certainty. The probability is, however, that the curve for steel flattens quite markedly, producing as will be seen from an examination of any of the graphs submitted, stresses in the concrete greater than those in the above table. This is within the realm of probability, since from the table given, it is seen that the average stress up to or coinciding with the elastic limit is only 1,260 pounds per square inch. Now the average ultimate compressive strength of the concrete, it will be remembered, was 1,720 pounds per square inch so that a margin for increase remains. The rising of the stress-strain curve after the elastic limit of the steel has been passed, is thus capable of an explanation, although an exact analysis of these later stresses is quite impossible. The assumption has been made in this discussion, that the elastic limit in compression is the same as that in tension. The error in this assumption is probably very small.

If concrete hardens in air, a shrinkage occurs; if in water, an expansion results. Experiment has shown that a 1:3 plain mortar hardened in air will shrink, in consequence, from 1-20 to 4-20 of one per cent. in its dimensions. Where reinforcement is used, the deformations due to this cause are much less, but notwithstanding their smaller magnitudes they occasion compressive stresses in the reinforcement. A perfect bond between the metal and the concrete is, of course, assumed. Considere cites a case where a 1:3 mortar reinforced with 5½ per cent. of steel sustained a shrinkage of 1-100 of