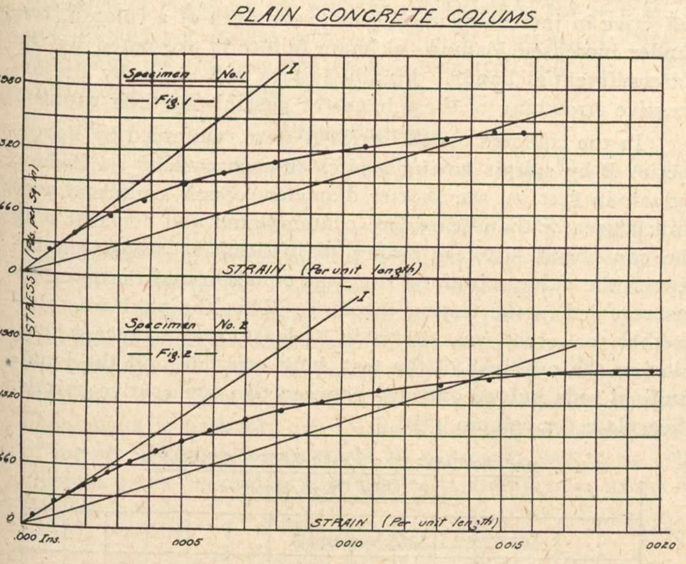
one per cent. in its length. This would occasion an initial compressive stress in the metal of approximately 3,000 pounds per square inch. There can be little doubt that such initial stresses do exist but as to their actual magnitude, little with certainty is known. While their presence in this instance has not been wholly ignored, no attempt to consider their magnitude and effect has been made.



As stated above, the features of the stress-strain curve for concrete as obtained by compressometer tests is the variation of its inclination to the axis of strain. This is interpreted as meaning that the material loses rigidity as the stress is increased and that the so-called modulus of elasticity meanwhile grows less. It was thought worth while, in order to get a comparison between working stresses and factors of safety in the two materials, to find for a working stress of 500 pounds per square inch in the concrete, the modulus of elasticity of that material. This was done by finding with a pair of dividers, that point on the diagram where the vertical intercept between the line for steel and the plotted curve, was the graphical equivalent of 500 pounds per square inch. The corresponding strain was noted and from the equation, Ec = c s, where Ec is the modulus of elasticity for concrete, c the stress, and s the strain, the modulus of elasticity was found. This quotient, of course, will give what might be called the average modulus of elasticity covering a range of stresses from zero up to 500 pounds per square inch. The corresponding stress in the steel was found from the equation f = Es S, Es being taken as 30,000,000.

The factors of safety given in the following table are based on an utimate crushing strength of concrete equal to 1,720 pounds per square inch, and an ultimate strength in steel of 66,400 pounds per square inch.

Moduli of Elasticity of Concrete Corresponding to a Working Stress of 500 Pounds Per Square Inch.

Column	Ec	Stress in Concrete	Strain	Stress in Steel	Safety Factor-Concrete	Safety Factor-Steel
1 B	1,400,000	500	.00036	10,800	3.4	6.1
2 A	1,900,000	500	.00026	7,800	3.4	8.5
3 B	1,700,000	500	.00029	8,700	3.4	7.6
4 A	1,360,000	500	.00037	11,100	3.4	6.0
Average	1,590,000	500	.00032	9,600	3.4	7.0

The anomaly from the above table is that at such a moderate stress as 500 pounds per square inch in the concrete, the factor of safety should be nearly twice as large in the steel as in the concrete. For this, no very satisfactory remedy seems to offer itself. There certainly could be no valid objection to utilizing stresses, in such steel as here employed, up to 16,000 pounds per square inch. But unless we care to raise the working stress in the concrete above 500 pounds per square inch we must be satisfied with low working stresses in the steel. The stresses manifestly will always be proportional to the moduli of elasticity of the two materials. Evidently the most economical combination would be the somewhat unusual one of high working stresses in the concrete, with low modulus of elasticity. This would tend to an equality in the safety factors of the two materials.

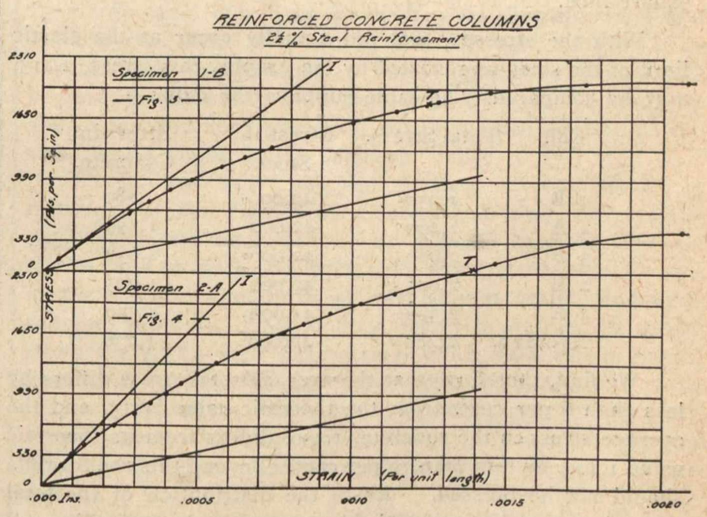
It will also be noted on the diagram that a tangent line has been drawn in each case to the initial direction of the curve. This line represents the initial modulus of the material. The initial modulus of the concrete can now be found by eliminating the value for the steel, according to Talbot's method as previously mentioned. This initial modulus is sometimes employed in theoretic investigations since it corresponds to working values, which are the maximum values with the usual safety factor employed. The following are the values of the initial modulus of concrete for each of the columns tested. There appears to be considerable variation but the average value compared favorably with published determinations.

Column.	Ec (Initial Modulus).
1 B	1,710,000
2 A	2,680,000
2 B	3,800,000
3 B	1,840,000
4 A	1,400,000
No. 1	2,630,000
No. 2	2,340,000
Average..	2,350,000

It will be noticed that the points designated T on the graphs correspond fairly well with the strain at the elastic limit of the metal viz., .0014. The modulus of elasticity for the concrete was found for this point also, the method adopted being that previously described. The results are contained in the table below:—

Modulus of Elasticity of Concrete at the Point T.

Column.	Ec.
1 B	710,000
2 A	940,000
3 B	1,100,000
2 B	1,000,000
4 A	1,080,000
Average	966,000



Evidently, for stresses accompanying or approaching the elastic limit of the steel, an approximate value for Ec of 1,000,000 may be taken. This will render n, the ratio $\frac{Es}{Ec}$ equal to 30 if Es, be taken equal to 30,000,000 as above.

Now where a column is reinforced longitudinally, it can be readily shown that the strength per unit area is given by the equation $c' = c\,[1 + (n - 1)\,p]$.