

crete in compression, whereas this modulus is a variable decreasing with increasing stress. In the formula employed in this discussion a parabola is assumed as the compression curve of concrete. There are two main groups of formula: those attempting to represent the condition of the beam under working conditions and working stresses, and from these assumptions arriving at the safe load that any beam can carry; and those representing the beam at its ultimate carrying capacity and hence at ultimate stresses, and from these assumptions arriving at the load which will cause any beam to fail, and then by the application of a safety factor to this load, determining the safe load to which the beam may be subjected. When straight line formula are used, that is, when it is assumed that the rate of strain or deformation of any fibre is directly proportional to its distance from the neutral axis, and that concrete in compression has therefore a constant modulus of elasticity, the area of compression may be represented as a triangle.

Providing the assumptions were correct, it would follow then that the condition of a beam under working conditions would be represented by substituting in a formula working stresses based on the ultimate stresses allowable in the materials used. In other words, the compression area at any working stress would be in the same proportion to the compression area at ultimate stress as the assumed working stress to the ultimate stress.

It has, however, been now established without doubt that the assumption of a uniform modulus of elasticity for concrete in compression is incorrect. The stress-strain curve cannot correctly be represented by a straight line. Some other curve must be assumed, and a parabola has been generally chosen as the closest approximation. It cannot be denied that with the use of straight line or empirical formula, safe designs may be made, but it must appeal to every engineer that a formula representing conditions as clearly as possible is much more desirable. When such a formula is derived, based on the assumption of a variable modulus of elasticity, the use of working stresses in connection with it must be condemned, principally, because at present there are in existence very few data on the condition of beams under ordinary working conditions. Nearly all the tests up to date have been to destruction, and from these the ultimate strength of beams is fairly well-known. Secondly, assuming a parabola or any other curve excepting a straight line as the stress-strain curve of concrete, the ratio of the area of the ultimate compression curve to the area of the compression curve for any working fibre stress cannot be the same as the ratio of ultimate stress to working stress. These ratios must vary as some function of the second or third power according to the equation of the curve assumed. The assumption of working