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STRESSES IN LATTICE BARS OF CHANNEL COLUMNS

DERIVATION OF THEORETICAL FORMULA THAT TAKES LENGTH INTO CONSIDERATION AND THEREFORE ALLOWS FOR STRESS CAUSED BY BENDING AND THAT ALSO AGREES CLOSELY WITH ACTUAL TEST RESULTS.

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FORMULÆ for calculating stresses in lattice bars of columns have hitherto generally been considered empirical, but the writer believes that in the following will be found a theoretical formula which will meet any and all conditions, and which checks up with actual tests.

As a matter of history, it might be noted that on November 2nd, 1907, an article by the writer was published in Engineering Record, of New York, in which the writer evolved a formula for transverse shear which has since been adopted by several authorities, but which does not take into account the length of the column. In the following article the writer has evolved a formula which takes length of column and bending into account.

The formula published nine years ago was as follows:

$$R = \frac{232\,Ar}{n} \quad \text{[Equation a.]}$$

where A = area of column.
r = radius of gyration, axis parallel to back of channels.
n = distance from neutral axis to extreme fibre.

Equation a was derived from the New York law for columns, as follows:—

$$\frac{P}{A} = 15{,}200 - 58\frac{l}{r} \quad . \quad \text{[Equation b.]}$$

Now, if the American Railway Engineering Association's formula is used, which is

$$\frac{P}{A} = 16{,}000 - 70\frac{l}{r} \quad , \quad \text{[Equation c.]}$$

$$\text{then } R = \frac{280\,Ar}{n} \quad . \quad \text{[Equation d.]}$$

Equation d is the value for the transverse shear adopted by several authorities. It can easily be proven by direct proportion that Equation a and Equation d are similar, as follows:—

$$58 : 70 :: 232 : x$$

Therefore, $x = 280$.

It will be noticed that in Equations a and d the length does not appear.

Now, it is evident if we put $l = 0$ in Equations b and c that the quantity to be deducted due to bending drops out, and that nothing would be deducted due to the bending of the column, or in other words as the length of the column approaches zero, the stress to be deducted due to the bending also approaches zero, or there is a much greater stress in the column due to bending when the column is long. As it is only the stress caused by the bending of the column that causes any stress in the lattice bars, it is evident that the longer the column is, the greater must be the stress in the lattice bars.

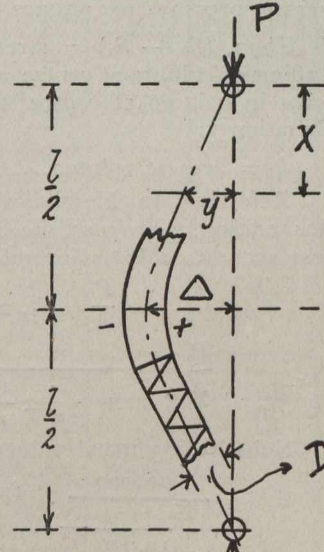
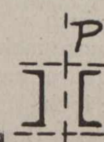


Fig. 1



By referring to Table No. 1, it will be noticed that the stresses for different lengths vary. Columns 9′ 0″ long have much less stress in the lattice bars than columns 20′ 0″, of the same cross-sections. (See Column 2 of Table No. 1.) It is, therefore, evident from the above that Equations a and c are incorrect except for one length of column, whatever that length may be.

For the same reason, the ratio given in Bulletin No. 44 of the University of Illinois, which was given as .0251 of the compression load, can only be correct for columns having a ratio of $\frac{l}{r} = 37.8$, or thereabouts. By referring again to Table 1, Cols. 11 and 12, it will be seen that for approximate ratios of $\frac{l}{r} = 37.8$, that the ratio .0251 compares very closely indeed with the result of the formula given hereafter.

Derivation of Formula.—Referring to Fig. 1, it has been assumed that column is hinged top and bottom, and that a load P is applied top and bottom.