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IMPACT FORMULAS FOR HIGHWAY BRIDGE DESIGN

Part II.

A DISCUSSION OF THE DOMINION GOVERNMENT AND ONTARIO GOVERNMENT IMPACT FORMULAS WITH SUGGESTIONS AS TO SIMPLIFICATION.

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In Ontario, most highway bridges are now built under the Ontario Government specifications, but a few, for various reasons, are designed according to the Dominion Government specifications. In the latter, the impact formula used is the Prichard formula, for all spans.

$$I = \frac{L^2}{L + D}$$

I = impact increment to be added to the live load stress.
L = live load stress.
D = dead load stress.

The maximum unit tensile stress allowed for medium steel is 20,000 lbs. per square inch.

In the Ontario Government specifications the same formula is used but it is reduced by a factor depending on s, the length of span, or the loaded length that produces the maximum stress, thus

$$I = \left(.4 - \frac{s}{500}\right)\frac{L^2}{L + D}$$

The maximum unit tensile stress allowed for medium steel is 16,000 lbs. per square inch. (For the sake of brevity only the formulas for stresses of the same kind are discussed.) This formula has been plotted on Diagram II., being for dead load = zero and for dead load equal live load. The Dominion Government formula is also shown by the two horizontal lines, for dead load equal to zero and for dead load equal to live load.

Now, consider how these formulas work out in practice, but before doing so it is only fair to state that both the above-mentioned specifications will probably be revised in the near future and the following discussion is more of an attempt to suggest improvement than to criticize what most bridge engineers agree in condemning.

Nearly all highway bridges now built are designed for concrete floors and for all spans, say, from 30 feet to 100 feet the dead load is approximately equal to the uniform live load of 100 lbs. per square foot. For longer spans, as this live load is reduced at the rate of one pound per square foot for every five feet increase in length until a minimum of 80 pounds for a 200-foot span is reached, and as at the same time the dead load increases very rapidly, the impact increment soon becomes so small that it may be neglected. But for spans of from 30 to 100 feet it may be seen from the diagram that the impact increment by the Ontario specifications will be approximately from 10 to 20 per cent. of the live load, or only 5 to 10 per cent. of the total load.

By the Dominion Government specifications the percentage of impact increment for the same assumptions would be, for all spans from 30 to 100 feet, about 25 per cent. of the total stress, but as the unit stress allowed is 25 per cent. higher than that allowed by the Ontario specifications, it works out that the former, with impact added, gives the same result as the latter without impact. For all practical purposes the Ontario impact formula might just as well be neglected for all spans over 100 feet.

For spans under 30 feet the concentrated live load usually controls in the design. The impact stresses produced by this load are probably of greater magnitude and therefore of more importance than those of the uniform load. With light wood floors and short spans or stringers and floor beams of long spans the dead load will be small compared with the live load and the impact increment will accordingly approach 40 per cent. of the live load for the Ontario specifications and 100 per cent. for the Dominion specifications, or reducing to the same unit stresses the actual increases are 40 and 60 per cent. respectively. For short spans with concrete floors, which is the usual construction, the dead load is approximately equal to half the live load. The corresponding values for the impact increment are consequently somewhere around 26.6 per cent. of the live load for the Ontario specifications and 33.3 per cent. for the Dominion, and reducing these as before to the same unit stresses we have in percentage of the total stress 17.7 per cent. for the former and 15.2 per cent. for the latter.

The use of s = loaded length, in a formula for concentrated loads produces very inconsistent results. After the distribution of the wheel loads has been figured the load is treated exactly the same as if it passed over the bridge like the uniform load. Take, for instance, in the design of floor beams or the hip vertical of a bridge, s is always taken as two panel lengths. Then, while the rear wheel of a road roller will produce exactly the same static stresses in these members, yet by the Ontario formula the impact increment will be 20 per cent. less for 30-foot panels than for 10-foot ones, even if the dead load were exactly the same in both cases. For stringers the difference is 10 per cent. Is there any logical reason why stringers and floor beams for long panel bridges should be relatively lighter than for short panel bridges when they both are to carry the same road roller?

Another thing that impresses one in examining these formulas is that 25 or 30 per cent. is not much to allow for impact for the concentrated load. A practical example will bring out this fact.

Assume a bridge having 16-foot stringers resting on solid abutments and having a 6-inch concrete floor. The