3. Available data indicates that:

a) Impact stresses vary directly with the speed of the truck, up to a limit of 15 miles per hour.

b) Impact stresses increase but slightly with the speed on clean floors (no obstructions other than natural roughness of floors and tires).

c) Impact stresses increase considerably with the speeds when the truck wheels run over obstructions.

d) The increase in impact stresses for given obstructions and speeds, is approximately the same for heavy or for light loads on the same truck. This indicates that the increase in stress (impact increment of stress) is caused primarily by the unsprung weight of the truck.

e) Impact varies inversely with the softness of truck tires and with the flexibility of the bridge floor. For this purpose, it may be assumed that the governing flexibility occurs when the unit stresses reach allowable limits.

f) It follows from d) and e) that the impact increment in percent varies inversely with the load on any given truck.

4. An engineer with judgment who notes the above general conclusions may provide for the proper impact by making use of the data in table 1.

TABLE 1

Impact increments of stress in percent, in highway bridge floors for trucks, with various tires unsprung weights and obstructions

15 Miles Per Hour

HEIGHT OF OBSTRUCTION	$d = 0{,}1$		$d = 0{,}6$		PNEUMATIC TIRES	
	$p = .20$	$p = .33$	$p = .20$	$p = .33$	$p = .20$	$p = .33$
None	14.	31.	4.	12,	1.	4.
1″	160.	286.	44,	77.	20.	38.
2″	362.	610.	87.	170.	38.	80.

In the table, p is the percent of unsprung weight to total weight of truck. ($p = .33$ represents a normally loaded heavy truck and $p = .20$ represents an overloaded truck such as a live load of 10 tons on a truck weighing 5 tons) $d =$ the deflection of the tire in inches due to a static load of 10 000 lbs. ($d = 0{,}1$ represents the hardest worn rubber tire which has been noted. $d = 0{,}6$ represents an average new solid rubber tire).

Trusses

The author is aware of but two pieces of experimental work in the United States for determining the impact in the trusses of highway bridges for which published data are available, those of F. O. Dufour[1] and the author.[2]

In all of these experiments, the loads have been too small to even approach the capacity of the bridges. The results show that impact decreases as unit stresses increase. The highest static live load stresses which have been developed, were due to trucks weighing 15 tons and were but slightly over 5000 pounds per square

[1] Proceedings, American Society of Civil Engineers, October 1926. Journal, Western Society of Engineers, Vol. 18, 1913.

[2] Bulletins 63 & 75, Engineering Experiment Station, Iowa State College, and "Public Roads", September 1924.

inch. For this load, with the maximum attainable speed of about 15 miles an hour, the impact increment in trusses of bridges with clean concrete floors and smooth timber floors for reasonably hard solid rubber tires, is below 25%.

As impact is important as a factor in design, only when the total unit stresses approach design values, and as the results show that impact decreases as unit stresses increase, 25% is apparently the maximum impact for which it is necessary to provide even for short spans under normal unit stresses. A higher impact due to obstructions, which might be suggested by the data in table 1 might be recognized as possible and be provided for by an increased unit stress.

Existing data are too meagre to establish a relation between impact and span length. The established reduction in impact for increased spans for railroad bridges may be the best guide for reductions for highway bridges and perhaps an adequate one for practical purposes.

Culverts

A series of experiments conducted by the Engineering Experiment Station of Iowa State College[1] reported in bulletin 79 of that organization, indicate a very wide range of impact factors on highway culverts under shallow depths of cover. These factors vary from zero in the case of smooth roadway surfaces to several hundred percent of the static load effect for various obstructions in the path of a truck wheel. The impact factor when considered as a percentage of the static load effect on the culvert, does not vary appreciably with the depth of cover. However, the static load effect decreases quite rapidly as the depth of cover increases so that for the greater depths, the increase in effect on the culvert due to impact is quite small in relation to the actual wheel weights.

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[1] Co-operative work with the U. S. Bureau of Public Roads.