STRESSES IN CONCRETE ROAD SLABS FROM WHEELS OF HEAVY TRUCKS

AT the present time it is impossible to calculate the proper thickness of a concrete road slab with much certainty. It is known that a thicker slab is required where the subgrade is soft than where it offers a good bearing, and that heavy loads require a thicker supporting slab than light loads; how much thicker, however, has not been determined. The stress in a slab depends upon the bending moment produced in the slab, and this in turn is dependent largely upon the distribution of pressure over the subgrade. It is recognized that ununiform subgrade pressures are due to causes other than the heavy traffic loads carried by the slabs. An investigation to discover how the road slab is stressed directly under the wheels of heavy trucks and to determine whether this stress is apt to be a governing influence in the design of the slab, has been initiated by the United States Bureau of Public Roads. This test is one of a series of investigations outlined to include an adequate range of the different varieties of subgrades and slab thicknesses. The test was made on the concrete road between Camp Humphreys and Alexandria, Va. The road surfacing at this point is 18 ft. wide, 8 in. thick at the centre, and 6 in. at the sides. A 1:1½:3 gravel concrete was used, having a crushing strength, as determined by 6 by 12 in. cylinders cast in the field at the time the road was laid, of 3,190 lb. per sq. in. The aggregates in the concrete at this point were Potomac River sand and gravel. Here the road runs through a 6-ft. cut and the subgrade in the past has remained rather wet and soft. The soil is composed of a sticky clay, which, when wet, has very low bearing value.

Designed Special Pressure Cells

To measure the pressure distribution, four pressure cells were designed in the Bureau of Public Roads. In order to determine the distribution of pressures under heavy wheel concentrations, a class B standard army truck was loaded with 5 tons of sand. The front wheels and rear wheel of the loaded truck were weighed separately and the axle loads were found to be 5,000 lbs. and 17,000 lbs., respectively.

On February 5th, 1919, a test was made on the Camp Humphreys road with this loaded truck. It was backed 1 ft. at a time up to the central measuring cells. When the rear wheels reached a position directly over the cells, the truck was backed 1 ft. at a time still farther until the front wheels were just over the cells. As a second test the truck was backed with the wheels as close to the side of the road as possible so that they would be made to come directly over the cell placed at the extreme side of the road. During the progress of the preliminary measurements, taken over a period of four months, opportunities offered themselves for obtaining some idea of the effect of light loads on the subgrade pressures, and these are presented in the following table:—

		Ford.	Boiler.	Front army truck.	Rear army truck.
Load on slab ...	[1]200	[1]350	[1]3,680	[1]2,500	[1]8,500
Maximum intensity of pressure	[2]0.2	[2]0.4	[2]3.5	[2]1	[2]6.5
Radius of area of distribution	..	[3]2	[3]5½	[3]3	[3]6

[1]Pounds. [2]Pounds per square inch. [3]Feet.

Summarized Results of Investigation

The results of the investigation are given by A. T. Goldbeck, engineer of tests, U.S. Bureau of Roads, in a report made public recently by the Bureau. The tentative conclusions drawn from this preliminary investigation are as follows:—

1. That a concrete road slab under the action of traffic or perhaps under the influence of frost and different percentages of moisture in the subgrade is continually bending, so that the reaction pressures between the subgrade and slab are neither constant nor uniform in intensity.

2. The reaction pressures due to heavy wheel loads are a maximum directly under the loads and vanish to zero in a comparatively small radius, which partially depends upon the intensity of the load. A heavy wheel load is distributed over a larger radius than a light wheel load. For this particular subgrade, a load of 8,500 lbs. has a radius of distribution of pressure of about 6 ft., most of the pressure, however, being exerted over a radius of about 4 ft.

3. As the concrete slab recovers from its deflection after the passage of a load more readily than the soft subgrade, there is a tendency for the continual deflection of the slab to produce areas having very little or no bearing. If the traffic is concentrated at the centre of the road, as it is on many concrete roads, the continual deflection tends to depress a soft subgrade away from the centre of the slab, which would then be more largely supported at its sides. In extreme instances this might account for some longitudinal cracking in concrete roads.

4. As nearly as can be estimated from the results of this test, the tensile stress in an 8-in. concrete slab directly under an 8,500 lb. wheel load at rest on the road is only 34 lbs. per square inch when the slab is well supported on the subgrade. As the modulus of rupture of 1:1½:3 concrete is about 600 lbs. per square inch, it is seen that this pavement should be able to withstand considerable impact before cracking. Should the concrete arch, over very soft spots, so that there is no support directly under the load, the tensile stress may become very high. Such a condition arises when the sides of the slab are raised by frost action or possibly when the subgrade is worked away from under the slab by continual deflection.

5. It is probable that the tensile stress which results in the slab directly under heavy wheel loads is never very great as long as the slab rests on the subgrade and it is unlikely that the slab design would ever be controlled by this stress.

ONTARIO HYDRO ASKS COMPENSATION

FORMAL application has been made to the Minister of Finance by the Hydro-Electric Power Commission of Ontario, asking that the Dominion government reimburse it approximately $5,000,000 for the extraordinary war expenditures incurred on unavoidable extensions due to the necessity of providing power on a large scale for the manufacture of munitions and other materials for war purposes in order to meet the demands made by the manufacturers and the power controller. In support of this application the commission has forwarded to Sir Henry Drayton a file containing the voluminous correspondence and orders covering the period when the extensions were made. It is pointed out by the commission that the power controller, under whose orders much of this work had to be undertaken to meet the needs of the munitions manufacturers, had authority only over Ontario. This control was exercised, it is claimed, almost solely over the Hydro-Electric Commission. In such cases as private companies ordered to make extensions, it is said by Sir Adam Beck that they were either reimbursed by the Imperial Munitions Board or the manufacturers whom they supplied.

In making this application to the Dominion government the commission states its belief that the Dominion government will recognize that the financial burden of the war should be borne by the people of the Dominion as a whole, and not by one province or group of municipalities who happened to be in the fortunate position, owing to the existence of cheap hydro-electric power, of contributing so largely to the defence of the Empire by the manufacture of these munitions.

The items in the Commission's bill, which is for $4,902,000, are as follows: $2,500,000 for the extension to the Ontario Power Co.'s plant, which was temporary for war purposes only and will soon be abandoned; $652,000 for duty on equipment for the O.P.C. extension and the Queenston-Chippawa development; and $1,750,000 for increase in cost, compared with normal times, of extensions of transmission lines and equipment on the Niagara system necessitated by the power requirements of the munition manufacturers. Sir Adam Beck points out that in the United States the government has compensated power companies for extraordinary war expenditures.