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EFFECTS OF LOADS ON PAVEMENTS AS INDICATED BY STRESS MEASUREMENTS

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In discussing the effect of loads on concrete pavements it has generally been the custom to divide the discussion into two parts and consider static and impact loads as being separate and distinct from each other Extensive researches are being conducted on the subject of motor truck impact and it may be that by these invesigations some law will be established which will show that the only difference between the effect of static and impact loads on pavements is that due to the time of application of the load It seems extremely probable that such a law exists, but at present our knowledge of it is very limited

The most direct method for determining the effect of loads upon a concrete pavement is by means of strain measurements The development of a suitable strain gage and a method of making strain measurements in concrete pavements under actual traffic loads has placed in the hands of the research engineer a most useful tool which has already added greatly to our knowledge of the behavior of the pavement structure in the course of its normal functioning The gage and the method of using it have been previously described in the Proceedings of the Highway Research Board for 1924 and 1925

Rather extensive experiments with this strain gage under static loads or very slowly rolling loads have indicated the following important facts to be true under these conditions of load.

FACTS ESTABLISHED

1 That, in a pavement slab of uniform thickness, the highest stress which can be obtained with a given wheel load occurs as longitudinal tension in the bottom of the pavement directly under the wheel when that wheel passes along the edge of the slab

2 That the next highest stress which can be produced by a given wheel load in a slab of uniform thickness will occur as a tension in the top surface of the pavement along the diagonal at the corner when the wheel of the vehicle rests on the corner of the pavement slab This stress approaches the magnitude of the edge stress but has never been observed to equal it

3 That, for the same given wheel load, the stresses in the interior of surface of a slab of uniform depth appear always to be appreciably less than the edge and corner stresses mentioned in 1 and 2

4. That a thickened-edge design results in more uniform stresses in the various parts of the pavement structure

5 That, for a given wheel load and cross sectional design, the condition of the subgrade affects the stress developed in the pavement

6 That the resistance of a slab does not increase exactly as the square of its depth

7 That the magnitude of the stress in a pavement slab of a given thickness is a direct function of the magnitude of the wheel load

8 That the tongue and groove type of longitudinal joint is capable of transmitting stress across the joint and that the percentage of stress transmitted apparently varies with the magnitude of the wheel load.

9. That, with a six-wheel vehicle of a type having equal load distribution on the four rear wheels and rear axle spacings between the limits of 3 feet and 10 feet, the maximum stress produced in the pavement is a function of the wheel load and not of the axle spacing

These same strain gages have been used in a number of tests where the loads were entirely dynamic in character and of the order characteristic of motor truck impact. From these investigations certain information has been developed regarding the effect of this condition of loading

An extensive series of impact tests on small pavement slabs was conducted by the U S. Bureau of Public Roads in 1923, from which certain conclusions concerning concrete pavement slabs were drawn, the more important being as follows:

1 The resistance of a slab to impact depends in part upon the supporting value of the subgrade A subgrade of high supporting value materially increases the resistance to impact.
2 In general, plain concrete slabs show no more resistance to impact delivered at the edge than to impact delivered at the corner.
3. Transverse cracks and longitudinal cracks near the edge of the road slab may be caused by impact delivered at the edge of the slab
4. Impact resistance of rigid slabs varies neither directly as the slab depth nor as the square of the depth, but as some intermediate relation.
5. Concrete of a rich mix offered greater and more uniform resistance to impact than concrete of a lean mix, the resistance of plain slabs of 1. 3: 6 mix ranging from 60 to 80 per cent of that of similar slabs of a 1: 1½ · 3 mix

An interesting observation made during the course of these experiments was an apparently elastic deformation of unusual magnitude under impact. The strains measured, multiplied by the known modulus of elasticity of the concrete, indicated elastic behavior in tension at unit stresses of roughly 1000 to 1200 pounds. There is no record of this having been observed before, and the question was at once raised as to whether or not it is possible to safely strain concrete to a greater degree under impact than it is under static or slowly applied loads. The Bureau of Public Roads, in cooperation with Johns Hopkins University, carried out a series of experiments wherein the elastic behavior of a series of concrete beams was studied under both static loads and impact loads of various periods of duration. These experiments yielded some interesting indications, among which were:

1. That concrete is capable of greater elastic deformation under impact than under ordinary static loads
2. That fatigue of concrete under repeated impact exists

3 That repeated impacts which stressed the concrete to about 55 per cent of its static modulus of rupture would eventually cause failure
4. That below this fatigue limit equivalent loads, without regard to their method of application (whether static or impact), produce the same stress, while beyond this limit it is indicated that the difference in behavior is due to the duration of the load application.

SUGGESTIONS FOR FURTHER RESEARCH

1. A study of the balance of various thickened-edge cross-sectional designs
2 A study of the efficiency of various forms of longitudinal joints with a view to determining what additional edge strengthening, if any, is needed by each

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THEORY OF CONCRETE PAVEMENT DESIGN

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The structural design of a concrete pavement is based on an estimate of the stresses occurring under given circumstances Two papers dealing with computation of stresses in concrete pavements were published in the Proceedings of the preceding two annual meetings of the Highway Research Board The first of these papers deals with stresses and deflections due to loads, the second with stresses and deflections due to variations of temperature