CONCLUSIONS

1 The cement-clay admixture appeared during construction, and shows in results since to be little if any different than the natural soil base
2 The porous bases show thus far much less cracking than do the natural soil and admixture of cement and soil bases
3 The increase in cracks during the second year show similarly favorable results for the porous bases
4 It is unsafe at this time to draw conclusions upon the sufficiency of 2, 4 or 6 inch porous bases to save the road maintenance an equivalent of their first cost

IMPACT FORCES EXERTED BY THE MOTOR TRUCK ON THE HIGHWAY

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THE COOPERATIVE MOTOR TRUCK IMPACT PROJECT

Two years ago, a progress report on the Motor Truck Impact Project was submitted to the Highway Research Board This project is cooperatively conducted by the Bureau of Public Roads, the Rubber Association of America, and the Society of Automotive Engineers All of the tests scheduled at that time have been completed and additional tests have also been made [1]

The investigation has so far been confined principally to the measurement of the vertical reaction between the road and the wheel and determination of the influences of tire equipment, load, speed, and road surface roughness The procedure and apparatus are substantially as outlined in the earlier report, and may be found in detail in the June, 1926, issue of *Public Roads*

The results of the tests reported below are illustrative of the effects of the variables and are believed to be generally accurate within 10 per cent They were obtained with equipment specified by a joint committee representing the three agencies cooperating in the Motor Truck Impact Tests, and the results apply specifically to the tire equipments used, which were standard at the time of the tests

The term "cushioning effect" as used refers only to the vertical reaction between the road and the wheel, and, although exerting an influence thereon, is not to be confused with the popular term

[1] More than 150 truck and tire combinations have been tested to date

"riding quality" This research has been concerned with only one phase of certain economic problems, full consideration of which should give due weight to various other highway transportation factors relevant to the subject

CONCLUSIONS

The tentative conclusions drawn in the previous progress report to this Board have been substantiated and certain others have been made from the data now available, namely

1 Maximum impact forces obtained with motor truck tires in service can be measured with an accuracy sufficient for the needs of this investigation
2 As static load increases, road impact reaction increases
3 As static load increases, the ratio of road impact reaction to static load decreases
4 Thickness and narrowness of tread rubber are desirable in reducing road impact reaction
5 Increasing the thickness or profile height of rubber has a very marked effect in reducing road impact reaction in both single and dual mountings
6 In the tire equipments tested, all of which were standard at the time of the tests, dual mounting caused heavier impact forces than the corresponding single mounting of the same total load-carrying capacity (This was determined on a pneumatic-tired, 2-ton truck and a solid-tired, 5-ton truck)
7 Appreciable variation of cross-sectional rubber, or breaks in its continuity, cause heavy repeated impacts to be delivered to the road
8 Dual-mounted tires should always be mounted with the tread design staggered

Auxiliary to the truck impact tests, the action of the tires under static loads is measured and recorded A conventional testing machine was modified to conveniently determine the vertical deflection, the contact width and the contact area of the tire as the load was slowly applied Figure 1 shows the average load intensity of various tires plotted against the total static load and is representative of the character of the data available from these tests It is hoped that a definite relation will be found between one of the characteristics under static load and the impact reactions of a truck equipped with the same tires under service conditions.

The impact reaction of a motor truck with a road surface is resolvable into two components They are simultaneous and additive,

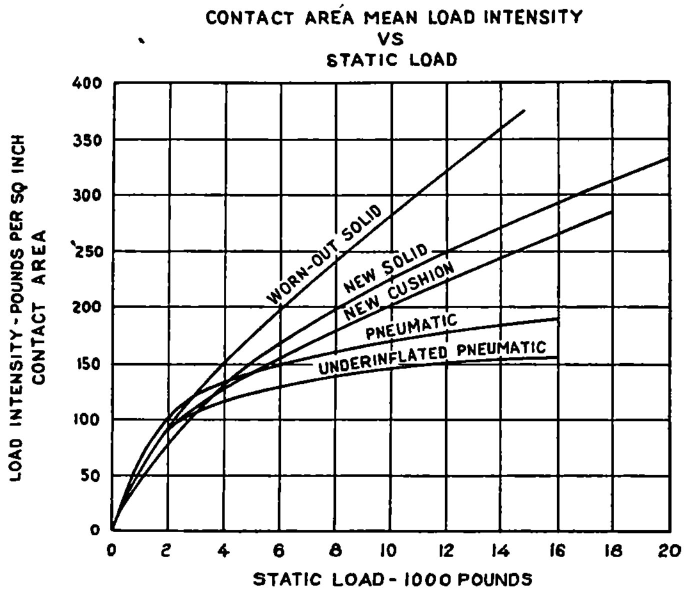

Figure 1

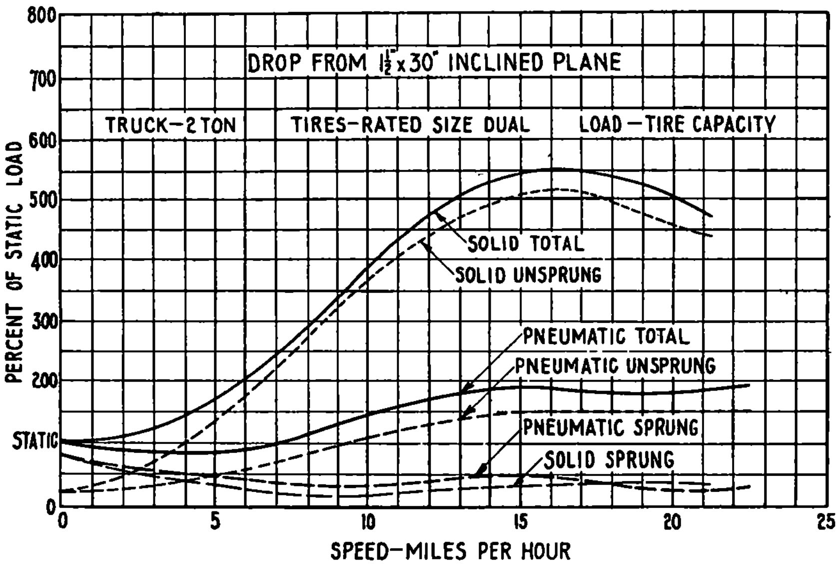

Figure 2

and are the forces exerted by the sprung and unsprung weights on each wheel A study of Figure 2 will show that, for normal operating conditions, it is the unsprung component which is the major quantity For this test condition, the unsprung component for the new solid tire equipment is at least 90 per cent of the total reaction at speeds above 6 m p h It can also be deduced that cushioning devices *above* the truck springs will have relatively little effect on the *road* reaction although the riding qualities may be appreciably affected

FOUR FACTORS INFLUENCE TRUCK IMPACT

There are four major factors which influence vertical impact forces of the truck on the road These are tire equipment, wheel load, speed, and road roughness The effect of any one factor may not be considered without reference to the other three, and the

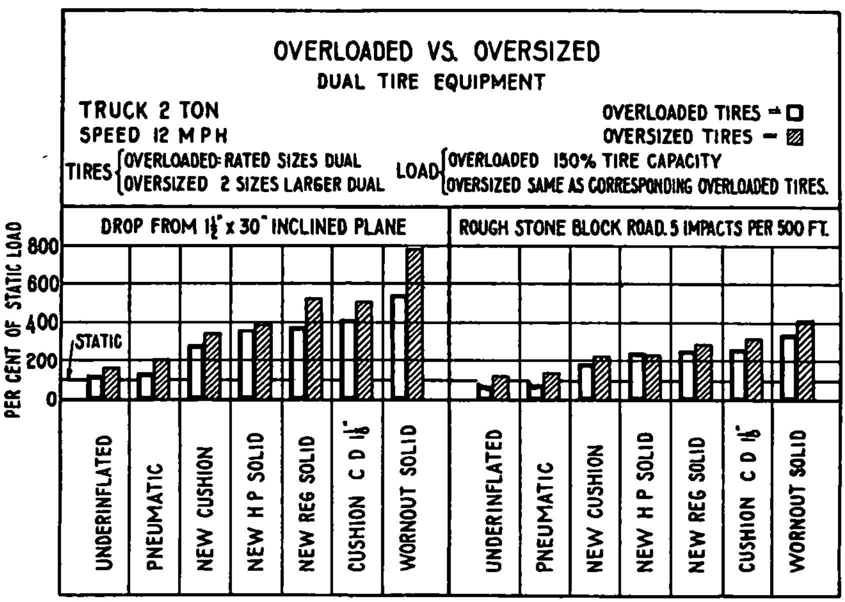

Figure 3

illustrations herewith submitted are intended to illustrate the influences of these variables

The effect of tire equipment may conveniently be considered from two angles the type and size of the tire and the physical arrangement of the tires Figure 3 shows the influence of tire type and the relation between overloaded and oversized tire equipments for a given load It is the markedly greater widths with comparatively the same heights that cause the larger tires in the oversized equipments to more rapidly alter the vertical velocities and consequently cause higher accelerations and impact reactions than the narrower widths of the respective overloaded tires The effect of varying the thickness of various solid and cushion types of tires has been studied

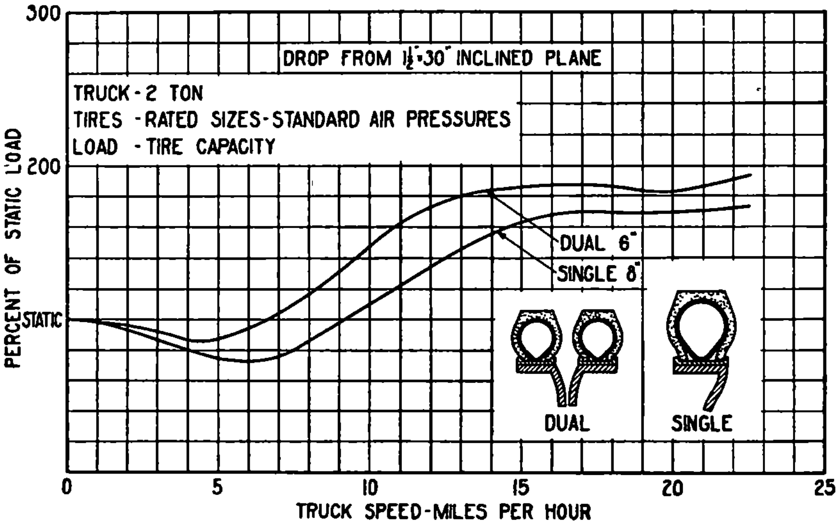

Figure 4

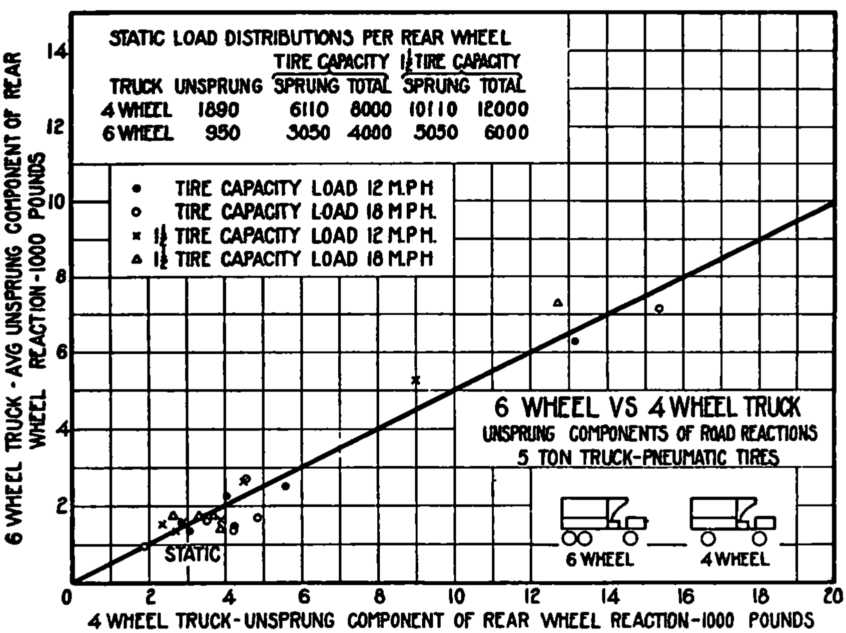

Figure 5

during the past summer, but the data have not yet been released by the Cooperative Committee

The effect of the physical arrangement of the tires is shown in Figure 4 Here, again, it is the relatively low, wide cross-section of the cushioning material of the dual mounting that causes higher reactions than the single mounting of a similar cushioning medium that is higher and narrower This same relation has also been brought out on a 5-ton truck with single and dual solid-tire equipments

In Figure 5, the unsprung components of the impact reactions of a six-wheel truck are shown to be one-half of the corresponding reactions of a four-wheel truck which differed only in the rear-axle arrangement, the total loads being the same on each truck This fact is substantiated by tests conducted to determine the relative effect of four and six wheel trucks on a pavement slab The fiber deformations produced in a six-inch concrete slab were twice as great by a four-wheel truck as they were by a six-wheel truck carrying on two rear axles the same load carried by the single rear axle of the four-wheel truck [1]

[1] The Six-Wheel Truck and the Pavement, by L W Teller, *Public Roads*, Vol 6, No 8, October, 1925

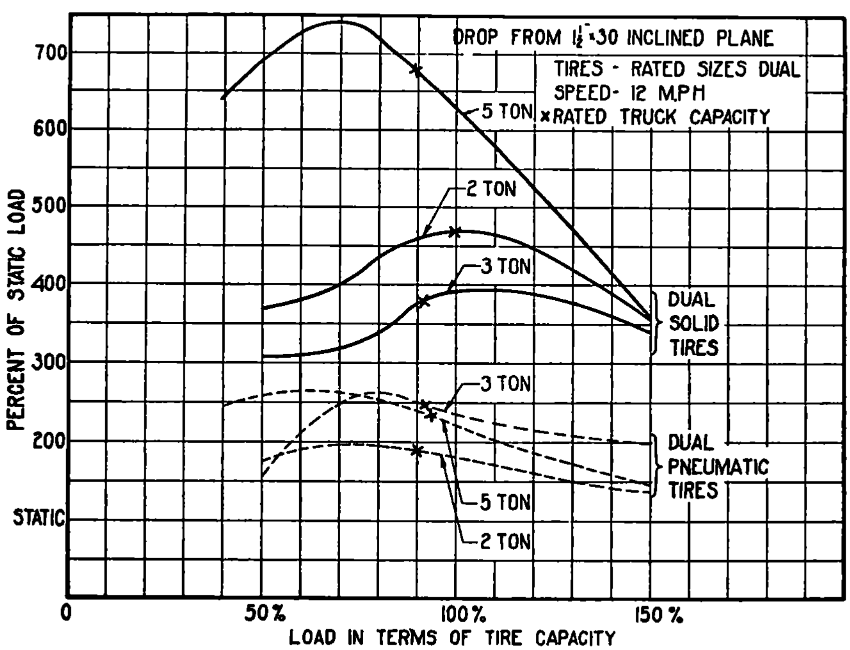

Figure 6

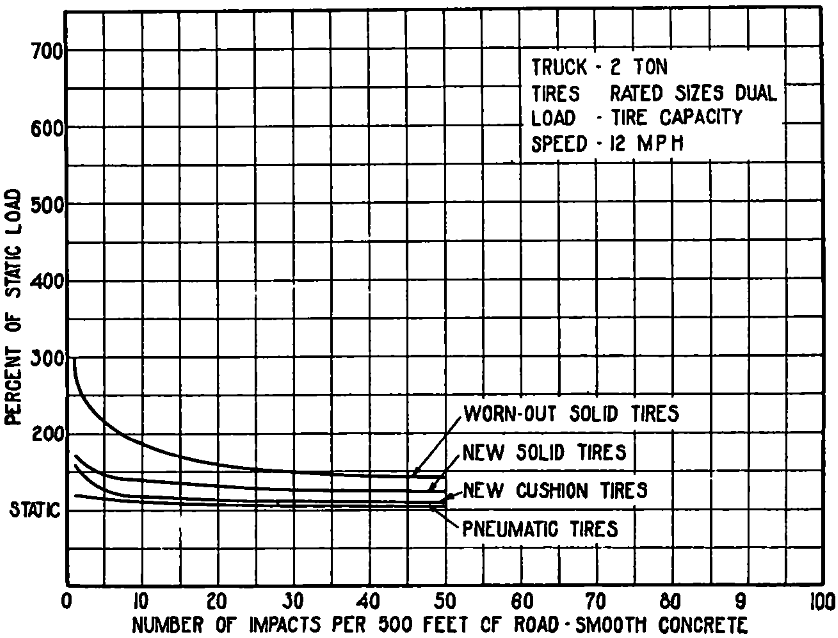

Figure 7

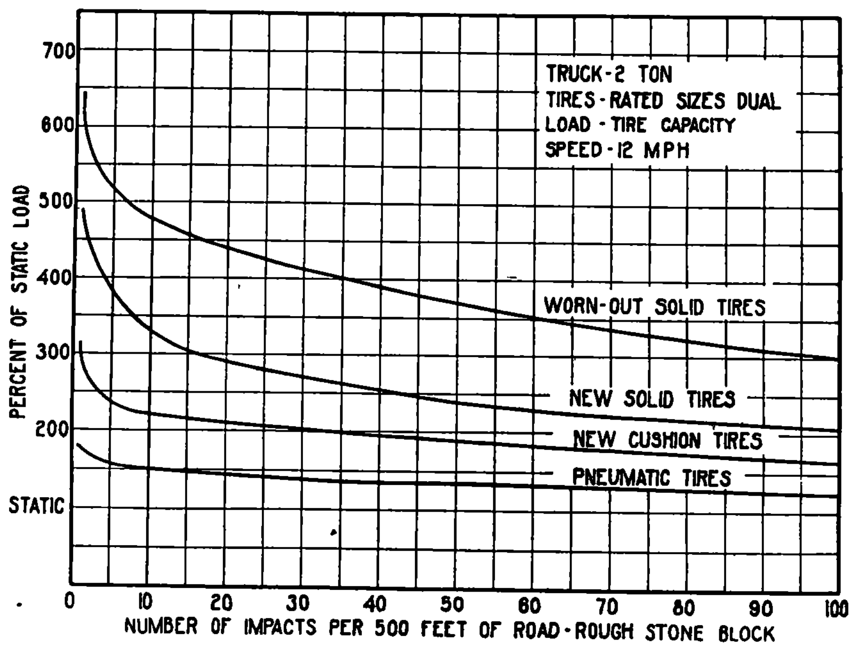

Figure 8

Figure 6 illustrates one method of showing the effect of wheel load Logical extrapolation of the curves shows that excessive overloading of truck and tire tends to eliminate the individual truck characteristics, as such This does not mean that the reactions, *in pounds,* are identical for all capacities of trucks, but that at about 200 per cent tire capacity load the percentage of the static wheel load representing the impact reaction would be approximately the same for each truck under this test condition

The influence of the truck speed is indicated in Figures 2 and 4. When the wheel encounters an obstruction in the road and acquires a vertical velocity in passing over it, this condition is called shock When the vertical velocity acquired under the influences of gravity and the truck spring is lost on strking the road, this condition is

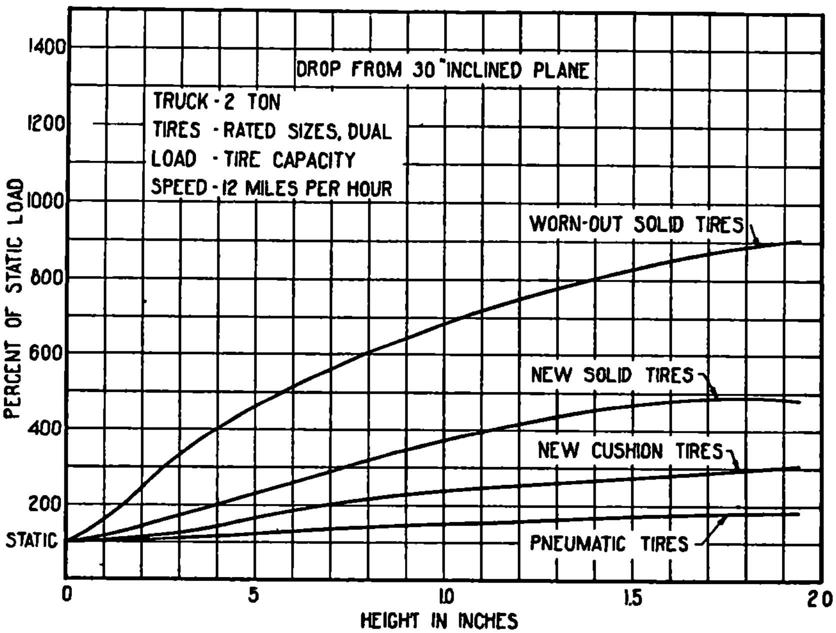

Figure 9

called drop In general, it is the drop condition which causes the heavier impact reaction Under shock conditions the impact reaction usually increases in almost direct proportion with the speed The generally heavier drop reactions show a series of nodes which are caused by variations in the downward velocity due to the truck springs and other factors

The influence of road roughness has been studied on two roads of different characters and on a special road on which numerous sizes and types of artificial obstructions were placed Figures 7 and 8 show results obtained on the highway test sections They show that poor tire equipment may be exceptionally severe on even a smooth road and that good tire equipment considerably reduces the impact reactions on a rough road Figure 9 shows the influence of height in the artificial obstructions and is representative of the type of data available from these tests

In the data herein presented, it has been convenient to express the impact forces as a percentage of the static load. In order to permit the highway engineer to make specific applications Table I of wheel loads and tire sizes has been included

TABLE I

Tire type	Truck capacity	Wheel load capacity of rated size of tire		Tire size			
				Rated size		Oversize	
		Single	Dual	Single	Dual	Single	Dual
		Pounds	*Pounds*	*Inches*	*Inches*	*Inches*	*Inches*
Pneumatic	2 tons	4,000	4,400	40 x 8	36 x 6		38 x 7
	3 tons		6,000		38 x 7		40 x 8
	5 tons		8,000		40 x 8		
Cushion	2 tons		3,400		36 x 5		36 x 7
	3 tons		7,000		36 x 7		36 x 8
	5 tons						
Solid	2 tons		4,000		36 x 4		36 x 6
	3 tons		6,000		36 x 5		36 x 7
	5 tons	8,400	8,400	40 x 12	40 x 6	40 x 14	40 x 8

As the duration of motor truck impact forces is of interest it is mentioned that a pneumatic tire is, during impact, deflected beyond its static load deformation for about 0 08 second, and a wornout solid tire for about 0 02 second During approximately one-fourth of the above intervals, the acceleration (and, therefore, the force) is within 10 per cent of the maximum It should be remembered that an
impact reactions on a rough road Figure 9 shows the influence of
way as a static force of the same numerical value in pounds A

study of static and impact strains in concrete was recently made and published in the July, 1926 issue of *Public Roads* [1]

In the conduct of the tests and the preparation and studies of the data, the author wishes to recognize the earnest and efficient cooperation of Mr J. W Reid, Special Representative of the Rubber Association of America

THINNER PAVING BRICK

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Since this Committee rendered its last report, the U S Bureau of Public Roads has completed a rather comprehensive investigation into the possibilities of paving brick of less than 4 inch thickness

The detailed report has recently appeared in *Public Roads* (Vol 7, No 7, September, 1926) but inasmuch as the conclusions drawn from this study directly concern the design of brick pavements, a brief review of this investigation may properly be presented at this time

Primarily, this research aimed to determine the service limitations of paving brick surfaces of different thicknesses with a collateral object of developing definite information concerning the other features of brick pavement design about which there is such a diversity of opinion

PROCEDURE

Briefly, the procedure adopted was as follows

A field survey was made of the service behavior of brick pavements which had been in service for an appreciable length of time, in which brick of less than 4-inch thickness had been used This survey involved the inspection of several million square yards of brick pavement in several States and the collection of all possible data relevant to the pavements inspected

At Arlington, Virginia, a series of ten brick pavement sections were laid to determine the relative resistance to traffic of brick surfaces of various thickness when supported on an adequate base Such a base was already available in a 6-inch reinforced concrete circular track which had been used for other tests and on this were laid the ten test sections which included five thicknesses of brick (2, 2½, 3, 3½ and 4 inch) and two types of bedding course (plain

[1] Static and Impact Strains in Concrete, by J T Thompson, *Public Roads*, Vol 7, No 5, July, 1926