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

sand and cement-sand Figure 1 shows the general plan of this test track These pavement sections were subjected to an accelerated traffic test with loaded motor trucks, the loads on these trucks ranging from 3 tons to 7½ tons A total of some 630,000 tons of truck traffic were applied to each section during the period of the test, and

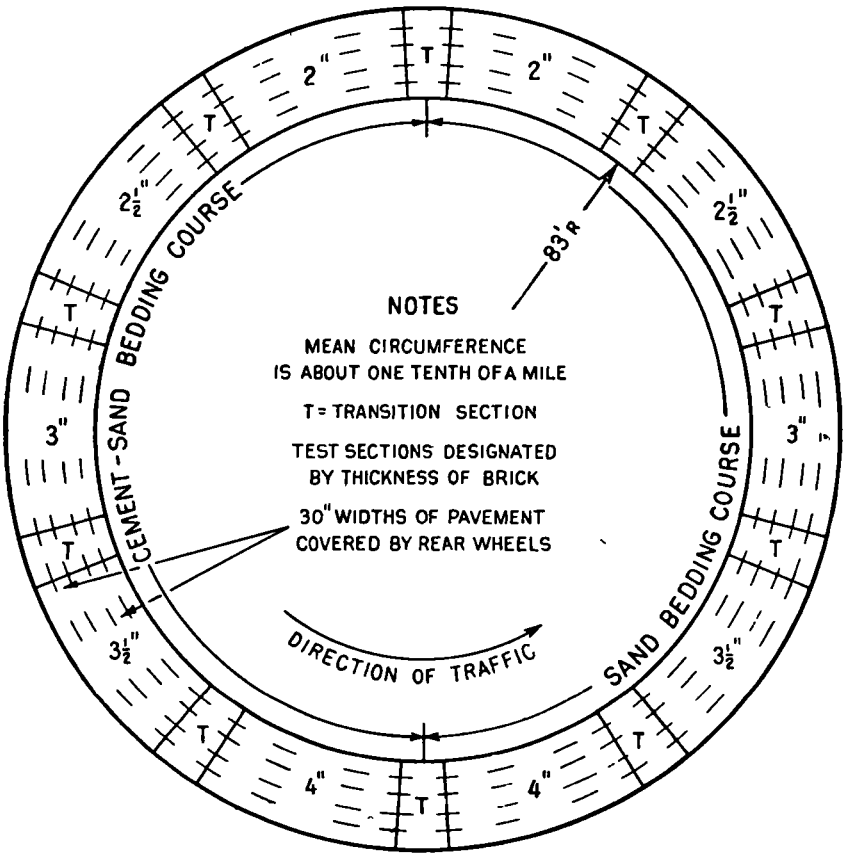

Figure 1

of this approximately one-third was equipped with heavy tire chains All of this traffic was concentrated in two 30-inch lanes or wheel paths, marked on the surface of the pavement In order to obtain some idea of what period of service this traffic would represent if applied to an actual highway, a comparison was made with the average truck traffic of all capacities from 3 to 7½ tons on the Cook County highway system and it was found to be equivalent to some 18 years of service

The behavior of the various sections was compared on the basis

of brick broken or other deterioration which developed under the various load increments of the test program

CONCLUSIONS

The more important conclusions as summarized at the beginning of the report are essentially as follows

1 That 2½-inch brick of the quality used in the Arlington traffic tests, when properly supported, will prove satisfactory for pavements carrying the heavier types of traffic
2 That brick of 2-inch thickness, when properly supported and of the quality used in the tests, will be adequate for pavements carrying the lighter types of traffic
3 That a bedding course of plain sand is more effective in reducing breakage of brick than a cement-sand bedding course, the breakage being much less on the former than on the latter The depth of the sand bedding course should not greatly exceed three-fourths inch Increasing the depth tends to produce roughness in the pavement
4 That cobbling of the brick is greatly increased as the spacing between the bricks is increased
5 That the use of excessive quantities of asphalt filler is a common and serious fault in construction, unnecessarily increasing the cost and resulting in a condition which impairs both the appearance and the serviceability of the pavement
6 That base construction of other than the rigid type may, in many cases, prove entirely satisfactory when the local conditions of traffic, subgrade and climate are such that this type of construction maintain its stability throughout the year
7 That no difference in the base construction is necessary for the different thicknesses of brick

DISCUSSION

The use of thinner paving brick places a definite responsibility on the paving brick industry There is a very considerable reduction in the factor of safety with the reduction of brick thickness These tests have shown that with brick of a certain quality, the 2, 2½ and 3 inch brick will provide adequate strength for particular traffic conditions The great economy in brick pavement construction made possible through the use of thinner brick is dependent on the reduction of this factor of safety to the lowest adequate value This is simply good engineering design Such a reduction should not be

made, however, unless there is a certainty that the quality of the product will be maintained at a uniformly high standard The economical use of any structural material can only be accomplished in this way, and there is no reason to believe that the brick manufacturer can not meet this requirement as well as the producer of other structural materials It is believed that the brick should be regarded as a surface, and that the base under this brick pavement surface must carry the load It is obvious that such a flexible wearing surface, which is not bonded to the base can not add to the structural strength of the base For this reason, great care should be exercised in the selection of a base design which will at all times be adequate

While it has been indicated that there are possibilities for economy in the use of non-rigid bases for brick pavements, where the local conditions of traffic, subgrade and climate are such that this type of construction will maintain it stability throughout the year, it should always be borne in mind that we are building for the future, and that as any roadway is improved the demands of traffic become greater The base we build today must be capable of carrying the traffic loads of the future, utilizing in full the long life of the brick wearing surface

Very definite information was developed in this study, on the design of the bedding course The Arlington traffic test indicated the plain sand bedding to have marked advantage over the cement-sand bedding For instance, on the 2-inch brick sections on the plain sand bedding, a total of 12 6 per cent of the brick in the two 30-inch traffic lanes were broken under all the traffic, on the cement-sand bedding 28 7 per cent of the brick were broken under the same loads The field survey indicated that smoother pavement surfaces were obtained where a carefully finished base was used, with a resultant uniformity of thickness and compaction in the bedding course The adverse effect of using too thick a bedding course or one of variable depth was very marked The design which seemed to give the best surface was one in which the brick were laid on plain sand bedding of a uniform thickness not greatly exceeding three quarters of an inch The use of a very fine sand had proved unsatisfactory in pavements where it had been tried

The field survey showed a general tendency to use an excessive amount of asphalt filler While this condition is not directly a matter of design, it tends to cause surface roughness which has a very important effect on the behavior of the design Attention is called to the importance of using only sufficient filler to fill the

joints and to use an asphalt which is properly adapted to the climatic conditions which prevail

Cobbling or rounding of the edges of the individual brick is shown to be almost entirely due to tire chains or steel-tired traffic The amount of cobbling under chain-tired traffic was found to be directly affected by the distance between bricks, wide joints causing marked increase in the rounding of the edges It would seem, therefore, that the proper spacing between bricks would be the minimum which will allow the proper penetration of the bituminous filler

SOME PRINCIPLES INVOLVED IN BITUMINOUS MACADAM CONSTRUCTION

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In order to build a bituminous macadam road of lasting integrity and whose riding qualities will be excellent, attention must be given to each detail of construction from the bottom to the top In all cases proper drainage should be provided, while in localities where considerable frost action prevails foundations must be provided through heavy retentive soil or the integrity of the pavement will be seriously threatened It is conceded that a layer of granular material directly beneath the pavement proper serves to break up capillarity and to lessen in a great measure the detrimental effect of frost action The depth of foundation to be provided varies with the tightness of the soil encountered

Through ledge sections where water seepage may be expected it is good practice to construct a stone foundation with sub-drains at least on one side of the road and frequent taps from the stone fill into the stone or gravel filled subdrain trench Through particularly bad mucky soil a blanket course of sand or fine gravel laid directly on the subsoil will serve to hold the muck down and prevent its rising and filling the interstices of the foundation above

Considering only the integrity of the pavement and its riding quality, several factors enter into successful construction Of prime importance, of course, is the preparation of the subbase upon which the base course of crushed stone is to be placed Whether the subgrade is of natural soil or a subgrade prepared by using gravel, coarse stone or any other granular material, it should be thoroughly compacted and made hard over the entire width of the pavement and preferably for at least twelve inches outside of the pavement Any soft spots that are allowed to remain in the subbase will finally work injury to the riding qualities of the pavement