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Evaluation of polymer grid reinforced asphalt pavement from the circular test track

T.Momoi
Nippon Hodo Research Laboratory, Tokyo, Japan

H.Tsukano, M.Matsui & T.Katsu
Nippon Hodo Research and Development Division, Tokyo, Japan

ABSTRACT : The structural behavior under traffic of asphalt pavement with strong polymer grid between surface course and base course, and between base course and subgrade was compared directly with control pavement of similar construction without grid. These tests were conducted by using the large scale circular test track.
The pressence of the grid did not affect the structural quality of the road as assesed by measuring the deflection and the vertical stresses acting on subgrade and base course. However the reinforcement of the base course reduced the developement of rutting and cracking on the road surface, and it was tentatively suggested that the pavement structure including combination of the grid reinforced thin asphalt surface course and the cement stabilised base course is effective for low traffic volume road and temporary road.

1 INTRODUCTION

This paper presents some results from a research program to investigate the effectiveness of a polymer grid [Tensar AR-1 and SS2. Mitsui] in improving the bearing capacity of bituminous pavement.

Many experiments [Brown(1985), Kennepohol (1985) and Haas(1984)] suggested that the considerable improvement in performance could be obtained by the application of grid placed between base course and subgrade, and between surface course and base-course.

The present investigation has involved large scale tests conducted by using the circular test track, which has the arm of 12m and makes it possible to experiment on pavement built by using the same equipment as is used for actual pavement (see Fig-1).

This facility was completed in the field test area of Nippon Hodo located in Omiya city Saitama Pref. in Feburary 1986.

The goal of the research using this test facility is to develop the engineering records and criteria which can be used in design and construction of the grid reinforced pavement as well as the improvement and maintenance of existing pavement by applying the grid.

As the first step of the research the structural behavior under traffic of a asphalt pavement containing the grid was compared directly with control pavement of simillar construction without the grid.

During loading, measurements were periodically made for the deflection, permanent deformation and extent of cracking on the pavement surface, and the transient vertical stress in each layer of pavement structure.

Suplemental investigations were also performed on the strain measurements acting on the surface of grid and the bituminous layer, and on the excavation of the pavement.

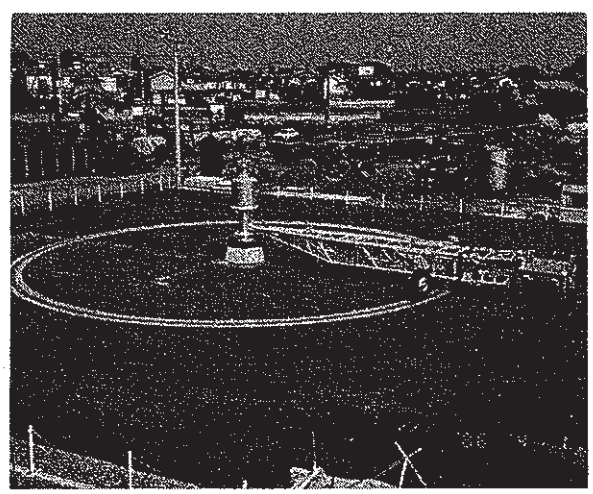

Fig-1 Circular test Track of Nippon Hodo Co., Ltd.

2 CONSTRUCTION OF THE PAVEMENT IN THE TEST AREA

The test sections were constructed in the field test area in Saitama Pref.where subgrade soil is Kantoh loam and is known to have a low bearing capacity. Kantoh loam soil of 90cm was replaced with the pit run material of CBR 40. Prior to being replaced with this material,the Kantoh loam layer within a depth of approximately 30 cm below the surface of soil after the excavation,were stabilised with lime of 10% by weight.

The surface of pit run material refered to as the level of subgrade(Fig-2). Plate bearing tests and Benkelman deflection tests were carried out on the subgarde level and the surface of stabilised soil. These test results are given in Table-1.

The layout of completed trial sections is shown in Fig-3. The bituminous sections containing the grid are numbered 2-a,2-b and 4, and the control sections 1 and 3.

The bearing capacity on the subgrade in control section 3, estimated by the deflection and K-value, was higher than the remaining sections, as shown in Table-1. Then the datum, obtained from the control section 3, was excluded from a subject of the present analysis.

The grid used was made from polypropylene.The installation of the grid at the test section 2-a and 2-b was conducted in the following process. Before the tack coat was applied to the surface of the base course, the grid(Tensar AR-1) was unrolled. The end of grid was anchored to the surface of base course by nailing through a thin metal strip.Once the roll had been in position,a tension of 130 kg/m was applied as the another end anchored.The grid was then held in position on the surface by an application of a thin layer of asphalt concrete.

Asphalt concrete of about 2cm was spread on the grid manually and compacted by a hand controlled Bomag vibrating roller to avoid movement of the grid under delivery lorries or the asphalt paver.Immediatly after the thin layer of asphalt concrete was appllied, the dense graded asphalt mix was spread by the asphalt finisher and compacted to a total thickness of 5cm including the manually laid layer by a 15 ton pneumatic tired roller followed by an 8 ton vibraing roller. However the slight degree of disturbance of grid were observed during the asphalt paving operation.

Dense graded asphalt concrete used was designed to meet for request of surface course mixture shown in "The manual for design and construction of asphalt pavement" published by Japan Road Association using granite aggregate and filler,from Kuzuh hill quarry. The aggregate grading, binder content, mixing and compaction temp erature were all within the raqges specified.

On the test section 4, the grid(Tensar SS -2) was placed on the subgrade.Immediatly

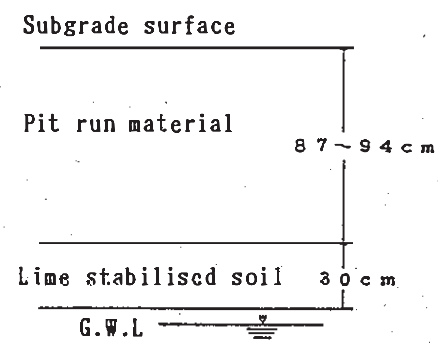

Fig-2 Soil strata in subgrade in field test area

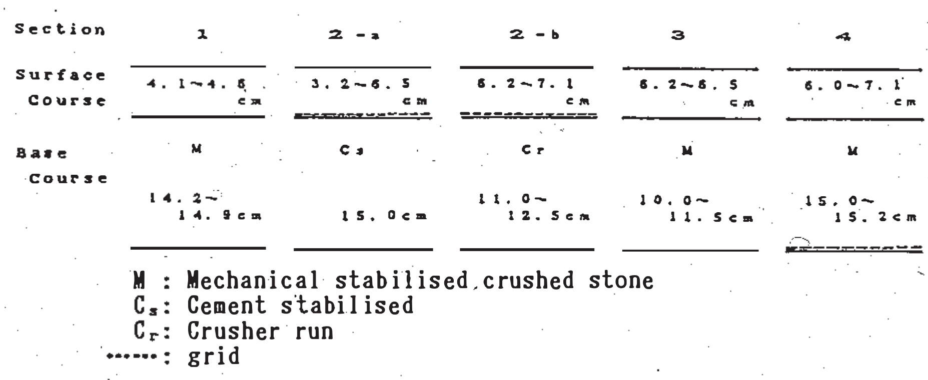

Fig-3 The layout of test section

after the grid was unrolled on the subgrade,grunular material was spread and compacted by a 15 ton pneumatic tired roller and an 8 ton vibrating roller.The cement stablised base course and the mechanically stabilised base course were mixed to the above mentioned specification .

3 NIPPON HODO CIRCULAR TEST TRACK

Nippon Hodo circular test track, which has a total weight of approximately 10500 kg,is circular. Dual tire is located at the end of special frame projecting from a center core as shown in Fig.-1. Electric motor, which is mounted on the frame, drives dual tire.The arm is 12m long and supported at its middle by a second rolling suport runing on the steel plate ring rested on the surface of pavement to prevent the weight of arm transmitting to the dual tire and to serve the dynamic stability of the arm.The parallel linkage system were designed to connect the axle of dual tire with the arm through the four tiebars and eight hinges,to keep the dual tire always perpendicular to the surface of pavement.

Both tires of dual tire were driven by electric motor mounted on the arm. Speed of 20km/hr was kept constant throughout the testing period, though this instrument has the capacity to have maximum speed of 30 km/hr and make it possible to change continuously.
The arm has the constant fixed radiaus of 12 m but an additional eccentric mechanism at the end of the assembly was provided to change the dual tire path slowly back and forth across the central wheel path.The stretching and treching movement of the arm was adjusted to constant speed of 1.3 cm/sec. Testing was continued by the number of load applications, which was approximately 200000 passes, to attain until the rate of cracking of 60 % in the test section 1.As this facility was operated only in the day time excluding the rainy or snowy days,testing was initiated in February 1986 and finished in January 1988.

4 INSTRUMENTATION AND FIELD MEASUREMENT

During construction, pressure gages to measure the vertical stress were installed in the subgrade and near the surface of basecourse.Thermocouples were also installed in the middle point of the surface layer. After construction,the holes of diameter of 15 cm were made in the surface course and or the base course by using coreboring machine to expose the surface of grid,then the strain gages were set on to the surface of the transverse and longitudinal members of the grid.Mesurements by using these gages were conducted periodically or after every 100000 passes.

In additon to the testing above,measurements of test track performance were conducted.Surface deflection were determined by using the Benkelmann beam.Rut depth was mesured by profilometer. Surface cracking was surveyed visually and mapped.

5 OBSERVATION OF PERFORMANCE

5.1 Permanent deformation and cracking

Fig-4,5 and 6 show the transverse surface profile of test section,the transverse distribution of dual tire versus mean radius of gyration and the cross section of the rut depth in section 1,respectively.

These figures show that the greater part of the deformation were resulted from

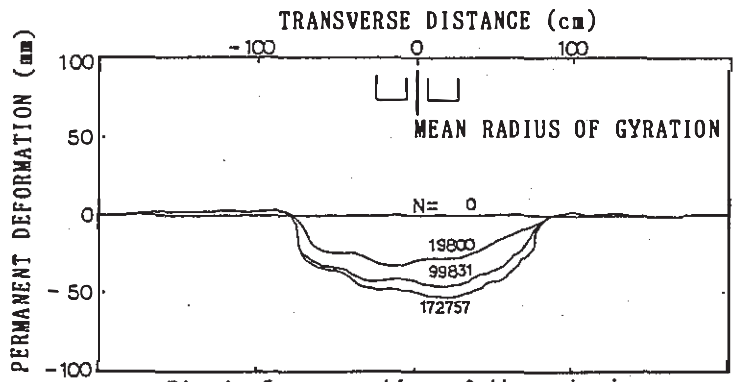

Fig-4 Cross section of the ruts in section 1

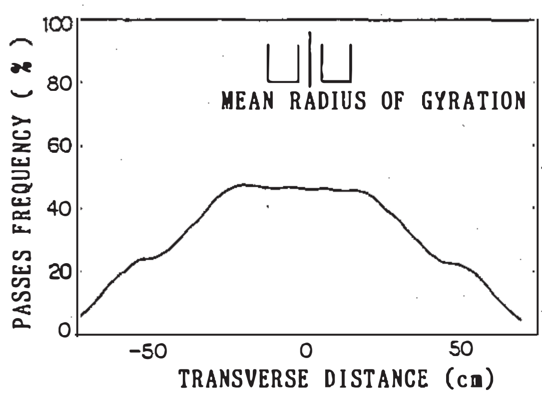

Fig-5 Transverse distribution of wheel loads versus mean radius of gyration

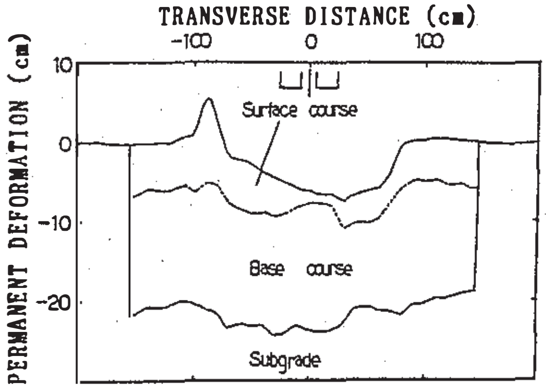

Fig-6 Cross section of pavement structure after number of two wheel passes 180000

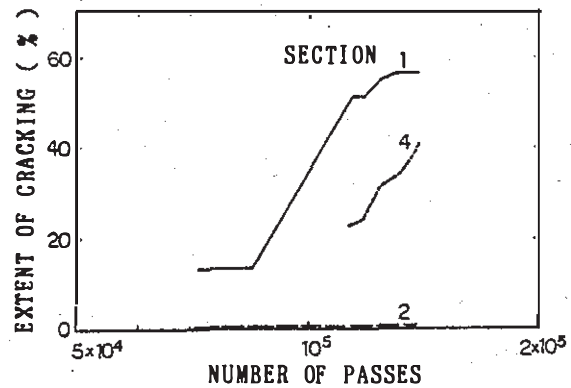

Fig-8 Variation of extent of cracking versus number of passes

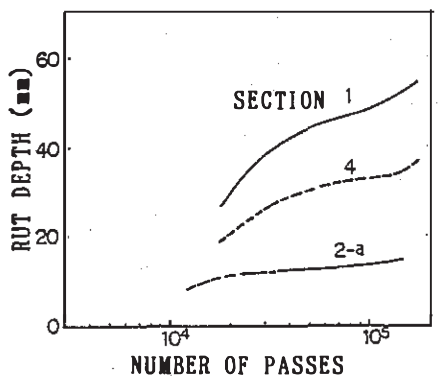

Fig-7 Measured rut depth versus number of pasess

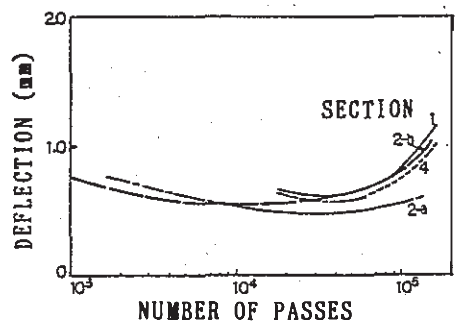

Fig-9 Benkelmann beam deflections

unbound layers and in particular from the subgrade. A very small part of deformation was resulted from the asphaltic mix and this deformation was remarkable in the position of greatest frequency of passes of dual tire.

Fig-7 shows the relation between the number of load applications and the rut depth. The developement of rut depth in test section 4 of which base course was reinforced by grid, was less than that of in the control section.

The relationship between the number of load applications and the surface cracking (Fig-8) shows that pressence of grid also reduced the extent of cracking on the pavement containing the unbound base course.

In the case of test section 2-a, the development of rut depth and craking was very slow. However as the section 2-a has the surface course under which was reinforced by the grid, and the cemented stabilized base course, it is not clear that these results were depended on installation of the grid or not.

5.2 Deflection

The effect of the grid on the deflection beneath a rolling wheel load was assesed by comparing deflections measured at 3-5 reference positions in each section. As noted above, considering that the test section 2-a has the cement stabilized base course, it should be concluded from Fig-9 that the deflection was not influenced by the presence of grid. Radius of curveture, which was estimsted from the deflection curve, was unchanged by the grid.

5.3 Transient stress and strain

Fig-10 shows the transverse distribution of the vertical stress in the control section 1 and the test section 4. Vertical stress acting on subgrade concentrated upon the center of wheel path and

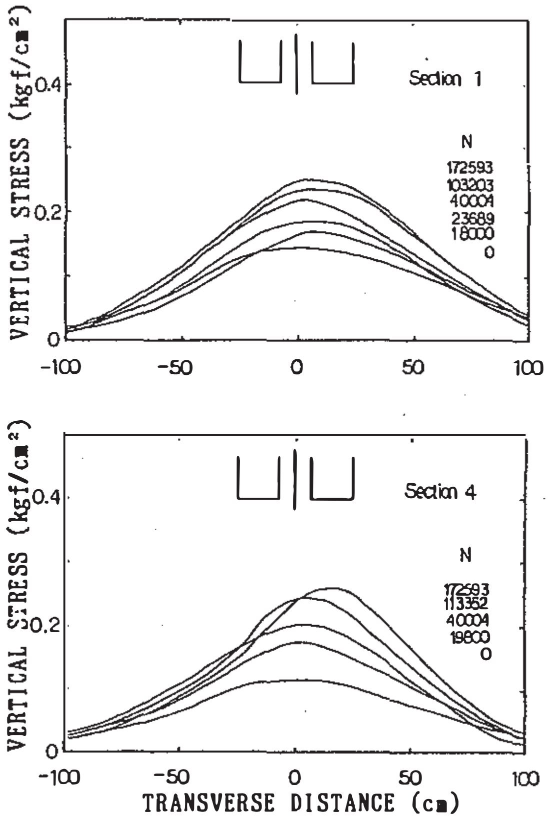

Fig-10 Variation of transient vertical stress acting on the subgrade

increased as the number of load application is increases, however stress level was unchanged.

The magnitude of the transient strain in the members of grid which were installed on the surface of base course and subgrade were very high and were influenced on each tire of dual tire.

6 COMPARISON WITH OBSERVATION

Many researches regarding to laboratory experiments using full-scall model pavement structures have shown that reinforcement of base layer and asphalt layer improve the deformation resistance of the pavement and dramatically extend the service life of the road. The effectiveness of the reinforcement increase is as the subgrade strength decreases.

The position of reinforcement is a significant variable and the existence of the optimum location is suggested. Furthermore reinforcement of the base layer is effective in distributing the load and reducing the stress levels acting on the subgrade.

Present tests confirmed the observation that the grid placed between base course and subgrade surely improved the performance of pavement assessed by measuring the developement of rutting and cracking. However the deflection on the road surface and the stress acting on the subgrade was not affected by the grid.

These results may be explained by considering that the strength of subgrade, on which reinforced pavement was constructed, was too high and the thickness of the surface course was too thin.

Furthermore considering that the deflection on road surface and the stress level acting on the subgrade are unchanged, though the performance of road are improved, it has been tentatively suggested that the effect of grid is not to delay in appearing of initial failure of pavement such as rutting and cracking, but to extend the period between initial failure and complete deterioration of pavement.

The service life of pavement structure of the section 2-a containing the reinforced surface course on the cement stabilised base course is very long and this structure withstands the traffic load by circular test track (N= 300000) and is still in good condition like initial condition while the remaining test sections were soon required the overlay of asphalt concrete of 5cm with the grid.

7 CONCLUSION

The structural behavior of a bituminous road of thin asphalt surface course including granular base course with a strong grid placed on the subgrade and including cement stabilised bace course with a grid under the surface course have been investigated by using the circular test track. The following conclusion may be drawn.

1. The presence of the grid was surely effective for the reduction of permanent deformation and the craking on the pavement surface.

2. The structural quality of the road as assesed by mesuring the deflection of pavement beneath a rolling wheel load and the transient stress acting on subgrade was unaffected by the presence of the grid.

3. The service life of pavement including of grid reinforced thin asphalt layer on the cement stabilised base course can be extended significantly. It is tentatively suggested that this pavement structure is effective for the low traffic volume road and temporary road.

Table-1 Bearing capacity on base and subgrade and dry density of base course in test area

	section No.	1	2	3	4
Bearing capacity K-value (Kgf/cm^3)	On surface of :				
	base course	39	34	49	35
	subgrade	12	13	18	15
	lime stabilised soil	5	3	4	6
Deflection (mm)	On the surface of :				
	base course	0.35	0.47	0.28	0.35
	subgrade	0.70	0.63	0.64	0.60
Dry density (gf/cm^3)	base course	2.209 ～2.199	2.000 ～2.075	2.207 ～2.19	2.209 ～2.199
Degree of compaction (%)	base course	95～96	94～96	96～97	95～97

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