Geosynthetics - 7th ICG - Delmas, Gourc & Girard (eds) © 2002 Swets & Zeitlinger, Lisse ISBN 90 5809 523 1

Research on the mechanical performance of the asphalt concrete reinforced with geosynthetics

Z. GUO, Y. HUANG & C. CHEN, Tongji University, Shanghai, China

Abstract: Reflective crack occurred inside the overlayers over existing cement concrete pavement or the asphalt layer of composite pavements with semi-rigid bases is still a key problem concerned by pavement engineers. The reinforced asphalt concrete with geosynthetics and the mechanical performance were studied in this paper with slab testing.

1 THE TEST DESIGN

1.1 *Determination of the subgrade resilient modulus*

Based on the test method of ASTM 1195, the equivalent resilient modulus at the surface of the subgrade inside the pavement test facility of Tongji University was measured. The resilient modulus at the original subgrade is 68Mpa. A capping layer with the thickness of 50mm was paved over the subgrade. The measured resilient modulus at the surface of capping layer is 42Mpa.

1.2 *The test slab of cement concrete*

Considering the real size of cement concrete pavement slabs and the pavement test facility, the test slabs of cement concrete are 1.5m in length and 1.2m in width. Three slabs were constructed as show in Figure 1. The horizontal joint with the width of 10mm was settled between each two slabs. The thickness of the test slabs was designed to be 150mm by considering two aspects of factors as follows:

(1) The deflection at the joint of test slabs under test loading could simulate that of the real pavement.
(2) The test slabs should not have rigid movement under test loadings.

1.3 *Asphalt layer*

The asphalt layer was paved twice. One at the second time was paved after completing the first time test and removing the asphalt layer paved at first time.

1.4 *Strain measurement elements*

Strain gauges were used to measure the strain at the bottom of the reinforced asphalt layer. The strain gainages were settled as show in Figure 1.

2 THE TEST PAVEMENT CONSTRUCTION

The test pavement construction was constructed according to in-site construction requirement and technology.

2.1 *Cement concrete*

The used cement concrete composition has CEMENT:SAND: STONE:WATER=400:600:1282:168, and the ration of water to cement is 0.42. The concrete was mixed with hand and then paved and compacted with vibrating bar and plate. The compressive strength of the concrete after curing 28days is 35.7Mpa, flexural strength, 4.99MPa and the corresponding flexural modules is 374000Mpa.

2.2 *The geo-synthetics*

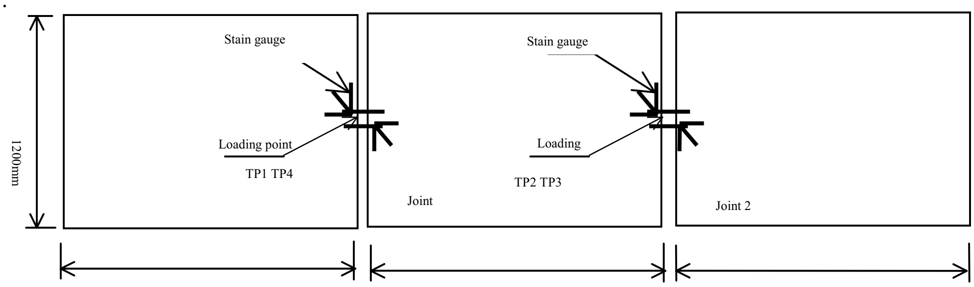
Both geo-textile and glass grid were used as the reinforcement materials. When the textile was placed, the tack coat of 2L/m^2 was used , which is emulsion asphalt with the asphalt content of 63.5%.

2.3 *Asphalt mixture*

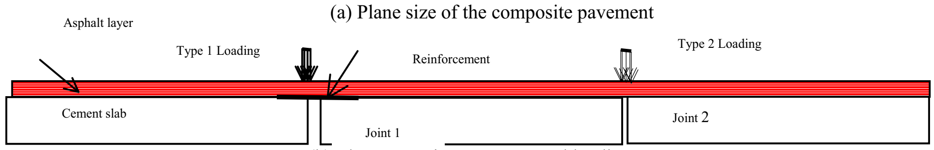
The asphalt mixtures named as AK-13A used in this test were taken directly from the mix plant. The Marshell stability is 7.5KN and void content is 6.1%, VMA is 17.94.

3 TEST

The performance of the composite pavement and the reinforced asphalt layer under static and dynamic loading were carried out at the temperature of 20±2ºC.



(a) Plane size of the composite pavement



(b) The composite pavement and loading type

Figure 1. The test pavement and loading type

3.1 *Test under static loading*

The deflection and the deflection difference between loaded and unloaded slabs were measured under two levels of loading of type II(as showed in Fig.1(b)) respectively (1) before asphalt concrete was paved at first time; (2) after the asphalt concrete was removed when completing first time test but before the asphalt concrete was paved at second times and (3) after the asphalt concrete paved at second time was removed.

After asphalt concrete was paved each time, the deflection at the top and the strain at the bottom of asphalt layer was also measured under two levels of loading of type 1 and 2.

3.2 *Test under dynamic loading*

The dynamic loading of type 2 applied at the top surface of the composite pavement is 15KN with the frequency of 4Hz and the contact stress of 0.5Mpa. During the test, the deflection at both sides of the joint, strain at the bottom of reinforced asphalt layer was measured.

4 ANALYSIS OF THE TEST RESULTS

4.1 *Test results under static loading*

(1) The deflection and deflection difference between the slabs under loading at the edge of cement concrete slabs and without loading before paving asphalt concrete are showed in Table 1. The measured deflection under the loading of first time indicates that the bearing capacity of cement concrete slab at joint 1 and joint 2 is little different. Compared with the deflection (in the brackets of table 1) calculated using Westgard, the measured deflection is small. The deflection difference δ that affect the life of asphalt concrete considering its resistance to reflective cracks at joint 1 and joint 2 is similar to each other and so comparative.

(2) After paving asphalt layer, the measured deflection data is showed in Table 2 and 3. the deflection and deflection difference at both joints were reduced after paving asphalt concrete layer to a certain content. The deflection at TP2 was reduced comparatively to a great extent. That indicates that the reinforced asphalt concrete with geo-glass grid can play a certain action of loading transfer and is more strengthen. The data about the measured strain at the bottom of asphalt concrete under the loading of Type 2 shows that there exists tensile strain in both direction X and Y for the slab with loading, compressive strain in X direction and tensile strain in Y direction for the slab without loading. The measured stain just over the joint in the direction of Y does not give a good regulation. The strain in both X and Y direction under the loading of Type 1 are tensile strain. Because there exists tensile strain at the bottom of asphalt layer as indicated by the test results, geo-synthetics can play the function of reinforcement to asphalt concrete.

4.2 *Test results under dynamic loading*

4.2.1 *The correlation between deflection and loading cycles*

Table 1. deflection and deflection difference of the slabs under the loading of type 2

Parameters	Before asphalt overlayer Paved first time				After removing asphalt layer paved firs time and before that paved second time				After removing asphalt layer paved second time			
	Joint 1		Joint 2		Joint 1		Joint 2		Joint 1		Joint 2	
	15K N	22K N	15K N	22K N	15K N	22K N	15K N	22K N	15K N	22K N	15K N	22 KN
Deflection (mm)	0.39 (1.04)	0.64 (1.5 3)	0. 36	0. 56	0. 83	1. 02	0. 76	1. 05	0. 57	0. 84	0.7 3	0 .97
Deflection difference (mm)	0 .25	0.41	0. 22	0. 38	0. 74	0. 88	0. 7	0. 91	0. 45	0. 67	0.6 4	0 .83

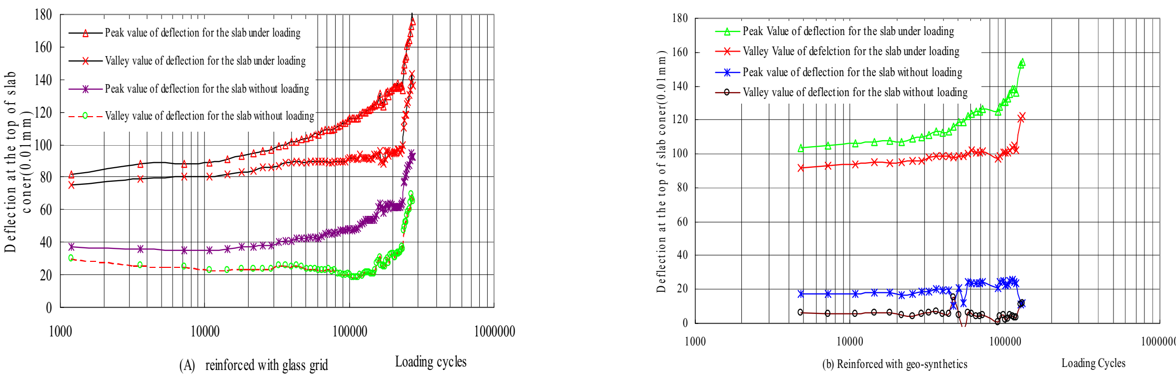


Figure 2. The correlation between deflection and loading cycles

The correlation between the measured deflection and loading cycles is showed in Fig 2. It can be seen that the deflection increases with loading cycles. The stiffness of asphalt layer, subgrade and interface are weakened under repeated loading. Therefore, the test results accord with the rule of fatigue test with stress control. The test results also indicate that there is no much difference among the deflection-loading cycle correlation of the composite pavement being reinforced with different geo-textiles and glass grid. That implies that glass-grid and geo-textile cannot improve the bearing capacity of the whole composite pavement constructions.

4.2.2 *The tensile strain at the bottom of asphalt layer*
The test results about the tensile strain at the bottom of asphalt layer under dynamic loading are not very good. It is difficult to make conclusion about the correlation between the strain and loading cycles.

4.2.3 *Fatigue life*
It is defined as failure that the crack propagates up to the asphalt layer top surface. The fatigue life of the asphalt layer to reflective cracks is showed in table 4. It can be seen that being reinforced with glass grid can significantly increase the fatigue life to resistance to reflective cracks.

5 CONCLUSIONS

(1) The strain along the joint direction at the bottom of asphalt layer over both slabs under static loading of type 2 and without loading is tensile. But the strain for the slab under the same loading in the direction crossing to the horizontal joint is tensile and that for the slab without loading is compressive. The strain at the bottom of asphalt layer in all direction for both slabs under static loading of Type 1 is tensile.

Table 2 Test results under dynamic loading of Type 2

Parameters		TP1		TP2		TP3		TP4	
		15KN	22KN	15KN	22KN	15KN	22KN	15KN	22KN
Deflection (mm)		0.63	0.95	0.59	0.9	0.64	0.86	0.52	0.68
Deflection difference (mm)		0.21	0.35	0.15	0.27	0.39	0.54	0.17	0.27
Strain for the slab under loading (με)	X direction	498.8	602.4	922.4	1274.7	-	-	181.4	265.6
	Y direction	187.8	142.5	704.7	798	-	-	-58.3	-155.5
	Shear	1114.1	1871.9	31.1	352.4	-	-	84.2	-19.4
Strain for the slab without loading (με)	X Direction	456	673.6	187.8	323.9	28.5	608.9	-570	-621.8
	Y Direction	-269.5	-497.5	-900.4	-1295.4	-272	-233.2	-82.9	-82.9
	Shear	-310.9	-383.5	-26	-13	127	-401.6	735.8	974.2
Strain across joint(με)		-254.5	-328.7	349.8	466.4	-	-	-159	-233.2

Table 3 Test results under dynamic loading of type 1

Parameters		TP1		TP2		TP3		TP4	
		15KN	22KN	15KN	22KN	15KN	22KN	15KN	22KN
Deflection (mm)		0.57	0.87	0.51	0.77	0.52	0.72	0.47	0.72
Strain (με)	X direction	801.2	1153	576.5	1009.8	1787.7*	2487.3*	212.5	358.8
	Y direction	1792.9	2464	1732.7	2810.5	116.6*	298*	358.8	505.9
	Shear	553.8	1002.7	-613.4	-856.3	-1230.7*	-1710*	-19.4	-73.2
Strain across joint (με)		1463.4	2089	4568.6	7377.6	-	-	95.4	53

*Strains in both table 3 and 4 are that at the bottom of asphalt overlayers. X direction is that parallel to horizontal joint.

Table 4 The fatigue life of asphalt layer

Test	Reinforcement	Static loading of Type 2 (15KN)		Dynamic loading of Type 1 (15KN,3600cycles)		Fatigue Life (×1000)
		Deflection for slab under loading (mm)	Deflection difference (mm)	Deflection for slab under loading (mm)	Deflection difference (mm)	
TP1	No	0.63	0.21	0.86-0.71	0.56	165.6
TP2	Glass-grid	0.59	0.15	0.67-0.59	0.29	273.6
TP3	Geotextile	0.64	0.39	1.36-1.188	0.78-0.51	129.6
TP4	No	0.52	0.17	0.87-0.78	0.78	161.2

(1) The strain at the bottom of asphalt layer in all direction for both slabs under dynamic loading of Type II is tensile. But the results do not give good relationship.

(2) The deflection at the surface for the slab under dynamic loading of type II increase with loading cycles and increase rapidly after cracking occurs. The deflection for the slab without loading increase slowly before cracks occur and then does rapidly after crack occurs. The reinforcement with glass grid can improve significantly the resistance of asphalt overlayer to reflective cracks.

(3) The deflection and deflection difference can be reduced where the asphalt layer is reinforced with glass grid.

6 REFERENCES

Geosynthetics design and construction guidelines participant notebook, Publication No. FHWA HI-95-038, May, 1995.

C. L. Monismith and N. F. Coetiee, reflection cracking: analysis, laboratory studies, and design considerations, AAPT,1980.