STRESS DISTRIBUTION UNDER CONCRETE BLOCKS

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Summary

In Japan, we design the concrete block pavement according to the asphalt pavement design method. As both of the pavements are classified as flexible pavements, it must be reasonable. But the function of the concrete blocks is a little different from the ordinary asphalt pavement surface. It is important to make the behavior of the concrete block pavement clear. This study tries to measure the stress distribution under concrete blocks experimentally, and to contribute to establishing the concrete block pavement design method.

1. Introduction

In Japan, the concrete block pavements were used for pedestrian pavements at first, but they have been in wide use for carriageways recently. The design method is based on the manual for design and construction of asphalt pavement in our country[1]. But, as shown in Fig. 1, when one block is subjected to a load, rigid displacement must occur, and the block receives reaction at the lower face and the side face[2].

When concrete blocks are used as a pavement surface, the movement of each block is restricted. But some rigid displacement and elastic deformation occur corresponding to the external force. The two dimensional stress distribution in concrete blocks were shown by the photo elastic experiment[3]. This is characteristic of the concrete block pavements, and is different from other pavement forms that have a continuous surface layer. Accordingly, the stress distribution under concrete blocks is

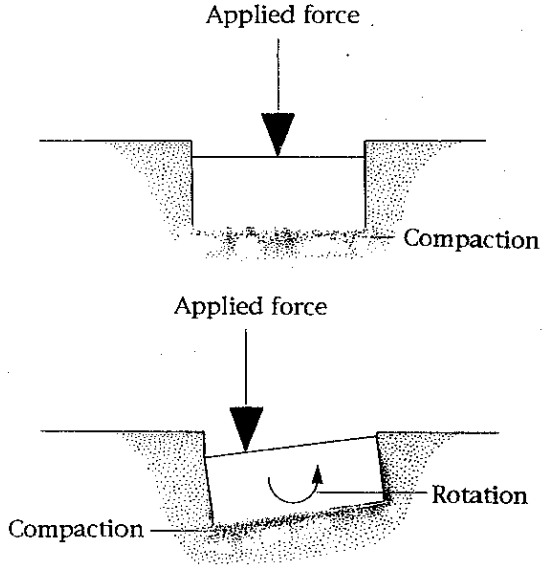


Fig.1 Rigid displacement of a concrete block

greatly affected by behavior of each block. So far, it has been impossible to show such stress. To bury some sensors in subbase means to change the mechanical values of the pavement structure. Moreover, only a few values of points are obtained by those sensors.

In this study the stresses under concrete blocks were measured continuously without changing the characteristic of the pavement structure by using the reactive paper. And, the result was compared with the value of asphalt pavements.

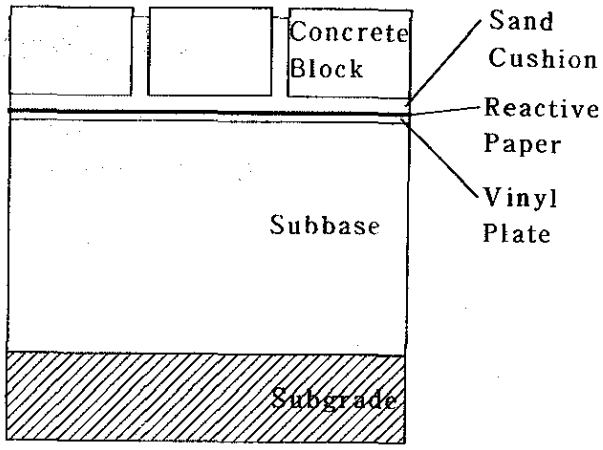


Fig.2 Block pavement structure

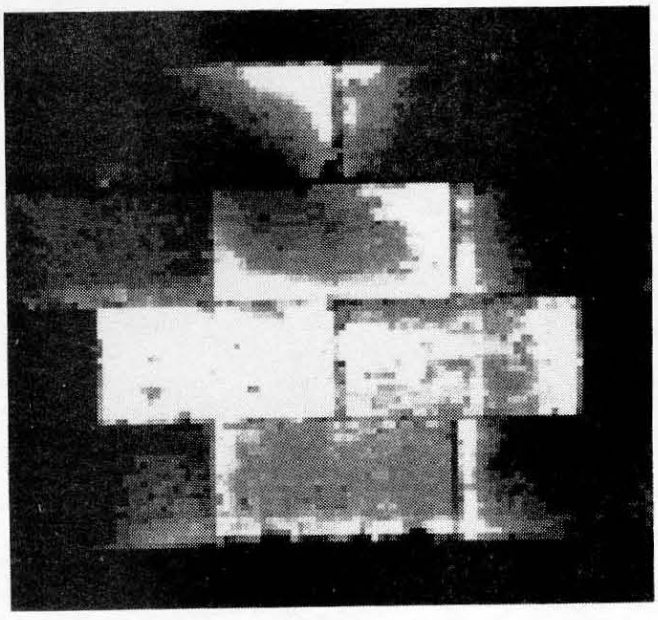
2. Experiment

Fig.2 shows the block pavement structure used for experiments. The experiment was carried out in an indoor pit. The area of concrete block pavement was 200cm*200 cm. The pavement structure was composed of concrete block layer, sand cushion layer and subbase. Reactive paper was inserted between the sand cushion layer and the subbase. The size of the reactive paper was 50cm*50 cm.

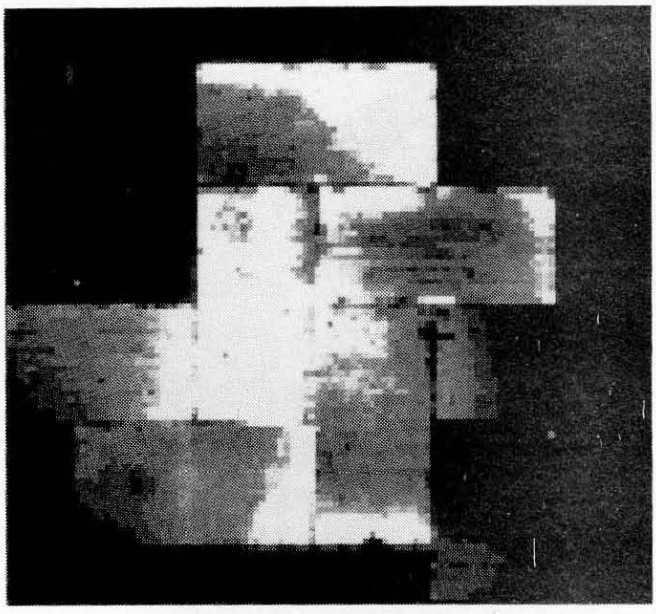
A thin vinyl chloride plate was placed under the reactive paper to get rid of the influence of the uneven subbase surface. The concrete block patterns were stretcher bond and herringbone bond, and the block shapes were plain straight type(rectangular shape) and top type (shaped type). An 8tf and circular load was used in this experiment. This load value was little bigger than that used for asphalt pavement design usually (5tf). Here, a little bigger load was used to know the stress condition widely.

3. Experiment results and consideration

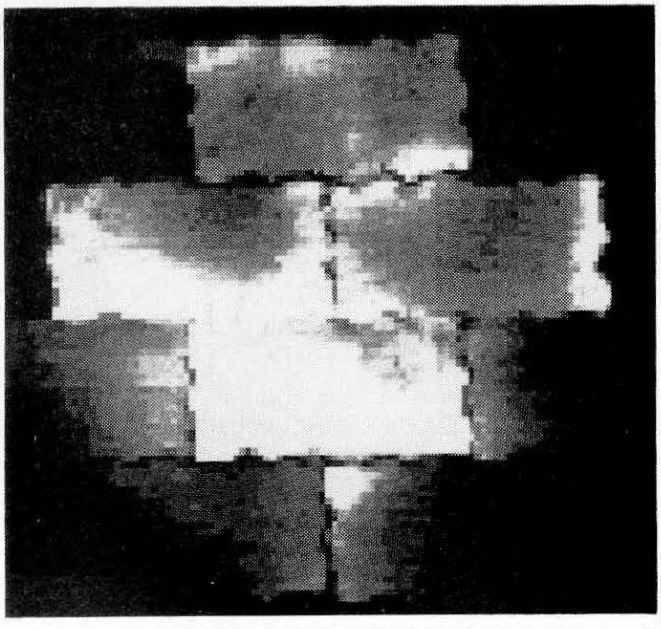
The stress value was shown as a value of 5 mm *5 mm. Accordingly, about 200*400 stress values were obtained for each block. The distribution of all these stresses is expressed in Fig.3 as computer graphics. What the abbreviation of this figure means is as follows:



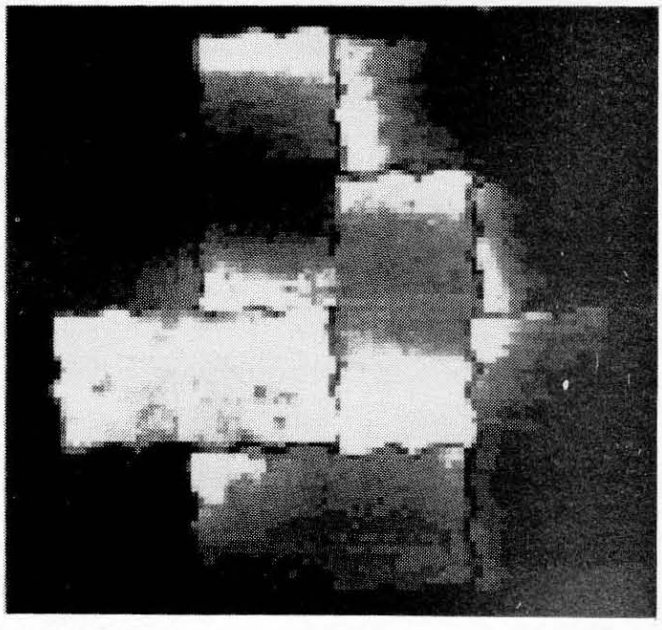
(1)SS



(2)SH



(3)TS



(4)TH

SS:straight block+stretcher bond

SH:straight block+herringbone bond

TS:top type+stretcher bond

TH:top type+herringbone bond.

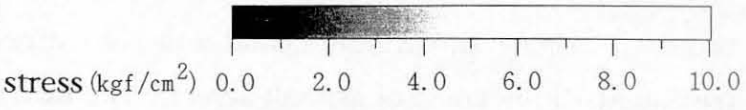
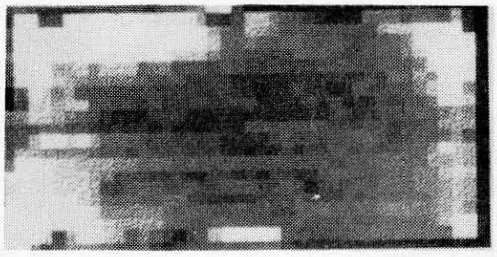


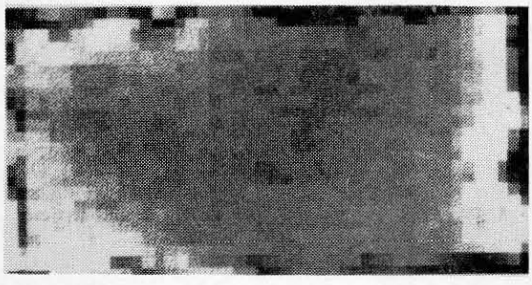
Fig.3 Stress distribution under concrete blocks

Each stress distribution of the block shape and the laying block type is shown. The behavior of each concrete block, which is shown at Fig.1, appears. And, a few stresses bigger than a certain level are seen at remote points from the loading point, and the places are along the contact lines of blocks. Fig.5 shows the enlarged stress distribution of typical blocks. The square dot indicates a 5mm*5mm area. It can be seen that the stresses changes continuously in each block.

Next, let's convert the stresses into a load. Table 1 shows the total value added up about measured points in 50cm*50 cm area. The configuration and the number of each block are shown too. From these results, the combination of top type and herringbone bond provides the most stable surface.



(1)Straight



(2)Top type

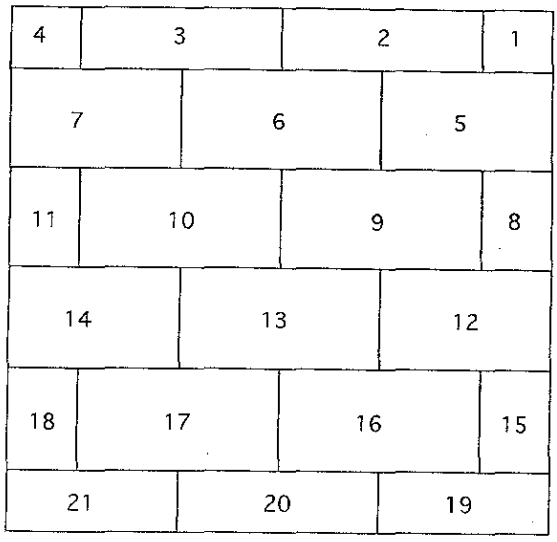
Fig.4 Enlarged stress distribution

Although some difference has been seen for the block shapes and spreading patterns, the load values of this area become around 70 percent on comparing with the applied load.

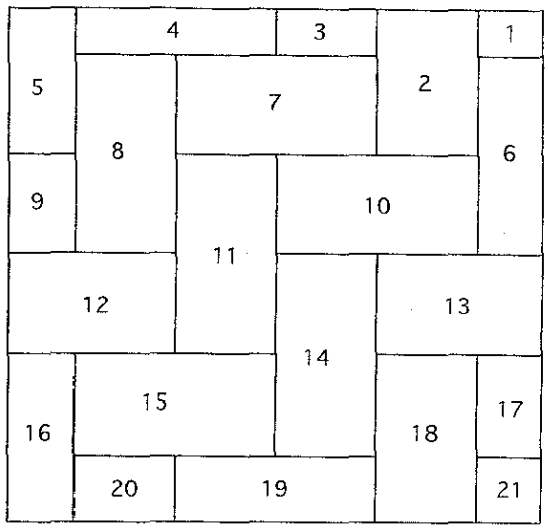
Stress analysis by multi layer structure theory was made to compare this value with that of the asphalt pavement. Elastic layer structure analyzing program (ELSA) is used to analyze the asphalt pavement structure.

The parameters taken into consideration are layer depth, Young modulus and Poisson's ratio. Fig.6 shows the condition of stress distribution for some asphalt pavements(h:thickness of asphalt layer). The load values of the same area as concrete block pavement are expressed in Table 2. When load distributive function is the same, asphalt pavement can be made thinner than concrete block pavement. In other words, high stress concentration of the concrete block pavement is observed near the loading point.

Table 1 Calculation for total load



(1)SS



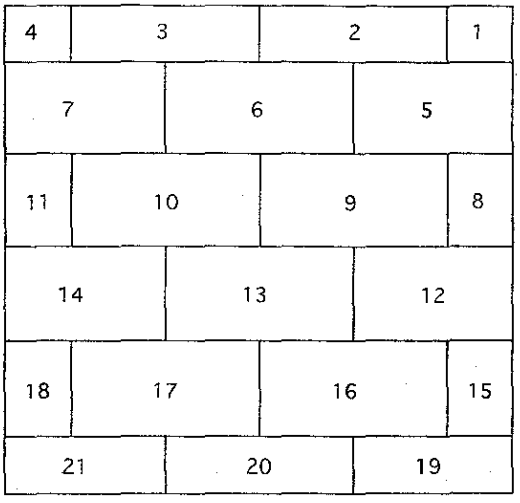
(2)SH

stress/4	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No.20	No.21	Total
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	0.575	2.375	3.225	1.150	5.425	1.025	0.975	0.475	0.050	0.125	1.200	0.225	0.000	0.175	1.050	0.275	1.050	1.025	3.675	6.450	1.000	31.525
0.075	1.125	3.225	6.900	1.575	6.375	1.725	12.525	5.025	0.450	1.350	2.775	0.075	0.075	12.750	4.500	0.375	4.500	3.675	0.450	1.125	0.600	71.175
0.125	0.250	11.625	5.125	0.500	10.875	15.875	7.625	15.250	3.875	3.750	1.875	0.375	0.875	10.750	9.500	2.125	14.375	1.625	0.000	0.250	0.375	116.875
0.175	0.000	7.175	0.175	0.700	8.400	28.000	1.400	26.950	2.975	7.525	0.000	1.050	1.750	1.400	16.275	1.575	16.800	0.175	0.000	0.350	0.000	122.675
0.250	0.000	1.750	0.000	0.000	18.000	33.250	0.000	25.750	3.750	56.750	0.000	2.000	1.250	0.750	38.250	7.500	37.750	0.000	0.000	0.250	0.000	227.000
0.375	0.000	0.000	0.000	0.000	15.000	33.375	0.000	14.250	31.125	100.500	0.000	6.375	4.875	1.125	26.625	5.250	39.750	0.000	0.000	0.375	0.000	278.625
0.500	0.000	0.000	0.000	0.000	22.500	18.000	0.000	15.000	50.000	16.500	0.000	8.000	7.500	0.500	16.500	13.500	21.500	0.000	0.000	0.000	0.000	189.500
0.625	0.000	0.000	0.000	0.000	15.625	22.500	0.000	14.375	51.250	13.750	0.000	30.625	12.500	1.250	13.750	46.250	8.125	0.000	0.000	0.000	0.000	230.000
0.750	0.000	0.000	0.000	0.000	18.750	19.500	0.000	13.500	58.500	5.250	0.000	43.500	15.000	0.000	10.500	156.750	6.750	0.000	0.000	0.000	0.000	348.000
0.875	0.000	0.000	0.000	0.000	15.750	14.000	0.000	9.625	47.250	1.750	0.000	66.500	15.750	0.000	12.250	150.500	7.875	0.000	0.000	0.000	0.000	341.250
1.000	0.000	0.000	0.000	0.000	9.000	17.000	0.000	16.000	33.000	4.000	0.000	101.000	22.000	0.000	7.000	91.000	4.000	0.000	0.000	0.000	0.000	304.000
1.125	0.000	0.000	0.000	0.000	1.125	4.500	0.000	5.625	30.375	1.125	0.000	70.875	18.000	0.000	6.750	45.000	0.000	0.000	0.000	0.000	0.000	183.375
1.250	0.000	0.000	0.000	0.000	6.250	8.750	0.000	6.250	48.750	0.000	0.000	125.000	27.500	0.000	11.250	56.250	0.000	0.000	0.000	0.000	0.000	290.000
1.500	0.000	0.000	0.000	0.000	10.500	16.500	0.000	9.000	99.000	0.000	0.000	130.500	88.500	0.000	24.000	57.000	0.000	0.000	0.000	0.000	0.000	435.000
1.750	0.000	0.000	0.000	0.000	8.750	14.000	0.000	14.000	89.250	0.000	0.000	92.750	253.750	0.000	17.500	17.500	0.000	0.000	0.000	0.000	0.000	507.500
2.000	0.000	0.000	0.000	0.000	2.000	18.000	0.000	8.000	46.000	0.000	0.000	82.000	248.000	0.000	10.000	8.000	0.000	0.000	0.000	0.000	0.000	420.000
2.250	0.000	0.000	0.000	0.000	0.000	22.500	0.000	4.500	63.000	0.000	0.000	42.750	218.250	0.000	2.250	0.000	0.000	0.000	0.000	0.000	0.000	353.250
2.500	0.000	0.000	0.000	0.000	7.500	97.500	0.000	10.000	162.500	0.000	0.000	210.000	515.000	0.000	7.500	0.000	0.000	0.000	0.000	0.000	0.000	1010.000
Total (kgf)	1.950	26.150	15.425	3.925	181.825	386.000	22.525	211.575	821.100	212.375	5.850	1013.600	1450.575	28.700	235.450	658.850	162.475	6.500	4.125	8.800	1.975	5459.750
(%)	0.04	0.48	0.28	0.07	3.33	7.07	0.41	3.88	15.04	3.89	0.11	18.56	26.57	0.53	4.31	12.07	2.98	0.12	0.08	0.16	0.04	100.00

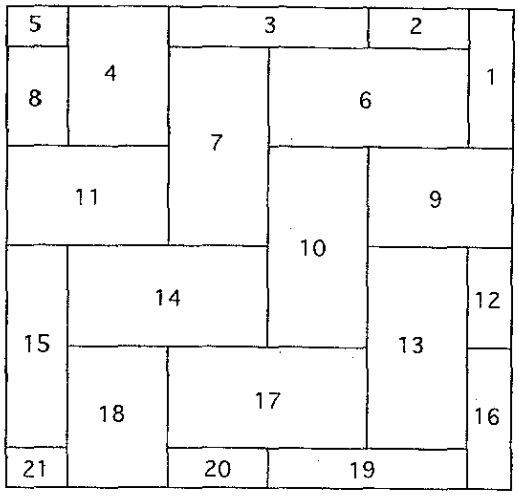
(1)SS

stress/4	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No.20	No.21	Total
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	0.875	2.900	1.550	2.975	4.675	4.825	0.550	4.000	3.150	0.025	0.025	0.025	0.300	0.125	0.000	5.100	3.825	0.575	2.850	0.150	1.600	40.100
0.075	0.525	22.200	2.475	5.100	2.100	6.300	0.750	8.100	4.125	0.750	0.075	0.375	8.475	0.300	0.300	5.100	5.400	1.350	6.900	1.650	3.825	86.175
0.125	0.000	16.125	3.500	13.250	0.000	7.750	1.375	9.750	0.375	1.875	0.125	1.250	30.125	0.875	3.125	0.000	0.000	4.250	9.125	14.500	0.000	117.375
0.175	0.000	4.375	0.000	5.075	0.000	5.950	1.050	7.000	0.000	1.575	2.450	2.450	23.450	1.750	4.375	0.000	0.000	46.725	5.250	5.950	0.000	117.425
0.250	0.000	1.000	0.000	0.000	0.000	3.250	5.250	4.000	0.000	4.000	3.500	10.500	15.750	5.500	14.000	0.000	0.000	38.000	0.500	0.000	0.000	105.250
0.375	0.000	0.000	0.000	0.000	0.000	1.125	26.250	1.125	0.000	28.875	4.500	30.375	20.625	13.500	38.625	0.000	0.000	28.500	0.750	0.000	0.000	194.250
0.500	0.000	0.000	0.000	0.000	0.000	0.000	21.000	0.000	0.000	56.500	3.000	27.500	9.500	19.000	38.000	0.000	0.000	0.000	1.000	0.000	0.000	175.500
0.625	0.000	0.000	0.000	0.000	0.000	0.000	36.875	0.000	0.000	75.000	5.000	60.000	18.750	72.500	74.375	0.000	0.000	0.000	0.000	0.000	0.000	342.500
0.750	0.000	0.000	0.000	0.000	0.000	0.000	52.500	0.750	0.000	67.500	16.500	56.250	21.000	122.250	78.750	0.000	0.000	0.750	0.000	0.000	0.000	416.250
0.875	0.000	0.000	0.000	0.000	0.000	0.000	43.750	0.000	0.000	57.750	17.500	42.000	19.250	73.500	87.500	0.000	0.000	0.000	0.000	0.000	0.000	341.250
1.000	0.000	0.000	0.000	0.000	0.000	0.000	39.000	0.000	0.000	51.000	34.000	53.000	3.000	93.000	42.000	0.000	0.000	0.000	0.000	0.000	0.000	315.000
1.125	0.000	0.000	0.000	0.000	0.000	0.000	16.875	0.000	0.000	47.250	29.250	27.000	0.000	49.500	14.625	0.000	0.000	0.000	0.000	0.000	0.000	184.500
1.250	0.000	0.000	0.000	0.000	0.000	0.000	28.750	0.000	0.000	60.000	52.500	15.000	0.000	62.500	21.250	0.000	0.000	0.000	0.000	0.000	0.000	240.000
1.500	0.000	0.000	0.000	0.000	0.000	0.000	49.500	0.000	0.000	75.000	118.500	25.500	0.000	81.000	46.500	0.000	0.000	0.000	0.000	0.000	0.000	396.000
1.750	0.000	0.000	0.000	0.000	0.000	0.000	108.500	0.000	0.000	66.500	154.000	24.500	0.000	47.250	35.000	0.000	0.000	0.000	0.000	0.000	0.000	435.750
2.000	0.000	0.000	0.000	0.000	0.000	0.000	104.000	0.000	0.000	38.000	140.000	34.000	0.000	28.000	24.000	0.000	0.000	0.000	0.000	0.000	0.000	368.000
2.250	0.000	0.000	0.000	0.000	0.000	0.000	87.750	0.000	0.000	29.250	105.750	6.750	0.000	27.000	11.250	0.000	0.000	0.000	0.000	0.000	0.000	267.750
2.500	0.000	0.000	0.000	0.000	0.000	0.000	437.500	0.000	0.000	52.500	787.500	82.500	0.000	52.500	117.500	0.000	0.000	0.000	0.000	0.000	0.000	1530.000
Total (kgf)	1.400	46.600	7.525	26.400	6.775	29.200	1061.225	34.725	7.650	713.350	1474.175	498.975	170.225	750.050	651.175	10.200	9.225	120.150	26.375	22.250	5.425	5673.075
(%)	0.02	0.82	0.13	0.47	0.12	0.51	18.71	0.61	0.13	12.57	25.99	8.80	3.00	13.22	11.48	0.18	0.16	2.12	0.46	0.39	0.10	100.00

(2)SH



(3)TS



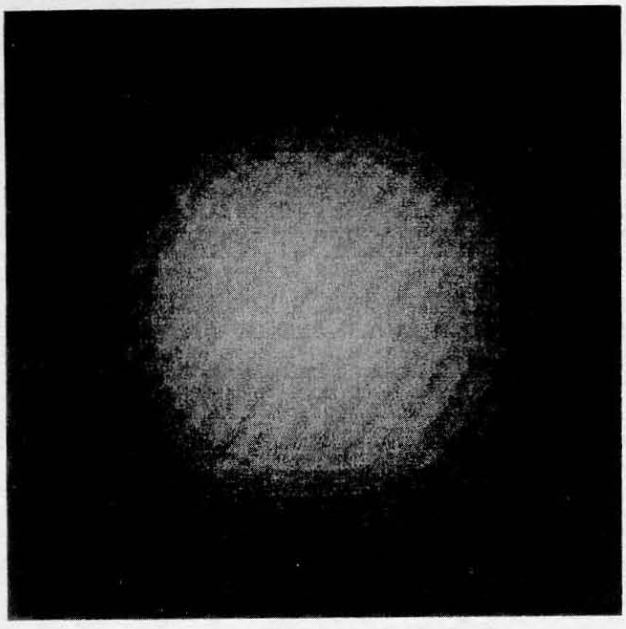
(4)TH

stress/4	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No.20	No.21	Total
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	0.550	1.900	0.425	0.325	1.875	0.075	2.725	0.800	0.525	0.200	1.050	0.275	0.000	0.425	1.650	1.225	2.650	1.250	2.875	2.025	0.625	23.450
0.075	0.300	2.175	4.350	0.075	3.825	0.225	3.825	0.300	0.225	0.375	7.425	2.100	0.000	1.950	0.600	5.400	6.075	0.675	0.225	5.175	0.975	46.275
0.125	0.375	5.625	21.000	0.000	2.375	1.125	5.125	0.125	1.000	2.125	3.000	32.375	0.375	4.000	0.000	26.500	8.250	0.250	0.750	1.625	1.000	117.000
0.175	0.000	1.925	2.800	0.000	4.725	2.100	3.150	0.000	2.450	1.575	0.525	19.425	1.225	9.275	0.000	34.300	14.875	0.175	0.000	1.050	0.350	99.925
0.250	0.000	0.500	0.250	0.000	0.000	4.250	6.500	0.000	4.250	6.000	0.750	22.250	2.750	23.750	0.000	34.000	35.500	0.250	0.000	1.000	0.000	142.000
0.375	0.000	0.750	1.875	0.000	0.000	15.750	0.375	0.000	28.875	27.375	1.500	24.000	4.875	30.000	0.000	34.125	84.750	0.000	0.000	0.750	0.000	255.000
0.500	0.000	1.500	2.000	0.000	0.000	68.500	0.500	0.000	80.000	45.500	0.000	15.500	6.000	42.500	0.000	21.000	41.000	0.000	0.000	1.000	0.000	325.000
0.625	0.000	0.000	0.625	0.000	0.000	183.750	0.000	0.000	112.500	48.750	0.625	24.375	8.750	46.250	0.000	35.625	51.250	0.000	0.000	0.625	0.000	513.125
0.750	0.000	0.000	0.000	0.000	0.000	126.750	2.250	0.000	133.500	63.000	0.000	19.500	10.500	45.750	0.000	19.500	12.000	0.000	0.000	0.750	0.000	433.500
0.875	0.000	0.000	0.000	0.000	0.000	95.375	0.875	0.000	78.750	57.750	0.875	20.125	19.250	38.500	0.000	26.250	9.500	0.000	0.000	0.875	0.000	342.125
1.000	0.000	0.000	0.000	0.000	0.000	77.000	2.000	0.000	74.000	64.000	2.000	18.000	45.000	70.000	0.000	15.000	2.000	0.000	0.000	0.000	0.000	370.000
1.125	0.000	0.000	0.000	0.000	0.000	43.875	0.000	0.000	41.625	55.125	1.125	5.625	51.750	36.000	0.000	12.375	0.000	0.000	0.000	0.000	0.000	247.500
1.250	0.000	0.000	0.000	0.000	0.000	55.000	1.250	0.000	68.750	77.500	2.500	1.250	102.500	25.000	0.000	7.500	0.000	0.000	0.000	0.000	0.000	341.250
1.500	0.000	0.000	0.000	0.000	0.000	28.500	0.000	0.000	61.500	123.000	0.000	0.000	175.500	1.500	0.000	7.500	0.000	0.000	0.000	0.000	0.000	397.500
1.750	0.000	0.000	0.000	0.000	0.000	21.000	0.000	0.000	57.750	164.500	1.750	0.000	315.000	0.000	0.000	12.250	0.000	0.000	0.000	0.000	0.000	572.250
2.000	0.000	0.000	0.000	0.000	0.000	8.000	0.000	0.000	26.000	148.000	0.000	0.000	278.000	0.000	0.000	4.000	0.000	0.000	0.000	0.000	0.000	464.000
2.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22.500	72.000	0.000	0.000	204.750	0.000	0.000	9.000	0.000	0.000	0.000	0.000	0.000	308.250
2.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	60.000	307.500	0.000	0.000	597.500	0.000	0.000	37.500	0.000	0.000	0.000	0.000	0.000	1002.500
Total (kgf)	1.225	14.375	33.325	0.400	12.800	731.275	28.575	1.225	854.200	1264.275	23.125	205.800	1823.725	374.900	2.250	343.050	261.850	2.600	3.850	14.875	2.950	6000.650
(%)	0.02	0.24	0.56	0.01	0.21	12.19	0.48	0.02	14.24	21.07	0.39	3.43	30.39	6.25	0.04	5.72	4.36	0.04	0.06	0.25	0.05	100.00

(3)TS

stress/4	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No.20	No.21	Total
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	1.800	1.775	4.625	6.225	0.700	2.900	0.075	2.525	1.175	0.000	0.525	1.100	0.350	0.000	3.750	3.450	0.150	5.575	3.650	2.000	0.400	42.750
0.075	1.425	1.425	0.975	5.100	0.000	10.350	0.300	0.450	8.325	0.075	3.675	1.800	2.700	0.000	0.525	2.250	0.075	0.450	2.550	1.950	1.350	45.750
0.125	1.250	1.000	1.625	1.875	0.125	16.500	10.375	0.000	20.750	0.000	18.500	1.875	21.500	1.000	0.750	0.250	0.750	0.375	1.750	1.875	0.125	102.250
0.175	0.700	1.225	0.700	0.525	0.175	27.125	17.500	0.000	18.375	0.525	38.500	1.925	30.975	1.575	0.700	0.000	3.500	0.175	3.675	1.750	0.000	149.625
0.250	0.750	0.500	0.500	0.000	0.000	31.000	38.500	0.000	23.500	0.500	41.000	0.000	48.000	4.500	0.750	0.000	24.250	0.750	2.250	0.250	0.000	217.000
0.375	0.000	0.375	0.375	0.750	0.000	26.250	38.250	0.000	15.750	9.000	15.375	0.000	63.750	4.875	0.375	0.000	101.625	1.125	5.250	0.000	0.000	283.125
0.500	0.000	0.500	0.000	0.500	0.000	19.000	40.000	0.000	8.500	15.000	9.500	0.000	35.500	5.500	0.500	0.000	97.500	0.500	0.500	0.000	0.000	233.000
0.625	0.000	0.000	0.000	1.250	0.000	23.125	41.875	0.000	15.000	83.750	10.000	0.000	26.250	4.375	0.000	0.000	89.375	0.625	0.000	0.000	0.000	295.625
0.750	0.000	0.000	0.750	0.750	0.000	20.250	48.500	0.000	10.500	139.500	3.000	0.000	15.000	6.750	0.000	0.000	75.000	2.250	0.000	0.000	0.000	323.250
0.875	0.000	0.000	1.750	0.000	0.000	16.625	36.750	0.000	13.125	76.125	0.000	0.000	10.500	25.375	0.000	0.000	35.000	0.000	0.000	0.000	0.000	215.250
1.000	0.000	0.000	0.000	0.000	0.000	23.000	48.000	0.000	10.000	71.000	0.000	0.000	19.000	49.000	0.000	0.000	33.000	0.000	0.000	0.000	0.000	253.000
1.125	0.000	0.000	1.125	0.000	0.000	9.000	32.625	0.000	11.250	38.250	0.000	0.000	7.875	65.250	0.000	0.000	10.125	0.000	0.000	0.000	0.000	175.500
1.250	0.000	0.000	1.250	0.000	0.000	21.250	30.000	0.000	10.000	50.000	0.000	0.000	16.250	198.750	0.000	0.000	23.750	0.000	0.000	0.000	0.000	351.250
1.500	0.000	0.000	0.000	0.000	0.000	48.000	67.500	0.000	25.500	126.000	0.000	0.000	18.000	379.500	0.000	0.000	22.500	0.000	0.000	0.000	0.000	687.000
1.750	0.000	0.000	1.750	0.000	0.000	42.000	40.250	0.000	3.500	82.250	0.000	0.000	14.000	236.250	0.000	0.000	12.250	0.000	0.000	0.000	0.000	432.250
2.000	0.000	0.000	0.000	0.000	0.000	28.000	40.000	0.000	0.000	108.000	0.000	0.000	0.000	106.000	0.000	0.000	16.000	0.000	0.000	0.000	0.000	298.000
2.250	0.000	0.000	0.000	0.000	0.000	11.250	29.250	0.000	0.000	105.750	0.000	0.000	4.500	85.500	0.000	0.000	11.250	0.000	0.000	0.000	0.000	247.500
2.500	0.000	0.000	2.500	0.000	0.000	25.000	217.500	0.000	0.000	365.000	0.000	0.000	32.500	352.500	0.000	0.000	37.500	0.000	0.000	0.000	0.000	1032.500
Total (kgf)	5.925	6.800	17.925	16.975	1.000	400.625	778.250	2.975	195.250	1270.725	140.075	6.700	366.650	1526.700	7.350	5.950	593.600	11.825	19.625	7.825	1.875	5384.625
(%)	0.11	0.13	0.33	0.32	0.02	7.44	14.45	0.06	3.63	23.60	2.60	0.12	6.81	28.35	0.14	0.11	11.02	0.22	0.36	0.15	0.03	100.00

(4)TH



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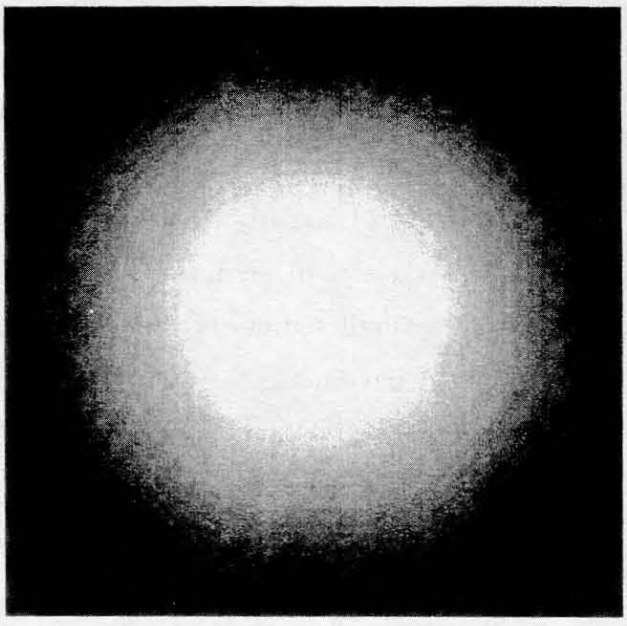

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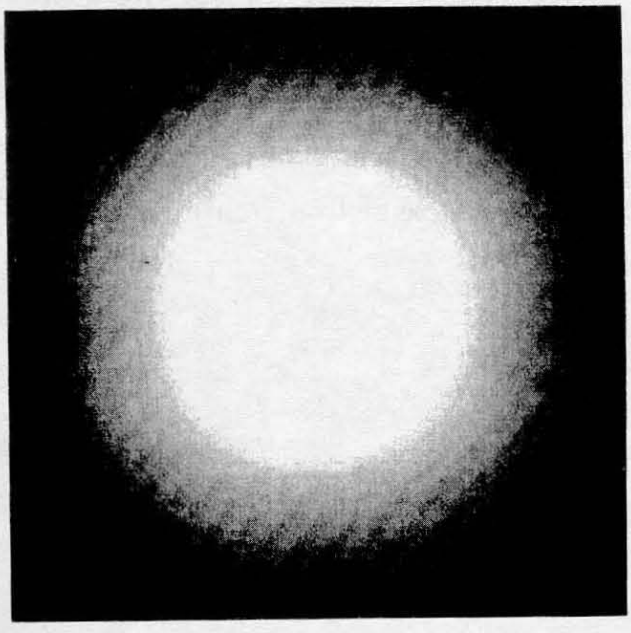

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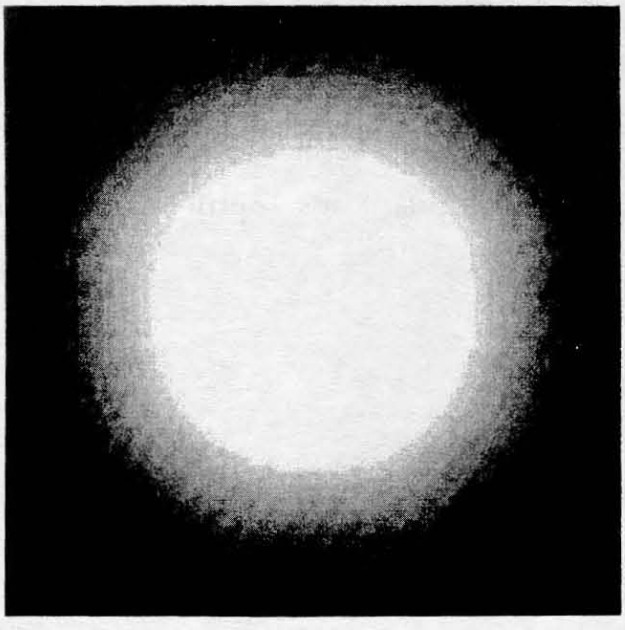

(4)4.0cm

Fig.5 Stress distribution under asphalt layer

Table 1-2 Total load

	Total Load(kgf)	Load Ratio to 8tf (%)
S S	5459.750	68.25
S H	5673.075	70.91
T S	6000.650	75.01
T H	5384.625	67.31

Table 2 Total load of asphalt pavement

H (cm)	Total Load(kgf)
8.0	3286.9
4.0	6031.1
4.5	5679.8
5.0	5238.3

4. Conclusion

This study tried to make the stress distribution under the concrete block clear by using the reactive paper. It was shown that behavior of individual block influenced the stress distribution greatly. Accordingly, the concrete block pavement has an unique function as pavement structure. In other words, as the concrete block pavement consists of a small segments, the area near the loading point is loaded a little bigger than general pavements. Accordingly, it needs to use a little thicker subbase than usual pavements. But, the crack, which is one of the biggest damage factors of pavements, need not be considered. The new design concept different from the asphalt pavement is necessary.

Reference

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