EVALUATION OF DURABILITY OF BEDDING SAND FOR INTERLOCKING BLOCK PAVEMENT UNDER REPEATED LOADING BY HEAVY VEHICLES

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Using sand of the proper quality for the bed and joint is important, to maintain the performance of interlocking (IL) blocks installed on roadway. Field tests at the Public Works Research Institute of the Japanese Ministry of Construction (PWRI) and many cases of IL block failure reported nationwide had confirmed this. A field test using actual vehicles started in FY 1997 at the PWRI, to evaluate the durability of bedding sand for roadway.

The sand used were natural sand, #7 crushed stone and heated sand. In general, #7 crushed stone and heated sand are easy to obtain. Prior to the field test, several kinds of sand were tested in the lab for selection of the one each from natural sand - heated sand that exhibits the most desirable properties. In addition, a method was employed to fix heated sand with special resin, because it is expected to afford movement-prevention of bedding sand. Natural sand performed the best, of the materials tested in the field test. Using resin to fix sand caused severe breakage of blocks or loss of joint sand. It was also found that to prevent the loss of joint sand, materials whose properties are similar to those of bedding sand are desirable. The result of our tests lead us to propose that to evaluate the quality of bedding sand used with IL blocks installed on roadway, resistance against fining should be tested by impact compaction .

1 . Introduction

Since 1987, the PWRI and the aggregate corporation Japan Interlocking Block Pavement Engineering Association (referred to as the association) have constructed real size pavement for testing in the pavement test field at the PWRI and continuously conducted heavy vehicle driving and durability evaluation to establish the methodology for roadway pavement design.

From the result of the tests between 1987 and 1995 [1)] , it was confirmed that the quality of bedding sand and joint sand affect the performance of the paved surface. Then new field tests started in 1997 to study the cause-and-effect between bedding/joint sand and the pavement condition in detail and to establish a quality standard.

This paper provides an evaluation on the effect of the difference of bedding sand quality and construction methods on the performance of the block pavement surface in detail. It also reports on the preferable quality of bedding/joint sand based on the test results together with the test methods.

2. Condition of roadway paving

The faulting between blocks, the movement of blocks, rutting, and localized settlement are pointed as characteristics of the damage of IL block paving.

As we can see in Table-1, there is a large faulting in the amount that went through the 75 μ m sieve between wheel path and non-wheel path, which means bedding sand hardening is due to the Pulverization. Hardening of the bedding sand occurred to a wide range of roads from L traffic to C traffic regardless of the materials used for the base course. But there is a possibility that stiffness upper base course material promotes Pulverization.

Judging from the field tests results at the PWR1 and the constructed examples of roadway pavement, hardening of the bedding sand increases in relation to the amount that goes through the 75 μ m sieve. And this hardening causes various types of damage. Hardening of bedding sand occurs because the sand is broken into smaller particles. Figure-1 shows the relationship between the years from the construction until the research for each construction case of hardening bedding sand under the wheel path in Table-1 and the amount that passes through the 75 μ m sieve. From this diagram, if we set the standard rate at 7% or less, 9 cases out of 11 satisfy this standard. The 2 cases which do not comply, are L and A traffic with many roadway examples. Therefore, the requirement is to choose materials which pass less than 5% through the 75 μ m sieve and also consists of a hardness which will maintain this rate even after Pulverization.

Table 1 CONDITION OF ROADWAY PAVING

No	Category of damage	Cause of damage	Type of	Road Classification	Time const roaed	Base course	Research time	Sampling location	Condition of	Test results	
										FM	Amount passed through 75 μ m passins(%)
1	Faulting the blocks	Hardening of bedding	City road (In Kanagawa prefecture)	L traffic	1986/12	Recycled crusher-run (10)	1989/8	Non-wheel	Not hardening	3.03	2.97
								Wheel path	hardening	2.56	9.90
2			City road (In Kanagawa prefecture)	A traffic	1987/3	Bituminous stabilization (10)	1989/10	Wheel path	Not hardening	2.03	6.86
								Wheel path	hardening	1.72	15.90
3			City road (In Kanagawa prefecture)	B traffic	1989/1	Coarse-graded As (5)	1989/10	Wheel path	Not har dening	3.06	7.20
								Wheel path	hardening	2.94	11.40
4			City road (In Shizuoka prefecture)	L traffic	1989/10	Bituminous stabilization (5)	1990/3	Wheel path	hardening	2.51	14.40
								Wheel path	hardening	2.52	10.30
5	Movement of blocks		City road (In Shizuoka prefecture)	A traffic	1990	Bituminous stabilization (6)	1993/8	Wheel path	hardening	2.67	11.30
6			City road (In Kyoto prefecture)	L traffic	1994/1	Bituminous stabilization (5)	1995/6	Wheel path	hardening	3.13	6.72
								Wheel path	hardening	3.19	7.63
7			City road (In Kanagawa prefecture)	A traffic	1994/3	Coarse-graded As (10)	1997/5	Wheel path	hardening	1.87	11.0
8	Rutting Localized Settlement	De formation of bedding	Ward road (In Tokyo)	A traffic	1986/12	Bituminous stabilization (20)	1992/6	Wheel path	Not hardening	1.47	11.0
								Wheel path	Not hardening	1.51	8.20
9			City road (In Shizuoka prefecture)	L traffic	1990	Bituminous stabilization (5)	1993/8	Wheel path	hardening	2.46	14.19
10			Ward road (In Tokyo)	L traffic	1995/3	Open-graded As (5)	1998/9	Wheel path	Not hardening	2.16	2.49
								Wheel path	hardening	1.28	11.23
11			City road (In Hokkaido)	C transport	1996/12	Bituminous stabilization (5)	1997/11	Wheel path	hardening	1.54	11.60
								Wheel path	hardening	1.64	14.0

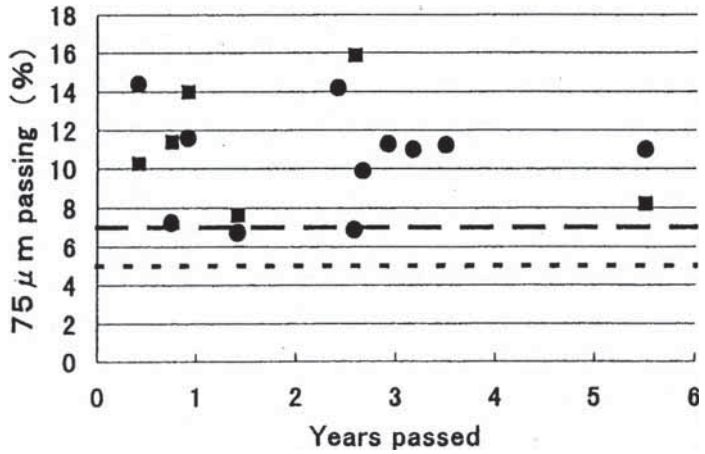


Figure 1 RELATIONSHIP BETWEEN YEARS PASSED AND 75 μ m PASSING

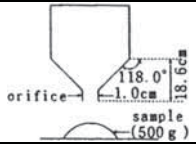
3. Laboratory test

(1) Outline of laboratory test

To confirm the effect of the quality of bedding sand on usability of IL block paved surfaces, 14 kinds of material were selected such as 9 types of natural sand which had been used for domestic roadway paving, and 3 types of #7 crushed stone and 2 types of heated sand which were easily obtainable material.

We confirmed the properties of these 14 types of bedding sand by the tests shown in Table2.and showed the result in Table 3.

Table 2. LABORATORY TEST OF BEDDING SAND

Category	Item	Test method
Properties test on sands	Maximum size Sieve analysis Specific gravity (surface-dry, open- dry condition) Water absorption unit weight solid volume percentage washing test	Based on IIS A 1102 n Based on JIS A 1109 or 1110 Based on JIS A 1104 Based on JIS A 1103
Hardness/shape test on sands	Hardness test of sand (FDR test)	Test machine: Deval test machine Ball: Φ 25mm wear resistant china ball with a volume of 2 liters Test material: open dry condition in a bulk density twice as much as the void between the balls. Grading is standard one. (2.5/1.2:1.2/0.6:0.6/03=1:1:1 - weight proportion) Length of test: 60 minutes
	Impact compaction test	Fill CBR testing mould of Φ = 15cm to 1/3 from the bottom with open dry condition sand. With 4.5kg rammer and 45cm height, 67 times of impact compaction sieving and washing test are conducted to compare the results.
	DV (dry viscosity) test 	Separate each grain of into 0.3 to 0.6 mm Using the test utensil as in the diagram on the left evaluate the shape of fine aggregate by measuring the time required for a certain weight(500g)of material fall out.

(2) **Test result**

The result of laboratory tests on bedding sand is listed in Table-3. From this, the following are confirmed.

1) Grading

9 types of natural sands and 2 types of heated sand have continuous grading. 14 types of sand can be categorized by FM as follows: 5 types of 3 or above (A, B, C, J, M), 7 types of 2 to under 3 (E, G, H, I, K, L, N) and 2 types of under 2 (D, F).

2) Specific gravity and water absorption

The specific gravity was between 2.5 and 2.7 for both surfaces dry and open dry condition. Water absorption varies depending on the production region for all kinds: #7 crushed stone, natural sand and heated sand.

3) Washing test

The 75 μ m sieve passing rate obtained by washing tests show that 12 types excluding H and N materials comply with the association standard of 5% or less for roadway paving.

4) Impact compaction test

When looking at the grading, based on 75 μ m sieve passing amount, before and after impact compaction test, 7 types (B, C, D, E, F, L, M), or half of 14 types were found to be satisfactory, given that the figure of before/after tests is the association standard of 5% or less and the increase finegrained fraction is 1% or less based on the research result in Britain[4]. Although there was a concern that the *#7* crushed stone would Pulverizatoin, a low figure was obtained as this was hard quality sandstone.

5) FDR test

The hardness of bedding sand was drawn by calculating FDR m (evaluation figure of material hardness) using the FDR test result and formula (1) [4] .

FDR m = FD after tesEFD before test . . . . (1)

Here FD: The total of passed percentage through the 75 μ m sieve 2.5, 1.2,0.6, 0.3, 0.15 and 0.0

In Table 3, FDR m figure for all 3 of the #7 crushed stones are high (2.97 to 6.49) while most of natural sands and heated sands remain in the range of 1.10 to 1.30. The reason for different evaluation of #7 crushed stone depends on the method of test, for example stronger impact on the material by FDR tests and the length of tests time. On the other hand, the increase of finegrained fraction amount obtained from impact compaction tests (resistance level against Pulverization) and FDRm data were not found to have correlation with specific gravity or water absorption, which is the guideline for durability of aggregate.

6) DV-valve

DV-valve with sand same grain size ranged from 24 to 32 seconds, which creates considerable differences among particle shapes. There was no correlation with the solid volume percentage, which is an indicator of the grain size quality.

(3) Selection of bedding sand

One type of each bedding sand was selected from natural sand, #7 crushed stone and heated sand for field tests at the PWRI, The reasons for this selection is as follows.

1)Natural sand from Hokkaido (D)

amount passed through 75 μ m sieve between before and after the impact compaction tests was small. Also DV-valve for the particle shapes evaluation is small. Therefore this material is considered difficult to Pulverization.

2) #7 crushed stone (A)

Good results are expected because it fits well with the base course surface processing with bituminous stabilization while future roadway base course material will often be processed that way.

3) Heated sand (M)

To confirm the effect by coarse sand. Also this is the base material for the special resin processing mentioned later.

4)Heated sand with special resin processing

In this special resin processing, special coating material with appropriate adherence are added to bedding sand and mixed in the plant to prepare the material. We intended to confirm its' hydrophobic, prevention of dirt osmosis and the effect which prevents sand from lateral moving by the adherence of resin. As is the case of heated sand (M), material with relatively large DV and FDRm-valve and passing amount through 75 μ m sieve.

5)Joint sand (F)

Finer material with a relatively small FDRm-valve, DV-valve and resistance to Pulverization was selected.

Table 3 LABORATORY TEST RESULT

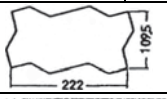
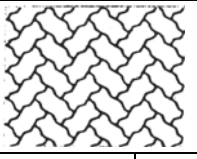
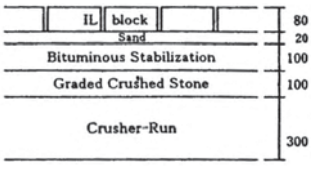
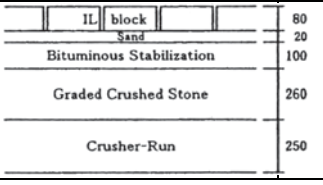
Type	Category'		Maximum size	Specific Gravity		Water absorpt-ion (%)	Unit weight-value (kg/l)	solid volume percent-tage (%)	washing test (%)	FDRm	DV-valve (second)	Impact compaction test								FM	Washing test (%)	Resist-ance to Pulveriza-tion (%)
				Surface	Open dry conditon							Test	Sieve passing rate(%)									
													10	5	2.5	1.2	0.6	0.3	0.15			
#7 crushed	A	Kanlo — 1	10	2.70	2.68	0.786	1.54	57.4	0.15	3.85	-	Before	100	87	10	3	2	1	1	4.96	1.5	1.50
												After	100	93	19	7	4	3	3	4.71	3.0	
	B	Tokai — 1	5	2.62	2.58	1.40	1.49	57.8	2.0	2.97	-	Before	100	92	16	3	1	1	1	4.86	2.0	-0.40
												After	100	97	30	10	5	3	2	4.53	1.6	
	C	Tokai — 2	10	2.61	2.57	1.44	1.63	63.4	0.71	6.49	-	Before	100	55	3	1	0	0	0	5.41	0.71	0.59
												After	100	61	7	3	2	1	1	5.25	1.3	
natural sand	D	Hokkaido	1.2	2.72	2.68	1.32	1.64	61.4	0.41	1.18	25"63	Before	100	100	100	97	84	32	1	1.86	0.41	0.59
												After	100	100	100	97	85	36	4	1.78	1.0	
	E	Tohoku	2.5	2.58	2.54	1.69	1.68	65.9	0.84	1.23	26"91	Before	100	99	95	80	44	15	2	2.65	0.84	0.36
												After	100	99	94	75	40	13	2	2.77	1.2	
	F	Kanlo — 1	0.6	2 58	2.53	2.01	1.54	60.7	1.5	1.24	26"69	Before	100	100	99	97	90	57	6	1.51	1.5	0.90
												After	100	100	89	96	90	57	8	1.50	2.4	
	G	Kanlo — 2	2.5	2.63	2.59	1.44	1.73	66.8	4.3	1.26	29"75	Before	100	100	92	58	32	17	8	2.93	4.3	1.30
												After	100	100	94	64	29	22	11	2.70	5.6	
	H	Kanlo — 3	2.5	2.60	2.55	1.84	1.69	66.3	12	-	28"32	Before	100	100	92	85	59	35	11	2.18	12	2.0
												After	100	100	93	64	42	29	18	2.54	14	
	I	Tokai	5	2.59	2.55	1.70	1.74	68.2	2.2	1.22	29"87	Before	100	100	87	59	38	23	9	2.84	2.2	1.4
												After	100	100	89	62	42	26	7	2.70	3.6	
	J	Chugoku— 1	5	2.54	2.49	2.18	1.60	64.5	1.0	1.64	32"33	Before	100	99	87	53	22	5	1	3.33	1.0	1.30
												After	100	99	85	57	30	11	4	3.14	2.3	
	K	Chugoku — 2	2.5	2.54	2.49	1.84	1.62	64.9	2.2	1.34	26"31	Before	100	100	94	64	38	20	6	2.78	2.2	1.20
												After	100	100	93	66	40	21	8	2.72	3.4	
	L	Kyushu	2.5	2.59	2.56	1.34	1.66	64.8	0.71	1.29	29"47	Before	100	99	96	82	46	9	1	2:67	0.71	0.29
												After	100	100	98	85	46	10	2	2.59	1.0	
heated sand	M	From paving company - 1	5	2.64	2.61	1.26	1.70	65.3	1.8	1.34	28"36	Before	100	100	86	53	29	13	2	3.17	1.8	0.60
												After	100	100	90	61	37	17	4	2.91	2.4	
	N	From paving company - 2	2.5	2.59	2.53	2.26	1.70	67.4	7.2	1.29	24"75	Before	100	100	100	76	52	24	8	2.40	7.2	0.80
												After	100	100	100	82	62	33	12	2.11	8.0	

4. Outline of field tests

Experimental paving to evaluate bedding sand durability was done for a length of 44m on the middle loop of the pavement test field . As for the structure of test paving, the bituminous stabilizing process with high durability was employed for the base course by reason of test results in the past. The difference of pavement structure in Table4 is due to the re-construction of existing pavement from upper base course layer. A herringbone bond 45-degree shape laying pattern of the blocks which allows little movement was employed.

In field tests, driverless radio-controlled vehicles with a wheel load of 49kNor 69kNran repeatedly on the pavement. When it reached certain times of the run, measurements shown in Table 5 were conducted.

Table 4 OUTLINE OF TEST PAVEMENTS

Test section	221	222	223	224
Type of bedding Sand	Heated sand	Heated sand with Special resin	Natural sand	#7 crushed stone
Joint sand	Fine sand (Kanto produce)			
Width (m)	5.1			
Length (m)	14.0	10.0	10.0	10.0
Shape of IL block				
Laying pattern	 Vehicle Driving Direction			
Pavement (mm) structure				
TA of base courses (cm)	19.0		23.4	

5. Test result

The condition of the IL block pavement surface with each bedding sand at the end of 1998 is listed in Table 5. The number of loading on each test section was 12,000 times, which is equivalent to 448,257 wheels of 49kN.

Table 5 PAVEMENT SURFACE CONDITION OF EACH TEST SECTIONS

Test section (Type)	number of drives ($\times 10^4$)	49kN ESWL	rutting (mm)	FWD deflection D_0 (mm)		Breakage(%) ():through cracks portion	movement (mm)	loss rate of joint sand (%)	average joint width of cross section(mm)		average joint width of vertical section (mm)		MC I_0
				On sub-base of bitumen stabilizing process	On IL block Ratio of():0-time figure				1	2	OUT	I N	
2 2 1 healed sand	0	0	0	0.79	0.71	0	0	0	-	-	-	-	10
	4	146,290	2.0	-	0.77 (1.08)	0	0	8.55	-	-	-	-	9.51
	8	292,953	2.0	-	0.90 (1.27)	0	2	11.80	3.03	3.09	2.76	2.14	9.51
	12	448,257	0.30	-	0.77 (1.08)	0.4(0)	0.4	8.90	2.84	2.92	2.54	2.81	8.72
2 2 2 healed sane with special resin	0	0	0	0.83	0.69 (1.0)	0	0	0	-	-	-	-	10
	4	146,290	1.40	-	0.72 (1.04)	0	1	5.75	-	-	-	-	9.62
	8	292.953	1.15	-	086 (1.25)	0.2(0)	6.5	27.75	2.89	2.92	2.77	1.29	8.74
	12	448,257	3.0	-	0.78 (1.13)	34(0.3)	7.85	20.40	3.17	2.73	3.97	2.59	7.17
2 2 3 healed sand	0	0	0	0.95	0.74 (1.0)	0	0	0	-	-	-	-	10
	4	146,290	1.85	-	0.67 (0.91)	0	0.5	0.15	-	-	-	-	9.54
	8	292,953	0.1	-	0.77 (1.04)	0.1(0)	0	1.65	2.60	2.58	2.09	2.70	9.94
	12	448,257	2.4	-	0.55 (0.74)	0.1(0)	0.3	0.90	2.82	2.69	3.20	2.55	8.69
2 2 4 #7 crushed	0	0	0	0.95	0.69 (1.0)	0	0	0	-	-	-	-	10
	4	146,290	4.65	-	0.68 (0.99)	0	0	1.50	-	-	-	-	9.12
	8	292.953	4.4	-	0.84 (1.22)	0.1	0	10.05	2.92	2.84	2.18	1.98	8.40
	12	448,257	3.5	-	0.73 (1.06)	0.3	0	10.08	2.94	2.84	2.84	3.28	8.23

(1) Analysis of correlation between the factors

Analysis of correlation of the breakage to blocks, rutting and deflection caused by wheel, movement, and loss rate of joint sand was conducted and results are in Table 6. Coefficient of correlation to show the accuracy of analysis were 0.75 between damage rate of blocks and movement, and 0.84 between movement and loss rate of joint sand, which indicate high correlation. Also relatively high correlation between the loss rate of joint sand and the deflection by wheels suggests joint sand tend to be lost by pumping when the deflection increases as usage continues after construction.

The loss of joint sand causes not only a malfunction as a continous layer consisting of small blocks interlocking together but negative effect laying course and base course as more water permeates from the joint. Therefore it is necessary to select joint sand which is difficult to lose as well as to refill joints immediately when joint sand lost.

Table 6 CORRELATION MATRIX

Items	Rutting	Deflection	Breakage	Movement	Loss rate of joint sand
Rutting	1.000				
Deflection	0.056	1.000			
Breakage	0.229	0 147	1.000		
Movement	0 124	0.421	0.750**		
Loss rate of joint sand	0 277	0.676**	0.505*	0 842**	1.000

**: significant at 1% * : significant at 5%

From these field tests, it was confirmed that joint sand loss results in the failure of IL block paving.

(2) Evaluation on bedding sand durability

1) Heated sand

While heated sand shows small rutting and block movement, the loss rate of joint sand tends to be large. Because the loss of joint sand affects usability of block paving substantially, it is necessary to study the properties (FM, DV-valve) of joint sand, as mentioned later, when using heated sand

2) Heated sand with special resin

Special resin processed heated sand did not only show larger figures in movement, breakage of the blocks and the loss of joint sand than other 3 test section, but also rut depth and vertical section variation of the joint width. A reason for this large variation of blocks is suspected to be due to slippage between IL block layer and the resin processed heated sand layer at their boarder. The block variation and high loss rate of joint sand are considered to be the causes for a substantial number of damages. It is considered that large variation of joint width along its vertical section is largely due to the movement of blocks.

3) Natural sand

Natural sand shows low figures for block movement, breakage of blocks, and loss rate of joint sand. Also the rutting tend to be relatively shallow. A reason for smaller joint sand loss rate in comparison to other 3 test section area is the similarity in properties between natural sand and joint sand, as seen in FM (natural sand - 1.86, joint sand - 1.51) and DV-valve (natural sand - 25.63 seconds, joint sand - 26.69 seconds). Therefore it is preferable to select material of similar properties to the bedding sand to prevent the loss of joint sand.

Moreover, only with natural sand, the tendency of decreasing FWD deflection was indicated as the number of runs increases. This means natural sand and joint sand stabilized with traffic load to enhance the joint between the blocks.

As for the reason of relatively large deflection at 80,000 times compared to that at 40,000 times is considered that joint sand loss rate drastically increases from 40,000 times stage to 80,000 times stage.

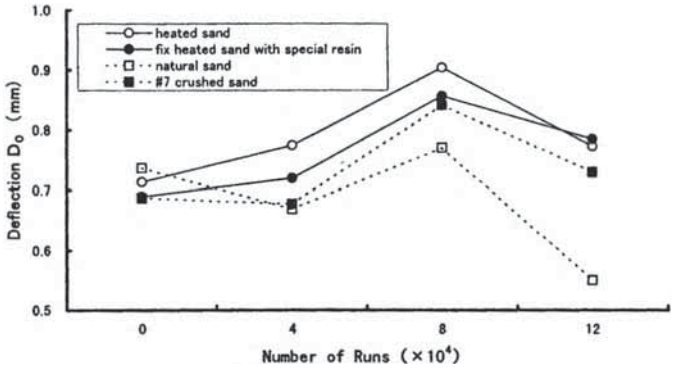


Figure 2 DEFLECTION CHANGE WITH DURATION

4) #7 crushed stone

While #7 crushed stone shows small movement of blocks, the figures for the rut depth, loss rate of joint sand and damage tend to be relatively large. Some reasons for the large loss rate of joint sand are FM compared to joint sand (#7 crushed stone = 4.96, joint sand - 1.51) and the difference in particle shapes. Parts of joint sand could

have come through to #7 crushed stone layer. With #7 crushed stone, there is a concern of the volume increasing by Pulverization to cause deformation of the pavement surface. Thus it is necessary to be aware of the above points and to study further about the use of materials of high resistance to Pulverization and joint sand feature.

(3) Calculation of MCI_0

The analysis of performance was conducted . Maintenance control Index (here in after referred as MCI) was developed to evaluate surface condition of asphalt pavement . The breakage rate (%) was drawn from the percentage of breakaged blocks to the total number of blocks laid inside the research area.

As for MCI evaluation formula, formula (2) was used in which the cracking rate was replaced with the amount rut depth and the breakage rate of blocks. The calculation results are shown in Figure-3.

$$MCI_0 = 10\text{-}1.51C^{0.3} - 0.30D^{0.7} \quad \ldots (2)$$

Here C: damage rate of blocks

D: average depth of digging by wheels (cm)

Based on this, MCI_0 at 120,000 times driving was in the descendant order of heated sand (8.72), natural sand (8.69), #7 crushed stone (8.23) and heated sand with special resin (7.17). Especially heated sand with special resin process shows apparent drop in MCI_0 after 80,000 times loading. Fixing bedding sand by some method should be avoided wherever possible. In inevitable cases to do so, the purpose and the extent should be limited.

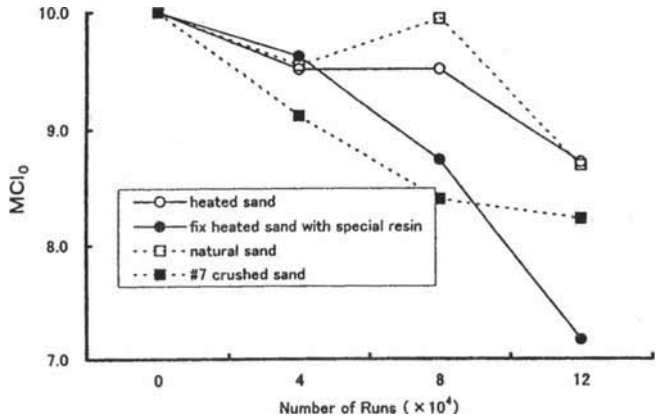


Figure 3 MCI_0 CHANGE AS DURATION

6. Quality of bedding sand and joint sand

(1) Quality of bedding sand

Natural sand provided the best road surface condition in the field tests at the Public Works Research Institute. As mentioned before, IL block paving with natural sand showed the least block breakage and joint sand loss rate, and the second in rutting and movement. Moreover, this sand only tends to decrease the deflection by wheels as more loading conducted.

The characteristic of this natural sand is small loss of 0.4% during washing tests and the resistance to Pulverization at 0.59%. As mentioned so far, bedding sand causes deformation of paved surface through Pulverization, and the movement or faulting by consolidation. Based on these, we decided to add the resistance to Pulverization process to the existing quality standard. This standard sets the passing rate through 75 μ m sieve

as 5% or less before and after impact compaction tests and the fluctuation within 1.0% in reference to the standard in United Kingdom etc. We decided to conduct impact compaction tests by the method shown in Table 2. Also FM of sand are set between 1.5 and 5.5, considering the use of #7 crushed stone.

(2) The quality of joints

The quality of joint sand remains the same, maximum size is 2.36mm or less and the amount that passes through 75 μ. m sieve is 10% or less. However, it is desired to keep 75 μ m sieve passing rate as low as possible and also to use material which has similar properties (FM, DV-valve) to the bedding sand.

7. Conclusion

From the result of bedding sand durability tests at pavement test field, the following became evident.

(1) High correlation was recognized between IL block damage and movement, or the movement and loss rate of joint sand. The loss of joint sand causes damage on IL block paving. Therefore it is necessary to refill the joint sand when it is lost, as well as to select joint sand which is difficult to lose.

Table 7 QUALITY OF BEDDING SAND AND JOINT SAND

Items	Bedding sand	Joint sand
Maximum size	4.75 mm or less	2.36mm or less
FM	1.5 ~ 5.5	
Washing test	75 μ m sieve passing rate of 5% or less	Same as the left but 10% or less
Resistance to pulverization	Change in 75 μ m sieve passing rate before /after impact compaction test is 1% or less	

(2) The quality of joint sand is left unchanged as in Table 8 with an additional note of lowering the amount that passes through a 75 μ m sieve as much as possible. Also for the sake of preventing joint sand loss, it is preferable to use material of similar properties (FM, DV-valve) to bedding sand.

(3) The quality standard of bedding sand and joint sand for roadway pavement is shown in Table 7.

(4) It is not preferable to fix bedding sand by some methods because the slippage between blocks and fixed bedding layer at the boarder causes the movement of blocks and the increase of joint sand loss rate resulting in increased damage of blocks. In case this method has to be applied, the use and the construction range should be limited.

(5) Both heated sand and #7 crushed stone can be sufficient enough to be used for roadway paving if it satisfies the quality standard in Table8. However, it is necessary to study joint sand grading etc.

REFERENCES

1) YAGINUMA Hiroshi, IIJIMA Takashi, IKEDA Takuya: Evaluation on durability of interlocking block pavement under Repeated Loading by Heavy Vehicles, HOSO, June 1998, pp4-10.