EVALUATION ABOUT THE PERFORMANCE OF INTERLOCKING BLOCK PAVEMENT APPLIED TO THE INDUSTRIAL YARD

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ABSTRACT

A series of research of authors clarifies the necessary condition for which base course, the cushion layer and the block in interlocking block pavement are asked, and aims at considering as the basic data of the design technique for applying interlocking block pavement to a heavy traffic. This paper adjusts and reports the knowledge obtained from an on-site pursuit investigation of interlocking block pavement applied to the industrial yard.

1. INTRODUCTION

Interlocking block pavement is introduced into our country, about 25 years will pass, and the construction actual result in the Heisei 10 fiscal year has attained to about 7,200,000 ㎡. And, although many of the uses are aimed at the pedestrian who thought important scene nature called an open space and a park, and a sidewalk and a street, or light traffic, it is accepted besides scene nature by the outstanding feature of high durability, and the flattery nature and the maintenance nature to non-grade subsidence, and its application to driveway pavement has increased in recent years. And, application in the pavement field on which a heavy traffic called the complete driveway, and an airport, a port and an industrial yard where the amount of large-sized vehicle traffic passes the one directions 1,000 vehicles/day acts is expected from now on.

On the one hand, interlocking block pavement is pavement of form which unlike other pavement material has a cushion layer between base course and a block, and gives load distribution effect by tabling during a block. Although the quality of base course and a cushion layer and the thickness of a block are considered to be important elements on structure when especially a heavy traffic, it is the present condition not to necessarily be clarified about the necessary condition for which it is asked.

Authors apply use of the cushion layer according to the small particle-diameter aggregate in part and a 100 mm thick block, and cement concrete reproduction aggregate base course, and the block construction machine of the industrial yard in the concrete product factory through which the vehicle of a heavy traffic passes frequently etc., to interlocking block pavement which harvested an experimental trial, and have evaluated since 1996, the performance by on-site pursuit investigation that basic data for clarifying those necessary condition should collect.

This paper adjusts and reports the knowledge obtained from this evaluation.

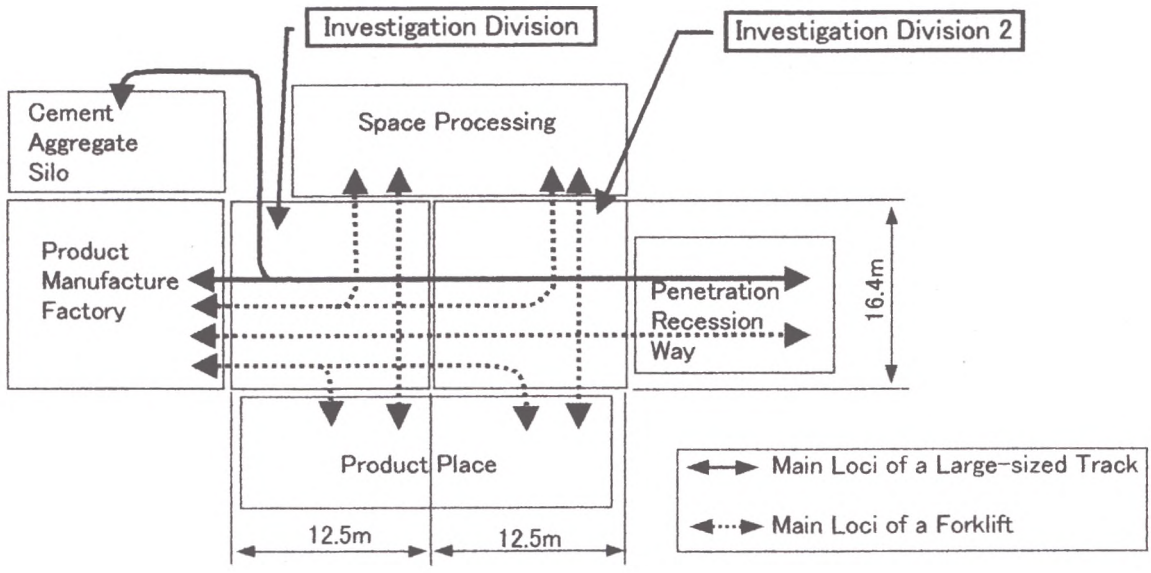


Figure 1 The main loci of the plan view of an industrial yard, and run vehicles

2. THE OUTLINE OF INDUSTRIAL YARD PAVEMENT

(1) Arrangement of an investigation division

The complete view of an industrial yard is shown in a photo 1. Moreover, the main loci of the plan view of an industrial yard and a run vehicle are shown in Figure1. Interlocking block pavement was applied to the division surrounded by most product manufacture factories of the amount of traffic, cement and aggregate silo, the space processing, and the product place in this industrial yard, pursuit investigation was periodically performed to it, and the performance was evaluated.



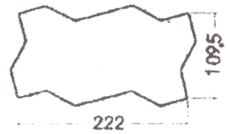
Photo 1 The complete view of an industrial yard

(2) Pavement structure

The pavement structure of an investigation division is shown in Table 1. Material which divides an investigation division into two divisions and differs in a cushion layer was used for pavement structure. Both the divisions of pavement structures other than a cushion layer are the same.

The division 1 used diameter crushed stone with a maximum size of 5 mm of a granule in a tentative way. The division 2 used few good crushed sand for silt. Having used diameter crushed stone of a granule in a tentative way is based on the following reasons.

Table 1 Pavement structure of the investigation division in an industrial yard

Investigation division		1	2
Block	Kind	Normal interlocking block.	
	Form	Wave type block  (mm)	
	Thickness	100mm	
	Intensity	7. 68 N/mm^2 (5 Test piece average)	
	Construction pattern	Herringbone 90 degree	
Joint sand		River sand (the maximum size 1.2mm, FM 2. 89, less than 75 μ 5.20%)	
Cushion layer	Kind	Granule crushed stone (the maximum size 5mm, FM 5.04, less than 75 μ 4.1%)	Crushed sand (the maximum size 2.5 mm, FM 2.66, less than 75 μ 4.8%)
	Thickness	20mm	
Base course	Kind	Cement concrete reproduction bone material base course (Correction CBR45%, 41% of the Los Angeles examination machine wear loss in quantity)	
	Thickness	200mm	
Subgrade		Design CBR=20%	
Pavement area		Width member 16.4m × extension 12.5m = 205 ㎡	Width member 16.4m × extension12.5m = 205 ㎡
Design term		10 years	
The amount of design traffic		It is 1,000,000 wheels the number of total 5ton conversion wheels.	
The designing method		The CBR-TA method	

■ Use of the cushion material which the support power fall and the movement by rain water or load seldom produce is considered to become conditions absolutely in order to develop interlocking block pavement under the road environment of Japan that there are a slope and many curves and for the year rainfall twice more than as many as a world average is as compared with many foreign countries at a heavy traffic. As a result of an indoor experiment, diameter crushed stone of a granule is checking that change of support power is small like few good sand for silt, even when it changes moisture ratio, as shown in Figure 2.

■ Even when a construction machine will run the block top of non-roller compacted from the increase in efficiency of construction, or the field of construction cost reduction if a cushion layer is diameter crushed stone of a granule although it is considered that the merit of block construction machine use is especially large in heavy traffic, it is hard to produce the non-land of a block, and movement.

■ In addition, machines such as a help or asphalt finisher, as well as sand can perform covering and leveling without a problem, and the flat nature after block roller compacted is equivalent to the case where few good sand for sit is used.

A block is not 80 mm thick of the standard blocks of a driveway in Japan, and used the thing of 100 mm thick in a tentative way. This is because it is considered that the case in which 100 mm thick block is applied increases, when it is checked that load distribution effect is so large that past research to a block is thick, and perpendicular stress of the amount of bending on the surface of pavement or pavement each class is small and the deployment to a future heavy traffic pavement field is taken into consideration.[1]

Construction of a block was performed using the block construction machine shown in LAYING equipment and the photo 3 which are shown in a photo 2. [2] LAYING equipment can correspond to a block of thick, and it is rearrange-able to 4 kinds of construction patterns in a block of 3 kinds of colors, and 3 kinds of form, and has the recombination capability of about 350 m /day by one worker. A block construction machine lays a block united and rearranged in the specification of the spot with LAYING equipment, and has the construction capability of about 600 m /day with the composition of one driver and two hand workers.

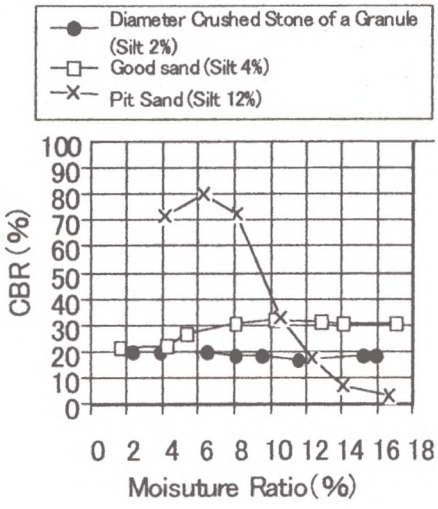


Figure 2 Relation between moisture ratio and CBR

The cement concrete lump of a construction by-product was separated in base course, and the cement concrete reproduction aggregate which carried out particle-size adjustment so that particle-size regulation of crushed stone for roads might be suited was used for it. This is because it is considered that reproduction use of a construction by-product is positively promoted from the reason of shortage of the space disposing, environmental preservation, and effective use of resources, and the use as base course material of these construction by-product will increase above until now from now on in Japan in recent years.

It was determined that a design of pavement structure will correspond to the amount of design traffic based on the CBR-TA method.[3] In addition to this, introduction performance evaluation is carried out many experimental trials, such as use of the metallic ornaments for move prevention of an end block, and use of the quantity durability bead entering block for road surface marking, in this spot.



Photo 2 Recombination work of the block by LAYING equipment



Photo 3 Construction work of the block by the construction machine

3. INVESTIGATION OUTLINE

(1) The investigation purpose

Investigation mainly carried out for the purpose of evaluation of the following items.

① Evaluation of the aptitude as a cushion layer for heavy traffic pavement of diameter crushed stone of a granule

② Evaluation of the aptitude as a block for heavy traffic pavement of 100 mm thick block

③ Evaluation of the aptitude as base course material for heavy traffic pavement of cement concrete reproduction aggregate

(2) Investigation schedule

An investigation schedule is shown in Table 2. This spot will start use in June, 1996, is planning investigation of a total of 5 times by use 5 year, and is in the stage which the investigation for the present use 3 year has ended.

Table 2 Investigation schedule

Use term	Investigation Enforcement and schedule Years	Enforcement situation
Immediately after construction	1996 June	Finishing
6 months	1996 December	Finishing
1 year	1997 June	Finishing
3 years	1999 June	Finishing
5 years	2001 June	Un-carrying it out.

(3) An investigation item and the investigation method

Investigation carried out about the item shown in Table 3.

Table 3 An investigation item and the investigation method

Investigation item		The investigation method
Grasp of the amount of traffic	The amount of traffic	It presumes from the amount of product manufactures, and amount data of shipment.
Evaluation of the shape of surface nature of pavement	Rut depth on the surface of pavement	The level surveying method
	Flat nature on the surface of pavement	The vertical-section profile meter method (The division 1 and the division 2 were traveled through and measured)
	The amount of bending on the surface of pavement	Benkelmans beam method
	Support power on the surface of pavement	Monotonous load examination
	Joint width	The slide-calipers method
	The cushion layer of Joint sand A spill through which it passes	A visual check
	Breakage of a block	The number of breakage is checked.

4. INVESTIGATION RESULT

(1) The amount of traffic

The amount of total traffic at the time of after 3 years progress presumed from data, such as the amount of product manufactures and the amount of product shipment, is shown in Table 4. Since the pavement structure of this spot sets the amount of design traffic to total 5 ton conversion wheel number 1,000,000 wheel and is designing it for design term 10 years, total 5 ton conversion wheel number 179,527 wheel at the time of after 3 year progress is equivalent to the total 5 ton conversion wheel number at the time of after 10 month progress on a design.

Table 4 Presumed value of the amount of total traffic at the time of after 3 years progress

The kind of vehicle	Vehicle weight (ton)	The number of total 5ton conversion wheels (wheel)		The use term on the design equivalent to ①
		By the vehicle	Sum total	
Rose cement vehicle	20	592	179,527 —— ①	10 months per year
Bone material delivery dumping	22	4,755		
Product shipment track	25	11,889		
Forklift	8	160,195		
Forklift	7	1,942		
Forklift	4	154		

(2) The shape of surface nature of pavement

The investigation result of the shape of surface nature of pavement is shown in Figure 3 ~ 8. It checked that the division 1 and the division 2 of the shape of surface nature of pavement were almost equivalent until it result from immediately after construction in 3 after use.

Next, if the performance of pavement evaluates from these investigation results, in rut depth, it can estimate that both divisions are 10 mm or less, and rut depth at the time of after 3 year progress of this spot is maintaining a good performance to the target value of the maintenance repair important-point unnecessary judgment of a general road in Japan being 40 mm. Moreover, it can be estimated that a good performance is maintained also from the investigation result in other investigation items at the time of after 3 year progress.

Furthermore, the phenomenon that joint sand which was the uneasiness matter was spilled out to air void of diameter crushed sand of a granule of a cushion layer did not accept at the time of after 3 year progress.

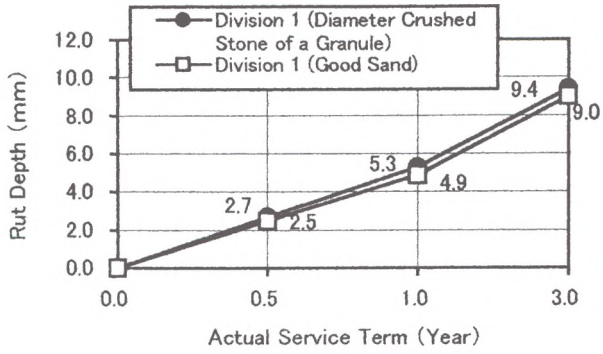


Figure 3 Change of maximum rut depth with the passage of time

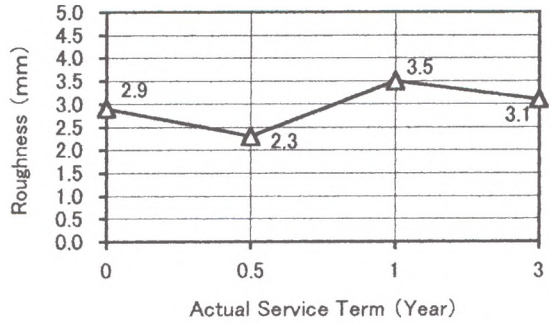


Figure 4 Change of flat nature with the passage of time

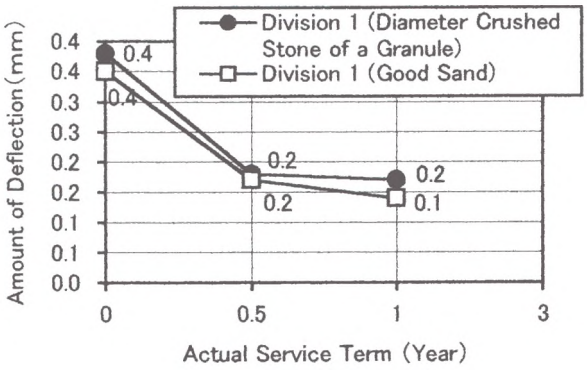


Figure 5 Change of amount of the maximum bending with the passage of time

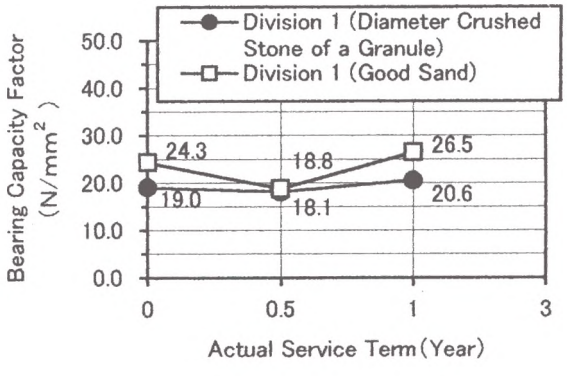


Figure 6 Change of a support power Coefficient with the passage of time

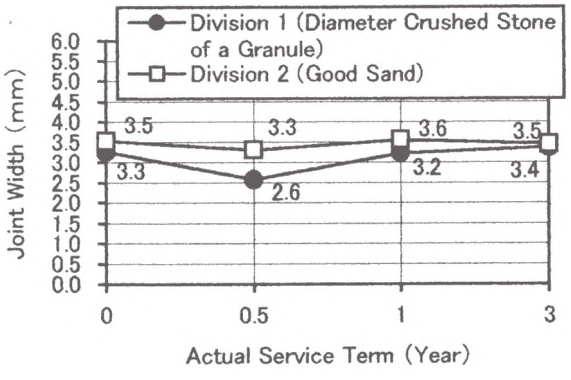


Figure 7 Change of joint width with the passage of time

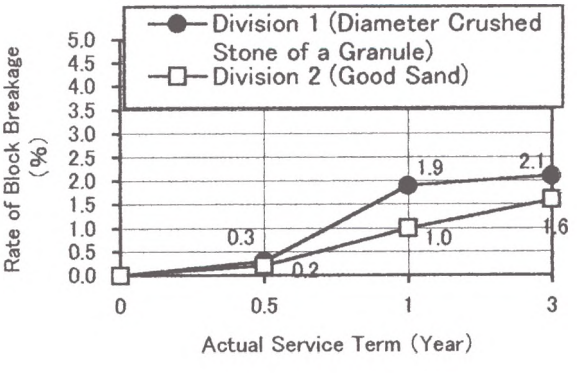


Figure 8 Change of the rate of block breakage with the passage of time

5. PERFORMANCE EVALUATION OF THE PAVEMENT BY THE PERFORMANCE EVALUATION FORMULA

As method of using an investigation result and evaluating pavement, there are a method of evaluating each investigation item individually, a method evaluated by the evaluation formula which combined and created some items. About the former, since it was estimated that a good performance was maintained at the time of after 3 year progress as above mentioned, the performance of pavement was evaluated by the latter method as a following step.

There is an evaluation formula of MCI (Maintenance Control Index) as an example of the evaluation formula which combined and created some items. The Ministry of Construction is the index created as an evaluation formula about asphalt pavement, and uses this for management of a direct-control national highway through the pavement data bank. A situation is embraced as it is shown in formula ①, and the evaluation formulas of MCI are formula ②~④. In interlocking block pavement, generally in consideration of the influence of the flat nature on joint, formula ② is used.

The evaluation classification of MCI is five stages shown in Table 5.

$$MCI = 10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2} \quad \text{①}$$

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

$$MCI_1 = 10 - 2.23C^{0.3} \quad \text{③}$$

$$MCI_2 = 10 - 0.54D^{0.7} \quad \text{④}$$

Here, it is MCI : Maintenance management index C : Rate of crack of a block (%), rate of breakage of a block (%) D : Average value of rut depth (mm) σ :Flat nature (mm)

MCI in the division 1 and the division 2 of this spot and its evaluation are shown in Table 6. The performance of pavement obtained evaluation that the division 1 and division 2 are almost equivalent and performance of a grade that repair is not required at the time of after 3 year progress is maintained until it resulted from immediately after construction in 3 after use (the number of 5 ton conversion wheels 179,527 wheels).

Table 5 Evaluation classification in MCI

Rank	Contents	Score
A	A defect does not accept at all.	10
B	Although there is a defect a little It is considered that it is good.	8
C	Although there are many defects, it is repair an important point. It bends.	6
D	Easy maintenance repair is required.	4
E	Large-scale repair is required.	2

Table 6 MCI in this spot, and its evaluation

The term for paformance	5ton conversion The number of wheels (wheel)	Division 1		Division 2	
		MCI_0	Rank	MCI_0	Rank
6 months	33,189	8.3	B	8.5	B
1 year	59,766	7.2	B~C	7.6	B~C
3 years	179,527	6.7	B~C	6.9	B~C

6. CONCLUSION

The above result and the investigation purpose are tested by comparison, and the matter made clear is described below.

① The performance of the division 1 which used diameter crushed stone with a maximum size of 5 mm of a granule, and the division 2 which used few good crushed sand for silt is almost equivalent until it results at the time 5 ton conversion wheel number 179,527 wheel of after 3 year progress, and when use of the block construction machine in heavy traffic took into consideration, it is considered that it is an effective cushion material from the field of usability and construction nature.

② The demerit of thick block use and cement concrete reproduction aggregate use does not accept 100 mm at the time of after 3 year progress, but it is considered that there is no 80mm difference in thick block, natural aggregate, and a performance. Although, since it becomes a cost rise 80 mm about thick bock 100 mm compared with thick block, if a performance does not improve, there is no merit on use. However, since it is checked that load distribution effect is so large that past research to a block is thick, and perpendicular stress of the amount of bending on the surface of pavement or pavement each class is small, it is due to consider that a use merit clarifies in future long-term use, and to investigate by continuing.

7. AT THE LAST

The necessary condition for which base course of interlocking block pavement, the cushion layer and the block in a heavy traffic are asked is clarified further from now on, and it is considered that we wants to advance various examination aiming at establishment of the design, construction / management technique.

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