THE USE OF INTERLOCKING BLOCK PAVEMENTS FOR THE REDUCTION OF TRAFFIC ACCIDENT

N. KANZAKI, Y. OHMORI, S. ISHIMURA

Onoda Cement Co., Ltd., Central Research Laboratory
Tokyo, Japan

SUMMARY:
This report shows the results of the test interlocking block pavement constructed in November 1981 at the intersection of Municipal Highways No.1 and No.5 in Ichihara City, Chiba Prefecture, for the purpose of preventing traffic accidents.
The application of interlocking blocks at this intersection is proven to produce the following effects, which bring forth a considerable reduction of material damages.
(a) The use of different colours and the design of joints help the drivers to recognize the intersection at an early stage.

(b) The slightly different vibrations resulting from the blocks can make the drivers feel that they are passing through an intersection.

(c) The distance required for complete stop can be reduces compared with that on an asphalt paving.

Furthermore, the follow-up inspections performed on the deformation of the road surface, the displacement of joints, the cracks of blocks, etc. at one-month intervals for the period of six months after the opening of the road to the traffic confirm the fact that the performance of this interlocking block pavement in practical use is more than expected.

1. INTRODUCTION

According to the statistics, more than 50% of traffic accidents occur at intersections or in their neighbourhood. We suppose these accidents are mainly caused by:

(1) the delay in recognizing the prsence of an intersection,

(2) running at an improper approaching speed toward the intersection, and

(3) poor visibility on the sides.

On the other hand, the asphalt pavement used in an intersection where vehicles usually stay for a longer period of time and it must continually support the stresses caused by repeated braking and starting operations, tends to produce rutting. When the drainage is insufficient under the rain, the rain water is accumulated in the rutting and this becomes the cause for one-sided application of a brake or for an accident due to the slippery.
In order to prevent the occurrence of such accidents at intersections, the use of interlocking block pavement has drawn the attention of the parties concerned for the following reasons.

(1) The use of different colours and the design of joints help the drivers to recognize the presence of an intersection in an early stage.

(2) The slightly different vibrations resulting from the blocks can warn the drivers through their senses against the intersection.

(3) This type of pavement prevents the rutting on the road surface.

(4) The skidding resistance can be improved.

This report describes the results of our experiment with the interlocking block pavement built in November 1981 at the intersection of Municipal Highways No.1 and No.5 in Ichihara City, Chiba Prefecture with the aim of confirming whether these effects will be reproduced on the existing road under practical traffic condition.

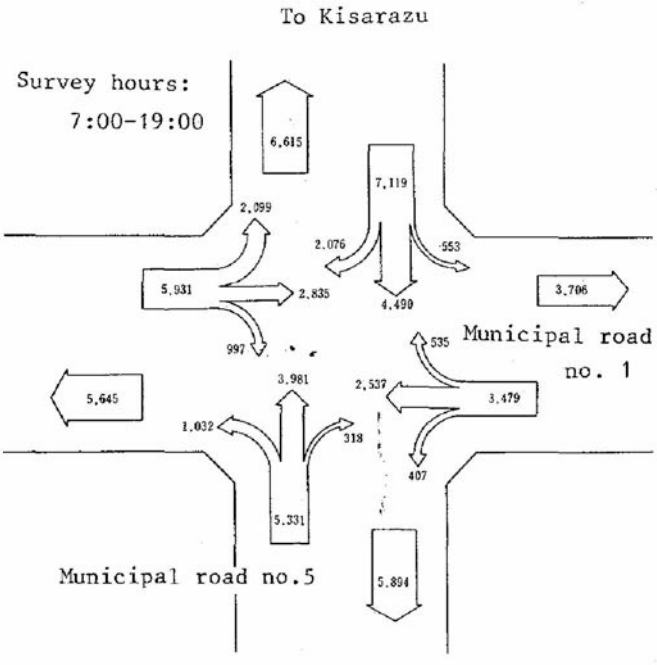


Figure 1: Traffic situation at the intersection

2. ADVANCE SURVEY

Prior to the experiment, the traffic volume, the cross-section of the existing asphalt pavement and the soil of the road bed were studied. The traffic volume for each route is shown in Figure 1 and in Table 1, which also indicates the percentage of heavy vehicles, where as Table 2 gives the number of wheels expressed in the converted 5t wheel load as the basis for the pavement design.

3. PAVEMENT QUALITIES

3.1 Laying

Figure 2 shows the plan of the interlocking block pavements laid for each approaching route toward the intersection.
The interlocking block pavements were built on two lanes of each route, one being the lane for vehicles going strait and the other for the vehicles turning to the right.
Two colours, natural and yellow, were adopted for the blocks. The construction of belt-shaped block pavements in two colours in the transversal direction of the road at the pitches of 2m was designed to give an effect to warn the drivers of the approach of the intersection in advance at the points located far from the intersection. Photo 1 shows how the blocks were laid.
The interlocking blocks are laid in stretcher bond in order to make the best use of the zebra pattern formed with yellow and natural colours.

3.2 Cross-section of pavement

The studies were made to determine whether it would be possible to lay interlocking blocks on the existing sub-base in compliance with "the guideline for asphalt pavement" established by Japan Highway Association. Table 2 indicates the results of these studies as well as the thickness of the existing pavements.
As shown in the table, even when the asphalt pavement is replaced by the interlocking block pavement on routes A1 and B1, the calculated thickness of the pavement is equal or superior to the desired value fixed by the Association while the said thickness is inferior to the desired value on routes A2 and B2. As the result, the sub-base was improved with cement-stabilizing treatment on routes A2 and B2 in order to increase the calculated thickness of the pavement.
Figure 3 shows the cross-sections of the existing pavements and of the interlocking block pavements.

3.3 Shape and qualities of interlocking blocks

Figure 4 gives the shape and the dimensions of the blocks used for the pavements. The blocks of this type are available on the market under the trade name "BONCO".
The water cement ratio in the base concrete used for the blocks is 28.5%, whereas the water cement ratio in the surface mortar is 26%.

Table 1: Results of traffic volume survey:

	Route no.	A1	A2	B1	B2
Actual traffic volume for 12 hours (7:00-19:00)	Heavy vehicles	412	496	444	733
	Light vehicles	4,919	6,623	3,035	5,198
	Total	5,331	7,119	3,479	5,931
	(percentage of heavy vehicles-%)	(7.7)	(7.0)	(42.8)	(12.4)

Table 2: Design condition and thickness of pavement:

	Route	A1	A2	B1	B2
Design conditions	Number of wheels expressed in converted 5t wheel load value	219	262	235	388
	Increase in traffic volume	1.35	1.35	1.35	1.35
	Design CBR value	7.9	25.4	14.7	4.6
Thickness of pavement (cm)	Asphalt pav.	47	36	45	41
	Standard value*	32	26	26	49
	Interlocking block pav.	47	36	45	41

* Japan Highway Association

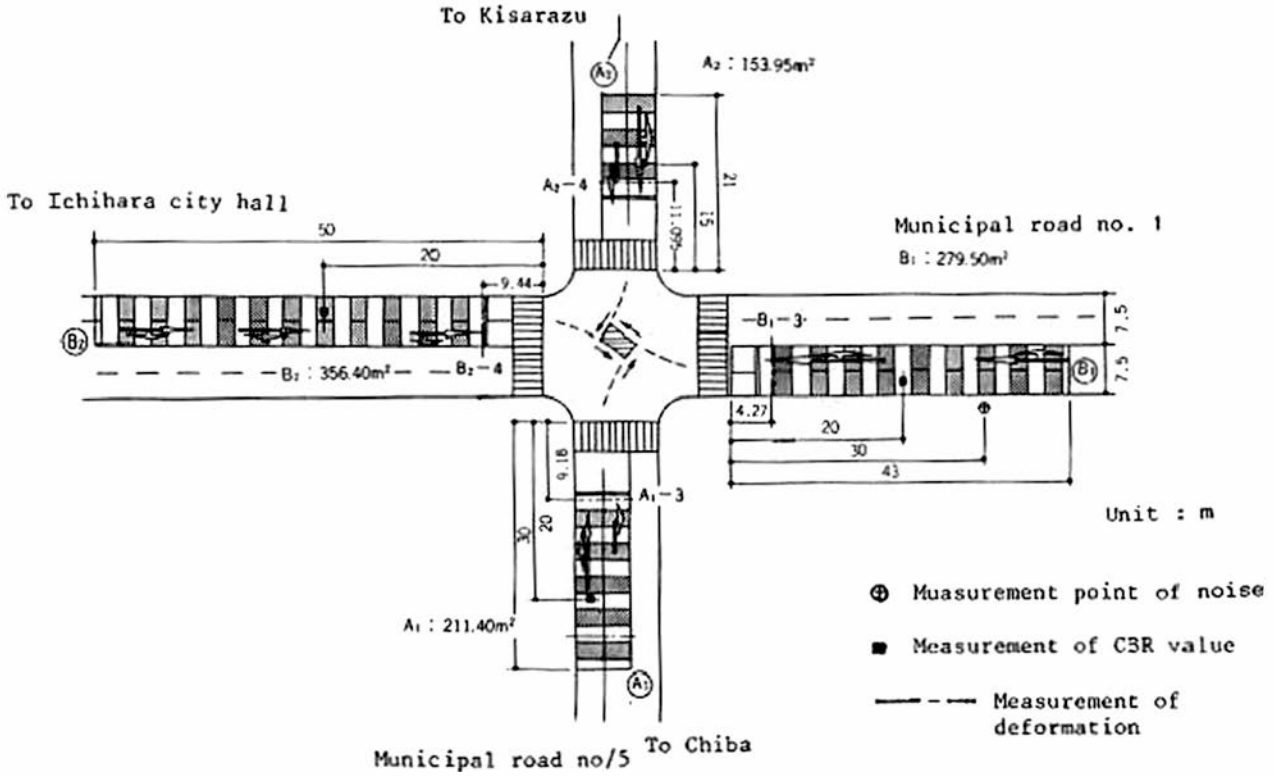


Figure 2: Plan of intersection

An inorganic pigment having good alkali resistance and weather resistance with $Fe_2O_3 \cdot H_2O$ as its main component was employed as the colouring agent.
The production of the blocks was accomplished with the use of Hydromat HP_3VA manufactured by Hess gmbh in West Germany at a vibration frequency of 6,000 rpm and at 45sec./cycle. The blocks were cured indoors for three days after the formation and subsequently for more than 14 days in the open air. When the compressive strength was verified to have attained more than 600 kgf/cm^2, the blocks were transported to the construction site.
Table 3 gives the qualities of the blocks.

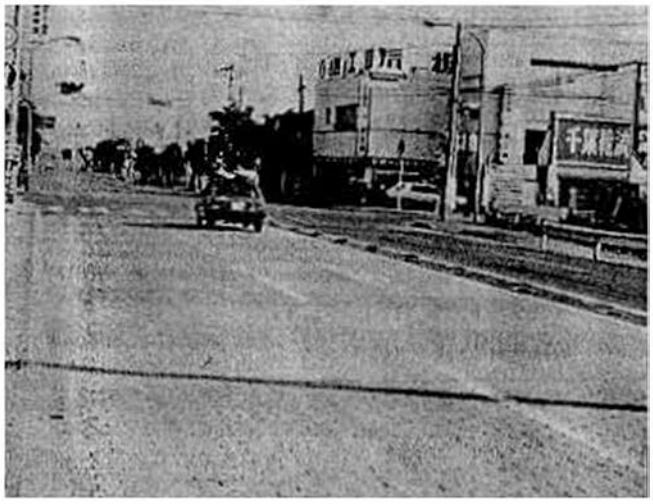


Photo 1 : General view of intersection

4. CONSTRUCTION

4.1 Removal of the existing asphalt pavement

The existing asphalt pavement had been removed by power shovel after having been cut into pieces of the prescribed dimensions with a diamond cutter.

4.2 Road surface

On the routes A1 and B1, the sub-base was built on compacted crusher-run C-20. On the routes A2 and B2, after the removal of the existing sub-base, cement stabilizing treatment was given with grain-size adjusted crushed stones M-30 and with ordinary Portland cement. After this treatment, the unconfined compressive strength attained qu = 30 kg /cm^2.

4.3 Prime coat

In order to prevent the weakening of the road after its finishing due to the rainfall, prime coating was effected by spreading 1 to 2ℓ/m^2 of asphalt emulsion Pk-3 over the surface immediately after a roller compression was completed on the road base.

4.4 Laying of interlocking blocks

i. Sand bed
By using good quality river sand with a

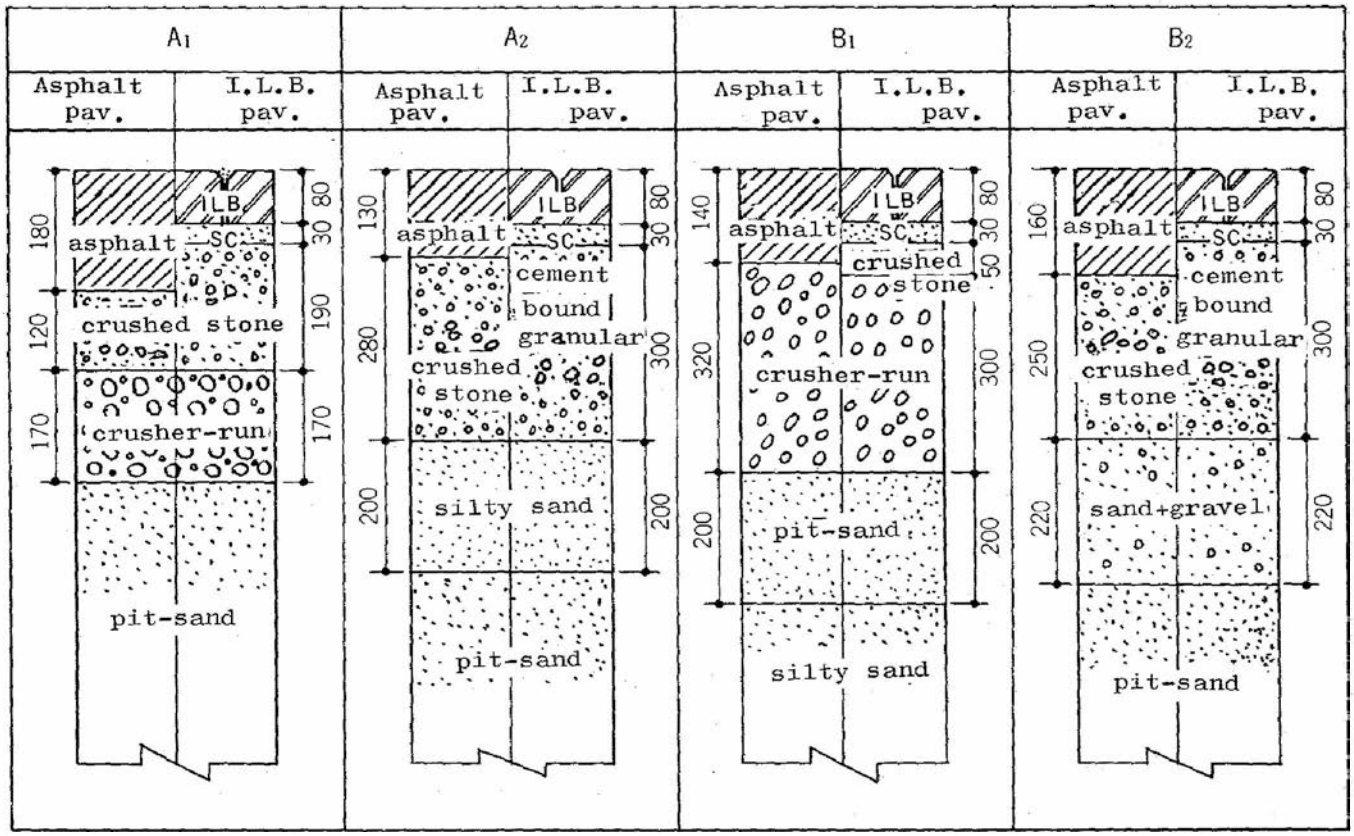


Figure 3: Comparison between existing asphalt pav. and I.L.B. pavement

Unit : mm

specific gravity of 2.52, a coefficient of water absorption of 3.68% and FM = 2.87, a sand bed was built so as to have a layer of 30mm±10mm in thickness after two operations of compressions given with a roller.

ii) Laying of blocks

Concrete blocks were placed one by one with hands to have the joint gaps of about 2 to 3mm between the blocks. The river sand used to fill the gaps had a specific gravity of 2.54, a coefficient of water absorption of 3.30% and FM=1.90.

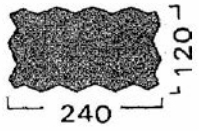
The compression was applied on the surface at a vibration frequency of 4,500rpm, and at the load of 20,000kg with a vibrating loading plate of 600cm^2, which was applied twice longitudinally and twice horizontally at the speed of 18m/min.

5. THE PERFORMANCE OF THE PAVEMENT

5.1 Investigations on the unevenness in the transversal direction

The changes in unevenness on the paved surface were measured at one-month intervals after the opening of the road to the traffic with the use of a profile-meter.

Figure 5 shows the results of the measurements. The deformation stopped at three months after the construction and was observed to have approximately the maximum value of 13mm.



Unit :mm

Figure 4: Interlocking brock "BONCO"

5.2 Measurements of stopping distances with an actual vehicle

The stopping distances were measured with the use of an experimental vehicle on the interlocking block pavement surface on the route B2 and also on the asphalt pavement surface.

i) Test conditions

Testing speeds:	20, 40, 60 km/h
Number of drivers:	Three
Surface conditions:	Dry surface and Wet surface
Experimental vehicle:	Toyota Crown Light Van
Exhaust disp:	1,996cc
Weight:	1,480kg
Tyre:	6.95 - 14.0, 8ply, bias type rib tyres
Number of tests performed:	Six



Photo 2 : Mesuring conditions of stopping distance



Photo 3 : High speed VTR HSV-200 and camera

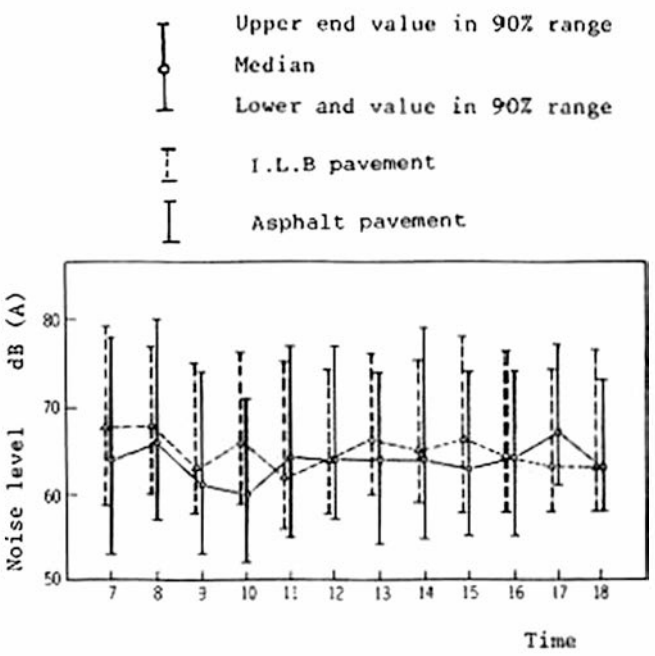


Figure 6: Measued values of noise level

5.4 Displacement of joints

The displacement of the joints of the blocks caused by the braking and the acceleration of vehicles was completely settled at about one month after the opening of the road to the traffic.

The maximum displacement of the joints recorded at a distance of 30m to 50m from the intersection was 28mm (0.4% of the width), but the displacement of this scale does not present any obstacles in practice as dust and sand can fill the gaps effectively.

We suppose that this displacement of joints was due to the stretcher bond used for laying the blocks.

5.3 Noise

The level of noise on the surface was measured at the point indicated in Figure 2 with a combined use of a vibration sound level meter and a high-speed level recorder as stipulated by JIS C-15110.

Figure 6 shows the results of the measurements. As the average noise level recorded was 64.8 db and σ=1.90 on the interlocking block pavement and 63.7 db and σ=1.80 on the asphalt pavement, there was no substantial difference between these two.

5.5 Cracks of the blocks

An inspection was carried out at six months after the opening of the road to the traffic to determine the degree of cracks of the blocks including the breakage of the angles. After the inspection, we found that the percentage of cracks of more than 1cm observed on the angles was 0.17% of the whole.

This breakage did not produce any adverse effect to reduce the performance or to present any hindrance to the traffic.

6. EFFECT OF INTERLOCKING BLOCKS

The occurrence of material damages caused by right-turn accidents, rear-end collisions, etc. was greatly reduced after the introduction of interlocking block pavement as shown in Table 5.

The questionnaires distributed among the drivers give the following effects of interlocking block pavement.

i) Improvement of braking effect.

ii) Amelioration of visible recognition.

iii) Awakening of the attention of the drivers due to the difference of feeling while passing on from an asphalt pavement to an interlocking block pavement.

Table 5: Number of traffic accidents

Period / Type	June-Nov. 1981	Dec.1981 - May 1982	Variation
Death	1	0	-1
Injury	0	1	+1
Material damage	10	1	-9

7. CONCLUSION

The results obtained through the experimental construction of interlocking block pavement at the intersection for the improvement of traffic safety revial the following facts.

i) Transversal deformation stopped at three months after the road to the traffic within the maximum value of 13mm.

ii) The stopping distances on a wet surface were considerably reduced in comparison with the performance on an asphalt pavement.

iii) The level of noise was almost at the same as on the surface of asphalt pavement.

iv) The displacement of the joints was about 28mm at the maximum, which represents about 0.4% of the width.

v) The percentage of failure of the blocks was 0.17% at six months after the construction.

vi) Material damages were greatly reduced.

Fallowing up closely the changes occurring on the surface of the pavement as well as the transition of the number of accidents, we will continue our efforts to confirm further high effectiveness of the interlocking block pavement when used as the facilities to improve traffic safety at intersections.