THE FIRST INTERBLOC PAVING RURAL (INTERCITY) ROAD SECTION IN INDONESIA

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ABSTRACT

The application of interlocking concrete paving blocks (hereafter called interbloc) for pavements in Indonesia commenced in 1977. Proper design methods and acceptable construction practice were only introduced a few years ago. Improper design methods and poor construction practice had, in a few cases, led to poor performance of interbloc paving. However, the majority of interbloc pavements in Indonesia have stood the test of time: a bus terminal in Jakarta has been performing well, without maintenance, since 1978. The successful performance of interbloc paving has resulted in many people seeing it as a viable alternative to asphalt paving. Indonesia still imports 40 per cent of its required asphalt and faces a drop in income due to the low oil prices. At the same time she has an over-supply of locally-produced cement. Therefore the Government, through the Directorate General of Highways (DGH), has been promoting the use of cement for road building. However, until recently, cement and concret roads have been an unfamiliar phenomenon. At the same time, there have been little, if any, technical records of interbloc roads that have been built. Therefore, when an opportunity arose to build a new road re-alignment section as part of the rural (intercity) road near Jakarta, the DGH opted to build a new concrete road which was divided into three sections of reinforced concrete, interbloc and unreinforced concrete. This paper discusses and evaluates various aspects of the interbloc road section.

INTRODUCTION

Applications of interbloc pavements in Indonesia range from sidewalks, parking areas, local roads, industrial pavements, bus terminals and container yards. All have specific traffic loads, either heavy axles or light vehicles with limited frequencies. The uses of interbloc were seen as specific and not for any type of traffic using public roads.

Fortunately, this image has changed, thanks to the use of interbloc on arterial and rural roads to the south of Jakarta. The performance of the interbloc rural road section was outstanding and better than expected. This road is loacted 35 km south-east of Jakarta and is part of the rural road connecting Citeureup and Bekasi: towns south and east of Jakarta. There was a need to re-align the old road which was too close to the Domestic Satellite Communication System Earth Station of Palapa. The new section was to be 1 km long. Instead of constructing the same asphlt pavement as before, new concrete road sections were introduced as part of a desire to study the behaviour of different types of concrete and interbloc pavements. The road was divided into three sub-sections: reinforced concrete, interbloc and unreinforced concrete.

Both concrete pavements sit in straight alignment, but the interbloc section is on a curved alignment. The traffic is two-directional. It took six months to construct the road, which was opened to traffic in March 1986 without any traffic limits on the amount or type of vehicles or vehicle speed. The road was constructed by the Department of Public Works, Directorate General of Highways (Bina Marga).

ENGINEERING DESIGN

PAVEMENT STRUCTURE

The interbloc pavement section was constructed on two types of sub-base as shown in Figs 1 and 2. The kerb was reinforced concrete, which was located next to a sandy-gravel shoulder compacted to 100 per cent according to AASHTO T.99 (Fig. 3), whilst joints were placed between the interbloc section and the rigid section (Fig. 4).

MATERIALS SPECIFICATION

The subgrade was the existing soil which was cut to the specified level. The basecourse was Class B crushed stone required to meet the Bina Marga

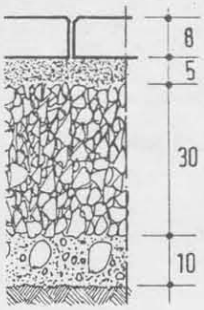


Fig. 1 - Pavement structure between stations 0+302 and 0+352

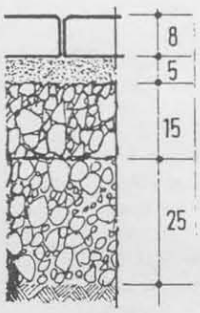


Fig. 2 - Pavement structure between stations 0+352 and 0+483

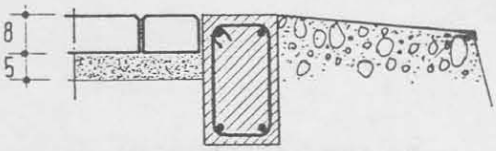


Fig. 3 - Kerb and shoulder

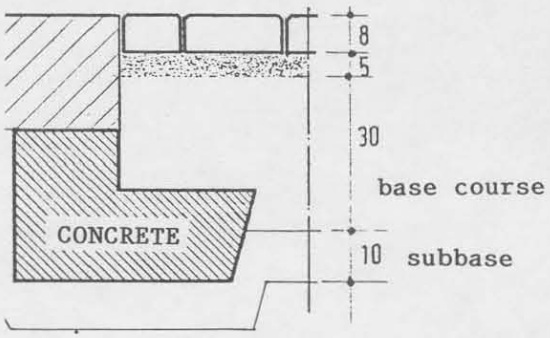


Fig. 4 - Junction between interbloc and rigid pavements

specification given in Table I. The Class C sub-base material was a well-graded sand-gravel required to meet the Bina Marga specification given in Table I, whilst the limestone sub-base was supplied 'as is' from a quarry. The specified grading of the bedding sand is also shown in Table I. The jointing sand was required to have a maximum size of 1.2 mm.

TABLE I

MATERIALS SPECIFICATION

Sieve Sizes		Basecourse Spec.	Sand-Gravel Sub-Base		Limestone Sub-Base	Bedding Sand		
AS (mm)	AST,		Spec.	Actual	Actual	Spec.	Rejected	Final
37.5	1½"	100	100 max.			100		
26.5	1"	60-100		76	81			
19.0	3/4"	55-85		55	75			
13.2	½"			29			100	
9.5	3/8"			22	63	100	96	100
4.75	No. 4	35-60		14	51	95-100	90	92
2.36	No. 7					80-100	83	68
	No. 10	25-50	80 max.		10	45		
1.18	No. 14					50-58	73	45
0.600	No. 25					25-60		
	No. 40	15-30		5	38			
0.300	No. 52					10-30	46	5
0.150	No.100					5-15	40	4
0.075	No. 200	8-15	15 min.		3	30	0-10	382
Min. CC (%)			25					
Max. LL		25						
PI		4-8						
Min. SE (%)		50						
Max. Abr.Loss (%)			40	19.3				
Min. MDD (t/m^3)			2.0					

The characteristic compressive strength of the interbloc was required to be a minimum of 40 MPa. Rectangular shaped interbloc was used, laid in the herringbone pattern at 45 degrees to the direction of traffic.

CONSTRUCTION SPECIFICATION

The subgrade was compacted to 95 per cent of AASHTO T-180, whilst the sub-base and basecourse were compacted to 100 per cent of the same specification. The tolerance on the final level of the basecourse was 10 mm. The bedding sand was required to be spread at very low moisture content or nearly dry, whilst the blocks and the filling sand were to be laid in accordance with the manufacturer's procedure.

STRUCTURAL CALCULATION

According to laboratory test results on the ASSHTO T-180 modified proctor, the average CBR of the soil in the soaked condition at 95 per cent density was 8.1 (soil support value 5.5).

The structural number of the interbloc and the bedding sand layer was assumed equivalent to an asphalt hotmix layer.

I. SN = (10x0.11) + (30x0.13) + (13x0.40) = 10.2
Regional factor = 2.5 (rainy, curved alignment, heavy traffic)
Surface index at the end of the pavement life = 2.0
Surface index at the start of the pavement life = 3.9-3.5
SN = 8.7
Average daily traffic = 950
Standard axle of 8.2 t

II. SN = (25x0.13) + (15x0.13) + (13x0.14) = 10.4
Other conditions the same as in I
SN = 8.8
Average daily traffic = 1000
Standard axle of 8.2 t

Thus the interbloc section was designed to be capable of carrying an average of 1000 standard axles per day over a ten-year design life, i.e. 365 x 10 x 1000 = 3,650,000 repetitions per lane.

ALIGNMENT DESIGN

Details of the horizontal alignment, and a plan view of the pavements, are shown in Fig. 5.

CONSTRUCTION

Construction took place during the rainy season late in 1985 and early in 1986. Heavy rainfall is common in that region and some delays in construction occurred. Initially construction had been scheduled to commence in mid-1985 but delays occurred owing to difficulties in land acquisition in the southern part of the section.

SUBGRADE, SUB-BASE AND BASECOURSE LAYERS

The condition of the subgrade was not too bad because side ditches had been constructed during grading work (Fig. 6). However, the over-saturated lateritic soil took some time to dry during sunny periods. Plastic covers were used when it rained (Fig. 7).

Another delay in construction was caused by a problem with supply of the limestone sub-base, which was not regular. As a result, the grading of

Horizontal :

PI station	0+410.574	meters
distance d	294.340	meters
design speed	40	km/hour
angle Δ	76 46'54"	
radius R	100	meters
straight length ls	60	meters
θs	17.891'	
tangent Ts	110.328	meters
Es	29.492	meters
curve length Lc	74.008	meters
total length L	194.008	meters
superelevation e	0.050	

Vertical : + 0.46% longitudinal slope.

A new road realignment away from the Satelite Earth Station was divided into 3 subsections :

Section I : reinforced concrete pavement.
Section II : interbloc.
Section III : plain concrete pavement.

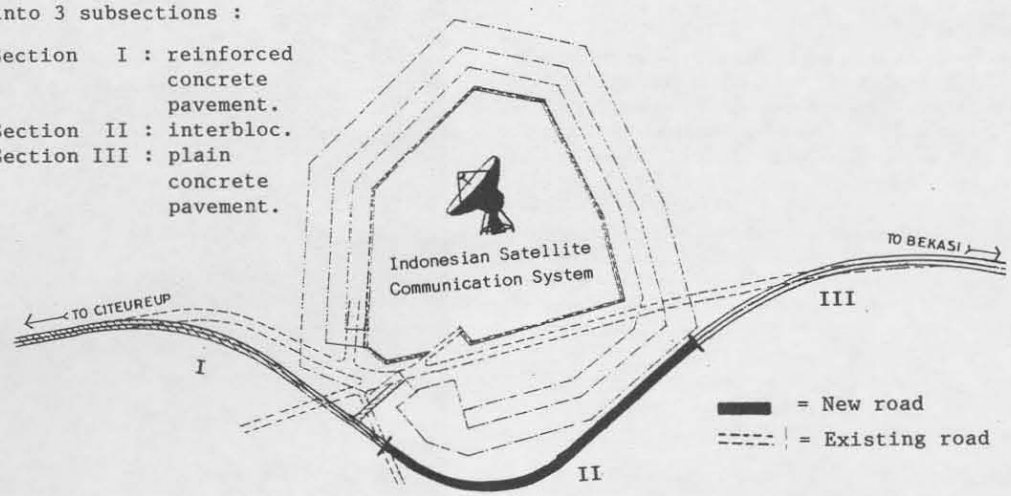


Fig. 5 - Plan and horizontal alignment of pavements



Fig. 6 - Cut subgrade at the curved alignment

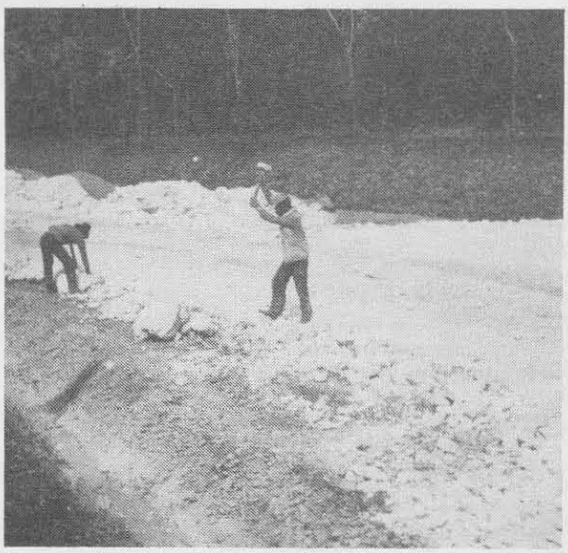


Fig. 8 - Limestone boulders that had to be crushed

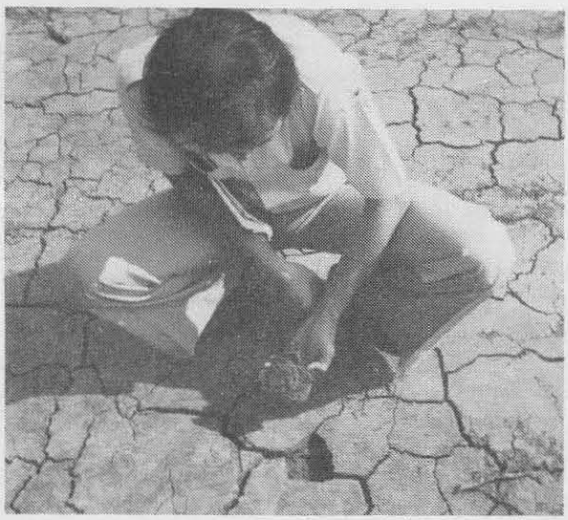


Fig. 7 - Highly plastic subgrade drying out



Fig. 9 - Fine-grained limestone material

the sub-base was not as good as expected, being gap graded. There was too much fine-grained and over-size material, but not enough medium-sized material (Figs 8 and 9). The non-plastic limestone was surprisingly vulnerable to the ingress of water, which had to be dried off.

The sand-gravel sub-base was a river quarry material (Fig. 10). Some segregation of the material occurred during spreading (Fig. 11). This was not a serious problem, because the layer was compacted relatively quickly due to the fact that material stock was ready nearby. However, it was decided that placement of the upper basecourse layer should proceed as quickly as possible to prevent the sand-gravel sub-base material becoming disturbed.

The quality of the basecourse material was good, being made up of well-graded crushed stone from a crushing plant (Fig. 12). No problems

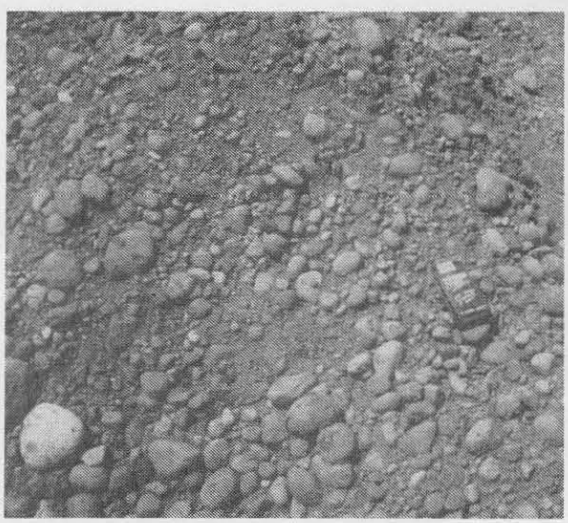


Fig. 10 - Stock of sand-gravel material



Fig. 11 - Some segregation of the sub-base material



Fig. 12 - Crushed stone base stockpile



Fig. 13 - Level correction by grader

were encountered during construction. However, there were some problems meeting the specified tolerances of the finished level. Corrections took place many times because the scissor of the grader scraped the already dense layer inaccurately (Figs 13 and 14).

KERBING

The cast-in-place kerb was constructed after the basecourse was completed (Fig. 15). Consequently it was necessary to dig at the edges of the layer alongside the road, with the result that the foundation was loose. Only a few centimetres of the kerb was embedded to the pavement with its free-standing form. Therefore the stability of the kerb was questionable (Fig. 16). Later the shoulder material was added to the surface level of the kerb. It was expected that the kerb would be sufficiently strong to restrain the horizontal force.



Fig. 14 - Segregation at the junction and uneveness caused by poor patching

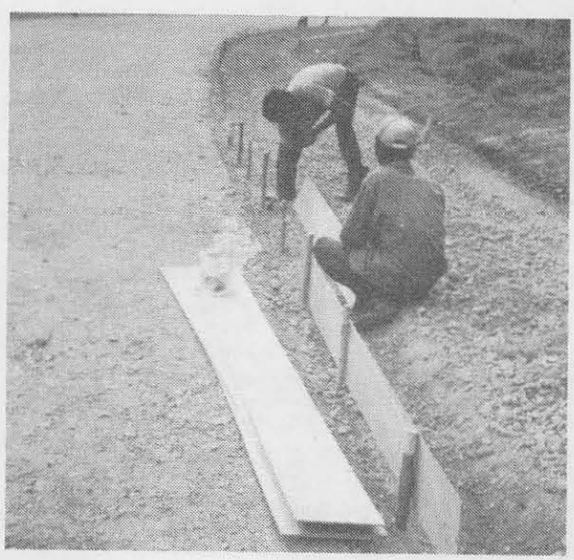


Fig. 15 - Formwork for kerbing

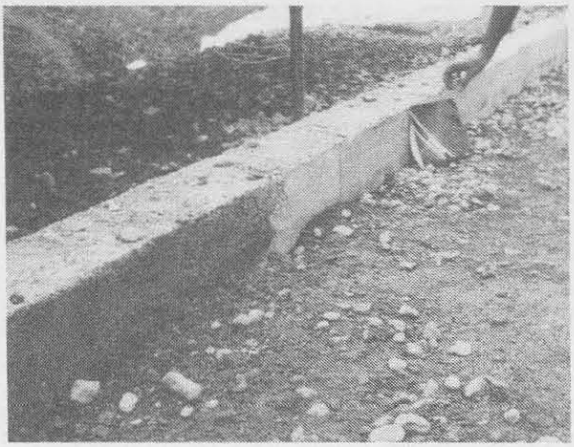


Fig. 16 - Basecourse finished level needing to be heightened

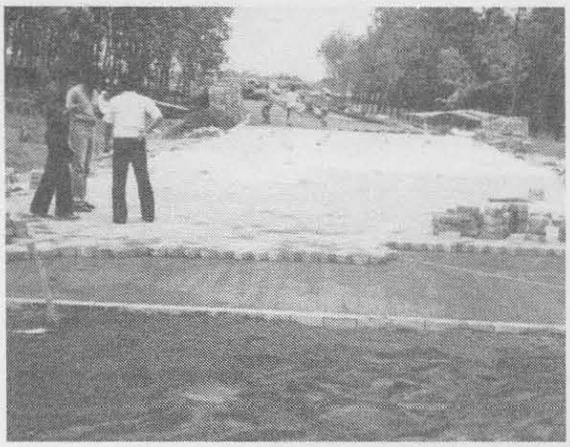


Fig. 18 - Dirty sand must be replaced with clean sand

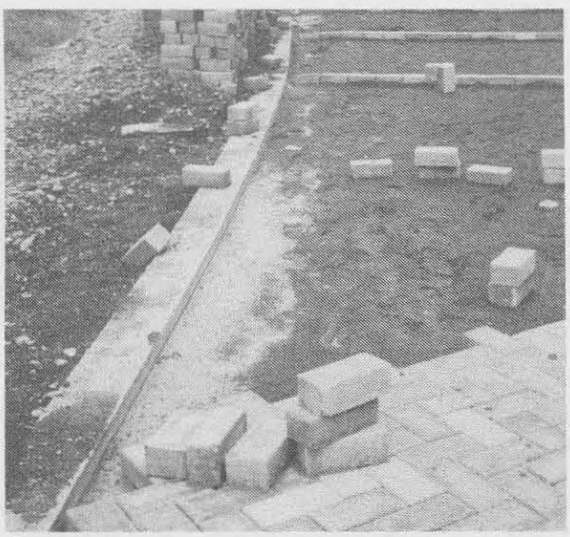


Fig. 17 - Very high clay content of the bedding sand



Fig. 19 - Cutting of blocks

BEDDING SAND

Because of the slightly uneven level of the basecourse surface, the sand bedding thickness varied. At locations were the sand bedding was thicker, differential settlement was expected, reflected later as immediate rutting in the surface of the interbloc. Worse still, the sand bedding could fill the basecourse at locations where it was open graded. These two problems usually determine the extent of the uneveness of the interbloc surface.

Another problem somewhat perennial in Jakarta is the difficulty of getting coarse and clean sand during the rainy season. Since sand pits around Jakarta hardly have the proper equipment for processing good and clean sand, rains often bring mud and clay into the sand. The fines content of such sands could reach up to 40 per cent of the total weight.

Such dirty sand was used on the interbloc project, resulting in pumping of the sand through the joints. When this pumping was observed, every effort was made to replace the dirty sand with clean, coarse and sharp sand.

INTERBLOC

Rains often interrupted the block laying. Plastic covers were used, but some water still found its way into the unfilled joints. Laying took only a few days because there were many block layers. It was thought that rectangular shaped blocks were easier to place than other shapes.

Normally experienced and skilled block layers should be able to lay paving to a 2 mm joint width. In this project many joint had only a 1 mm width (Fig. 20). The same material as the bedding sand was used to fill the joints. This, of course, was ineffective, with many joints left unfilled or only partially filled. This lessened the interlocking effect between the blocks. A correction of this somewhat dangerous situation was made later.

Plate vibrators were used to compace the interbloc surface (Fig. 21). At least ten passes of a pneumatic-tyred roller were also applied as proof rolling (Fig. 22). This tended to promote interlocking and more uniform or even pre-settlement.



Fig. 20 - Joint size too small to allow sand filler to get in



Fig. 21 - Compaction with plate vibrator

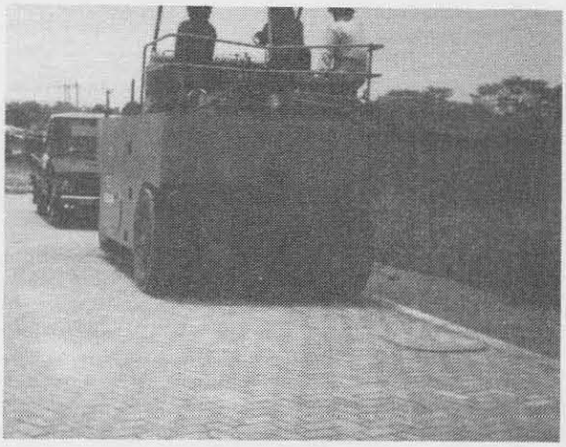


Fig. 22 - Proof rolling with pneumatic-tyred roller

QUALITY CONTROL

The results of field and laboratory testing carried out on the existing soil subgrade, the sand-gravel and limestone sub-bases, and the crushed stone basecourse are given in Table 2. The gradings of these materials, and of the bedding sand, are given in Table I along with the specified values discussed earlier. Sieve analyses could not be performed on the limestone sub-base because of the oversize boulders present. The grading given in Table I was found after these boulders were removed. The first type of sand was rejected because of its too high clay and fines content. A good, clean sand was later brought in (see Table I). In the beginning the same coarse material as the sand bedding was used for filler, sieved with a 1.2 mm sieve opening.

TABLE 2

RESULTS OF FIELD AND LABORATORY TESTING

Material	In Situ Tests			Laboratory Tests						
	m/c (%)	DDR (%)	CBR (%)	OMC (%)	CBR (%)	LL (%)	PL (%)	PI (%)	SE	Abr. (%)
Subgrade	27.8	101		32.5	10.1*	92	52	40		
	40.5	95				83	45	38		
	28.7	107				104	45	59		
Sand/Gravel Sub-Base	7.7	104			66*	28	16	11	27.5	19.3
Limestone Sub-Base	18.5				33#	24	19	5		
Crushed Stone Basecourse	4.1	101								
	4.2	102								
	4.0	100								
(after rain stopped)	20.5	65								
	18.8	65								
	16.1	75								
Bedding Sand	24.5									

m/c - moisture content; DDR - dry density ratio; SE - sand equivalency reading Abr- abrasion;

* 95% modified AASHTO T.180, unsoaked.
\# 100% modified AASHTO T.180, soaked.

Random samples of interbloc were tested for compressive strength, and the results are shown in Table 3. The characteristic compressive strength (39.3 MPa) is not reliable because there were not enough samples tested. Upon inspecting the individual block strength, one remains optimistic that the strength would not deviate too far from 40 MPa.

TABLE 3

COMPRESSIVE STRENGTH TESTING OF BLOCKS

Compressive Strength (MPa)	Mean	Deviation	Square
51.3	46.7	+4.60	21.16
42.0		-4.67	21.81
51.5		+4.80	23.04
45.6		-1.07	1.14
43.0		-3.64	13.25

Standard deviation = (80.4/4) = 4.48

Characteristic Compressive Strength = 46.7 - 1.64(4.48)
= 39.4 MPa

SUITABILITY OF INTERBLOC CONSTRUCTION METHOD IN INDONESIA

Interbloc road construction does not need to employ sophisticated methods or equipment. The construction of the sub-layers is the same as with other types of pavement. Interbloc laying is only a minor part of the total process. One of the more prominent difficulties is to achieve the specified basecourse finished level, within the tolerance. Failing that, the bedding sand will become a correcting level, causing varying thicknesses of the sand layer. This promotes minor differential settlement in the form of an uneven interbloc pavement surface.

Naturally, interbloc paving is very labour intensive. The only equipment needed are plate vibrators and cutters. Correcting mistakes is much easier with interbloc paving than with any other types of pavement. For instance, there was a case where the sand bedding had to be replaced with a freash supply after the blocks had been placed. This was quite easily done. It only added a minor additional labour cost plus a few days delay. The cost of laying the blocks in Indonesia is approximately U.S.$1 per square metre.

For a country like Indonesia, with an abundance of cheap labour, such a labour intensive technology employed in making interbloc pavements must be very attractive and competitive.

TRAFFIC RECORD

Traffic counting was done for a period of several days three months after the road was opened to traffic. The average number of vehicles passing in one day (24 hours) is shown in Table 4, and typical vehicles using the pavement are shown in Figs 23-28.

TABLE 4

TRAFFIC RECORD

Vehicle Type	No./Day	Equivalence Factor	ESAs
Passenger car and jeep	2060	0.0004	0.82
pickup & microbus	1152	0.0038	4.38
bus	323	0.31	100.13
light truck	237	0.31	73.47
medium truck	751	0.50	375.50
single axle truck and tanker	1024	0.98	1003.52
tandem axle truck	62	1.12	69.44
single axle truck with rear cart	522	1.00	522.00
tandem axle truck with rear cart	5	1.36	6.80
bulk cement truck	112	2.19	245.28
single axle semi-trailer	2	1.91	3.82
tandem axle semi-trailer	14	1.81	25.34
double tandem axle semi-trailer	2	2.19	4.38
coal trailer truck	150	4.18	627.00

Total daily two-directional traffic = 3061.66 ESAs

Using the data in Table 4, and taking into account a traffic growth factor of 5 per cent (very probable for a road serving an industrial region):

Correction number = $\frac{(1+0.05)^{10} - 1}{10 \times 0.05}$ = 1.25778

Two-directional average daily traffic = 1.25778 x 3061.66 = 3851 standard axles

One directional traffic = 60% x 3851 = 2311 standard axles.

It was found that the actual traffic exceeded the design estimate. Hence the expected service life would be less than the design life.

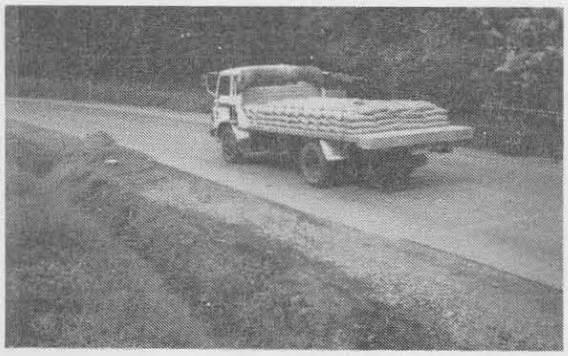


Fig. 23 - Cement truck: GVW = 12 t approx.



Fig. 24 - Goods truck: GVW = 25 t approx.



Fig. 25 - Cement truck: GVW = 27 t approx.



Fig. 26 - Bulk cement truck: GVW = 22 t approx.



Fig. 27 - Bulk cement truck: GVW = 27 t approx.



Fig. 28 - Coal container truck: GVW = 44 t approx.

PAVEMENT PERFORMANCE

RIDING COMFORT

The riding comfort on the interbloc pavement was surprisingly good. Even at a speed of 60-70 km/h the ride was quite smooth and without vibration, which had been expected to some degree. In fact, the riding comfort on the interbloc tended to be somewhat better than that on the rigid pavement. During the first three months of its service life there had been no noticeable change or deterioration of the riding comfort on the interbloc road.

There was almost no abrupt change in the steering wheel when crossing from the rigid to the interbloc pavement and vice versa (Figs 29 and 30). There was a slight settlement of about 10 mm on the interbloc surface at its junction with the rigid pavement. No more settlement due to compaction of the bedding sand is expected, except for possible settlement of the lower layers or the subgrade. This means that interlocking has been reached (see Figs 31 and 32).

Elastic deflections were also negligible because the pavement bearing capacity is sufficient (see Fig. 33)

Three months after opening, traffic surveying work using a water level was carried out on the interbloc section to determine the actual surface uneveness. The designed and as-built profiles were not physically measured, but

estimated accordingly. Rutting had occurred at point P2 and P17 (see Figs 34-36). This had been expected, as vehicles accelerate and decelerate when leaving and approaching the curve (e.g. see Fig. 30). The maximum rutting was less than 20 mm.



Fig. 29 - North junction



Fig. 30 - South junction was given special transition band on the concrete pavement surface

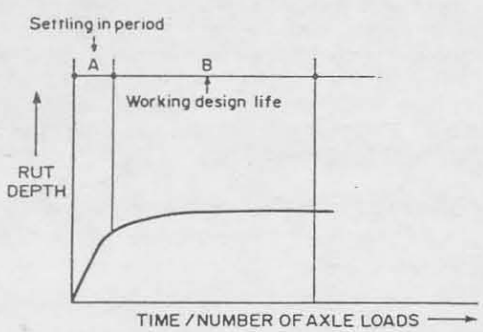


Fig. 31 - Equilibrium condition as described by Clifford (1984)



Fig. 32 - Interlocking seemed effective because the pull-out force required was large (no actual measurements taken). Note the cemented sand filler: sand bedding thickness less than 20 mm (dense)





Fig. 33 - One month after opening to traffic there was no significant deflection

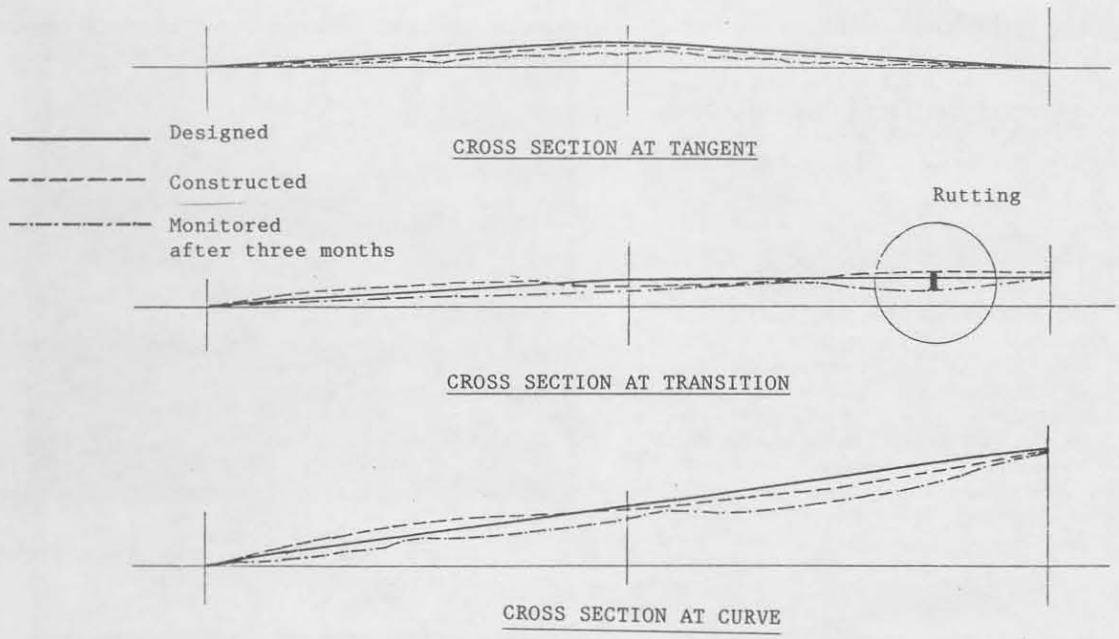


Fig. 34 - Profile measurements: designed, 'as built', and three months later. This sketch is only to estimate the probable surface uneveness that might have happened (there were no measurements and scales used)

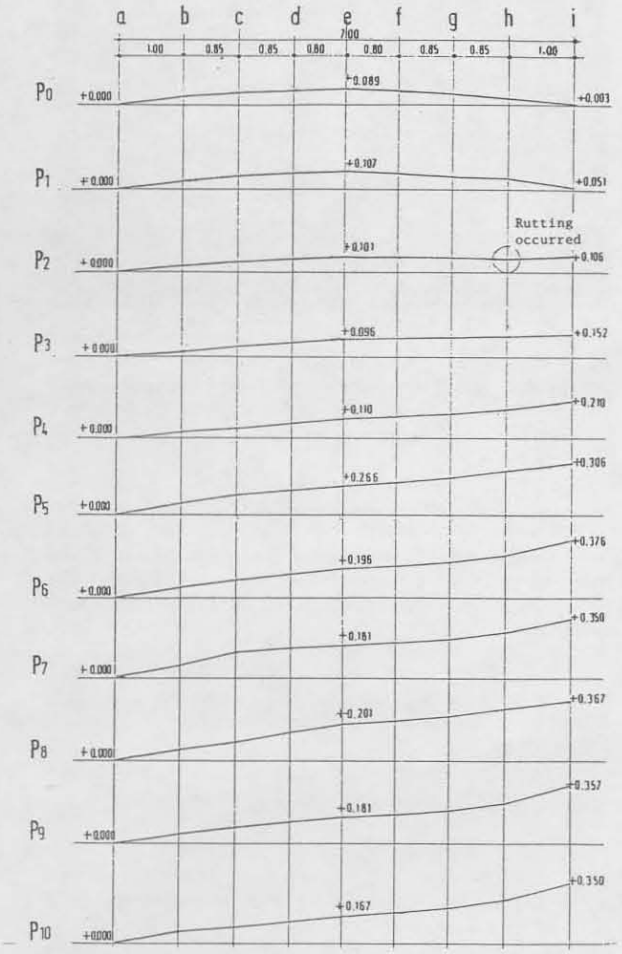


Fig. 35 - Actual cross-profiles of the interbloc road surface measured about three months after opening to traffic at 10 m intervals (stations 0+302 to 0+402)

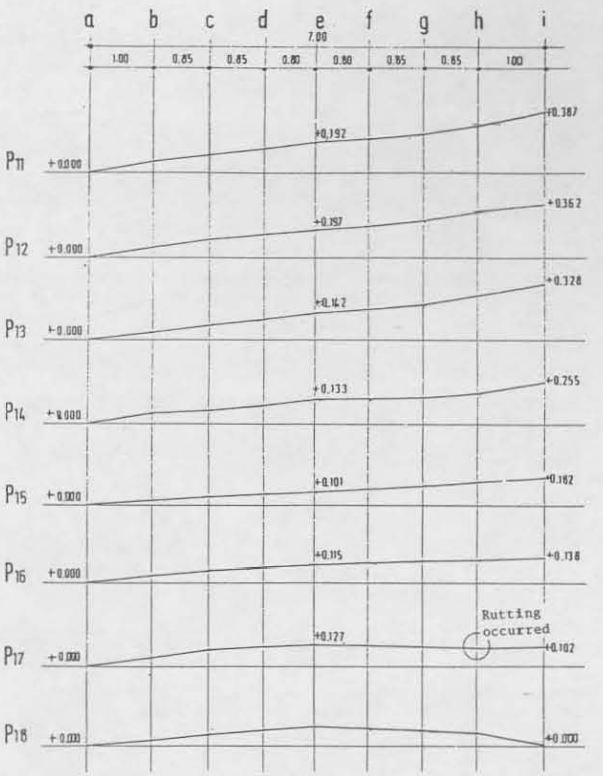


Fig. 36 - Actual cross-profiles of the interbloc road surface measured about three months after opening to traffic at 10 m intervals (stations 0+412 to 0+482)

BLOCK SURFACE

The interbloc surface remained unchanged during the first three months of trafficking; there was very little spalling (Fig. 37). Visual observation did not show any noticeable change in the surface skid resistance (Fig. 38).

There was practically no excessive deformation on the interbloc pavement, except at some locations close to the inner curved edge, where the centrifugal force of the traffic had shifted the kerb some tens of millimetres away from the pavement (Fig. 39). This phenomenon has caused creeping and made the joint widths much larger, up to 20 mm (see Fig. 40). When such large joint widths were first discovered, there was serious worry that it would ruin the interbloc pavement. No treatment was given other than constantly filling the joints with sand. Months later, there was no sign of pavement failure.



Fig. 39 - Kerb shifted beyond the carriageway, causing enlargement of block joints



Fig. 37 - Spalling on very rare occasions. Note the block surface: dense but relatively rough (one month old)

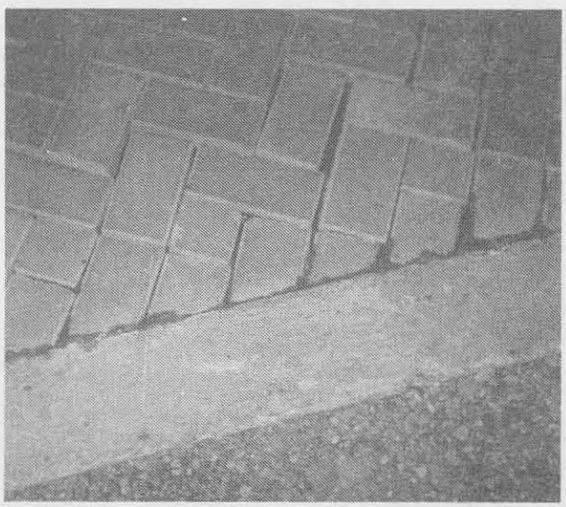


Fig. 40 - An extreme condition when sand filler was sucked out and the blocks shifted and somewhat rotated

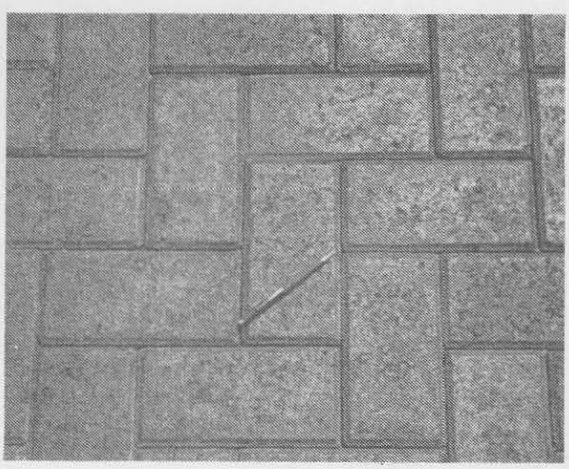


Fig. 38 - Block chamfer was very good and effective. Note the block surface: rough and shiny (three months old)

Horizontal creeping did occur at the curved alignment where the traffic speed up to 70 km/h was much higher than the design speed of 40 km/h (see Fig. 41). With heavy axle loads, the damaging effect was multiplied, sufficient to move some blocks.

There was some minor rutting observed in some loactions (see Fig. 42). This was probably caused by unsound compaction of the lower layers.

EVALUATION OF BEDDING SAND AND BASECOURSE

After three months trafficking of the pavement, field density testing was performed on the sub-layers in the loaction of the wheelpaths. This involved the removal of blocks at these locations. Density testing (using the sand replacement test) was carried out on the sand plus basecourse layers, and the basecourse layer (there is not as yet a specific method for testing the density of the sand layer alone). The tests are described in Figs 43-45.



Fig. 41 - Horizontal creep at the curved road station



Fig. 43 - Density testing: a hammer was needed to dig out the bedding sand and the basecourse. It was so hard that some stones were broken.



Fig. 42 - Minor rutting at the tangent (straight road section)



Fig. 44 - Sand cone test: note the broken stone grains

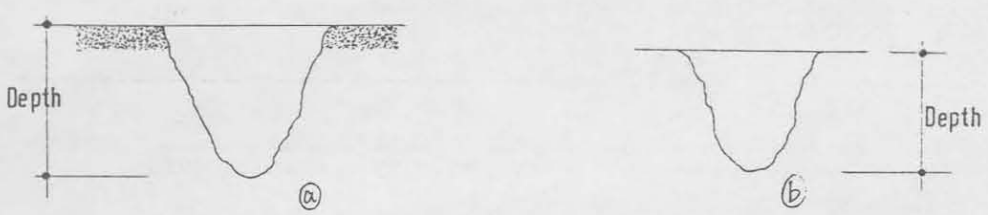


Fig. 45 - Two kinds of sand cone tests were applied at each location: one including the bedding sand layer, the other the basecourse alone

The results are shown in Table 5. It had been determined in the laboratory that the maximum modified dry density, according to AASHTO T-180 (100%) was 2.158 t/m^3 for the basecourse and 1.733 t/m^3 for the bedding sand. It was expected that the extra densification at the tangent (near the junction) was caused by the compacting action when vehicles bumped down and braked from the rigid pavement to the interbloc pavement. The lower density at the curve was caused by some water infiltration and some pumping that occurred early in the life of the pavement when there were still heavy rains. The 2 m distance from the edge also indicated less wheel tracks.

OVERALL PERFORMANCE

Interviews with drivers of a variety of vehicles indicated that they had a high opinion of the riding comfort of the interbloc pavement. The once popular preconception that interbloc paving was not suitable for medium speed (up to 70 km/h) traffic is now changed. Many drivers felt so comfortable driving on the smooth interbloc section that they tended to accelerate their vehicles and then had to suddenly brake when taking on the sharp curve a few metres in front of them.

TREATMENT AND MAINTENANCE

Interbloc paving is known to need very little maintenance; if any is needed it is easy and cheap. This has been demonstrated by this project.

As mentioned earlier, the joint widths between the blocks were originally small - 1 to 2 mm - and the sand used to fill the joints was the same material as that used for the bedding sand. This caused a significant proportion of the joints to be only partly or superficially filled with sand. Under the action of traffic travelling at 70 km/h, the sand in the top of the joints tended to drop down or be sucked out. A serious situation developed where many of the joints had no sand in them.

It was realised that it had been a serious mistake to use the same sand to fill the joints as the bedding sand. In fact, the sand used as filler must have a fines content of about 10 per cent, so that it can act as a binder in order to promote friction and sealing and hence the interlocking effect. Therefore, a remedy was taken immediately. Crusher dust material was used to keep filling in the empty or partially-filled joints. It was difficult to apply the fine fine crusher dust while traffic travelling at 70 km/h was using the pavement (see Fig. 46).



Fig. 46 - Filling the joints with fine crusher dust while traffic is passing

Despite the presence of unfilled joints in some locations, with the result that some blocks came into direct contact with each other, there was surprisingly little breakage or spalling (less than 1 per cent). Replacing the broken blocks was easy (Fig. 47).

TABLE 5

FIELD DENSITY RESULTS ON BASECOURSE

Test No.	Position		Depth (mm)	Moisture Content (%)	Dry Density (t/m^3)	Relative Density (%)
1	2 m from inner kerb at curve	a	120	9.20	2.14	
		b	130	5.20	2.15	99.7
2	1 m from outer kerb at tangent	a	110	6.17	2.18	
		b	130	5.06	2.32	107.4



Fig. 47 - Replacing broken blocks was easy

OTHER SIMILAR PROJECTS IN INDONESIA

Interbloc has been used as a pavement surfacing in many projects in Indonesia, particularly for specific traffic loads. The successful performance of interbloc pavements, as discussed in this paper, has brought a new confidence in interbloc's suitability and viability as an attractive, alternative pavement material, alongside rigid pavements and the more conventional hotmixed asphalt.

An example where interbloc was considered a better choice than a rigid pavement or asphalt was along some sections of the Arterial Road Project, south of Jakarta, where there were high embankments filled with a large amount of highly-plastic laterite soil (Fig. 48). This naturally would cause differential settlement in the future. The estimated traffic (ADT) of the road was about 8000. Interbloc was selected in preference to other pavement types because, in the event of settlement, it was believed that the ease and low cost of interlock repair would be much better than other pavement types.

Construction of this road had just been completed at the time of writing this paper. It will be interesting to observe the performance of the pavement over time.

CONCLUSIONS

Although the interbloc road section described in this paper was not intended for road research or testing, the results of investigations, observations and evaluation of this road have been very useful as input for developing alternatives in the road construction industry in Indonesia.

During the first three months of its service life, visual monitoring of this road section indicated a normal concrete block pavement behaviour (Fig. 31). Deformation progressed rapidly soon after the road was opened to traffic, especially in the curved section. Along the straight section, deformation was practically negligible.

The average traffic speed was much higher that the design speed, and the actual traffic count showed a higher traffic density than was initially estimated. The most dominant damaging factors were the overweight axle loads and the rather sharp curved alignment of the road section.

In the beginning there was some deterioration of the pavement in terms of creeping and rutting. However, as interlock was achieved, a relatively stable condition prevailed. It is predicted that the equilibrium condition will prevail for the remainder of the pavement's service life.

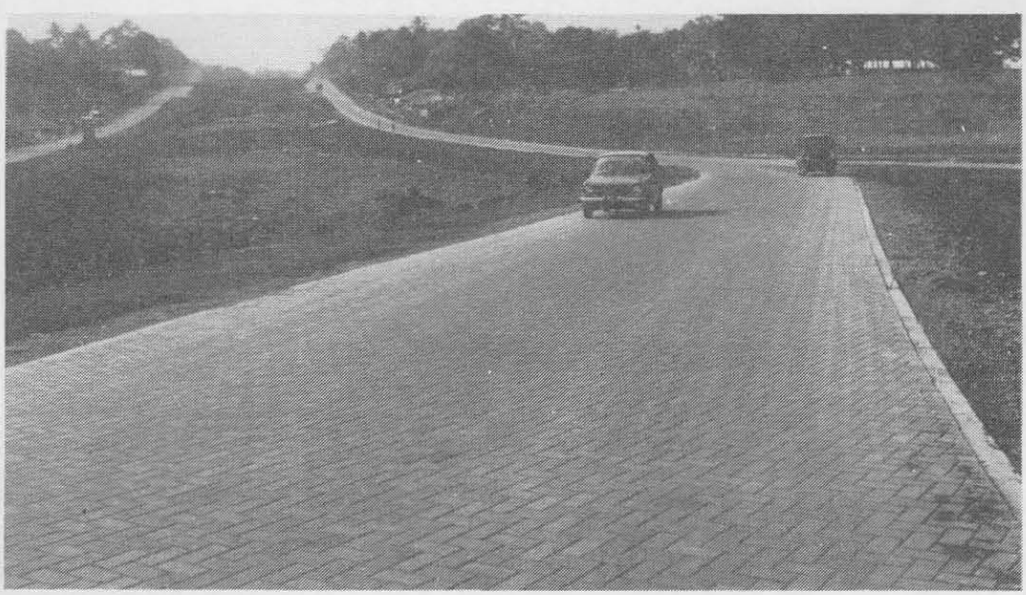


Fig. 48 - Interbloc for Outer Ring Road south of Jakarta

Some interesting facts worth noting are as follows.

(1) In the tangent (straight) section, there was no significant deterioration of the pavement.

(2) In the curved section, there were creep symptoms, but they were not too excessive. The biggest joint spaces occurred near the kerb, which shifted some tens of millimetres away from the track alignment owing to centrifugal force. The design speed was 40 km/h, but traffic travelled up to 70 km/h. The kerb was under-designed. On difficult alignments, interlock must be properly designed and constructed.

(3) The critical period only occurred practically within the first month of the pavement's service life, or after about 100,000 standard axle load repetitions. Beyond that, deformation seems to be independent of the number of wheel passes.

(4) The interbloc pavement structure is relatively more sensitive to the deviation of road alignment (geometric) design than other types of pavements.

BIBLIOGRAPHY

ALY, M.A. (1979). Tinjauan Terhadap Buku Pedoman Penentuan Tebal Perkerasan Flexible Jalan Raya No. 04/PD/BM/1974, Direktorat Jenderal Bina Marga, Oktober.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (1972). Interim guide for design of pavement structures. (AASHTO: Washington.)

CLIFFORD, J.M. (1984). A description of 'interlock' and 'lock up' in block pavements. Proc. 2nd Int. Conf. Conc. Block Paving, Delft, pp. 50-54.

Departemen Pekerjaan Umum, Direktorat Jenderal Bina Marga, Peraturan Pelaksanaan Pembangunan Jalan Raya No. 02/ST/BM/1973.

Departemen Pekerjaan Umum, Direktorat Jenderal Bina Marga, Pedoman Penentuan Tebal Perkerasan Lentur Jalan Raya No. 01/PD/B/1983.

Dinas Pekerjaan Umum DKI Jakarta, Seksi Laboratorium Jalan, Tinjauan Singkat Perkerasan Dengan Mempergunakan Interblock, Nopember, 1983.

ISKANDAR, P. (1984). Concrete block paving in Indonesia. Proc. 2nd Int. Conf. Conc. Block Paving, Delft, pp. 216-21.

KELLERSMANN, G.H. (undated). Concrete block paving in Indonesia. Road Dept, Public Works, City of Amsterdam.

KNAPTON, J. (1976). The design of concrete block roads. Cement Conc. Assoc. Tech. Rep. 42.515.

KREBS, R.D. and WALKER, R.D. (1971). Highway Materials. (McGraw Hill: New York.)

Seminar Pembuatan Jalan Di atas Tanah Lembek, Jakarta, June, 1986.

SHARP, K.G., MAVIN, K.C. and ARMSTRONG, P.J. (1983). The potential use of concrete block paving in developing countries. Proc. 4th Conf. REAAA, 2, pp. 149-70.

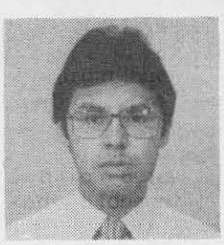
WONOSAPUTRA, S. (1984). Interbloc Sebagai Perkerasan Jalan, Konperensi Tahunan Teknik Jalan Kedua Puslittbang Jalan, Bandung, December.



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