TESTING OF CONCRETE BLOCK PAVEMENTS BY THE AUSTRALIAN ROAD RESEARCH BOARD

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SUMMARY

The Australian Road Research Board (ARRB) commenced a study of the performance of interlocking concrete block pavements (ICBPs) at the end of 1980. The project is being sponsored by a local concrete block manufacturer, and is concentrating on testing ICBPs that could be suitable for use in local government applications such as minor residential streets. This paper concentrates on the deformation, deflection and moisture movement observations on the test pavements, plus an evaluation of the materials used to construct them and the quality of construction. ARRB was responsible for the testing of the pavements only; the quality of materials used, and the construction of the pavement, was the responsibility of the manufacturer. So far nine pavements have been or are being tested, ranging from grossly under-designed sections to sections designed in accordance with the Australian design specifications. Of the tests that have been concluded, no pavement survived more than 500 equivalent standard axles (ESAs) though most of these were under-designed. The current sections, designed in accordance with the Australian design guide, have developed ruts after a small number of ESAs and further testing is required before any definite conclusions regarding the adequacy of the Australian design guides for low traffic, low subgrade CBR conditions can be made. Two block shapes are being compared and so far there is no difference in their performance. The problems associated with water entering the pavement through the joints of the surface are highlighted.

1. INTRODUCTION

The Australian Road Research Board (ARRB) commenced a study of the performance of interlocking concrete block pavements (ICBPs) at the end of 1980. The project is being sponsored by a local concrete block manufacturer, and is concentrating on testing ICBPs that could be suitable for use in local government applications such as minor residential streets. The project is the first full-scale testing of ICBPs carried out in Australia since those conducted at the University of New South Wales and reported in Shackel(1). Shackel's work in Australia led to the formulation of an interim Australian design guide for concrete block pavements(2). His later work in South Africa(3) resulted in the claim that these design curves were suitably conservative, and the Australian design guide was reissued in 1982 as TN40(4). Although some changes were made to the guide, the design curves remained unaltered (Figure 1).

The ARRB project was instigated because it was thought necessary to conduct tests under Australian conditions on pavements with a subgrade CBR substantially less than 66, the unsoaked CBR value of the subgrade used in the New South Wales tests(1), and on which the design guide TN40(4) is based.

2. OBJECTIVES OF TEST PROGRAM

The objectives of the program at ARRB were to review the results of previous research and to examine several claimed advantages of ICBPs. Specifically, the research would study the following.

Anticipated Traffic Loading				Required Paving Units			
Traffic Classification	No. of vehicles per day >3 t gross	Total Equivalent Standard Axle repetitions after 20 years' service	Examples of Usage	Shape Type	Minimum Thickness	Laying Pattern(1)	Strength Grade (MPa)
T1	0-15	$0-4.5\times10^4$	Multi-dwelling driveways, car parks, cul-de-sacs.	A B	60 mm 60 mm	H or S S	35 35
			Malls not accepting delivery vehicles(2)	C	75 mm	H or S	35
T2	15-45	4.5×10^4-1.4×10^5	Minor residential streets subject to garbage vehicles. Commercial carparks	A B C	60 mm 80 mm 80 mm	H or S S H	35 35 35
T3	45-150	1.4×10^5-4.5×10^5	Residential streets. Malls accepting vehicular traffic(2,3)	A B C	60 mm 80 mm 100 mm	H S H	35 35 35
T4	150-450	4.5×10^5-1.4×10^6	Minor through roads etc. in urban areas with 60 km/h limit. Industrial hardstandings(4)	A	80 mm	H	45
T5	450-1500	1.4×10^6-4.5×10^6	Major through roads in urban areas within 60 km/h limit. City streets, bus interchanges. Industrial hardstandings subject to truck traffic only(4)	A	80 mm	H	45

Notes:
(1) H = Herringbone
S = Stretcher bond or basket-weave.
(2) 80 mm units may be required to cope with high point loads associated with fire fighting equipment, etc.
(3) For malls laid over sound existing pavements 75 mm cobblestones or 60 mm Type B units may be suitable.
(4) Excluding areas where straddle carriers or fork lifts carrying shipping containers are in use.

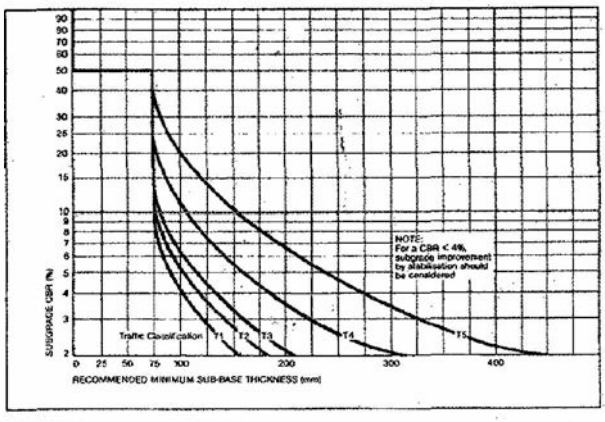


Figure 1: Australian design guide for concrete block pavements (4).

a) The accumulation of permanent deformation (rutting) under loading and the claim that a block pavement gains stiffness with use and is ultimately unaffected by increases in wheel load or frequency of single wheel loads within the range 2 to 7 t(4).

b) The relative performance of block shapes, recognising the conflict of opinion between Western European practice(5, 6) and the results of Shackel's testing in Australia and South Africa(1, 3).

(c) The ability of block pavements to withstand recoverable surface deflections up to 2 mm without affecting performance(3).

(d) The relationship between accumulation of permanent deformation and damage to the individual paving blocks.

(e) The skid resistance of concrete blocks under trafficking and over time.

(f) The performance of sections reinstated rather than reconstructed.

(g) The noise levels generated by vehicular traffic on concrete block pavements compared to asphalt pavements.

(h) The perceived colour variation between ICBPs and asphalt surfacings.

(i) The distribution of stress within the layers of an ICBP produced by a standard axle (8.2 t on a dual-wheeled single axle).

(j) The 'sealing' properties of the joints of the surface of an ICBP, specifically the monitoring of moisture movement within the sub-base and subgrade materials.

(k) An evaluation of the materials used to construct the pavement, and the construction tolerances achieved. ARRB was responsible for the testing of the pavement only, not for the quality of the material used or for the quality of construction of the pavement. This was the responsibility of the manufacturer.

This paper will concentrate on deformation, deflection and moisture movement observations on the test pavements. Noise and colour testing have been carried out and the results will be reported elsewhere. The evaluation of stress distribution is being conducted with the aid of pressure cells placed in the pavement, plus an analysis of deflection bowl data using linear elastic theory. This evaluation is only in the preliminary stages at present.

Extensive skid resistance data have been collected at a second test pavement being monitored by ARRB: an over-designed, heavily-trafficked pavement located at the entrance to a quarry in Melbourne. A report on the performance of this pavement is currently being prepared. The skid resistance data are being reported in a companion paper at this Conference(7).

3. TEST PROGRAM

The initial test pavement at ARRB was described in detail in Sharp(8)(see Figure 2). Very briefly, the program has been carried out in three stages:

(a) The evaluation of four sections of under-designed pavements using a block shape (Unidecor, see Figure 3) that provides geometric `lock up' on two sides only. Also, no subsoil drainage (in the form of porous agricultural (AG) drains) was provided on the `low' side of the pavement(8).

(b) The evaluation of one section of under-designed pavement using a block

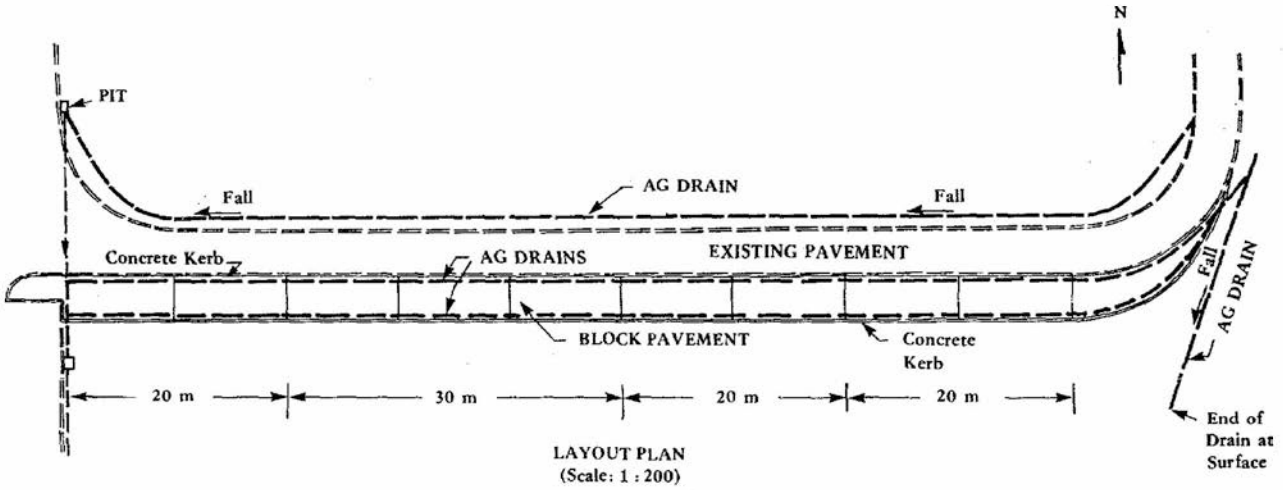


Figure 2: Plan of test pavement at ARRB.

shape that provides geometric `lock up' on all four sides (Unipave, see Figure 3) and one section of pavement designed in accordance with traffic classification curve T2 of TN40 (Figure 1) for a CBR of about 3.

(c) The installation of an AG drain on the `low' side of the pavement and the evaluation of four sections designed in accordance with TN40 for traffic curves ranging for T2 to T4. Both block shapes as already described were used.

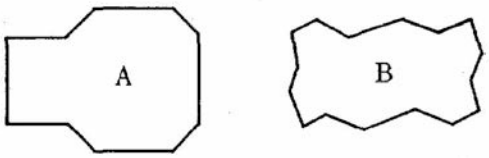


Figure 3: The two block shapes used in the ARRB tests. (a) Unidecor, (b) Unipave.

The sections that have, or are currently being, tested are given in Table 1. The first stage of testing involved Sections 1 to 4, the second stage Sections 5 and 6A, and the third (current) stage involves sections 6B/6C, 7, 8 and 9. Following testing of Section 6A, half of it, including the entire outer wheel path (OWP), was removed and the second AG drain installed, as already described. This half was then reinstated and became Section 6C. The other half of the section remained largely undisturbed and, for convenience, was renamed Section 6B. The installation of the second drain resulted in the location of the wheel paths being moved. This affected the subsequent performance of Section 6B, as will be explained in Section 6.1.

3.1 Design Rationale

Sections 1 to 4 were deliberately under-designed and expected to fail under trafficking. The depth of sub-base (75 mm) installed in Sections 1 and 2 was the minimum depth for construction expedience.

An extensive series of dynamic cone penetrometer (DCP) tests was carried out on the site prior to construction and a nominal design CBR value of 10 was arrived at. However, as Sections 1-4 were very shallow, subgrade material had to be imported from a borrow pit located on ARRB premises and placed over the existing subgrade layer. It was possible, and later tests confirmed this, that the imported material was not the same as the existing material and that its CBR might have been lower. This was not a concern at this stage because the design CBR was not a consideration. In reality, if the design CBR was 10, then 75 mm of sub-base should have been adequate for all traffic curves except T4 and T5 in TN40.

Following the early failure of Sections 1 to 4, Sections 3 and 4 were removed and replaced by Sections 5 and 6A. Section 5 was again deliberately under-designed in order that the performance of 80 mm Unipave blocks could be compared with the Unidecor blocks. Section 6A was the first attempt to design a section in conformity with TN40. Soaked CBR testing was performed on one sample of both the existing clay and the imported clay subgrade materials and CBR values of 10 and 2 respectively resulted. It was decided that traffic curve T2 approximated the loading conditions existing. From Figure 1 it can be seen that for a design CBR of 2, the depth of sub-base required would be 180 mm, but for a CBR of 10 the depth would be 75 mm. The depth of imported clay in this section was 160 mm, so to design for a CBR of 2 would lead to an over-designed pavement (because all the imported clay would be removed) and to design for a CBR of 10 would result in an under-designed pavement (because 85 mm of imported clay would still be present).

As only one sample of each subgrade material was tested for soaked CBR, and because of the variations in subgrade CBR noted in the first stage of testing (see Section 6.3), it was decided to remove all the imported clay and install 160 mm of `A' grade fine crushed rock (FCR) sub-base. This corresponded to a design CBR of between 2.5 and 3 for curve T2.

TABLE 1: Sections Tested By ARRB

Section No.	Type of Block	Thickness of Block	Nominal Thickness of FCR 'A' Grade	'B' Grade
1	Unidecor	80	75	0
2	Unidecor	60	75	0
3	Unidecor	80	0	0
4	Unidecor	60	0	0
5	Unipave	80	0	0
6A) 6B,6C)	Unipave	60	160	0
7	Unidecor	80	75	190
8	Unipave	80	75	160
9	Unipave	80	250	0

FCR = Fine crushed rock.

The existing Sections 6B/6C, 7, 8 and 9 represent the reinstated Section 6A, and three more sections having a total depth of sub-base of 265, 250 and 235 mm. The sub-base in Sections 7-9 was made up of a combination of `A' and `B' grade FCR as outlined in Table 1. The construction of these sections involved the removal of all the imported clay, plus the excavation of some of the existing clay layer. Sections 7 to 9 all have approximately the same depth of sub-base to allow for another evaluation of the relative performance of Unipave and Unidecor blocks. From Figure 1 it can be seen that the design of Sections 7, 8 and 9 approximates the T4 curve for a range of design CBRs from 2 to 3. Laboratory soaked subgrade CBR testing is currently been carried out in these sections. However, in situ CBR and moisture content readings have been taken and are discussed below.

In summary, the test program commenced with the testing of under-designed, inadequately drained, pavements. The latest testing involves the evaluation of pavements designed in accordance with TN40 for various traffic curves with adequate drainage provided.

3.2 Loading

All sections were trafficked by a loaded truck in one direction only. The truck had a front single axle with single tyres and a rear single axle with dual tyres. The maximum gross axle load permitted in TN40 is 4.8 t for single axles with single tyres and 9.0 t for single axles with dual tyres. TN40 also specifies the number of vehicles per day greaer than 3 t gross that traffic the pavement and the anticipated number of equivalent standard axles (ESAs) after 20 years service. TN40 differentiates between the 20-year traffic and the amount of traffic to achieve `lock up' as described by Shackel(3). The basis of the design in TN40 is in line with Shackel's recommendation that once `lock up' is achieved, an increase in load and trafficking will not affect performance. The calculation of ESAs and the damaging affect of axle loads is based on the well known `fourth power law'.

The loading applied to the pavements at ARRB, in terms of both the axle loads and frequency, was within the limits set by TN40. For example, in the latest series of tests, the loading is equivalent to 1 ESA per truck pass whereas TN40 allows up to 2 ESAs. No more than 50 passes have been made per day, with the average number of passes being about 20. On many days, no traffic was applied to the pavement. The latest test sections were constructed eight months before testing commenced and, during that time, some cars and light commercial vehicles trafficked the pavement. Whilst it can be argued that minor residential streets such as typified by the T2 curve in TN40 would not receive even this amount of loading, the following two points are valid:

(a) the loading applied was within the limits set by TN40; and

(b) there is the possibility that minor streets in new estates would receive heavy construction traffic early in their life.

4. QUALITY OF MATERIALS USED

The pavements tested at ARRB were of the type more likely to be constructed by local government authorities rather than national road construction authorities. The use of ICBPs in Australia is restricted in the main to local streets. One of the secondary considerations of the projects was, therefore, to assess the construction and material standards achieved, these being indicative of what a local government engineer could achieve in normal practice. Given that both the contractor and the sponsor knew that the performance of the pavement was to be evaluated it could be expected that they would strive to achieve as high a standard of construction as possible.

4.1 Blocks

The dimensions of a sample of both the Unipave and Unidecor blocks were measured and all were within the Australian specification(9), i.e. plan dimensions to a tolerance of ± 2 mm, and thickness within ± 3 mm.

The compressive strengths of a sample of Unidecor blocks were also determined in accordance with the Australian specification(9), except only three 60 mm blocks and three 80 mm blocks were tested instead of the specified five. All strengths were well in excess of the Australian specification of 35 MPa, with characteristic strength values (based on a sample of three) of 56.4 MPa and 58.5 MPa for the 80 mm and 60 mm blocks respectively.

In view of the Dutch recommendation that flexural strength is a more realistic quality parameter for concrete blocks, flexural strength testing was carried out on 60 mm and 80 mm Unipave and Unidecor blocks in accorance with NEN 7000(10). The loading rate was 0.05 ± 0.02 MPa/s and eight samples of each block type and thickness were tested. The flexural strength values recorded were:

60 mm Unidecor: 5.0 ± 0.7 MPa

80 mm Unidecor: 6.8 ± 0.3 MPa

60 mm Unipave: 6.1 ± 0.6 MPa

80 mm Unipave: 7.0 ± 0.7 MPa

compared to the NEN 7000 recommendations of a minimum flexural strength of 6 MPa.

4.2 Sand

Figure 4 is typical of the gradings of the sand used in the ARRB tests. Comparison with the grading recommended in TN40 indicates that the sand was too single-sized. Shackel(11) indicated that the choice of bedding sand could be crucial to the performance of the pavement in that sands such as those used at ARRB could lack sufficient particle size distribution to ensure good compaction and adequate sealing of the joints.

4.3 Sub-base

In Australia, the `base' layer is that located immediately under the surfacing layer, whilst the `sub-base' layer is located under the base. TN40 specifies that the sub-base material should comply with local authority requirements: it recommends a grading envelope, that the liquid limit should not exceed 23 and the plasticity index should not exceed 6. The Interim Guide to Pavement Thickness Design published by the National Association of Australian State Road Authorities (NAASRA)(12) specifies quality parameters for base material. Whilst NAASRA recommend that base materials should have a minimum in situ CBR of 80, the maximum CBR of the sub-base material need only be about 30.

The quality requirements of `base' materials are therefore more stringent than `sub-base' materials, and, by specifying design depths in terms of the `sub-base', TN40 allows for more flexibility in the choice of materials that would be the case if the thickness of the pavement was specified in terms of `base'.

Table 2 shows the in situ CBR values on the sub-base layers at construction, together with the compaction levels achieved. In all cases, the in situ CBR values are within the NAASRA recommendations.

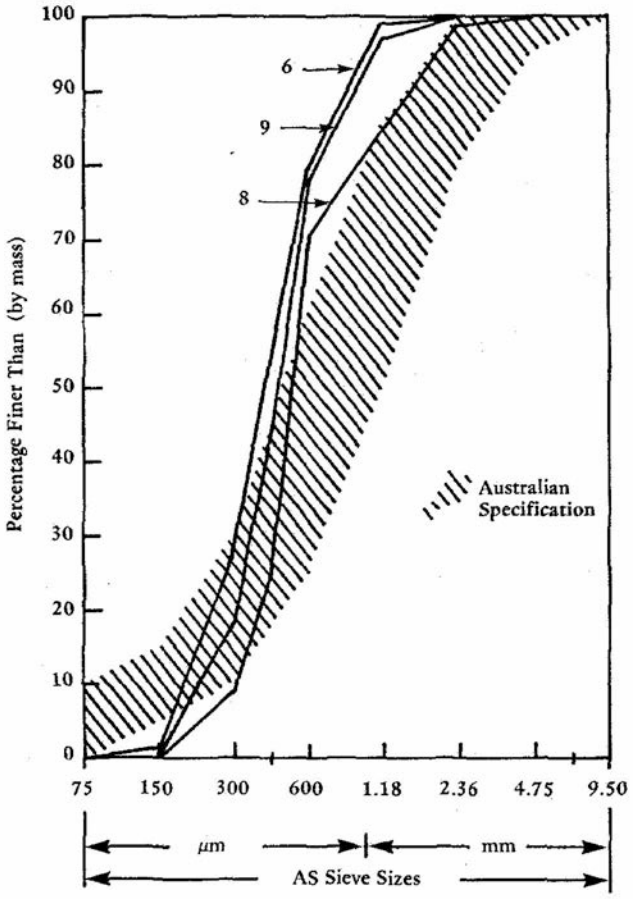


Figure 4: Comparison of gradings of bedding sands used in ARRB tests with Australian specification.

TABLE 2: Material Characteristics at Construction

Section No.	'A' Grade Fine Crushed Rock			'B' Grade Fine Crushed Rock			Subgrade	
	Nominal Depth (mm)	% Modified AASHO Compaction at Construction	In Situ CBR at Construction (Mean Value)	Nominal Depth (mm)	% Modified AASHO Compaction at Construction	In Situ CBR at Construction (Mean Value)	%Standard Compaction at Construction	In Situ CBR at Construction
1	75	94	35	-	-	-	96*, 98	18*, 25
2	75	94	40	-	-	-	91*, NT	25, NT
3	-	-	-	-	-	-	NT, 96	25, 50
4	-	-	-	-	-	-	NT, NT	25, NT
5	-	-	-	-	-	-	99, NT	NT, NT
6A	160	102	NT	-	-	-	96	NT
6B	160	99	NT	-	-	-	97	NT
6C	160	98	NT	-	-	-	NT	NT
7	75	98	50	190	103	35	NA	25
8	75	98	55	160	104	35	NA	25
9	250	99	65	-	-	-	NA	18

NT = Not Tested
NA = Not yet available
\- = Not applicable

* First value is the 'imported' clay, second value the 'existing' clay.

Hodgkinson(13), in his specification for the construction of ICBPs, requires 100% standard compaction. In the ARRB tests, compaction was specified in terms of its modified value, and for most materials 95% modified compaction is generally considered to be at least the equivalent of 100% standard compaction. Table 2 indicates that in almost all sections the compaction requirements were met. In all cases, the sub-base material was non-plastic.

4.4 Subgrade

Table 2 indicates that the compaction levels were generally between 95 and 100 per cent standard, except for Section 2 where the compaction was poor.

The high in situ CBR values of the subgrade at construction (Table 2) are very interesting in view of the soaked CBR values, the design CBR adopted and the moisture movement in the pavement after construction (see Section 6.3).

5. CONSTRUCTION TOLERANCES

Levels were taken at the construction of each of the test sections using an engineer's level at five points across the pavement at chainages 2, 5, 8, 12, 15, 18 m, etc. Levels were therefore taken at 15 points in each 10 m length on top of the subgrade, sub-base and blocks (before and after plate vibration).

Hodgkinson(13) specifies that the compacted thickness of the sand layer should be in the range 20 to 40 mm which is at variance with Western European practice to use 50 mm(6).

In all but Section 9, the mean sand thickness was within the limits set by Hodgkinson, though the values in many cases were higher than expected. However, as the pavements were constructed by experienced contractors who knew the levels were being checked, it is thought that the levels achieved would be at least typical of those achieved in actual practice.

Table 3: Permanent Deformations and Recoverable Surface Deflections of Test Sections

Section	ESAs												Sample Size	
	0	50	110	200	300	410	411	460	550	551	750	1000		
1		9.5	24.5										R	18
		4.6±1.2	-										D	12
2		17.5	2.3										R	28
		6.3±1.3	-										D	18
3		12	27.5										R	18
		3.7±0.9	-										D	12
4		42											R	18
													D	-
5	0					9	-	23					R	18
	1.3±1.0					-	5.7±1.4	-					D	12
6A	0		4						17				R	18
	1.8±1.5		-						5.7±2.3				D	12
6B	3								9	6.5*	6	8	R	4
	1.2±6.2								3.3±0.5	1.8±0.3	1.9±0.4	-	D	3
6C	1			24	28			37					R	9
	-			3.7±0.7	3.9±0.3			-					D	6
7	0			5	6			7					R	18
	1.6±0.3			1.4±0.4	1.7±0.4			-					D	12
8	1			5.5	6.5			8					R	28
	1.4±0.2			1.3±0.3	1.5±0.4			-					D	18
9	1.5			5.5	6.5			7					R	18
	1.8±0.3			1.7±0.5	1.6±0.6			-					D	12

R = Average rut depth (mm) of inner and outer wheelpaths D = Mean recoverable surface deflection (mm)
* Position of wheelpath changed.

6. PERFORMANCE OF THE TEST SECTIONS

6.1 Rutting

The development of rutting under trafficking is given in Table 3. The values given are the average of measurements taken in both wheelpaths. Rutting was measured using a 1.2 m straight edge at 2 m intervals in each wheelpath. It can be seen that Sections 1 to 6A and 6C all failed within about 500 ESAs, `failure' in this case being defined by TN40 as the permanent deformation exceeding 10 mm. In most cases sections were tested until the deformation exceeded 20 mm.

The following points can be noted.

(a) Comparison of the performance of Sections 1 to 5 indicate the initial superior performance of the Unipave blocks (Section 5) over the Unidecor blocks (Section 1 to 4). Sections 1 and 3 (80 mm blocks) initially outperformed Sections 2 and 4 (60 mm blocks). However, all five sections failed to reach a stable condition and it is difficult to draw any real conclusions.

(b) The performance of Section 6A was disappointing, but the amount of water that entered the pavement and wet up the subgrade (see Section 6.3) stressed the need for a boxed construction to be properly drained and prompted the installation of the second AG drain on the `low' side of the pavement. The better performance of Section 6B after the location of the wheelpaths was altered pointed to the `ironing out' effect on surface deformation if traffic is not channelised. The poor performance of Section 6C (despite the addition of the second AG drain) pointed out the dangers of reinstating, rather than reconstructing, a failed section of pavement.

(c) Testing of Sections 7, 8 and 9 is continuing. Reference to Table 1 and Figure 1 indicates that these sections should perform adequately under the traffic being applied, though it is noted that the deformation in the OWP of these sections is higher than the `average' value given in Table 3. For example, the deformation in the OWP in Sections 7, 8 and 9 is 9 mm, 10.5 mm and 8 mm respectively after about 460 ESAs.

Figure 5 shows the rut depth v. ESAs relationship for Sections 1, 2, 7 and 9. Section 2 could have been approaching an equilibrium condition, but the surface deformation necessary to achieve this was excessive. This finding is similar to that of Knapton and Barber(14). A similar pattern was observed in other sections. However, once the deformation exceeded 25 mm, structural integrity was lost and failure often reached catastrophic proportions.

The amount of rutting (especially in the OWP, see Table 3) of Sections 7 to 9 seems a little excessive after so few ESAs and further testing is required to determine if the rutting continues to accumulate beyond 10 mm (hence casting doubt on the design chart in TN40 at low subgrade CBRs) or obtains an equilibrium condition.

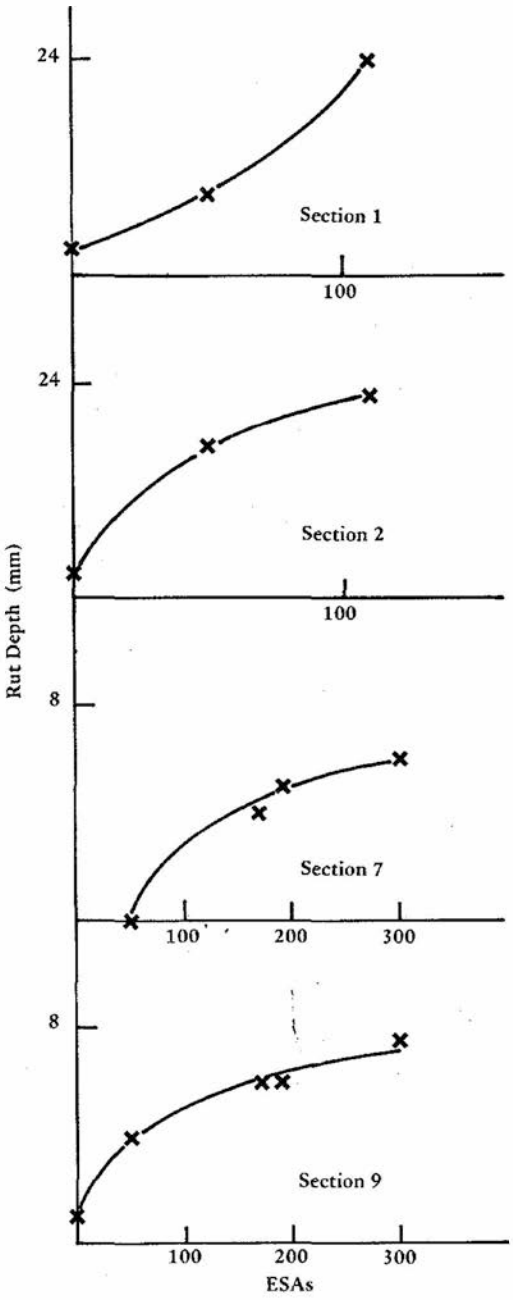


Figure 5: Rut depth v. ESAs for some of the test pavements at ARRB.

6.2 Deflections

Table 3 also shows the values of recoverable surface deflections recorded on each section. The deflection measurements were recorded using a Benkelman beam under a truck loaded to 8.2 t on its rear axle. Very limited testing was carried out on the early sections but more comprehensive testing, including the collection of deflection bowl data, has been performed on the sections currently being tested.

In all cases, the values were far higher than could be tolerated by a conventional asphalt pavement. However, it is significant that where the deflections were less than 2 mm, then performance up to that stage was satisfactory. It is also significant that, in Sections 7-9, the deflections are remaining relatively stable, even though the amount of permanent deformation is increasing.

6.3 Moisture Movement

Figure 6 typifies the change in subgrade moisture content, CBR and sub-base moisture content over time and trafficking. From a reasonably high value at construction, the subgrade CBR (determined from DCP tests) falls to a low value and the moisture contents rise accordingly, indicating that water is entering the pavement. The results also indicate that the joints of an ICBP do not become impermeable, especially in the short term, and any later sealing of the joints could be irrelevant to the performance of the pavement if the base layers have been allowed to wet up in their early life. It is suggested, therefore, that soaked CBR values be adopted as the design parameter in these situations.

TN40 specifies that the determination of subgrade strength be carried out using the following methods in descending order of reliability:

(a) Extrapolation from existing roads using in situ CBR tests.

(b) Estimates based on laboratory measurement of CBR.

(c) The use of the dynamic cone penetrometer(DCP).

(d) Estimates based on regional experience.

(e) Estimates based on empirically correlated in situ measurements.

Subgrade CBR has been determined throughout the project using both the in situ method and the DCP and a comparison of the results obtained on Sections 6B, 6C, 7, 8 and 9 in April 1983 is shown in Table 4. Given that the in situ method is specified as the most reliable, the decision to adopt a design CBR of 2.5 to 3 appears to have been justified.

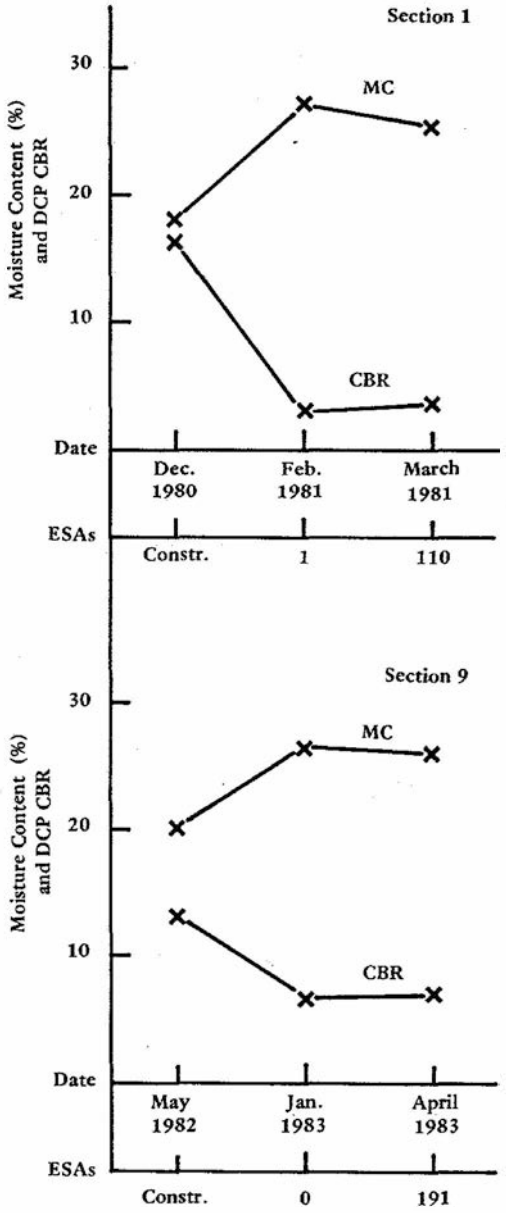


Figure 6: Variation in subgrade CBR and moisture content with time and trafficking of test pavements.

Nevertheless, soaked CBR testing on the subgrade in all the sections currently being tested is being carried out.

6.4 Damage to Blocks Under Traffic

The damage caused to blocks by trafficking, including chipping, spalling and breaking was monitored closely in the early stages of the project, especially during the testing of Sections 1 to 5.

The results were reported in Sharp and Armstrong(15). They confirmed Shackel's finding(3) that blocks do not become damaged by trafficking until the permanent deformation exceeds about 20 mm. The Unipave blocks tended to break more than the Unidecor blocks because their geometri: lock up on all four sides tended

TABLE 4: Comparison of In Situ and DCP CBR Values Obtained on Subgrade (Sections 6-9) April 1983

Section	In Situ Value	DCP Value*
6B	7, 5.5	5.5, 5.5
6C	14, 8	5.5, 5.5
7	11	5
8	10, 16	4.4, 4.5
9	7, 7, 8	6, 7, 8
$\bar{x}$	9.77 (10)	5.7 (5.5)
s.d.	3.30 (3)	1.1 (1)
$\bar{x}$ - 1.3 s.d.	6	4

* DCP values arrived at using method described in (16)
Testing carried out after Sections 6C, 7, 8, 9 had received 200 ESAs.

to resist `pop out' far better.

7. CONCLUSIONS

This paper has reported the program of testing and performance data for trial sections of ICBP's located at ARRB headquarters in Melbourne, Australia. The pavement is located on a gently sloping site having a low subgrade CBR and trafficking is channelised. The main objective of the project was to examine the Australian design charts for ICBP's, specifically for low traffic, low CBR conditions. As such, the results are primarily of interest to local government authorities involved with the design and construction of minor residential streets.

The pavements initially constructed were deliberately under-designed and expected to fail under traffic. Since then, the pavements have been gradually strengthened and the current sections are designed in accordance with TN40 for a range of subgrade CBR 2.5 to 3 and traffic classifications T2 to T4. Whilst ARRB was not responsible for the construction of the test sections, the layer levels achieved at construction, the quality of the materials used and the compaction levels achieved were monitored.

The following conclusions can be drawn from the project to date.

(a) The blocks used in the tests were of a high quality and did not become unduly damaged until the permanent deformation became excessive.

(b) The bedding sand used in the test was somewhat single-sized and did not conform to the Australian specification.

(c) The sub-base materials used in the tests conformed with Australian specifications, recognising that TN40 specifies pavement thickness in terms of sub-base and not base materials.

(d) Of the tests that have been concluded, none of the pavements have survived more than about 500 ESAs, though most of these were under-designed. The sections currently being tested are designed in accordance with TN40 and although they have developed ruts after a small number of ESAs, further testing is required before any definite conclusions regarding the adequacy of the Australian design guides for low traffic, low subgrade CBR conditions can be made. The sections currently being tested include a comparison of the performance of two block shapes, and so far there is no difference in their performance.

(e) Provided the degree of rutting in the pavement remained within tolerable limits (i.e. < 10 mm), then the elastic deflections on the surface of the block pavement were less than about 2 mm. An increase in rutting beyond 10 mm was accompanied by large increases in deflections.

(f) The joints of the surface of an ICBP did not seal up after construction and water easily penetrates to the base and subgrade layers. Consequently, soaked CBR testing should be carried out if it is desired to construct ICBP's on expansive clay subgrades. The possible sealing properties of an ICBP should not be relied upon to dispense with adequate subsurface drainage.

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ACKNOWLEDGEMENTS

This paper is presented with the permission of the Executive Director of the Australian Road Research Board, Dr M.G. Lay. The assistance of Mr N. Rizio of Monier Industries, Melbourne is also acknowledged.