TWO INVESTIGATIONS OF SUB-BASE PROVISION FOR LIGHT TRAFFIC

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SUMMARY
Interpave, the United Kingdom association of manufacturers of concrete block paving, have undertaken the installation of two trial areas whose aim was to investigate the use of sub-base thicknesses thinner than normal design methods would indicate.
One trial area installed within the works of a major Cement manufacturer employed a cement bound sub-base layer, whilst the other area used a traditional granular sub-base of reduced thickness, both areas being constructed on clay sub-grades.
An account is presented of the areas' performance under accelerated trafficking.

1. PITSTONE TRIAL AREA

In July 1976, joint meetings between Interpave and Cement and Concrete Association identified that a joint trial area should be established to demonstrate the suitability of Concrete Block Paving for installations to be subjected to high traffic loadings under conditions then applying in the United Kingdom. C. & C.A. were to design a road which would yield firm data regarding practical failure limits, with Interpave assisting with finance, material and staffing.
During the ensuing six months a number of possible sites were visited, but all were rejected on various grounds such as insufficient traffic intensities or over adequate sub-grade materials.
Finally in March 1977 a site within the works of the Tunnel Cement Company at Pitstone was identified. The site appeared to offer ideal conditions since traffic flows were likely to be composed of heavy articulated Bulk Tankers whose axle loadings were known, together with vehicles collecting bagged cement all of which passed over the Company weigh bridge. The total load on the paving was predicted to be 12000 tonnes per week, and furthermore the underlying ground was reported as heavy grey clay typical of the Vale of Aylesbury with an estimated CBR in the region of 3%.
Accordingly a preliminary design study was carried out, and a detail prepared which involved an overall construction depth of 1.2 metres to reach undisturbed clay, followed by clay or marl infill and the provision of three differing depths of granular type 1 sub-base material.

Site Work

The trial area was to be located in the area of the main cement storage silos at Pitstone, and the existing pavement consisted of reinforced concrete slab construction. The area involved was subject to considerable skewing, braking and accelerating forces, and the existing slabs were observed to be highly polished. It was decided to remove a panel of the existing concrete pavement 15 metres by 5 metres and to replace this by an equivalent area of 80mm Rectangular block paving 100mm x 200mm. The sub-base thickness would be adjusted to give three bays 500, 400 and 300mm respectively each 5 metres long. The 80mm blocks would be laid in Herringbone pattern on a 50mm thickness of compacted sand in the usual way, and it was anticipated that the majority of laying would be carried out by previously inexperienced labour provided by the site Contractor.
A trial hole was excavated in June 1977, and it was found that undisturbed clay appeared to be present at a depth of 300mm below the surface. As a consequence, the original intention to excavate overall to a depth of 1.2 metres was withdrawn and it was decided to place sub-base material directly upon the exposed clay sub-grade.
Subsequently, concern felt by the design engineers about the possible effects upon the sub-grade of variations in moisture content, and the use of lean concrete for the sub-base was mooted. Despite concerns expressed about the effects of this decision on the trial aims, the construction of a 20:1 dry lean sub-base went ahead.
The design considerations related to the sub-base are shown at Appendix A, and construction proceeded in June 1977.
Laboratory examination of the clay sub-grade material subsequent to the completion of the installation revealed a CBR of no less than 30% at the optimium moisture content of 19%, although the liquid limit value was reported as 38%. It became clear therefore that the CBR value of the area's sub-grade was considerably in excess of 3% and that the predicted failure of the thinnest area of construction after three months was unlikely to occur.

Performance Monitoring

Monitoring of the surface levels of the trial areas was undertaken by the establishment of two reference lines of level for each bay of construction, and the surface profiles were recorded.
Initially monitoring of profile was carried out at weekly intervals but as the trial progressed

the time between observations was progressively increased.
The monitoring work showed that little significant deflection of the areas had taken place, and the results should be assessed in conjunction not only with the changes in design of the sub-base and subsequent laboratory reports, but also with the fact that the trafficking of the area in practice fell short of the predicted levels, at a realised annual volume of about 9500 tonnes.
Other aspects of the area's performance proved of considerable interest however. The polishing and abrasion of the blocks in the area resulted in the removal of surface laitance and the development of surface texture with the resulting surface being judged highly satisfactory. The blocks have certainly not polished to the same glazed condition which is exhibited by the surrounding in-situ concrete.
There has been no evidence of any deterioration of blocks which could be related to freeze thaw durability, although there appears to be evidence of some spalling of adjacent concrete boundaries. there is some slight evidence of creep under horizontal traffic stresses, but the area continues to perform satisfactorily, and won the confidence of the operators of the heavy vehicles using the site.

2. SEACROFT TRIAL AREA

During 1980, Interpave became more convinced than ever that the methods shown in Road Note 29 [1] for the design of sub-base for very lightly trafficked roads might well be producing required thicknesses of sub-base which were very conservative.
Accordingly, a search was begun for a site where accelerated trafficking trials could be undertaken with recorded traffic flows. Around this time, the West Yorkshire Metropolitan County Council were undertaking the construction of their new refuse transfer depot at Limewood Road, Seacroft, Leeds, and an approach was made for permission to construct a trial area of road at this installation.
The depot was to receive household and industrial waste collected in 2 Axle vehicles of up to 10 tonnes gross approximate weight, and to compact it and to load larger four axle skip vehicles with the refuse for onward transmission to tip.
A section of the approach road was identified by the Authority as being suitable for this trial, and consisted of half the width of the carriageway between the weighbridge and the compactor building over a length of 15 metres. The area was bounded on one side by the normal upstand kerb detail and on the other three sides by a flush kerb set in a mortar bed onto the normal sub-base. The surrounding areas of road were constructed in standard bituminous bound materials, and the trial area contained two road gulleys.
Following the experience on the trial at Pitstone it was clearly identified that the area, in order to yield useful information on sub-base design, should be constructed, at least in part, in such a way as to give early failure and assurances were given to the Authority regarding Interpave's commitment to reinstate the areas once failure developed.
The underlying sub-grade material on site as identified as clay with a probable CBR in the region of 2-3%. It was decided to sub-divide the trial area into four areas, with three areas having sub-base design thicknesses of 150mm, 200mm and 250mm thickness of Type 1 granular material respectively and a rectangular block 200 x 100 x 65mm in thickness. The fourth bay was also to have a sub-base thickness of 250mm but to employ 60mm shaped blocks of the SF pattern, known in the U.K. as Monolok.
Construction work on the trial area was undertaken by Interpave at the end of 1980 under far from ideal conditions. Temperatures below freezing were encountered during construction with the sub-grade material having been over-excavated, and the material itself being frozen and containing large quantities of ice. The timetable for the opening of the Depot did not permit any delay in the construction of the area, and the defective levels in the area of thinnest sub-base provision were made up with excavated material being poorly compacted into position. Granular sub-base material Type 1 was then placed to the required thickness and compacted with a 3T vibrating roller. An immediate problem was encountered once again in the bay with least sub-base thickness, where the underlying saturated clay punched up through the sub-base during compaction. The remainder of the construction proceeded without further major problems and the area completed in time for the opening of the Depot.
There was however almost immediately a catastrophic failure under preliminary site traffic of the thinnest bay with large displacements of the block surface, almost certainly related to the unsatisfactory conditions of the sub-grade at the time of laying, and remedial work was undertaken to correct the sub-base defects with the area being restored to its designed condition in January 1981.
Trafficking of the area then proceeded, and all areas carried load without incident for the ensuing six months, although some initial cracking and spalling of blocks was reported after about two months.
After the first six months trafficking, rutting developed in the thinnest bay in relation to the channelised traffic movements and at the leading edge of the bay, large upward movements occurred in the vicinity of a road gulley, with the blocks being squeezed sideways and upwards to level about the 100mm kerb line.
Accordingly the area was deemed to have failed and the blocks were lifted, and the sub-base removed and replaced with dry lean materials in July 1981.
The area has continued to give acceptable performance through to the present time (September 1983) without further remedial work being carried out, although by now some rutting is beginning to appear in the remaining three bays, and there is also a noticeable depression developing in the area of the Bay 1/Bay 2

interface. The position of this depression seems to be related to the area where the worst sub-grade conditions were originally encountered.

Conclusions

Practical construction considerations will probably prove to be the limiting factors for thin overall construction depths, and it is probable that the use of engineering filter fabric materials may be advantageous for this class of construction.
The trial at Seacroft provides some evidence that the design methods of Road Note 29 may well be conservative for lightly trafficked roads, and it is hoped that when this design document is updated, specific reference to Concrete Block Paving as a component material for road construction will be made.

Acknowledgements

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4) Messrs. Powerbuild for the site construction works at Pitstone.
5) The Tunnel Cement company for their co-operation in making the Pitstone trial site available.

Reference

1) Road Note 29: A guide to the structural design of Pavements for New Roads: Road Research Laboratory.

Appendix A

Sub-base Design - Pitstone

Predicted traffic intensity - 75,000 Standard Axles per annum. From Figure 6 Road Note 29 predicted design life in million Standard Axles

Table A1

Sub base Depth (mm)	Range of CBR values (%)		
	2	3	4
250		0.015	0.7
350	0.025	2.0	50.0
450	1.5	50.0	100.0

Hence the expected life in years is shown in Table A2

Table A2

Sub base depth mm	Axle Load Tonnes	Sub grade (%)		
		2	3	4
250	8		0.2	9.3
	10		0.1	4.7
350	8	3.0	27	67
	10	1.7	13	33
450	8	20	67	100+
	10	10	33	100+

According to Road Note 29, the thickness of a surfacing and rolled asphalte road base in mm for the number of Standard Axles quoted in Table A1 should not be less than the figures given in Table A3

Table A3

Sub base depth mm	Sub grade CBR (%)		
	2	3	4
250		110	145
350	110	165	280
450	155	280	320

Previous research had suggested that the blocks plus laying course have a load spreading ability equal to approximately 150mm of asphalt road base and wearing course. This implies that a section with a 250mm sub-base or a 350mm sub-base on a sub-grade of 2% CBR will have a slightly longer life than shown in Table 2.
The converse is true of the remaining sections on sub-grades having a CBR of 3% and 4%.

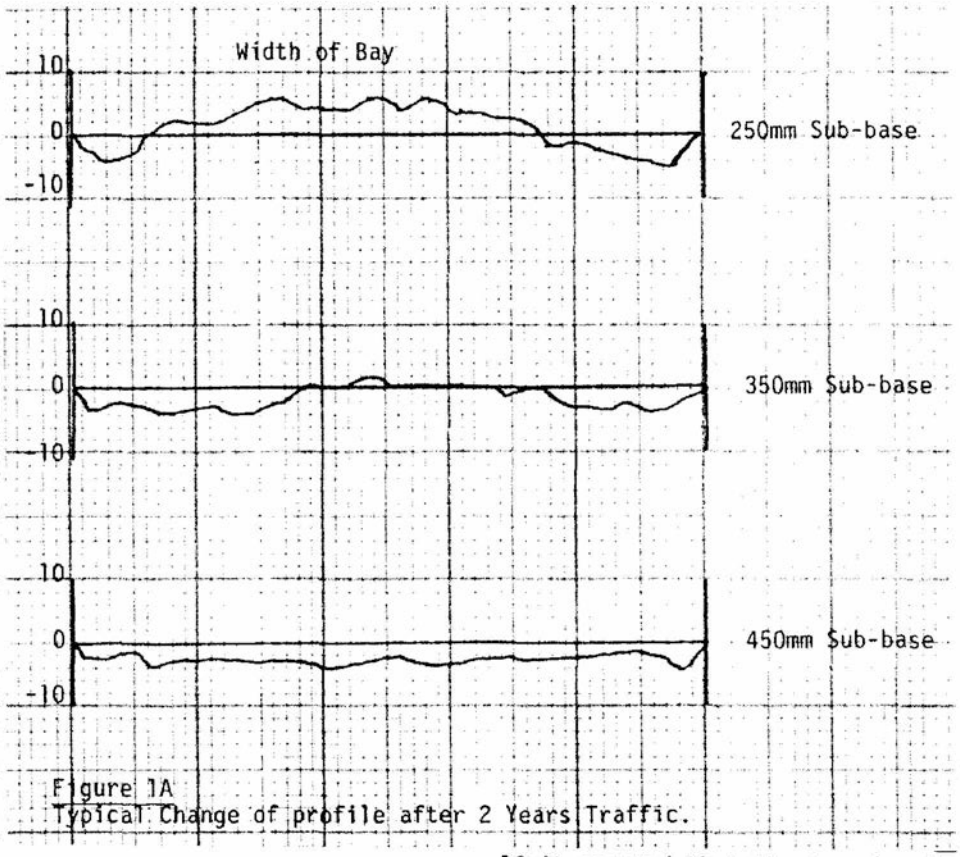


Figure 1A
Typical Change of profile after 2 Years Traffic.

Appendix B

Sub-base Design - Seacroft.

Reference to the design guidance given in Road Note 29 gives predicted load carrying capability in Standard Axles of 8200Kg as shown in Table B1.

Table B1

Sub-base Depth mm	Range of CBR Values (%)		
	2	3	4
150	10,000	10,000	10,000
200	10,000	10,000	10,000
250	10,000	10,000	40,000

If it assumed that the area has been trafficked by 10tonne gross weight vehicles only, then the predicted lifetimes before failure in years are as shown in Table B2

Table B2

Sub-base Depth mm	Range of CBR Value (%)		
	2	3	4
150	0.75	0.75	0.75
200	0.75	0.75	0.75
250	0.75	0.75	3.0

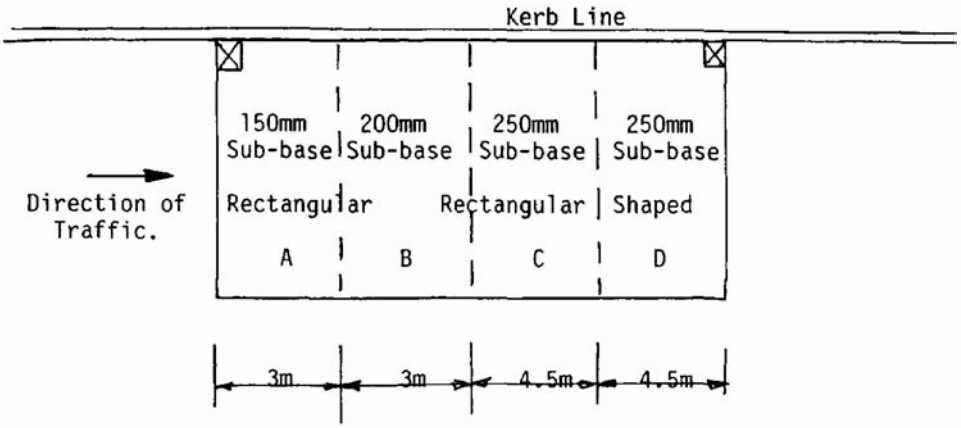


Figure B1

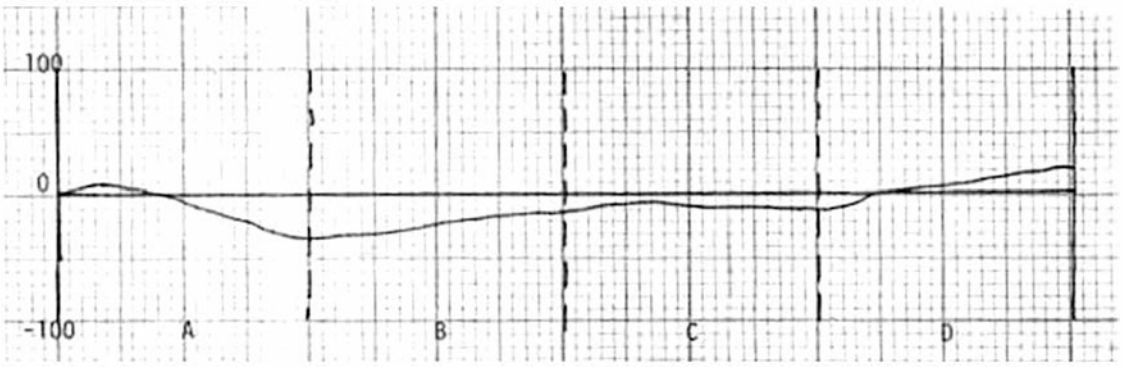


Figure B2

Typical change of profile after 40,000 Standard Axles.



Figure 1. Pitstone- Laying in progress-June 1977



Figure 3. Seacroft.16Tonne Tare Container vehicle.



Figure 2. Seacroft Trial Area-September 1983