THE PERFORMANCE OF RCC PAVEMENTS IN AUSTRALIA

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1 INTRODUCTION

Australia has been involved with the development of modern roller compacted concrete (RCC) pavements since late 1986, with numerous projects, including industrial hardstands, haul roads and several public roadways being completed. Whilst typical pavements are not large, in comparison to some US applications, the Australian examples cover a wide range of pavement types and show a progression in design, detailing and construction technique. The Australian projects were amongst the earliest RCC pavements to include purpose designed contraction joints. A range of mix designs has been used with cementitious materials including silica fume and flyash.

This paper describes the current status of several of the earlier Australian pavements, as noted by the authors on recent inspections. The performance characteristics noted, such as wear, cracking, structural failures and others, are described and put in context with the design and construction of the pavements. Design and construction techniques are criticised, where appropriate, and improvements proposed for each case. Major features of the projects reviewed are summarised in Table 1. Further details of design, together with details of other Australian projects have been previously published (Brett 1988(1,2), Petrie et al 1990, Brett et al 1990).

2 CASE HISTORIES

2.1 Duncan Colliery Haul Road

This 7 m wide by 3.5 km long road was the first application of modern RCC paving in Australia. Constructed over the summer of 1986/87 it comprised a 180 mm thick RCC overlay on an original steep, winding bitumen sealed gravel road used for transport of coal from the Duncan mine to the washery at Fingal, in north eastern Tasmania. The RCC mix comprised locally available materials including mine tailings and sand. Details are summarised in Table 1. Restricted access to the site resulted in construction in two 3.5 m wide lanes with a grader cut central joint. The second lane was placed several days after the first and trafficking by loaded trucks was allowed on the RCC after as little as 24 hours.

TABLE 1
Project Details - Summary

Project	Area (m^2)	Date	Design F'c (MPa)	Mix Detail*	Thickness (mm)**	Joints
Duncan Road	35000	1986	30	300 C 30 CSF	180	none
Tea Tree Road	6000	1987	30	300 C 30 CSF	150	various
Westgate Yard	10000	1988	30	300 C	300 RCC 150 CTB	sawn 15m
Finemores Yard	32000	1989	30	172 C 98 FA	175 RCC 125 CTB	sawn 6m
Wells Road	7700	1988	35	-	200 RCC 120 CTB	sawn various
Brew Road	7700	1989	35	256 C 64 FA	200 RCC 120 CTB	sawn 10m
Cashmere Acres	14500	1988	30	205 C 70 FA	150	sawn 10m
Tarong Road	26500	1991	40	240 C 80 FA	170 RCC 125 CTB	sawn 6m

* C denotes type A cement, CSF denotes "condensed silica fume", FA denotes flyash.
** CTB denotes cement treated subbase.

Construction faults noted during and shortly after construction included:

(i) steps in level at construction joints
(ii) early structural failure in local "poor subgrade" areas
(iii) local areas of fretting surface
(iv) development of lateral cracking at between 7 and 23 metres spacing
(v) development of a central crack at the joint between lanes with considerable spalling.

The areas of early structural failures were found to be subgrade related and the areas of surface fretting were due to low strength due to lack of compaction, compounded by poor curing and the hot weather at the time of construction. Cores from the pavement showed that the average strength was 26 MPa at 28 days. This was less than allowed in design. Strength was expected to continue to rise but later age test results are unavailable. The central joint was repaired by sealing with a bituminous seal strip to fill the spalled areas.

The road performed well for the first 12 months with the mine reporting a 25% increase in truck productivity and a dramatic reduction in vehicle maintenance costs. However, during the summer of 1987/88 movement of the pavement was noted, resulting in opening of central joints by up to 60 mm on several sharper corners, and severe faulting at construction joints on steep sections of the road. These features are shown in Figures 1 and 2.

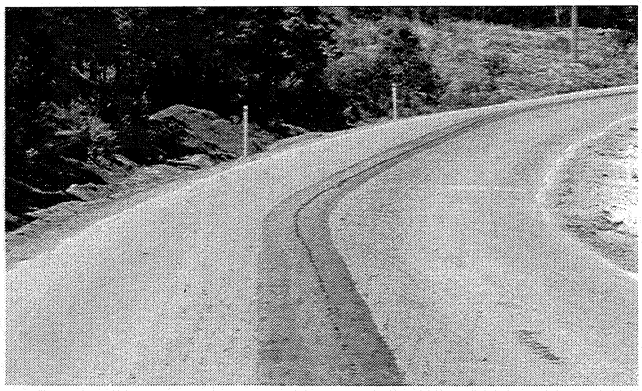


FIGURE 1
Opened Central Joint - Duncan Road

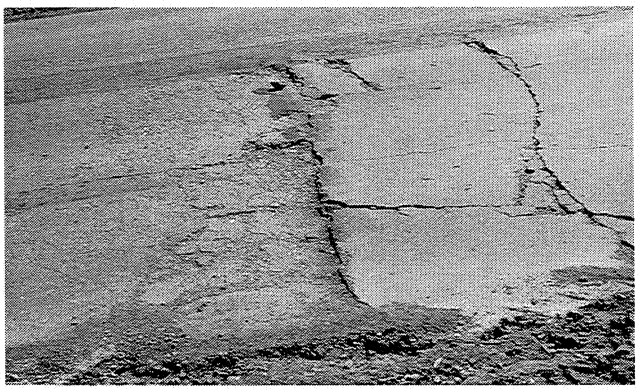


FIGURE 2
Slab Faulting - Duncan Road

The cause of these features was determined to be thermal expansion. With the low shrinkage of RCC, the total crack width can be less than the subsequent thermal expansion, particularly if joints fill with hard particles during open periods. At the Duncan Haul Road this led to a net expansion of the roadway. The longer outer lanes on corners expanded more than the shorter inner lanes with resulting lateral displacement of the outer lane.

On the steep road section the thermal movement is believed to have been exacerbated by downhill creep resulting in a build up of force on poorly formed lateral cold joints. The faulting of slabs appears to have been the result of one slab riding up over another where the cold joint face had not been vertical.

The solution to these problems was to provide expansion joints in conjunction with reinforced concrete anchors set into the pavement as shown in Figure 3. These anchors were constructed at strategic locations on the pavement during April 1988. Faulted slabs were removed and the opened central joints were filled with patching concrete.

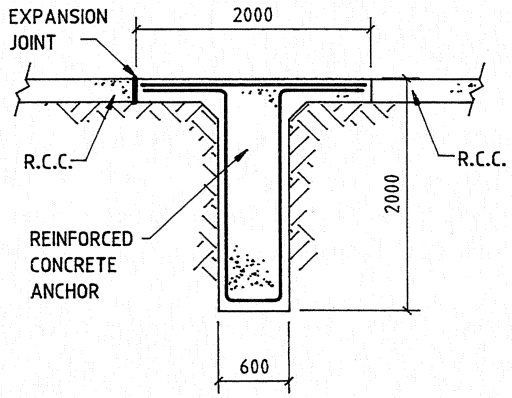


FIGURE 3
Pavement Anchor Detail - Duncan Road

The pavement performance over the next twelve months was satisfactory apart from the progressive structural failure of several distinct areas totalling approximately 2,500 m^2, representing roughly 10% of the road. These were broken out and replaced with 200 mm of RCC, in January 1990. On removal of the pavement in these areas the RCC was found to be generally less than the design thickness, in some cases by up to 40%.

Recent inspection of the pavement in August 1992, found it to be in good operating condition and performing to the satisfaction of the owner, Cornwall Coal Company. During the 5 $^1/_2$ years since completion approximately 3.3 x 10^6 tonnes of coal had been carted down the road and approximately 1.0 x 10^6 tonnes of washery reject had been carted back up.

Of note during the recent inspection were the following;

a) areas of local structural failure were still performing adequately as shown in Fig. 4,
b) the surface was generally sound, hard and providing good skid resistance as shown in Fig 5,
c) concrete anchors and expansion joints were performing satisfactorily with no recurrence of joint opening or faulting as shown in Fig 6,
d) new sections of road at 200 mm thickness and featuring sawn out joints at 7 m showed no sign of structural damage or unplanned cracking after 2 $^1/_2$ years' service.



FIGURE 4
"Failed" Pavement Section - Duncan Road

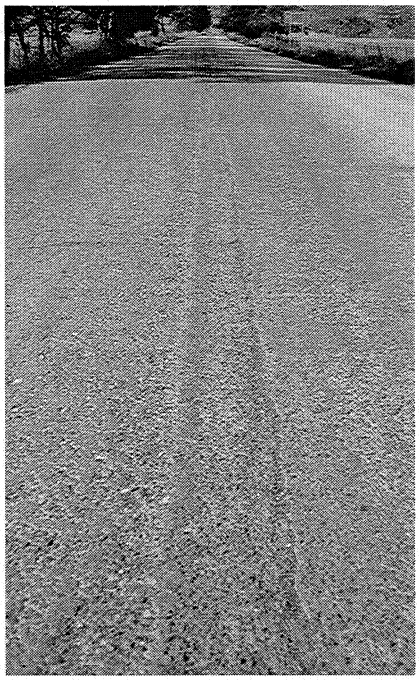


FIGURE 5
Typical Surface - Duncan Road



FIGURE 6
Surface At Anchor Location - Duncan Road

In summary, the road has been successful as a demonstration project. It has been an economic success for the owner whilst highlighting critical areas to be considered in design and construction. These include;

a) The need for adequate anchorage and provision of expansion joints for long RCC pavements, particularly on steep, winding sections of road.
b) The need for conservative thickness design, particularly when formal joints are not provided,
c) The need for proper construction control to ensure design parameters are met.

2.2 Tea Tree Road

This 800 metre long trial section of pavement on a public road near Hobart, in southern Tasmania, was constructed for the Tasmanian Department of Main Roads (DMR). The pavement comprised a direct overlay of the existing sealed pavement that had been judged suitable as a sub-base but had poor surface profile due to extensive past repairs. The road was subjected to heavy traffic loadings, predominantly by trucks hauling logs to a nearby woodchip mill. The design minimum thickness was 150 mm of 30 MPa concrete. A crushed basalt available from a nearby quarry was used as aggregate. The cement content was 14% of dry weight with a further 1.4% silica fume added.

As with the Duncan Haul Road, space for side roads was not available and the DMR required at least two lanes of traffic be maintained overnight. This inevitably led to traffic being allowed over the RCC as early as two hours after placing. Visible results of this early trafficking were limited to minor wheel rutting in one or two areas and plucking of fines from the surface during the first few hours resulting in an "exposed aggregate" finish over the areas under the wheel paths.

Field compaction results on this project were consistently high with dry densities in excess of 99% of maximum "Modified Proctor" density. Consequently, compressive strengths measured by cores cut from the pavement at 90 days exhibited compressive strengths in excess of 40 MPa with some in excess of 50 MPa. Only limited trial formal jointing was carried out with the majority of the pavement allowed to crack naturally. Eight months after placing the crack spacing was found to range from 23 to 53 metres. The project is fully described by Brett (Brett, 1989).

Since construction in April 1987 only minor maintenance has been carried out. This has comprised bitumen sealing of some joints and cracks and covering of a short section of one end of the road with a chip seal, as part of reconstruction of the adjacent roadway.

The project was inspected on 1 September 1992, some five years after construction. The pavement was found to be in good serviceable condition as shown in Figure 7. Crack spacing is variable with some locally close spaced cracking, possibly indicating potential structural failure, although pavement performance is not yet being affected. Some sections of pavement are still uncracked over relatively long lengths.

However, overall, there has been a significant increase in cracking since construction as shown in Table 2.

TABLE 2
Tea Tree Road Crack Spacing

	After 8 Months	After 5 Years
Range	7* - 53	1.1 - 49
Mean	36.5	13.7
St. Deviation	10.5	9.0

* saw cut joints

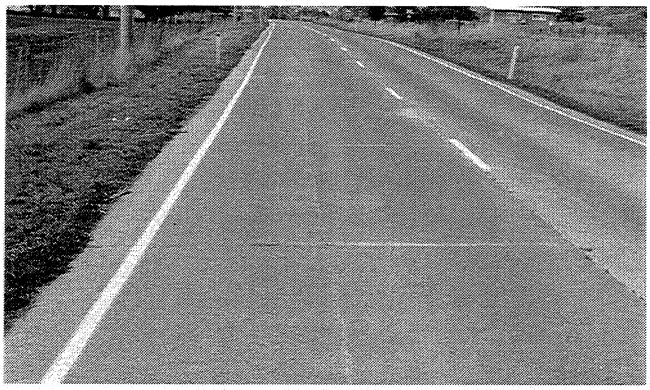


FIGURE 7
Tea Tree Road

Crack widths range from hair line to typically 2 to 3 millimetres, at the time of inspection during a cold, winters day. However, several cracks at either end of the pavement were significantly wider with one over 5 mm wide and another approximately 20 mm wide as shown in Figure 8.

The central construction joint showed minor spalling and had been filled with bitumen in some areas. A hair line, mid-lane crack was noted over much of the pavement, effectively cutting the road into four 1.75 m wide strips. However, no crack opening was evident. This crack location has been noted on other RCC projects and is believed to be related to the operation of the paving machine.

Saw cut joints were in good condition with no edge spalling. The bituminous sealant had hardened, lost bond and in most cases been removed from the joint, however, the 3 mm wide saw cuts were surprisingly clean and free of any accumulation of detritus.

The concrete surface was in very good condition being, visibly, little different from the previous inspection shortly after completion. Some areas of multi-tyre roller imprints from construction were still clearly visible. The surface texture was relatively rough and exposed aggregate particles were sharp with no sign of significant polishing. Skid resistance measurements were not carried out but it appeared that the results would be little changed from the originally reported good figures (Brett 1988).

Rideability tests were similarly not carried out. However, the ride was noted to be quite reasonable in a passenger car although somewhat harsher than the adjacent newly constructed bitumen sealed flexible pavement.

In summary, the trial road appears to have been successful and should give many more years of satisfactory service. The wide cracks at the road end suggest that terminal anchors would be desirable, as was found at the Duncan mine. Some minor faulting suggests loss of load transfer ability at the wider cracks, although no structural block cracking was noted in these areas. Nevertheless this highlights the need for conservative thickness design if the designer cannot be confident that full load transfer can be achieved.

Limited joint sealing trials have not been successful in this case but it seems that sealing is not warranted on a road of this type as all joints and cracks appeared clean, presumably due to the action of traffic.

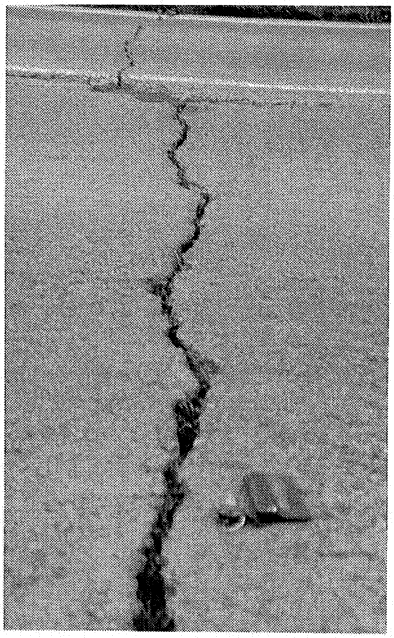


FIGURE 8
Wide Crack - Tea Tree Road

2.3 Westgate Transport Company - Container Yard

A container yard of approximately 10,000 m^2 area was constructed for the Westgate Transport Company in Melbourne, Victoria in February 1989. The yard was designed for large fork lifts with axle loads of 65 tonne. Pavement details are summarised in Table 1.

Subgrade was poor with a CBR of approximately 2%. Concrete aggregate comprised a salvaged crushed rock material blended with new materials. Joints were saw cut at 15 m centres and sealed with Dow Corning 888 silicone sealant.

Weather during construction was hot and dry and some difficulty was experienced in keeping the RCC surface damp during placing, although final curing was of high standard using irrigation sprinklers. Compaction was lower than desirable in some areas. Consequently final strengths were down over approximately 1/3 of the pavement area. In addition, surface dusting resulted in some early loss of surface fines.

The container yard was inspected on 3 August 1992, and found to be in excellent condition although minor surface wear was evident in localised areas. Very few unplanned cracks were noted and all saw cut joints were in good condition with sealant intact and performing well. The surface of the yard was dirty due to carry over of mud from adjacent unsealed container storage areas but, in clean areas, it could be seen that surface was in good condition and visually unchanged since previous inspection shortly after completion. The yard owner reported no expenditure on maintenance over the past 4 $^1/_2$ years and was very pleased with the performance of the yard, particularly in comparison with other surfaces with which he had experience.

2.4 Finemores Transport Yard

A hardstand of approximately 32,000 m^2 was constructed for Finemores Transport Company in Melbourne, Victoria in November 1989. The yard was designed for trucks and light fork traffic. Other freight loads included new motor vehicles that are driven on and off the trucks. Pavement details are summarised in Table 1. The pavement has been inspected progressively since construction, most recently in August 1992.

In the more frequently trafficked areas, where channelisation has occurred, the cement paste has been eroded away giving an exposed aggregate surface similar to asphalt as shown in Fig. 9.

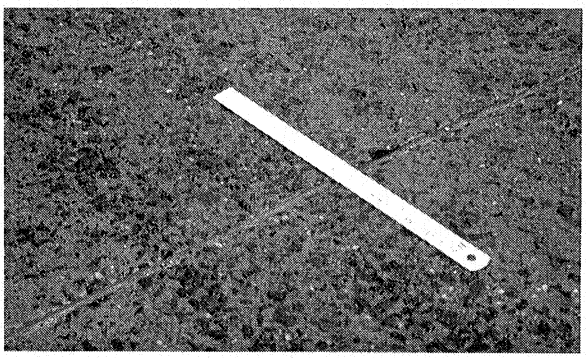


FIGURE 9
Surface Wear - Finemores Transport Yard

The coarse aggregate used was of durable type with adequate abrasion resistance. Functionally, the surface wear is not considered a problem for this type of industrial application. No interruption to freight activities has been experienced and the operators, while initially concerned by the surface wear, are currently satisfied with performance, particularly as the initial construction cost was substantially cheaper than conventional concrete.

Two types of cracking are evident, longitudinal and transverse, though in terms of the total pavement area only a small percentage of the total area is affected. The longitudinal cracks appear to be parallel to paver runs and to be located both at the edge of, and mid paver run. These cracks have possibly been initiated by variable density across the pavement and some of the longitudinal joints may not have been completed early enough, thus forming a cold joint.

An innovative aspect of the pavement was the construction of spoon drains from conventional concrete as shown in Fig. 10. By having the drain divide the pavement into a series of parallel strips, the RCC could be placed with a minimum number of 'cold' joints. This innovation overcame two of the limitations of RCC:

a) surface tolerances are more difficult to achieve with RCC and this is more critical in a drainage invert in order to ensure that water is drained away,
b) cold joints in RCC often result in an unsatisfactory joint.

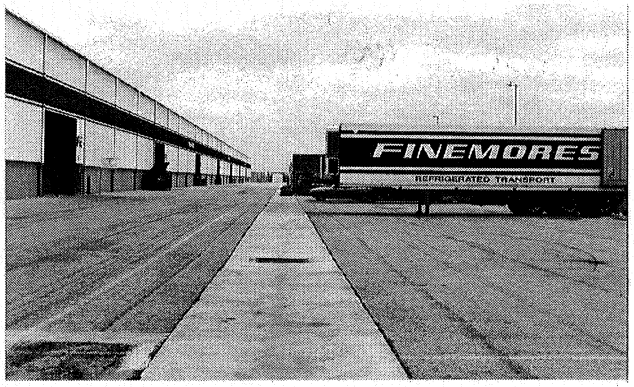


FIGURE 10
Concrete Spoon Drains - Finemores Transport Yard

2.5 Wells Road

VicRoads, the Victorian State Road Authority, constructed two trial pavements to assess the potential of RCC for high speed traffic applications. The two projects both in, or near, Melbourne, were Wells Road and Brew Road. As the pavements were trials, a number of factors including joint spacing and multi-layer construction were explored. Wells Road (Jamieson et al 1990), is the subject of ongoing research, and so will only be briefly discussed in this paper. Pavement thickness design was based on design traffic of 1.4 x 10^7 commercial vehicles. Traffic operating speeds would be up to, and possibly in excess of 100 km/h. The pavement consisted of a 7.7 m wide, 200 mm thick RCC base, on a 4% cement stabilised crushed rock sub-base.

Construction occurred during October 1988 with placement of two 3.85 m wide strips using an ABG Titan 280 paver. Most of the RCC was placed in two layers but some single lift construction was carried out. Two layer construction was used

in an attempt to achieve a higher degree of surface smoothness than normal for RCC pavements at the time. Where the top layer was placed 60 minutes or more after the first, a cement slurry was used as a bonding agent. However this appears to have been largely unsuccessful as significant sections have not achieved bond.

Contraction joints were sawn at various trial spacings ranging from 10 to 20 m with one 100 m section. Silicone and neoprene joint sealants were used. A longitudinal sawcut was not used.

Longitudinal mid lane cracks formed along the majority of each paver run soon after construction. Beams from the pavement indicate this was probably due to segregation of the mix in this zone as there was a lack of fines present. The augers on the paver push material outwards from the central auger bearing housing. The augers were not fitted with reverse flight, or 'flicker', paddles which are fitted to the larger ABG pavers in Australia. This may have contributed to lack of fines in the mid-paver location. At Brew Road where an ABG Titan 410 paver, fitted with 'flicker' plates, was used, a sawn cross-section indicated a homogenous cross-section.

Longitudinal cracks also appeared, within six months, along the pavement centreline. This is considered to be due to warping stresses and similar cracks can be seen in conventional concrete roads which have not been sawn. However, the crack is considerably straighter than normal and so the construction of the RCC in two longitudinal strips is also considered to be a contributing factor.

Transverse cracking has occurred at spacings as small as 3 to 4 m, while on some 10 m joint spacings no unplanned cracking has occurred. The short spacing of the random cracks is considered to have been largely contributed to by the three longitudinal cracks forming long narrow slabs, in combination with the lack of bond in the multi-layer sections. Other projects in Australia have not experienced this level of random transverse cracking.

Nevertheless, at the time of recent inspection in August 1992, after nearly 4 years of very heavy traffic, the pavement was functioning adequately and minimal maintenance works had been carried out.

2.6 Brew Road

Brew Road was constructed for VicRoads, as its second road trial of RCC in February 1990. The site near Melbourne, Victoria was selected as an access road which had to be constructed from a major highway. The new road was free from abutting development, or infrastructure, and though it would be subject to only low traffic volume it would service a rock quarry and would therefore be subject to heavy axle roads.

The pavement consisted of a 7 m wide, 200 mm thick RCC base on a 120 mm thick, 3% cement stabilised crushed rock sub-base. A 5 mm primer seal was applied as a debonding layer between the two layers.

The pavement was placed in a single width and, due to its trial nature, one half of the 500 m long road was placed in 2 x 100 layers and the remaining half in a single lift. A longitudinal warping joint was sawcut and lateral joints were sawn at 10 m centres. All joints were cut to one third depth and sealed with a Dow Corning 888 silicone sealant.

A cement slurry was applied between the 100 mm RCC layers. The slurry consisted of 3 parts cement to 1 part water at an actual applied rate of 1.4 kg/m^2, though the specification required 2 kg/m^2. Ten cores were taken in this section, but only four cores exhibited significant bonding. A chlorinated rubber curing compound was applied at 0.2 L/m^2. This would appear to have been effective, as despite the RCC being placed at air temperatures up to 37^{o}C, little surface wear is evident.

Transverse joints were sawcut the morning after placement in the belief that the lower shrinkage stresses with RCC would permit this. However several cases of unplanned cracking close to saw cuts confirm that the normal industry practice for conventional concrete of sawcutting the concrete as soon as it can be cut with only a small amount of ravelling should be followed.

The roughness measurement of 134 counts/km achieved for Brew Road was significantly greater than the 84 counts/km at the Wells Road trial. This compares to normal industry standards for flexible pavements of approximately 50 counts/km for new construction and a terminal roughness condition of 150 counts/km.

The relatively high roughness count at Brew Road is attributed to:

a) poor operation of the ABG paver and the vibratory rollers, and
b) variation of moisture content which made it difficult to control density and hence final pavement shape

At Brew Road, during placement, the paver was regularly being stopped and adjusted. Poor operation of the rollers also resulted in a number of roller marks on the surface. This problem was the result of operator inexperience.

At the time of recent inspection the road was in excellent condition, visually similar to its appearance shortly after completion 2^1/$_2$ years earlier.

2.7 Cashmere Acres Estate

This example of RCC is located in a housing subdivision 20 km north of Brisbane in South East Queensland. It comprises 3 km of residential road of which 500 m is 6 m wide and the remaining 2.5 km is 4.5 m wide. Included in the layout are 4 cul-de-sacs. Construction took place in November 1988. The climate in the area is typically sub tropical with November approaching mid-summer.

The developer selected RCC as an economic solution for a rigid pavement. The assessed design CBR of the subgrade was 5%. The design RCC thickness was 150 mm, based on a design RCC compressive strength of 30 MPa and the normal housing estate traffic loads, including a once weekly garbage collection truck. The RCC was placed directly on to the prepared subgrade. An interesting aspect of the paving operation on this project was the paving of the RCC full width with a central crown. This was achieved by providing a 'break' in the units that form the rear-mounted tamping bar on the paver. Transverse control joints were sawn at regular intervals and left unsealed at the direction of the developer.

So far about three quarters of the 72 allotments, each 2000-3000 m^2 in area, have been developed, thus there is still some construction traffic to be experienced when the remaining houses are built.

An inspection during August 1992, after nearly 4 years of operation showed that the performance of the pavement has generally been good. However, there are a few items worth noting.

The 6 metre wide section of pavement displays a central longitudinal crack along its length. This suggests the need for a longitudinal joint formed by sawcutting, with appropriate consideration of lateral restraint. Some longitudinal cracking was also evident on the 4.5 m wide pavement sections but only in a small number of localised areas. The unsealed transverse joints have now filled with detritus and, in some instances, are causing local distress as a result of thermal movement.

The general surface condition of the pavement is good and confirms the durability of RCC having regard to the relatively light traffic to date. In particular, the close texture finish that was achieved for most of the pavement has remained virtually intact. A couple of sections that could not be placed using a paving machine were placed by grader and these have displayed a somewhat poorer performance with loss of surface uniformity. Whilst the cause of this has not been confirmed it does suggest that RCC construction is not a particularly forgiving technique and where a high quality consistent finish is sought constant monitoring of materials, production and placing are vital throughout the work.

The use of RCC in this instance has confirmed the suitability for narrow roads constructed in suitable runs for which paving machines are ideal. There appears to be a need to verify the ability to provide tied longitudinal joints for roads without any edge restraint such as suitably designed kerbs. Oddly shaped areas in a development, such as cul-de-sac heads and intersections, require to be paved in some other medium such as conventional concrete or "interlocking" pavers in view of such areas not being suited to paving machines.

2.8 Tarong Road

The longest section of RCC public road to be constructed in Australia is on Rocky Creek Road in South East Queensland. It links the Tarong Power Station with the main highway just west of Yarraman.

The original road was built in 1980 as part of the power station construction work. Since then the flexible pavement had deteriorated and required rehabilitation. Although classed as part of a public road, maintenance has been undertaken by the Queensland Electricity Commission (QEC). The principal user of the road since the power station was commissioned has been Pozzolanic Industries who use the road to transport flyash from the power station. The option of using RCC was proposed by Pozzolanic as joint venturer in the project.

Just under 4 km, of the 5 km road, was considered to require rehabilitation. It was decided to construct a trial section of 300 m of the road and this was done in August 1989. One half of the test length had 160 mm thick RCC on 100 mm cement treated subbase (CTSB) while the other half had 200 mm RCC on 125 mm CTSB. Transverse joint spacing at 8 m and 10 m centres was used. The 2 lane single pass construction did not incorporate provision of shoulders.

Weather conditions during construction were cool and zero temperatures were experienced overnight. This is considered to have contributed to the development of random transverse cracking prior to sawcutting that could not be undertaken until the following day without ravelling occurring. Longitudinal edge cracking developed on the inside curve forming this section of the road. This was considered to have resulted from insufficient shoulder provision, coupled with the inherently lower density achievable at the free edges of RCC pavements. However, the trial was considered successful and construction of the main RCC section, amounting to 3.4 km, was undertaken in February 1991.

The RCC was required to be fully compacted within two hours. Moisture content was set at 1% below standard optimum, a set retarder was incorporated in the mix and close attention was paid to moisture content at the time of placing and to prompt and effective rolling patterns.

Two aspects of importance when considering RCC for public roads are skid resistance and roughness. Queensland Department of Transport (QDT) has undertaken tests on the road which were reported in their progress report in November 1991 (QDT 1991). Skid resistance values are generally in excess of 60, with values of at least 55 measured at all sites. NAASRA Roughness values range from 74 to 87. Whilst roughness values are in excess of the acceptable values required for new flexible pavement construction on the State's "declared roads", they are unlikely to deteriorate noticeably and, having regard to the use of the road they are considered most acceptable.

The only significant technical concern in the Tarong pavement is the occurrence of a longitudinal crack along the centreline over a distance totalling about 1 km. This occurs in a few separate areas and is not continuous. While no investigation has been undertaken to date to establish the cause of the cracking, it is believed that it may be linked to areas where some minor adjustments to the horizontal realignment of the road were undertaken and may involve areas of fill. In some locations these cracks have opened to 15 or 20 mm, believed due to lack of edge restraint. The cracks have been filled with a sealant to prevent ingress of water and dirt.

3 CONCLUSIONS

The examples described in this paper have highlighted various aspects of RCC pavements that need attention in the design and construction of future projects. These are summarised as follows:

3.1 Roads

a) Positional restraint is essential for RCC roads, particularly in steep or winding locations. Longitudinal restraint should take the form of concrete anchors. Lateral restraint could be in the form of edge support by shoulders or concrete kerbing with appropriate backing. Alternatively, a system of tying RCC slabs together needs to be developed. Some limited experiments with reinforcing laid on the sub-base have been promising.

b) Thermal expansion of RCC needs to be taken into account by the provision of expansion joints. These should preferably be associated with anchors.

c) Thin multi-layer construction has not been successful as a means of improving rideability due to poor experience with layer bonding. Layers less than 150 mm are not recommended. Adequate rideability has been achieved with thick layer placement and this will improve with technological development of placement machinery and operator skill.

d) Joint sawing has been successful but unplanned cracking has been common due to excessive delay in sawing. Sawing of RCC should be carried out with the same urgency as for conventional concrete.

e) Joint sealing is only successful if high quality materials are used. However, experience with thin, unsealed joints has been good in highly trafficked areas and the need for sealing should be carefully considered. The problem of saw cut timing may be avoided by development of alternative joint construction. Limited trial use of crack inducer strips placed during laying have been successful, and the "stamping" of joints by vibrating plate equipment has been proposed but not attempted in Australia to date.

f) RCC road pavements should be constructed with integral shoulders to prevent edge failure due to loading of the less well compacted edge zone. A minimum 0.5 m is recommended.

3.2 Hardstands

Most of the problems associated with roads have not been experienced with hardstands which are usually more compact in size. Nevertheless in some cases positional restraint may be important.

The need for joint sealing would depend on the use of the pavement and the nature of likely surface contamination.

Multi-layer construction of thick pavements has been successful, particularly using retarder in the lower layers, but also with cement slurry bonding.

3.3 General

RCC has been found not to be a "forgiving" material and mistakes are very difficult to repair. For this reason design must be conservative and construction carried out with great care and attention to quality control.

Nevertheless experience in Australia has been positive and RCC pavements have been performing adequately for over 5 years. It expected that further development will build on the past experiences and that RCC pavements will develop a niche in the pavement market as a viable, economic rigid pavement system.

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