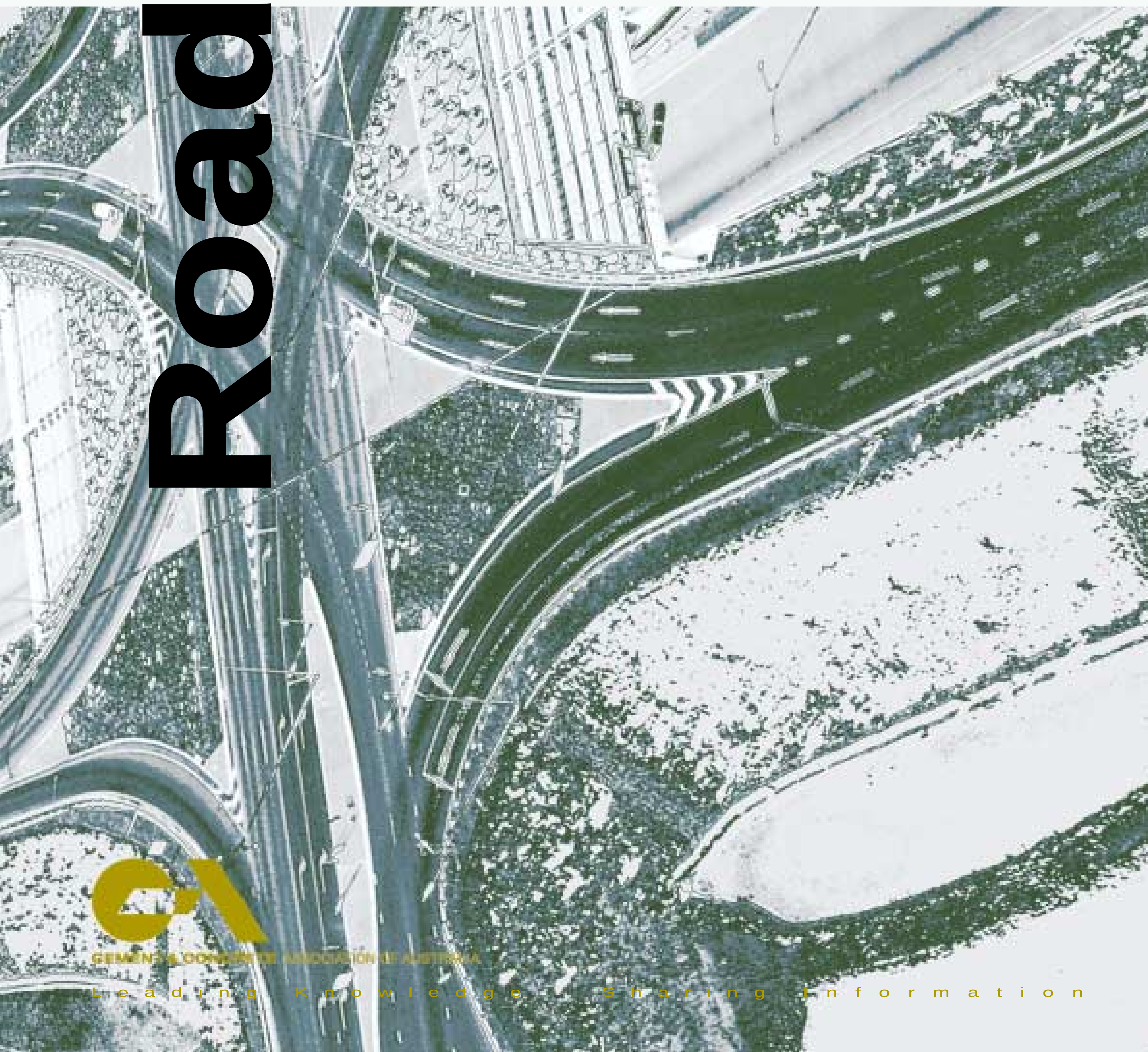
PRINT POST APPROVED PP 241613/00002

Road Note 62

FEBRUARY 2002

World Class Concrete Pavements
Skid Resistant Paving
Cowpasture Road Acoustic Barriers



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FEBRUARY 2002

Front cover image: Oxenford Interchange, Pacific Motorway, Queensland

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Printing: Vaughan Printing
Scanning: ABB GRAPHIX
ISSN: 0313-9964

World-Class Concrete Pavements for the Pacific Motorway, Queensland

INTRODUCTION

The Pacific Highway is the major road link between Brisbane and the Gold Coast and currently carries up to 85,000 vehicles per day. Continuing rapid population growth in the south-east corner of Queensland will result in estimated traffic volumes of 170,000 vehicles per day within forty years.

Over the past ten years, several options have been considered to improve this link and in April 1996 approval was given for 43 km of highway upgrading, comprising widening to eight lanes from Logan Motorway to the Smith Street Motorway, and to six lanes from Smith Street to Nerang. Major construction commenced in late 1997 and the motorway was finished in September 2000—the full cycle of planning, design and construction of 43 km of world-class motorway completed in just four-and-a-half years.

The new Pacific Motorway is an outstanding example of construction excellence that will provide a long-term, low-maintenance solution to traffic capacity in the Brisbane to Gold Coast corridor.

PAVEMENT SELECTION

The key objective for the motorway pavement was to provide “a safe, heavy duty, low maintenance pavement solution which is soundly based on technical and economic grounds”.[1] In keeping with this objective, the Transport Technology Division of the Queensland Department of Main Roads conducted detailed assessments and commissioned an independent review led by Professor Keith Wallace.

Due to the staging of the project, short sections of the motorway required rapid switching of traffic during construction. Because of constructability issues, these sections, which totalled less than one-third of the project, were specified as heavy duty asphalt pavement. The remainder of the motorway was specified as plain concrete pavement (PCP).

The ultimate goal of the project was to achieve best practice in both the design and construction of a world-class motorway. To do this, it was necessary to identify and fully understand the critical issues affecting the design and construction of concrete pavements. There was a broad range of design issues to consider, while during construction under heavy traffic, the prime objectives were quality and minimising delay to motorists.

DESIGN ISSUES

Drainage

The most important issue associated with drainage was hydroplaning—or aquaplaning on a wide pavement. The new Pacific Motorway has an alignment that allows a posted speed limit of 110 km/h for most of its length, so it was therefore necessary to design the vertical and horizontal alignments to minimise the length of water travel and water film thickness.

Water spray generation affects visibility and is accepted as an issue on a four-lane carriageway of any surface type. It was addressed at the design stage by specifying suitable line marking and raised delineation devices.

Embankment Stability

Measures were taken to guarantee the long-term stability of embankment and soft-soil areas by specifying quality earthworks materials. Allowance was made for the use of jointed reinforced concrete pavement (JRCP) in soft soil areas, and the timing of any preloading was scheduled to minimise delays to the construction process.

Pavement Thickness

A conservative attitude was taken to pavement design, as studies have shown that thickness-related failures often do not emerge for at least ten years. A “premium pavement design approach”[2] was adopted that applied a 40-year design life, and included allowances for potential increases in axle loadings over the design period. Particular attention was paid to the pavement support in the provision of a layer of controlled subgrade.

To ensure that the design intent was achieved, penalties were applied to the contract for under thickness, low concrete strength and low compaction.

Package	*Pavement Type*	*Carriageway Length*	*Contractor*
1. Loganholme to Stapylton	Heavy Duty Asphalt	7.4 km	John Holland Construction / Barclay Mowlem Pty Ltd
2. Stapylton to Pimpama	Plain Concrete Pavement	11.3 km	Leighton Contractors Pty Ltd
3. Pimpama to Oxenford	Plain Concrete Pavement	10.3 km	Abigroup Contractors Pty Ltd
4. Oxenford to Gaven	Plain Concrete Pavement	8.3 km	Thiess Contractors Pty Ltd
5. Gaven to Nerang River	Heavy Duty Asphalt	3.2 km	Thiess Contractors Pty Ltd
6. Nerang River to Pappas Way	Heavy Duty Asphalt	2.5 km	John Holland Construction & Engineering Pty Ltd

Table 1 Pacific Motorway Contact Packages

Jointing

Uncontrolled cracking of the concrete pavement was addressed by increasing the focus on the design and detailing of joints. An intensive review of the successes and failures in Queensland and New South Wales was undertaken to determine best practice in joint design and construction.

The application of a combination of wax emulsion and bitumen debonding layer between the base and sub-base, effective and durable sealants and modified saw-cutting techniques were applied to allow greater control over pavement cracking.

CONSTRUCTION ISSUES

Due to the magnitude of the project and the associated time restrictions, the construction contract was separated into six packages as shown in Table 1. Each contract package was supervised by consultant contract managers, with Queensland Department of Main Roads as the Principal.

Construction Programme

During construction it was necessary to maintain a two-lane traffic flow of up to 85,000 vehicles per day travelling at a maximum speed of 80 km/h.

Sequencing of work minimised disruptions and provided a safe working environment for construction personnel. This involved opening one carriageway to traffic while construction works were carried out on the adjacent carriageway. Regularly updated construction programmes were required so that the public could be kept informed of sequencing activities.

Experienced Personnel

The size and duration of the Pacific Motorway Project meant that additional skills had to be sourced externally as well as from Queensland Department of Main Roads. In particular, the experience and advice of the Roads & Traffic Authority of New South Wales was utilised extensively.

At the peak of construction activities, over 6,000 people were directly involved in the project. The levels of experience varied considerably and supervision became much more important. Relationship management was introduced into the project to minimise conflict and improve quality.

Design Intent

Translating the design and specification intent into practice proved to be a major challenge. Queensland Department of Main Roads conducted seminars for contractors and contract managers to ensure that there was an understanding of the level of quality required and how to achieve it.

The seminars clearly demonstrated what specific levels of quality are achievable given severe cost and time constraints. It also provided invaluable feedback from the construction site to the design office.

Construction Equipment

Several Wirtgen and CMI slipform paving machines were used to place the concrete pavement in widths of up to three lanes, see figure 1.

These machines are capable of laying pavement at between 1.0 and 1.5 metres per minute. Concrete was

Figure 1 View of slipform paving machinery

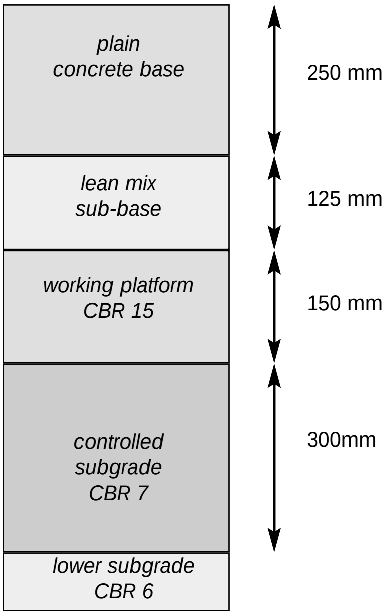


Figure 2 Structure of plain concrete pavement

transported to site in open bodied tippers and transferred to the slipform paving machines. Immersion vibrators within the paving machine provided the compactive effort.

Longitudinal tie bars can be inserted automatically by the paving machine, or manually using prefabricated bar cages. Compaction over the tie bars was identified as a critical construction issue, and for this reason, some contractors preferred the manual insertion method.

Surface Texture

Adequate texturing is required to meet skid resistance and surface drainage requirements, while maintaining a high standard of rideability. A bonus/penalty system was imposed to ensure compliance with rideability specifications.

PAVEMENT DETAILS

Concrete Pavement Structure

The concrete pavement consisted of a 250-mm plain concrete base overlaying a 125-mm lean-mix sub-base. A 300-mm controlled subgrade and 150-mm working platform provided uniform support to the base and sub-base, see figure 2.

The base concrete has a specified minimum flexural strength of 4.2 MPa at 28 days. However, in some areas, locally sourced coarse aggregates and sand enabled flexural strengths in excess of 5.0 MPa to be achieved.

The lean-mix sub-base contains a high proportion of flyash, and has a specified minimum characteristic compressive strength of 6.0 MPa and a maximum of 15.0 MPa with no flexural strength requirements.

Surface Finish

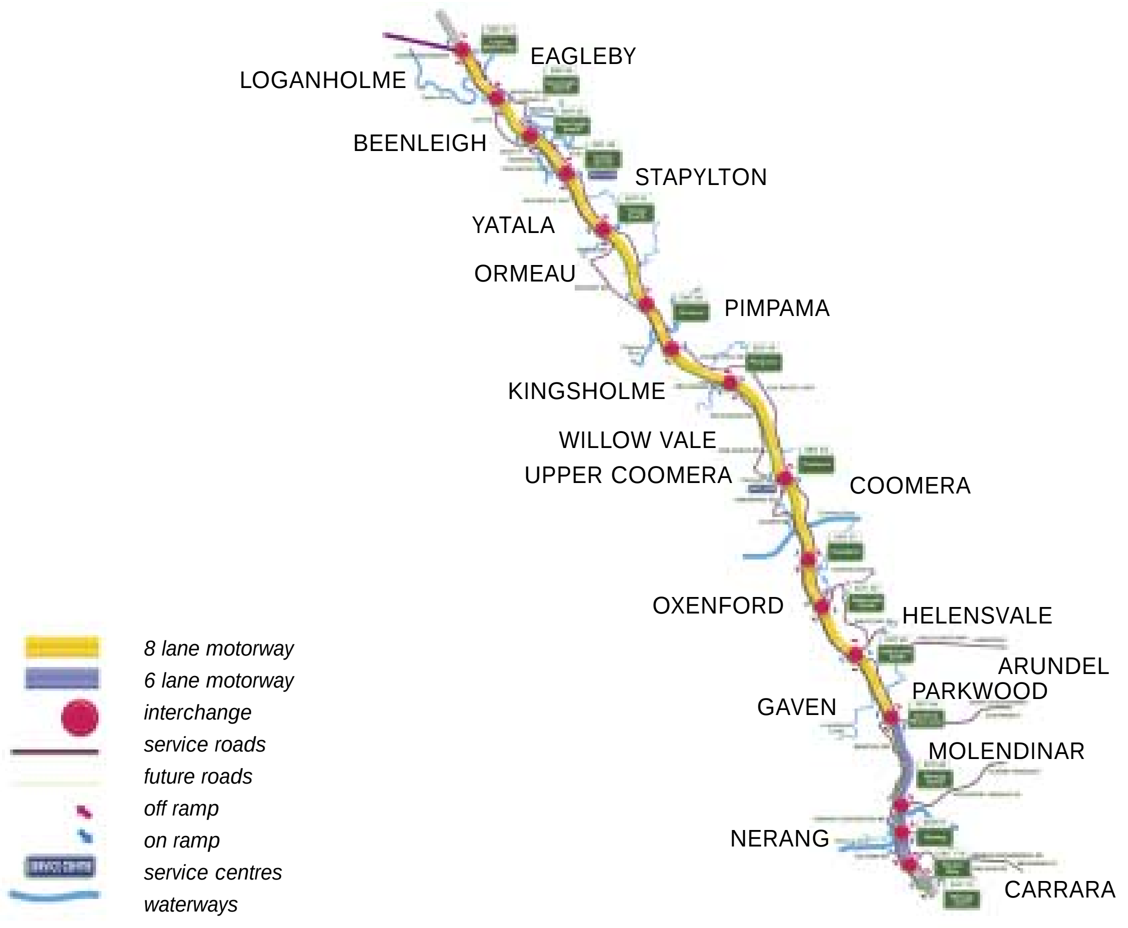
The surface is initially given a fine longitudinal texture by using a hessian drag attached to the paver. As soon as possible afterwards, transverse texturing is carried out using steel tynes that are randomly spaced at between 10 and 21 mm. This two-stage operation provides the optimum combination of skid-resistance, rideability, noise control and surface drainage. Curing is by application of a liquid membrane forming compound. Longitudinal and transverse joints are formed by saw cutting to induce planned cracking. Timing of the cutting is critical and is a function of the maturity of the placed concrete—if joints are cut too late, unplanned cracking will inevitably occur.

PACIFIC MOTORWAY LEARNINGS PROJECT

Upon completion of the Pacific Motorway Project, the Queensland Department of Main Roads initiated a Learnings Project to identify, record and apply knowledge gained through experience on the project.

Twenty teams were established to cover all aspects of the project from initiation to completion. The teams reviewed systems, specifications, design procedures, consultation processes and project and relationship management practices with a view to enhancing the capabilities of Queensland Department of Main Roads and its agents. The project has included several workshops and industry forums where contractors, consultants and industry groups can identify key issues and provide feedback.

Due for completion in June 2002, the Learnings Project will ensure that future construction works benefit from the experiences on the Pacific Motorway Project.



To Brisbane via the South-East Busway and Transit Lane Project

Pacific Highway Legend

To planned Tugun Bypass and NSW Pacific Highway

CONCLUSION

An analysis of the tendered prices by Queensland Department of Main Roads[3] found that the average tender prices for the two heavy-duty pavement types were:

- Plain Concrete Pavement—$70/m2
- Asphalt Pavement—$85/m2

The final total project cost, including 16 interchanges and 90 bridges and major culverts, of $951 million for 328 lane kilometres (86 carriageway kilometres) represents $2.9 million per lane kilometre. This compares favourably with interstate and international experience and highlights the level of expertise and innovation applied to the Pacific Motorway project.

The concrete paving industry has come a long way since 1983 when the maximum daily pour on the Pacific Highway deviation at West Burleigh was 815 cubic metres.[4] Compare this to outputs of up to 1800 cubic metres of concrete per day on each contract package for the Pacific Motorway. In fact, a total of 400,000 cubic metres of concrete were laid, making the Pacific Motorway one of the largest concrete construction projects in Australia.

ACKNOWLEDGMENTS

The assistance provided by Bob Higgins (Pacific Motorway Project Director) and John Worrall (Pacific Motorway Learnings Project Director) of Queensland Department of Main Roads in the preparation of this discussion paper is gratefully acknowledged.

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Figure 3

Figure 4

Figure 5

Figure 6

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Figure 3 Miranbeena Drive Interchange, looking south

Figure 4 Oxenford Interchange, looking south

Figure 5 Yawalpah Road Interchange, looking south

Figure 6 Yawalpah Road Interchange to LeMans, looking south

Skid Resistance of Decorative Concrete Paving

INTRODUCTION

Skid resistance study

A study has been undertaken by the Cement & Concrete Association of Australia to assess the skid resistance qualities of decorative concrete finishes used in residential streets, footpaths, cycleways and pedestrian areas. The study comprised a literature review of skid resistance and experimental work, both in the laboratory and in the field.

The literature review considered:

- current statutory requirements for skid resistance;
- the major factors affecting skid resistance of each surfacing type; and
- typical skid resistance ranges for surfacing currently in use.

Experimental work was conducted in order to:

- determine and compare the skid resistance qualities of various concrete paving types that are used for residential streets and pavements;
- compare these results with any established skid resistance criteria; and
- determine whether particular surface finishes or concrete paving types are more appropriate for different applications.

BACKGROUND

Skid resistance is described as the ability of a surface to provide friction to a reference tyre or slider usually measured wet. Skid resistance is primarily dependent upon the surface macro and microstructure, as shown in figure 1.

Other parameters affecting skid resistance are:

- environmental conditions, including surface contaminants and temperature;
- physical properties of the paving materials;
- age of pavement and traffic volumes;
- pavement geometry; and
- seasonal conditions, ie amount of rain.

DEVICES FOR MEASURING SKID RESISTANCE

High Speed Devices

SCRIM (Sideways force Coefficient Routine Investigation Machine) is a vehicle-mounted device comprising one or two specially manufactured testing wheels and a water tank which continually tests the pavement surface for skid resistance. The measure of skid resistance from SCRIM is termed the Sideways Force Coefficient (SFC) and is expressed as a ratio of the sideways force upon a free-to-rotate test wheel, angled to the direction of travel, and the vertical force exerted by the mass of the equipment.

ROAR is a trailer-mounted device towed by a vehicle which can operate in either a fixed degree of slip or in a variable-slip mode. The basic unit comprises a precision hydraulic brake machine with a standard ASTM 1551 test tyre. ROAR is able to measure surface friction over a range of slip speeds.

Low(er) Speed Devices

British Pendulum, also known as the Portable Skid Resistance Tester, is a device primarily used in a laboratory to determine the frictional qualities of small areas of surfaces, typically sealing aggregates. The unit of measure is the Skid Resistance Value or the Skid Resistance Number and is approximately 100 times the value of the coefficient of friction (Kennedy et al).[2] Details of the test are in BS 812: Part 114 and in AS1141.42 with preparation of samples as given in AS1141.40 and AS1141.41.[3]

The Grip Tester is a device that can be towed by a vehicle or pushed by hand and can thus test confined areas such as intersections and pedestrian walkways which devices like SCRIM and ROAR can not easily access. This device measures a wet coefficient of friction, using a braked wheel aligned in the direction of travel. Drag and load are continuously measured and the quotient is displayed on a laptop computer. The force on the axle due to the surface friction is divided by the mass of the assembly and a ‘grip number’ is derived, which is a ratio of less than unity. The value is different from, but can be correlated to, those of other devices.

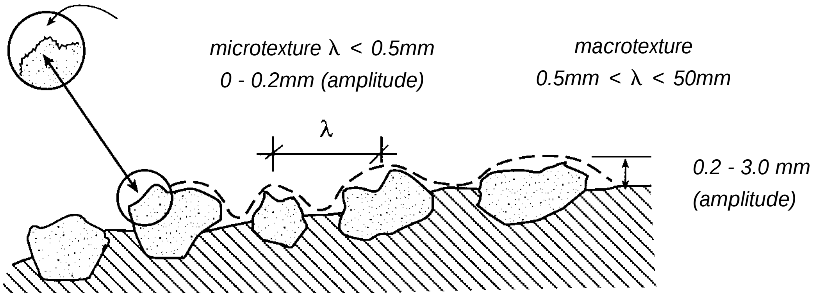

Figure 1 Comparison between microtexture and macrotexture (after Rogers and Gargett)[1]

FACTORS AFFECTING SKID RESISTANCE

General

As previously mentioned, skid resistance is usually described as the ability of a surface to provide friction to a reference type or slider, usually measured wet. Friction is dependent upon the pavement macro- and micro-texture.

Micro-texture has greater influence on friction at the low speeds encountered in residential areas. Macro-texture becomes dominant at higher speeds, although micro-texture is still important. Macro-texture supplies the paths through which water can escape from between the tyre and road surface, thereby allowing the micro-texture to provide resistance to the relative movement between the tyre and the road surface.

Skid resistance is a function of many variables, some of which are independent of the pavement surfacing type, eg traffic volume, traffic speed, the presence of contaminants or lubricants, and seasonal variations. These are not discussed further. Factors relating to the concrete pavement are briefly discussed below, based on the literature review.

Improvement of skid resistance for concrete pavements is documented by the Highway Research Board (USA:1968) where the use of silica-sand mixes, non-polishing aggregates and the imparting of a suitably deep macro-texture to the plastic concrete is emphasised. Quartz, which comprises silica, is generally regarded as the hardest road-surfacing mineral, with only other silica minerals able to polish quartz.

Abrasion resistance

Good abrasion resistance of the pavement slows the rate of decrease of skid resistance with time and trafficking. A minimum compressive strength, typically specified at 32 MPa, generally ensures durability to allow the retention of texture during the design life of the pavement.

Concrete surfacing practice has been primarily directed to provide a surface that is naturally safe in terms of resistance to skidding and also to maintaining the required friction throughout the life of the pavement.

Surface texture

Surface texture is dependent upon the aggregate type and the concrete composition. For example, the different textures are produced by varying sand content versus coarse aggregate content; or by varying the density or porosity of the concrete. At low speeds, skid resistance is primarily provided by fine surface texture, ie the sand in the mortar.

At higher speeds on wet roads, the surface must contain in addition to fine surface texture, sufficient drainage paths for the water to be dispersed before the fine texture can come into play. Surface macro-texture can also be achieved by longitudinal tining, transverse brooming, exposing the aggregate, applying aggregate chips and by the use of open-graded concrete. The longer the contact length of the hessian drag with the plastic concrete, the greater the depth of the longitudinal striations. For traffic speeds up to 80 km/h, a “hessian drag” finish provides acceptable skid resistance. For greater speeds, transverse tining is required to provide greater drainage capacity. This lessens the likelihood of aquaplaning at high speeds by providing macro-texture.

Sand/fine aggregate

A full-scale experiment involving the construction of twelve 150-m-long sections of concrete pavement over a ten-year period in the UK was reported by Franklin.[4] An assessment of the skidding resistance was made for various quality limestone coarse aggregate and for various quantity of limestone or shell used in the fine aggregate. The factor having the most effect on skid resistance was the acid-soluble content of the fine aggregate. The greater the acid-soluble content, the lower the measured skid resistance of the concrete. This concurs with studies undertaken by Colony in the USA.[5] A carbonate (sea shell) content of 25% of the fine aggregate (either retained on or passing through the 600-µm sieve) reduced the Sideways Force Coefficient (SFC) by 0.11 when compared to a fine aggregate with no acid-soluble content.

		TRL/DTp skid resistance values		BS 5395 friction limits for stairs	
Skid resistance value (SRV)	*Description of surface*	*Skid resistance value (SRV)*	*Description of surface*	*Coefficient of friction*	*Description of surface*
Below 19	Dangerous	Below 45	Potentially slippery	Below 0.2	Very Poor
20-39	Marginal	Above 45	Satisfactory (in favourable circumstances)	0.2 to 0.39	Poor to fair
40-74	Satisfactory	Above 55	Generally satisfactory	0.4 to 0.75	Good
Above 75	Excellent	Above 65	Good	Above 0.75	Very Good

Table 1 Previously published skid and friction limits [Greater London Council skid test criteria for pedestrian surfaces]

Category	*Type of Site*	*Minimum Skid Resistance (SRV)*
A	Difficult sites such as: Roundabouts Bends with radius less than 150 m on unrestricted roads Gradients 1 in 20 or steeper of lengths greater than 100 m Approaches to traffic lights on unrestricted roads	65
B	Motorways, trunk and Class 1 roads and heavily trafficked roads in urban areas (carrying more than 2000 vehicles per day)	55
C	All other sites	45

Table 2 Suggested minimum skid resistance values for wet surfaces, measured by British Pendulum [Hosking:1992]

	Before Trafficking				4 Weeks		12 Weeks		18 Weeks	
Finish	*SMV_CA*	*COV%*	*SMV_C B*	*COV%*	*SMVc*	*COV%*	*SMV_C*	*COV%*	*SMV_C*	*COV%*
Slate	28.5	12.21	26.3	23.74	30.5	5.99	40.4	11.36	39.3	14.97
Cobble-stone	30.6	18.93	27.8	18.89	32.2	8.85	41.8	7.05	39.2	10.05
Stencil	44.6	14.76	42.4	18.23	40.0	16.52	53.7	6.48	54.2	6.18
Stippled	66.1	3.44	65.4	3.34	59.0	1.71	68.8	2.44	63.9	3.18
Broom	71.0	2.28	70.1	4.39	63.5	4.37	66.4	3.95	67.0	1.18
Wood float	69.8	3.11	67.9	4.17	66.9	2.79	71.5	8.82	70.1	2.52
Ex. Aggregate	74.3	6.89	76.9	7.29	72.5	1.81	74.0	3.77	73.2	5.69

SMV_C: Sample mean value corrected for temperature to the nearest 0.1; COV %: Coefficient of variation = (standard deviation/mean)%

Table 3 The skid resistance of the external decorative concrete finishes [Test Method: Wet Pendulum AS 1141.42 TRRL rubber]

	Before Trafficking		12 Weeks		18 Weeks	
Finish	*(µm)*	*COV %*	*(µm)*	*COV %*	*(µm)*	*COV %*
Slate	25.2	42.07	32.2	21.17	43.7	42.29
Cobblestone*	28.9	35.59	27.2	27.80	33.7	29.22
Stencil*	39.2	34.76	52.9	39.87	55.5	37.46
Stippled	69.5	24.89	52.1	34.49	71.3	15.90
Broom	79.3	33.96	56.8	31.96	67.3	20.42
Wood Float	64.8	26.77	59.5	40.35	58.5	42.14
Ex Aggregate	59.9	40.11	67.3	37.44	75.9	43.24

** The mean R_z surface roughness of the cobblestone and stencil laboratory specimens were 49.9 and 61.8 microns respectively*

Table 4 The R_z surface roughness of the external decorative concrete pavements (using a cut-off length of 0.8 mm)

*Finish**	*Suitability for residential streets*	*Suitability for public footpaths*
Slate	Unsuitable	Unsuitable
Cobblestone (smooth)	Unsuitable	Probably unsuitable **
Rough Cobblestone	Suitable **	Probably unsuitable **
Stencilled paver (smooth)	Unsuitable	Probably suitable
Coarse stencilled paver	Suitable ***	Suitable
Stippled	Marginal	Suitable
Broom	Appears suitable	Suitable
Wood float	Suitable	Suitable
Exposed aggregate	Suitable	Suitable

** There is no accepted standard method of achieving these finishes, and they should be considered generic rather than specific.*

*** Could present unacceptable difficulties for wheelchair traffic on pavements and road crossings; unsuitable for bicycles on residential streets.*

**** The abrasion resistance with trafficking would determine the longevity of such a finish.*

Table 5 Interpretative summary of the experimental results

The Roads and Traffic Authority of NSW (Nichols and Dash)[6] requires that the sand component of concrete (less than 5-mm particle size) comprise not less than 70% quartz.

Coarse aggregate

Durability of the coarse aggregate also can contribute to, and slow the rate of decrease of, skid resistance. The higher the Polished Stone Value (PSV) of the aggregate, the greater the retardation of any reduction in skid resistance. In Franklin's study, the mineral aggregates' PSV also had a significant effect on the pavement's skid resistance. However, the SFC was unlikely to change by more than 0.05 over the range of coarse aggregates normally used in concrete pavements.

Kennedy et al in citing work by others stated: *Measurements of skid resistance on concrete roads have shown that the choice of fine aggregates has a major effect on the level of results. Compressive strength of the concrete and the proportion of fine aggregates also affect resistance to skidding, but the characteristics of the coarse aggregates have little effect.* [1991]

Statutory Requirements

The results of the literature search indicate that at present there are no statutory requirements for the skid resistance of local roads. However, based on extensive studies undertaken in the UK, investigatory skid resistance levels were introduced in the UK for different site categories, see Table 1. Hosking suggested minimum values of skid resistance as measured by a Portable Skid Resistance Tester (British Pendulum) as shown in Table 2.[7]

THE TEST PAVEMENT EXPERIMENT

An 8-m-long section of an internal CSIRO site in Highett, Victoria, was made available for the study. The road leads to a staff parking area and would be trafficked by about 20 vehicles a day, including a number of trucks making deliveries to the canteen.

The road was prepared for the construction of an 8 x 5 m concrete slab, 180 mm thick, with one layer of F82 mesh, six decorative concrete finishes and buffer zone at each end, shown in figure 2.

The slab (figures 3 and 4) was poured in two stages with Y12 dowel bars placed at 400-mm centres at all construction joints. The concrete strength was 32 MPa. Laboratory specimens were also cast as 500 x 400 x 50-mm slabs.

These specimens were used to determine pedestrian slip resistance; the results of which will be discussed in a separate article.

The curing procedure was to cover all finishes with polythene sheet as they were completed, and to secure it for seven days. The completed pavement is shown in figure 5 and examples of some of the finishes in figures 6, 7 and 8.

The skid resistance of the concrete finishes was determined on the basis of AS1141.42. The surface roughness of the finishes was measured using a Surtronic 10 R_Z instrument, as recommended by the UK Slip Resistance Group. It is a pocket-size, electronic, stylus instrument which measures the maximum peak to trough amplitude readings over a 4-mm length of floor which is divided into five lengths of 0.8 mm. The average of the five values is displayed.

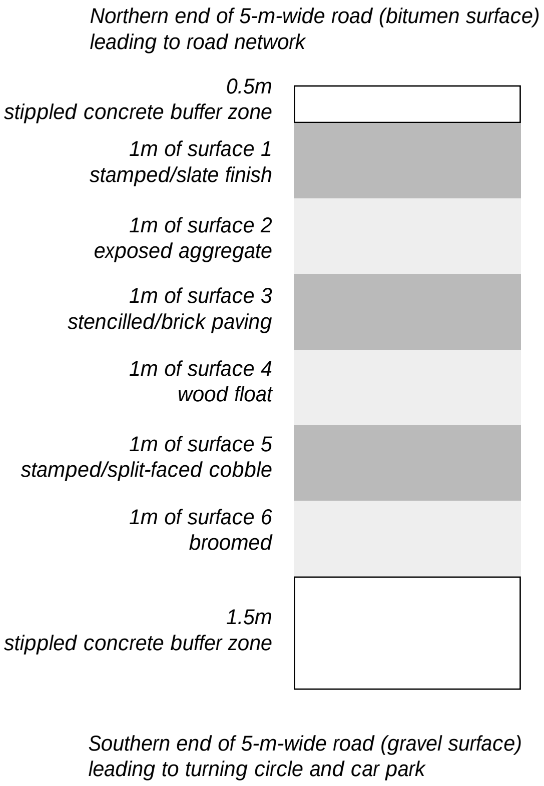

Figure 2

Figure 3

Figure 2	*Layout of the concrete test pavement*
Figure 3	*The pavement was placed in two stages with tie bars*
Figure 4	*The test pavement*
Figure 5	*Completed section of the road after it was opened to traffic*
Figure 6	*Exposed aggregate finish shown with a 50-mm scale*
Figure 7	*Broomed finish shown with a 50-mm scale*
Figure 8	*Wood floated finish shown with a 50-mm scale*

TEST RESULTS

In Table 3, two sets of results (A and B) are given for the initial test results. This work was performed in duplicate in order to obtain a better understanding of the variability of the results, given that each of the five measurements was made on an area of the test pavement measuring 126 x 75 mm.

On this scale, the profiled nature of the patterned finishes represents a heterogeneous surface. Thus, the exact positioning of the pendulum can have a significant influence on the measurements. Positioning of the pendulum in exactly the same place for each set of measurements was considered to be unachievable.

The variability in the individual results has been expressed as a coefficient of variation. The coefficients of variation of the patterned finishes were high (up to 23.7%) and the difference between the two sets of mean results for the initial test results was up to 2.8 measurement units. This suggests that all of the results should be considered to have a precision of perhaps ±3 units.

The surface roughness of the decorative concrete pavements is shown in Table 4. It should be noted that second laboratory samples of cobblestone and stencil finishes were prepared and were intentionally made rougher. The cobblestone finish was brushed and a 10-mesh grit was used for the stencil finish.

DISCUSSION AND RECOMMENDATIONS

As mentioned, there are currently no statutory requirements for the skid resistance of roads. Hosking suggested that a wet surface should have a minimum skid resistance value of 65 in order to provide adequate skid resistance on difficult sites (see Table 2). A lower level of skid resistance may be acceptable in some residential streets depending on their geometry and traffic conditions.

Assuming that some residential streets will have sharp curves, roundabouts, steep gradients and intersections—where a high level of skid resistance is required—Table 5 has been based on a minimum SRV of 65 and provides a cautious conservative interpretation of the results obtained in the study.

The initial SRV of the grey finishes (stippled, broom, wood float and exposed aggregate) was in excess of 65 and this was generally maintained with trafficking, although the heterogeneous nature of the finishes resulted in high coefficients of variation.

The original patterned, somewhat smooth, finishes—stamped slate, stamped cobblestone and stencilled—had lower initial skid resistance, but it increased with trafficking. It was shown that some rougher finishes might provide suitable skid resistance, although some accelerated wear testing should be undertaken to ensure that the finish is likely to retain its skid resistance.

Figure 4

Figure 5

Figure 6

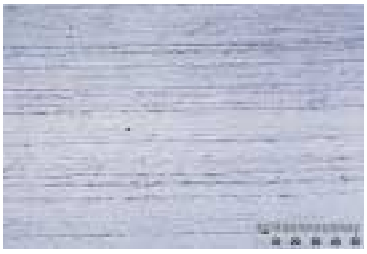

Figure 7

Figure 8

CONCLUSION

Caution should be exercised in using generic products such as stamped or stencilled finishes since their heterogeneous nature could lead to wide variations in skid resistance properties. The stippled, broom, wood float and exposed aggregate finishes had the skid resistance required for local roads and was generally maintained with trafficking. The criteria adopted is conservative and a lower value for skid resistance may be adopted based on the particular conditions of a street.

Based on the same conservative criteria, the 'smooth' stamped slate and cobblestone and stencilled finishes were less skid resistant initially but improved with trafficking. However, it is reasonable to assume that skid resistance is required from the time the street is open for traffic. Therefore, it may be necessary to add more texture or greater roughness to these finishes in order to provide the required skid resistance.

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Cowpasture Road Noise Walls
Integrating Acoustic Barriers in the Sydney Suburbs

CLIENT:	Roads & Traffic Authority, NSW
CONTRACTOR:	Nace Civil Engineering Pty Ltd
ARCHITECT:	Bates Smart Architects Pty Ltd
DESIGNER:	Noizwol Pty Ltd
ENGINEER:	Philip Allen & Associates Pty Ltd
PRECASTER:	Rescrete Industries Pty Ltd

Throughout Australia, noise barrier systems have become an integral part of the roadscape along major arterial roadways such as freeways and motorways, to control the transmission of ever increasing traffic noise. However, with the greater demand placed on not only major arterial roadways, but also sub-orbital link roads—such as Cowpasture Road—the use of noise barriers is extending further into residential precincts. There is therefore a greater emphasis on providing a noise barrier system that is not only effective in the management of the traffic noise, but also visually acceptable and sympathetic to its local context.

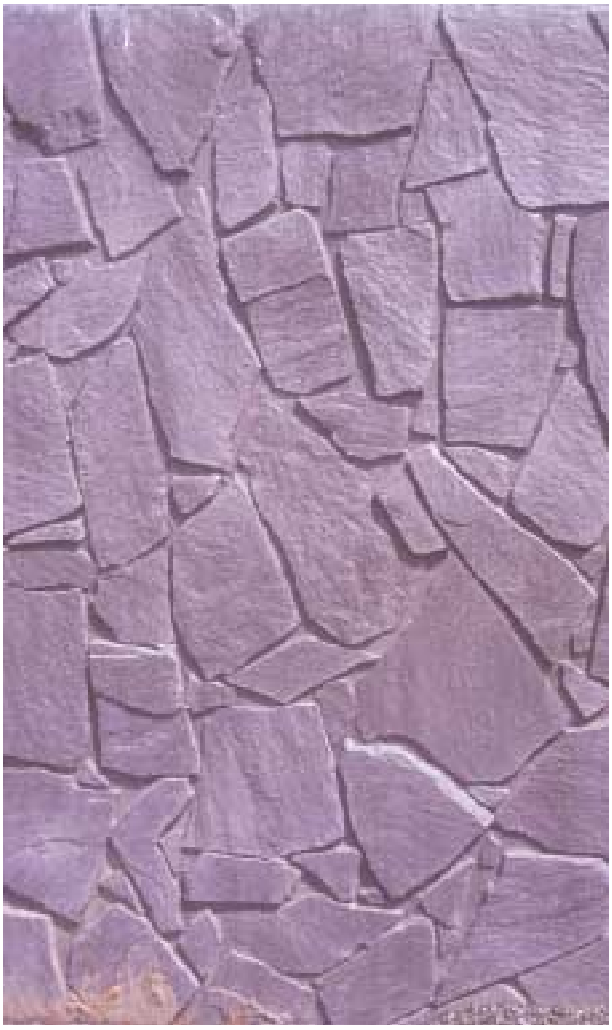
The Cowpasture Road project is located along the northern section of Cowpasture Road in Horsley Park, south-west of the Sydney CBD. The noise barrier system is used to control the traffic noise along both western and eastern sides of the road for the adjacent residential precincts. To satisfy all the required objectives of the Roads and Traffic Authority, and following thorough consultation with local residents, a system of precast concrete noise wall panels was adopted.

Bates Smart Architects prepared the conceptual design scheme, while noise barrier design specialist Noizwol Pty Ltd provided the structural longitudinal gradient design. Brian Bradley, Director of Noizwol, advises that the design philosophy was to provide a noise barrier to both compliment the existing topography and to reflect the surrounding texture of the land on both faces of the noise barrier. The roadside faces of the panels were given a rock-formed patterned texture, while an exposed aggregate surface was provided on the other side of the walls. Additionally, the barrier conforms to RTA requirements in terms of reduced traffic noise reaching adjacent residential properties.

The precast concrete panel system was chosen for many reasons, including:

- The favourable acoustic properties of concrete due to its solid mass in both reflecting and dispersing airborne sound. In this case, the noise wall panels were designed to purely reflect and disperse the transmitted traffic noise. The system used by Noizwol can provide noise reduction up to 20 dBa.[1]
- The ability of concrete to provide the desired colour and texture to reflect the local surroundings. In addition, its ability to be formed into numerous configurations and off-form shapes, either as flat or curved panels, provides many design possibilities. Its integrated colour and texture means that applied finishes—such as painting—is not required, therefore minimising future maintenance costs.
- The speed of installation and its versatility to be installed in stages to suit individual residential precincts. This results in minimising disturbance to existing traffic flows and adjoining roadside residential properties.
- The manufacture of purpose-designed precast panels off-site under controlled conditions and supervision provides a superior product quality.
- Concrete is highly resistant against bushfires and temperature extremes and its inherent rigidity prevents it warping and thus impairing its acoustic performance.

The Cowpasture Road noise barriers comprise 794 precast panels, 44 of which are curved in plan. The finish on the roadway-facing side is either plain or a rock relief texture produced by the use of formliners. On the other face, some panels have an exposed aggregate finish (a medium sized river gravel aggregate in off-white cement). In addition, some panels have a curved top edge to echo the topography. The combination of such a variety of finishes and shapes maintains interest in its expression within the material's own natural character. All roadway-facing panel surfaces were integrally mineral-oxide coloured in various earthy shades of brown to further blend with the surroundings.



All panels were designed to be self-supporting, acting in a cantilever action as they are keyed into concrete “boot” footings at each end. The panels and columns were cast integrally, eliminating protruding posts and providing an uninterrupted line of wall. The edges of the panels have a bevelled profile to facilitate installation—whereby panels are simply butted against adjacent panels—leaving a nominal 10-mm joint that does not require sealing, and which does not significantly impair the barrier’s acoustic performance.

This interesting design, incorporated by Noizwol, is covered by Australian Patent and has been used in other projects in NSW. The majority of the modular panels are sized at 6.0 m long, 3.6 m high, 190 mm thick and weigh a maximum of 8.4 tonne’s. The total area of walling for the project amounted to approximately 12,500 square metres. The contract price for the noise barrier system including the manufacture, transport and installation was $2.72 million.

1. Quoted results from tests performed by the National Acoustic Laboratories for Noizwol Pty Ltd.

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FEBRUARY 2002