ROADnote

70
APRIL
2005

Segmental Paving and Flags

CEMENT CONCRETE
& AGGREGATES AUSTRALIA

Leading Knowledge-Sharing Information

Olympic Performance – Five-year performance assessment of segmental concrete pavements at Sydney Olympic Park.

01

Client: Olympic Co-ordination Authority (OCA)
Developer: NSW State Government
Landscape Architect: Denton Corker Marshall (Sydney)
Principal Contractor: Multiplex and Abigroup
Concrete Contractor: Sam the Paving Man
Paving Supplier: C&M Brick Pty Ltd

Stronger, Higher, Faster – that was the performance motto of the Olympic athletes for Sydney 2000 — but five years on how have the Sydney Olympic infrastructure investments performed? This article takes a close look at the performance of some of the most 'down-trodden' and yet 'well-heeled' investments at Sydney Olympic Park: the pavements of the Olympic Plaza and Olympic Boulevard.

Since 2000 an estimated 30 million people have visited the site, equating to 60 million feet pounding the pavement, a multitude of buses and coaches, and in off-peak hours a plethora of trucks and transports, replenishing food, drink, supplies and services to sustain an estimated100 000 visitors each day. A rigorous test for any precinct pavement material!

The stadium precinct was an abandoned industrial site in 1993 when the words of Juan Antonio Samaranch echoed around the world with the proclamation: "And the winner is Sydenee". And so began the enormous task of designing and building a complex venue that would provide a diverse, lasting and environmentally sensitive range of facilities including: a 110 000-seat stadium; multi-use sports arena; aquatic, tennis and hockey stadiums; showground complex, hotel complex and major rail station.

These key facilities were all kept within walking distance of the mass transport rail centre, creating the need for a vast pedestrian plaza capable of managing large numbers of people quickly and safely.

Olympic Boulevard – the main mixed-use thorough-fair through Sydney Olympic Park

Segmental paver colours provide delineation for vehicular and pedestrian movements

Shading and rest areas were considered essential, and thus a pavement which could accommodate both medium and large trees (and their associated requirement for long- term growth and irrigation) was sought. In addition, stipulated surface characteristics included abrasion resistance, skid and slip resistance in both wet and dry weather, and — equally important — visual appeal through colour, pattern and texture to create a 'welcome mat' and be the tour-guide throughout the complex.

The client's brief also required the pavement material to be pedestrian friendly for people of all physical abilities, to communicate tactile information to the visually impaired, and to provide a step-free and trip-free surface. This pedestrian-friendly surface condition was also required to need minimal maintenance for the design-life typical of a pavement.

In addition to the extensive pedestrian requirements, there are mixed-use and roadway areas accommodating coach buses, industrial

C&M's Eco-Trihex – permeable segmental paver

Paving surrounding Telstra Stadium and associated structures

vehicles, trucks and semi-trailers. The dilemma of finding a paving product to accommodate all of these requirements was resolved by the concrete segmental block offerings of C&M Brick Pty Ltd.

Various complementary product types were employed:

- *Trihex* — an attractive triple-hexagon pedestrian unit,
- *Eco-Trihex* — a matching permeable paver system to irrigate and sustain medium to large trees and to provide source storm-water control,
- *Unipave* - an interlocking block unit that could manage the continual punishment of semi-trailers and coach buses,
- *Trupave* - a rectangular paving unit for headers and transitions.

Of the numerous colour combinations considered, the main scheme chosen was a palette of Sierra (yellow), Terracotta (earthy red), and Charcoal (grey/blue). The range of considered surface textures included polished, shot-blasted, and bush-hammered. A honed finish was chosen because it produced a durable skid-resistant surface whilst providing an attractive appearance through exposure of the aggregate.

Since installation in 1999, performance of the pavement has been closely monitored by the Sydney Olympic Park Authority. Regular inspections have also been conducted by the installing contractor, Sam-the-Paving-Man. These inspections and assessment activities are part of an ongoing Pavement Management Plan.

Because of an intensive events schedule and the high-profile nature of the site, the inspection regime for the 160 000 m^2 pavement area has been designed to ensure that the pedestrian surfaces are always in good condition. An emergency response crew is also available to ensure a timely response to any unforeseen developments. The inspection regime includes assessment of:

- Surface profile vertical alignment — settlement, paver lipping, trip hazards, alignment with abutments, kerbs, gutters, street furniture, drain covers, pit lids and grates; permanent vertical deformation using a 2-metre straightedge and a string line; rutting under main heavy vehicle traffic areas and instantaneous deflection under heavy axles.
- Surface profile horizontal alignment — movement and creep of paver joint lines and sheering.
- Surface damage and deterioration — cracks, chips, spalling and impact damage.
- Surface texture — skid resistance, slip resistance, consistency of texture.
- Surface colour — consistency of colour, aging, fading of colour, contrast, build-up of grime.
- Permeable pavers — permeability effectiveness, drainage, irrigation of trees, evidence of successful drainage during rain.

Some minor problems have been identified, with localised settlement of pavers at base course transition areas. These are isolated areas where pavers traverse a strong concrete base and an adjacent weaker flexible base course. Under the influence of vehicular traffic some relative settlement has occurred. This problem is rectified by locally removing the affected pavers, cement stabilisation and recompaction of the flexible base course providing a more graduated transition between the rigid and flexible base courses.

Sam-the-Paving-Man is quoted as saying: "the hardest part in doing these repairs is lifting the first paver. They are quite solid units (manufactured to an Unconfined Compressive Strength of 60 MPa with a thickness of 80 mm), and with the constant kneading of foot traffic and the hexagonal profile they become locked-in".

Other minor settlement problems have

Olympic Boulevard leading through to water feature

occurred at fixed service-pit locations where, at the time of original construction, access for compaction equipment was limited.

Isolated instances of high impact damage to individual pavers resulting in some chipping and gouging has occurred, due to use of heavy maintenance machinery (crane outriggers with steel feet used during other construction activity). This problem is rectified by simple spot replacement of individual units from a stock of spare pavers. This type of relatively fast, simple and easy maintenance is a key feature of segmental concrete pavements.

C&M's Trihex – honed surface provides contrast with dark aggregate and optimises slip resistance

Even with these localised maintenance issues, the pavement performance at Sydney Olympic Park still rates very high. It is instructive to note that municipal engineers in the UK and Europe expect to have to replace at least 5% of their paving each year[1]. The beauty of segmental concrete pavements is that, typically, the pavers can be re-used directly (whereas other flexible pavement materials cannot), presenting a significant saving in maintenance costs.

In five years the pavements at Sydney Olympic Park have been subjected to considerable punishment — clearly demonstrating that concrete segmental pavers provide lasting and enduring performance. The pavement has retained its integrity and performed to a high standard, and with minimal effort from a maintenance viewpoint — and therefore minimal disruption to the use of Sydney Olympic Park. Such performance can be described as *truly Olympic!*

[1] Shackel, B and Pearson, A, **Concrete Flag Paving in Municipal Engineering,** Paper presented at IPEWA National Conference, Hobart, Aug 2003.

Riverbank Promenade & Convention Centre – Adelaide

02

Client/Developer: Adelaide City Council
Landscape Architect: Hassell PTY LTD
Architect: Hassell PTY LTD
Principal Contractor: Baulderstone Hornibrook
Concrete Contractor: Commercial Ceramics
Paving Supplier: UrbanStone

The Riverbank Promenade and Convention Centre development in Adelaide is an excellent example of segmental paving utilised to enhance the visual appeal of public space.

Completed in 2002, the 3500 m^2 palette of concrete flagstone pavers was the brain-child of Hassell Pty Ltd. The intent was to incorporate a pavement with distinctive aesthetic appeal, utilising a variety of size, shape, colour and texture. The inherent characteristic strength of concrete provides unparalleled abrasion and impact resistance compared with traditional paving materials, along with the added benefits of minimal pavement profile depth, economy and quality control.

UrbanStone (www.urbanstone.com.au), a premium supplier to concrete paving products, was consulted due of the variety and flexibility of their standard precast concrete product range. Mike Falconer, Urbanstone's General Manager, suggests that 'increasingly imaginative approaches are being sought by the country's best design professionals'. As an additional creative service offering, the company worked with Hassell to supply customised paving colours and sizes to suite the stringent visual and technical requirements demanded by the architects. Seven different paving sizes were eventually employed to realise the bold ideas of the design team, and specialty precast stair treads up

Bowtell Clarke + Yole

Riverbank Promenade

Urbanstone

Section of square-set uniform paving denoting entrance area

to 2400 mm long (incorporating a nosing groove formed specifically to fit a carborundrum safety strip) was also supplied to supplement UrbanStone's street furniture and accessories range. The predominant paving palette featured a shot-blast finish, ideal for slip and skid resistance, while a 200 x 200-mm premium honed unit was employed as feature banding. The colour employed was UrbanStone *Riverbank mix 1408*.

The pavement profile adopted was made up of 40-mm-thick pavers bedded in 20 mm of mortar, over a concrete sub-base. This type of installation promotes durability and reduces maintenance by eliminating paver movement, bedding erosion and surface subsidence. A typical cleaning/maintenance regime would require only the occasional pass of a mechanical sweeper and an even less frequent pressure wash.

Urbanstone

Special order precast stair treads supplementing street furniture and accessories range

Elizabeth Street, North Hobart — bespoke art pavers

Client/Developer: Hobart City Council, Tasmania
Urban Designer: Carole Edwards, Tecton Projects, Hobart City Council
Principal Engineering Consultants: Tecton Projects, Hobart City Council
Specialist Concrete Consultant: Garry Webb
Art Paver Design and Manufacture: Peter Battaglene / Watermark Pottery

03

With a vision of revitalising the cultural aspects of Elizabeth Street, North Hobart (next to the CBD), the Hobart City Council (HCC) commissioned local Tasmanian artists to provide input for the embellishment of a proposed streetscape upgrade.

Watermark was selected by the HCC Arts Advisory Committee to design and manufacture a bespoke segmental paver series to act as unifying sub-elements across the kilometre length of the project.

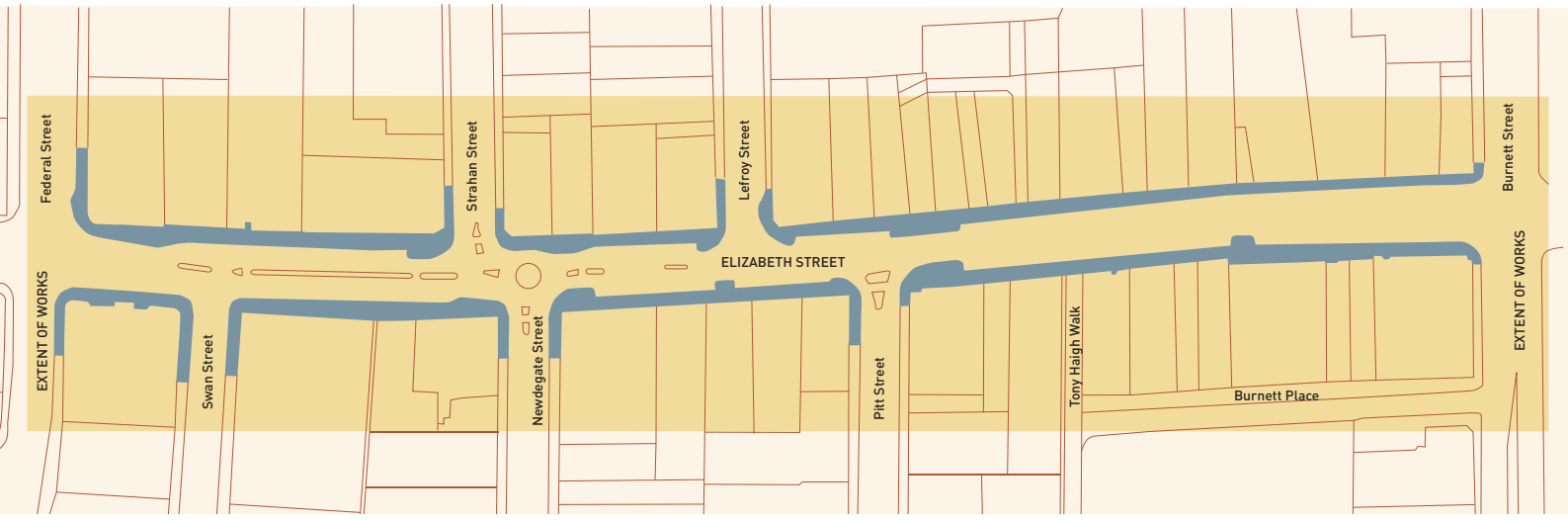
Watermark's response to the brief was to ".....address the physical and metaphoric communal link created by the footpath, focusing on the connective nature of a journey through the community. Both geometry and pattern were employed to create a sustaining contemporary design, unifying the pavement with existing as well as future art works. The uniformity and proximity of the laid pavers is intended to aid the notion of a journey, with the device of pattern providing both movement and interest. The artistic design draws the viewer along the span of the project with an evolving journey expressed by changes in colour, texture, shape, and scale at each interval".

The company's background includes some twenty years experience in pottery, and the Elizabeth Street commission was seen as offering a unique opportunity and challenge in embracing a new construction medium. Concrete was chosen for the bespoke art-paver manufacture because of its great versatility. Peter Battaglene of Watermark considers concrete "...a material able to be cast, resistant to wear, and offering designers a broad palette of colour options. Our research into the chemistry of concrete highlighted many influencing factors similar to ceramics, particularly the effects of water, temperature and time."

Having sourced raw materials for the project, various pigment colours were extensively trialled, as were combinations of sand and aggregate and the requirements of curing and sandblasting practices. Twenty precasting moulds were produced by a plastic fabricating business local to Hobart, using 7-mm-thick nylon sheet. A proprietary release agent ensured the moulds performed beautifully to produce the 1200 individual concrete paving units.

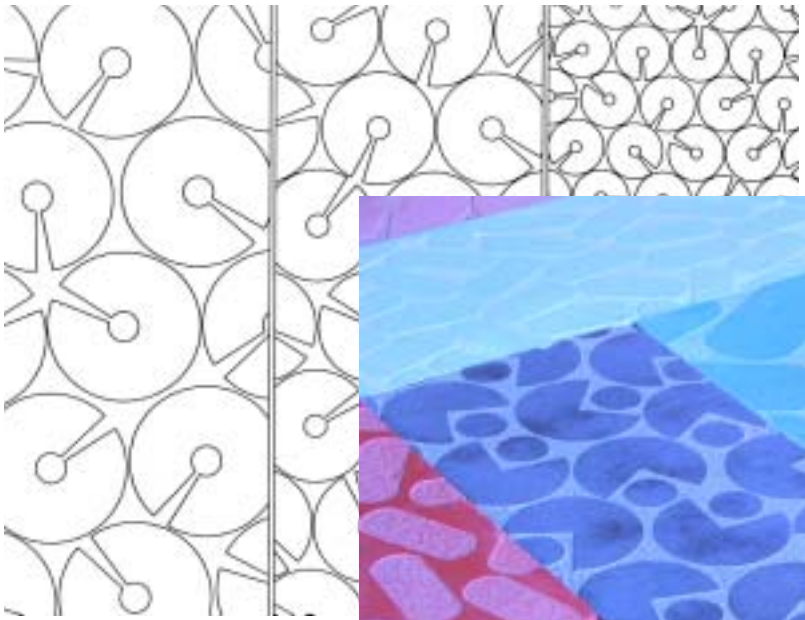
The segmental pavers (60-MPa compressive strength) were cast in two layers within the internal mould dimensions of 555-mm-long x 225-mm-wide x 65-mm-deep. A structural 50-mm-thick backing layer was produced incorporating cement, Bluestone (a common type of granite) coarse aggregate, and sand. The 15-mm-thick pigmented decorative wear surface was then immediately cast against the plastic structural layer incorporating two dose rates of Cathy Pigments Australasia's *Byron Blue, Blood Red, Uluru Red, Black* and *Jade Green.* Adelaide Brighton's Brighton Lite (off-white) cement and white quartzite sand were used to promote consistency of colour and tone. Screeding was followed by steel-trowel burnishing.

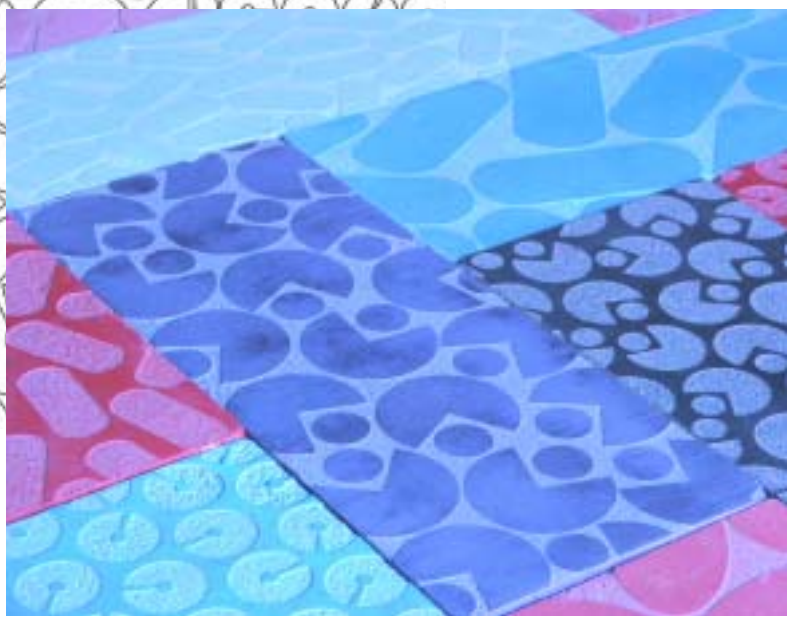
Hobart City Council



Watermark

Elizabeth Street, Hobart





Watermark

Unique hand-made pavers by Watermark

Watermark

Watermark

Constant water curing was employed for twenty-one days, ensuring optimum abrasion resistance and durability.

Masking stencils were used to achieve the detailed sandblasted pattern upon the bespoke coloured pavers. This decorative process was also used on a generic commercial paver — providing the background palette for the insitu bespoke work. Placed in a staggered oblique formation with groups of three bespoke pavers, the pavement palette contributes further visual interest as honed pavers catch the light (both sunlight and moonlight) — drawing the viewers eye along the pathway.

The structural pavement profile consisted of 65-mm-thick pavers, bedded on 20 mm of metal dust, 30 mm asphaltic concrete seal, and 150mm compacted fine crushed rock as a unifying sub-base over the existing sub-grade profile.

Watermark attributes the success of their bespoke paver manufacture to extensive preliminary research, and the guidance and encouragement of their community. Also, without the dedication, support and motivation displayed by project trades people, little could have been achieved with (and even less learned about) the variety and potential of concrete for the streetscape environment.

Hervey Bay adopts European flare

Client/Developer: Morgan and Griffin
Architect: Ceccato Hall & Associates
Principal Engineering Consultant: Larkin Teys Consulting Pty Ltd
Paving Contractor: Gympie Building Company
Paving Supplier: Hanson Building Products
Date of Practical Completion: February 2005

Hanson Masonry launched its Euro Paving System in late 2004 — a sophisticated flag paver designed to contribute as a key architectural element both indoors and outdoors.

A significant commercial project already completed with Euro is an upgrade to Urangan Central shopping centre in Hervey Bay — a city on Queensland's Fraser Coast.

The Euro collection features a variety of off-the-self colours and finishes:

FINISH Name	Description	COLOUR Name	Dominant Shade
Classic	smooth pressed with moulded-bevel edges	Paris	burgundy
		Rome	deep cream
Slate	stone pattern with moulded-bevel edges	Prague	ageless grey tones
		Athens	bone/fawn
		London	khaki/brown
Elegance	honed (terrazzo-like) with ground-bevel edges	Berlin	tan-brown
		Madrid	luxuriant-red
Grande	honed and shot-blast with ground-bevel edges	Monaco	aqua-blue
		Dublin	sophisticated green

Architects Ceccato Hall & Associates nominated the Grande finish for the Urangan project, with a colour palette including Prague, Rome and London. The honed surfaces of Elegance and Grande reveal the integral aggregates, exposing a complexity of rich colours and tones. Shot-blasting, particular to the Grande finish, provides additional slip/skid resistance for external trafficked surfaces. Also, for major commercial orders of both Elegance and Grande, Hanson offers to custom mix aggregate proportions using some of Australia's best and brightest marble and granite to create a unique and individual product. The Euro range is produced with state-of-the-art paving plant as integral two-part wet/dry paver units — increasing the affordability of flag pavements.

This shopping centre refurbishment included 650 m^2 of new paving. Ceccato Hall & Associates called for a large format paver embodying the look of polished concrete. Peter Wolff of Ceccato Hall suggests that "a range of terrazzo-like finishes can be achieved, and given the availability of different aggregates the effects can be stunning".

The Euro Paving System also combines an innovative bedding solution, enabling trafficking by commercial vehicles in excess of three tonnes. This proprietary system and associated advanced installation techniques were developed in conjunction with Mapei Australia Pty Ltd, to produce a 'Drop and Go' specialist adhesive.

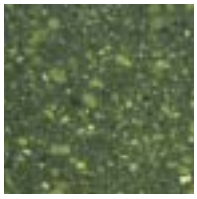
Urangan Central refurbishment: sweeping curves of the ground plane reference the seaside context of Hervey Bay

StewArt Photography

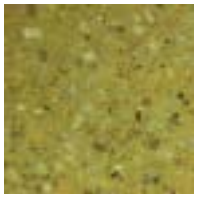
Typical butt-jointed flag paving utilising mortar bedding, whilst able to accommodate pedestrian traffic and light vehicles, has occasionally resulted in the cracking of flags. In the majority of instances

StewArt Photography

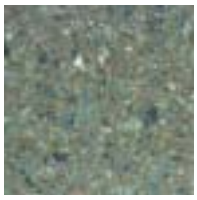
this reduced design-life is the direct result of underestimated traffic loadings. Recent developments resulting in proprietary systems such as Euro are enabling improved performance under high vehicular traffic loads.



Finish —Elegance/Grande
Colour — Prague



Finish —Elegance/Grande
Colour — Rome



Finish —Elegance/Grande
Colour — London

The Urangan project incorporates a rigid bedding system, as recommended for pedestrian and light vehicle loads (less than three tonnes). An adhesive bedding type, as detailed in Hanson's Euro Paving Installation Guide, was employed ensuring the ultimate provision of serviceability/durability.

The Euro Paving System is said to be changing the way we look at paved areas and floors. Australia's outdoor lifestyle means a high demand for pavers, but this product is equally suited to indoor use — further accommodating our adoption of the indoor/outdoor lifestyle.

05

The design of concrete pavers and flags for pedestrian and vehicular traffic

Concrete block paving technology has evolved over the last twenty-five years, and whilst related commercial technologies are certainly sufficiently matured, disseminating relevant information to the design community and end-users is an ongoing and iterative process.

Benefits realised through technology development of concrete segmental and flag pavers include:

- Reduced lipping and hence reduced tripping hazard, due to tight dimensional tolerances,
- Readily available honed finishes offering adequate slip/skid resistance and increased ease of cleaning,
- A very large choice of paver size, shape, colour, texture and laying patterns enabling high control over appearance, sense of scale, etc,
- High albedo (a measure of reflectivity) – concrete pavements of all colours minimise the 'heat island' effect common in paved urban areas.

Design development

After a long history in Europe, concrete pavers were introduced in Australia and NZ in the 1970s. Sustained world-wide adoption of this pavement type has developed, with research into design and

performance mostly superseding original craft-orientated, experienced-based specifications. European and American manufacturing experience has led the world, impacting on both aesthetics (colours, textures and surface finishes) and environmental amenity (slip/skid resistance, noise control, source storm-water control, etc).

Shackel (Oct 2003) lists four key performance components that can be applied to segmental (including interlocking) and flag pavements, these are shown in **Table 1**.

Table 1 Factors Affecting the Performance of Concrete Segmental and Flag Pavements

Pavement component	Factors affecting performance under trafficking
Pavers	Shape Thickness Size Laying pattern Joint width
Bedding and jointing sands	Layer thickness Grading Angularity Moisture Mineralogy
Base coarse and sub-base	Material type Grading Plasticity Strength and Durability
Subgrade	Soil Type, Stiffness and Strength Moisture regime

Table reprinted with permission from Shackel (Oct 2003)

Concrete segmental pavements (including interlocking types)

An issue not generally acknowledged by the design community is that small-format segmental concrete pavers behave differently to asphalt or insitu-concrete pavements, as well as other segmental paving materials such as brick and stone. Due to the high precision and consistency of dimensions afforded by modern manufacturing technology, concrete segmental pavers behave more like an articulated slab than a flexible pavement, thus providing:

- increased stiffness and strength under traffic load repetition;
- minimised potential for rutting, whilst simultaneously exhibiting levels of resilient deflection very much higher than that tolerated by asphalt pavements.

Adhoc modification to conventional flexible pavement design procedures fail to account for these unique structural features; standard design procedures are therefore being replaced by computer-based mechanistic design programs. *Lockpave V15.*1 by the Concrete Masonry Association of Australia (CMAA), www.cmaa.com.au, is one such program developed to assist engineers, landscapers and architects. The mechanistic elastic layer analysis format enables design of roads, industrial, and even airport pavements for a variety of paver shapes and laying patterns. In addition to guiding users through the selection of materials, loads, and drainage factors, the program also caters for the structural design of permeable pavements.

Whilst it seems that the requirements for optimal performance are too infrequently communicated, installer training and qualification programs are available in Australia, endorsed by the Construction Industry Training Advisory Board.

Concrete flag pavements

Flag pavers are defined as having a plan area equal to or greater than 0.08 m^2 (typically 300 x 300 mm or larger in plan). Around 100 years ago concrete flags gradually started replacing stone flags in the UK, with popularity increasing due to reduced costs and of course greater dimensional accuracy.

Whilst flags are accepted internationally as being one of the most attractive and durable forms of pavement surfacing, three key criteria need to be considered with respect to application:

- As the plan area of the flag increases, the ability of a flag to resist traffic loads and volume decreases,
- Large-format flags can be an issue with respect to Occupational Health and Safety (OHS) considerations (eg weight/size) – generally 400 x 400 mm flags meet OHS requirements for hand placement,
- Both serviceability and safety need appropriate address at the design stage of a project.

The design and in-service performance of flags has on occasion presented challenges when utilised for municipal applications. The enhanced requirements for any paving material in the municipal environment include:

- cost efficiency and durability with minimal maintenance;
- integration with services & intrusion requirements;

OHS requirements in relation to laying, lifting (segmental pavers), repair and cleaning;

- the control of pedestrian and vehicular movements by visual means and traffic calming;
- harmony with other pavements and finishes.

Flags have been rediscovered by designers and specifiers, as modern manufacturing technology has enabled economies in production. Unfortunately use through the 1990s, preceded national or even industry standards for addressing specification, design, and detailing. Failures at some significant projects in Brisbane and Newcastle included cracking and disintegration of the flags, predominately due to an under estimation of the type and volume of vehicular traffic.

Even 'pedestrian' precincts carry some occasional vehicular traffic — such as service vehicles (less than 3 tonne), commercial vehicles (greater than 3 tonne), fire engines and even armoured vehicles for the servicing of automatic teller-machines. Stresses generated within a paver depend on both plan dimensions and paver thickness; to address the correct design of flag pavements CMAA therefore introduced *Concrete Flag pavements Design and Construction Guide* MA44 in 2000. This document provides guidance in terms of maximum paver size and flexible bedding requirements for precincts subjected to occasional vehicular traffic. For higher traffic intensities, only stabilised base-course materials are recommended (Shackel and Pearson, Aug 2003).

A number of flag pavements have been laid butt-jointed in 1:1:6 mortar over concrete slab bases for domestic driveways and some residential streets. There is unfortunately little documentation available in support of satisfactory performance at this time, and moreover the use of mortared flags is too often associated with early failure under vehicular traffic.

Recently, however, the development of specialised proprietary mortar products and adhesives for the bedding of flag pavers is providing an alternative and improved functionality. Testing undertaken at the ARRB Accelerated Loading Facility in Melbourne, as presented by Shackel and Yeo (2003), indicates that good levels of performance can be achieved utilising proprietary systems under traffic loading — as appropriate for malls, minor and local access streets. Shackel and Yeo's testing provides guidance for the functional requirements of vehicular trafficked flags, bedded with high technology mortars or adhesives over a concrete slab base.

Shackel and Pearson (Aug 2003) also reference *Concrete Flag Pavements: Design and Construction Guide* MA44 in providing guidance for the suitable properties of concrete flag pavers for municipal use, as shown in **Table 2**.

It must be remembered, however, that typically produced (and lift-able) flag thicknesses can never provide the level of performance now routinely available from segmental concrete pavers.

Guidelines & Australian Standards

Manufacture and testing

The standards relevant to the commercial production and testing of concrete paving units are:

- AS/NZS 4455:1997 *Masonry units and segmental pavers,* Standards Australia and Standards New Zealand.
- AS/NZS 4456 *Masonry units and segmental pavers and flags - Methods of test* (numerous parts addressing particular testing methods and requirements), Standards Australia and Standards New Zealand.

Design, installation, and maintenance of concrete block pavements

Industry guidelines for the use and maintenance of both concrete segmental and flag pavers have been published by the Concrete Masonry Association of Australia (CMAA) and Cement Concrete & Aggregates Australia (CCAA):

- *Concrete Segmental Pavements: Guide to Specifying* (T44), CCAA & CMAA, 1997.
- *Concrete Segmental Pavements: Design Guide for Residential Accessways and Roads* (T45), CCAA & CMAA, 1997.
- *Concrete Segmental Pavements: Detailing Guide* (T46), CCAA & CMAA, 1997.
- *Concrete Segmental Paving – Maintenance Guide* (MA48), CMAA, 2001.

- *Concrete Flag Pavements: Design and Construction Guide* (MA44), CMAA, 2000

These documents are available for free download from the CMAA website — www.cmaa.com.au.

Table 2 Concrete Flag Properties

Pavement application[1]	Vehicle traffic[2]	Nominal size (mm)	Minimum thickness (mm)	Characteristic breaking load[3,4] (kN)	Dimensional deviations/work size dimensions (mm)				Abrasion resistance (mean)[5] for pedestrian volume			Slip resistance (Class)
					Plan		Height		Low	Med.	High	
					SD[6]	Mean	SD[6]	Mean				
Pedestrian only	Nil	Any	Any	5.0	1	+/- 1.5	1	+/- 2	7	5	3.5	W
Pedestrian & light vehicles (LV) only	LV only	Any up to 450 x 450	50	7.0	1	+/- 1.5	1	+/- 2	7	5	3.5	W
Pedestrian /commercial vehicles (CV) only, streets	<100,000 CVs	300 x 300 400 x 400 450 x 450	60 65 70	13.8 15.5 18.8	1 1 1	+/- 1.5 +/- 1.5 +/- 1.5	1 1 1	+/- 2 +/- 2 +/- 2	7 7 7	5 5 5	3.5 3.5 3.5	W W W
AS/NZS Standard	Not currently applicable			AS/NZS 4456.5	AS/NZS 4456.3		Method B		AS/NZS 4456.9			AS/NZS 4586

Reproduced with permission from Concrete Flag Pavements: Design and Construction Guide MA44, 2000
Notes:

1 Salt resistance for concrete flags is determined by Test Method – AS/NZS 4456.10.
2 For CV traffic > 100,000 an interlocking concrete segmental pavement should be designed, specified and detailed in accordance with CCAA/CMAAs T44, T45, T46.
3 At 28 days:
Characteristic Value – the value that will be expected by at least 95% of the units in the lot (see AS/NZS 4455.1.4.5)
Lot - a group of units of a single type with specific characteristics and dimensions presented for sampling at the same time (see AS/NZS 4455.1.4.13)
4 It is common to test at an early age and correlate results
5 At 90 days
6 SD = Standard deviation

Standards Australia review committee BD-098 is presently working on national standards:

AS 4960.1 Segmental and flag pavements Part 1: Residential

This standard will cover requirements for the design and construction of segmental and flag pavements for use in residential applications such as patios, paths, driveways and vehicle crossovers.

AS 4960.2 Segmental and flag pavements Part 2: Public space

This standard will cover requirements for the design and construction of segmental and flag pavements which predominantly carry pedestrian traffic but which may also carry occasional vehicular traffic.

AS 4960.3 Segmental and flag pavements Part 2: Roads

This standard will cover requirements for the design and construction of pavements that will carry normal on-road vehicular traffic. It excludes roads carrying off-road, industrial oversized and abnormally loaded vehicles.

Draft versions of the above are to be released for public comment in 2005, with formal publication due in 2006. Refer to Standards Australia for further details.

References

Shackel, B and Pearson, A, *Concrete flag paving in municipal engineering, presented at IPEWA National conference, Hobart, Aug 2003*

Shackel, B, *The challenges of concrete block paving as a mature technology, presented at Pave Africa, Oct 2003*

Shackel, B and Yeo, R, *Accelerated Traffic Tests of Concrete Flag Paving, paper presented at 21st ARRB and 11th REAAA Conference, Cairns, May 2003.*

Concrete Flag Pavements: Design and Construction Guide (MA44), Concrete Masonry Association of Australia, 2000

70
APRIL
2005

ROAD note

CCAA OFFICES

SYDNEY OFFICE:
Level 6, 504 Pacific Highway
St Leonards NSW Australia 2065
POSTAL ADDRESS:
Locked Bag 2010
St Leonards NSW 1590
TELEPHONE: (61 2) 9437 9711
FACSIMILE: (61 2) 9437 9470

BRISBANE OFFICE:
Level 14, IBM Building
348 Edward Street
Brisbane QLD 4000
TELEPHONE: (61 7) 3831 3288
FACSIMILE: (61 7) 3839 6005

EXTRACTIVE INDUSTRIES OFFICE:
375 Wickham Terrace
Brisbane QLD 4000
TELEPHONE: (61 7) 3886 1543
FACSIMILE: (61 7) 3832 3195

MELBOURNE OFFICE:
2nd Floor, 1 Hobson Street
South Yarra VIC 3141
TELEPHONE: (61 3) 9825 0200
FACSIMILE: (61 3) 9825 0222

EXTRACTIVE INDUSTRIES OFFICE:
486 Albert Street
Melbourne VIC 3002
POSTAL ADDRESS:
GPO Box 4352QQ
Melbourne VIC 3001
TELEPHONE: (61 3) 8662 5333
FACSIMILE: (61 3) 8662 5358

PERTH OFFICE:
45 Ventnor Avenue
West Perth WA 6005
TELEPHONE: (61 8) 9389 4452
FACSIMILE: (61 8) 9389 4451

ADELAIDE OFFICE:
Greenhill Executive Suites
213 Greenhill Road
Eastwood SA 5063
POSTAL ADDRESS:
PO Box 229
Fullarton SA 5063
TELEPHONE: (61 8) 8274 3758
FACSIMILE: (61 8) 8373 7210

EXTRACTIVE INDUSTRIES OFFICE:
Enterprise House
136 Greenhill Road
Unley SA 5061
TELEPHONE: (61 8) 8300 0180
FACSIMILE: (61 8) 8300 0001

TASMANIAN OFFICE:
EXTRACTIVE INDUSTRIES OFFICE::
PO Box 59
Riverside TAS 7250
TELEPHONE: (61 3) 6330 2476
FACSIMILE: (61 3) 6330 2179

WEBSITE: www.concrete.net.au
EMAIL: info@ccaa.com.au

EDITOR: John Tuxworth
EMAIL: info@ccaa.com.au

ORIGINAL DESIGN: FFT Design
PRODUCTION: H_2O Creative Communication
PRINTING:
The Printing Department

Cover: Riverbank Promenade & Convention Centre – Adelaide
Photography: Bowtell Clarke + Yole

ISSN 0313-9964

CEMENT CONCRETE & AGGREGATES AUSTRALIA

Leading Knowledge - Sharing Information