AUSTRALIAN NATIONAL STANDARDS FOR SEGMENTAL AND FLAG PAVEMENTS

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ABSTRACT

Segmental paving has been successfully used in a wide range of applications in Australia for nearly 30 years and more recently flag paving has been rediscovered. However, it is only recently that national standards for pavers have been produced. By contrast, the design, detailing, specification and construction of such pavements have been supported, to date, only by industry or company recommendations rather than by national standards. This is in marked contrast to competing surfacings such as asphalt or cast in-situ concrete for which numerous specifications and codes of practice have long been available. This situation is now being rectified.

In this paper the authors describe how Australian Standards are being developed for the now well established and growing markets representing residential, pedestrian, municipal, heavy-duty and airport segmental pavement applications. The advantages of developing such standards after market development are discussed and the underlying philosophy and framework of the emerging standards are described. The paper then presents the case for the development of and the future directions for national Australian Standards for segmental and flag pavements.

1. INTRODUCTION

Today segmental paving is used for all forms of pavements varying from landscaping and footpaths to roads, courtyards and airports. Recently, new forms of permeable environmental paving have begun to enter the marketplace offering a wider choice of paving than ever before. Flags, typically 300 x 300 mm or larger in plan, have also begun to be used in Australia. These need a different approach to design and detailing and cannot carry as much commercial vehicle traffic as segmental pavers.

To be durable, pavers and flags need to be purpose-made in specialised manufacturing plants. Many such plants are in operation across Australia. These produce high quality products which are regulatory tested to maintain standards and conform to quality assurance requirements. However, the need for specialised manufacture is not always apparent to the end-user and it is only by enforcing National Standards that good quality paving can be ensured.

A large range of technical information is already available for most segmental or flag paving applications. Some of this is briefly described in this paper. However, the authors believe that this information needs to be supported and consolidated by the development of national Australian Standards as these are critical to the sustainable growth of the paving industry. Only when the manufacture, design and laying of paving units can be specified to the highest standards will segmental and flag paving be seen as an innovative, exciting and growing industry.

At least 20 independent specifications for pavers have been issued worldwide. The evolution of these specifications and their principal features have been reviewed elsewhere (e.g. Shackel, 1990) Specifications in English fall into two groups. The first of these embraces specification for pavers designed to perform satisfactorily in cold climates with emphasis on freeze-thaw durability. This group includes the American, Canadian and British specifications. The second group of specifications issued in South Africa, New Zealand and Australia, are designed to suit temperate climates and, accordingly, place less emphasis on strength and weathering resistance.

2. THE ROLE OF STANDARDS

Standards provide the link between paver manufacture and the design and construction of segmental and flag pavements. This is illustrated schematically in Figure 1. Here, the requirements are for more than just specifications for the pavers alone. Rather, a comprehensive set of construction and practice guidelines are needed. This paper shows how the paving industry, through Standards Australia and CMAA are addressing these issues.

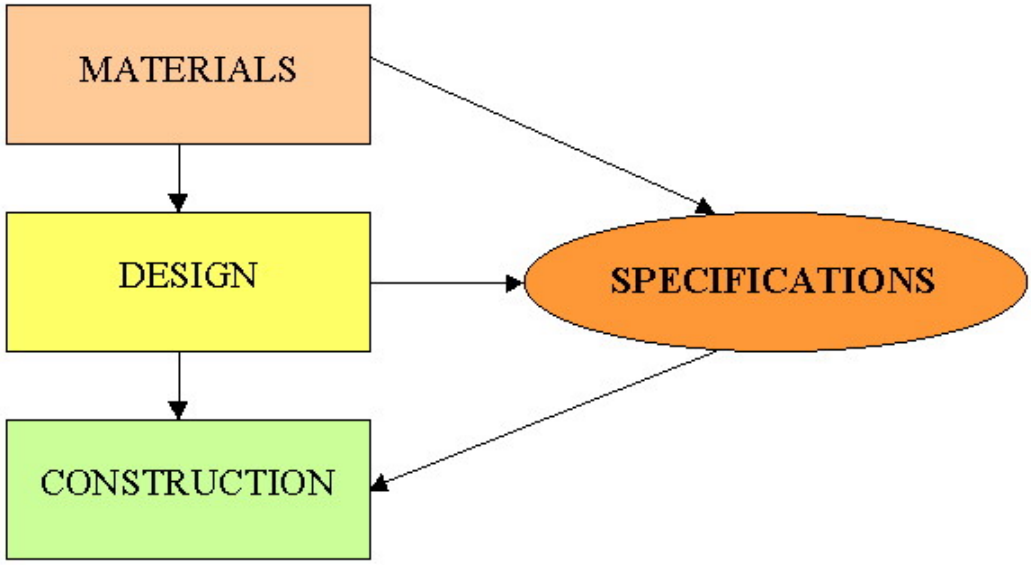

Figure 1. Specifications as the crucial link between materials, design and construction.

Standards represent just one component of the design and construction system and need to be complemented with design tools. Australia has been in the forefront of developing design methods for segmental and flag pavements. The principal tool for designing segmental pavements in Australia is the LOCKPAVE computer program for designing roads, airports, industrial pavements and overlays. Pavement thickness design is complemented within the program by routines for drafting model materials and construction specifications. These routines automatically reference the appropriate Australian Standards. Technical details have been given elsewhere (Shackel 1992, 2000). The Concrete Masonry Association has recently released an updated version of the computer program.

2.1 The Pathway to National Standards

Chronologically the development of industry standards and national standards can be summarised as follows:

- 1970s High emphasis was placed on the development of appropriate support technology – of particular significance were:
  Segmental paver and construction standards
  Segmental pavement thickness design procedures

e.g. LOCKPAVE ® segmental pavement design software

- 1980s Revised industry standards
  Emphasis on pavement management, refined design methodology, product specifications and maintenance
- 1990s Introduction of accredited paviour training programmes
  Development of first national Australian product and testing standards

3. 1997 – DEVELOPMENT OF AS/NZS 4455.1997 AND AS/NZS 4456 – PARTS 0-18

3.1 AS/NZS 4455-1997 Masonry Units and Segmental Pavers

This standard specifies the requirements for the verification of nominated values of commercially manufactured masonry units for walling and segmental pavers of up to 0.1m^2 face area. For segmental pavers it calls up:

- Dimensional Deviations from Work Size
- Breaking Load
- Integrity

3.2 AS/NZS 4456.0-18-1997 Masonry Units and Segmental Pavers – Methods of Test

Calls up some 18 test methods for masonry units and segmental pavers. Those relevant to segmental pavers are:

AS/NZS 4456.1 Sampling for Compliance Testing
AS/NZS 4456.2 Assessment of Mean and Standard Deviation
AS/NZS 4456.3 Determining Dimensions
AS/NZS 4456.5 Determining Breaking Load of Segmental Paving Units
AS/NZS 4456.9 Determining Abrasion Resistance
AS/NZS 4586 Slip Resistance Classification of New Pedestrian Surface Materials

3.3 Refinement and Development of Industry Publications

To provide specifiers with an understanding of the product, the design process and some detailing and construction aspects, the CMAA published the following documentation that fully referenced AS/NZS 4455 and AS/NZS 4456:

- T44 Concrete Segmental Pavements – Guide to Specifying – 1997
- T45 Concrete Segmental Pavements – Design Guide for Residential Accessways and Roads – 1997
- T46 Concrete Segmental Pavements – Detailing Guide – 1997

Towards the late 1990s and early 2000s flag paving was rediscovered by landscape architects and specifiers – in the absence of industry standards and Australian Standards the CMAA published:

- MA44 Concrete Flag Pavements – Design and Construction Guide – 2000

In early 2002 Standards Australia and the segmental and flag pavement industry joined forces to produce a suite of national standards that would encompass the specification, design and performance construction criteria.

4. THE DEVELOPMENT OF DRAFT NATIONAL AUSTRALIAN STANDARDS

4.1 BD-98 Segmental and Flag Pavements Committee

In mid 2002 Standards Australia convened a committee BD-98 Segmental and Flag Pavements, charged with the development of new Australian Standards, with a target completion date of December 2003.

The membership of the committee is diverse and representatives from manufacturers, specifiers and consumer groups are members.

The main objectives of the committee are to:

- Develop appropriate national standards for segmental and flag pavements
- Be materials generic, ie cover clay and concrete
- Be market segment specific (see 4.2 below)
- Standardise product requirements, design requirements, material requirements and construction tolerances
- A handbook to be produced by Standards Australia and industry, encapsulating the standards and other issues such as design software, materials and construction detailing advice

4.2 Choice of Standard

The brief is to produce market segment specific standards namely:

- Segmental Paver and Flag Specification Standard
- Residential Standard (Pavers and Flags)
- Public Accessways Standard (Pavers and Flags)
- Roads Standard (Pavers and Flags)
- Heavy Duty Pavements Standard (Pavers)
- Environmental Paving Standard (Pavers)

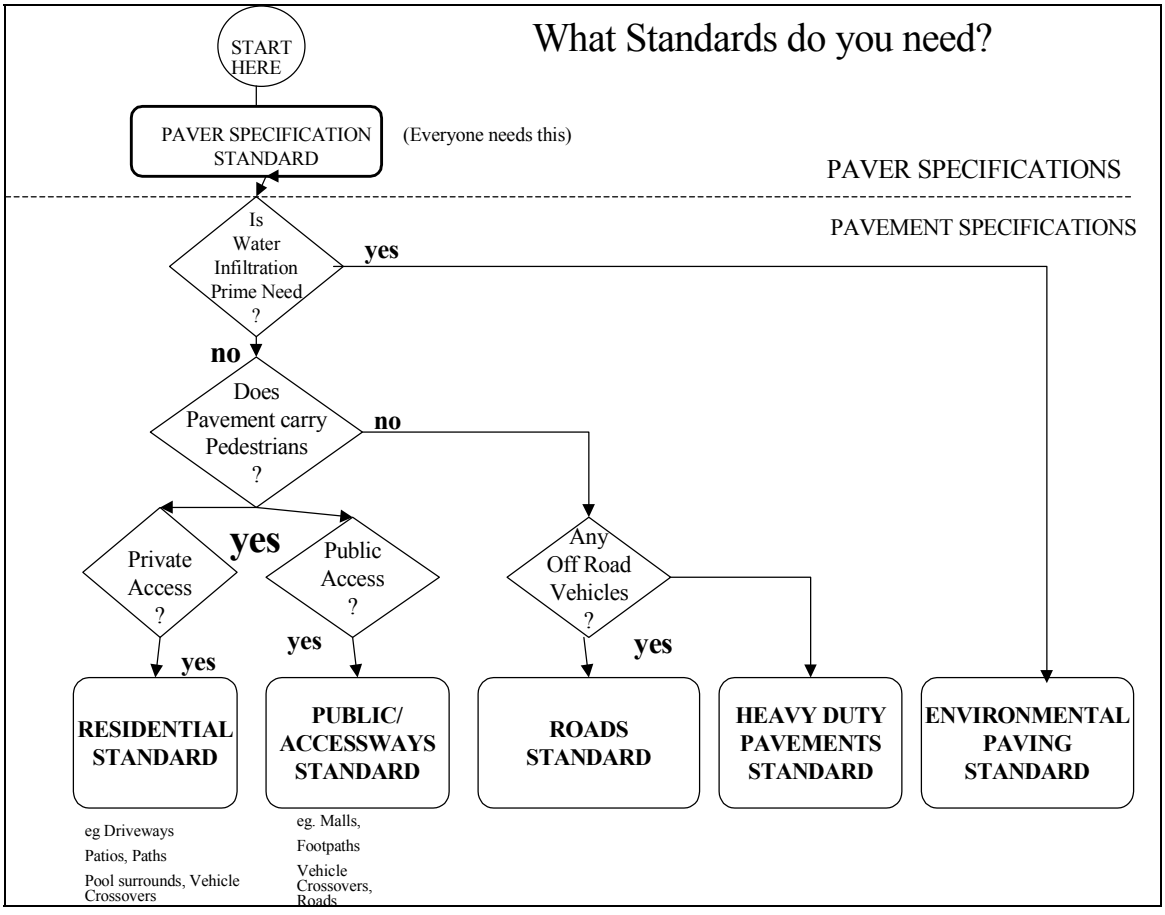

Figure 2. Flowchart – Draft Standard Pathway.

Figure 2 illustrates the interaction and position of each standard within the overriding head specification standard. It will be seen that there are two major factors governing the pathway that an end user will choose when navigating the flowchart. First, if water infiltration is the prime need the user will be directed to the standard for permeable paving.

This falls under the broader heading of environmental paving which will also deal with the issues of handling contaminants etc. The second factor governing navigation through the flow chart is the question of the loads to be carried. Experience has shown that many designers fail to adequately identify the nature of traffic. All too often pavements are loosely described as being for pedestrian use when, in reality, they also carry vehicles. Moreover, designers frequently fail to recognise that design procedures that are adequate for roads are totally inappropriate for industrial vehicles. For these reasons, it will be seen that the choice of the most appropriate standard using Figure 2 is strictly governed by questions and definitions concerning the type of traffic.

4.3 Draft ASXXXX Specification Requirements for Segmental Pavers and Flags

This specification specifies the quality requirements for segmental pavers and flags – not the design requirements. It includes performance criteria, general requirements and deemed-to-satisfy solutions for both concrete and clay units. These requirements are summarised in Table 1 below.

			Characteristic Breaking Load (KN) [1]		Minimum Thickness (mm)		Dimensional Deviations		Abrasion Resistance [2] (Mean Abrasion Index)			Slip Resistance Classification
			Segmental Pavers	*Flags*	*Segmental Pavers*	*Flags*	*Segmental Pavers*	*Flags*				
Residential	Pathways	Paths, Patios and outdoor areas	2	5	40	40	DPO	DPA1	NA			W
	Driveways	Light Vehicles	3	7	40	50	DPA1	DPA2	NA			W
		Commercial Vehicles	5	7	60	60	DPA1	DPA2	NA			W
									Pedestrian Traffic Volume			
									Low	**Medium**	**High**	
Public/ Municipal Space		Pedestrians only	2	5	40	40	DPA1 or B1	DPA1	7[3]	5.5	3.5	W
		Pedestrian and light vehicles only	3	7	50	50	DPA2 or B2	DPA2 or B2	7[3]	5.5	3.5	W
		Pedestrian and commercial vehicles	5	13.8 18.8	60	60-70	DPA2 or B2	DPA2 or B2	7[3]	5.5	3.5	W
Roads		Minor	6	NA	60	NA	DPA2 or B2	NA	NA			W
		Local	6	NA	60	NA	DPA2 or B2	NA	NA			W
		Collector	6	NA	80	NA	DPA2 or B2	NA	NA			W
Heavy Duty		Industrial	10	NA	80	NA	DPB3	NA	NA			W
		Aircraft	10	NA	80	NA	DPB3	NA	NA			W
Relevant Australian Standard			AS 4456.5		NA		AS 4456.3		AS 4456.9			AS 4586

NA Not applicable

- Durability classification for segmental pavers and flags is determined by Test Method AS/NZS 4456.10
- For clay products EXP grade units are required for use in severe marine environments and around salt water swimming pools.

NOTES:

1 At 28 days for concrete products only (add to test method)

2 At 90 days for concrete products only (add to test method)

3 Pavers showing a higher value, where supported by performance, may be used. Where other test methods have been used extensively and have been shown to relate to performance data, those other test methods may be used.

Table 1. Draft Guide Requirements for Segmental Pavers and Flags.

4.4 Other Draft Australian Standards

The following proposed standards are in their early drafting stages and are too embryonic to detail in this paper:

- Residential Standard
- Public Accessway Standard
- Roads Standard
- Heavy Duty Pavements Standard
- Environmental Paving Standard

5. DEFINITIONS

For the purposes of the draft Specification Standard, Figure 2 and Table 1 the following definitions apply:

- *Segmental Paver:* Paver with a gross plan area less than 0.08 m^2, laid on a bedding course material to form a surfacing layer.

- *Flag:* Large format unit with a gross plan area greater than or equal to 0.08 m^2, laid on a bedding course material to form a surfacing layer.

- *Pathways:* Pathways subjected to only foot traffic

- *Light Vehicles:* Light vehicles (LV) are vehicles which when fully loaded have a gross weight less than 3 tonnes. This category includes cars, utilities, delivery vans and some light 2-axle trucks.

- *Commercial Vehicles:* Commercial vehicles (CV) are defined as vehicles having a gross weight of 3 tonnes or more and which comply with state or national legislation for the axle loads, tyre pressures and dimensions of normal on-road vehicles. Off-road, industrial, oversize, abnormally loaded or overloaded vehicles are specifically excluded. This vehicle category principally comprises 2 and 3 axle trucks. Trucks having 5 axles or more should not comprise more than 5% of the commercial vehicles. If data on the gross weights of the vehicles to be carried on the pavement are not available then all vehicles fitted with dual tyres and all trucks shall be classed as commercial vehicles.

- *Pedestrian Pavements:* are assumed to be subject to foot traffic only. These include footpaths not subject to vehicle over-run or parking, pedestrian precincts which are completely closed to vehicle access, residential paths and patios and hard landscaping.

  Within this context the following sub-divisions have been defined:
  - *Low Volume*: Residential paths, paths in public gardens, pavements at schools or campuses, hard landscape areas, common outdoor areas of residential buildings. Suburban shopping area pavements, pedestrian areas around institutional buildings, sporting or recreational areas. Pavements with less than 3,000 Pedestrian passes per day.
  - *Medium Volume:* Pavements with greater than 3,000 and less than 30,000 Pedestrian passes per day.
  - *High Volume:* Pavements with high-volume pedestrian traffic exceeding 30,000 Pedestrian passes per day – typically inner-city and major suburban pedestrian malls and paths.

- *Pedestrian and Light Vehicle Pavements:* are those carrying pedestrians and light vehicles (LV) only. This includes residential driveways.

- *Pedestrian and Commercial Vehicles Pavements:* represent areas carrying both pedestrian and mixed vehicular traffic. Normally mall traffic will comprise a mix of light vehicles such as delivery vans with a gross weight less than 3 tonnes and commercial vehicles such as trucks, emergency and service vehicles having gross weights of 3 tonnes or more. This category of pavement includes commercial vehicle crossovers, driveways carrying occasional truck traffic, footpaths subject to truck over-run or parking, pedestrian malls accepting service vehicles and commercial vehicles, pedestrian crossings and lightly trafficked streets.

- *Roads:* Minor roads carry up to 150 vehicles per day, local roads carry up to 150 – 1,000 vehicles per day whilst Collector roads carry up to 1,000 – 3,000 vehicles per day.

- *Heavy Duty*: Heavy duty pavements are defined as those carrying vehicles that are not licensed for routine use on public highways. Within this category industrial pavements are defined as those that may be subject to a range of unregulated vehicle types, axle configurations and tyre pressures. Whilst Aircraft pavements are subject to aircraft wheel loads and aircraft service vehicles.

- *Characteristic Value:* The value that will be exceeded by at least 95% of the units in the lot.

- *Breaking Load:* Intuitively it can be argued that pavers and flags must possess sufficient strength to resist handling, construction stresses and the effects of traffic. However, the incidence of mechanical failure in segmental pavements due to inadequate strength is extremely small. Little or no consensus exists worldwide on the most appropriate sampling, testing and reporting procedures for determining paver strength and the Australian paver industry devoted considerable argument and debate to this topic. As a result, the test used in Australia now comprises Breaking Load based on flexural strength. Here the paver strength has been defined as the failure load determined in accordance with AS/NZS 4456.5.

- *Dimensional Deviation:* The deviation from work size of pavers when determined in accordance with AS/NZS 4456.3. Two important factors are influenced by the dimensional tolerances of the pavers. First, the ease and precision of both laying and repairing segmental and flag paving is affected by the paver dimensions. The dimensions of the pavers also influence the long-term riding quality of a segmental or flag pavement. In this respect it is important to note that experience has shown that variations in the thicknesses of pavers supplied to a job can cause the gradual loss of surface profile in a pavement under traffic. Thus it is important that unit thickness be controlled as accurately as possible during manufacture.

- *Abrasion Resistance* is the volume loss of a paver, expressed as an index, determined in accordance with AS/NZS 4456.9. In this respect it should perhaps be noted that, because Australia enjoys temperate climates, freeze-thaw durability is not an issue. To ensure that adequate paver quality is still achieved it is therefore necessary to include some other measure of durability. Abrasion resistance fulfils this role.

- *Lot:* A group of pavers of a single type with specific characteristics and dimensions presented for sampling at the same time.

- *Work Size:* The size of a paver specified for its manufacture, from which deviations are measured**.**

- *Slip Resistance Classification:* A pedestrian surface is slip resistive if the available friction is sufficient to enable a person to traverse that surface without an unreasonable risk of slipping in accordance with AS/NZS 4586 – Table 2 Class W – low risk of slipping when wet.

6. CONCLUSIONS

The strong development of segmental and flag paving in Australia has been directly consequent upon the development of a sound underlying technology for segmental and flag paving design and specification. Initially such work was largely industry based. However, as the technology of segmental paving has matured, the development of National Standards and Codes of Practice has become a prime goal for CMAA. This has required considerable effort to codify and make accessible the now substantial body of research, knowledge and expertise developed within the paving industry and the universities. Much of this technology is of relevance beyond Australia. The ultimate goal is to provide a comprehensive set of documents that can be used with confidence by both paving producers and end-users alike.

7. REFERENCES

AS/NZS 4455 Masonry Units and Segmental Pavers – 1997

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