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Australia's Progress Toward Sustainable Construction Practices – Examples from a Road Agency

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ABSTRACT

Australia is a vast continent supported by a tax base of only 22 million people. This presents a variety of challenges to the construction industry which has been answered by innovations in policy and the development of industry alliances. This paper outlines how the Australian construction industry, specifically the commercial and public infrastructure sectors, is meeting the challenges of defining, measuring, and integrating sustainability in new building projects. It reviews the last 20 years of evolution towards sustainable construction in Australia and by way of a series of case studies it illustrates the regulatory environment that has motivated new business partnerships and innovated old ones. It considers the tools being used to better integrate sustainability principles into the planning and delivery of resource consumption, materials recycling and greenhouse gas management programs. This paper reconciles governmental goals with the commercial realities and presents a report on sustainability advancement in the construction industry in Australia.

The comments and views expressed in the paper are those of the authors and not necessarily of the Roads and Traffic Authority of NSW.

INTRODUCTION

This paper outlines how the Australian construction industry, specifically the commercial and public infrastructure sectors, is meeting the challenges of defining, measuring, and integrating sustainability in new building projects. It reviews the last 20 years of evolution towards sustainable construction in Australia, from conservation, through recycling to sustainability.

Beginning from a National perspective and narrowing in on the experience of the Roads and Traffic Authority NSW (RTA) implementation of sustainability principles, it illustrates the regulatory environment that has motivated new business partnerships and innovated old ones. It considers the tools being used to better integrate sustainability principles into the planning and delivery of resource consumption, materials recycling and greenhouse gas management programs.

A range of case studies covering materials, partnerships and strategy are presented to examine some of the lessons learned. In doing so, this paper attempts to reconcile governmental goals with the commercial realities of sustainability advancement in the construction industry in Australia.

Population and land mass

Australia is the Earth's largest island and sixth largest nation, stretching some 3700 kilometres from north to south and 4000 kilometres from east to west with an area of 7.69 million square kilometres [DFAT 2009]. Despite its size, Australia supports a relatively small population of around 22 million which is concentrated in two widely separated coastal regions along the east to south-east and south-west parts of the continent [ABS 2006, p27]. The coastal concentration is such that 84% of the population live within 1% of the continent [ABS 2006, p26] and more than 80% of Australians live within 100km of the coast [DFAT 2009]. The geographic spread of Australia's population can be seen in Figure 1 and compared against other developed countries in Table 1.

Table 1. Population Density of Selected Countries, People per Square Kilometre – 2001 [ABS 2006, p27]

Australia	2
Canada	3
Italy	190
Japan	336
Korea	476
New Zealand	14
United Kingdom	244
United States of America	29

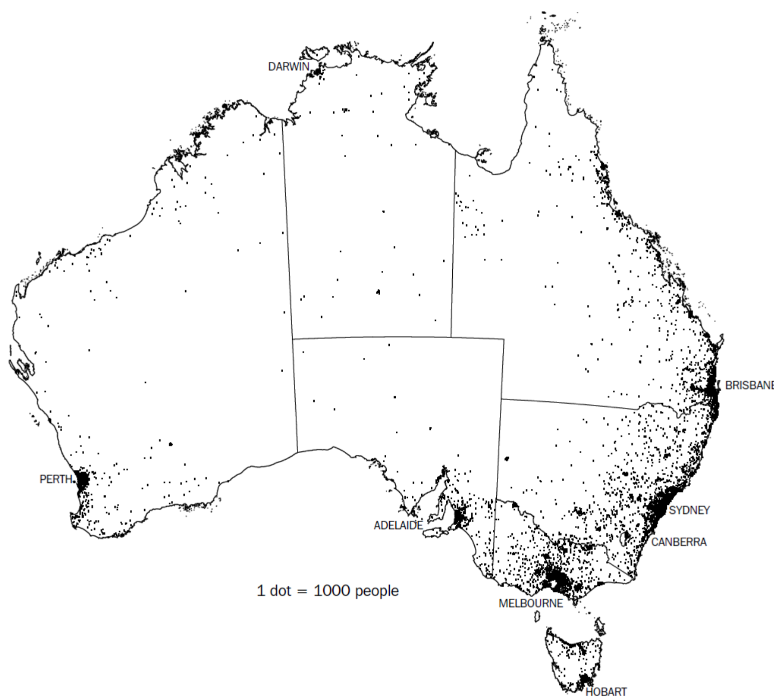

Fig. 1. Estimated Resident Population Distribution as at 30 June 2001 [ABS 2004, map 5.15, p88]

Australian Construction

The construction industry plays an important role in the Australian economy employing about 9% of the Australian workforce [ABS 2009a] and generating about 7% of the Australian Gross Domestic Product [ABS 2009b].

Engineering construction (the building of roads, bridges, water and sewerage infrastructure) makes up about half of the total spend in the construction industry, with the remaining spend being due to construction of residential and non-residential buildings (see Figure 2).

There has been dramatic growth in the engineering construction industry over the past eight years with the value of work done more than doubling during this time, with the majority of this work being due to growth in private sector construction spending (see Figure 3).

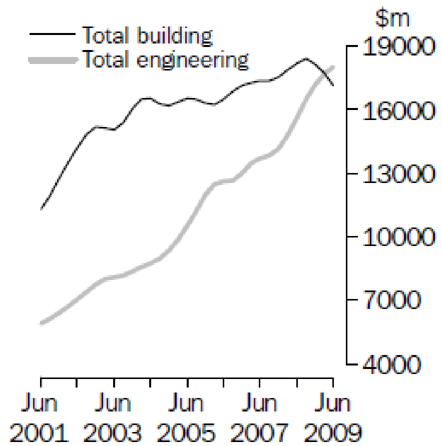

Fig. 2. Value of Work in Total Construction Industry ($m/quarter) [ABS 2009c, p1]

Building spend includes value of work done in residential and non-residential building sectors.

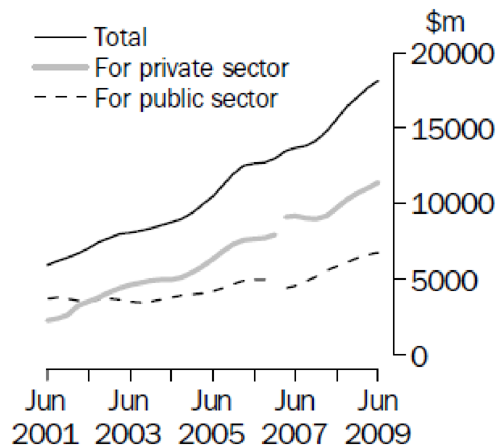

Fig. 3. Value of Work Done in Engineering Construction ($m/quarter) [ABS 2009d, p1]

Public sector spend includes value of work done by the private sector for the public sector and value of work done by the public sector.

New South Wales (NSW) is the country's most populous state, accounting for about one-third of the total population but it only accounts for about 22% of current spending on construction. The value of construction spending is currently highest in those states that have experienced high population growth in recent years including Queensland and Western Australia; in which of these two states account for about 30% of current construction work [ABS 2009c, ABS 2009d].

A large component, some 21%, of the value of current engineering construction work in Australia relates to spending on roads and highways (see Figure 4) [ABS 2009d]. The development of road infrastructure is essential to expanding the Australian economy given the large role played by road transport in moving people and goods long distances between major centres[1]. With the role of road freight transport projected to increase in importance over time

[1] According to the Department of Infrastructure, Transport, Regional Development and Local Government (2009) the road freight industry accounts for about 37 per cent of the total domestic freight task (tonne-kilometres) and 72 per cent of the total freight moved within Australia in 2004-05.

[BITRE 2006], it is imperative that both the transport operations and construction of road corridors be made more sustainable.

The public sector in Australia consists of three levels of government - the federal Australian Government, the governments of the six states and two territories, and about 700 local government authorities. The public sector plays a key role in initiating and undertaking engineering construction activity. The value of engineering construction work done for and by the public sector currently accounts for about 35% of total engineering construction spend (value of work done) and 60% of construction relating to roads and highways [ABS 2009d].

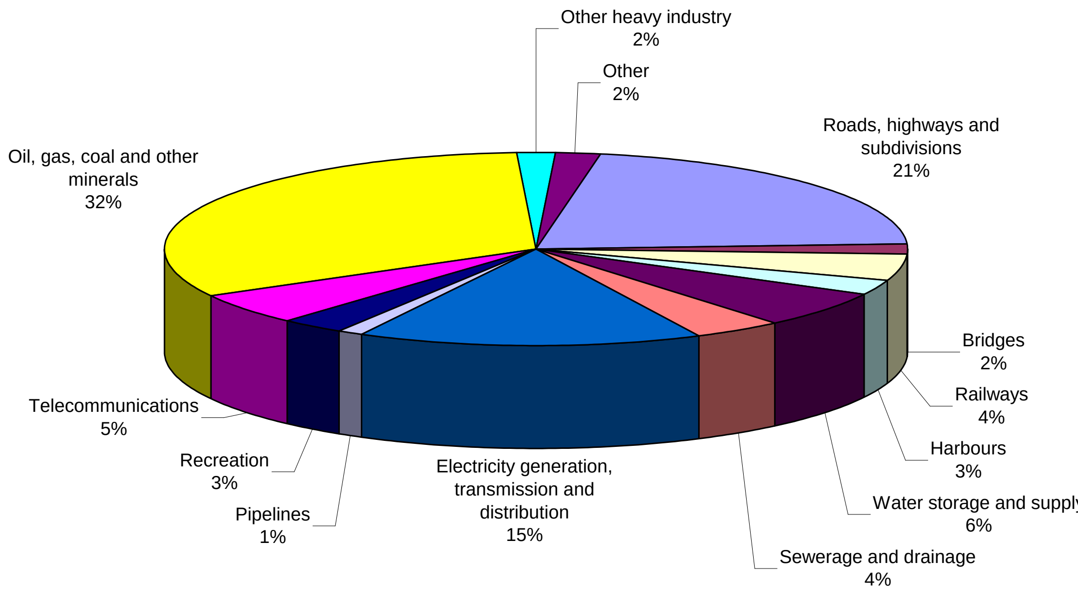

Fig. 4. Spending by Activity on Engineering Construction (2008-09) (based on data in ABS 2009d)

SUSTAINABILITY IN CONSTRUCTION

Defining Sustainability

Definitions of sustainability tend to include aspirational statements for development as a whole without necessarily defining what 'sustainability' might look like in any particular industry or application. The Australian National Strategy for Ecologically Sustainable Development (NSESD), which was adopted by all levels of Australian government in 1992, has the goal of achieving "*development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends*" [DEWHA 2009].

Whilst the objectives and guiding principles of the NSESD have been translated into various State legislation and policy requirements for development, there is little guidance provided on what specifically constitutes a sustainable product or material. Barriers to gaining agreement on what exactly is a 'sustainable' construction material have been identified to include poor knowledge of the environment and understanding of overall global resource stocks, an inability to generalise impacts from actions as they can be time and space specific, difficulty in modelling dynamic natural systems and hence understanding the actual limits of these systems [DEH 2006, p12].

However, whilst there is no agreed definition of what is a sustainable material, Australian specialists in general support adoption of eco-efficiency principles and broad eco-efficiency objectives such as those developed by the World Business Council for Sustainable Development[2]. It is also recognised that there needs to be consideration of the whole of life impacts of new materials and technologies within the current context of the construction sector as although "a material may have characteristics such as renewable energy production or 100% recyclability … unless it is used in a system and context that takes advantage of these characteristics it cannot be described as sustainable" [DEH 2006, p14].

Measuring Sustainability

The assessment of the sustainability of a construction project has in the past generally tended to be a qualitative summation of project impacts against ecologically sustainable development (ESD) principles, drawing on some quantitative measures where available and where they can be directly compared with a useful benchmark. Similarly, assessment of the choice on construction materials has generally been undertaken by considering the likely performance of materials against desirable sustainability characteristics.

The use of more quantitative measures, such as Life Cycle Assessment (LCA) to provide a measurement of sustainable construction materials is however becoming more common place. For example the Australian Government is working with the Australian Building Codes Board to investigate and develop sustainability measures for the Building Code of Australia [BCA][3]. As part of this work it has commissioned research aimed to identify and quantify the range of environmental impacts, associated with the building fabric, using LCA and to measures that could improve the sustainability of building materials across the life cycle/supply chain [DEH 2006].

Similarly, the Australian National Life Cycle Inventory Database Initiative (AusLCI) project is establishing a methodology to standardise the interpretation of ISO 14040 (*Environmental Management – Life Cycle Assessment*] in Australia. It will include development of a database of consistent life cycle data for a wide range of Australian products and services over their entire life cycle and a consistent set of weightings for the relative importance of different environmental impacts in different climates [AusLCI, 2009].

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[2] The World Business Council for Sustainable Development (2000, p15) identifies eco-efficiency objectives to include: reducing the consumption of resources, reducing the impact on nature, and increasing product or service value. Selecting materials based on consideration of the following is said to improve eco-efficiency: reduce material intensity, reduce energy intensity, reduce dispersion of toxic substances, enhance recyclability, maximize sustainable use of renewables, extend product durability, increase service intensity.

[3] The Building Code of Australia is has been given the status of building regulations by all Australian States and Territories. It contains technical provisions for the design and construction of buildings and other structures.

Other examples of Australian initiatives to improve the measurement and benchmarking, and hence integration, of sustainability in construction through the use of metric based benchmarking include those listed in Table 2. From the examples it is clear that metric measures for assessing sustainability for buildings are more developed when compared with other sectors of the built environment. There is however a move to introduce a similar ‘star’ rating scheme for this type of construction via the Australian Green Infrastructure Council (AGIC) which propose to develop a rating scheme for a range of infrastructure projects including roads, rail, bridges and tunnels. Rating assessment categories are expected to include 28 sub-categories under the groupings of: project management and governance, economic performance, using resources, emissions, pollution and waste, biodiversity, people and place; and workforce [AGIC 2009].

Table 2. Initiatives to Improve the Integration of Sustainability into Construction

Program Target Area	Initiative & Description
Design and construction of buildings	Green Star (National) - ratings assess the environmental impact of building projects that is a direct consequence of a projects site selection, design, construction and maintenance. Nine categories are considered in assessing the rating: management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation. This is a voluntary rating program.
Construction and renovation of buildings	BASIX (The Building Sustainability Index) – an on-line program that assesses a house or unit design, and compares it against energy and water reduction targets. The design must meet these targets before a BASIX Certificate can be printed. Every development application for a new home must be submitted to the approving authority with a BASIX Certificate.
Performance of existing buildings	NABERS (National Australian Built Environment Rating System) - rates a building on the basis of its measured operational impacts on the environment in the areas of energy, water, waste and indoor air environment. The ratings are provided in terms of stars, reflecting the performance of the building relative to the market, from least efficient (one star) to best practice (five stars). Obtaining NABERs rating is voluntary for most organizations with the exception of some government agencies.

The Changing Definition of Sustainability

Whilst the above section outlines current initiatives to better measure sustainability as it applies to new construction projects, it is interesting to reflect on the evolution in thinking that has led to this current position. Although ESD principles were generally well understood in the 1990’s, it is arguable that evidence of how they were put into practice in construction projects was not evident until the 2000’s.

Prior to the 1990's, it could be argued that the drivers for materials selection choices in construction were primarily the performance benefits of using specific materials. Then, as more information became available about resource depletion and the benefits of 'closed-loop' processes, there was a shift in behaviour to conserve finite resources and promote of recycling as a means of improving environmental outcomes.

The 1990's and early 2000's saw the rise of a number of waste reduction and recycling initiatives at all levels of government. Programs targeted at the construction industry included the Federal Government WasteWise Construction Program - Phase I (1995 - 1998) and Phase II (1999 – 2001). Under the WasteWise program [DEWHA 2008]:

- Government and industry partners attempted to identify and address the technical and behavioural barriers to efficiently and economically reducing waste; and
- Significant volumes of building material waste, including concrete and steel, were reused and recycled.

This program was significant as at the time it was recognised that "while governments could set the framework, significant progress would only be made with industry taking the lead" and "because waste reduction methods were not well understood at the time, the participating construction companies facilitated the first detailed assessment of waste reduction opportunities and industry coordination issues - from supply, through production, to recycling". [DEWHA 2008]

Now in the 2000's (as outlined above) it is recognised that achieving a state of sustainability requires more than just using less resources and recycling the wastes we generate, it requires consideration of a range of broader environmental impacts over the life cycle of products and projects. The practical implementation of sustainability in large scale Australian infrastructure projects is perhaps best demonstrated through the use of case studies, one of the most well-known examples being the construction of Sydney's Olympic Park in preparation of hosting the 2000 Olympic and Paralympic Games (refer "Case Studies" below).

Recycled Material Use in NSW

In NSW, the RTA currently makes provision for a wide range of recycled materials in roadworks, bridgeworks and associated construction specifications. An overview of these materials and applications is shown in Table 3 below.

Table 3. Applications for Recycled Material and Construction Benefits

Recycled Material	**Applications (current and draft)**
Asphalt (recovered)	Granular material in pavements; Aggregate in asphalt (blended, neat in shoulders)
Bottom ash	Earthworks (cut-fill); Granular pavement materials; Subsurface drainage materials
Brick/tile	Earthworks and granular pavement materials

Crushed concrete	Earthworks and granular pavement materials
Fly ash	Cementitious/binder/filler in concrete, stabilisation & asphalt; Filler in slurry sealing
Glass	Cementitious/binder/filler in concrete, stabilisation & asphalt; Manufactured sand in concrete and asphalt; Granular material in pavements
Quarry by-product	Granular material in pavements (often blended)
Roadbase (pavement)	Earthworks and granular pavement materials (up to 100% via in situ stabilisation)
Scrap rubber	Sprayed sealing; Asphalt
Slag (blast furnace)	Cementitious/binder in concrete & pavements stabilisation
Slag (steel)	Earthworks & granular pavement materials; Aggregate in sprayed sealing and asphalt

CASE STUDIES

The following is a cross-section of case studies encompassing the NSW and RTA experience with sustainable projects, recycled materials, new regulations and partnering arrangements.

Sydney Olympic and Paralympic Games 2000

Sydney's 1993 winning bid for the Sydney 2000 Olympic and Paralympic Games featured a strong commitment to the environment. Sydney's environmental commitments and recommendations for future Olympic host cities were contained in the *Environmental Guidelines for the Summer Olympic Games (September 1993)*. The commitments were broadly grouped into five categories: energy conservation, water conservation, waste avoidance and minimization, protection of human health, and protection of natural and cultural heritage. Some examples of how ESD [Laginestra et al, undated] was put into practice to transform a degraded urban area into innovative sporting facilities, residential areas and extensive parkland include:

- The completion of the Athletes Village as one of the world's largest solar-powered suburbs, with photovoltaic solar energy panels fitted to 665 houses.
- Collection and treatment of sewage and stormwater from venues and areas around the site for non drinking water uses thus reducing the sites demand on Sydney's potable water supply by 50%.
- Recycling of 94.7% of construction waste.
- Extensive site remediation work, costing over AUD$137 million (year 2000 dollars), using a "consolidate, contain and cap" program.

Recycled Glass

Australians are prolific recyclers with, for example, 200kT of container glass collected in NSW annually [DECCW 2007]. However, whilst glass is typically separated for collection and processed at Materials Recovery Facilities (MRFs), approximately 30% of glass handled in this manner cannot be reintroduced into the glass production line due to minimum size (30mm) limitations on glass cullet for reprocessing. As a result, approximately 400,000T of glass is stockpiled or sent to landfill nationally per annum.

Low to high value applications for glass products in civil construction are emerging using basic- to highly-decontaminated streams of mixed coloured food and drink packaging glass. In NSW 20,000T of recycled container glass is presently being used in drainage applications such as pipe bedding [DECCW 2007].

Glass is currently allowed for use in limited construction applications by RTA specifications in two forms: as a fine aggregate (less than approximately 2mm) and a powder (passing 90 micron). As a fine aggregate (less than 2mm), it may be used as a sand in concrete or asphalt. In its powdered form, glass may be used as a supplementary cementitious material (SCM; to offset cement) in concrete, as a binder in stabilised pavements or a filler in asphalt.

Tables 4 illustrates the potential benefits of the substitution of conservative proportions of natural sand and portland cement in concrete based on NSW and VIC production [CCAA 2007].

Table 4. Recycled Glass – An example of Potential Use and CO2 Reduction

Application	Approximate Markets (p.a.)			Potential benefit (p.a)
	Primary (MT)	Current (%)	Potential (%)	
Sand in Concrete	5.7	<0.1	5	Beneficial reuse
Cement in Concrete	1.6	<0.1	3	350kT of CO2e

Manufactured Sands

To address a predicted shortage of quarried ‘natural sands’ (those from quaternary deposits in streams, rivers, estuaries, lakes, lagoons or dunes) in the Sydney basin for use in concrete production and to utilise waste from the crushing quarried material for coarse aggregate production, usually in the form of tailings (-5mm), the CCAA and the RTA have conducted separate research projects to evaluate a range of ‘Manufactured Sands’ for use in general purpose and paving concrete.

Although these projects generally proved the technical viability of such measures, both projects concluded that the use of by-product materials such as these, will generally have mild to moderate adverse effects when compared to concrete made with their natural sand equivalents [CCAA 2008]. For example, many of the materials evaluated exhibited shape and fineness characteristics that demanded additions of cement and water to compensate for the effect on workability of the mixes in order to match the control concrete produced with natural quarried sands. In concrete, these types of effects can be minimised by blending with natural sands, which is already a common practice to extend the supply life of existing natural sand quarries, however RTA specifications are continually evolving to accommodate the increased use of these materials with the inclusion of flow tests (to assess fine aggregate’s shape effect on water demand) and specific performance specifications for abrasion resistance to ensure minium skid resistance performance – a property which is currently control by the specification of a physical property requirement of minimum quartz or chert content (for pavements as a wearing course).

Coal Furnace Ashes

The majority of power on the Australian electrical network is derived from burning coal, predominately black coal. Approximately 25% by weight of coal burnt converts to fly ash and bottom ash – as demand for our best coal by export markets increases, this proportion increases.

The fly ashes are light to mid-grey in colour and have the appearance of cement powder with particle sizes range from 1μm to 200μm, being irregular to spherical in shape. The majority of Australian ash produced is categorised as Class F, highly pozzolanic that reacts well with cementitious materials. It is composed mainly of silica and alumina (80-85%) and 10% or more CaO. The majority of current beneficial use of fly ash is currently as a supplementary cementitious material. In domestic concrete applications, fly ash typically replaces between between 10 and 20% of Portland cement, whilst in road construction it replaces between 15 and 75% of cement (up to 160kg/m^3). Fly ash is a concrete mix component which is mandated in lean mix concrete sub-base, where slow strength gain and workability advantages provided by the material are dictated by design (eg, low shrinkage). Other drivers for the inclusion of fly ash in 35MPa concrete (and above) in road and bridge construction include cost reduction, siliceous aggregate reaction control and exposure conditions. Fly ash also allowed for use in asphalt (as a filler) and granular bases or select fill (as a binder).

Bottom ash and boiler slag comprise approximately 10% of the total ash produced and range in grain size from fine sand to large coarse aggregations. They have chemical compositions similar to fly ash. The furnace bottom ash is used as a sand replacement, aggregate for lightweight blocks, a road-base component, for agricultural drainage mediums and as engineered bulk fill.

Excess coal furnace ash not collected or processed for beneficial use is usually stored in ‘ash dams’ which are usually located on the generator’s property. The collection and storage of an annual 11MT of fly ash is however impinging on producers’ dams capacities.

Future proposed applications for coal ash products to be used as both the cementitious and inert filler components in the production of alumina-silicate concrete (also known as geopolymer concrete, in which all portland cement is replaced by fly ash) promise to provide dramatically improved beneficial use rates for both fly ash and bottom ash.

Table 5 represents a snapshot of the current use of ash products, along with a illustration of potential reuse. Such illustrations are however dependent upon satisfactory development of materials and the improvement of transport networks (refer “Transportation Costs”).

Table 5. Coal Furnace Ash - An example of Potential Use and CO2 Reduction

Application	Approximate Market (p.a.)		Potential (p.a.)	
	Primary	Current	Market	Benefit
SCMs, binder & fillers	8.0 MT	1.8 MT	6 MT	6MT of CO2e
Structural fill	>100 MT	0.2 MT	2 MT	Beneficial reuse

Partnerships with Industry

Through facilitating organisations such as the Waste Management Association of Australia's Industrial Ecology Network, the Packaging Stewardship Forum, and government-industry partnership agreements such as the Department of Environment Climate Change and Water (DECCW)'s 'Sustainability Advantage Program', the RTA is able to effectively partner with producers and processors of industrial by-products for civil construction to develop new materials and/or processes. Such partnerships enable government and private organisations to work together in the development of mutually beneficial products and processes. For example, signatories to Sustainability Advantage typically commit to:

- Engage with their suppliers and customers to improve environmental performance
- Integrate sustainability principals into core business leading to more sustainable products
- Minimise the ecological footprint their operations

Outputs arising from any given research project, sometimes initially discussed perhaps in the context of intellectual property, are effectively made public by virtue of government agency's involvement in the relevant agreements. For example, findings from the RTA's involvement in a sustainability compact including Boral Resources, Australian Glass Technologies and DECCW have been incorporated into an updated version of the RTA's specification for cements, binders and fillers where powdered glass is now permissible as a supplementary cementitious material in low risk applications (refer "Durability and Risk Management").

Waste Regulations

The Environment Protection Authority NSW (EPA), the regulatory branch of DECCW has enacted and progressively amended an increasing schedule of metropolitan and regional levies against materials received by waste handy facilities. The levy, described in the Protection of the Environment Operations Act [EPA 1997] and illustrated in Figure 5 below, aims to reduce the amount of waste being directed to landfill, and promote recycling and resource recovery through the redirection of recyclable waste to MRFs.

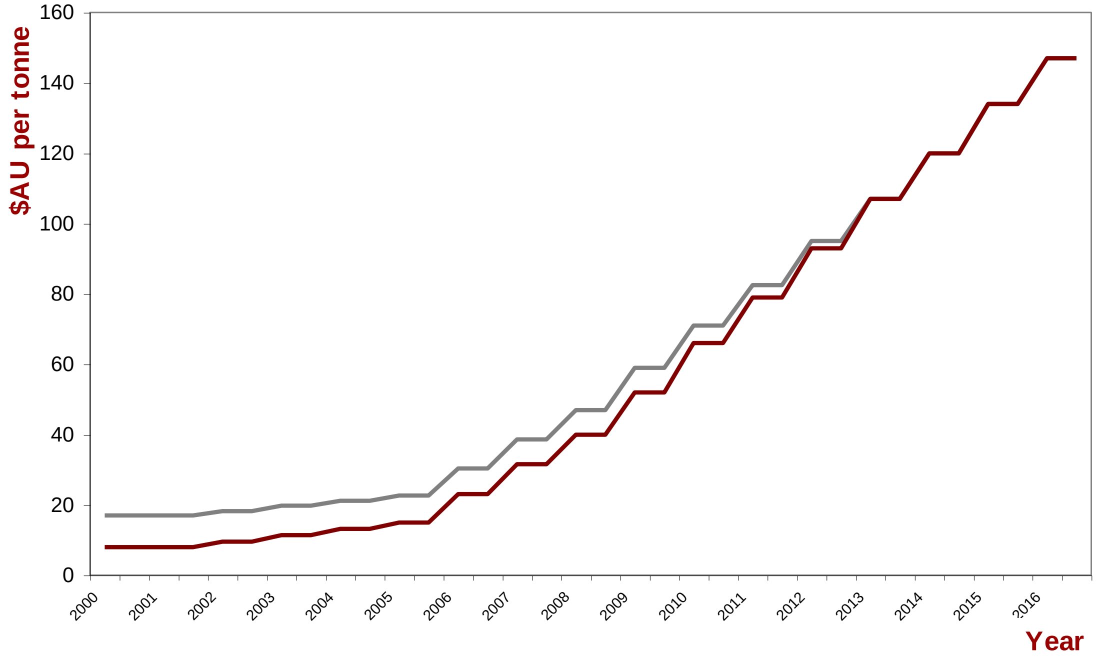

Fig. 5. EPA Waste and Environment Levy (Metropolitan and Regional)

Leadership and Influence

While contracts let by the RTA in NSW represent a small proportion of the total volume of materials used in building and engineering construction applications, the RTA recognises that, in its Corporate Plan [RTA 2008], it has a key role in the promotion of positive environmental outcomes in road development (in addition to reducing its own impact on the environment). As the constructor and manager of the largest state road network, and as an organisation that requires durable long-life structures, the leadership affected by its activities impacts and influences nationally through other state road authorities, local councils and public works agencies.

This leadership role, which arises from the RTA's experience with sustainability initiatives, is imparted in the form of published specifications and guidelines, and through peer participation within national working groups and committees, such as Austroads, an association of Australian and New Zealand road transport and traffic authorities.

Environmental Impact Assessment Tools

In the absence of national sustainability assessment tools for infrastructure projects, the RTA is in the process of developing its own tools to assist in the planning and assessment of its road construction projects. These include a Greenhouse Emissions Inventory Tool for Road Projects that considers greenhouse gas emissions associated with the construction and operation of roads and a Pavements 'Whole-of-Life' Greenhouse Emissions Tool. This latter tool will be used to provide information on greenhouse gas emissions associated with different pavement types over the pavements design life taking into consideration different construction and maintenance requirements. Whilst both these tools are currently focused on greenhouse gas emissions, there is scope for them to be expanded in the future to also consider other environmental impacts (such as impacts to water and air quality) using LCA approaches.

NEW MATERIALS - NEW ISSUES

Transportation Costs

As with any construction material, but particularly in Australia with its low population density , transportation distances between by-product source and/or processing location is made inefficient by the large distances involved. For example, blast furnace slag, a large supply of which is typically produced in Wollongong NSW (South of Sydney), is currently limited in its use by the costs of road and rail network transportation options – typically a 200km radius.

Despite studies that show that by-products used as supplementary cementitious materials in concrete can be transported nearly 1000km and still reduce embodied GHG emissions [O'Moore et al 2009], transportation costs continue to be a natural inhibitor of the use of such low value products beyond relative short haul distances from their source [ASA 2007].

By-Products and Variability

Particularly in the case of recovered or waste materials (as distinct from recycled materials) like fly ash and slag, these materials are by-products, not primary products or even co-products. The production of these materials ultimately receives second priority behind the quality of the primary industrial output – for example, electricity in the case of a coal fired power station that also produces fly ash as a by-product. This results in a material which is more variable between regions and between seasons than the primary product it seeks to replace (e.g., cement). This presents a need for increased vigilance in the form of additional quality control that is sensitive to the magnitude of these variations.

An example of this is the requirement to monitor Loss on Ignition levels (a measure of unburnt coal/carbon) in fly ash. The presence, and moreover the variability, of carbon levels (even between 1% and 4%) can cause significant fluctuations in the effectiveness of chemicals added to the concrete to entrain air (required for durability). The subsequent effect on concrete is to produce materials which, whilst still compliant in terms of strength, are potentially less consistent in terms of quality.

Increasingly, RTA projects include bonus-linked key performance indicators (KPIs) such as coefficients of variance in compressive strength. Where input materials are by-products and thus likely to be more variable, the likelihood that KPIs will not be met is increased.

Durability and Risk Management

Whilst the initial performance of by-products may satisfy existing performance-based materials specifications including conventional predictive test regimes for durability, the inclusion of recycled materials presents additional risks in the form of the long term durability and unproven performance.

The RTA manages these risks in two ways – firstly, additional performance-based criteria are built into specifications. These requirements are tailored to the differential characteristics when compared with the material it replaces and where possible are accelerated type methods that seek to predict long term durability - for example, wear, chemical reactions and incompatibilities arising from slow-reacting compounds in the by-product. Secondly, the incorporation of new materials into specifications is implemented into low-risk before higher risk high volume applications – for example, powdered glass is currently only permitted in small quantities as a supplementary cementitious binder and only in the RTA's general concrete application specifications, not its model paving or bridgeworks specifications.

CONCLUSION

Australia's definition of 'sustainability' in a construction context has evolved significantly over the past 20 years. A broad range of industrial by-products and domestically recycled materials are commonly included into road construction activities. With increasing vigilance with respect to quality, extended participation and innovation between industry and regulatory agencies, and a closer review of whole-of-life costing, this trend is likely to continue.

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