Attachment: Research and Case Study Analysis Framework

Listing of Key Case Studies

Tullamarine Calder Interchange, VIC: The Tullamarine Calder Interchange is a main arterial located north west of Melbourne (approx. 2km long). The introduction of the new interchange allowed less traffic and congestion on local roads, and included safer signalised intersections at Bulla Road and Melrose Drive. Many important environmental options were implemented in this project to allow it to be under budget. Through the application of these key options as well other innovative ideas, the Tullamarine Calder Interchange was awarded the National Award for Excellence in Major Capital Alliances and a finalist in the 2008 Banksia Foundation Environmental Awards.

Mickleham Road Duplication, VIC: Mickleham Road Duplication is a sub arterial road located in Greenvale, Victoria, north of Melbourne. The main features of stage two of the duplication of Mickleham Road were the new and upgraded traffic signals, associated street lighting, service relocations and drainage. Other features included construction of off-road shared user paths and allowance for a future third lane in each direction. Mickleham Road Duplication was the first project to calculate the amount of greenhouse gases (GHG) it emitted during construction, including from materials used and associated transport. From this initiative VicRoads have developed a framework for future road infrastructure projects to enable them to calculate their own carbon footprint.

Cunningham Highway, QLD: The Queensland Department of Transport and Main Roads (DTMR) utilized in-situ stabilization techniques to drastically reduces the amount of aggregates needed and therefore the amount of greenhouse emissions from a road project. The trial used higher quantities of lime than had previously been tested, resulting in exceptionally durable outcomes in the high heave soil. DTMR also utilizes a foam bitumen process that has process excellent long-term results on Queensland roads (in the Border District, North and South Coast Hinterlands and Redland Shire).

Mannington City Council, VIC - Alternative Roadbase and Glassphalt:: In Chile between 2003 and 2006 the “Caminos Básicos 5000” programme has improved 5,000 km of low traffic roads using new low-cost construction techniques. In the north of the country some 2,000 km of roads have been made with salt (magnesium and calcium chlorides etc). This salt method has allowed the construction of inexpensive roads at the same time as providing local inhabitants with employment. The techniques of the “Caminos Básicos 5000” programme are now being applied in Mexico, Bolivia, Peru and Argentina. Salt roads have also been built in Botswana and Namibia.

Appropriate technology, Uzbekistan – Caravan roads to highways: In Uzbekistan, the development of the road network took account of the local conditions and budgetary constraints. As a first step roads were created quickly using local building materials with small investments to provide the largest possible network across the country. The sub base, bridges and culverts were constructed according to international standards, but the road pavement was constructed from local natural stone bound with local crude oil. As traffic increased the surface was upgraded with concrete or tarmac depending on the local conditions. By this method some 5-6,000 km of roads were built per year in Uzbekistan, and Uzbek road engineers opened 250 km of new roads on high mountainous routes such as the Osh - Irkeshtam road between Kyrgyzstan and China.

Vietnam – Clay Brick Roads and Nuptials: In Viet Nam there is a tradition of building brick roads. In the past, when a girl got married to a boy from another village, then the boy's family had to pay 500 to 1000 pieces of brick to the girl's village. This kind of traditional custom existed in many communities before 1945 but has now lapsed. Apart from the bricks contributed by the groom's family, the village people paid for the other materials such as lime and sand and the hire of a construction team to build the section of road. This was an important contribution to development of the community infrastructure. The Ministry of Transport of Viet Nam and international donors are now looking again at the possibility of building rural brick roads, particularly in the deltas of the Mekong and Red rivers where there is plenty of clay for bricks but very little stone.

Aluminum of Greece and Aristotle University, Greece – Red mud road embankment: One project dealing with alternative aggregates is the research led by Aluninum of Greece together with the Laboratory of Highway Engineering of the Aristotle University of Thessaloniki in Greece. They are currently monitoring roads built with different mix of natural materials and red mud; red mud being used as a stabilizing material. This project includes two major steps. The first one was to study the physico-chemical properties of red mud (1993-1995). The results of this study show some strengthening properties of this material, specifically, the bearing capacity of the soil structure seems to increase up to 3 times with respect to its initial value. And the second step was to build an experimental embankment (2001-2004). Kegahia in his review (2010) reveals that the experimental roads are showing good mechanical behaviour.

Vegecol, France and EcoPave, Australia - Bitumen alternatives: Bitumen aggregate replacements can also be made from a range of materials, includingpPine resin or tall oil, also called liquid rosin or tallol, is a viscous yellow-black odorous liquid obtained as a by-product of the Kraft process of wood pulp manufacture. Tall oil is a mixture of fatty acids and resins that tend to be separated into "tall oil rosin", "tall oil pitch" and tall oil fatty acids, and has been employed as a tar/bitumen substitute often in combination with other bio materials. The gTKP report presents this solution as the most promising option to replace bitumen. The use of pine pitch, rosin and vegetable oils to produce bituminous binder has been the subject of many patents, but recent innovations only started to attain commercial success as ecologically acceptable alternatives. The process is kept secret and the gTKP report assumes that more sophisticated control over polymerisation conditions using oxidation catalysts and various pre-treatments may have lead to this success. Products using this technology already exist; there are Vegecol from Colas or Ecopave from Australia. UNEP gives details about the technology used by ecopave, noting that it is an invention that turns sugars (from sugar cane) and a wide range of other natural materials including tree resins and gums, vegetable oils, potato and rice starches, and molasses into road paving. The process is said to involve negligible levels of fumes during the laying and, unlike bitumen, which must be constantly heated at temperatures of 170 degrees C, the new material can be stored and transported at room temperature. A novel advantage is that the product can be pigmented to reflect heat and thus help to cool cities, the company claims. The main barriers to the wider use of these materials are the cost and appropriate technology implementation.

Warm and semi warm asphalt processes: Traditionally, asphalt is produced at temperatures of about 150-180°C. At these temperatures the bitumen can fully coat the dried aggregate. This ensures that the bitumen is fluid enough to be workable during mixing, laying and compaction, which normally take

place at temperatures of between 140-170°C. From the same report cited above, Saunier et Associé, warm asphalt is described as a material manufactured between 80°C and 130°C with various mixing processes. It has the same performances as HMA as soon as it is applied: there is no development/waiting period as for cold mixes. There are two kinds of warm asphalt: those which are manufactured above the evaporation temperature of water (100°C), semi warm asphalt, and those under, warm mix asphalt (WMA). A significant amount of the energy consumed in coating is due to the latent heat required to evaporate water. For this reason asphalts manufactured under 100°C are interesting.

Cold asphalt processes: The definition given by Saunier et Associés of cold asphalt is a process where the manufacturing temperature is under 60°C. Their report emphasizes that, as for warm asphalt, working conditions are improved (safer work environment, less dust and fume emissions at the mixing plant and during the paving operation) and roads can be quickly reopened. The binder is heated less, which reduces the artificial ageing and hardening of the bitumen. Companies are still working to improve performances of cold mixes to use them in the wearing and base courses of the pavement. The company Eurovia (in the Czech Republic) has developed a new material: Aspha-min® admixture. It is a special admixture for bituminous mixtures which allows the temperature of the mixture during the placement process to be decreased by up to 30 degrees Celsius. Currently, it is mainly used for maintenance on low trafficked roads (rut).

Fulton Hogan, Christchurch NZ – CoolPave: In 2006, Fulton Hogan combined additive technology with plant and process modifications to create an asphalt that could be produced below 100ºC and placed at temperatures as low as 60ºC. The two major benefits resulting from this technology are a reduction in greenhouse gas emissions (by as much as 50%) and major improvements to field crew health and safety (mainly due to the considerable reduction in temperature). As a result, Fulton Hogan has produced over 6000 tones of 'CoolPave', which has been used on minor city streets, multi lane city arterials, airport taxiways and factory yards and car parks. Vigorous performance testing shows excellent compaction results and rutting levels comparable to that of hot mix asphalts, demonstrating that paving quality need not be compromised when using low emissions production techniques.

Melbourne, VIC – Greenpave: The Greenpave technology, developed and trialed in Melbourne, Australia, is very similar to the cool pave technology found in Christchurch, New Zealand. Greenpave has been laid at 17 sites across metropolitan Melbourne and all sites have passed independent audits. The new asphalt production facility, situated in North Melbourne, meets tough European environmental standards and has reported gas and electricity consumption savings of 30%, noise and odour reduction, improved site drainage to reduce storm water contamination and asphalt recycling facilities.

Carbon negative cement by Novacem, UK - Alternative to GP cement using Magnesium: Novacem has developed a new cement based on magnesium oxide which will address the carbon problem faced by the cement industry, and as a result will contribute significantly to an overall shift to a low carbon world. Production of our cement is carbon negative; more carbon dioxide (CO2) is absorbed during the process than is emitted. We aim to offer cost parity with traditional cement, even before any cost of carbon is factored in, and also performance parity. Abundant accessible sources of the magnesium

silicates we use to produce magnesium oxide exist on Earth, and will support large scale roll out of Novacem cement production.

Great Eastern Highway – Roe Highway Interchange: The Great Eastern Highway – Roe Highway Interchange is currently under construction with a date for completion of May 2012. The project will create a grade separated interchange between the Great Eastern Highway and the Roe Highway at Midland, an eastern suburb of Perth. "Once complete, it will enable Roe Highway traffic to flow freely over Great Eastern Highway via a bridge and efficiently and safely integrate connecting traffic in all directions."

Great Eastern Highway – Kooyong Road to Tonkin Highway: The Great Eastern Highway upgrade project between Kooyong Road, Rivervale to the Tonkin Highway, Redcliffe will widen the Great Eastern Highway from four to six lanes over a distance of 4.1km. The project is in the preconstruction phase with construction scheduled for commencement in 2011 and completion in 2013. A central median will be constructed to limit the number of conflicting movements to increase road safety. All major intersections will have dedicated turn pockets and allow U-turns. Parallel walk phases will be installed at all signalled intersections. Bus priority will be included in all major intersections to improve public transport travel times to make public transport more attractive through this area. More pedestrian and cycle friendly facilities will be included to all safe crossing of the highway. A pedestrian crossing near Abernethy Road will improve access to the Swan River and its foreshore and connect to the existing recreational path.

Gateway WA: The project covers the section of Tonkin Highway between Great Eastern Highway and Roe Highway, as well as Leach Highway from Orrong Road to Perth Airport. The primary objective is to provide safe and efficient access for all road users that will enhance social, economic and regional. The project is currently in the planning phase.

James Price Point: MRWA, in consultation with the Department of State Development, is responsible for constructing a new 19 km fully sealed, all weather access road from the Broome – Cape Leveque Road to the proposed Browse LNG Precinct Site, an area just south of James Price Point approximately 60km north of Broome. At least two LNG projects are proposed for the site. The project will also include the reconstruction of 25km of the existing Broome - Cape Leveque Road from the Broome Highway and compliment the plans to seal the remaining 90km of unsealed section. The project aims to foster economic growth in the Kimberley Region by providing safe access for the provision of goods and services on the Dampier Peninsula, increase State Revenue and provide employment and training opportunities for local workers and businesses.

Wheatbelt ISA: The Wheatbelt Integrated Service Arrangement has been formed to provide road infrastructure maintenance services for the Wheatbelt North and Wheatbelt South Regions. The operational phase of the road network is the critical phase of the life of the asset. It will test how effective the tool is for an existing large piece of infrastructure. The Wheatbelt ISA manages 3445km of national and state roads.

Additional Case studies include:

- Eastern Busway Alliance, Brisbane, QLD,
- Great Northern Highway, WA - Saline Water in Road Construction,
- Municipal Association of Victoria - Recycled Roads To Zero Waste,
- City of Canning WA - Performance of recycled materials,
- CLEM7 tunnel QLD – Recycled Aggregates,
- Alcoa aluminium byproducts, Kwinana WA – Red mud roadbase,
- Warm Asphalt Validation Project, AAPA Australia – creating the new standard,
- Earth friendly Concrete by Wagners, QLD – geopolymer,
- MRWA Lighting - LED traffic signals, and
- Northern Alliance for Greenhouse Action, Melbourne Vic – Streetlighting.