The Newsletter of

Engineering Heritage Australia

ENGINEERS AUSTRALIA
Engineering Heritage Australia

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CALLINGTON FLOUR MILL AT OATLANDS RESTORED

Martin Farley from Creating Preferred Futures and Hugh Murphy, Consulting Engineer presented a paper on the recent restoration and re-commissioning of this historic mill.

This wind-driven flour mill built in 1837 is back in business, with authentic replica equipment producing a commercial product. It is Australia's only remaining example of a Lincolnshire style windmill. Built to the highest standards by John Vincent, speculator and sly grog seller, the 15 m high sandstone tower mill had four floors and the best machinery and grinding stones. While initially successful, a recession saw it pass through several hands and the addition of a steam–driven mill to maintain production in calm weather. It finally closed in 1892-93 and fell into disrepair.

The sandstone tower remained a significant landmark on the Oatlands skyline and attracted periodic interest in its restoration. Some works were carried out in 1976 with the aim of preventing further deterioration. For the 1988 bi-centenary, funding allowed the re-installation of four timber floors, stairs and a hemispherical cap. In 1999 a new fantail was installed on the cap.

In 2004 the concept of restoring the mill and adjacent buildings to enable the mill to produce flour from locally grown grain was explored and, after a further round of planning and assessment, this proposal was found to be a viable option. Government grants of $2.4 million in 2008 enabled millwright Neil Medcalf to design and fabricate an authentic set of mid 19th Century milling machinery, cap and sails in the UK and deliver them in 2010. The millwright then installed the machinery into the mill tower refurbished to meet current approvals to operate as a commercial mill.

The four large sails have adjustable louvres to regulate the speed, and a clever fantail (tail rotor) turns the cap to keep the sails pointing into the wind. Through wooden

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LOST IN SPACE? BIOGRAPHY ACROSS THE HEMISPHERES

Mike Chrimes, Institution of Civil Engineers UK, was a keynote speaker who is still deeply involved in the ICE Biographical Dictionary of Civil Engineers project. His paper addressed the challenges of engineering biography. Here are a few snippets:

Selecting great engineers: How does one measure the greatness of an engineer – innovation, great work(s), aggregate scale of contribution, size of estate/wealth, legislative impact, contribution to the profession? Mike gave examples where well known names may have had a lesser claim than others, when more research was done. Although the early great names – Smeaton, Telford and Rennie – held their own by most criteria, in the Victorian period the relatively unknown (to the public at least) Sir John Hawkshaw scored highest in most categories.

Credit for great works: Mike quoted several examples in which due credit was in dispute: the development of NSW railways (Whitton or Fowler?), the Port of Melbourne (Coode?) and the Mersey Tunnel in the UK (Brodie or the consultant/contractor?). In relation to the Sydney Harbour Bridge (Bradfield or Freeman?), Mike's own view was that Freeman Fox and Partners capitalised on

Engineers inspecting the Sydney Harbour Bridge

their association with the bridge globally while Bradfield, despite his considerable engagement with ICE, had never really been appreciated for his work on the development of Sydney outside Australasia.

Access to biographical information: The greatest challenge facing biographical researchers seeking information across the world was access to information to create a full biography. Thanks to the efforts of various national archives, the Mormon Church and www.ancestry.co.uk, a good deal of basic genealogical information was now available over the internet for researchers.

Careers in two hemispheres: Tracking British engineers who came to Australia can be difficult if they did not come directly, e.g. via time in India. In relation to Melbourne's Yan

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EDITORS'S NOTE

Unlike usual editions of the EHA newsletter, this edition is concerned solely with the 2011 Hobart Engineering Heritage Conference. Papers selected by the conference committee and EHA board members have been summarised by them for a general readership. Most of the papers referred to will be published shortly in a special edition of the Australian Journal of Multidisciplinary Engineering.

16th ENGINEERING HERITAGE AUSTRALIA CONFERENCE
Hobart November 2011

The 16th Engineering Heritage Australia Conference was held at the Wrest Point Conference Centre in Hobart on 13-16 November 2011. Delegates numbered 110 and there were 40 accompanying persons.

The Governor of Tasmania opened the conference. Professor Geoffrey Blainey and Michael Chrimes were the two keynote speakers.

Forty-four papers were presented in two combined sessions and fourteen parallel sessions over two & a half days. Each presenter was given 20 minutes for the presentation within a 30 minute period. The two lecture rooms were adjacent allowing easy transfer between presentations. The rooms were amalgamated for the opening session.

The setting of Wrest Point alongside the Derwent River provided a spectacular setting for conference attendees to enjoy morning and afternoon teas, and lunches. All delegates enjoyed the wonderful vista and hospitality provided.

Social functions during the conference consisted of a Welcome Reception, a reception at Government House and the Conference Dinner at which the 2011 Colin Crisp Awards were announced and presented.

A pre-conference tour is described elsewhere in the Newsletter, with the other major organised excursion being a trip to Glenorchy for an inspection of the Tasmanian Transport Museum and to witness a Heritage Recognition Ceremony at which the Governor of Tasmania and the Immediate Past President of Engineers Australia unveiled an Engineering Heritage Marker and Interpretation Panel for the Museum (also described separately in this Newsletter).

Overall the conference was deemed to be an outstanding success. The wide variety of session and paper topics attracted special praise, and the Government House reception proved to be a special highlight.

Bruce Cole

16th ENGINEERING HERITAGE AUSTRALIA CONFERENCE
Pre-conference tour November 2011

As a precursor to the Engineering Heritage Australia Conference, a pre-conference tour was conducted to showcase the engineering highlights of Tasmania to conference participants. The tour began by heading north through Hobart, crossing the River Derwent via the Bridgewater Causeway and Bridge (1942) with its recently re-furbished vertical lift span. From here we followed the Heritage Highway to Oatlands where some of the group were able to inspect the re-commissioned 1837 Callington wind-driven flour mill.

Further north the convict built Ross Bridge and the Red Bridge at Campbell Town were admired and photographed. The latter was strengthened in 2000 using the Archtec system of tension rods over its three red brick arches.

In Launceston the tour stopped for lunch at the Queen Victoria Museum where the blacksmith's shop of the former Tasmanian Railway Workshops was visited. After lunch we travelled via the East Tamar Highway and the Batman Bridge (the first cable-stayed bridge in Australia, 1968) to the Beaconsfield Mine & Heritage Centre. This gold mine had three of the largest mine pumping steam engines in the world before closing in 1914, but reopened in the 1990s. The Museum includes a model of the tiny cage where two miners were trapped underground for two weeks in 2005.

On Day Two the tour stopped for an inspection of Pearn's Steam World at Westbury. Large and small working steam traction engines (Foden and Fowler) were on display here, as well as a wide range of other steam and diesel operated farming equipment. This was followed by an extended inspection, and lunch, at the Redwater Creek Tourist Railway establishment at Sheffield. Delegates were able to experience steam travel along the RCTR's rail line as well as observe Marshall and McLaren steam traction engines in action. There was also an announcement that Chris Martin, the President of RCTR, was to receive the 2011 John Monash Medal for his personal contribution to the conservation of engineering heritage (formal presentation later in Canberra).

ABT Railway: stop to take on more water

During the afternoon there was a brief stop at the 110 m high Cethana concrete faced rockfill dam, recognised as a National Engineering Landmark.

Day Three began with an optional inspection of Robert Sticht's former office at the Mount Lyell Mining & Railway Co. Robert Sticht joined the company in 1893 and became its first general manager (1897 -1922). He was responsible for the economical pyritic smelting process which used the combustion of the sulphur in the ore to replace expensive NSW coal.

The main attraction of the day was a trip on the iconic West Coast Wilderness Railway from Queenstown to Regatta Point, Strahan. This vital rail connection had been built by the MLM&R Co. in 1895-6 to export its copper to the Mainland. The line was closed in 1963 but with the aid of a $20M government grant, work commenced in 2000 on re-opening the railway as a tourist venture. The 35 km rail line follows the steep sided, densely wooded Queen and King River valleys, via steep grades and narrow cuttings. Three original steam locomotives have been fully restored to run on the line.

During the afternoon, the tour continued onto Zeehan for an inspection of its Pioneers Memorial Museum.

Sunday started with an inspection of the Upper Lake Margaret Power Station, one of the oldest hydro power developments in Tasmania. It was built by the MLM&R Co and supplied electricity for its Queenstown operations from 1914 to 2006 when it was closed by Hydro Tasmania. The power development has recently been re-opened with its original machines, new wood-stave pipelines and automated control systems.

The trip back to Hobart was via the Lyell Highway, which follows the Derwent River with its six hydro power developments, construction of which commenced during the late 1930s and was completed in the 1960s. A brief stop was made at the Tarraleah Lookout, which provides a view of the Tarraleah and Tungatinah power stations.

Thanks to those individuals on the tour who provided historical and specific technical information for this article: Bill Jordan on bridges, Peter Stevenson on dolerite, Robert Vincent on Robert Sticht's office, Bruce Cole on hydro power developments, and Brian George (our coach driver) on general points of interest.

Bram Knoop

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Callington Flour Mill at Oatlands Restored

bevel gears, the sails drive a vertical shaft down the centre of the tower, and that shaft rotates the upper grinding stone into which the grain is fed. An electrically-powered "Hurst Mill" maintains production during periods of low winds.

In late 2010, two trained millers recommenced operations using locally-grown millable-quality grain. The mill has achieved the production quality expectations, is accredited as an organic food processor, and will be able to produce in excess of the volumes identified in the initial feasibility. The mill operation has an association with a baker to ensure the ongoing quality of the product.

Guided groups kitted out in the visitors centre are able climb up the tower to follow the whole fascinating operation. They see the millers in action, constantly dashing up and down their own stairs to make minor adjustments.

Throughout the project the steering committee has held solidly to the view that authenticity was essential. Restoration of the mill and associated buildings on the site (granary, stables, mill owners house and millers cottage) provides visitors with a unique example of a colonial industrial site during a foundation period of Australia.

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LOST IN SPACE? BIOGRAPHY ACROSS THE HEMISPHERES

Yean water supply, Binnie had limited success in tracking the career of Matthew Jackson, designer of the dam and water works, based on Blackburn's proposal. Continuing the water supply theme, Mike outlined the careers of Dobson and Gordon who pooled their experience in building Lower Stony Creek Dam (1875) in mass concrete at Geelong.

Changing criteria for inclusion: For the first volume, 1500-1830, inclusion could be justified for involvement with a major work, usually in the UK. However, for the proposed second volume, 1830-1890, a different scale of activity had to be considered as British projects took place all around the globe, although many engineers returned to the UK. The third volume, 1890-1920, was likely to have less Australian and New Zealand entries because antipodean careers were the province of local engineering historians, even though many leading engineers were ICE members.

Conclusion: Mike concluded by saying that a profession with no history is no profession at all. If engineers could point to a bridge and only explain its design, without relating that to the people who conceived and built it, how could they expect the public to appreciate the work of the individuals who made up the profession? The ICE building is full of names on stones, and portraits of gloomy old men. If we cannot tell their stories, the building is a mausoleum, not a celebration of life and progress.

MOBILE APPS for Heritage

Whether you use mobile applications (apps) or not, you could not help but be inspired by the paper presented by Daniel Woo, Design and User Experience Engineer, University of New South Wales, on his work producing engaging stories which visitors walking to heritage sites can view and hear on their mobile devices.

His Digimacq project aims to bring heritage to life and to engage a younger generation. From a whole range of possible sites and interesting stories, the connecting theme of people living in Parramatta at the time of Governor Lachlan Macquarie was chosen for six sites, and the project was completed in time for the Lachlan Macquarie bicentennial in 2010. It was not focussed on merely delivering historical facts, rather it looked to tell great stories. Creative character development is not generally an engineer's forte, so it was necessary for collaborative teams to be put together in order deliver engaging outcomes.

Digimacq was designed to run on iPhones & iPods on loan to the visitor from the Paramatta Council. The overall parameters were to limit the tour to one hour and each story to 2 minutes. The final result produced a series of stories that had direct connection to the actual places on the walking tour told by several characters that lived at that time, using high quality video and audio. For navigation between sites, the screen displayed progressive street scenes and an animated map. On arrival at a heritage site, the visitor had to key in three icons displayed on a sign to receive a clue which enabled them to play the main story for that site.

Daniel went on to describe what can be achieved using next generation devices such as tablets. The UNSW Green Trail is a project to highlight examples of native Australian bush tucker plants that can be found on campus. Being outdoors, the GPS location sensor and compass were used to determine the user's location and orientation. Using this information, the app presents information about relevant plants within the field of view.

For the Powerhouse Museum, a web service is used to search for items in the collections database. Finally, digital books (or "ePubs") are gaining popularity in the market place as both the readers mature and the on-line availability and purchase experience improves. This means that heritage content could be distributed to the mobile masses using the latest technologies.

MURTOA STICK SHED - New Life for a Wheatbelt Cathedral

Martin Zweep, Conservation Officer from Heritage Victoria, presented a paper on the spectacular Murtoa Stick Shed dealing primarily with recent conservation work.

The Murtoa Grain Store is the earliest and only remaining of three large sheds of this type built in Victoria. By the outbreak of World War Two there was a worldwide glut of wheat, and Australia had a massive surplus which it was unable to export. The storage deficit had become an emergency by 1941 as Britain obtained its imports from North America, rather than over the lengthy and difficult shipping route from Australia.

The shed is 280 m long, 60 m wide and 19 m high at the ridge with a capacity of 3.4 million bushels (124,000 m^3). The hipped corrugated iron roof is supported on 560 unmilled hardwood poles set in a concrete slab floor and braced with iron tie rods.

It is considered the largest timber framed shed in Australia and has high heritage significance. The building had been unused since 1989 and was progressively deteriorating while a new use was being sought. In early 2009 the Heritage Council of Victoria funded conservation works with an initial budget of $1.2 million to repair the building.

The majority of the causes of deterioration were associated with rot of the poles supporting the roof where they were buried in the ground. In addition there was significant termite damage, particularly to the unmilled poles and borer damage to some timber members. This damaged resulted in many structural failures and, aided by the wind on the exposed site, there was considerable loss of roof sheeting.

A repair strategy was developed, aided by reference to the Burra Charter but limited by the funding available. This work consisted primarily of stabilisation of the structure followed by repair of damaged or missing components. Damaged poles were either replaced by steel poles or strengthened by adding bow trusses. All poles which had not already been repaired were given new bases. The steel rod bracing was tightened and augmented. The upper timber work (rafters, purlins, etc) was repaired and the roof sheeting was patched where collapse had occurred.

That the building has been successfully repaired puts it in a better position to attract new uses under new management, as any new management body does not have to contend with the repair of the building prior to use.

The cathedral-like interior of the Murtoa Stick Shed.

TASMANIAN TRANSPORT MUSEUM Heritage Recognition

On Tuesday 15 November 2011, the Tasmanian Transport Museum in Glenorchy was recognised by Engineers Australia for its collection of transport items that have engineering heritage significance.

The formal ceremony included an address from His Excellency the Honourable Peter Underwood AC, Governor of Tasmania. The ceremony was performed at the museum and was attended by 160 dignitaries and guests including delegates to the 16th Engineering Heritage Australia Conference held in Hobart.

With the imminent closure of Hobart's electric tramway system in June 1962, the Metropolitan Transport Trust agreed to donate tram No. 141 for preservation and thus the collection of Tasmania's transport heritage began with the formation of the Tasmanian Transport Museum Society. In 1972 the Glenorchy City Council leased the current site to the Society, conveniently beside the main north-south railway, and the Museum officially opened in 1983.

The collection continues to grow and represents various forms of transportation and associated systems from previous eras. Significant exhibits include the:

- only Australian-built Steam Locomotive preserved in Tasmania
- first Main Line Diesel Electric Locomotive operated in Australia
- only Hobart Electric Tram preserved in original operating condition
- only Tasmanian Trolley Buses in original operating condition
- first production bus to be built with a Hino chassis in Australia
- only original Vertical Boiler Locomotive preserved in Australia
- oldest preserved Tasmanian railway carriage
- oldest surviving Tasmanian Railway Station building

His Excellency and guests were treated to train rides featuring Tasmania's oldest railway carriage, built in 1869, and the 1902 built steam locomotive, C22. The Tasmanian Fire Services Museum also shares the site and were on hand with an impressive display of early Tasmanian fire fighting appliances.

Ben Johnston

Unveiling the Heritage Marker and Interpretation Panel are (l-r) His Excellency the Honourable Peter Underwood AC, Governor of Tasmania, Professor Doug Hargreaves, Immediate Past President of Engineers Australia, and Philip Lange, President of the Tasmanian Transport Museum Society. Photo: Stuart Dix

Tasmanian Transport Museum Society Life Member, Graham Clements addresses the crowd during the heritage recognition ceremony. Photo: Stuart Dix

Tasmanian Transport Museum

GETTING IT RIGHT at Heritage Sites

Keith Baker presented a paper entitled "Getting it Right at Heritage Sites" at the conference, where he set out opportunities for greater engineering involvement in heritage conservation, with examples where engineering input is absent, mis-directed or undervalued. He made suggestions as to the stronger role engineers could play.

Opportunities sometimes present themselves for engineers when there is a structural failure or a requirement for a statutory assessment, but lack of sympathy for heritage can sometimes result in an easy condemnation of the structure rather than a more considered preservation approach. But there are wider avenues for engineering involvement when engineers are more proactive in the heritage conservation field.

The built heritage conservation profession is strongly represented by architects, historians and archaeologists, with some materials specialists and a few engineers, lawyers and other professionals. It is rightly multi-disciplinary, but engineers tend to be involved in structural assessments and repairs, more than in areas across the board where they also have useful expertise. The paper did not suggest that all engineers are insensitive to conservation issues, but argued that engineers are able to contribute more than they are often asked to do.

The paper addressed a number of these areas, including:

- providing appropriate conservation expertise where needed;
- contributing to the balance of views on significance;
- helping to protect places at risk;
- engaging in adaptive reuse;
- interpreting the original function and process, not just the shell;
- taking care of building services sensitively;
- nominating significant engineering and industrial works for national recognition; and
- engaging in the development and review of conservation codes.

The paper argued that if engineers are to claim a stronger role in heritage conservation, they must be prepared to back this up with skills development, community education and the use of professional influence where needed with decision makers. The heritage engineer firstly needs to have the knowledge and experience of an engineer in their chosen field of practice, to overlay this with an understanding of general conservation principles and conventions, and to couple this with an understanding of the materials and processes used in their profession in the past.

Engineering Heritage Australia has taken steps to recognise Heritage as a discipline, and the need to provide training for registration as a heritage engineer. The National Engineering Registration Board now recognises Heritage and Conservation Engineering as a specific area of practice in the National Professional Engineers Register.

Several conservation organisations are open to engineers on a voluntary basis, as well as some specialist salaried positions. But given the extent of engineering and industrial works that have contributed to our society, engineers are generally under-represented in the bodies that make decisions about our heritage, and those that develop and implement the codes of practice or promote built heritage conservation. While recognising the centrality of place to significance in the Burra Charter, engineers need to make it known that for the appreciation of engineering heritage works, function is often more important than place.

Engineering Heritage Australia is moving with current best practice and is open to change. The organisation is keen to engage with the public in broadening their understanding of engineering, and to get it right at heritage sites.

How do you provide an authentic heritage experience?

GIT-Restored Traction Engine

GIT – Unrestored Traction Engine

HOBART'S FLOATING BRIDGE, 1943-1964

Bruce Cole from Engineering Heritage Tasmania presented a paper on the first road bridge across the Derwent River at Hobart.

The wide and deep Derwent Estuary formed a natural barrier between Hobart on the western shore and the growing settlements and farms to the east. Crossings depended on passenger and vehicular ferries but there was a growing need for easier access. Many different designs for bridging the estuary had been suggested and abandoned over the years. At last in 1936 Alan Knight, Chief Engineer of the Public Works Department (PWD), proposed a floating concrete bridge with a lift span for shipping as a feasible and affordable solution. He realised that a horizontal three-pinned arch securely attached to each abutment would not require mid-stream anchors like straight bridges, after tests showed that anchors were unlikely to hold in the soft mud of the river bed.

The Hobart Bridge Company obtained Government approval and financed the project, hoping to profit from land appreciation on the eastern shore. The PWD designed the bridge, assisted by David Isaacs from Melbourne. Foundation investigations and detailed designs took two years. The construction contract was let to the Timms Bridge Construction Pty Ltd and work began in April 1938. The contractor had difficulty excavating the foundation for the river-side lift-span tower where sound rock was 10 metres lower than expected, and he eventually withdrew, leaving the Hobart Bridge Company to carry on.

The two-lane floating arch consisted of 24 reinforced concrete pontoons launched individually and joined into two 480 m long half arches. Hinges at each abutment allowed for the rise and fall of the tide, and there were three vertical swivel pins, one at each abutment and one to join the two half arches at mid-river.

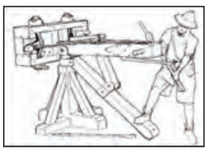
Installing the arch segments bridge across the river was a major logistical operation, using a motley flotilla of local vessels as no tugs were available. The bridge was virtually complete when, on 4th December 1943, a ferocious storm occurred. Parapet panels along the sides were smashed and undulations were observed along the roadway as the bridge rode the waves. At the western end, four of the ten bolts attaching one hinge to the pontoon snapped. (Those bolts were found to be made of wrought iron instead of mild steel.) However the bridge survived and was opened on schedule on 24 December 1943. The bridge was insured as a ship and, after the storm, the insurers paid out $250,000 under the terms of the policy.

After 21 years of service, the two-lane floating bridge was removed when its high level four-lane replacement immediately downstream opened in 1964.

ANCIENT & MEDIEVAL ARTILLERY

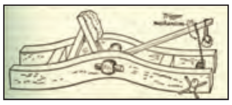
This entertaining paper was presented by Tasmanian Consulting Engineer Jim Gandy, who has made an in-depth study of historical records of ancient and medieval artillery. He has established the performance of three different types of artillery by mathematical analysis, by model testing and by building replicas.

Long before gunpowder, artillery existed in the form of war engines that harnessed the muscle power of their crews. There are stories in the ancient texts of engines that could pin men to walls with spears, smash castle walls with huge stones or hurl plague-ridden corpses over the walls of besieged towns. But not one these engines has survived intact. The historical descriptions or illustrations are usually drawn by men with no engineering training and are often difficult to interpret. The only hard evidence we have is a few fragments of mechanisms and a lot of abandoned ammunition.



The first type of mechanical artillery, the **Ballista**, was invented by the Greeks about 350 BC in the form of a large crossbow on a stand, but with the bow arms powered by torsion skeins, not by bending. The ancient engineers used horse hair, human hair or sinew to power catapults. The weapon was cocked by working a winch set on the back end of the missile track. They could be configured to throw either arrows or balls.

Accounts of engines pinning men to trees or walls with spears hurled from way outside bow range refer to ballistae. To do this a ballista would have to throw an arrow of about 0.5kg at least 150 m on a fairly flat trajectory.



The **Onager** is powered by a tightly-twisted skein strung between the two side frames and holding the firing arm at midspan. The engine is cocked by pulling the arm down. When released, the skein swings the arm up and the sling flicks the missile in an overarm action.

As it was imperative that artillery outrange bowmen, it must be the case that ancient catapults could throw at least 18 kg stones at least 200 m.

The **Trebochet** was most likely invented in China about 1000 AD, but in very short time they were to be found all over Europe as well. Powered by gravity it comprises a frame asymmetrically supporting a long beam, with a heavy counterweight on the short end and a sling for the missile on the other. It is cocked by the crew raising the counterweight using an arrangement of pulleys and winches. When triggered, the counterweight drops, the arms swings over and the sling flicks the missile overarm like an onager.

To be capable of breaching a medieval castle with stone walls some metres thick, while sited outside bow range, a trebuchet would have had to be able to throw missiles of about 50 kg at least 200 m uphill - the equivalent of about 300 m on the flat.

Analysis of performance: Assuming that all the stored energy was transferred to the missile, the author arrived at the upper bound of performance of these machines, i.e. the maximum ranges for various missile masses if the machines were 100% efficient.

Models: The author designed and built a number of models to find out the key parameters which affected the performance, and how these parameters changed if the whole machine was scaled up to a larger size. In the presentation, videos of tests on these and other models were highly entertaining, with a toilet bowl, a TV and a grand piano hurled considerable distances, disintegrating spectacularly on impact.

PROTECTING AUSTRALIA'S OLDEST BRIDGE Managing motor vehicles on a horse and cart design

The paper Vibration Monitoring as a Management Tool for Masonry Bridges by Tasmanian Consulting Engineer, Peter Spratt presents a new and innovative technique for the protection of the six span sandstone masonry arch bridge at Richmond in Tasmania.

The 1823 bridge was designed and constructed for horse and cart transport.

189 years later it is still in use on a major road and carries a range of motor vehicles and loads never envisaged by the people who designed and built it.

The bridge is cracked both longitudinally and laterally and has a history of foundation movements of its piers.

The bridge has both an arbitrary load and speed limit, and management techniques include the periodic monitoring of crack movements, of which there is no recent evidence.

The traditional conservation approach is to repair an item after it is damaged.

The vibration technique described in the paper carries heritage conservation to a new level enabling action before damage occurs.

The author was involved in the preparation of a Conservation Management Plan for the bridge and made the recommendation to the bridge authority to trial vibration testing as a possible technique for obtaining an automatic advance warning of structural problems. The authority accepted the recommendation.

The paper describes the bridge construction background and the vibration monitoring test used to determine whether the technique was applicable to a masonry structure of doubtful continuity.

The results demonstrated beyond doubt the usefulness of the proposal.

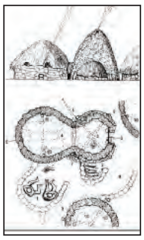
Tests were done using different vehicles at varying speeds and showed the most sensitive arch in the bridge, the vehicle giving most vibration, the effect of speed and the effect of a pavement failure. It also verified that the arbitrary limits on load and speed are appropriate. The most sensitive arch identified by the vibration agreed with previous structural analysis.

Vibration levels were set by reference to ground vibrations from blasting with the German standard DIN 4150 chosen as being the most appropriate. The test involved the temporary installation of both vertical and horizontal vibration sensors with sensors located at the midspan of each arch on both sides of the bridge. The results were consistent over the test range of vehicles with multiple testing of particular vehicles. They showed that the vertical vibrations are the most important and that sensors need only be mounted on one side of the bridge. None of the measured vibrations at the loads and speed limit currently set exceeded the adopted vibration damage limits.

The usefulness of the technique is the ability to pick up vibrations which can damage the bridge before damage occurs. The monitoring gives advance warning of a problem enabling action.

Information subsequent to the Paper is that a permanent monitoring system with an alarm vibration trigger level with linked camera and automatic recording has been installed. The sensors are located at arch midspans below surface level on the upstream gravel footpath and the only visible parts of the installation are a steel pole set clear of the bridge containing the small control cabinet with its landline data transmission equipment, and a camera linked to the preset alarm activated by sensor reading.

THE ENGINEERING OF BUDJ BIM and the evolution of a societal structure in Aboriginal Australia



This paper by Bill Jordan explains why the aquaculture works constructed by the Gunditjmara clans more than 6000 years ago are recognised as significant engineering works.

The works are located in south-west Victoria north-east of Portland, where the lava flows from Budj Bim (Mt Eccles) changed the topography between Mt Eccles and Bass Strait. The new watercourses and wetlands were soon populated with a number of fish species and, in particular, became a migratory and breeding ground for Short-finned Eels, Anguilla australis. The changes made conditions suitable for the harvesting of eels and the establishment of permanent settlement, in stark contrast to the normal nomadic hunter-gatherer existence of Aboriginal occupation.

Aboriginal fish–trapping sites are known in many parts of Australia, particularly in NSW inland rivers and coastal Queensland. These sites are generally within existing river or tidal flows and little needed to be done except to create structures, using available stones and boulders, in which to set fish traps. The major difference in the Budj Bim landscape was that channels were excavated and races were constructed above the natural surface, to direct the flow to the fish trapping structures, and dams were built as holding ponds to keep the eels fresh and ready to be harvested.

In the Lake Condah area, five different systems were built to operate at widely different lake levels.

The secondary fishery was off Darlot Creek, near Tyrendarra, where a single system of channels with weirs and traps was constructed "off–creek", partly with diverted water. The eel traps were woven funnel–shaped baskets which were either placed singly in a stone weir or, in wider channels, multiple baskets were placed in a woven timber "fence".

The Gunditjmara clans used the conveniently sized basalt blocks to build permanent dwellings in which they lived year round. A sketch of a pre-contact 'village' made about 1840 (Wettenhall, 2010) shows details of what was described as a group of 20 – 30 bee-hive domed shaped houses. Recent archaeological and architectural studies have reconstructed interconnecting stone–based houses. Groups of between two and sixteen houses were common along the Tyrendarra lava flow and early European accounts of Gunditjmara describe how they were ruled by hereditary chiefs (Wettenhall, 2010).

Not only did the settlement enjoy a permanent food supply for the three Gunditjmara clans, the eels and other fish were smoked for storage and trading in the language group meetings of up to 1000 people, held to organise marriages, settle disputes, dance at corroborees and play sport (Wettenhall, 2010).

The transition from a hunter-gatherer to a settled lifestyle changed the societal and governance structures of the communities concerned. The different form of society of the people of Budj Bim was not appreciated by most European settlers and governments, but continuing "discovery" and recognition is now taking place, so allowing modern Australians to appreciate better this aspect of their country's history.

Two of the Budj Bim sites are on the Australian Heritage List, and the works were recognised as an Engineering Heritage National Landmark by the Institution of Engineers Australia in October 2011.

SUBMARINES in Australia

Owen Peake presented a paper on the history of submarines in Australia and the conservation of submarine-related engineering heritage in Australia to the 16th Engineering Heritage Australia Conference in Hobart in November 2011.

The history of submarines in Australia has been characterised by indecision about the use of submarines by the Royal Australian Navy; lack of a submarine capability during the critical years of World War II and the emergence of a well refined submarine service from the 1960s onward.

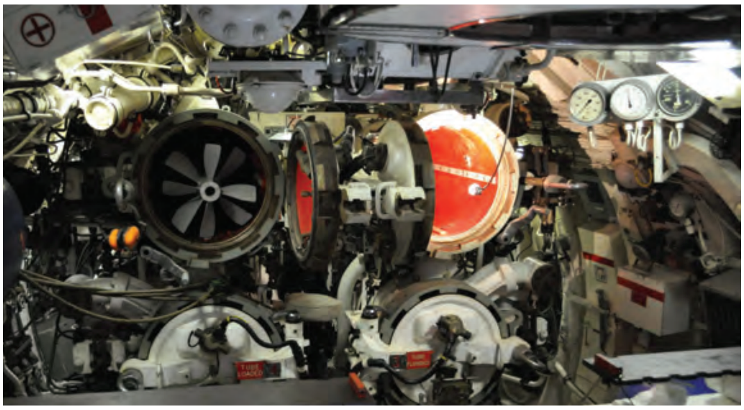
The start was promising with the acquisition of two competent British boats (AE1 and AE2) just prior to World War I. AE1 was lost with all hands in New Guinea waters at the very beginning of World War I in mysterious circumstances and the wreck has never been found.

AE2 was then placed under Royal Navy control and was in the Mediterranean prior to the Gallipoli Landings. She was the first Allied submarine to successfully navigate through the treacherous and well-defended confines of the Dardanelles and reached the Sea of Marmara just as the landings were commenced at Gallipoli on 25 April 2015. She caused panic amongst the Turkish naval forces and local fishermen, seriously disrupting sea transport of supplies to the troops defending the Gallipoli Peninsula. After several days of disrupting Turkish shipping she was damaged by gunfire from a Turkish patrol boat and was scuttled by her crew, all of whom were taken prisoner by the gunboat and spent the remainder of the war as Turkish Prisoners of War. The wreck was found in 1998 and is recognised as a significant site by both Turkey and Australia.

Australia entered World War II without a submarine service although large scale operations by submarines of several Allied nations occurred from Australian ports during this period. Fremantle was the principal submarine port in the region with American, British and Dutch submarines operating out of the port against the Japanese. Brisbane was also used as a submarine base, primarily by the US Navy. Submarine operations from these ports destroyed large tonnages of Japanese shipping, seriously depleting the Japanese war effort.

The acquisition of the competent British-designed and built Oberon Class submarines during the 1960s placed the Royal Australian Navy in a strong position and these boats were significantly refined during their service lives. The Oberons were replaced by the ambitious, controversial and successful Collins Class boats, built in Australia, which remain in service today.

Conservation of submarines in Australia has had some notable successes. All, or parts, of Australia's six Oberon Class boats are conserved, including HMAS Onslow at the National Maritime Museum, Sydney and HMAS Ovens at the Western Australian Maritime Museum, Fremantle. Visitors to both museums can experience guided tours of the internal spaces of the boats. The Western Australian Maritime Museum also has an exhibit showcasing the story of the submarine operations from the Port of Fremantle during World War II. These are world class museum exhibits. Conservation of the Collins Class boats, after they retire, represents a future challenge for the engineering heritage and submariner communities.



The business end - forward torpedo room of HMAS Onslow

Steam Tug *Wattle* - a restoration story

Anthony Mansfield presented a paper titled "To Repair or Restore the steam tug Wattle".

The steam tug Wattle was built at the Cockatoo Island Dockyard in Sydney as an apprentice project during the Great Depression and was launched in 1933. On completion she was acquired by the Royal Australian Navy and served the navy around Sydney Harbour until she retired in 1969. Wattle was then used for tourist cruises around the harbour by the Wattle Syndicate until 1976 when she was laid up and was later acquired by the Victorian Steamship Association who had her towed to Melbourne in 1979. After a refit Wattle was returned to tourist cruise duty around Port Philip Bay in 1984. In 2003 Wattle was refused survey due to the condition of her hull.

Wattle is a small tug, 24.76 m long with a beam of 5.33 m and a gross tonnage of 99.8 tons. She is powered by a compound steam engine of 287 indicated horsepower giving the ship a speed of 10.8 knots at 132 revolutions per minute. The ship was built, and remains, oil-fired. She was the first oil-fired steam tug in Australia. She was also built at the cusp of another major change in ship building with parts of her original structure being welded and parts riveted.

Finding funding and physical resources for the restoration of Wattle was difficult and took considerable time. Fortunately, in 2007 arrangements were made with the steam rail enthusiast group Sorrento Steam to fund and manage the project. A site was acquired as a temporary shipyard, on the Yarra River bank under the Bolte Bridge, and the Wattle was lifted out of the water and set on keel blocks in October 2009 so that work on restoration could commence. This work has proceeded since then and it is expected to reach the point where the ship can be refloated in 2013.

Along the way detailed inspection has revealed further "emergent work" which needs to be attended to. Also the group has had a difficult debate centred on carrying out the repairs using either traditional materials and methods (as used at the time of original construction) or using modern materials and repair methods. Modern materials and repair methods have the advantage of speeding up the work and have now been adopted in areas of the ship where this work is not highly visible. This method has the further advantage of speeding up progress for the satisfaction of the volunteer workforce who are retired and aging and are concerned to see the Wattle back in the water while they are still around to see it.

When the work is completed it is hoped that Wattle will be fit for another eighty years of work.

Steam tug Wattle at Garden Island, Sydney in 1939 while in navy service.
Source: NSW Public Records Office.

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