



concrete

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Makatote Viaduct - Underpinning Pier 7

Standing 78.6m above the Makatote River, between Ohakune and National Park, the Makatote Viaduct was completed in 1908 by J. and A. Anderson & Co for £53,369.

Over the ensuing decades, land instability and erosion to Pier 7 of the viaduct made it vulnerable to foundation failure and resulted in it being designated as the structure at greatest risk on New Zealand's railway network.

ONTRACK, Fulton Hogan Ltd and specialist engineering consultants worked collaboratively to complete the \$4.2 million restoration project between May 2006 and February 2007. The project presented a number of demands, including the environmental challenges of working within a national park and the possibility that the construction activity could destabilise the viaduct itself.

During the scope and conceptual phase of the project it was proposed to underpin the two front footings with two 2m diameter bored concrete piles constructed to a depth of 38m. A post-tensioned cast-in-situ concrete beam 38m long, 1.5m wide and 3m deep would span the piles. The horizontal loads would then be transferred through three steel struts from the concrete cross beam to six ground anchors, which would be installed in pairs of two and connected with a pre-cast concrete tie beam.

A major focus of the project was the minimisation of environmental impacts, so all work was planned and executed in close co-ordination with the Department of Conservation (DoC), Horizon Regional Council and Fish and Game New Zealand. The Makatote River's scenic characteristics and unique habitat for the blue duck (whio) and spawning trout had to be carefully monitored.

Access to the construction site required the widening of an existing track. At the bottom of the gorge a bridge across the river and an access track to Pier 7 then had to be constructed.

During initial ground investigations, which included boring two 40m deep holes at each pile location and three 12m deep boreholes at each ground anchor set, an aquifer was struck. The investigation bores had to be plugged using grout to ensure that no artesian water would penetrate into the pile during the excavation.

The presence of artesian water in the pile bore led to the downstream pile design being reviewed. A telescopic pile, which tapered to a 1.8m diameter over the lower 10m, was selected. This allowed the 2m diameter pile section to be constructed to a safe depth above the aquifer without pressured water penetrating the pile bore.

To minimise drilling vibrations near the downstream foundation, an oscillator drill rig was used to excavate the pile.



Makatote Viaduct - Pier 7 concrete crossbeam and steel struts.

Pile excavation was arduous with an average production of 400 to 500mm per day.

While the piling operation continued on the downstream pile, a temporary staging platform was constructed over the Makatote River to access the upstream pile. Driving piles into the river required a down-the-hole hammer rig to break up the larger boulders in order to ease the driving of the temporary piles.

Without the presence of high water pressures near founding level, the upstream pile was constructed as per the original 2m diameter pile design

Continual monitoring of the ground conditions during piling operations detected no movement of the existing footings during construction.

Work on the 38m long post tensioned crossbeam, which transfers the load from the tower legs to the piles, commenced once the downstream pile and pier were completed. By strategically shaping the 3m deep x 1.5m wide rectangular crossbeam, a reduction of concrete volume of about 40% was achieved. This reduction had a major effect on the seismic loading and ground anchor requirement and also reduced pile vertical loading.

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Cement & Concrete Association of New Zealand

Upfront...



Patrick McGuire,
CEO.

It's hard to believe the end of the year is upon us and what a busy year it has been! One of the highlights of the year for us was our sustainability initiative Concrete³, which was launched at the end of September by the then Minister for Building and Construction Hon Clayton Cosgrove. The initiative aims to raise awareness of the sustainable qualities of concrete and endorse

concrete's contribution to New Zealand's sustainable development across all areas of economic, social and environmental endeavour. If you haven't yet visited the dedicated Concrete³ website I urge you to do so. Go to www.sustainableconcrete.org.nz where you'll be able to find out about the many ways in which concrete contributes to a more sustainable and future-focused New Zealand.

In late September we also welcomed Glenda Harvey as the new chair of our Board of Directors, replacing Andrew Moss who stepped down after two years in the role. Glenda represents the Portland Cement Association and is human resources manager for Holcim (New Zealand) Ltd.

We are also very pleased to have appointed an architect to our permanent staff. In late October David Baird, a registered architect and member of the New Zealand Institute of Architects, joined us as a project manager. David has spent the past 10 years working in the multi-disciplinary environment of Babbage Consultants Limited in Auckland.

This appointment is unique in the long history of CCANZ, and it reflects our desire to better cater to the requirements of the architectural profession.

In the last issue of *Concrete* magazine I promised to keep you updated with what we were doing about the Ministry of Agriculture and Forestry's timber design options policy. Now that the Cabinet reshuffle has taken place and the new Minister for Building and Construction, Hon Shane Jones, has settled into his portfolio, we have made representations to him seeking withdrawal of the policy because of its implications for the cement and concrete sector and more broadly the building and construction industry. We hope to meet with him in the New Year to discuss this further.

Many of you may have read the story published recently in the NZ Herald about the terrible death of a motorcyclist after he lost control of his vehicle and collided with the wire-rope barriers adjacent to the road on Auckland's Southern Motorway. This accident again highlights the need for an urgent reassessment of the type of safety barriers being installed throughout New Zealand's roading network. We continue to advocate the use of concrete road barriers to the Government and relevant agencies. We urge you all to take care on our roads over the holiday period.

I'd like to take this opportunity to thank all at CCANZ for their hard work during the past year and we look forward to a prosperous and sustainable 2008. I'd like to wish you and your families a very Happy Christmas, and a safe and relaxing summer holiday.

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It was decided to use a combined support system transferring part of the load on to the existing viaduct footings and the remainder on to the surrounding ground.

Doka Framax[®] formwork system was used for the straight runs of the beam walls with conventional timber formwork around the tower leg bracings and the tapered section.

The nearest certified batching plant was located one hour from the site, and only had a maximum output of 25m³ per hour. The concrete crossbeam was therefore constructed in three sections of 60m³ to reduce the quantity of concrete needed per pour and the time required to carry out each pour.

The crossbeam was post-tensioned with 8 BBR CONA[®] Type M3 Anchors with 19 x 12.7mm strands to a point slightly above load balanced conditions. The anchor holes for the six 12m long 40mm solid Macalloy[®] bar ground anchors were drilled with temporary casing using a down-the-hole hammer drill, with all six anchors installed within a tolerance of less than 50mm. The double corrosion protected ground anchors were grouted and tested after curing to 75% UTS and locked off at 500kN. The tie back struts consisting of 400mm diameter steel tubes were then lifted in to place to connect the main cross beam to the ground anchors.

After a 10 month-construction period involving more than 26,000 man-hours, the project was completed in February 2007 within programme and budget. The safety performance was exemplary and the environmental compliance exceeded the consent conditions.



Pier 7 strategically shaped crossbeam, reduced concrete volume and load requirements.

The Cement & Concrete Association of New Zealand would like to acknowledge the assistance of Fulton Hogan Ltd., ONTRACK & Novare Design Ltd. in the preparation and publication of this article.

People News...

CCANZ Appoints New Board Chair

Glenda Harvey, manager – human resources, at Holcim (New Zealand) Limited was appointed chair of the CCANZ Board of Directors at the recent AGM. Former chair Andrew Moss, the general manager of Golden Bay Cement, will remain on the board as a representative of the Portland Cement Association.



Standards New Zealand appoints new Chief Executive

Debbie Chin has taken up the role of chief executive at Standards New Zealand.

“After an extensive search involving a number of high calibre candidates, we’re delighted to announce Debbie’s appointment,” said John Albertson, the acting chair of the Standards Council.



“Debbie’s background and experience in both public and private sector organisations, combined with her financial knowledge and in-depth understanding of Government processes make her the ideal person to lead the Standards New Zealand team.”

“Debbie was previously the deputy director general corporate and information at the Ministry of Health, and was one of the first female partners at KPMG Wellington. During her time at KPMG, Debbie was seconded as an advisor to the Department of Prime Minister and Cabinet.”

Debbie took up her role on October 15, 2007.

CCANZ Appoints New Project Manager

The Cement and Concrete Association of New Zealand has appointed David Baird, a registered architect and member of the New Zealand Institute of Architects, as a project manager.



Chief Executive Patrick McGuire welcomed David’s professional voice to the CCANZ team.

“This appointment is unique in the organisation’s long history, and it reflects CCANZ’s desire to cater for the technical requirements of the architectural profession in the area of concrete,” says Mr McGuire. “We believe that the support David can offer, in particular to architects, will encourage a broader adoption of concrete as the construction material of choice.”

David has spent the past 10 years working in the multi-disciplinary environment of Babbage Consultants Limited in Auckland, most recently at associate level.

He has coordinated and managed many commercial construction projects, including the Royal Oak and Mangere Pak’n’Save supermarkets, and the New World complex in Mt Maunganui.

He has extensive experience in the innovative use of concrete in practical and aesthetic applications, ranging from in-situ floor slabs and precast panels to concrete masonry and shotcrete.

David took up his role at CCANZ on October 29, 2007.

Sustainability initiative launched

CCANZ launch sustainability initiative - Concrete³ Hon Clayton Cosgrove, former Minister for Building and Construction, recently launched Concrete³, an initiative to raise awareness of the sustainable qualities of concrete.

Spearheaded by CCANZ, the initiative promotes concrete’s contribution to New Zealand’s sustainable development across all areas of economic, social and environmental endeavour.

“As New Zealand looks towards more sustainable solutions for the built environment, concrete’s credentials guarantee its contribution will continue to be significant,” says CCANZ chief executive Patrick McGuire.

“In short, concrete should be the building material of choice for current as well as future generations.” Concrete³ aims to assist architects, engineers, policy makers, contractors and clients, as well as others involved with the design, construction and operation of buildings and infrastructure to make more informed choices.

Ian Athfield, president of the New Zealand Institute of Architects and advocate of concrete in building design,



Patrick McGuire (CCANZ) with Hon Clayton Cosgrove, former Minister for Building and Construction at the Concrete³ launch.

was guest speaker at the launch of Concrete³, held at Te Papa in Wellington.

A copy of the Concrete³ booklet is enclosed with this issue of *Concrete* magazine.

Industry News...

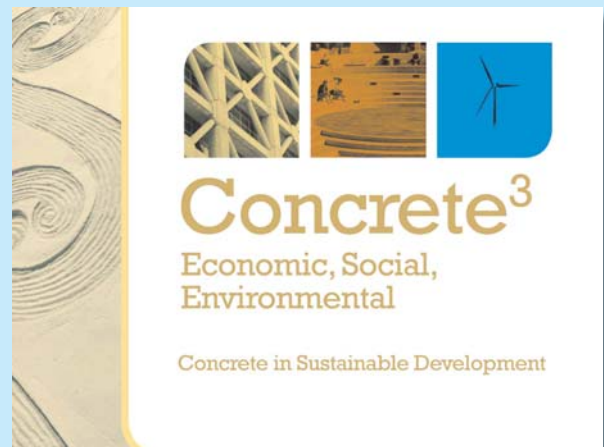
CCANZ Wins 2007 Best Conference Paper Award

CCANZ project manager Rob Gaimster was presented with the New Zealand Concrete Society's Sandy Cormack Award at the 2007 New Zealand Concrete Industry Annual Conference which was held recently at the Bayview Wairakei Resort in Taupo.

Rob was judged to have prepared and presented the most original and innovative paper on the development of the knowledge and use of concrete at the conference.

Chris Munn of Allied Concrete, who is a former CCANZ project manager, was also presented with the award.

A copy of the paper The Role of Concrete in Sustainable Development is available from the Concrete³ website - www.sustainableconcrete.org.nz



Melbourne Cement Facility – State-of-the-Art Silo

A new state-of-the-art cement silo in Port Melbourne, Victoria, is the most recent example of the innovative post-tensioning and construction engineering work done by members of the BBR Network.

The recently completed cement storage silo has a capacity of 35,000t and is the latest addition to Melbourne's largest cement plant. The facility supplies 80 per cent of the cement required by five of the major ready mixed concrete companies in Melbourne.

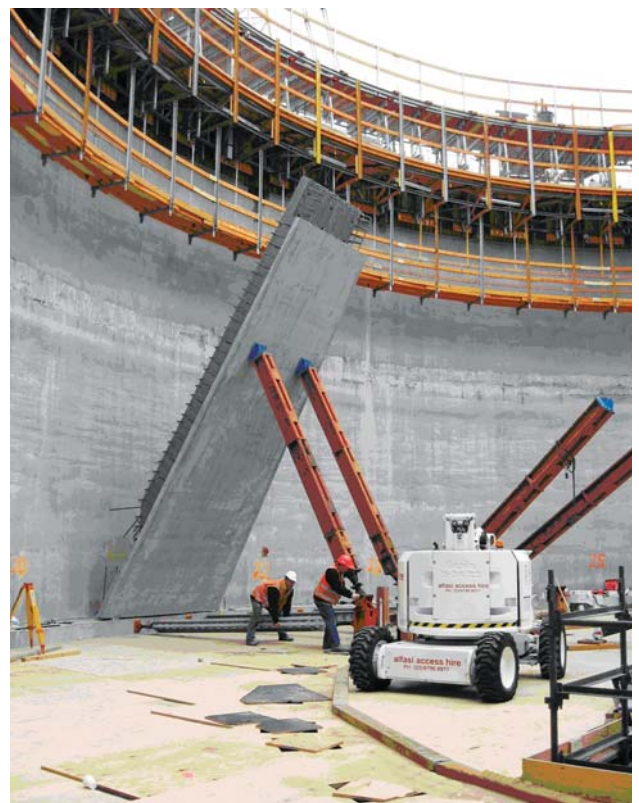
This new cement silo will be able to load three tanker trucks within its perimeter at one time. This innovation means that a separate loading plant is not required – so tanker trucks can turn around much more efficiently and quickly.

Construction of the ring cap required the use of a fast, reliable formwork system as work began on April 1, 2006 and had to be completed by December 22, 2006. BBR Network member Structural Systems Limited successfully bid for the project, based on using its own in-house slipform system. Coupled with the BBR CONA post-tensioning system, this presented the client with a packaged solution for a difficult project with a tight construction programme.

Structural Systems Limited work on the project included:

- Slipform – supply and operation
- Post-tensioning – supply and installation
- Reinforcement – installation

The on-site set-up of the slipform system took four and a half weeks to complete prior to the first pour. Pouring



Melbourne cement silo - precast concrete cone panels positioned.

the concrete fixing of the reinforcement and installing the post-tensioning ducts and castings was done in continuous 24-hour pouring cycles, which reduced the need for unsightly construction joints in the external wall.

POURING CONCRETE

The silo was broken into three pouring sections that combined a total of 2860m³ of concrete.

The first was a six-day process where the walls on the inside face were stepped from 900mm thick to 450mm thick. Pouring concrete to change the wall thickness formed a shelf on the inside of the silo where the precast concrete panels, which are used to form the cone, can sit. The internal cone structure is the basis of the internal loading feature.

The second pouring sequence was at the start of the post-tensioning. The silo has 72 1906 hoop tendons, at 1m centres, which are broken into four segments and stressed through four buttresses. Heavy-duty 3mm thick galvanized metal-ribbed duct with an ID of 105mm was used to minimise the risk of damage to the empty duct during the continuous concrete pouring cycle. It also reduced any problems with strands jamming in the subsequent post-tensioning strand-pushing activity.

The required stopping height of this second pour was determined by the weight and the crane capacity for the erection of the precast concrete cone panels. Each panel weighed 26t with a total of 24t in the bottom section and 12t in the top section of the cone, separated with a concrete, in-situ ring beam.

When the desired height was reached, a PVC waterstop was installed in the top of the wall to alleviate any moisture penetrating through the wall from the construction joint.

The third concrete pour began some nine weeks after the second pour was completed to allow for cone works within the silo structure.

NEW HIGH SPEED PUSHERS

After the third pour was completed, newly developed, computerised, high-speed strand pushers were used to install the 72 1906 tendons, enabling post-tensioning installers to work efficiently and safely from mast climbers mounted on all four buttresses. The 102m long strand tendons were installed in less than 12 days.

STRESSING & GROUTING

When the strand installation was completed, the tendons were stressed in a predetermined sequence to a load of 4,225kN using a 630t jack in less than 10 days. All components of the BBR CONA post-tensioning system proved reliable, user-friendly and readily available within the project's tight schedule. The final stage of the post-tensioning was grouting the hoop tendons, which followed the stressing and cutting of the tendons, once each one had been completed.

SLIPFORMING

The slipform pouring cycles were managed in two daily, 12-hour shifts. Slipform is a continuously moving formwork system climbing at a rate of approximately 200mm an hour and requiring 30 workers, including concrete placers, on each shift. Structural Systems Limited, with its experienced and motivated workforce, completed the project on time and within budget.

The Cement & Concrete Association of New Zealand would like to acknowledge the assistance of Structural Systems Ltd of Australia (who carried out the silo work) and Construction Techniques Ltd (BBR Network's New Zealand representative) in the preparation and publication of this article.



Project facts & figures

Capacity -	35,000t
Height -	57m
Diameter -	30m
Wall thickness -	900mm reducing to 450mm
Reinforcement -	535t
Post-tensioning -	130t
Concrete -	2860m ³

Melbourne cement silo - capacity three tanker trucks simultaneously.

New Zealand Concrete Society Awards 2007

The NZ Concrete Society named Transit New Zealand's Wellington Inner City Bypass as the supreme winner in the biennial New Zealand Concrete Society Awards, announced at the society's gala conference dinner on September 28.

The bypass won both the overall Concrete Award and the Infrastructure Award in the awards, which every two years celebrate the best in concrete design and construction in New Zealand.



Concrete Award and the Infrastructure Award winner Wellington Inner City Bypass.

The judges commended the high quality and attractively detailed exposed concrete walls of the bypass's 450m trench section, which reflect the density of the surrounding urban fabric and the underlying reasons for the bypass.

"People don't want motorways to exist, but like to use them – especially this Inner City Bypass," said Andrew Charleson, convenor of the judges. "Here, travellers experience both the strength of construction and the physical constraints of the project location."

The bypass incorporates a wide variety of concrete construction methods and concrete elements, which the jury says have successfully overcome the design challenges of high seismic loads, significant ground water issues, poor ground conditions and a cramped construction zone.

"The consultant Opus International and contractor Fulton Hogan have delivered an infrastructure project of the highest quality in terms of design and execution."

The awards were judged by Andrew Charleson (convenor), Paul Wymer and Sheldon Bruce (on behalf of NZ Concrete Society), Ian Garrett (on behalf of IPENZ), Rob Gaimster (on behalf of CCANZ), and Ian Athfield (on behalf of the NZ Institute of Architects).

For more information, contact Allan Bluett 09 5365410, or concrete@bluepacificevents.com

Other winners in the New Zealand Concrete Society Awards 2007 were:

Monte Craven Architectural Building Award

Woollaston Estates Winery, built by Kidson Construction Ltd, received the Monte Craven Architectural Building Award.

Architect Laurence Ferar of Arthouse Architecture Ltd and consulting engineer W.R. Andrew Ltd created an example of vintage concrete architecture, which exemplifies a total commitment to concrete. It not only used numerous types of concrete including self-compacting and fibre concrete, but attractive concrete elements such as vaulted ceilings and curved roof beams dominate interior spaces. From the outside, concrete buttresses express the inherent strength of this partially embedded building. The aesthetic and fabric storage qualities of its interior elements set this building apart.



Monte Craven Architectural Building Award winner Woollaston Estates Winery.

Residential Award

Dunning Thornton Consultants won the Residential Award for McCallum House.

Designed by Architecture Workshop, and contracted to Christensen and Allan Ltd, this is architecture of concrete and glass. Concrete is well suited to achieve the vaulted roof forms, the provision of thermal mass and the client's desire for longevity on an exposed site. The interior is characterised by vaulted ceilings and openness of space. The care and attention of the structural engineer and high quality workmanship combine to make this a very special home.



Residential Award winner McCallum House

Technology Award

The upgrade of Transpower Ltd Upper South Island Grid, which was contracted to Construction Techniques Group Ltd, received the Technology Award.

This challenging project involved the strengthening of transmission line pylon foundations in difficult and environmentally challenging locations. The wide variation in soil conditions necessitated specially developed grouting techniques. In doing so, the award-winners have extended the range of soils for which these procedures are effective. The advanced grouting techniques, as well as the adaptation of those already existing, that have made this project so successful will no doubt be applied to other projects in the future.



Technology Award winner of Transpower Ltd Upper South Island Grid upgrade.

Landscape Award

Christchurch City Council's Peace Bell Pavilion designed by City Solutions architects and engineers won the Landscape Award.

Lightweight concrete has been formed into a subtly detailed penetrated slab. Its slender supporting structure impacts lightly on the landscape and avoids disturbing the surrounding area.

This elegant piece of landscape architecture, which was contracted to McNab & Sons Ltd, not only required concrete to be used innovatively but provides a most appropriate setting for celebrating a symbol of peace.



Landscape Award winner Christchurch City Council's Peace Bell Pavilion.

New Zealand's Largest Post-Tensioned Floor and Pavement Presents Challenges

Even though post-tensioned slabs on grade have been used successfully in New Zealand for many years, the sheer scale of the floor and pavement at Fonterra Co-Operative Group Ltd's Te Rapa milk powder storehouse presented a series of significant challenges.

The Fonterra milk powder storehouse incorporates the largest post-tensioned concrete slab constructed in New Zealand, with a combined area of 50,000m². The choice of a post-tensioned concrete slab on grade solution had several key advantages including large, joint-free bays, enhanced durability and high load capacity. The post-tensioned slabs on grade for the project included:

- a 35,000m² internal post-tensioned floor for the dry goods storehouse
- a 15,000m² external pavement container stand
- a steel fibre reinforced tunnel slab used for unloading material directly from trains
- a heavily reinforced slab supporting the rail track

Internal Storehouse

More than 6000m³ of concrete were used to construct the 75m by 460m internal post-tensioned floor of the storehouse. The 165mm thick floor is designed to cater for axle loads of up to 24.6t and was constructed in 12 pours. The post-tensioning tendons in each pour were crossed over with the adjacent stage across the building, resulting in joint-free bays of up to 6000m².

External Container Stand

The external pavement is 30m by 460m, 270mm thick and designed to carry 84t axle loads and 40 containers stacked two high. It was constructed in six pours, and incorporated 506 post-tensioning tendons. Extra safety precautions had to be taken as the pavements was constructed only 2m away from a railway track.

Unloading Tunnel & Rail Track Support Slab

The rail unloading tunnel sits next to the internal storehouse so material can be directly unloaded under cover from trains. The tunnel incorporates a 4m wide slab to support the railway, a 12.5m wide area for unloading and runs the full, 460m length of the storehouse.

The 4m wide slab that supports the railway tracks was heavily reinforced with continuous deformed bars. The depth of the slab varied from 250 to 350mm, with the thickest part of the section directly beneath the tracks. The remaining 12.5m of the unloading tunnel were constructed as a "joint-free" steel fibre reinforced floor. This was 175mm thick, and incorporated 35 MPa concrete with 40 kg/m² of steel fibre.



Fonterra storehouse - post-tensioned floor finished using eight rideon paver trowels.

The design of the slab was unusual as the bays had an aspect ratio of 3:1. A high dose of steel fibre reinforcement countered the risk of mid-panel cracking.

Project Challenges

A significant challenge of producing large, joint-free slabs is reducing the restraint on the slab, which in turn, reduces the risk of cracking. As the slab shrinks, friction forces are generated between it and the sub base, which needs to be flat and even to reduce those forces.

A typical concrete pour for the project required around 550m³ of concrete to be delivered throughout the day. Both Allied Concrete and Holcim, who stockpiled material at the plant, supplied and continuously delivered concrete during the pour.

It is not practical to discharge concrete directly from trucks when constructing a post-tensioned slab, as they would have to cross a large number of PT ducts, which could be damaged. So concrete is pumped for the construction of PT slabs using a "discharge" and "feeder" pump configuration.

The management of each pour required expertise, as well as clear and consistent communication with the concrete dispatch team. The flow of concrete to the site had to be constantly adjusted to account for changes in placing speed or delays caused by pump movements or minor breakdowns. The dosage of retarder was adjusted throughout the pour, and an onsite technician monitored the slump.

Finishing such large pours can be a challenge, as concrete in adjacent areas can set at different rates. Approximately eight ride-on power trowels were used for finishing of the slabs. Internally, the finish was specified as a burnished U3 finish. Externally the pavement required a finish that would provide grip in the wet.

Thermal cracking was a significant threat because the thick, high-strength concrete slab was being poured through the middle of winter. So two layers of polythene were placed over the slab to provide insulation. Slab and air temperature measurements revealed that the depth of the slab generated enough heat to ensure that its temperature did not move a degree despite frost.

The Cement & Concrete Association of New Zealand would like to acknowledge the assistance of Conslab Ltd., Allied Concrete Ltd. & BBR Contech Ltd. in the preparation and publication of this article.



Fonterra storehouse - New Zealand's largest post-tensioned floor.

Tower foundation strengthening - Upper South Island grid upgrade

The tower foundation strengthening of Transpower's upper South Island grid by Construction Techniques Group Ltd was unanimously voted winner of the Utilities, Networks & Amenities Award, and the Supreme Award at the 2007 New Zealand Engineering Excellence Awards.

Judges thought the upgrade was an outstanding example of engineering, which excelled in all of their criteria. They were particularly impressed by the calibre of the technical and logistical management of such an extended site.

The project involved upgrading transmission tower foundations over a 450km route in the upper South Island. Much of the line followed a remote and bleak path from Hanmer to St Arnaud, passing through Island Saddle which, at 1,370 metres (or 4,500 feet), is the highest road crossing in the country.

Severe weather conditions over the last few years highlighted the need for a secure national electricity transmission system, which is vital to New Zealand's economy.

Traditionally, providing greater uplift resistance to tower foundations has involved the use of mass concrete. However, for this project, the team used four more focused techniques: grout enhancement of existing piles, self-drilling ground anchors, passive soil anchors and post-tensioned ground anchors. Some of these techniques were not previously thought suitable for the site's soil conditions, but close co-operation and interaction between the contractor and technical experts ensured a successful outcome. The chosen solutions also caused minimal disturbance to the existing foundations and the environment.



Paul Wymer (Construction Techniques Group Ltd) and Simon Leitch (Transpower) are presented with the NZEE Supreme Award by Minister of Commerce Lianne Dalziel

The project team successfully met the challenges of getting workers, materials and equipment to remote sites efficiently, within a tight deadline and in an unforgiving environment. The knowledge and experience gained during this project will undoubtedly be used in the future to help preserve the integrity of power transmission systems in New Zealand and overseas.

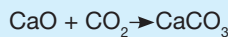
Please note the project also won an award at the New Zealand Concrete Society Awards – refer to pages 6-7

Technical Talk...

Does Concrete Carbonate Or Recarbonate?

An important issue often overlooked in the sustainability debate is the re-absorption of CO₂ from the atmosphere by concrete and other cementitious materials during their service life, and secondary life following recycling. Concrete technology ascribes the term 'carbonation' to this process. However, the term recarbonation is more accurate.

The carbonation of concrete is the reaction between atmospheric carbon dioxide gas (CO₂), a weak acid, and calcium oxide (CaO), an alkaline product of hardened concrete, to form calcium carbonate (CaCO₃):



From the cement manufacturer's perspective, the process can be correctly identified as recarbonation because the final product, calcium carbonate, is chemically the same as one of cement's primary raw ingredients.

The manufacture of one tonne of cement typically generates approximately 0.85 tonnes of direct CO₂ emissions. Some 40% of this is from the fuel used, and around 60% is from the thermal decomposition of calcium carbonate (CaCO₃), a process known as calcination. Emissions of CO₂ associated with calcium carbonate decomposition are not only distinct in terms of the process that generates them; they are also partly reversible through the recarbonation process¹.

The mix design of structural concrete limits any recarbonation to the surface layer, helping to prevent corrosion of embedded steel reinforcement. There is, however, a greater degree of recarbonation at the end of concrete's structural life when it is typically crushed for reuse as an aggregate. This results from the significant increase in surface area, allowing CO₂ to be more readily absorbed, even when used in ground works.

In low strength concrete such as blocks, and cementitious materials such as mortar, recarbonation is much more rapid during the service life, as CO₂ can permeate the material more easily. This does not affect durability because there is no steel reinforcement.

A study by the British Cement Association shows about a 20 per cent take back of CO₂ over the life cycle of cement². In whole life terms it can be argued that this significantly reduces the impact of one tonne of cement to approximately 0.65 tonnes of CO₂. This reduction is an average based on the various applications and markets for cement and concrete in the UK, and is an important factor when considering the environmental impact of cementitious materials.



Recycled aggregate stockpile.

Furthermore, the Norwegian Building Research Institute BYGGFORSK has examined recarbonation in some detail³. As part of their research, the recarbonation of a number of concretes was examined under laboratory conditions. They found that 60 to 80% of the CO₂ associated with calcination has the potential to be chemically reabsorbed by concrete mixtures with w/c of 0.6 or higher for the grain size of 1 to 8 mm within 20 to 35 days of exposure.

While the recarbonation process cannot be said to diminish CO₂ emissions resulting from cement manufacture (the main contributor to the embodied CO₂ in concrete), when viewed in terms of whole life performance it will ultimately reduce its environmental impact. Recarbonation is clearly an important concept, which CCANZ will be promoting as part of its Concrete³ initiative.

References

1. Clear, C, & De Saulles, T.; BCA Recarbonation Scoping Study; Confidential report by British Cement Association, 2007
2. Ibid
3. Danish Technological Institute www.danishtechnology.dk/building/14460, 2 [accessed 2007]

Kingsford Quay Wharf Concrete Deck Strengthening at Port Nelson

Overloading of the Kingsford Quay Wharf at Port Nelson and the corrosion of its slab pre-stressing wires, had resulted in its load capacity being seriously compromised. After the wharf was examined, it was determined that a thin heavily reinforced concrete overlay should be applied to the decking for the shear transfer between slabs to be restored cost effectively. This would double the axle load capacity and restore the wharf's life expectancy.

Constructed in 1969, Kingsford Quay Wharf is a timber piled structure supporting a concrete deck. The wharf had been constructed mainly to handle fruit pallets but in recent years had been used for handling export logs and sawn timber.

Maintenance inspections revealed severe damage to deck slabs involving failure of the keys between slabs, spalling of concrete, exposure and corrosion of pre-stressing wires and evidence of chloride-accelerated corrosion of reinforcing. The deterioration was due to of overloading by log loaders.

It was decided to investigate repair and upgrading options for Kingsford Quay that would allow high axle load log stackers to be used for the remainder of the wharf's 50-year life expectancy.

Preliminary design work had shown that deck slabs could be upgraded by using a thin, heavily reinforced topping which would provide negative moment capacity over the pile capping beams and greater effective depth to bottom reinforcing in the existing deck slabs. Existing piles, capping beams and rear retaining wall slabs were found to be sound and unlikely to need repair or upgrading in the short term. So work was limited to repairing the wharf deck and upgrading it to allow full use of the existing piles and capping beams.

The first step in the restoration process was to remove all asphalt concrete, to leave a rough and clean deck surface. Where required, damaged shear keys were excavated, the keyway was cleared of grout and water blasted to provide a good, exposed aggregate bond surface. As a post tensioning cable passed through the keys, a 300mm section of key was left in place around the stressing wire so the post tensioning would not be disturbed.

A chloride reducing agent was applied to the deck surface before any steel or concrete, including the shear keys, was put in place.

The underside of the pre-cast deck units was then repaired by removing loose concrete and cleaning the concrete surface, scraping off any rust on exposed steel, treating the steel with approved rust inhibitor, applying a chloride reducing / bonding agent to the exposed and surrounding area of concrete, and reinstating the cover with an approved repair system or product.

Following cleaning and the application of a curing compound, the shear keys were re-poured using a customised 50MPa concrete mix design, with 12mm maximum aggregate, steel fibre reinforcing, and a shrinkage reducing agent, to produce a slump of 120mm.



Kingsford Quay Wharf - desired surfaced texture for effective bonding.

The reinforcing steel was then put in place for the topping slab which involved using transverse HD12 bars at 300mm centres, and 12.5mm pre-stressing wires at 200mm centres. A brushed on grout mix bonding agent was applied immediately before the 65mm concrete topping pour, which used a customised 50MPa concrete mix design, with 12mm maximum aggregate, 2mm polypropylene fibre reinforcing, and a shrinkage reducing agent, to produce a slump of 120mm. After power floating was completed, a curing and sealing compound was applied.

Port Nelson infrastructure manager Dick Carter said the overlay of Kingsford Quay proved to be a cost-effective way to increase the wharf load capacity and extend the useful life of the asset.

Installing new topping and restoring existing deck slabs extended the wharf's service life by 20 to 30 years and doubled its axle loading capacity. Existing timber piles will need to be monitored as some may require jacketing similar to those at the nearby McGlashen Quay. It will also be necessary to monitor the topping for delamination, to carry out normal maintenance checks and to plan for possible future treatment with chloride reducing agents.

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DIARY DATES 2007:**January 24**

PCNZ Executive meeting – TBA

February 21

CCANZ Board meeting – Wellington

Concrete Road Leads to Allied Concrete Ltd's New Plant

Work is almost complete on a 70m stretch of concrete pavement leading to Allied Concrete Ltd's new Palmerston North batching plant at Setters Line.

On an average day the batching plant services numerous heavily loaded vehicles, including aggregate truck-and-trailers and cement tankers, all with challenging axle configurations that have to traverse a tight curve.

The Palmerston North City Council and Allied Concrete Ltd agreed that the existing narrow 5m-wide chip seal road would fail quickly due to the high volumes of heavy vehicle traffic and the tight curvature of the plant entry.

Both parties were eager to explore concrete pavement options that would achieve a long-term, low maintenance pavement solution. The result was a cost-sharing agreement to construct the pavement, with the City Council covering the cost of road surface preparation, and Allied Concrete Ltd supplying and placing all concrete.

The 30MPa, 250mm thick, 8m-wide concrete pavement, with saw cuts and transverse dowel joints at 8m centres longitudinally, will be heavily reinforced with steel fibres.

The pavement is being completed in several pours, the most recent of which was a four-hour 50m (linear) / 400m² pour, requiring 94m³ of concrete. The use of high, early strength cement in warm temperatures means the pavement will be available for traffic after only three days.

The superior strength and robustness of concrete pavements, especially in heavily trafficked commercial areas, is becoming increasingly attractive to local authorities that want to minimise the whole-of-life costs of their roading infrastructures.



Concrete Pavement pour - Setters Line, Palmerston North.

Call for feedback

Stabilisation Conference

CCANZ would like to hear from anyone interested in presenting a paper at the Recycling & Stabilisation - Better Roads for a Sustainable Environment conference being held in Auckland from June 22 to 24 in 2008.

The New Zealand Institute of Highway Technology (NZIHT) conference will expand on design and construction techniques that can be used in road pavement stabilisation and recycling in New Zealand and overseas.

To discuss ideas for a paper or to seek advice, contact CCANZ project manager Alan Kirby on 04 915-0387 or alan@cca.org.nz.

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