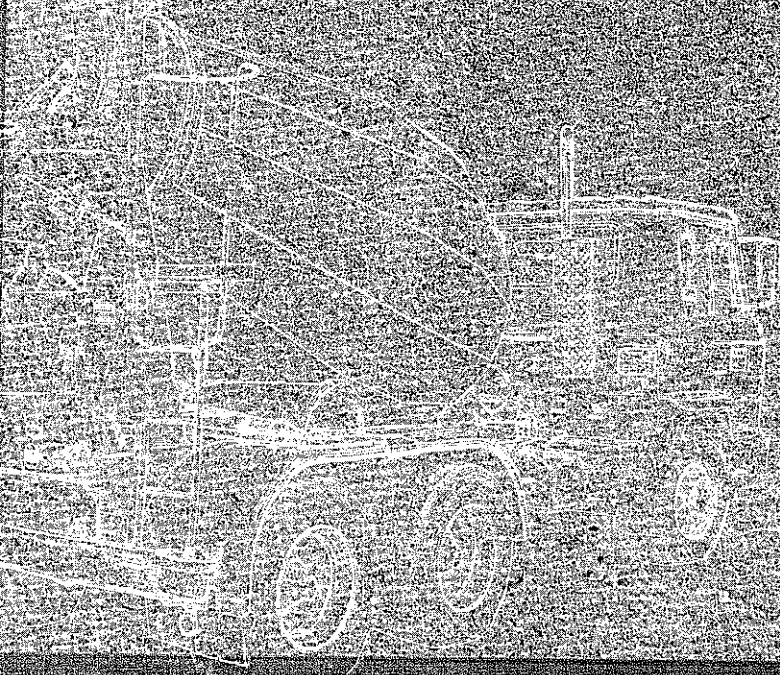


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Commerce of Concrete

Source to Market



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Combined Concrete
Industry Conference

Wellington Festival & Convention Centre 8 - 10 October 1998

Technical Papers

Combined Concrete Industry Conference 1998

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COMBINED 1998 CONCRETE INDUSTRY CONFERENCE WELLINGTON FESTIVAL & CONVENTION CENTRE

8 - 10 OCTOBER 1998

Conference Programme

THURSDAY 8 OCTOBER

11.00am - 12 noon	New Zealand Concrete Masonry Association Annual General Meeting
12.00noon-1.00pm	Registration
1.00pm – 1.15pm	Welcome and Conference Opening
1.15pm – 3.00pm	Plenary Session 1: Current Developments in Precast Concrete from Europe Chairperson: Wayne Raymond <i>Keynote Speaker: Arnold van Acker - Director Research and Development Addteck International, Belgium</i> Questions
3.00pm – 3.30pm	Tea/Coffee
3.30pm – 5.00pm	Concurrent Session 2: The Wellington WestpacTrust Stadium Chairperson: Bob Park 1. Stadia – Sporting Cathedrals of Our Time <i>Alastair Richardson – Manager - Bligh Lobb Sports Architecture</i> 2. WestpacTrust Wellington Stadium – Procurement of a Stadium <i>Alan Gray – Contracts Manager - Fletcher Construction Ltd</i> 3. Lightweight Concrete An Economical Choice for the WestpacTrust Wellington Stadium <i>Len McSaveney – Market Development Manager - Firth Industries Ltd</i>
3.30pm – 5.00pm	Concurrent Session 3: Capturing Customers and Keeping Them Chairperson: Bary Williams 1. Thermal Research and the Marketing of Concrete <i>Larry Ballemey – Principal Research Engineer - Lincoln University</i> 2. Building with Concrete <i>Nigel Marshall – Director – Marshall Homes</i> 3. Cement Your Ideas in Concrete - Direct Marketing Programme <i>Grant Thomas – Marketing Manager - Cement & Concrete Association</i> 4. What Can You Do? <i>Alan Hard – Executive Director - Marketing Impact Ltd</i>
5.00pm – 6.00pm	New Zealand Concrete Society Annual General Meeting
6.00pm – 7.00pm	Cocktails
7.00pm	Café Trail

FRIDAY 9 OCTOBER

8.30am – 10.00am **Plenary Session 4: Concrete Floors – What Really Happens, An Industry Debate**
Chairperson: Andrew Dallas
Facilitator: Wayne Raymond

The Panel:
Engineer: Des Bull – Director Technical Services
– Holmes Consulting Group Christchurch

Contractor: Kelvin Hale – Managing Director
– Ebert Construction, Wellington

Concrete Placer: Craig Muir – Managing Director
– Muir Concrete Ltd, Hibiscus Coast

Concrete Supplier: Jim Shaw – National Technical Manager
– Ready Mixed Concrete Limited, Hamilton

10.00am–10.30am Tea/Coffee

10.30am-12 noon **Concurrent Session 5: New Opportunities In Masonry**
Chairperson: Grant Honeycombe

1. The Future of Non Specific Design for Masonry
Andy Wilton – Residential Design Engineer - Firth Industries Ltd
2. Issues Associated with the Use of Prestressed Masonry
Kevin Brownlie – Postgraduate - University of Auckland
3. Seismic Load Sharing in Structures with Reinforced Masonry and Timber Framed Walls
Graham Beattie – Senior Engineer - BRANZ

10.30am-12 noon **Concurrent Session 6: Advances in Concrete Floor Techniques**
Chairperson: Craig Muir

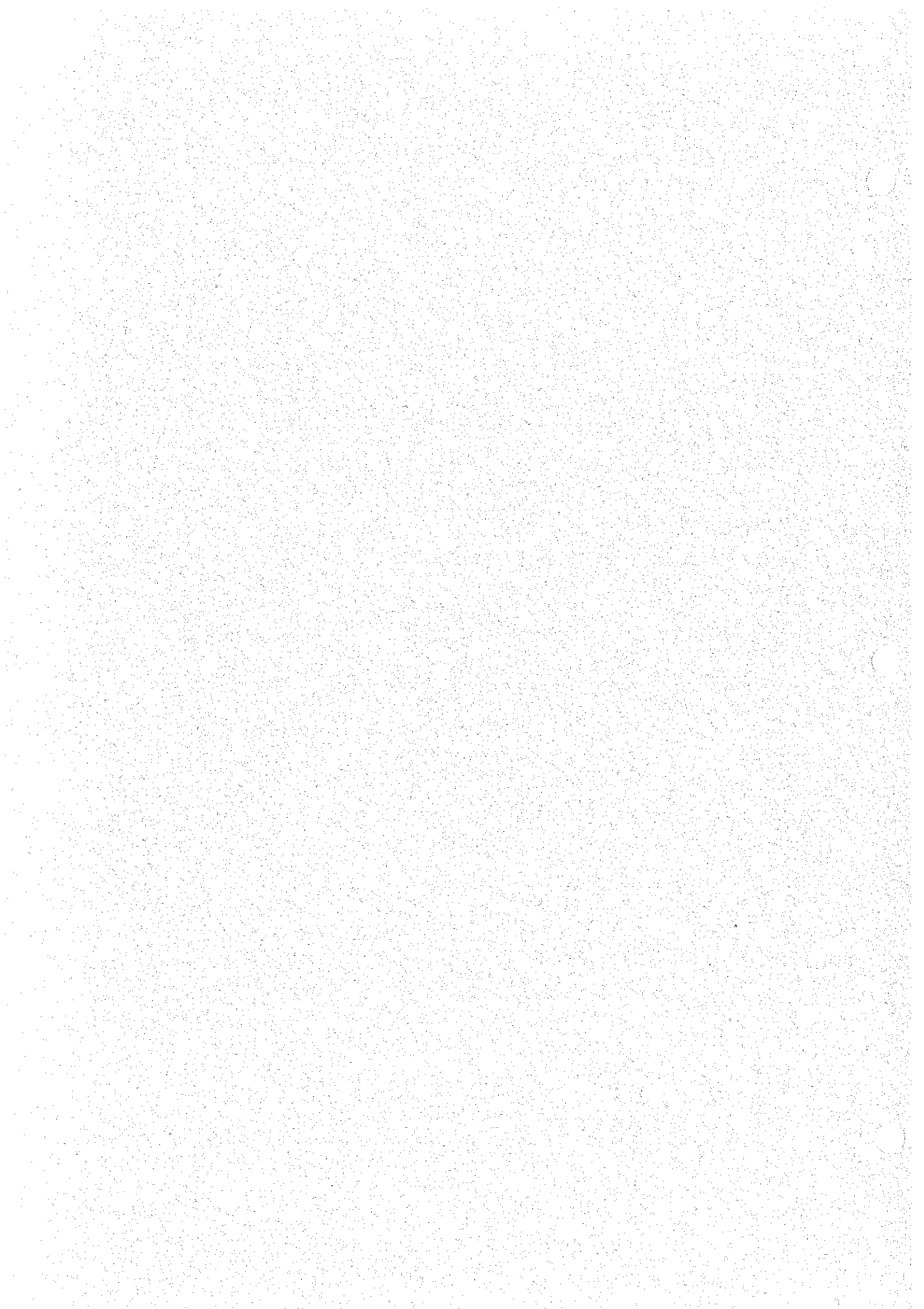
1. High Quality Flat Floors in New Zealand
Graeme Bergham – Managing Director - Bercom Construction
2. Introducing New Technology for Concrete Placing and Finishing
Brian Mooney – Managing Director - Laser Screed NZ Ltd
3. Panel Discussion Open to Questions From the Floor
“Avoiding Problems Associated with Concrete Paving”

12 noon – 1.00pm New Zealand Ready Mixed Concrete Assn Annual General Meeting

1.00pm – 2.00pm Lunch

2.00pm Site Visits/Activites

7.00pm Conference Dinner



SATURDAY 10 OCTOBER

9.00am – 10.30am

Concurrent Session 7: Concrete Opportunities Offshore – Some Practical Considerations

Chairperson: Graham Rowe

1. Concrete in India
Rob Frost – General Manager – Firth Industries Limited
2. International Consulting – Not for the Faint Hearted
David Bunting – General Manager/International – Opus International Consultants
3. Concrete Opportunities Offshore – Exporters Co-operating to Compete
Tim Harris – Manager, Engineering, Building and Construction – New Zealand Trade Development Board

9.00am – 10.30am

Concurrent Session 8: The Case for No Log Books

Chairperson: Paul Commons

1. Land Transport Bill
Ian James – National Co-ordinator Commercial Vehicle Investigations, Traffic Safety Division
2. Fatigue Management
Ann-Marie Feyer – NZ Environmental and Occupational Health Research Centre
3. Fatigue Management and Log Books
Chris Foley – Senior Technical Adviser - The Land Transport Authority

10.30am–11.00am

Tea/Coffee

11.00am–12.30pm

Plenary Session 9: Environmental Winners and Losers – Where Will We Be?

Chairperson: Richard Henderson

1. Win Win Options for Industry and the Environment
Barry Weaver – Forest and Bird Protection Society
2. Economic Implications of Environmental Legislation
Gareth Morgan – Infometrics
3. Land Transport Pricing Study
Tony Freidlander – Road Transport Forum

12.30pm – 1.30pm

Lunch

1.30pm – 3.00pm

Concurrent Session 10: Innovations

Chairperson: Alex Gray

1. Innovations in Glass Reinforced Concrete
Stuart George – Managing Director - Buller George Engineers Ltd
Andrew de Jong – Contracts Manager - GRC New Zealand
2. Rosebank Patiki Interchange Bridges
Alan Powell – Associate / Nigel Snoep – Senior Engineer
Beca Carter Hollings & Ferner Ltd
3. Changing the Cement Recipe – Why and How?
Brett Beatson – Technical Operations Manager – W Stevenson & Sons Ltd
Warren South – Technical Team Leader - Golden Bay Cement

SATURDAY 10 OCTOBER

1.30pm – 3.00pm

Concurrent Session 11: Are We Special or Ordinary

Chairperson: Peter Rae

1. Ready Mixed Concrete Production Quality Control Systems
David Brathwaite – Chairman - NZRMCA Classification Committee
2. Classification Committee – An Alternative View
Neil Turnbull – Consulting Engineer
3. Engineering Acceptance of the Classification Scheme
Rudolph Kotze – Regional Engineer – Cement & Concrete Association

3.00pm – 3.30pm

Tea/Coffee

3.30pm – 5.00pm

Concurrent Session 12: Concrete Briefs

Chairperson: Des Bull

1. The Whakapapa – Wanganui Tunnel Lining Repairs
Chris Munn – Manager – Consultech
2. Ductility of Lightweight Aggregate Concrete Columns
Chris Allington – University of Canterbury
3. Reinforced Earth Wing Walls at Manapouri
Don Asby-Palmer – Engineering Manager – Environetics Civil Ltd
4. Concrete Block Paving – An International Perspective
David Barnard – Technical and Training Manager – Cement & Concrete Association

3.30pm – 5.00pm

Concurrent Session 13: Ready Mix Concrete Issues

Chairperson: Andrew Dallas

1. An Investigation into New Zealand Pozzolana and Fillers
Chris Mercer – Product Development Chemist – Golden Bay Cement
2. Environmental Management Systems In the Concrete Industry
Barry Fairburn – Consulting Civil Engineer - Connell Wagner
3. Use of Recycled Concrete
Stuart Park – Cement and Concrete Engineer – BRANZ
4. Designing Mixes to Meet 50 Year Life Expectancies
Larry Gaerty – Director – Concrete Consultancy Services Ltd

5.00pm

Conference Closure

7.30pm

Banquet

Further copies of this volume, price \$45.00 (GST inclusive) are available from:

The Secretary
Conference '98

New Zealand Concrete Society
P O Box 12, Beachlands, Auckland

Phone: (09) 536 5410

Fax: (09) 536 5442

Email: toplev@xtra.co.nz

Session 12

Concrete Briefs

**The Whakapapa – Wanganui
Tunnel Lining Repairs**

Chris Munn – Manager - Consultech

**Ductility of Lightweight Aggregate
Concrete Columns**

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Concrete Block Paving – An International Perspective

*David Barnard – Technical and Training Manager
- Cement & Concrete Association*

The Whakapapa - Wanganui Tunnel Lining Repairs

3 February - 13 March 1998

Chris Munn¹

Synopsis

This paper discusses the invert repair of the Whakapapa - Wanganui tunnel system, which forms part of the Tongariro Power Scheme, located in an isolated part of the central North Island. Consultech was engaged to design an underwater concrete mix which enabled the repairs to proceed without dewatering the invert. The contract presented some challenging tasks to the contractor, Construction Techniques Ltd, who provided an innovative approach to a demanding set of site conditions, strict Resource Management Act requirements, and tight time constraints. Consultech's involvement continued through to the initial production phase to carry out final mix design adjustments.

Introduction

The Whakapapa - Wanganui tunnel system forms an integral part of the Western Diversions of the Tongariro Power Scheme, situated on the volcanic plateau of the Central North Island. The tunnels carry water from the diverted Whakapapa River, and are aligned to collect water from the Okupata, Taurewa, Tawhitikuri and Mangatepopo Streams. The tunnel exits into the Te Whaiau Canal and the water eventually proceeds to Lake Rotoaira, and then on to the 200 MW Tokaanu Power Station.

Description of Tunnels

The tunnels intersect the ground level at the Tawhitikuri Stream, essentially cutting the tunnel into two sections, the upstream length being 11 Km long and the lower section approximately 5.5 Km long. Access was therefore available at three locations. Both tunnels are completely concrete lined, with a minimum invert thickness varying from 250 to 450 mm. The shape of the tunnels is essentially circular, with a diameter of 3 to 3.5 metres. In some sections, the shape was described as a "modified D shape". Gradients within the tunnels ranged from 1:310 to 1:360.

With the water flow completely diverted, the remaining uncontrolled infiltration produced a maximum flow of approximately 0.3 cumecs, at a velocity of approximately 1m/s. Water depths were approximately 200 to 300 mm.

Condition of Invert

Due to high bed loads during flood events, and inappropriate intake design, there was rapid abrasion

of the tunnel inverts over a period of years, until 1991 when the Whakapapa intake was modified to exclude ingress of bed load. After the intake modifications were completed, damage to the invert essentially ceased.

Investigations carried out during a planned shutdown revealed that there was extensive abrasion damage to the invert of the tunnel. The damage was evenly spread over the 16 kilometre length of the tunnel.

The worst areas of damage had been repaired on previous occasions using a variety of techniques, including the fixing of steel wear plates to the dewatered invert and insitu concrete repairs. This work was carried out using a large number of pumps, to control water inflows which reached a total of 300 litres per second.

Approximately 4 km needed plating and grouting due to excessive wear, in some cases the wear extended through the lining. Internal steel sets were put in place in some areas that were at risk of collapse. This work had been carried out during previous shutdowns.

This left an approximate length of 12.5 kilometres that required repairs to the worn invert. In addition to the invert repairs, contact grouting of voids behind the lining also formed part of the contract, as did the installation of well points at several locations in the tunnel.

During a previous shutdown, trial repairs had been carried out using insitu concrete placed in the invert. The water had been diverted over short lengths of the tunnel to enable concrete to be poured. It was decided by the client that the philosophy of invert

¹ Manager, Consultech

repair with concrete was an appropriate repair technique to preserve the structural integrity of the tunnel and to avoid the need for costly repairs utilising grouted steel plates. Consequently, contract documents were drawn up specifying the invert repair methodology. The work was planned for February/March to tie in with ECNZ's requirement to maintain a minimum low flow in the Wanganui River as a part of its Resource Consent. The loss of water for generation purposes and its consequent spilling into the headwaters of the Wanganui River while the tunnel was out of service was therefore not a concern.

Repair Strategy

Because of the large volumes of water still flowing in the tunnel after decommissioning, it was decided to "go with the flow" and live with the water, rather than try and overpump. This decision was made at time of tender, and represented a significant contractual risk. Had it not been possible to place the concrete under existing conditions, then large sums of money would have been necessary to provide over pumping capacity. Time constraints for completing the work would have also been tight if not impossible had overpumping been needed.

Once the contract had been awarded, Consultech was commissioned to develop a concrete mix that conformed with the mix proportions set out in the tender documentation. This basic mix was then modified to permit placement under flowing water. It became apparent that off the shelf proprietary admixtures were not available in New Zealand in the quantities needed for the work.

Consultech then concentrated on formulating its own anti-washout admixtures in preference to proprietary formulations. This proved to be simple on one hand, as there is plenty of information available on these products. However, on the other hand, this work was complicated by the physical effects of one component on the mix properties required two or more other admixtures to offset undesirable side effects, such as large air content increases. This phenomenon was expected, but there was not much information available regarding likely dosage rates for each admixture when used alone, let alone in combination with others. The concrete also had to be able to withstand a bumpy 11 kilometre trip in a skip and be discharged without any form of agitation, after a travel time of up to 30 minutes. The use of retarders was not desirable due to the need for the concrete to commence stiffening as soon as possible after placement in water that was approximately 9 degrees Celsius.

A series of trial mixes were carried out prior to and after Christmas to check mix design assumptions on density, yield, air content and compressive strength. Once the most useable one was selected, trials on

its anti washout properties were carried out in an operating culvert. While the results were promising they were not conclusively indicative of a water resisting concrete mix. Time precluded any further work on this as mobilisation and site establishment was underway.

Concrete Supply

Initial indications were that the concrete volumes needed for the work were in the order of 400 to 700 m³. In addition to this, the programme for the work was based around a 24 hour, seven day per week operation. The nearest ready mix supply was in Turangi but there were concerns over the delivery time to site, particularly with summer temperatures. Also, it was going to be difficult to co-ordinate delivery times to match production.

It was thus decided to mix on site using prebatched aggregates and cement, delivered to site in one tonne bags. Mixing was carried out using a mobile batcher / mixer. On-site dosing of the concrete was necessary, as there were both powders and liquids to be added to the prebatched mix.

Tests carried out on site included air content, slump and samples for density and compressive strength.

Records were kept on each prebatched one tonne mix, detailing admixture addition rates, mixing times, together with physical test results where applicable. Test cylinders taken confirmed concrete strengths of approximately 35 to 40 MPa at 7 days, and 50 MPa at 28 days. These values satisfied the client's strength requirements for this work.

Production

Site mixing commenced on February 3 and was completed on 13 March. A total of 600 m³ of concrete were placed in 37 working days at a daily average of 16.2 m³. Careful planning was needed to match on site deliveries of prebatched dry mix, with deliveries arriving on a two day cycle. Deliveries of new material were coordinated with the removal from site of the empty one tonne bags for reuse, together with large numbers of pallets. As the flat area for storage on site was limited, these operations required careful co-ordination.

Concrete Placement

The contract documents allowed for the placement of battens either side of the abraded section of the invert to provide a defined edge to the repaired area.

Initially, the night shift was allocated this task with the day shift concentrating on concrete placement.

Once production commenced however, the Client authorised a trial with the battens removed. The success of this trial led to the deletion of battens on the remaining repairs and an effective doubling of production and complete the whole tunnel repairs in

one shutdown, rather than the three remaining scheduled closures.

Conditions imposed under the Resource Management Act required the outflow at the outlet of the tunnel to be treated to remove suspended materials. This system, consisting of holding / overflow tanks located within semi permeable bund wall, needed to be modified part way through the contract to satisfy these requirements.

Concrete slump was typically 200 to 250 mm, but the mix was still resistant to washout. This was only possible due to the rheological properties of the concrete, which despite the anti-washout admixture, was able to flow under water to fill the abraded section. This was the case even in water flows high enough to produce standing waves in the invert. The placement philosophy was based upon minimal hand finishing, to reduce any washout of the mix to a minimum. This was only necessary to smooth out small excesses of concrete which sometimes occurred at the commencement of each skip placement.

At a Glance

Some vital statistics for the contract:

Contract sum:		\$1 million
Contract duration:		Seven weeks
Placement: m ³ (daily)	av.	16.2
	max.	38.0
	min.	1.0

Placement: metres (daily)		
	av.	323
	max.	1124
	min.	12

Conclusions

The invert repair of the Whakapapa - Wanganui tunnel system presented Consultech with some challenging tasks with respect to the design of an underwater concrete mix for the contractor, Construction Techniques Ltd. Difficult site conditions required an innovative approach to satisfy a demanding set of Resource Management Act conditions, together with tight time constraints. Adding to the problems, mobilisation was over the Christmas shutdown period. Despite these time restrictions, Consultech carried out a series of trial mixes to develop a mix which enabled Construction Techniques to achieve the required production rates to ensure that the work was completed within time and budget.

We gratefully acknowledge the co-operation of ECNZ in the preparation of this paper and their agreement to have it presented at this conference.