Austroads

Austroads 5th Bridge Conference

Bridges Another Dimension

- design - construction - procurement - maintenance -

PROGRAM

19-21 MAY 2004 - HOBART TASMANIA

Tasmania
Department *of* Infrastructure,
Energy *and* Resources

AUSTROADS

conference sponsors

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All papers in this volume have been peer reviewed by individuals experienced in the subject areas represented by the papers.

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Bridges Another Dimension

Proceedings of the Austroads 2004 Bridge Conference

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contents

contacts

Conference Organisers

The Conference has been organised on behalf of Austroads, the Association of Australian and New Zealand Road Transport and Traffic Authorities, by the Department of Infrastructure, Energy and Resources, Tasmania.

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Graeme Nichols

Conference Chairman

welcome

On behalf of the Organising Committee I extend to you a warm welcome and invite you to participate in the full program and organised social functions of our conference in Hobart.

The theme for the conference is "Bridges: Another Dimension" to highlight the diversity of topics now covered by bridge engineering including design, construction, procurement, maintenance, asset management, architecture, technology, strengthening and upgrading, and historic bridges.

The conference will be of interest to any person with an involvement in bridge engineering including asset managers and technical staff. An optional technical tour is planned which will feature both new and historic bridges. Morning tea will be taken at the Meadowbank Estate Winery in the Coal Valley.

The program also features a number of local tours which may appeal to the partners of delegates.

Austroads and the Department of Infrastructure, Energy and Resources welcomes you to Hobart.

Conference Venue

The Conference and associated exhibition will be held in the Wrest Point Convention Centre, a five star hotel located on the shores of the Derwent River in Sandy Bay which provides spectacular views of the river, city and Mount Wellington. There are pleasant walks and jogging areas nearby, with historic Battery Point and the city centre just 3km away. Wrest Point is a five minute taxi ride from the city, and buses depart outside the hotel every 15 minutes. Refer to locality map in this brochure.

Hobart, Tasmania's capital city, has something to offer everyone - colonial architecture, excellent eating houses, the waterfront area famous for the finish of the Sydney to Hobart yacht race, and of course the well-known Saturday market at Salamanca Place. It is also the gateway to many places of scenic and historic interest.

keynote speakers

Dr Cam Middleton

Senior lecturer in Structural Engineering - University of Cambridge, United Kingdom.

Campbell Middleton is Chairman of the UK Bridge Owners Forum (www.bridgeforum.org), which was established in 2000 by representatives of all the major national, regional and private bridge owning organisations in the UK to promote co-operation amongst bridge engineers, and identify research needs and priorities for the bridge infrastructure. Joint forums with bridge owners and delegates from many of the major UK bridge consultancies, research organisations and Universities have been held to identify the major issues facing the industry, and a framework of bridge research priorities has been established.

He is a Senior Lecturer in Structural Engineering in the Department of Engineering at the University of Cambridge having joined the staff in 1989 after nearly ten years experience in bridge and highway construction and design with the Tasmanian state highways authority and later with Ove Arup and Partners in London. He holds a MSc in Concrete Structures from Imperial College, London and a doctorate from the University of Cambridge. Dr Middleton currently leads a research group at Cambridge whose main interests cover strength and safety assessment of concrete bridges. He is consultant to a number of clients in the UK, Europe, Australia and North America, and is also involved in the development of codes of practice for the assessment and management of concrete bridges.

Mr Jean Philipe Fuzier

Senior Vice President and Scientific Director, Freyssinet.

Jean Philipe Fuzier is Emeritus Scientific Director of the Freyssinet Group. In this position he had until the 31st January 2003 a worldwide technical responsibility for application and use of Freyssinet services and products, such as post-tensioning and cable-stay systems. Today he acts as a Consultant for the Group.

Freyssinet produces specialist equipment and processes for the concrete construction industry, including bridge bearings and expansion joints for bridges. Jean is particularly interested in rehabilitation of concrete structures.

He graduated in Civil Engineering in 1965 from the Ecole Centrale de Paris. In 1967 he joined Gannett Fleming, Corddry and Carpenter (Harrisburg, PA / USA) as Design Engineer. He came back to France as Project Engineer and Technical Director of a Freyssinet subsidiary for 17 years. Then in 1987, as Technical Director and later Scientific Director, he joined the headquarters of the Freyssinet Group.

He has been involved in the design and construction of many prestressed concrete structures (offshore platforms, nuclear containments, stadium buildings, bridges and viaducts). He published several technical papers and is still representing the Freysinnet Group in international organisations and various technical committees (FIB, PTI, ASBI, IABSE).

Mr Peter Lundhus

Director of Sund & Baelt Partner A/S, Denmark.

Peter was Technical Director of Oresundconsortiet, the joint Swedish-Danish Directorate that oversaw the building of the Oresund crossing between Sweden and Denmark.

Peter Lundhus graduated in 1965 from the Technical University of Denmark with a M.Sc. in civil engineering. For 21 years he worked internationally as a heavy civil engineering contractor.

From 1989 he joined the Owner organisation - the Great Belt Link Ltd., Denmark - as Project Director on the 17 km long and Euro 3 billion road and rail project and was selected for the similar sized project of joining Denmark and Sweden in 1992 as the Technical Director for the Øresund Link from the beginning in 1992 until completion in 2000.

From 2001 he heads a team preparing a similar 20 km long Fehmarn Belt Link between Denmark and Germany with an expected government agreement in 2003/2004.

Mr Michael Bushby

General Manager, Infrastructure Maintenance with the Roads and Traffic Authority of NSW.

Michael has responsibility for programs including the management of 20,000 kilometres of NSW roads and 4700 bridges (replacement value of $35 Billion), with an annual expenditure of approximately $650 million.

Michael has previously held positions in Tasmania, including responsibility for the Asset Management of the State Road Network. He has previously been a member of the Austroads Asset Management Reference Group and has participated in numerous projects. Michael has studied and gained his Engineering qualifications in both Australia and Canada.

PROGRAM

WEDNESDAY 19 MAY

8.30am	Registration	
9.00	Conference Opening	**PLENARY HALL**
9.30	Keynote Address - J.P.Fuzier "Preservation of our Infrastructure Heritage"	**PLENARY HALL**
10.10	Morning Tea	**SPONSORED BY TAS SPAN**

	Venue: **Tasman Room A**	Venue: **Tasman Room B**	Venue: **Tasman Room C**
	Session 1A: Design	Session 1B: Assessment	Session 1C: Strengthening & Upgrading
10.30	Computer-aided design and analysis of multiple Tee-beam bridges. **Author:** Pircher and Pircher	Testing and assessment of a three-span steel-concrete highway bridge using dynamic methods. **Author:** Ariyaratne, Al-Dawod, Samali, Saleah & Bakoss	Shelly Beach overbridge modification, Auckland New Zealand. **Author:** Brown
11.05	Footbridge design for synchronous lateral excitation. **Author:** Burnton & Low	Improved load rating assessment of Princes Bridge through load testing. **Author:** Brimfield, Coe & Sie	Carbon fibre strengthening of precast reinforced concrete inverted U bridge beams. **Author:** Chandler
11.40	Integral abutment bridges - Australian and US practice. **Author:** Connal	Reliability based load rating of existing bridges. **Author:** Reid	Western Distributor Viaduct Modifications for the Cross City Tunnel Project, Sydney. **Author:** Sheasby, Cox, Steele & Marwick
12.15pm	Lunch		**SPONSORED BY LUDOWICI**
	Session 2A: Design	Session 2B: Concrete Technology	Session 2C: Bridge Management
1.15	Advanced Bridge Analysis and Design Methods Simplified. **Author:** Gallagher & Skinner	Spatial Variation of Pitting Corrosion and Its Effect on the Strength and Reliability of Prestressed Concrete Bridge Beams. **Author:** Darmawan & Stewart	Rehabilitation and Monitoring of Sawtells Inlet Bridge - 12 years later. **Author:** Andrews-Phaedonos, Shayan & Xu
1.50	Sorell Causeway Channel Bridge, Tasmania. **Author:** Gibbens, Selby Smith & Joynson	Suitable Intervention Strategies for Structures Affected by Alkali-Silica Reaction (ASR). **Author:** Carse	Towards a Uniform Bridge Management System for Aust and New Zealand. **Author:** Rummey & Dowling
2.25	Modular Bridge Joints- Reduction of noise emissions by use of Hermholtz Resonator. **Author:** Ancich & Brown	Probability Based Chloride Diffusion Model to Predict the Condition States of RC Bridges. **Author:** Maheswaran & Sanjayan	Risk Based Bridge Asset Management. **Author:** Coe
3.00pm	Afternoon Tea		
	Session 3A: Design	Session 3B: Historic Bridges	Session 3C: Testing & Construction
3.20	Bridge Deck Behaviour revisited. **Author:** Jenkins	Management of State Heritage Significant Bridges. **Author:** Manamperi	Alternative Hardwood Girders-An Innovation with Composites. **Author:** Heldt, Cattell, Oates, Prasad, Arthur & Van Erp
3.55	Wildlife Friendly Design of Road Structures. **Author:** Hyde & Chirgwin	Covered Bridges of America. **Author:** Maxwell	Port River Expressway - Stage 1 - Bridge Over Eastern Parade. **Author:** Selby Smith, Joynson & McGain
4.30	Crash Barrier On Reinforced Earth Wall - Liverpool Parramatta Transitway. **Author:** MacKinlay & Wyche	Strengthening of Heritage Timber Truss Bridges. Bridge over Abercrombie River Abercrombie, NSW. **Author:** Oates, Taylor & Berger	Some Outcomes from Load Testing of Bridge 631 in Western Australia. **Author:** Chandler
5.00pm	Close		
5.30pm	Government House Reception - Bus Departs 5.00pm		

PROGRAM

THURSDAY 20 MAY

9.00	Keynote Address - P. Lundhus "Bridge Building in Practice- Mentally and Physically"	PLENARY HALL
9.35	Quality: "Quality Infrastructure a Different Approach" Van Der Molen	PLENARY HALL
10.10	Morning Tea	SPONSORED BY PITT & SHERRY

	Venue: Tasman Room A	Venue: Tasman Room B	Venue: Tasman Room C
	Session 4A: Design	Session 4B: Assessment	Session 4C: Strengthening , Upgrading & Quality
10.30	The Otira Viaduct. **Author:** Billings	Assessment of bridge Response using weigh in motion data. **Author:** Grundy & Boully	Ensuring Quality in Construction. **Author:** Fenwick
11.05	Highway Gantry using Aluminium Extrusions. **Author:** Morris	Shear Damage Control in Assessing Flat Slab Bridges. **Author:** Candy, Pressley, Walton & Sanjayan	Dublin Light Rail. **Author:** Noonan
11.40	Safety First for Bridges- by Design. **Author:** Rapattoni	Condition assessment of a reinforced concrete jetty structure, its load capacity and suggested rehabilitation strategy. **Author:** Shayan, Xu & Al-Mahaidi	Bridge over Cooks River at Tempe - Sydney NSW. Emergency Underpinning of Piers. **Author:** Oates, Prasad & Stalder

12.15pm	Lunch	SPONSORED BY THE PRECASTERS PTY LTD

	Session 5A: Bridge Design Code	Session 5B: New & Concrete Technology	Session 5C: Bridge Management
1.15	Fatigue Design in the New Australian Bridge Design Code. **Author:** Grundy & Boully	Design and Construction of Black River Bridge, Tasmania. **Author:** Hughes & Walter	Applying a Systems Method for Setting Structure Performance Targets and Measures for a Longterm Concession. **Author:** McCarten
1.50	Fatigue- It will change our culture. **Author:** Heywood & Roberts	Australia's First Fibre Reinforced Polymer Bridge Deck in a Road Network - The anatomy of innovation. **Author:** Heldt, Oates, Van Erp & Marsh	Bridge Management Progression in New Zealand. **Author:** Reynolds & Owen
2.25	Design Loads for Box Culverts for the SM1600 Design Loading of the Australian Bridge Design Code AS 5100. **Author:** Nechvoglod & Forster	The Worlds First RPC Road Bridge, Shepherds Gully Creek Bridge, NSW. **Author:** Cavill & Chirgwin	Reliability Analysis to Verify the currently used partial safety factors in Bridge Design: A Case Study using Baandee Lakes Bridge No.1049. **Author:** Sanjayan & Candy

3.00pm	Afternoon Tea

	Venue: Tasman Room A	Venue: Tasman Room B	Venue: Tasman Room C	Venue: Plenary Hall
	Session 6A: Design	Session 6B: Research & Testing	Session 6C: Strengthening & Upgrading	Session 6D: Local Government Workshop
3.20	Green Bridge in Brisbane: Planning. **Author:** Rassalski, Leeson & Rotolone	Measured Live Loads on an Instrumented Sinusoidal Profile Helical Culvert. **Author:** Pritchard, Day, Dux & Yuln	Selection of option for replacement of major bridge expansion joints. **Author:** Forster	The inspection, assessment and maintenance of state-owned timber bridges in Queensland. **Speaker:** Shane Crawford
3.55	Terragong Swamp Bridge, North Kiama Bypass- Innovative Design. **Author:** Sloane, Sribelan & Sheasby	Destructive Load Testing of Bridge No. 1049 - Analyses, Predictions and Tests. **Author:** Pressley, Candy, Walton & Sanjayan	Feasibility study of life extension of a 100 year old timber truss rail bridge over the Grey River, New Zealand. **Author:** Kotze & Rushbrook	Timber Bridge Preservation and Maintenance Practice **Speaker:** Lloyd Margetts
4.30	Compressive Membrane Action in Bridge Deck Slabs. **Author:** Taplin & Hon	On Site Hardness Testing of Reinforcement. **Author:** Sonnerberg & Boully	Strengthening of Bridge over Iron Cove, Sydney NSW- A Realistic Design Load. **Author:** Ariyaratne, Shah and Fok	Beaudesert Shire's experience with bridge asset management. **Speaker:** Stewart Wall

5.00pm	Close

CONFERENCE DINNER AND BRIDGE AWARDS — **SPONSORED BY VEC TESTING & DESIGN**

6.30	Board Ferry for 6.45pm departure
7.00	Pre Dinner Drinks
7.30	Dinner and Awards

PROGRAM

FRIDAY 21 MAY

8.45am	Keynote Address: Dr C Middleton "Bridge Management and Assessment"	**PLENARY HALL**
9.30	Keynote Address: M.Bushby "Asset Management for RTA Bridges in NSW"	**PLENARY HALL**
10.10	Morning Tea	

	Venue: **Tasman Room A**	Venue: **Tasman Room B**	Venue: **Tasman Room C**
	Session 7A: Design	Session 7B: Assessment	Session 7C: Strengthening & Upgrading
10.30	Redbournberry Bridge- Dual Composite Design. **Author:** Turner, Steele, Powell & Jones	A simple method for rating of reinforced concrete slab bridges. **Author:** Ariyaratne, Shah & Kodakalla	Rehabilitation of Willaston Bridge: Utilisation of Rivet Heads as Shear Connectors. **Author:** Paul, Oehlers & Seracino
11.05	Three Dimensional ACES models for Bridges. **Author:** Wenham & Wyche	Condition assessment of an 8-year old Freeway bridge, its load capacity and rehabilitation assessment. **Author:** Sanjayan & Andrews-Phaedonos	A Future with Advanced Composites in Bridge Engineering. **Author:** Shanmuganathan
11.40	Unique Cable Stayed Bridge Deck for Shopping Centre. **Author:** Wrightson & Sheasby	Overview of Assessing the load carrying capacity of timber bridges using dynamic methods. **Author:** Crews, Samali, Bakoss & Champion	Flexural Retrofitting of Concrete Bridge Beams using CFRP Fabrics. **Author:** Pham and Al-Mahaidi
12.15pm	Lunch		
	Session 8A: Bridge Design Code	Session 8B: Bridge Architecture	Session 8C: Design
1.15	Bridge Barriers- Implementing the Provisions of the Australian Bridge Design Code. **Author:** Colosimo	More than just a Pedestrian Link - The Goodwill Bridge, Brisbane. **Author:** Ainsworth & Burvton	Modular Deck Joints - Investigations into Structural Behaviour and some Implications for New Joints. **Author:** Ancich, Brown and Chirgwin
1.50	Design, Specification, Manufacture and Testing of Laminated Elastomeric and Pot Bearings to AS-5100.4. **Author:** Davidson, Sarmiento, Williams & Robinson	Design of Aesthetically Pleasing Bridges for the Dubai Marina. **Author:** Kalra & Vigneswaran	Design of Grade Separation of Gipsland Railway at Narre Warren Canbourne Road. **Author:** Srivelan, de Araugo and Hirons
2.25	Australian Standard AS-5100 Section 4- Bearings and Expansion Joints. Trends in rehabilitation of deck joints and design developments of modular joints **Author:** Velo	Design and Construction of the New Upper Harbour Crossing. **Author:** Dickson, Billings and Evans	Bridging on the Alice Springs to Darwin Railway. **Author:** Ross, Ashdown & Dawson

3.00pm	Afternoon Tea	
3.20	Plenary Session	**PLENARY HALL**
4.00pm	Close	

RICHMOND BRIDGE

technical tour

9.00am to 1.00pm
Saturday 22 May, 2004

This is an optional technical site visit of Bridgewater Bridge, Richmond Bridge and McGees Bridge.

9.00am	Depart Wrest Point
9.30am	Inspect Bridgewater Bridge
10.00am	Depart
10.30am	Inspect Richmond Bridge
10.45am	Depart
11.00am	Morning Tea at Meadowbank Estate Winery
11.45am	Depart
Noon	Inspect McGees Bridge
12.30pm	Depart
1.00pm	End tour at Wrest Point or can be dropped off at the famous Salamanca Market

Tickets can be purchased at the registration desk for $30.00 per person.

BRIDGEWATER BRIDGE

Between 1830 and 1840 a causeway was constructed across the Derwent River at Bridgewater. The causeway is founded on ti-tree mats over deep silts and constructed from stone quarried on the southern bank of the river. A ferry ran from the causeway to the Bridgewater shore.

In 1849 a bridge was constructed with a rolling moveable span to allow passage of shipping.

In 1876 a rail bridge was constructed downstream of the road bridge to allow the rail passage to Hobart. On 22 July 1886 a lock on the swing span failed and an engine fell into the gap killing the fireman.

In 1892 the first bridge became unserviceable so the road and rail shared the 1876 bridge whilst a new bridge was built upstream of the original structure.

The third bridge, designed for either road or rail, was completed in 1893 and used for road traffic until 1908 at which time the rail used the new structure with road traffic moving to the downstream bridge. Whilst the 1876 bridge was being repiled and converted from rail to two lanes of road traffic both shared the 1892 bridge much to the disquiet of the travelling public.

In 1939 a new structure incorporating welded through trusses and a lift span was commenced on the alignment of the original bridge. Wartime shortages extended the construction period so that the structure, providing for both road and rail traffic, opened to road and rail traffic in 1942 but did not open to river traffic until August 1946.

Proposals for a new crossing at this site are under consideration. The Tasmanian Heritage Council is insisting that the current structure be retained for local traffic use.

RICHMOND BRIDGE

The six span masonry arch bridge over the Coal River at Richmond is the oldest existing bridge in Australia. Construction commenced using convict labour in December 1823 and was completed in September 1824 with an official opening on 1 January 1825.

Floods damaged the bridge in 1828. That damage resulted in the wavy stringline evident on the structure. The structure continues to carry traffic although a load limit has been imposed to reduce the risk of damage to the structure.

McGEE'S BRIDGE

In 1956 the first prestressed concrete bridge constructed for the Tasmanian PWD was constructed by an emerging construction company, John Holland Contractors. A bridge of 34 spans of 13 metres length it spanned the Pittwater estuary which is now partly a Ramsar reserve.

Ten years, or so, ago cracks were observed in some beams along the level of the prestressing cables. Tests on the concrete indicated advanced chloride induced deterioration with rusting of the prestressed tendons. Monitoring revealed a rapid growth in the population of cracks and an alarming rate of growth in the crack width - up to 15 mm.

Rod McGee was Bridge Engineer who had an international reputation in concrete technology. The uncertainty of the timing of stressing strand failure and the consequences of severing this critical highway link prompted a submission to senior management stressing the urgency for a bridge replacement.

Rod worked with the concrete industry to develop a durable concrete mix and had the Departments specifications changed to include the use of stainless steel reinforcing in critical elements of the bridge.

The new structure was designed by Maunsell and Partners and constructed by John Holland Constructions and completed in January 2003. 18 spans of 25.5m length of a through trough form with a cantilevered footpath make up the new structure. Most of the components of the bridge were prefabricated off site and assembled on a construction girder span by span.

In February 2002 Rod McGee (at age 47) succumbed to cancer, having the day before visited the bridge under construction. The Government agreed to the naming of the bridge in his honour.

Welcome Function

6.00pm to 8.00pm Tuesday, 18 May
Welcome Reception, Wrest Point Convention Centre

To welcome delegates to the Conference and open the exhibition, an informal reception will be held on the Tuesday evening, in conjunction with conference registration. The cost is included in the full conference registration.

Additional tickets for guests are available at $30.00 per person.

Sponsored by Granor

Conference Dinner and Presentation of Bridge Awards

7.30pm Thursday, 20 May
Grand Ballroom, Grand Chancellor Hotel

Enjoy a fun-filled night with fine Tasmanian fare and excellent entertainment. The presentation of the Awards will be made at the conference dinner, along with a few other surprises. We will be starting the evening on board the river ferry which will transport you from Wrest Point Pier to Sullivans Cove.

6.30pm Board ferry at Wrest Point Boardwalk Pier

6.45pm Ferry Departs

7.00pm Pre-dinner drinks at the venue

7.30pm Dinner and Awards

Extra tickets may be purchased for $100.00 per person.

We promise you a night of Tasmanian hospitality at its best. Dress is lounge suit.

Sponsored by VEC Testing & Design

Bridge Awards

To raise the profile and standard of excellence of road and railway bridge design, construction and maintenance in Australia and New Zealand, Austroads will present three bridge awards at the Conference dinner.

Technical Tour

9.00am - 1.00pm Saturday, 22 May

Following the conference the Technical tour will visit three bridges of interest.

- Richmond Bridge
- Bridgewater Bridge
- McGee's Bridge
- A local winery will be the location for morning tea

Tickets are available at $30.00 per person for both delegates and accompanying persons.

Government House Cocktail Reception

5:30pm - 6:30pm Wednesday, 19 May

Delegates have been kindly invited by the Governor to attend a cocktail reception at Government House. Your invitation will be included in your delegate satchel, please bring it with you on the day as it is required for entry into Government House.

The reception will commence at Government house at 5:30pm and buses will be leaving immediately after the last session of the day at around 5:00pm. Please leave satchels with the registration desk until the following morning.

The reception will finish at 6:30pm with buses returning guests to Wrest Point or other hotels along the way from 6:30pm onwards. Neat casual dress required.

To book any of the above events please see the Registration Desk in the foyer of the convention centre.

social program

accompanying persons program

Cadbury Cruise **"The Sweetest Cruise in Australia"**

TOUR 744 (Half Day) $45.00 (adults) $22.50 (children)

Relax and enjoy the natural beauty of Hobart's harbour and Derwent River to Cadbury's chocolate factory. Be guided on a fascinating tour, taste test delicious samples - a chocoholic's dream. An opportunity to purchase chocolate is available on completing the tour before cruising back to Hobart.

Departs 10.00 and returns to the dock at 2.30pm.

No hotel drop off - enclosed footwear must be worn.
(No sandals or thongs please). Tour available Monday to Friday inc.

Port Arthur Historic **- includes harbour cruise**

TOUR 774 (Full Day) $75.00 (adults) $37.50 (children)

The fascination of the convict era comes to life with the opportunity to discover the Tasman Peninsula. You will also visit the Tasman Arch, Devil's Kitchen and Pirates Bay Lookout.

Departs 9.15am and returns 5.00pm.

This tour includes hotel pick up and return.
Tour available Monday, Wednesday, Friday and Sunday

Bonorong Wildlife Park and Richmond

TOUR 760 $52.00 (adults) $26.00 (children)

"Meet the Natives", wombats, wallabies, kangaroos, quolls and the Tasmania Devil. With the keeper learn of the habits and habitats of wildlife before travelling to the historic village of Richmond. Explore the charm and history the village has to offer. Included is an inspection of the old gaol, Australia's oldest bridge and Catholic Church.

Free time to visit the many art, craft and antique galleries.

Departs 1.30pm and returns 5.00pm

Tour available Tuesday, Thursday, Friday and Saturday.

Huon Valley, Tahune Forest Air Walk, Salmon Farm

TOUR 783 $99.00 (adults) $49.50 (children)

Walk the tree tops of pristine forest at Tahune Forest Airwalk having travelled the Huon River Valley, a region of tended fields, superb forest clad rivers and fishing villages set by picturesque inlets. Highlights include Salamanca Place, views of Hobart, scenic views of the Huon Valley, airwalk amongst the forest, view the Huon River from up high, lunch at a farm property, visit Aquaculture salmon farm and the Apple Valley tearooms.

Departs 9.15am and returns 5.00pm

This tour includes hotel pick up and return.Tour available Monday to Friday inc.

You will be informed of your hotel pick up time but it is approximately 20-30 minutes prior to the departure time. When booking please make sure you have clearly marked which day you wish to travel. Other tour options are available on request.

To book any of the above events please see the Registration Desk in the foyer of the convention centre.

West Coast Wilderness Railway Trip

5:30am sharp - 9:30pm Saturday, 22 May

On Saturday 22nd of May 2004, the day after the close of the Austroads Bridge Conference in Hobart, Sinclair Knight Merz is organising a post conference one day tour to the west coast of Tasmania to enable delegate, partners and friends to travel on the recently opened West Coast Wilderness Railway (previously known as the Abt Railway).

The railway was Tasmania's principal Federation Project and involved the full restoration of the old 1890's Railway including 40 bridges over 38kms of track through rugged terrain and thick pristine rainforest. Two of the original 5 rack and pinion steam locomotives have been fully restored and period carriages have been replicated for service on the line.

How to Book

To book or find out more information please contact Janelle Marsh on (03) 6221 3711 or email: jmarsh@skm.com.au. Information flyers can also be found at the registration desk.

©Tourism Tasmania – Abt Railway, Tim Dubb

©Tourism Tasmania – Abt Railway, Nick Osborne

additional tour

general information

Venue

Wrest Point Convention Centre

410 Sandy Bay Road, Sandy Bay 7005

Contact numbers for the conference registration desk

Phone 03 6221 1720 or 6221 1721
Fax 03 6225 1588

Registration Desk

The Registration Desk is located in the foyer of the Convention Centre and the staff of Convention Wise will be at the desk to assist you at the following times.

Tuesday 18th May, 2004	5.00pm - 8.00pm
Wednesday 19th May, 2004	8.30am - 5.00pm
Thursday 20th May, 2004	8.30am - 5.30pm
Friday 21th May, 2004	8.30am - 4.00pm

Name Badges

All delegates, sponsors, trade exhibitors and speakers will be provided with a name badge.

The badge is you official pass and must be worn to obtain entry to all sessions, morning and afternoon teas, lunches and the Welcome Reception and the Dinner.

Speaker Preparation

Speakers are asked to report to the Registration Desk from where they will be directed to the room available for checking their audio visual. This can be checked in the lunch and morning tea breaks usually in the room where they will be presenting.

A technician will be available to assist you.

Messages and Announcements

There is a message board next to the Registration Desk. All private messages, general housekeeping announcements and changes to the program will be placed here. Announcements in Plenary sessions will be kept to a minimum. PLEASE CHECK under the DAILY NEWS section on the message board regularly.

Mobile Phones and Pagers

As a courtesy to other delegates, please ensure that all mobile telephones and pagers are tuned off or are in 'silent' mode during all sessions and social functions.

Public Telephones

Public telephones accepting coins, credit cards and telephone cards are available in the Foyer.

Special Needs

Every effort has been made to ensure people with special needs are catered for. Should you require any specific assistance, please inform the Secretariat at the Registration Desk.

No Smoking Policy

The Convention Centre has a firm No Smoking Policy. Please refrain from smoking in the Convention Centre and at all associated functions.

Banking and Shopping

There are limited card withdrawal facilities in the foyer of Wrest Point, the Commonwealth Bank of Australia (CBA) is near the conference centre and there is another near the Porters Desk. Full banking services are available in the heart of the Sandy Bay shopping centre and a five minute taxi ride from Wrest Point. Banks represented include the CBA, Westpac and ANZ.

There are quality shops in the same area in Magnet Court and in Sandy Bay Road. Other shopping for souveniers is available in Salamanca Place and the city.

Post Office

Situated on the corner of King Street and Sandy Bay Road in the Sandy Bay shopping area.

Dentists - Business Hours

Dr Ian Gurner	6224 3647
Dr John Moffatt	6223 5514
Dental Emergencies	Telephone/Mobile 0418 128 953

Doctors - For After Hours Help

Hobart Private Hospital (Private - 24 hours)
Argyle Street Hobart - Phone 6214 3000

Royal Hobart Hospital (Public - 24 hours)
48 Liverpool Street Hobart - Phone 6222 8636
Emergency - Phone 6222 8423

Bus and Taxi Services

Metro buses are available every 10-15 minutes from Wrest Point Casino main foyer to Sandy Bay and Hobart City. (See Map on page X for bus route)

Taxi Combined (Cabcharge) - Phone 6234 8444

City Cabs - Phone 6234 3633

Maxi Taxi - Phone 6234 8061
(For people with disabilities and special requirement)

Coaches to the Airport For delegates departing by air "The Airporter" will leave from the main entrance of Wrest Point approximately one hour prior to your flight time and will take you to the airport for a cost of $9.00 (best to book at the front foyer).

Social Programs & Accompanying Persons Tours

We have a number of tours available for Accompanying Person or any delegates staying on after the conference. Please see the Registration Desk for bookings.

Eating Out

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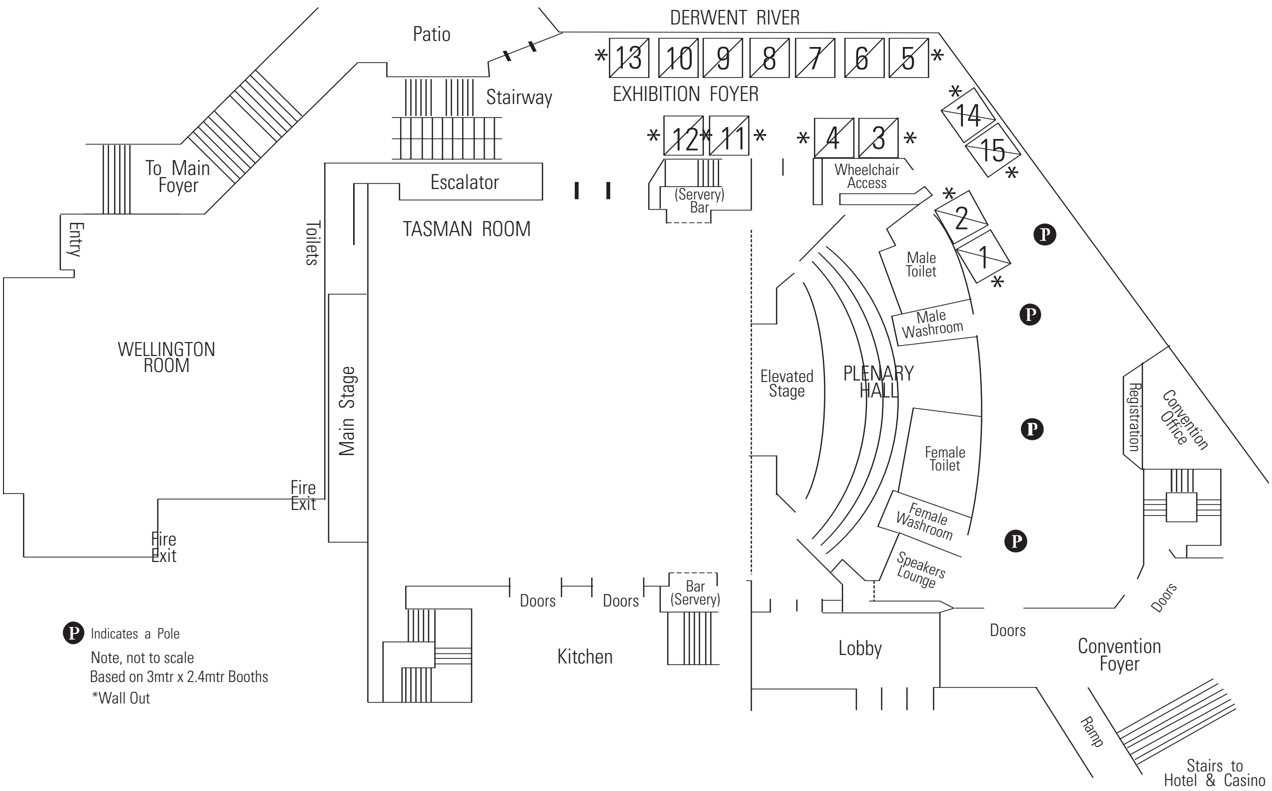

List of exhibitors

1. MBT Australia Pty Ltd
2. Ludowici Rubber & Plastics
3. SIKA Australia
4. Hilti (Aust) Pty Ltd
5. Pitt & Sherry Pty Ltd
6. Reinforced Earth Company
7. Structural Systems
8. Novex Services Pty Ltd
9. Austroads
10. Austress Freyssinet Pty Ltd
11. Department of Infrastructure, Energy and Resources
12. Department of Infrastructure, Energy and Resources
13. Granor Rubber & Engineering Pty Ltd
14. VSL Prestressing (Aust) Pty Ltd
15. Opus International Consultants

Wrest Point TASMANIA

alphabetical synopsis listing

NOTE: The synopsis pages are in session and time order, not alphabetically as shown below.

alphabetical synopsis listing

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Preservation of our Infrastructure Heritage

Jean-Philippe FUZIER, Scientific Director Emeritus,
Consultant for Freyssinet

The sustainable development of our world is closely linked to the strength and to the reliability of its infrastructure. Long-lasting rehabilitation of existing structures that meet a multiplicity of demands and construction constraints is the challenge facing us today.

Some of these structures are part of our patrimony, of our heritage. They represent by themselves a cultural signature left by our parents. Sometimes, it is not only preservation which is needed but rescue works should rather be carried out.

Several recent structures all over the world will draw our attention : the Guatemala Cathedral after the 1976 earthquake and the Paris Triumph Arch will serve as an introduction, then suspension bridges (at Agen over Garonne river), the Saint Laurent bridge (stone masonry 900 years old), the Cerna viaduct in Romania (a prestressed cantilever bridge) and the Geelong aqueduct over the Barwon river (Australia).

Each of these structures tells us something about the various techniques and technologies which have been used for their rehabilitation and preservation.

Computer-aided design and analysis of multiple Tee-beam bridges

Georg Pircher, Martin Pircher
Centre for Construction Technology and Research
University of Western Sydney

Bridge girders consisting of multiple parallel pre-stressed Tee-beams are often analysed as grillage systems. Such grillage systems can be categorised and the analysis of such systems can be automated to a high degree exploiting common features of such multiple Tee-beams. A study has been undertaken to define these features and to form the basis for a computer method for the analysis and the design checks of multiple Tee-beam bridges. Application examples given in this paper illustrate this method and its application in a computer program.

Footbridge Design for Synchronous Lateral Excitation

Angus Low, Arup London

Peter Burnton, Arup Brisbane

It is well known that longer span footbridges can feel lively to those walking over them. In general the acceptability of such liveliness is subjective, and depends on the individuals experiencing it, and the context. However it is now clear that there is an effect which is not subjective. It is called Synchronous Lateral Excitation (SLE), and when it occurs normal walking on the footbridge is disrupted.

Information on SLE was derived for the London Millennium Bridge (LMB) and is given in (1). The purpose of this paper is to show how a footbridge can be designed to take account of SLE.

For susceptible designs the relationship between the key parameters is studied in order to understand how the designs can be made non-susceptible. A distinction is made between elevated walkways, where most of the lateral flexibility is in the substructure, and long span footbridges, where most of the lateral flexibility is in the span. The former may have critical lateral frequencies even with short spans. SLE can occur in bridges of any span.

The inherent damping of modern footbridges is often very low, and designers will be surprised how many designs require additional dampers to meet the requirements of SLE. Configurations for dampers are discussed briefly.

Integral Abutment Bridges - Australian and US Practice

John Connal
Maunsell Australia Pty Ltd

The structural system offered by bridges made integral between superstructure and abutments can provide structural efficiencies as well as enable the elimination of bearings and expansion joints. In some circumstances the durability of the bridge is improved and maintenance costs reduced. The benefits to be gained are greater in more severe climates and under more severe loading conditions.

The use of integral abutment bridges is not widespread in Australia where climatic conditions are relatively benign. However there are a number of examples of integral abutment bridges, and their design and the typical Australian practice is illustrated along with a particular case study.

Integral abutment bridges are more widespread in the USA, and have been used for many years. The frequent use of integral abutments and their reported good performance has led to a number of US Departments of Transportation developing standard details and design guidelines.

The performance of integral abutment bridges in the US is described by reference to the literature and in particular to surveys of US Departments of Transportation. The typical limits on bridge length, skew and thermal ranges are indicated, based on the average practice of the departments.

Particular design issues are discussed based on past performance of integral bridges in Australia and US practice.

Testing and Assessment of a 3-span Steel-Concrete Highway Bridge Using Dynamic Methods

A Case-Study

Wije Arijaratne[1], Mohammed Al-Dawod[2], Bijan Samali[2], Ali Saleh[2] and Steve Bakoss[2]

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[2] Post Doctoral Fellow, Professor, Senior Lecturer, Emeritus Professor respectively, Centre for Built Infrastructure Research, Faculty of Engineering, University of Technology, Sydney PO Box 123, Broadway, NSW, Australia 2007

This paper describes the testing and assessment of a three span steel and concrete highway bridge based on a cost-effective dynamic technique. It describes the application of a recently developed dynamic method used to assess the structural condition of Redbank Creek Bridge at North Richmond NSW.

The data obtained from the field tests is presented and the method for predicting the load-deflection response and load capacity based on this data is detailed. The results obtained from conventional static load tests and from the dynamic and static finite-element analyses undertaken as part of this investigation are also given.

Comparison of the stiffness and strength results obtained from the dynamic tests with those based on the results of static load tests and finite element modelling show excellent agreement.

The case study described in this paper as well as a large number of bridge tests conducted as part of a major project show that the dynamic techniques that were used provide a reliable cost-effective method for the assessment of the structural condition of a wide variety of short and medium span bridges. The case-study presented illustrates that the methods described in the paper provide quantitative information on the structural behaviour and integrity required for the rational long-term management of bridge assets.

Improved Load Rating Assessment of Princes Bridge through Load Testing

Aaron Brimfield

David Coe

Princes Bridge is Melbourne's grandest bridge linking the southern commercial and art centres to the heart of the city. It is also one of the busiest bridges in Australia servicing vehicular, tram and extensive pedestrian traffic. Located on one of Melbourne's busiest roads there was pressure on Melbourne City Council to assess Princes Bridge for the new higher mass vehicles specified for the Mass Limit Review (MLR). A subsequent desktop analysis suggested the bridge was significantly under strength for the higher loads and extensive strengthening was proposed.

Council originally proposed to design, document and tender the strengthening work based on the desktop analysis. With such a complex structure it was apparent there would be benefits in taking the assessment to an increased level of investigation.

A successful alternative proposal was put forward which included a diagnostic load test on the bridge. The objective of the performance test was to develop a calibrated structural model of the bridge from which strengthening design could be based. This paper will investigate that test and subsequent findings which resulted in significantly reduced strengthening requirements.

Reliability-Based Load-Rating of Existing Bridges

S.G. Reid, University of Sydney

Work has been carried out to develop theoretical (probabilistic) models of loads and resistances, and to develop calculation procedures to provide a general framework for the evaluation of the reliability of existing bridges. A probabilistic model of peak truck loads has been developed to model not only the anticipated truck loads (accounting for the expected number of over-load events), but also historical loads (which act as uncertain proof-loads). Reliability analyses have been carried out considering combinations of uncertain resistances (such as ultimate moment capacities) together with uncertain load-effects due to the permanent loading (the weight of the bridge) and traffic loading. For the purposes of developing a simple checking procedure, reliability results have been evaluated in relation to the uncertain reserve resistance (i.e., the resistance that is available to resist the traffic loading after the application of the permanent loads). Results have also been obtained to illustrate the enhancement of reliability after a period of trouble-free traffic loading

(constituting an uncertain proof-load). The probabilistic model of truck loads is outlined in the paper. General reliability results are presented in the form of reliability contours on graphs based on the mean and coefficient of variation of the reserve strength (estimated by the design engineer). Reliability contours are given for structures with or without a history of previous traffic-loading. A simple procedure to check the structural reliability for a specified level of traffic loading is described and illustrated. Sample reliability calculations are also presented for a particular bridge on Camp St in the Municipality of Forbes.

Shelly Beach Overbridge Modification, Auckland

Geoff Brown
Opus International Consultants, Wellington

Shelly Beach Overbridge is located on one of the busiest motorways in New Zealand on the southern approach to the Auckland Harbour Bridge. With over 100,000 vehicles passing below this bridge every day in each direction, increasing the span to accommodate motorway widening presented a unique challenge.

Cutting the bridge in half and sliding onto a new pier, with infilling and strengthening of the bridge superstructure, provided a cost effective and robust solution to this challenge. This paper describes how the design concept for modifying the bridge was developed and successfully carried through to construction.

Carbon Fibre Strengthening of Precast Reinforced Concrete Inverted U Bridge Beams

Dr Ian Chandler
Curtin University of Technology, Perth, Western Australia

Main Roads Western Australia has a number of bridges constructed from precast reinforced concrete inverted U beams (approx 6400 mm long, 940 mm wide and 410 mm deep). These bridges were designed and constructed in the 1950's with plain bar reinforcement for trucks with a single rear axle, and concern has been expressed about their shear capacity and moment capacity at the location of curtailment of the main flexural reinforcement, particularly with loads from dual and tri axle groups.

Recently three bridges were removed from service and replaced with new construction. This provided the opportunity to test the ultimate capacity of the removed beams. A series of laboratory tests was conducted as the initial phase of research into the strength characteristics of these beams. The testing utilised 13 standard internal beams, 7 non-standard internal beams with external strengthening by 100 mm by 10 mm steel plate, and six standard internal beams which had 80 mm by 1.2 mm carbon fibre straps applied to the bottom of both webs as part of the testing program.

The strengthening with carbon fibre straps increased the stiffness of the beams and resulted in strength increases of between 20% to 30% when compared with the standard beams.

Western Distributor Viaduct Modifications for the Cross City Tunnel Project - Sydney

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CW-DC Pty Ltd, Sydney, Australia

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CW-DC Pty Ltd, Sydney, Australia

I Cox, Senior Associate
CW-DC Pty Ltd, Sydney, Australia

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CW-DC Pty Ltd, Sydney, Australia

The Cross City Tunnel Project in Sydney has provided many challenges for Engineers of all disciplines with the design of this new Motorway within areas of the City containing existing roadways, structures and utilities. This paper outlines the features of the structural design for the modifications necessary to the existing Western Distributor Viaducts in Darling Harbour to incorporate additional traffic lanes on the viaducts for merging traffic to and from the Motorway and the modifications to the viaduct substructures for changes to the road alignments under the viaducts

Advanced Bridge Analysis and Design Methods Simplified

Andrew Gallagher, Novex Services Pty Ltd

Barry Skinner, Bestech Systems Limited

Advanced bridge analysis and design methods have been simplified with the aid of modern bridge software. This paper provides a summary of these new analysis and design methods and the advantages that can be achieved. Topics covered include automated vehicle load pattern generation methods to the new Australian Bridge Code (AS5100) and the New Zealand Transit Manual, recent developments in composite analysis methods for bridges, and the integration of analysis and design procedures.

Automated loading methods use influence surfaces which are a powerful tool for generating vehicle load patterns in accordance with the provisions of the various bridge codes. Complex load patterns can be generated to a high level of accuracy for any desired load effect in both two dimensional and three dimensional bridge models using the influence surface method. The theoretical background and application of this method are presented.

Composite analysis methods have recently been developed such that advanced 3D models incorporating finite elements can be analysed to produce “composite member” load effects. In the example provided in this paper, finite element analysis results from a 3D finite element of a box girder can be easily converted to useful “overall” design effects such as longitudinal bending, torsion, and web shear. This greatly expands the application of finite element models for analysis of complex structures.

Integrated analysis and design technique involves the provision of links between section - beam - analysis - and automated bridge loading procedures. This means that section properties, vehicle positions, analysis results, and design and code checking calculations can be linked together under the one seamless interface. The advantages of this integration are presented.

The above topics are discussed in detail in relation to their implementation of the current release of SAM Integrated Bridge Design software.

Sorell Causeway Channel Bridge, Tasmania

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One of Australia's first post-tensioned beam and slab bridges was constructed in 1957 in a maritime environment north-east of Hobart, Tasmania. A feature of this bridge is that the voids for the tendons were created using inflated rubber tubes which were withdrawn after the concrete had hardened.

In light of serious deterioration of this bridge caused by the ingress of chlorides, the Owner awarded a design/build contract for its removal and replacement in 2001.

The $18.7m (AUD) replacement Sorell Causeway bridge is thought to be the only match-cast precast-segmental channel-type road bridge outside of France or the USA. This paper describes the successful use of this rare bridge form, which provides for a very small depth of structure below roadway level. The Authors recommend the channel form for widespread use. Conclusions are drawn with the aim that others can more easily adopt and develop the concept further.

Keywords: channel girder, trough girder, through girder, finite element model, age adjusted, linking slab, segmental precast, post tensioned, long line method, epoxy joint, durability, crack control.

Modular Bridge Joints - Reduction of noise emissions by use of Helmholtz Absorber

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Stephen C. Brown, Associate, Richard Heggie Associates Pty Ltd, PO Box 176 Lane Cove 1595, Australia. Email: steve.brown@heggies.com.au

Modular bridge expansion joints are widely used throughout the world for the provision of controlled thermal expansion and contraction in bridges. Modular Bridge Joint Systems (MBJS) are considered to be the most modern design of waterproof bridge expansion joint currently available. It was known that an environmental noise nuisance occurred as motor vehicle wheels passed over the joint but the mechanism for the generation of the noise nuisance was not previously known.

Observation suggested that the noise generation mechanism involved possibly both parts of the bridge structure and the joint itself as it was unlikely that there was sufficient acoustic power in the simple tyre impact to explain the persistence of the noise in the surrounding environment. Engineering measurements were undertaken at Georges River (Tom Ugly's) Bridge and the analysis of these measurements indicated that an environmental noise nuisance resulted from the interaction of vibration of the modular bridge expansion joint with acoustic resonances produced within the void space of the abutment below the joint. A number of engineering methods of noise abatement were considered or investigated before a Helmholtz Absorber installation was adopted.

"Before" and "After" noise measurement results show a significant decrease of low frequency noise due to the Helmholtz Absorber installation. The benefit is most obvious in the frequency range of 50 to 200 Hz which encompasses all the natural vibration modes. The noise reduction provided by the Helmholtz Absorber installation is of the order of 10 dBA which is equivalent to a halving of the perceived loudness.

Spatial Variability of Pitting Corrosion and Its Effect on the Strength and Reliability of Prestressed Concrete Bridge Beams

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Corrosion of reinforcing and prestressing steel due to chloride attack is one of the major causes of deterioration of concrete structures. This is of most concern because of the associated reduction in steel cross-sectional area, spalling and loss of bond. In the case of prestressed concrete structures, the corrosion of prestressing strands can lead to a sudden failure due to higher stress levels in the steel.

The paper deals with the development of probabilistic models to predict the strength and reliability of prestressing strands subjected to pitting corrosion. A pitting corrosion model was developed from accelerated corrosion tests in a chloride-concrete environment. From the accelerated corrosion tests, the spatial distribution of maximum pit-depth along strands for various lengths and corrosion rates is developed. From the model, the section loss of the strand can then be calculated. The probabilistic model can also be combined with appropriate failure criterion to calculate the probability of failure of prestressing strands under pitting corrosion attack.

Finally, the probabilistic model of pitting corrosion is combined with Finite Element Analysis and models of corrosion initiation and propagation to study the effect of pitting corrosion on prestressed concrete bridge beams. This will allow time to failure and estimates of structural reliability to be calculated. From the analysis, it was found that the corrosion rate and the failure criterion have a significant effect to the time to failure for a girder. This probabilistic approach will lead to more realistic predictions of the actual behaviour of prestressed concrete bridge beams suffering corrosion attack.

Suitable Intervention Strategies for Structures Affected by Alkali-Silica Reaction (ASR)

Alan Carse, Structures Division
Queensland Main Roads

The purpose of this paper is to provide a review of the issues facing the Maintenance Engineer in relation to repairing bridge structures affected by alkali-silica reaction cracking. The bridge structures chosen cover problems with a superstructure and also a substructure. The superstructure example consists of an original section of 8 prestressed T girders and was subsequently widened in 1990 with 11 deck units on the Western side and 9 deck units on the Eastern side. The deck units have been identified by number for each widening starting from the upstream unit in each case. All of the cracking previously identified by others was reported as being confined to the new deck units in both widening sections. This bridge consists of 6/16 m spans supported on prestressed concrete piles. Field inspection indicates the soffit of the deck units is very close to the high water mark in the tidal creek (approx. 1000 mm clearance). This means that the deck units reside in a very aggressive environment in relation to concrete durability and the environment would be classified as Type C in relation to the Austroads Bridge Code requirements. As a result of the work performed in this report, Alkali-Silica Reaction (ASR) was determined as the primary mechanism causing the observed cracking in the prestressed deck units used in the widening of this bridge in 1990. An approach to the rehabilitation of this structure is outlined which had a degree of urgency in relation to the satisfactory long-term performance of this structure. The substructure example chosen consists of significant vertical cracking (up to 8mm in width) in prestressed piles in a marine environment. The vertical cracking was proven to have been initiated by ASR distress and subsequently widened due to corrosion of the underlying reinforcement and prestressing strands. A combination of concrete encasement below water and fibre composite encasement above water was chosen to arrest the rapid deterioration of these major supporting elements of this structure. Further developments in the repair of piles underwater using fibre composite systems will be discussed during the presentation of this paper.

Probability Based Chloride Diffusion Model to Predict the Condition States of RC Bridge Elements

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Major cause of deterioration of reinforced concrete bridge components is corrosion of reinforcement due to chloride ingress. This paper presents a probability-based model to assess the deterioration of reinforced concrete elements due to chloride ingress. The aim of the model is to estimate the lifetime of bridge components incorporating the time to corrosion initiation, crack initiation and crack propagation models. The model is based on probability distribution of chlorides, concrete types and cover to reinforcement of the bridge elements in a particular region under consideration. The analysis is based on time varying diffusion parameters, which gives better results than the commonly used simplified error function formula. The crack initiation and propagations are then related to the condition states defined by VicRoads bridge inspection manual. This manual is used to assess the condition states of the existing bridge stock. The condition states of RC elements are defined based on cracking and spalling of concrete, and percentage loss of area of the reinforcement.

The application of this methodology is illustrated using chloride profiles for a bridge deck component along coastal regions of Victoria. The results are compared with the actual inspection data of the bridge components made available from VicRoads for this region. The comparison demonstrates that the future condition states of the bridge components can be estimated using the chloride diffusion model presented in this paper. The ability to predict the future condition states of bridge components based on rational model is an essential tool in a bridge management system.

Rehabilitation and Monitoring of Sawtells Inlet Bridge - 12 Years Later

Fred Andrews-Phaedonos, GeoPave, VicRoads
Ahmad Shayan, ARRB Transport Research Pty Ltd
Aimin Xu, ARRB Transport Research Pty Ltd

The Sawtells Inlet Bridge was the subject of a major rehabilitation undertaken in three stages in 1991 and 1992. This comprised the replacement of superstructure components, construction of a strengthening and waterproofing deck overlay, conventional patch repairs of parts of the substructure and application of suitable protective coatings for the whole of the bridge, in both atmospheric and tidal/splash zone microclimates. A permanent corrosion monitoring system in the form of half-cell potential reference electrodes and resistivity pins was also installed at the time, to enable the ongoing monitoring of the effectiveness of the various concrete repair methods and protective coatings in limiting chloride induced corrosion of concrete coastal bridges in Victoria. Additional testing over the years included chloride and pH testing, and more recently corrosion rate measurements, as well as visual inspection and delamination survey. Recent investigations and assessments reveal that although after nearly 12 years of service a significant proportion of the concrete repairs and protective coatings are approaching the need for re-intervention in this very aggressive marine environment, overall the combination of some repairs and associated coatings has proven to have performed in a reasonably satisfactory manner. Analysis of selected elements has shown that sufficient amounts of chloride ions have penetrated to the level of steel reinforcement in the columns, although these commenced from an already high base prior to the application of the protective coatings. This has been associated with low to moderate corrosion rate of the steel, as indicated by the half-cell potential values and the direct measurement of corrosion rate of the steel, particularly in the unprotected control areas and the lower portions of the columns. Prestressed concrete deck planks that had been installed as part of the rehabilitation process showed that the extent of chloride ingress and corrosion was insignificant. This is due to the dual protective coating (silane and anti-carbonation coating) applied to the planks after installation in the bridge.

As a result of this ongoing monitoring over the 12 year period, it may be concluded that both a polymer modified cementitious coating and an epoxy coating have been relatively effective in limiting the ingress of chlorides into the concrete piers, despite their shortcomings which may be attributed to mixing, application, curing and other operational practices. The application of polymer modified cementitious repair material does not seem to have caused or enhanced macrocell corrosion in the neighbouring coated areas. Because of significant chloride levels in the columns, consideration may have to be given to the installation of a CP system (vs. ongoing patch repairs and coatings) to protect the piers from further progress of corrosion, based on a life cycle costing analysis.

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Towards a Uniform Bridge Management System for Australia and New Zealand

Graham D Rummey and
Laurie B Dowling, FIE Aust

Austroads has sponsored a study of the information data needs to support effective agency management of bridge infrastructure assets. Overall objectives of the study were to develop national inventory and condition datasets, and an integrated approach to the determination of bridge condition indices that could be used for budgetary planning, prioritisation of maintenance activities, benchmarking and performance review.

At workshops involving bridge asset personnel from 9 participating agencies the current status of bridge management systems as developed throughout Australasia was confirmed. Those systems were compared and formed the basis to establish common sets of bridge identification and structure inventories suitable for adoption in a uniform bridge management system. Inspection frequencies and bridge condition assessments of those systems were also compared and reviewed for adoption in the uniform system as being representative of current practice. Findings would be presented in the format of a guideline.

The guideline produced from the study proposes a minimum basic set of bridge inventory detail, the frequency of 4 levels of inspection and criteria by which to determine the condition of bridge elements. Consensus on a method to interpret the condition of a bridge from the condition of its element was not achieved. However, examples of algorithms used by VicRoads and by RTA of NSW are provided to indicate how that interpretation may be achieved, and a third simple method is suggested.

Risk Based Bridge Asset Management

David Coe
Director Pitt & Sherry

Following the High Court decision in May 2001 in Brodie vs Singleton Shire Council, common law non feasance protection can no longer be guaranteed. While some States have reinstated non-feasance immunity through statute law, there is a greater reliance on "policy defence" to manage civil liability.

In order to effectively implement a policy defence it is important to document and implement a risk based asset management system encompassing the following features:

- Regular documented inspection programs
- Document allocation of funding for repair and maintenance
- Document competing demands on resources
- Determined intervention levels
- Prioritisation actions and document reasons for prioritisation
- Determination if further proactive inspections are required.

As bridges are complex structures with a multitude of components and structural forms, a comprehensive management system is required. Ideally the system will use computer processes to store and manipulate data to provide outcomes to meet the risk based asset management objectives of a road authority.

This paper provides further details on the philosophy of policy defence and the requirements to ensure bridge management practices can rely on such a defence. In particular the paper outlines contemporary bridge risk management processes and how they are used to deliver an effective bridge

Bridge Deck Behaviour Revisited

Doug Jenkins

Since it's publication in 1976 up to the present day, Edmund Hambly's book "Bridge Deck Behaviour" has remained a valuable resource for bridge engineers. During this period the processing power and storage capacity of computers has increased by a factor of over 1000 and analysis software has improved greatly in sophistication and ease of use. In spite of the increases in computing power, bridge deck analysis methods have not changed to the same extent, and grillage analysis remains the standard procedure for most structures.

In this paper the advantages and disadvantages of using more complex analysis procedures are examined.

The following topics are covered:

- Alternatives to grillage analysis
- Comparison of design actions and deflections from alternative analysis methods
- Analysis of secondary effects
- Non-linear analysis
- Advanced analysis in the design office. Is it worth the effort?

Recommendations are presented that enable the advantages of advanced analysis techniques to be realised, whilst retaining the efficiency of grillage analysis.

Wildlife Friendly Design of Road Structures

Brendon Hyde, Technical Adviser, Australia

Brendon has 36 years experience designing bridges and heavy industrial structures, engaged with government authorities and consulting firms both in Australia and 9 overseas countries - from Asia to Africa. He has authored several technical guidelines for the Roads and Traffic Authority, NSW

Gordon Chirgwin, Manager, Bridge Policies, Standards and Records, Roads and Traffic Authority, NSW Australia

Gordon has 31 years experience in roads and bridges, and for the last 10 years has been managing technical policy in the bridge and structural fields.

Many road projects cross watercourses and wildlife corridors that are important for the survival of native wildlife. Insensitive construction of the road structures that cross such watercourses and wildlife corridors can sever both fish and fauna passage. Such practices can cause potentially serious consequences for the local fish and fauna populations (Figure 1).

Fig 1: Fish unfriendly design. Piers located in midstream, abutments located too close to top of bank - eliminating riparian vegetation and causing pollution. Construction method pollutes river and destroys riparian vegetation.

Where road structures are not 'fauna friendly', terrestrial, arboreal and aquatic fauna or flightless birds will attempt to cross over the roadway. Thus a considerable variety of our unique native wildlife, especially kangaroos, wombats, koalas, platypuses and cassowaries, are killed annually on Australian roads. In addition to these wildlife mortalities, road user fatalities occur annually when motorists loose control of their vehicles after hitting or swerving to avoid wildlife obstructing the carriageway.

Current road projects provide for passage of identified local wildlife, accommodating issues raised during the Environmental Impact Assessment for the project. However, as Bennett (3) points out, good design and construction cannot substitute for poor environmental planning.

This paper adopts the definition of 'fish' in the NSW Fisheries Management Act 1994. Thus 'aquatic fauna' refers only to air breathing water dwelling animals, including amphibians.

Crash Barrier on Reinforced Earth Wall - Liverpool Parramatta Transitway

Ros MacKinlay - Design Engineer, Wyche Consulting

Joe Wyche - Director, Wyche Consulting

Reinforced earth walls are increasing being utilised for economic and aesthetic reasons as earth retaining structures on and around road traffic installations. Abigroup, the contractor for the Liverpool Parramatta Bus Transitway project based their successful tender on the use of reinforced earth for the retaining walls in the elevated sections of the transitway with continuous slip formed concrete crash barriers.

Reinforced earth walls are often a very competitive solution for earth retaining structures, but when crash barriers have to be placed on top of them, it is difficult to carry the crash load forces back into the reinforced earth.

A solution was required by Abigroup Contractors to comply with the specified barrier impact loadings without overloading the reinforced earth wall, while at the same time minimising the barrier concrete foundation costs.

This paper shows how an economical and effective solution was achieved using designs to isolate the crash barrier lateral impact loads from the reinforced earth retaining walls and the method of allowing for thermal and shrinkage effects along the long slip-formed concrete barriers.

Management of State Heritage Significant Bridges

P. B. Manamperi - Bridge Strategy Manager, RTA, NSW

The RTA NSW manages 31 timber truss bridges and two timber beam bridges that are assessed as being of State heritage significance. These bridges were designed to carry a traffic loading significantly lower that the current traffic. While these bridges have served NSW well for around 100 years their continued service requires proactive management.

This paper discusses

- How each of the elements that comprise the Bridge contributes to its overall significance.
- Analysis of form and fabric of each element and determination what constitute significant form and fabric
- Structural capacity of each element to carry current loads and
- Development of a heritage sympathetic approach to rehabilitation and strengthening for the Hinton Bridge to the required level and minimise the future maintenance costs.

Covered Bridges of America

Ken Maxwell
Principal Bridge Engineer, GHD Pty Ltd, Sydney

This paper provides an overview of the early nineteenth century evolution of American covered bridges by describing the development of the four main truss types used.

The first National Covered Bridge Conference was held in Burlington, Vermont, USA in June 2003 and this presentation also covers information obtained from that conference on the history and engineering analysis of these structures that typify rural America.

Strengthening of Heritage Timber Truss Bridges. Bridge over Abercrombie River, Abercrombie, NSW

R. Oates (RTA), R. J. Taylor
(R J Taylor Consulting Pty Ltd), I. Berger (RTA)

With increasing live loads on NSW roads, the load carrying capacity of most of the State's aging 53 remaining timber truss bridges is under threat. These bridges were built between 1877 and 1930 and most are classified as heritage structures.

The Bridge over Abercrombie River on MR54 was built in 1919 on the masonry foundations of a previous bridge swept away by floods in 1916. The superstructure consists of 2/21.6m Allan truss spans; 1/27.4m Allan truss span, 2/10.4m and 2/7.6m timber beam approach spans. MR54 links Bathurst with Goulburn and is being progressively upgraded to carry B-Double vehicles. Strengthening was, therefore, required for this locally significant heritage bridge to allow greater live loading.

The three Allan truss spans were strengthened by the installation of continuous steel plates inside the bottom chord timber flitches, new steel cross girders and transversely stressed Stress Laminated Timber (SLT) decks. The approach spans were strengthened by lowering the main timber girders; introducing steel cross beams and providing transversely stressed SLT decks. Austroads Level 2 traffic barriers attached to the steel cross beams and girders were also provided over the full length of the structure to increase safety.

The renovating methods used on this bridge have demonstrated acceptable ways of upgrading and strengthening timber truss bridges that are classified as heritage significant.

This paper provides an overview of the strengthening design and construction with emphasis on design and heritage issues that were encountered.

Alternative Hardwood Girders - An Innovation with Composites

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Australian hardwoods are an excellent general purpose building material, however in recent years they are becoming more expensive, less available, and of poorer general quality than has previously been the case. Many Australian timber bridges will remain in service for the foreseeable future, and the maintenance and potential upgrading of these structures will be an on-going demand, while the availability of traditional resources declines. Compatible alternative timber bridge components are therefore required.

FCDD has been developing hybrid composite/timber beams for several years in collaboration with major timber bridge asset owners, and is now in the process of specialising products to meet the needs of specific asset owners. This collaborative process has revealed a range of philosophical approaches to the establishment of "target parameters" for hardwood alternatives that vary significantly in terms of product behaviour and performance. This is compounded by the lack of a recognised national approach to timber bridge design and evaluation, and the additional structural behaviour possibilities associated with emerging technologies.

This paper begins by discussing some of the contemporary issues to be considered in timber bridge engineering and management, which leads to the pursuit of hardwood alternatives. Recent developments at FCDD are then described, and some typical cases are illustrated. A series of questions are raised as a result of this discussion, and these are summarised. These and other issues require further detailed consideration.

Port River Expressway - Stage 1 - Bridge Over Eastern Parade

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The Port River Expressway Project will provide a four-lane road linking the Port of Adelaide with the Salisbury Highway.

Stage 1 involves the road works component extending 4.7 km from east of the port to South road. The project includes provision of a bridge over Eastern Parade and the railway to the west of the intersection.

The bridge is a nine span continuous structure, crossing the railway and eastern parade at a 40 degree skew. The western abutment and the first two piers at the western end are unskewed.

It has seven internal spans of 32 metres and end spans of 27.2 metres making a total length of 278.4 metres.

The deck has an overall width of 18.2 metres, which accommodates 2 eastbound lanes and 2 westbound lanes, separated by a 1.0 metre wide central median.

The superstructure consists of four steel box girders with an in-situ concrete slab.

The piers and abutments are of reinforced concrete and are founded on bored piles.

The presence of aggressive soils and the possibility of acid sulphate attack has led to additional protective requirements in the components in contact with the existing soil strata identified as the St. Kilda formation. This includes the piles, pile caps and bases of retaining walls.

Ground improvement techniques were required on the approaches, including use of stone columns and preloading.

Keywords: steel box girders, in-situ concrete slab, acid sulphate, durability, stone columns.

Some Outcomes from Load Testing of Bridge 631 in Western Australia

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Bridge 631 is a 190m long timber bridge with 31 spans over the Avon River in Toodyay (a small town approximately 100 km from Perth the capital city of Western Australia). The bridge was constructed from local hardwood timbers (Jarrah and Wandoo) in 1950 and has had a series of repairs in 1965, 1980, 1994 and 1998. However as the width between kerbs was only 5.5 metres and it did not have a footpath it was decided to replace the bridge with a new wider concrete structure during 2001-2002.

The proposed removal of the existing timber bridge provided an opportunity to pursue a program of research into aspects of bridge inspection, timber material properties, structural failure and modelling and improved repair techniques and strengthening methods. This paper describes and discusses some of that research.

Non destructive evaluation of the bridge prior to construction of the new bridge was conducted during May 2000 using trucks to provide both static and dynamic loadings. Additional static tests were conducted in March 2002 prior to the removal of the bridge in April 2002.

Outcomes from the research could be applied to improved maintenance and load rating of the remaining 1400 timber bridges in the road network. As such this research work offers significant benefits to the community, including local government, road users, road freight industry and tertiary institutions.

Bridge building in practice - mentally and physically

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Peter Lundhus graduated in 1965 from the Technical University of Denmark with a M.Sc. in civil engineering.

For 21 years he worked internationally as a heavy civil engineering contractor.

From 1989 he joined the Owner organisation - the Great Belt Link Ltd., Denmark - as Project Director on the 17 km long and Euro 3 billion road and rail project and was selected for the similar sized project of joining Denmark and Sweden in 1992 as the Technical Director for the Øresund Link from the beginning in 1992 until completion in 2000.

From 2001 he heads a team preparing a similar 20 km long Fehmarn Belt Link between Denmark and Germany with an expected government agreement in 2003/2004.

This paper describes a constructive Owner's approach to the successful management and implementation of a claims and litigation free construction project.

The project concerned is the Øresund Link joining Denmark and Sweden. The Link is a 17 km long toll funded motorway and high speed rail link, which includes the largest immersed tunnel and the most severely loaded cable stayed bridge at the time. The Link was built between 1992-2000 with a value of Euro 3 billion. The result was a remarkable project: Finished early, below budget and all involved in the construction process made money.

The verdict: Co-operation is far more profitable for all parties than the traditional adversary attitude.

Quality Infrastructure - A Different Approach

J.L. van der Molen, Structural Engineer

In the past fifteen years or so a transformation has occurred in the construction industry, mainly driven by new concepts of economics under the local banner of "economic rationalism". It is timely to take stock of the impact of these changes on the quality of our built infrastructure, on the personnel responsible for its design, construction and maintenance, and on the public served by it.

The paper will discuss some aspects of this impact on the viability and product quality of the design and the construction industry, viz. the lack of profitability, of new investment and of R&D funding, downsizing and the associated failures of corporate memory, outsourcing, lack of personnel training and development, reduction in quality of design, construction and planned maintenance, and finally, the high incidence of accidents in the workplace, pointing to overall shortcomings in safe work practices.

These trends were probably most pronounced in UK, under the Prime Ministership of Margaret Thatcher. It is not surprising that the resulting unsatisfactory state of the construction industry is producing a reaction. The paper will refer to recent work by Sir John Egan and Prof. David Blockley. Essentially, this work is based on the notion of co-operative leadership, and on a systems approach, incorporating the whole of the creative process. It is similar to the model advocated by Dr. W. Edwards Deming and promoted in the Japanese car industry in the1950's, with outstanding results.

The paper will outline the main characteristics of this process, which is essentially a co-operative one across all the stakeholders in the system, contrasting it with the current adversarial practice. The paper will demonstrate the economic fallacy of the practice of compulsory competitive tendering based on the assumption that this gives expression to the "free market".

Design and Construction of the Otira Viaduct

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The Otira Viaduct is a major prestressed concrete box girder bridge sited amongst majestic mountains in the Arthur's Pass National Park in the Southern Alps of New Zealand. The area's tectonic, geological, geotechnical and environmental conditions together with the terrain and active river conditions made this an unusually challenging and demanding project. The 445m long balanced cantilever bridge has spans up to 134m and piers constructed deep into avalanche material with rock compressive strengths of up to 250 MPa.

Highway Gantry using Aluminium Extrusions

D.R. Morris, Project Director, GHD Pty Ltd

A new modular lightweight highway gantry was conceived to meet the growing need for structures to support driver information messages on the UK highway network. David Morris (then with KBR) led a team, which included a UK specialist aluminium alloy extruder to design, fabricate, and test a prototype highway gantry, which comprised new aluminium alloy extrusions. The system of components, which was connected using the alloy pin and collar fasteners (Huck bolts), was found to be suitable for manual handling of elements (light weight), as well as facilitating rapid assembly. Uniquely, the prototype gantry proved to be light enough to allow the pre-installation of signal equipment on the superstructure prior to lifting the entire span to a permanent location. Aluminium extrusions were developed by the designer to provide a convenient and robust method of connecting the main sections. Huck bolts were used to avoid the strength reduction and fatigue issues associated with welded connections. The reduction in strength around welded joints is normally rectified in small components by the use of artificial ageing, but this is clearly not a practical proposition for a large structure such as a highway gantry. By using a modern equivalent of the rivet in conjunction with new structural sections, an efficient light, and economic structural system was produced. A 15m span prototype gantry was designed and load tested. The speed and ease of manufacture for the gantry, and the predictable performance of the gantry under load were confirmed during the prototype development and load testing.

'Safety first' for bridges - by design

Frank Rapattoni
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'Safety first' is the overriding criterion which governs key provisions in the new Australian Bridge Design Code. The safety provisions for bridges over railways are at the leading edge of world practice with emphasis on catering for derailed trains by providing clear spans or 'pier-redundant' bridges with frangible piers. The catalyst for the provisions was provided by the train disasters at Granville and at Eschede, Germany. 'Pier-redundant' bridges are also recommended for bridges over navigable waterways to avoid collapses such as that of the Tasman Bridge. This concept can minimise risks in many other situations such as bridges over streambeds susceptible to unpredictable or high rates of scour and piers susceptible to impact by road traffic. Two 'pier-redundant' bridges have been constructed in Australia over the Murray River at Berri and at Hindmarsh Island. These bridges enabled substantial savings in construction costs as well as ensuring the maximum safety for traffic on and under the bridge. Bridges over roads, especially freeways, can provide significant safety hazards to road traffic. The benefits of using safer bridging options by eliminating accident costs and human trauma need to be recognised in selecting the best bridging solutions. The prescriptive requirements for safety provisions in the Code are designed to ensure that bridges are selected taking a holistic view of the project, by considering the hazard they create as well as their function. This should ensure that bridge solutions are not selected just on the basis of lowest initial cost, which currently is the prevailing criterion. A methodology is required to clearly and objectively select the best bridging solutions taking safety aspects into account within available funds.

Assessment of Bridge Response Using Weigh-in-Motion Data

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Weigh-in-motion data gathered on highways provides statistics on gross vehicle mass (GVM), axle mass distribution, type of truck, speed, etc. It can be used to monitor freight volume and trends, and to detect illegally loaded trucks. The data is used in conjunction with vehicle mass limits to develop "design vehicles" such as SM1600 for bridge loading to be used for assessing performance against the limit states of ultimate strength, serviceability, fatigue, etc.

A system has been developed for applying the individual trucks as loads to specific bridges or to a class of bridge of given span and influence function to see how they perform under current traffic. This replaces the use of "design vehicles" with the actual historical traffic. The load effects are a function of the span and the shape of the influence line or surface. The system provides valuable insights into the performance of actual ageing bridges and it enables the direct probabilistic structural risk assessment of existing bridges.

Shear Damage Control in Assessing Flat Slab Bridge Decks

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Full scale destructive load testing of flat slab Bridge No. 1049, over Baandee Lakes on Great Eastern Highway was commissioned in 2002 by Main Roads Western Australia. Two bending tests and two punching shear tests were carried out. The 5 x 7.5m span reinforced concrete flat slab bridge is typical of many similar structures.

Comparisons are made between the current empirically based treatment of punching shear and general shear in codes, and the observations from the tests.

Rationally based axial/shear stress models of each of the tested spans are proposed, examining the uncracked "slab compression field" in the concrete. Correlation is described between the indicated positions of local breaches of the Mohr/Coulomb stress envelope and the actual positions of diagonal shear cracking observed in the tests, at the failure loads.

For punching shear failure over column supports, predictions from a recently published (Dec 2002) theoretical plasticity model are compared with the ultimate punching shear test results.

Conclusions reached include a rational approach to shear assessment of flat slab bridge decks.

Condition assessment of a reinforced concrete jetty structure, its load capacity and suggested rehabilitation strategy

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A reinforced concrete jetty structure built in 1970 has developed severe deterioration due to chloride-induced corrosion of the steel reinforcement bars in the piles and cross-heads. The piles have shown severe vertical cracking and the crossheads severe horizontal cracking and delamination of the cover concrete at the soffit. After a thorough visual inspection, concrete cores were extracted from representative elements and tested for strength, density, and chloride penetration. Electrochemical properties of steel, including half-cell potential and corrosion rate were determined, and concrete cover thickness measured on site to map the corrosion status of the various elements. The load capacity of the jetty was analysed based on the original design and taking into account the observed deterioration of the concrete and the corrosion of the steel reinforcing bars, and the trend of decay in the load capacity determined. In spite of severe deterioration of crossheads, the load bearing capacity remains adequate for the current load rating of 7 tonnes and 10 tonnes for single axle and double axle, respectively. A rehabilitation strategy was suggested based on the overall results, comprising patch repair to deteriorated concrete elements followed by cathodic protection of steel bars.

Quality In Construction - The Long-term Owner's Needs The Necessary Policy and Management Actions

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This paper discusses the general principles that can assure road projects conform to specification. The principles are general, but it is a bridge engineers perspective on quality.

It assumes the road authority is capable of selecting a contractor who is technically competent to do the job, and the detailed specifications to guide the contractor are in the contract documents.

This paper focuses on the responsibilities and actions of the road authority to ensure they are delivered the quality they specified. The supply chain for a bridge can be through five or six organisations. Quality of intermediate products will not be assured by a contract between a road authority and a contractor. The road authority needs to monitor quality issues in casting yards, concrete suppliers, cement, aggregate and steel suppliers, and others. Unless care is taken, the certificate of compliance to a standard may be worthless.

It takes effort and expertise and a long term systematic approach. The wealth of a community can be very adversely effected by poor quality basic infrastructure.

Dublin Light Rail

John J. Noonan, Sinclair Knight Merz

The Dublin Light Rail system, designed by Sinclair Knight Merz in Melbourne, included an elevated section that followed the route of a former rail line and involved reconstruction of a number of rail bridges. The original line was constructed in 1854 and closed in 1959. One section of the line had been constructed on a 5m high embankment retained by masonry gravity retaining walls along each side of the embankment. The bridges crossed roads and a canal that intersected the line. The previous bridges would have been wrought iron with a ballasted track, and the replacement bridges are steel with a reinforced concrete deck and direct fixation of the rails to a track slab on the bridge deck.

The considerations that influenced the design task for the bridges included:

- The re-use of existing gravity stone abutments
- The re-use of existing gravity stone retaining walls along each side of the embankment
- The approval process administered by the authority set up to manage the contract
- The substantial increases in under-bridge clearance, by comparison with that which existed with the former bridges
- Preservation of the character of these historically significant structures

This paper discusses how these constraints were handled and the structural solutions arrived at. It also includes a brief reference to other significant structures constructed as part of the project.

Bridge Over Cooks River at Tempe - Sydney NSW Emergency Underpinning of Piers

R.Oates (RTA), L.Prasad (RTA), W.Stalder (RTA)

Underwater inspections during April 2002, revealed that the driven prestressed concrete piles of the existing 42 year old, 3 span, 100m long, 6 lane bridge across Cooks River at Tempe were in extremely poor condition due to a phenomena known as Delayed Ettringite Formation. The bridge is on the Princes Highway, a major heavy vehicle route in Sydney with an AADT of 55000 vehicles. A bridge closure would have caused great inconvenience to the travelling public and heavy transportation industry in the southern part of the City.

The Bridge Section of the Roads and Traffic Authority of NSW (RTA) developed an innovative concept for supporting and jacking each pier without the need for closing the bridge to traffic. Both pilecaps were supported on steel yoke beams held up by stressing bars attached to steel transverse beams located on top of new bored piles. The supporting system was carefully designed to eliminate the need for even minor demolition of any part of the existing structure during installation and allowed for future encapsulation into permanent works.

The project was successfully completed through the joint effort of RTA's in-house resources and the expeditious contractors, Waterway Construction. Constraints were numerous and included conducting the design and construction concurrently, lack of redundancy in the structure, night construction, safety of the travelling public, safety of workmen, monitoring and control of traffic, monitoring of bridge movements, environmental issues, construction machinery loadings and weather.

This paper provides an overview of the project with emphasis on how the issues encountered in design and construction of the emergency underpinning of the piers, were resolved.

Fatigue Design in the New Australian Bridge Design Code

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The introduction of SM1600 Loading in the new AS5100 Bridge Design Code provided the opportunity to bring the fatigue design rules up to date. The new loading looks ahead and accommodates the actual trends of truck traffic loading. The new standard fatigue assessment uses the concept of the equivalent number of cycles of the stress range resulting from the passage of an M1600 load, without the UDL component. A160 loading is used for very short span elements. The effective number of cycles is a function of the current number of trucks per day per lane, the route, and the span, L.

Two "fatigue design trucks" were initially proposed which accurately developed the average fatigue damage per truck on different routes. However, they required fatigue damage calculations by the rainflow method. They were replaced by reference to the stress range of an M1600 load, which required the introduction of a factor based on span.

Advantage is taken of software which analyses Culway weigh-in-motion data for its structural effect in specific locations and for specific spans. The fatigue damage per truck varied from highest on interstate routes to lowest on urban main roads.

Current annual growth rates of the freight task - highest 6.5% on Hume Freeway - were consistent with weigh-in-motion data indicating 3.1% p.a. growth in the number of trucks, 2.1% p.a. growth in 2-axle mass and 2.5% p.a. growth in 3-axle mass for the same route. These factors compounded to give an annual growth in fatigue damage of 9-15%. These data indicate that the fatigue limit state will be highly significant for short span bridges on heavily trafficked routes in the future.

Fatigue - It Will Change Our Culture

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The first road bridge design loads represented the load applied by horses and carts. These design loads were followed by the steam roller used to construct the pavement between the bridges, bullock drays, rigid trucks, semi trailers (T44) and now B Triples and Road Trains represented by the Austroads SM1600 design load for bridges. During this progression, design methodology has moved from working stress methods, to designing for the strength limit state and convincing ourselves that the serviceability limit state is satisfied. Fatigue has rarely been a dominant consideration in the design of Australian Road Bridges.

Along with this increase in load, the current strength limit state mindset in combination with the competitive design and construct process has lead to designs adopting higher strength materials. The consequence of this is that the stress ranges induced by live loads are increasing, raising the probability of fatigue failures.

The Austroads SM1600 loading was developed to ensure that bridges were constructed with a 100 year design life in an environment where heavy vehicle masses and dimensions continue to increase for the greater economic benefit of the nation. In the initial development of this loading, the strength and serviceability limit states were considered but not the fatigue limit state. Even a rudimentary analysis of the current T44 fatigue loading (500,000 trucks per lane) will demonstrate that this loading is only appropriate for lowly trafficked roads. It is orders of magnitude too small for our most heavily trafficked routes even before consideration of future growth in both mass and volume of heavy vehicle traffic.

This paper presents the results of an Austroads research project which was designed to develop a new fatigue load model that was consistent with the SM1600 design loading. The findings challenge the current design process and the selection of materials. It raises issues about consistency and how to implement what would be a step change in design culture. Consequently the findings have been debated intensely. This paper documents and encourages the debate with the goal of appropriate fatigue design of bridges that is consistent with the 100 year design life of bridge in an environment of increasing loads.

Design Loads for Box Culverts for the SM1600 Design Loading of the Australian Bridge Design Code AS 5100

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The new SM1600 design loading of the draft Australian Bridge Design Code AS 5100 is complex. The interpretation of some aspects of the loading and its application in the practical design of large precast reinforced concrete box culverts is not clear. In an attempt to clarify these aspects, published material relating to the development of the SM1600 design loading is reviewed, and the SM1600 loading is briefly compared with previous Australian codes, with overseas codes, and with current knowledge.

It appears that the SM1600 loading was not developed with box culverts and other short span or buried structures in mind. Modifications are suggested to the AS 5100 loading provisions for the design of box culverts, particularly in regard to live load surcharge and compaction pressure. The fatigue design provisions of AS 5100 are such that check for fatigue from moment and shear effects will usually be required for precast box culverts under shallow fill. In the past, this was only required for railway traffic loadings.

The use of the accompanying lane factors, together with the different uniform lane loads associated with the M1600 and S1600 design vehicles, appears to add complexity to the design of large precast box culverts and other short span or buried structures that is not required for these structures.

Accordingly, it is suggested that the SM1600 loading be modified with a view to simplifying it for the purpose of designing culverts and other short span buried structures, to a tandem or a triaxle loading applied without uniform lane load or accompanying lane factors. The limit for the length of short spans and associated axle loads as well as the fatigue loading should be decided as part of this modification.

The adequacy of the current M1600 triaxle load is reviewed using available data from Culway sites, and the use of this data for verification and adjustments of design vehicle loads is briefly discussed

Design and Construction of Black River Bridge, Tasmania

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A $1.9 million design, construct and demolish project to replace a significantly deteriorated 45-year old bridge over the Black River on Tasmania's northwest coast recently won a national Case Earth Award. The bridge is located on the Bass Highway approximately 20km east of Smithton and 1.5km from Bass Strait.

Van Ek Contracting carried out the construction of the new bridge and its approaches downstream from and adjacent to the old bridge, before demolishing the old structure. The concept design was developed by Graeme P. Walter Pty Ltd in conjunction with Van Ek Contracting with Sinclair Knight Merz responsible for the detailed structural design of the new bridge. Graeme P Walter Pty Ltd was responsible for proof engineering and for the design of the temporary works.

The design and construction processes were integrated in the conceptual planning of the project, with the co-operative input and involvement of the construction contractor, the designer and the proof engineer. An exemplary synergistic outcome was achieved, satisfying all project requirements specified by the owner and the local community, which has resulted in an attractive, durable concrete replacement structure.

Australia's First Fibre Reinforced Polymer Bridge Deck in a Road Network - The Anatomy of Innovation

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In Europe, Japan, China, the USA and Canada over seventy bridges employing composite materials have been built as technology demonstrators. Australia's first Fibre Reinforced Polymer (FRP) Bridge Deck on a road network was installed on 19 February 2003. This was the culmination of over 5 years of development and innovation involving a wide range of interested parties. This paper documents the path, participants and activities that lead to Australia's first fibre composite bridge in the road network. It provides an overview of the development from preferred concept to installed structure. The rationale behind selection of the preferred structural concept is summarised, before an overview of the product development process is of the concept is described including some of the technical issues that required resolution. Evaluation of the resulting prototype structure is then described. The rationale used to extend the prototype structural concept to a bridge in the public road network is described, including organisational and management issues that were critical to enable delivery of the project. The importance of organisational inputs that facilitated this innovation are then summarised.

The World's First RPC Road Bridge at Shepherds Gully Creek, NSW

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Reactive Powder Concrete (RPC) is a cementitious material consisting of cement, sand, silica fume, silica flour, superplastiser and water. The material was developed by Bouygues, the parent company of VSL, and is marketed under the brand name of Ductal.

It is almost self placing, and has a compressive strength of 180 MPa. The durability properties are orders of magnitude better than current high performance concrete.

In structural applications, RPC is used without any passive reinforcement. Very fine high strength steel fibres are able to withstand secondary tensile stresses. Prestressing counterbalances the main tensile stresses due to bending.

Ductal has been used worldwide for a number of structural applications, including several long span pedestrian bridges. However, the bridge over Shepherd's Gully Creek is the first bridge in the world to be constructed using Ductal for normal highway traffic.

The bridge is approximately 150km north of Sydney and replaces an existing timber bridge. It comprises four traffic lanes plus a footway. The live loading is the maximum of T44 and HLP320 truck loading.

The bridge is a single span of 15 m. It has a width of 21m, a skew of 16 degrees and is constructed in two stages. The bridge will be load tested by the Roads and Traffic Authority NSW after completion of the first half.

The superstructure comprises 16 precast pretensioned RPC beams and an in-situ reinforced concrete deck slab. The slab is placed onto thin precast RPC permanent formwork slabs that span between the beams.

The beams are of I section, with a depth of 600mm and a weight of 280 kg/m. They are spaced at 1.3m. The formwork slabs are 1.1m wide, 2.4m long, with a thickness of 25mm. The reinforced concrete slab is 170mm thick.

This paper presents the properties of Ductal and the details of the bridge. It also presents the conditions under which the use of RPC is favourable.

Applying a Systems Method for Setting Structure Performance Targets and Measures for a Long Term Concession

By Peter McCarten, MIPENZ, Chartered Professional Engineer, Group Technical Leader, Opus International Consultants, Napier, New Zealand

The objectives of setting structure performance targets and measures for a long term concession are to encourage the Concessionaire to;

- Accept a high level of ownership of the asset
- Be a good custodian
- Comply with the concession requirements for network serviceability
- Limit asset consumption
- Apply innovation in technology and contracting methods.

The systems method follows the general hierarchy of asset owner needs and sets performance targets and measures at strategic, asset preservation and operational levels.

Condition Rating, Indices and States based on structure inspections are proposed as the measure for defining the intervention levels. The Concessionaire is expected to improve the reliability of the condition assessment by undertaking appropriate non-destructive testing and evaluation. The road controlling authority needs to have a Bridge Management System in place that records structure condition and the targets are based on five condition states, ranging from CS1 excellent to CS5 very poor. The indices and ratings used are those typically available within the Bridge Management System. While the Stock Condition Index sets the overall minimum condition standard the other Structure Feature targets are set to encourage the Concessionaire to implement proactive preventive maintenance strategies.

The need for the asset owner or Road Controlling Authority to be involved throughout the process to 'buy in' to the performance targets and measures and ensure the standards and practices are consistent with the wider network is emphasised

Bridge Management Progression in New Zealand

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Over recent years, management of the New Zealand national highway network has been reformed. Previously this was the responsibility of a single Government Department. Now the highway management functions are split between funding provider, owner, consultants and contractors. Private sector services are procured using competitive pricing procedures. The resulting reforms to bridge management in particular, have been successfully implemented, with significant cost savings. The reforms have demanded careful consideration of contractual arrangements, systems development and personnel issues.

Reliability Analysis to Verify the Currently used Partial Safety Factors in Bridge Design: A Case Study using Baandee Lakes Bridge No. 1049

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Reinforced concrete flat slab bridges form a significant proportion of the older bridges in Western Australia. Many of these bridges are found to be "deficient" in load capacity when assessed by currently used elastic methods, but can be justified to have a higher load capacity using the yield line analysis method. A load rating increase using any method will inevitably lead to reduction in the safety levels previously enjoyed. The question is whether the reduced safety levels are still satisfactory.

This paper presents some of the results from a research program to investigate the suitability of the currently used partial safety factors with the yield line approach. The safety factors currently used in the Austroads Bridge Design Code (ABDC) are mainly based on past-experience. Changing the analysis method from elastic to yield line analysis, therefore require an appraisal of the safety factors used. To carry out this task, a reliability analysis was carried out based on the guidance provided by Eurocode. The analysis was undertaken by using a commercially available software, COBRAS.

The paper presents (a) a critical review of the reliability analysis methodology adopted in the software COBRAS, (b) a methodology for a reliability analysis, (c) the results of the reliability analysis of Bridge No. 1049, and (d) conclusions about the existing partial safety factors used in Austroads design guides.

Green Bridge in Brisbane: Planning

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Brisbane City Council (BCC) invited Main Roads Department (MRD) to join a team identifying a preferred design concept for the new bridge spanning Brisbane River at Dutton Park. The proposed structure will become part of an essential link between the South East Busway and the University of Queensland at St. Lucia. One of the main objectives is to facilitate access to the campus without channelling large volumes of traffic through the university grounds. A number of road alignments as well as structural systems have been investigated in some detail. Structural systems included box girder, arch, cable stayed and suspension bridges. As the project will be highly visible, the visual impact and aesthetics received high priority. The team conducted extensive public consultations addressing the needs and concerns of various interest groups as part of the process. The preferred option takes the form of a twin tower cable stayed bridge with a 195m main span. Innovative solutions have been proposed for the design of the piers for ship impact in the 18m deep river. The project will go to tender in January 2004 as a design and construct contract. A number of leading local and overseas consortia have already expressed interest in submitting tenders.

Terragong Swamp Bridge, North Kiama Bypass - Innovative Design

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The design and construction of the Terragong Swamp bridge incorporates a number of innovative features which allowed Baulderstone Hornibrook and Connell Wagner to secure this project in a fiercely competitive market. The significant economic benefits of the alternate design in terms of material cost and constructability ensured the success of the project for all parties, particularly the facility owner, the Roads and Traffic Authority of NSW (RTA).

This has been recognised in the Excellence Awards awarded to the project team by The Institution of Engineers and the Concrete Institute of Australia.

Compressive Membrane Action in Bridge Deck Slabs

Geoff Taplin Maunsell Australia Pty Ltd

Alan Hon Maintenance Technology Institute, Monash University

Compressive membrane action is usually ignored in bridge design, and the entire load is assumed to be carried by flexure of the deck slab. Allowing for the contribution of compressive membrane action may reduce the need for strengthening or replacement of deck slabs that do not have adequate flexural strength.

This paper describes a method for assessing typical beam-and-slab bridge decks taking into account compressive membrane action. The method has been developed through the laboratory testing of concrete specimens and the use of non-linear finite element modelling. The application of the method however only requires a frame analysis program.

Measured Live Loads on an Instrumented Sinusoidal Profile Helical Culvert

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Department of Main Roads, Queensland

Dr. Robert Day, Department of Civil Engineering,
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University of Queensland

Dr. Wong Koon Yuln, RPM Engineers, Malaysia

The current design method of helical lock-seam culverts in accordance with AS 1761 and AS 1762 is based on hoop ring compression. A research program was initiated by the University of Queensland in association with Australian Standards committee CE/25 to investigate the adequacy of the design requirements and performance of helical culverts with low overburden fill.

This project includes instrumentation of four circular culverts with pressure transducers, displacement transducers and strain gauges. Depending on location, the strain gauges were configured to record strain on the centroid of the section or strain on the extreme fibres of the profile. This arrangement allowed the hoop force and bending effects to be determined.

This paper examines the response to a legally loaded vehicle travelling across a 3000 mm diameter sinusoidal profile culvert.

The test program has measured a significant bending effect in association with a hoop force on the culvert. This paper examines the distribution of the force and bending effects about the circumference of the culvert. There are major differences between the measured behaviour of the culvert from the assumed ring compression design methodology in the current Australian standard.

Destructive Load Testing of Bridge No. 1049 - Analyses, Predictions and Testing

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Candy CCE, Technical Director Structures - Maunsell WA

Walton BL, Structural Engineer - Maunsell WA

Sanjayan JG, Associate Professor
- Monash University and Consultant to Maunsell

Bridge No 1049 over Baandee Lakes on Great Eastern Highway (Highway 1) is a 5 x 7.5 m span reinforced concrete flat slab structure built in 1969. The bridge is typical of a number of similar structures in Western Australia, many of which, when analysed by conventional methods, appear to be under strength for current vehicle loads.

This paper provides details of two destructive bending, and two destructive punching shear tests carried out on Bridge No 1049. It describes the analyses performed prior to testing, aimed at predicting the response of the structure at both serviceability and ultimate states, and discusses the results obtained.

The results showed that in the bending tests, the load-displacement response of the structure was accurately predicted by LUSAS FE analyses, but a general shear failure mode that accompanied the ultimate bending failure was not predicted. COBRAS yield line analyses gave accurate predictions of ultimate bending capacity. The results from the punching shear tests indicated that load distribution and pile-soil interaction greatly affect pile-head load at failure and this must be modelled accurately if analysis is to provide a correct assessment of punching shear force.

Onsite Hardness Testing of Reinforcement

Andrew Sonnenberg and Geoff Boully - VicRoads Design

Onsite hardness testing and laboratory based tensile testing was conducted on reinforcement used in pre 1960 bridges. The primary purpose of the testing was to develop a procedure to determine the yield strength of reinforcement insitu using a non destructive test method to improve the estimation of the load carrying capacity of existing bridges. The secondary objective was to collect data on the yield strength of reinforcement to assist in predicting the benefits which may be obtained from onsite hardness testing of bridges.

From the test data collected a correlation between the onsite hardness and the yield strength of reinforcement was determined. This empirical correlation may be used to assess onsite the yield strength of reinforcement. The average yield strength of reinforcement tested was found to be approximately 30% higher than the manufactures specifications. The results of the tensile testing indicated that assuming a yield strength of 230 MPa is conservative for unidentified reinforcement and that characteristic strengths of up to 285 MPa are possible in pre 1960 bridges.

Flexural Retrofitting of Concrete Bridge Beams Using CFRP Fabrics

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Monash University, Melbourne

Fibre reinforced polymers (FRP) have been used recently to strengthen RC structures. With current improvement in the quality of adhesives for construction, bonding between FRP and concrete is generally satisfactory. However, concrete cannot take high shear stresses. Therefore, FRP still tend to delaminate or debond from the structures. To study this debonding failure mechanism, a testing program including eight rectangular reinforced concrete beams is carried out. Testing shows two type of debonding: end debond and mid-span debond. Two theoretical models are then developed and verified with a relatively large database. It has been showed that the models are able to predict the ultimate debonding loads. For more inside understanding of the delamination phenomenon, a non-linear finite element model cooperated smeared cracks is also constructed. The model proves to be able to represent the beams' behaviour well, giving similar crack patterns and loading curves.

Feasibility study of the life extension of a 100-year old timber truss rail bridge over the Grey River, New Zealand

Rudolph Kotze, Director, Bridging
Holmes Consulting Group Ltd, New Zealand

Walter Rushbrook, Manager, Track and Structures,
Professional Services Group, Tranz Rail Ltd, New Zealand

The existing Grey River Rail Bridge, built in the late 1800's, crosses the Grey River in Greymouth, New Zealand. The bridge, also known as the Cobden Bridge, is approximately 300m long and is made up of 80ft and 40ft timber truss spans and a small number of timber spans. The timber trusses include steel bottom cords and vertical ties to carry tension forces, while the timber truss members were designed to carry compression forces. The piers are made up of driven timber piles. In plan the bridge has a double-S curve which is believed to be unique in the world.

Over the last 100 years the bridge has successfully carried rail traffic and currently still forms a critical link in the transport of coal for Solid Energy International from the West Coast of the South Island to Lyttelton Port on the East Coast. Planning for substantial increase in coal exports has prompted both Solid Energy International and Tranz Rail to focus on the ability of the existing Cobden Bridge to carry the increased traffic volumes as well as increased axle loads. Holmes Consulting Group Ltd. was commissioned to undertake a feasibility study into life-extension options of the bridge.

The feasibility study included an initial qualitative risk-based assessment of the bridge condition. This study was supplemented by a structural analysis of all major bridge elements. The results of this analysis were modified to incorporate current deteriorated steel and timber member properties. As-built information was included in the study and actual and allowable stresses were compared to determine overall bridge condition.

The results of the feasibility study showed that the bridge had reached the point where it would not be cost-effective to extend its life to carry the projected increased coal tonnages. Recommendations have been accepted by Solid Energy International and Tranz Rail Ltd. to strengthen the existing bridge in order to extend the life of the bridge for a limited period of time, while a replacement bridge is designed and constructed. The paper describes the history of the bridge, the methodology followed in assessing the condition of the bridge, results of the feasibility study and remedial work required.

Strengthening of Bridge over Iron Cove, Sydney NSW - A Realistic Design Load

Wije Ariyaratne, Manager Bridge Engineering, Bridge Section, RTA Operations

Parvez Shah, Manager, Bridge Evaluation and Assessment, Bridge Section, RTA Operations

Henry Fok, Project Engineer, Bridge Evaluation and Assessment, Bridge Section, RTA Operations

The bridge over Iron Cove on Victoria Road consists of seven steel truss spans of 52m and four continuous plate girder approach spans of 18m. The bridge has a carriageway width of 13.7m between kerbs and it carries four lanes of traffic. In addition it has one 3.1m wide dedicated BUS lane on the southern side and one footway on the northern side. The bridge is on a major arterial road and carries B-Doubles. The bridge was built in 1955 when the design load was MS18 (33t), which was significantly less than current legal loads (eg 42.5t Semi-Trailers and 62.5t B-Doubles).

Generally, strengthening of bridges is carried out in accordance with the 1996 AUSTROADS Bridge Design Code ('96 ABDC). However, because of the earlier studies conducted in assessing the bridge, it was evident that strengthening the bridge as per '96 ABDC would have been exceptionally expensive. In addition, it was thought that the bridge would not experience the live loads stipulated in the '96 ABDC for the next 50 years or during its expected life.

Therefore, the Bridge Section proposed a realistic method of determining live loads for strengthening the bridge for legal loads based on the current legal loads experienced by the bridge, the probability of multiple presences of legal loads and the predicted future growth of legal loads over the route.

The method was to conduct a traffic survey of the bridge for four weeks and determine the actual legal loads on the bridge and determine the multiple presences of these loads on different lanes. From this data projected legal loads, their multiple presences and the probability of occurrences were estimated. The client accepted the method, the traffic survey was completed and the bridge is currently being designed by the Bridge Section for the projected future legal load combinations.

This realistic approach will result a significant saving in the strengthening of the bridge. This paper discusses the use of the approach and it is believed that the use of such an approach would be beneficial in strengthening other similar bridges with more than two lanes of traffic.

The inspection, assessment and maintenance of state-owned timber bridges in Queensland

Shane Crawford
Engineer in the Bridge Asset Management Section,
Department of Main Roads Queensland.

Outline: The session is directed towards Local Government regarding: the development of the bridge information system; the state wide prioritisation of bridge repair work; the new about to be published timber bridge maintenance manual; and timber bridge testing in the field and in the laboratory.

This presentation describes the development and operation of the QMR bridge asset management system over the last five years, with emphasis on the 500 timber bridges on main roads. This is directly relevant to local authorities who have approx. 3000 similar bridges. Inspection policy and practice, data base info, analysis of the data base, prioritisation of repairs / replacement, and keeping the network available for the transport of heavy loads. Risks are being managed with inspections, field testing laboratory testing, and targeted repairs.

The new QMR timber bridge.

Timber Bridge Preservation and Maintenance Practice

Lloyd Margetts, – Structures Delivery Standards Engineer,
Main Roads Western Australia

Outline: The presentation will cover a range of preservation and maintenance practices undertaken as standard practice on timber structures by Main Roads Western Australia. Included in the presentation will be practical observations on points of maximum risk to timber structures and preservation of the bridges different structural elements. It will also include details on the practical application and use of preservatives such as fungicides and strategies for termite control.

Beaudesert Shire's experience with bridge asset management

Stewart Wall, Infrastructure Engineer,
Beaudesert Shire Council, Queensland.

Following the High Court Case on a collapsed shire bridge in NSW, Beaudesert Shire implemented the "asset management principles" laid out in the judgement.

All bridges were inspected, and their load capacities and risks assessed. A considerable number were found to be unsafe, and load limits, bypasses and closures were implemented. This caused considerable disruption to the transport task in a rural community, and the shire has worked with the community to prioritise works and remove restrictions as quickly as possible.

The shire's experience will provide valuable guidance to others when they adopt an effective bridge asset management system.

Bridge Management and Assessment in the UK

Campbell Middleton
Cambridge University Engineering Department, UK

What can be learned from the experience gained in the UK now that its 15-year national programme of assessment and strengthening has in principle come to an end? What sources of information and guidance are currently available to bridge engineers responsible for maintaining the bridge stock? The principle findings of audit reports on the assessment program and also on the implementation of guidance for the management of substandard bridges are presented along with specific procedures for improving our predictions of load carrying capacity. Recent initiatives in bridge management are outlined and questions raised relating to the fundamental assumptions underlying our current definition of failure. Finally, several new bridge-related developments are reviewed and possible areas for utilisation of emerging technologies are discussed.

Bridge Asset Management in NSW

Michael B Bushby
General Manager Infrastructure Maintenance
Roads and Traffic Authority (NSW)

Management of the arterial road infrastructure bridges in NSW is a component of the overall road network infrastructure management undertaken by the Roads and Traffic Authority (RTA). Asset management principles are applied in the context of the NSW Government Policy and Strategic context.

The RTA recognises the importance of managing bridges and their load carrying capacity, to ensure overall network connectivity and level of service to road users. A committed and competent bridge owner and manager, the RTA continues to proactively manage its bridge stock by:

- understanding issues related to the relevant design era,
- identifying and responding to changes in condition of bridge elements through a systematic and structured inspection regime,
- addressing emerging bridge issues, investing in new technologies and
- implementing innovative solutions in the management of its heritage bridge stock.

The RTA's bridge inventory has been constructed over more than 100 years and as such there are many emerging technological issues regarding bridge management. The RTA will continue to address these emerging issues in a professional manner.

Strategies have been developed and adopted based on material type, historical or geographical groupings. The RTA plans to continue to manage the NSW bridge inventory, balancing the often competing demands of capacity and required usage.

Redbournberry Bridge - Dual Composite Design

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J Steele, Project Engineer, Connell Wagner Sydney

C Jones, Manager Bridge Design (External)
Roads and Traffic Authority, NSW

S Powell, Engineer, Connell Wagner Sydney

The new $9.5M Redbournberry Bridge spans the Hunter River near Singleton in NSW, alongside an existing 19th century historically significant iron truss bridge. The main spans consist of continuous steel composite trough girders. A limitation of conventional composite structures is the inefficiency of hogging sections. One solution to this problem is to provide a second composite slab at the bottom flange level, thus providing several advantages over more traditional methods. This paper will outline this and other innovative features of the design and construction of the main river spans and describe the preservation of the existing iron spans as a working part of the new bridge scheme. The bridge is currently under construction by John Holland.

Three Dimensional ACES Models for Bridges

Noel Wenham, Design Engineer, Wyche Consulting

Joe Wyche, Director, Wyche Consulting

Plane grillage models are widely used for the design of bridges, and are suitable where bridges can be characterised as having a beam and slab arrangement, but have limitations when box girder sections are required. For box girders, a three dimensional analysis is necessary, which usually involves using finite elements. There are many practical difficulties using finite elements as a direct design tool, such as the size of model required to get sufficient accuracy, the difficulty of converting what are generally stress outcomes to design action parameters, and the limitations of computers, software and/or available design time.

This paper shows how a three dimensional arrangement of members, similar to those which would be used in a plane grillage, can provide direct design actions such as bending moments and shear forces, for any bridge type from a simple beam and slab through to a haunched continuous box girder. The method is as accurate as a fine mesh finite element model, but requires considerably less computation power, which means even large structures can be modelled with a relatively small program like ACES. A box girder example is worked through to illustrate how the analysis method may be applied and highlight the advantages of this method.

In conjunction with the three dimensional model, a new simple approach for treating shear lag is suggested. Both the shear lag analysis, and the three dimensional grillage method are very "transparent" about the interactions of the various parts of the structure carrying the loads, and both should also prove useful as teaching aid.

Unique Cable Stayed Bridge for Shopping Centre

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P.T. Sheasby, Senior Project Engineer
Connell Wagner Pty Ltd, Sydney, Australia

The new Westfield Shopping World development at Bondi Junction, Sydney, comprises major shopping blocks located on either side of busy Oxford Street which are linked by an underground multileveled structure located beneath the street. The development conditions required that at least two traffic lanes plus provision for pedestrians and existing services be maintained at all times during construction.

This paper focuses on special features of the adopted bridge option, constructed to meet the development conditions. It describes the reasons behind the need, structural options considered and the design and construction features of the innovative cable stayed solution that was incorporated into the final building structure.

A Simple Method for Rating of Reinforced Concrete Slab Bridges

Wije Ariyaratne, Manager, Bridge Engineering
Bridge Section, RTA

Parvez Shah, Manager, Bridge Evaluation and Assessment, Bridge Section, RTA

Vijay Kodakalla, Project Engineer, Bridge Evaluation and Assessment, Bridge Section, RTA

There are over 180 reinforced concrete slab bridges under the jurisdiction of the Roads and Traffic Authority of New South Wales (RTA). Of these bridges about 70 were built prior to 1948 when the design loading was between 16 and 17 tonnes.

The aim of the project is to develop a quick and a simple method to determine the rating of the reinforced concrete slab bridges. Yet this method needed to be safe and be able to deliver realistic results.

This paper discusses three different assessment methods used for a typical concrete slab bridge, which was earlier proof load tested by the RTA. These methods are the NAASRA 1976, Linear Grillage (LG) analysis and Effective Width Method (EWM). The results obtained from these methods are compared with the rating obtained from the proof load testing of this bridge.

Finite Element Analysis (FEA) of a bridge will give rating close to that obtained from a Proof Load Test. However, this is time consuming and is therefore suitable for rating of an individual bridge. Of the three methods compared, the EWM has the advantage of being is easy to apply, less time consuming, reliable and conservative and is therefore suitable for load rating of a group or groups of reinforced concrete slab bridges.

It is therefore concluded that the 'EWM' is a suitable method for load rating of a group or groups of concrete slab bridges.

Condition assessment of an 8-year old Freeway bridge, its load capacity and rehabilitation assessment

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Very early deterioration, in the form of cracking, has started in the in-situ cast concrete columns, cross-heads, abutment and parapet walls, and in the pre-cast, pre-stressed T-beams at the exposed sides of the bridge. The bridge was only 8 years old at the time of the investigation. The vertical cracking of the columns, parallel horizontal cracking of the external faces of the edge T-beams, map-cracking of the cross-head ends, and the abutment walls closely resembled those caused by alkali-aggregate reaction (AAR). However, AAR was not strongly suspected, because it was known that the concrete contains fly ash and due to the relatively early onset of cracking. Representative elements of the bridge were cored and investigated for possible cause(s) of deterioration. The results presented in this paper discount AAR as a cause of cracking at the present time. Three possible mechanisms of distress were identified for this bridge, namely, (a) mechanical overloading causing structural cracking of pier crossheads (and possibly columns); (b) drying shrinkage and (c) cyclic thermal stresses, contributing to the cracking of the columns and external surfaces of the edge beams. The observed cracking, caused by these mechanisms, probably arose from inadequate material formulation, concrete mixing and placement practices. The results of load capacity assessment and recommended rehabilitation are also presented, including carbon fibre strengthening and re-coating with anti-carbonation and finally antigraffiti coatings.

Overview of Assessing the Load Carrying Capacity of Timber Bridges Using Dynamic Methods

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A key element of an effective asset management system for bridges is the ability to undertake cost-effective load assessment and evaluation of the current state of bridges and to be able to understand the causes and quantify the rate of their deterioration. Whilst proof-load testing and health monitoring procedures provide valuable tools, such procedures are generally too complex and too costly to be applied across the entire inventory of short span timber bridges. Such testing is costly to conduct, requires equipment and expertise not readily available to many local government bodies and has significant inherent uncertainties in regard to the assumed relationship between stiffness and strength of timber girders.

This paper describes procedures that have been specifically developed to address the need for relatively inexpensive load assessment, costing less than 25% of the expenditure required for static load tests, (and no more than 1%-5% of the replacement cost of the asset) that will provide reliable, quantitative information on the performance of short and medium span bridges. These procedures contain two significant innovations - the first is accurate determination of the global deck stiffness of a timber deck using dynamic frequency analysis; the second is prediction of load capacity of a bridge deck, using a probabilistic relationship between bending strength and gross stiffness (EI) of timber girders.

Rehabilitation of Willaston Bridge: Utilisation of Rivet Heads as Shear Connectors

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Centre for Infrastructure Diagnosis,
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The University of Adelaide

The Willaston Bridge at Gawler, S.A. was built during 1890 using rivetted wrought iron plate girders. The original timber deck was replaced with a non-composite reinforced concrete deck during 1956, which was cast on top of the girders with the top flange rivet heads embedded in the deck concrete.

A need for this bridge to carry Higher Mass Limits (HML) vehicles has arisen, but its theoretical girder capacity is too low, based on the assumption of non-composite behaviour. However, composite action has been suspected in view of the lack of evidence of damage caused by overloading.

Bridge load testing, in conjunction with laboratory tests, was used to determine the effectiveness of rivet heads acting as shear connectors. Rivet heads are quite capable of transferring the concrete/girder interface shear, but are unable to prevent separation. A laboratory push test was developed to measure the shear transferred by the rivet heads for varying interface pressures, representing the dead and live loads on the bridge. A “clamped” push test was also developed to investigate the increase in strength by clamping the concrete deck slab to the wrought iron girders.

The results of the bridge testing showed that partial composite action was occurring at the serviceability limit state, but the laboratory tests showed that its extent was unreliable at the ultimate limit state. The clamped push tests showed that clamping the deck concrete to the girders is a viable strengthening method for the ultimate limit state.

A future with Advanced Composites in Bridge Engineering

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Opus International Consultants, Auckland, New Zealand

This paper highlights some of the key contributions that advanced composites have made to bridge strengthening, with some case studies in New Zealand.

Selection of Option for Replacement of Major Bridge Expansion Joints

Greg Forster, Roads and Traffic Authority, NSW

Large bridges usually have large expansion joints to cater for movements due to concrete shrinkage and creep and temperature variations. When these joints wear out, the selection of a replacement option needs to consider a range of factors, including bridge articulation, traffic volumes, and future maintenance. The process of selecting the replacement option is discussed, using as examples the actual and planned replacement of joints for two major road bridges in NSW, at Pheasants Nest on the F5 South-Western Freeway south of Sydney and Mooney Mooney Creek on the F3 Sydney/Newcastle Freeway, north of Sydney. Issues associated with the reasons for joint replacement, delivery of the project, and replacement joint design and installation are discussed. Suggestions for avoiding similar problems with expansion joints in the future are offered.

Bridge Barriers - Implementing the AS5100 Bridge Design Code Provisions

Vincenzo Colosimo, Bridge Loads Engineer
- VicRoads Design, VicRoads

Bridge Barriers have been the subject of extensive world wide investigations in recent years as emphasis on road safety has intensified. There has also been a major shift in road traffic towards smaller vehicles and heavier commercial trucks. The implementation of cost-effective bridge and roadside barriers relevant to the traffic mix and site risk, is extremely important in order to improve road safety.

VicRoads has since October 1997 implemented guidelines for the design and performance selection of appropriate barriers relevant to site risk. Investigations for this work have drawn on international best practices and have formed the basis of the current Austroads et al. AS 5100 Australian Bridge Design Code (4) provisions. The Code provides guidance and direction for multiple performance level selection, design and acceptance of crashworthy barriers.

The paper includes details of tested barrier systems which with minor modifications have formed the basis for the design of recognisable multiple performance level barriers. It presents new or retrofitted barriers designed or upgraded where possible to conform with the requirements of the new code. It also details minor improvements to systems used aimed at fulfilling the code requirements and thus leading to possible future standards. In addition the paper outlines barrier options for the higher performance levels, which subject to prototype crashworthiness may be considered for approval, for specific uses.

Keywords: bridge barriers, parapets, design, code, selection, containment, road safety.

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Design, Specification, Manufacture and Testing of Laminated Elastomeric and Pot Bearings to AS5100.4

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The Australian Bridge Design Code is about to be re-published as Australian Standard AS 5100. This paper provides some notes for bridge designers on the specification of bearings to Part 4 of this Standard, "Bearings and Deck Joints" AS5100.4, and compares it with its forerunners, ABDC ('92/96 "Austroads Bridge Design Code, Part 4") and AS1523 "Elastomeric Bearings for Use in Structures", as well as other international codes.

We concentrate on the following differences between AS5100.4 and ABDC:

- Pot bearings and sliding surfaces are now specified at the more logical ultimate limit state (ULS), with a new set of design criteria and generally more conservative stresses.
- Laminated elastomeric (LE) bearings are still specified at the serviceability limit state (SLS), but with tighter limits for shear and rotation.
- Anchorage requirements for both pot bearings and elastomeric bearings are amended, again slightly more conservative.
- Reaction to sliding of bearings has been rationalised (for the effect on the structure).
- Guidance for uplift is provided.
- Testing provisions have been clarified for elastomer, for LE's, and for pot bearings.

Although we discuss some clauses in AS5100.4, this is not an official commentary. The authors represent Ludowici Ltd, an Australian designer and manufacturer of elastomeric, pot bearings, and other engineered products (joints etc), whether for bridges, buildings, earthquake, or vibration isolation. It is from this perspective that we discuss the need for a clear understanding between all team members involved in the design and manufacture of the bridge (or building) and its critical components. The use of testing is discussed in detail, whether to "prove" designs of pot bearings, or for the quality control of LE bearings.

Essential design parameters and their "permissible interaction" are discussed. We emphasise the information that must be transferred from the bridge designer to the bearing designer to permit an economical and adequate design of bearings. An example of a detailed Bearing Questionnaire is given, and some design rules additional to AS5100.4 are also suggested.

Draft Australian Bridge Design Code AS-5100 Section 4 - Bearings & Expansion Joints. Trends in rehabilitation of deck joints and design developments of modular joints

Oscar Velo

The Draft of Australian Standard AS-5100 released for public comment is the intended replacement for the current Austroads Bridge Design Code 1996. Section 4 of AS-5100 addresses the important structural bearings and deck expansion joint components of bridge structures. This paper will review the key changes in specification requirements of expansion joints between the current Austroads BDC and draft AS-5100 (released for public comment).

In further review of bridge deck expansion joints this paper will discuss recent trends in the approach to the rehabilitation of single element deck expansion joint systems with movement range up to 100mm. The paper will highlight the need for assessment by the specifying engineer of correct process control of the rehabilitation methodology.

Larger movement multi seal element "modular" expansion joints have recently been the subject of significant review by Road Authorities with respect to their requirements to the design approach of the product. Such reviews have been driven by the in-service failure of some proprietary systems. This paper will summarise the principal areas addressed in current design of new generation modular expansion joints arising from these more demanding specifications.

A case history of the replacement of one such failed modular joint will be reviewed at the conference presentation and is not referenced in this actual paper, as the replacement event will occur in early 2004 and after the writing of this paper.

More than just a pedestrian link - The Goodwill Bridge, Brisbane

I.D. Ainsworth and P.A. Burnton

Since opening in October 2001, the Goodwill Bridge has attracted large numbers of pedestrians and cyclists, both commuters and casual users eager to take advantage of the new link formed between Southbank and Brisbane's CBD.

The spectacular steel and concrete bridge has a unique form that was initially established in an architectural concept design competition. The winning concept broke the 460m long bridge in to visually different sections to enliven the journey for users with the middle section being an extraordinarily slender arch that spans over the navigation channel of the Brisbane River.

The daring form has generated great interested in the previously neglected southern end of Southbank and has revitalised QUT's Gardens Point campus. The visual and functional contribution that the bridge makes to the urban fabric of inner city Brisbane has been recognised in awards for architects Cox Rayner, and the quality of the engineering design and construction techniques has been recognised by a series of industry awards for Engineers Arup and contractor John Holland.

The paper outlines the main features of the design, and describes the role that close cooperation between designer and contractor played in the successful prefabrication and erection of the bridge. The paper also provides insights in to the challenges and rewards of working with architects on infrastructure projects that have traditionally been driven primarily by engineering considerations.

Design of aesthetically pleasing bridges for the Dubai Marina

Rajiv Kalra, Principal - Civil Structures,
Hyder Consulting Pty Ltd

Rasaratnam Vigneswaran, Senior Bridge Engineer,
Hyder Consulting Pty Ltd

Dubai Marina is a 700-acre development and promises to be a city within a city and marks one of Gulf's biggest real estate development projects. The development vision is for over 40 million square feet of building area. A major infrastructure program is currently under way and as part of the new road network four new bridges, with the main spans of up to 126m, are being built. The bridges have an overall width of 28m and will connect the island Marina to the existing road network over a 3.5km long featured canal. The client's desire was for the bridges to be of high aesthetic and engineering quality. Hyder Consulting's specialist bridge design team spent a considerable time developing their concept with the project architect. The most prominent feature of the structure is its soffit which comprises a crescent shaped curved and dished profile. The solution adopted for the bridge design is essentially a three span continuous post tensioned box girder structure but to provide a visual effect of a single span structure the two back spans "disappear" inside the abutment structures. The concept of a multi span box girder appears simple but the geometric requirements of a structure increasing in cross section not only in depth but also in width of the box posed serious challenges to the design team. The project was delivered successfully to a very tight time scale taking local environmental conditions into account while designing the structure to British Standards.

Design and Construction of the New Upper Harbour Crossing

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Ian Billings - Chief Bridge Engineer, Beca Infrastructure, Auckland, New Zealand

Mark Evans - Project Manager, Fletcher Construction, Auckland, New Zealand

The New Upper Harbour Bridge consists of a 458m long balanced cantilever bridge together with approach spans and is under construction alongside the existing crossing of the Waitemata Harbour in Auckland. The new bridge is being implemented under a Design and Construct contract.

The design employs a wide transversely post tensioned single cell box girder, elimination of joints and bearings (except at abutments), use of approach span deck units for temporary access staging, two stage pours for cantilever segments and the use of external and internal longitudinal post tensioning in the box girder. It meets or exceeds all project aesthetic, environmental, durability and operational requirements and was proved via the tender process to be particularly cost-effective.

Modular Deck Joints - Investigations into structural behaviour and some implications for new joints

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Eric has over 20 years experience in acoustics, vibration and for the last three years he has directed the structural dynamics studies of four RTA road bridges to determine the mechanism causing the premature fatigue induced failure of modular expansion joints. It is considered that this work has identified a major defect in the quasi-static load case assumption used universally in bridge design codes.

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For the last 20 years, Steve has practiced the field of noise and vibration. He has a particular talent in experimental modal analysis and is noted for his innovative and cost-effective solutions to complex dynamic problems.

Gordon J. Chirgwin, Manager, Bridge Policies Standards & Records,
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Gordon has 31 years experience in roads and bridges, and for the last 10 years has been managing technical policy in the bridge and structural fields.

Environmental noise complaints from homeowners near bridges with modular expansion joints (MBEJ) led to an engineering investigation into the noise production mechanism. The investigation identified modal vibration frequencies in the MBEJ coupling with acoustic resonances in the chamber cast into the bridge abutment below the MBEJ. This initial acoustic investigation was soon overtaken by observations of fatigue induced cracking in structural beams transverse to the direction of traffic. These beams are, in the English-speaking world, universally referred to as centre beams. However, in Europe the use of lamella to describe these beams is equally common. A literature search revealed little to describe the structural dynamics behaviour of MBEJ's but showed that there was an accepted belief amongst academic researchers dating from around 1973 that the loading was dynamic. In spite of this knowledge almost all designers use a static or quasi-static design with little consideration of the dynamic behaviour, either in the analysis or the detailing.

Principally, this paper identifies the natural modes of vibration of the single support bar design MBEJ installed into Sydney's Anzac Bridge and the welded multiple support bar design MBEJ installed into the southern abutment of the southbound carriageway of the bridge over the south channel of the Manning River (Taree By-pass). Secondly, the paper will report the dynamic amplification factors (DAF) obtained after extensive static and dynamic strain gauge measurements of both MBEJ's.

Design of the grade separation of Gippsland Railway at Narre Warren Cranbourne Road

K. Srivelan, Project Engineer, Connell Wagner Pty Ltd

John de Araugo, Principal, Connell Wagner Pty Ltd

Michael Hirons, Project Manager, McConnell Dowell Construction Pty Ltd

This paper discusses the design of the grade separation of the existing level crossing of the Gippsland Railway and Narre Warren Cranbourne Road in the rapidly growing outer Melbourne suburb of Narre Warren. The grade separation is achieved by lowering of the road gradeline to underpass the railway and duplicating the road. The aim of the design is to minimise the road lowering to attain a satisfactory vertical alignment for the grade separation such that required sight distances are achieved whilst maintaining the existing rail grade. This design aim was achieved by minimising the structural depth through adoption of a "through girder" type bridge constructed from prestressed concrete. The bridge was designed to be constructed alongside its final position and then jacked into place within a single weekend occupation of the rail tracks. The innovative solution discussed in this paper will maintain a safe operation for rail customers, without prolonged reduction in the level of service for both road and rail traffic and meet the objectives of the project.

Bridging on the Alice Springs to Darwin Railway

Ken Ross, Principal Engineer
Kellogg, Brown and Root, Brisbane

Scott Ashdown, Senior Engineer
Kellogg, Brown and Root, Brisbane

Tony Dawson, Chief Engineer
Kellogg, Brown and Root, Melbourne

The ADrail Design & Construct Joint Venture was responsible for the design and construction of the Alice Springs - Darwin Railway project. The 1420km project required 93 bridges to be constructed in remote locations, many where the readily available workforce was unskilled, and the infrastructure to support construction projects was minimal. Emphasis was thus needed to be placed on appropriate constructability, minimising site activity, and maximising prefabricated steel and precast concrete components. The result is an economical portfolio of bridges.

Notes

Notes

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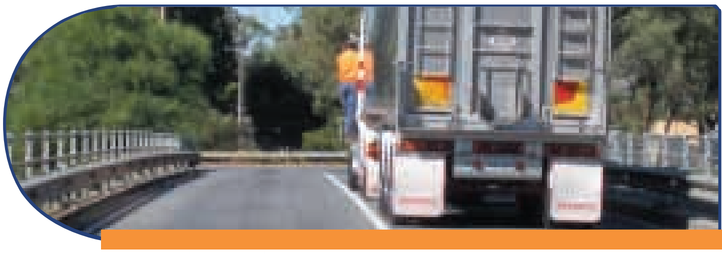

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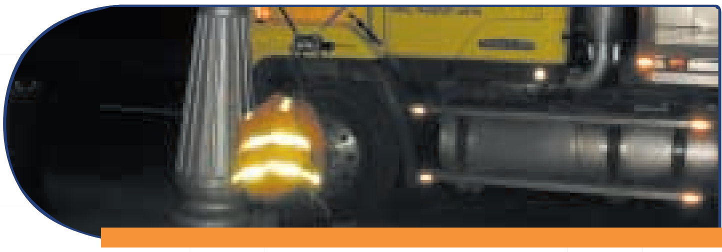

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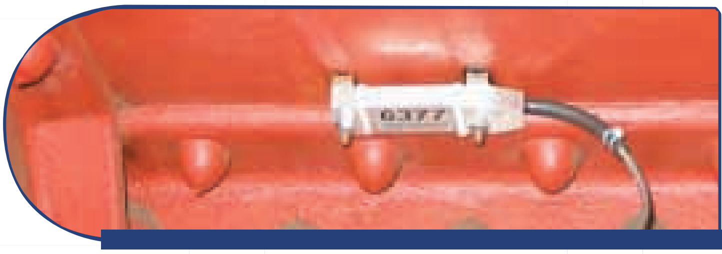

Important Note:
Aaron will be detailing how the system works in his presentation on Day 1 of the conference.

Don't miss it –
Session 1B at 10.30am on Wednesday, 19 May.

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Call Aaron Brimfield on 0418 512 125

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