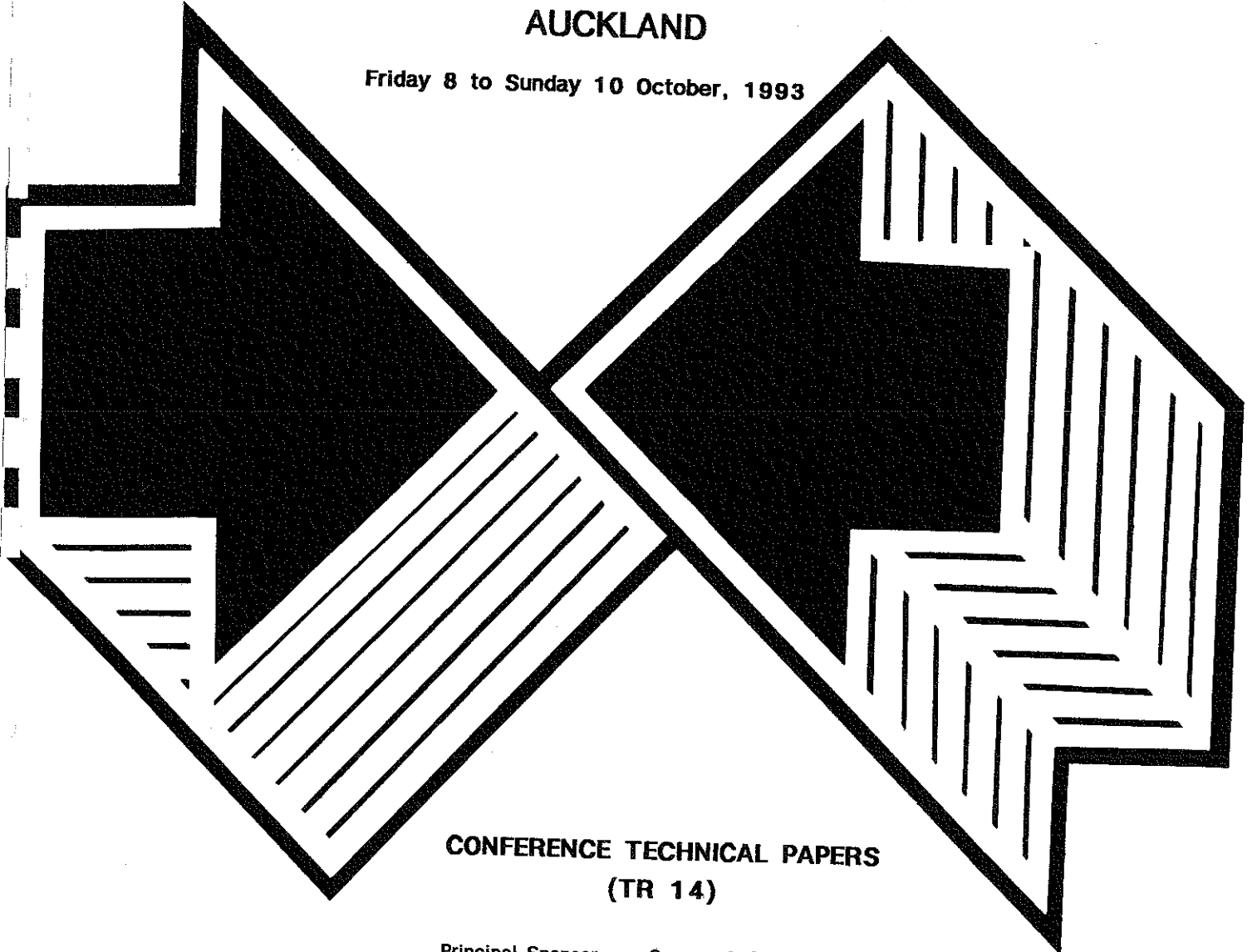


NEW ZEALAND CONCRETE SOCIETY

**CRETE
CON'93**

**TECHNICAL CONFERENCE AND AGM
WAIPUNA LODGE, MT WELLINGTON
AUCKLAND**

Friday 8 to Sunday 10 October, 1993



**CONFERENCE TECHNICAL PAPERS
(TR 14)**

**Principal Sponsor : Cement & Concrete
Association of NZ**
**Co-sponsors : Firth Industries
Fosroc Expandite
Humes Concrete
Nuplex Industries
Pacific Steel 'Seismic 430'
Works Consultancy Services**

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

NEW ZEALAND CONCRETE SOCIETY

CONCRETE '93

Technical Conference and AGM
Waipuna Lodge, Mt Wellington, Auckland
8-10 October

CONFERENCE PROGRAMME AND TABLE OF CONTENTS

FRIDAY 8 OCTOBER

- 1200 Registration check-in
1300 Welcome and conference opening
- E P Sansom, NZ Concrete Society
- D Aitken, NZ Concrete Masonry Association

SEMINAR:

"Creating Structures in Masonry and Concrete"	
1310 - 1500	Session 1 Chairman: E P Sansom
	Keynote Address: 'Masonry Yesterday, Today & Tomorrow' and 'Whoops! Sorry About Those Goofs' - Jim Amrhein, Executive Director, Masonry Institute of America 1
	Summary of Masonry Design Codes - Tanya Wylie, Firth Industries 8
	Impact of Recent Bracing Tests - S F George, Wass Buller & Assocs 10
1500 - 1530	Tea/Coffee
1530 - 1720	Session 2 Chairman: D Aitken 17
	Keynote Address 'Non Poured Concrete in Domestic Construction' - R Walker, Roger Walker Architects
	Panel Discussion on Design and Construction
	- Acoustics and Passive Solar Energy - D P Barnard 21 Cement & Concrete Association of NZ
	- Architectural Details and Waterproofing - E P Sansom, Sansom Contract Services 27
	- Concrete Floors and Site Problems - D Morrison Firth Industries Ltd 31
	Close of seminar
1730	NZ Concrete Society Annual Meeting
1830	President's Reception followed by buffet dinner

SATURDAY 9 OCTOBER

0900 - 1030	Session 3 Industrial Structural Systems Chairman: D P Barnard	
	The Hurricane Iniki - J Amrhein	32
	Tilt-up Concrete - A Designer's Perspective	34
	- G N Banks, Alan Reay Consultants	
	Review of Tilt-up Construction Details - J f Restrepo	38
	and R Park, University of Canterbury	
1030 - 1100	Tea/Coffee	
1100 - 1230	Session 4 Recent and Current Innovative Concrete Construction	
	Chairman: L G Cormack	
	Chaffers Marina Breakwater, Wellington	44
	- A Collow, Beca Consultants and B E Habershon, Downer & Co.	
	The Use of Cement Stabilised Marine Mud in Breastworks for the Ports of Auckland	49
	- S J Priestley, Beca Consultants	
	The Restoration of the Historic Fairfield Bridge, Hamilton	53
	- L Leach, Hamilton City Council and R Robinson, Contech Group	
1230	Light lunch	
1400	Optional afternoon programme including site visits	
1900	Conference Dinner and Entertainment - Auckland Maritime Museum	

SUNDAY 10 OCTOBER

0900 - 1030	Session 5 Concrete Research Chairman: G H Rowe	
	Support of Hollow-Core Precast Concrete Floors	61
	- J C Mejia and R Park, University of Canterbury	
	Elongation in Frame Structures - R Fenwick, B Davidson	73
	and K Douglas, University of Auckland	
	The Cyclic Load Performance of a High Strength Concrete Beam-Column Joint	79
	- G J Beattie, Central Laboratories, Works Consultancy Services	
	The Analysis of Hardened Concrete - D A St John, Industrial Research	90
1030 - 1100	Tea/Coffee	
1100 - 1230	Session 6 Technical Advancements Chairman: R W Irwin	
	Recent Developments in the Application of Cathodic Protection	95
	to Reinforced Concrete Structures - M Z Lourenco, Monash University, Melbourne	
	Development of a High Performance Concrete Topping for a Refuse Transfer Station	102
	- J Plutecki, Hamilton City Council and D Chisholm, C&CA NZ	
1230	Conference closure	

Further copies of this volume, designated NZCS
Technical Report (TR) 14, Price \$40 + GST, are available from:

The New Zealand Concrete Society
P O Box 17-268, Karori
Wellington
NEW ZEALAND

Phone/Fax (04) 476-6866

ISBN 0-473-02233-8



THE RESTORATION OF THE HISTORIC FAIRFIELD BRIDGE, HAMILTON

Leroy Leach (*) and Robert Robinson (**)

SYNOPSIS

The Fairfield Bridge with its distinctive concrete bowstring arches has been a Hamilton landmark since the mid-1930's. Recently its importance was recognised by the Historic Places Trust by the application of a "B" classification.

Extensive cracking, particularly on the arch end blocks, has been identified as being the result of alkali-aggregate reaction. An intensive investigation in 1991 however indicated that the main concerns were more likely to be caused by poor detailing and poor construction control. This has allowed subsequent corrosion of reinforcing bars in some areas.

Hamilton City Council recognised the need to carry out a major rehabilitation project to protect the value of the asset and ensure its long-term serviceability.

The full extent of the work involved in the project (the first of two stages) could not be determined until the bridge was completely cleaned down and defective concrete broken out. The contract needed very careful consideration and attention to quality materials and methods.

The paper which is jointly prepared by the client and the contractor describes the contract and the execution of the works. It compares the objectives and expectations of the client with the actual outcomes.

1.0 INTRODUCTION

Construction of the Fairfield Bridge across the Waikato River was undertaken by Roose Shipping Company, Hamilton and completed in 1937. The bridge is 139m long, consists of three main bowstring arch spans and two approach spans and is constructed of reinforced concrete. It is one of four such bridges, with others located at Tuakau and Balclutha. The fourth bridge is now demolished and was located in Palmerston North.

In 1981 the DSIR was commissioned by Hamilton City Council to investigate the cause of cracking in the archbows and endblocks. St John (1981) concluded that the cracking was caused by alkali aggregate reaction.

In 1990 the New Zealand Historic Places Trust (The Trust) gave the bridge a "B" classification which is allocated to structures which require care and permanent preservation based on the merit of historical significance or architectural quality.

The Trust finds particular architectural quality in the form of bowstring arches and the pierced concrete balustrades.

An implication of the Trusts classification is that the bridge will have to be retained and when no longer serviceable a replacement bridge would have to be built at a different location. Because of this Hamilton City Council considered it important that remedial works and an ongoing maintenance programme be implemented to maximise the serviceable life of the bridge.

In 1991 Hamilton City Council Design Services were commissioned by the City's Streets Engineer to inspect the bridge. The investigation revealed considerable corrosion of primary reinforcing steel and a more detailed specialist investigation was considered necessary. The specialist survey was awarded to and carried out by Works Central Laboratories in 1991.

(*) Civil Engineer, Design Services, Hamilton City Council
(**) General Manager, Construction Techniques Limited

2.0 REHABILITATION WORKS

The results of Works survey pointed to poor quality cover concrete and poor stormwater drainage detailing as the main causes of the bridges degradation. The report clearly indicated that remaining life could be extended by carrying out appropriate remedial works. Remedial recommendations were to:-

- i) repair areas of damage that had occurred and
- ii) prevent the ingress of moisture into the structure while allowing the concrete to dry.

Hamilton City Council Design Services were commissioned by the Streets Engineer to manage, design and supervise the first stage of the rehabilitation works through to successful completion.

Rehabilitation works were programmed into two stages to:

- a) allow time for water stored in reservoirs within parts of the structure to seep away prior to overcoating the lower elements, and
- b) spread the financial commitment.

The first stage works were confined mainly to above-deck areas including the river sides of the footpath balustrades.

3.0 PROJECT REQUIREMENTS

3.1 General

This section outlines some of the requirements included within the first stage of the bridge project.

3.2 Scope of Work

In summary project works included:

- cleaning of the superstructure by high pressure water blasting
- identification of concrete defects and repair requirements
- repair of unsound concrete and corroded reinforcement
- repair and/or rebuilding of balustrade infill panels
- plugging of cracks
- improving concrete detailing
- upgrading existing drainage ports
- replacement of carriageway and footpath sealcoats
- replacement and improvement of bridge joints

- protective coatings to concrete surfaces
- protective coatings to metal hardware
- installation of upgraded lighting compatible with the bridges form
- replacement sealcoats and kerb and channel to the approach road
- roadmarking

3.3 Project Considerations

3.3.1 Programming

With the bridge being an important traffic link across the Waikato River it was vital that the works were carried out in a way that minimised inconvenience to road users. To assist with this aim the works were programmed to commence in January. This timing avoids the higher volumes of traffic over the Christmas period and also encompasses the lower traffic volumes of the year. Additionally, and at least as important, this time of year has good daylight hours and tends to provide good drying weather.

3.3.2 Contract Period

The contract was for an 8 week period incorporating a 5 week bridge closure period to vehicular traffic. The five week closure period was minimal but considered adequate and was necessary to minimise inconvenience to road users.

At all times the bridge was to remain open to pedestrians and cyclists. Requiring these users to detour was not practical due to the additional travel distances required.

3.3.3 Identification of Concrete Repair Requirements

The contract requirements included undertaking technical inspections of the bridge to determine in conjunction with the Engineer the extent of repairs required.

The documents listed some of the typical bridge element defects likely to be encountered. They were not to be considered as absolute as the full extent of the repair works required would only be determined when the bridge was cleaned down and defective concrete broken out.

3.3.4 Concrete Repair

Concrete repair was required to rectify:

- cracked or spalled concrete caused by corroding reinforcement
- cracked concrete caused by other reasons

- honeycombed concrete
- impact damage
- substandard previous repairs including both cementitious and epoxy materials
- delaminated plaster from the concrete substrate
- redundant detailing which had reduced the thickness of cover concrete
- efflorescent deposits

The contract allowed the contractor to select a proprietary method of concrete repair which was to meet the following performance criteria:

- be cement based
- have a minimum specified strength of 35 MPa
- have good workability and be shrinkage compensated
- have excellent bond strength with reinforcing steel and concrete substrate
- be prebatched, requiring only site mixing by the addition of water plus modifiers.

The materials supplier was to evaluate the conditions of the bridge, select appropriate repair systems and provide technical specifications for the repair systems with the tender.

3.3.5 Concrete Coatings

The concrete of the bridge had suffered through an ingress of moisture into the structure. All concrete surfaces within the limits of the contract, except for the carriageway and footpath (which were to have new seal coats) were to have a protective coatings system applied. The coatings system, in addition to being a waterproofing barrier, was to provide resistance to carbon dioxide diffusion, allow water vapour transmission from within the concrete to the atmosphere, and retain the original character of the bridge in appearance.

The Contract also allowed the contractor to select the proprietary coatings with the following performance criteria:

- provide a full life of not less than 15 years
- provide a uniform surface that masked all existing surface irregularities excluding formwork lines
- be an effective barrier against liquid water (reduction in water absorption to ASTM C642 - 80% minimum at 28 days)
- provide a minimum Water Vapour Transmission Rate of 13 grams per metre squared per 24 hours

- provide a minimum carbon dioxide diffusion resistance equivalent to 50 metres of air
- be able to accommodate movements of up to 0.3 mm over both elongation and recovery
- provide and retain a colour near to the flat appearance of clean concrete while also being free from colour variations or pinholes
- remain free of physical defects such as peeling, blisters, cracks and fading
- competently adhere to the substrate under all service conditions that could be expected.

3.3.6 Guarantees and Bonds

A 15 year guarantee and bond was required to be provided by both the concrete repair and coatings system materials suppliers. The reason for the guarantees was to:

- ensure suitable concrete repair materials and coatings product were used
- ensure that materials suppliers used competent personnel to install their products.

3.3.7 Quality Assurance

Quality Assurance procedures were included as an important requirement of the project. Specific Quality Assurance procedures were required for the following work:

- concrete repair
- concrete detailing
- concrete coatings system
- drainage ports
- carriageway and footpath surfacings
- bridge joints
- metal protective coatings

3.3.8 As Built Records

The applied concrete coatings would tend to mask over the repair works carried out to the bridge. To aid identification of works implemented and more importantly provide for competent archive records on the rehabilitation works the contractor was required to maintain As Built records. These records included information on the type, position and size of all concrete repairs; positions of chased in lighting cables; dimensions and profiles of new deck joints.

3.3.9 Assessment of Tenders

The contract was bid under the framework of NZS 3910 Conditions of Contract for Building and Civil Engineering Construction and Transit New Zealand (TNZ) Competitive Pricing Procedures using the Weighted Attribute Method. The tenderer's non-price attributes were graded from 0 (fail) to 4 (excellent) with the following percentages:

Relevant experience	2%
Track record	3%
Technical details	5%
Resources	7%
Management skills	3%
Methodology and Quality Assurance	10%
Price	70%

The project needed to be carried out with the contractor 'getting it right' first time while the bridge was closed to vehicular traffic. To achieve this a significant emphasis was placed on the non-priced attributes of the tender submissions, with these attributes as shown totalling 30% of the weightings.

4.0 CONTRACT AWARD

Four tenders were received of which 2 were non conforming and disqualified from further consideration. Both conforming tenders offered substantial price reductions if the guarantees and bonds on the concrete repair and coatings systems were reduced from the required 15 years to be compatible with the 12 month maintenance requirement on other contract works.

The contract was awarded to Construction Techniques Limited on the basis of acceptance of the Guarantee Reduction. The tender offered:

- proprietary materials systems manufactured within the framework of quality assurance accreditation to ISO 9000
- proprietary materials systems which were specifically designed for the purpose
- installation by a company with a very good quality assurance programme submitted for this project.

The 8 week contract commenced on 25 January 1993 with the 5 week road closure commencing one week later.

5.0 EXECUTION

5.1 Reinforced Concrete Balustrades

Balustrades along the river side of the footpath comprised cast in situ posts and rails confining precast pierced concrete infill panels. The majority of panels were showing signs of distress, with cracking and spalling concrete evident throughout most panels. The distress was clearly caused by corroding reinforcement.

The Trust considers the form of the balustrades has particular architectural quality and requested that replacement balustrades should duplicate in appearance the original design.

The contract required replacement of seven of the 82 panels and localised breakout and repair to the remaining panels.

Instead of localised repair to the panels the contractor proposed removal and replacement with reinforced concrete shotcreted in place. They offered a saving to the contract price with this proposal which was readily accepted by Hamilton City Council.

5.2 Co-ordination

Upcoming roading works to River Rd/Clarkin Rd were programmed to be let concurrently with the bridge project. River Rd adjoins the eastern approach of the bridge.

The intent of the co-ordination was to minimise inconvenience to the public and carry out the road works while there were reduced traffic volumes on River Road with the bridge closed.

5.3 Arch Hanger/Arch Bow Junction Repairs

Concrete defects were visible at the tops of the hangers and the arch soffit near the hangers prior to contract commencement. During the course of the contract it became clear that virtually all hanger/bow junctions would require remedial works to protect corroding reinforcement.

This required the contractor to carry out more hard concrete repair than could reasonably have been anticipated.

5.4 Weather

During the contract period there were only 2 days of significant rainfall. This provided benefits in

contract progress particularly regarding application of carriageway and footpath seal coats and concrete protective coatings.

5.5 Feedback During Implementation

Feedback from the public during construction was positive with very few complaints. They tended to concentrate on late night or early morning noise which for a few days in the programme was desirable to meet project deadlines. All complainants were however sympathetic of the situation.

5.6 New Zealand Historic Places Trust

The Trust has been complimentary of the approach taken by Hamilton City Council to renovate and protect this historic structure. In particular the refurbishment of the balustrades in kind and the installation of period lighting supplied by 'buried' cabling has received their commendations.

5.7 Publicity

As the Fairfield Bridge is a vital traffic link across the Waikato River the objective of the publicity campaign was to inform as many residents of Hamilton as practical of the temporary closure.

Pre-publicity signs were installed in the vicinity of the bridge two weeks prior to the bridge closure, advising of the upcoming work.

A special edition of the Hamilton "Mirror" was published and delivered to all Hamilton households. The publication provides information on topical Hamilton City Council activities and this edition was centred around the bridge project.

In conjunction with the above, press releases were regularly provided to the media which were readily broadcast due to the considerable interest in this project.

6.0 **PROJECT RESULT**

The Fairfield Bridge within the limits of the project has had:-

- deficient concrete removed and replaced with proprietary materials
- corroding reinforcement prepared and protected against corrosion
- balustrade infill panels reconstructed in new materials
- installation of more positive drainage control
- installation of carriageway and footpath waterproofing seal coats

- bridge joints upgraded, with all now having a significant remaining life
- concrete protective coatings applied
- lighting installed which is in harmony with the character of the bridge

The bridge was reopened to vehicular traffic within the time allowed for in the contract, and the contract ran to budget.

7.0 **REMAINING REHABILITATION WORKS**

Works to the superstructure soffit, abutments, bank and river piers are required to complete the rehabilitation of this bridge.

Specific works are likely to include:-

- cleaning of superstructure soffit and substructure
- concrete and reinforcement repair
- completion of drainage control
- seismic detailing
- upgrading of bridge bearings
- upgrading the utility services attached to the bridge
- installation of concrete protective coatings
- discouraging pigeon roosting

As with the Stage 1 works the New Zealand Historic Places Trust will be consulted regarding the proposed upgrade.

The remaining works are provisionally planned for implementation early in the new year.

THE CONTRACTOR'S PERSPECTIVE

1.0 **THE CONTRACT**

1.1 Concrete Repair Requirements

Concrete repair included breakout of deteriorated concrete, sandblast clean of reinforcement, coat reinforcement with an anti-corrosion coating, prime the concrete surface, rebuild the concrete with compatible repair mortar, fair the surface and finally coat the entire structure. Most operations have their own time constraint for drying, curing etc, and this made the task of estimating the programme difficult. The location of areas of damaged concrete were not identified in the document and could not be determined until the whole structure was cleaned by water blasting. Quantities of likely work for each operation were scheduled by m³ for volume or m² for area, without indication of where these quantities might

be located. Further, it was not possible to identify if the quantities given came from a few locations of may locations. Thus the planning of resources such as scaffold, equipment and even manpower was a matter of judgement.

1.2 Repair and Coating Materials

The quality requirements of the specification were extremely high. The material and workmanship specified for repair and coating were required to be guaranteed for 15 years, be furnished in the name of the Principal and cover the full cost of reinstatement of any defects in performance criteria of the repair and coating systems to the standard of the original repair and coating specification.

It made good sense to have one supplier for all the repair and coating materials.

A questionnaire along with the tender specification was sent out at tender, asking the major material suppliers to provide technical details of a conforming system.

1.3 Balustrade Repairs

It was considered from the site inspection that there were alternative ways of repair of the balustrade panels which offered a lump sum to the Principal and which hopefully gave the tender an advantage over others. This avenue was pursued.

1.4 Guarantee Reduction

The question of providing long-term guarantees was of concern throughout the tender assessment, as it was for the specialist material suppliers. The cost of providing such guarantees was estimated to be in the order of 20% of the contract price. Finally, it was decided to offer the Principal the alternative of having the works carried out on a full ISO 9002 QA/QC basis with the choice of removing the guarantees. Thus the work and the materials were all integrated into a quality standard with the client saving the cost of the guarantees.

1.5 Arch Hanger/Arch Bow Junctions

Subsequent to the cleaning of the entire structure and carrying out a series of trial repairs and overall inspection to mark out the location of all types of repairs in conjunction with the engineer's representation, it was found that the connections between the vertical hangers and the arches were significantly decayed. During construction of these connections, poor detailing and workmanship has allowed large honeycombed areas to be formed

within the confines of the very concentrated reinforcement cages. This condition had been present over the life of the bridge and had never been detected.

The condition of the vertical tension reinforcement was of concern and it was necessary to excavate as far as possible into the joint to rectify this fault. The amount of work at these locations changed the execution of the contract as a greater percentage of work was required at high level.

To expedite the contract and attempt to keep the closure of the bridge down to the specified 5 weeks, resources were increased to cope with this problem. In the end, the contract was completed 4.5 days behind the scheduled 5 weeks, notwithstanding the nature of the work at the hanger-arch connections. An extension of time was applied for and granted for the connection problem with a further 2 days for wet weather.

2.0 DEMANDS ON THE CONTRACTOR

Many aspects of the construction project placed demands on the contractor of an unusual nature. In completing the contract within the specified time frame, it is considered that the following achievements make the project worthy of note.

2.1 Organisation of the scope of work into specialist activities working concurrently within the limited time frame

As well as the contractor's workforce of 20, 18 subtrades were employed on the site. These various activities included waterblasting of the structure, erection and striking of scaffolding, sandblasting of rebar, ready mix suppliers, relocation of 33 Kv powercables, roading, bridge deck and footpath resurfacing, application of fairing and elastic coatings, painting of all steel hardware, bridge lighting, bridge joints.

A great deal of time was spent co-ordinating the activities of these subcontractors over the short period of time. Most of the activities required access of some description as generally all were on the critical path.

Works scheduled for each day were planned to utilise the areas available to work in most efficiently. This included considerations for:

- the routing of pedestrian traffic to avoid dangerous/harmful activities
- ensuring work on breakout at the high level did not coincide with work underneath

- ensuring watercuring did not take place adjacent to elements where repairs, fairing or coating were taking place

With all these factors to consider the general philosophy was that the project would be a production line type set up for all works associated with the arches and the balustrades. This production line was visible as crews carried out each specialised task and worked their way around the arches and balustrades.

2.2 The alternative proposed to completely rebuild the historic balustrade panels using sprayed concrete against temporary moulds and the saving to the client for this method

The specification called for 7 of the 82 panels to be replaced with the remainder being repaired by the "patch" method, some 430m of repair being scheduled. It was concluded that once breakout commenced on the balustrade fins, virtually all of the fins (and hence the panels) would require replacement as the reinforcement within the thin-sectioned fins was in a severely corroded state.

The solution chosen for this was to rebuild the panels using site assembled timber moulds and sprayed concrete. Timber forms were erected panel by panel, and filled with sprayed concrete. After one day of curing, the timber forms were removed, repaired and re-used. Curing continued for a further 6 days.

2.3 The use for the first time of the coating system on a major structure in NZ

Master Builders Technologies Barracryl Elastic Coating System was the chosen coating. This proprietary product has not been previously used in NZ before and it had to come from the ISO 9000 accredited factory in Sydney. Careful attention was paid during the tender period to ensure all material suppliers' coatings were compatible with the requirements of the specification and that the necessary track record of the product was available in a form acceptable to the client.

3.0 **PERFORMANCE ACHIEVED BY THE CONTRACTOR**

3.1 Planning and Control of Operations

Initial project planning was undertaken from Head Office but it was soon found that the Project Manager was better able to accommodate the daily variances which were necessary. A "hands on" approach was used to fine-tune the programme of

works as each day presented different problems. The PM was assisted by two site foremen.

3.2 Construction Methods

3.2.1 **Methods for concrete repairs and coatings included:**

- breakout using electric and pneumatic breakers
- repairs using hand applied mortars and boxed pumped fluid mortars
- application of special coatings using rollers and airless sprays

3.2.2 **Bridge Joints**

Joints comprising nosings and compression seals were installed in the carriageway and footpaths.

The carriageway nosings comprised elastomeric binder premixed with graded aggregate and vulcanised in place. The footpath nosings comprised proprietary cement based mortars. Subsequently the compression seals were bonded in place to give water tight joints.

3.2.3 **Rebuilding of Balustrades**

Fine readymix concrete was sprayed into wooden moulds to reconstruct the historic balustrades.

3.2.4 **Bridge Carriageway and Footpath Sealcoats**

These works required careful stripping of the existing surfacing, application of a waterproof seal coat and wear surface profiled to ensure drainage.

3.3 Quality of Work

The QA programme implemented included preconstruction approvals for all items of work, as well as inspections and test plans as work progressed. The final release from the work was made by the contractor's Quality Manager, who checked all documentation for completeness and visually inspected the finished works.

3.4 Site Conditions and Logistics Problems

A requirement of the contract was that the bridge remain open at all times to pedestrians and cyclists.

The arches down both sides of the bridge were completely scaffolded for a good part of the contract. This rendered the footpaths unusable and left only a 3m wide strip down the centreline of the bridge to station plant and to provide access for the pedestrians. The rebuild of the balustrades had to

take place in advance of the scaffold erection and behind its striking, to give room on the footpath to spray the concrete. The outsides of the balustrades were accessed from moving scaffolds.

The most difficult logistical problem to overcome was associated with the water-curing system required for each repaired area. No curing membranes could be used as this would have been detrimental to the coating system adherence. Water-curing by spray thus took place for a period of 4 days on all repair areas, often when work was being carried out on adjacent areas.

4.0 ENVIRONMENTAL FACTORS

Working over a river poses difficulties. The main problem was the possibilities of pollutants being dropped into the river. These included un-hydrated repair materials or acrylic based coating system. Great care was taken to avoid this and whilst acknowledged that some demolition materials fell into the river, precautions and sensible controls ensured that this was minimised.

Noise pollution was a potential problem with many houses located nearby. This was minimised by being selective with the hours of work which caused noise and the banning of radios from site.

ACKNOWLEDGEMENTS

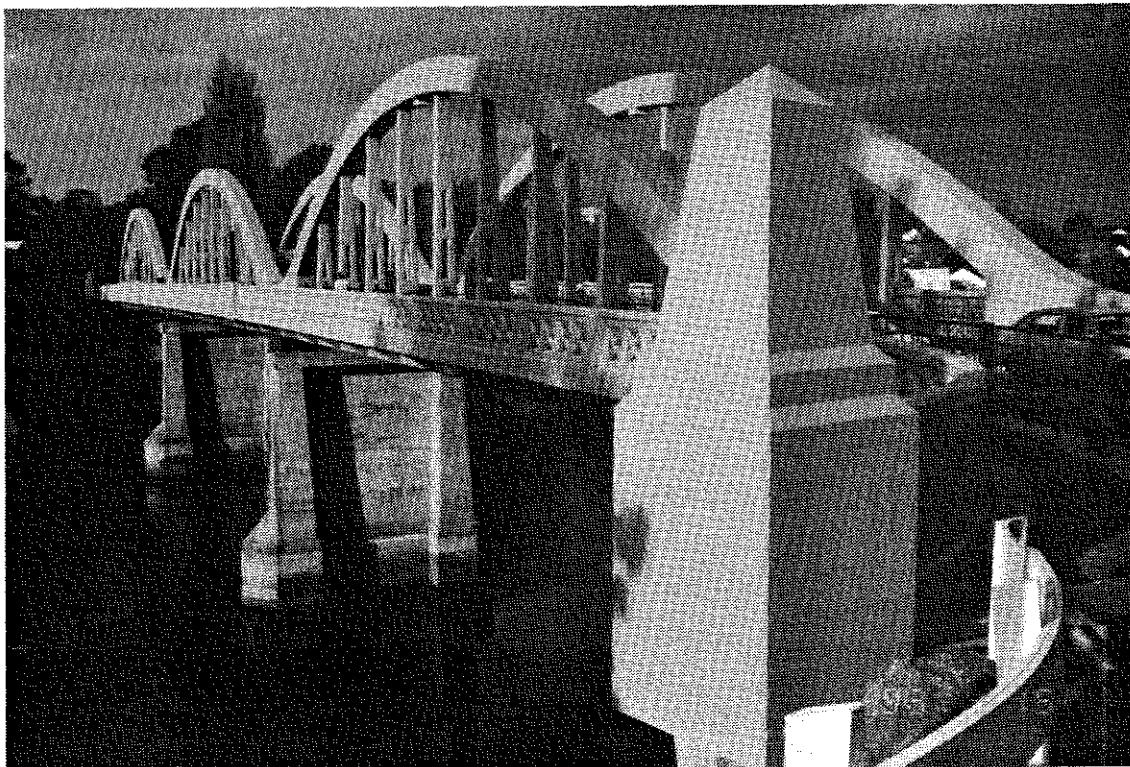
The authors would like to thank Mr Peter Bielby, Streets Engineer, Hamilton City Council for permission to publish this paper. The authors also thank Mr Cliff Boyt, Design Services Manager and Mr Jan Plutecki, Senior Structural Engineer both of Hamilton City Council for their significant contributions during project design and implementation stages. Also MBT New Zealand for their technical assistance.

REFERENCES

Bruce, S.M. and Rowe, G.H. (1991): "Condition Survey of Fairfield Bridge, Hamilton", Central Laboratories Report 91-24303, Works Consultancy Services Ltd, Lower Hutt, 103 p.

Leach, L. (1991) : "Fairfield Bridge, Inspection and Recommendations", Design Services Section, Hamilton City council, January 1991.

St John, D.A. (1981): "Fairfield Bridge, Hamilton", Hamilton City council Reference 250/2/11, DSIR Letter Report, reference BB 360, CD 25/554.



Fairfield Bridge : view of downstream elevation