13 APPENDICES

APPENDIX 13.1

Durability of New Zealand Concrete Bridges

DURABILITY OF NEW ZEALAND CONCRETE BRIDGES

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1. INTRODUCTION

This paper has been prepared as a contribution to Austroads Project 3B41 "Concrete Structures - Durability, Inspection and Maintenance Procedures". The following paper provides a summary of the nature of New Zealand's state highway bridge stock, deterioration mechanisms which affect the concrete bridges, the inspection techniques used, and remedial measures taken. It also describes the codes and standards used to ensure construction of durable concrete, and research currently underway in New Zealand related to concrete durability.

This paper specifically addresses the durability of reinforced concrete in bridges, and the mechanisms likely to cause deterioration of the concrete itself or initiate corrosion of the reinforcing steel. Deterioration due to overloading, pier scour, seismic activity or other events likely to cause structural failure is not considered.

2. NEW ZEALAND'S BRIDGE ASSET

Transit New Zealand is responsible for management of New Zealand's state highway network, including the bridges and major culverts. Management of other public roads and bridges is vested in the appropriate local authority, although Transit New Zealand contributes some funding to their maintenance. A summary of the number and type of bridges and major culverts on the New Zealand state highway network is shown in Tables 1 to 3. Figure 1 shows the age distribution of state highway bridge structures.

Transit New Zealand contracts out all design, construction and maintenance services on a competitive pricing policy (CPP) basis.

3. CONCRETE DETERIORATION MECHANISMS

3.1 Reinforcement Corrosion

Chloride contamination and carbonation are the major contributing causes to reinforcement corrosion.

(a) <u>Chloride Contamination</u>

Reinforcement corrosion as a result of chloride contamination is the most significant durability problem affecting New Zealand's concrete bridges. Chlorides are usually an external contaminant derived from the sea. Many New Zealand bridges cross saline coastal estuaries, are sited within the coastal margin, or are influenced by salt carried inland by onshore winds.

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Table 1: State Highway Bridges and Culverts

Type	Number
Bridges	2392
Bridges with concrete superstructures	1820
Bailey bridges	2
Major culverts (waterway area greater than 2.5 m^2)	1192

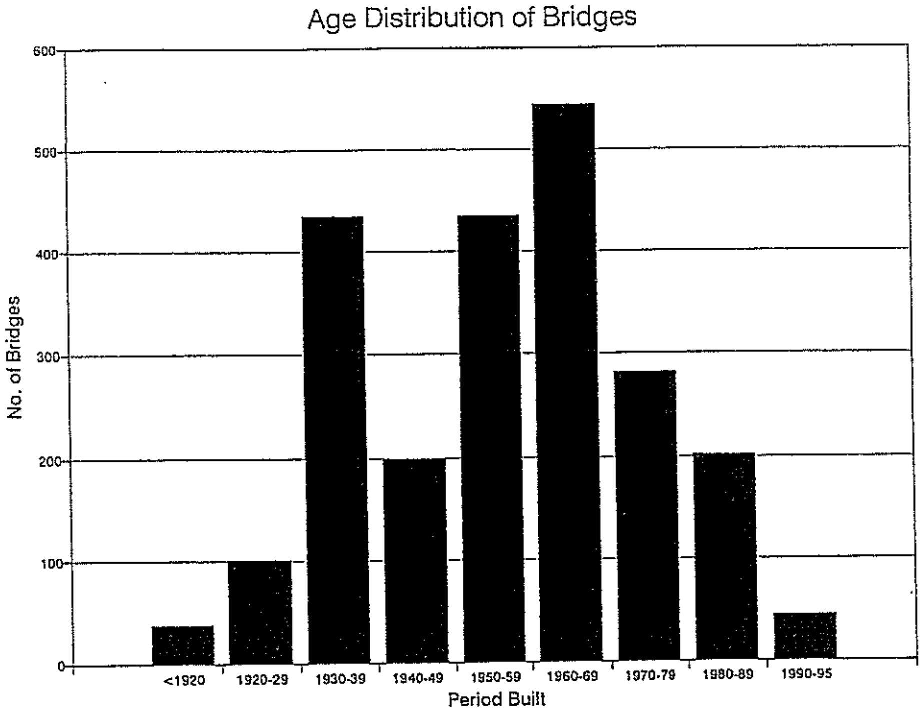
Table 2: Superstructure Materials on State Highway Bridges

Superstructure Material	% of Bridges
Steel	20
Concrete cast in situ reinforced	47
Concrete cast in situ prestressed	3
Concrete precast reinforced	1
Concrete precast pretensioned	24
Concrete precast pre/post-tensioned	2
Masonry	2
Other	1

Table 3: Construction Materials in Major Culverts on State Highways

Culvert Material	% of Culverts
Concrete cast in situ reinforced	59
Concrete precast reinforced	21
Steel	17
Timber	1
Other	2

Figure 1: Age Distribution of New Zealand State Highway Bridges



Local exposure to chloride contamination depends on both proximity to the coast and the strength and direction of the prevailing wind, and these factors are recognised in NZS 3101 : 1995 "Concrete Structures Standard". The exposure classification maps derived from this standard for the North and South Islands of New Zealand are shown in Figure 2.

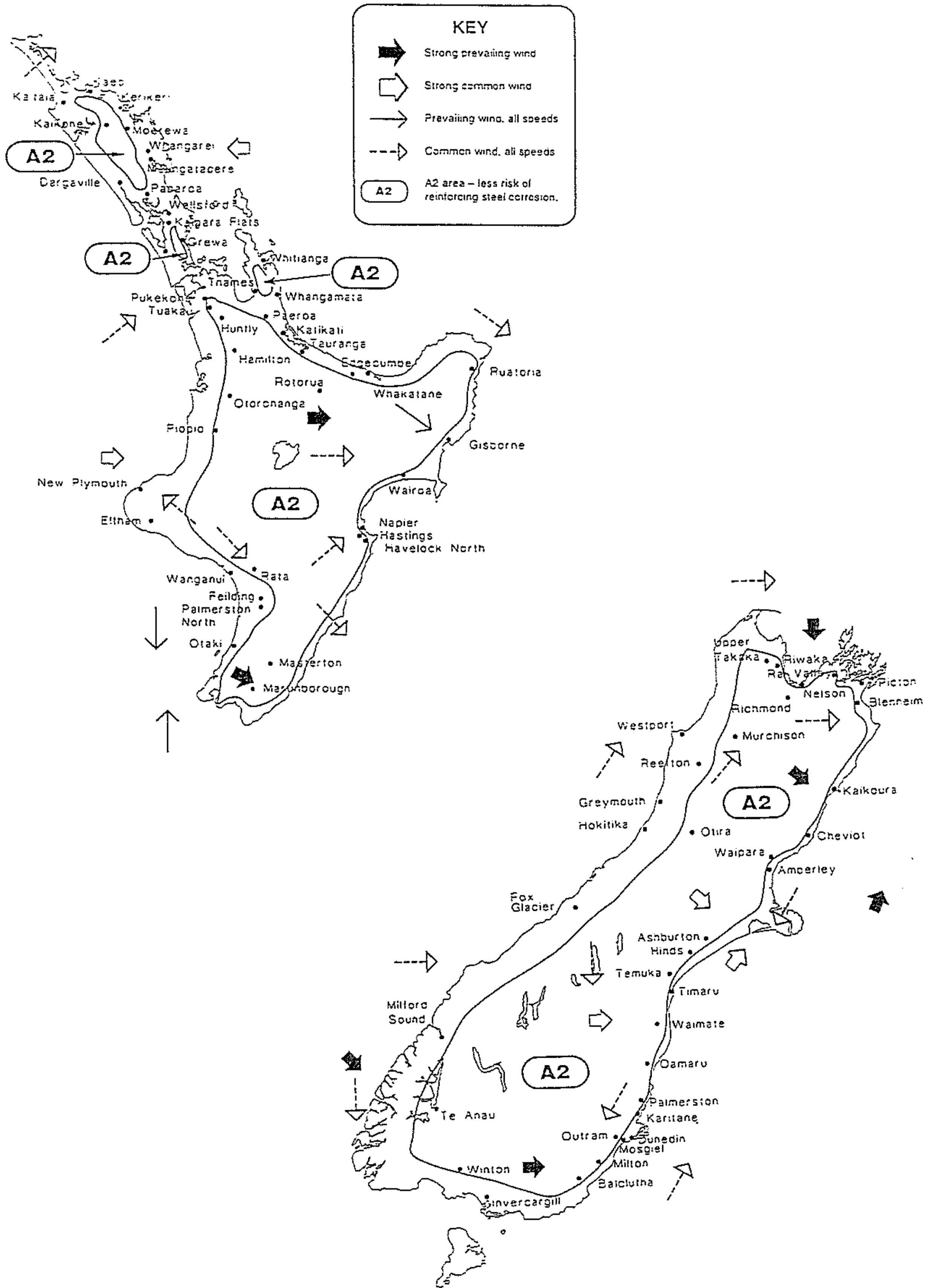
Chlorides can also be included in fresh concrete either in the form of contaminated aggregates or accelerating admixtures. It is likely that some bridges constructed before about 1940 contained aggregates from locally won unwashed beach deposits which may have contributed to chloride contamination. Chloride-containing accelerating admixtures were used in limited quantities in the New Zealand concrete industry from the late 1950s through to the early 1970s, although no associated bridge durability problems have yet been encountered.

Deicing salts are not currently used on New Zealand roads. However, a proposal to salt the Desert Road in the central North Island, to reduce winter road closures, is currently being considered. The impact of deicing salts on concrete bridges in the northern hemisphere has been well documented. Bridges on the Desert Road will be carefully monitored if salting is approved.

(b) Carbonation

Reinforcement corrosion as a result of carbonation is a less significant problem than chloride induced corrosion. This deterioration commonly affects inland bridges or sheltered bridge sub-structures where climatic conditions are more suited to carbonation. In these conditions the corrosion rates, hence the rates of deterioration, are relatively slow.

Figure 2: Exposure Classification Maps for the North and South Islands of New Zealand (taken from NZS 3101 : Part 1 : 1995)



3.2 Alkali Aggregate Reactivity (AAR)

AAR occurs in about 10% of structures in areas where potentially reactive aggregates are used. Volcanic aggregates sourced from both Taranaki and the Central Volcanic Region have been identified as reactive. Abutments are most often affected. In most cases the effects are believed to be cosmetic only. Four bridges to date have required major repair due to deterioration of the superstructure caused by a combination of factors, including AAR, and another four with extensive abutment cracks have been identified.

3.3 Sulphates

Sulphate attack is currently not a major issue for concrete durability in bridges. However, the risk is higher in the central North Island geothermal areas where bridge foundation concrete can be exposed to "aggressive" soils containing sulphate ions.

3.4 Freeze-Thaw

Freeze-thaw damage is a minor problem for concrete durability in New Zealand. Repetitive freezing and thawing cycles which would promote this deterioration are only likely to occur in Otago and inland Canterbury, including the roads crossing the Southern Alps, and in the central North Island. Deterioration in the latter area is confined to superficial cracking of kerbs and wingwalls, and is believed to be associated with AAR.

3.5 Physical Damage

Physical damage due to vehicle impact occurs irregularly. It includes collisions with overpass structures with restricted height clearance, and damage to the concrete handrails and end posts which predominate on pre-1960s bridges.

4. INSPECTION AND INVESTIGATION TECHNIQUES

Routine bridge inspections are carried out under the guidelines of the Bridge Inspection and Maintenance Manual (Transit New Zealand, 1991a). The frequency for bridge inspections is set out in the Bridge Inspection Policy (Transit New Zealand, 1991b) which identifies the following levels of inspection:

- Superficial Inspection

This inspection should identify any obvious defect which may affect the safety of highway users or anything else needing urgent attention. The minimum frequency for inspection is set out in the Maintenance Guidelines for State Highways (Transit New Zealand, 1991c).

- General Inspection

The procedure required is described in the Bridge Inspection Guide (Department of Transport, 1983) and should be carried out at intervals not exceeding two years.

- Detailed Inspection

The procedure described in the Bridge Inspection Guide (Department of Transport, 1983) should be followed but all external surfaces above water level and, where appropriate, all internal surfaces should be inspected at close quarters. These inspections should be carried out at intervals not exceeding six years.

The inspections are carried out by Transit New Zealand's regional maintenance consultants.

If, in the course of a general or detailed inspection, faults are identified which are outside the competence of the normal inspection staff then specialist consultants are permitted to be employed.

There are several consultants in New Zealand who specialise in concrete durability problems and who conduct on-site condition surveys. Commonly the problem identified is corrosion of reinforcing steel. The following techniques are used, in conjunction with an appropriate sampling frequency, to give an indication of the current and future risk for corrosion:

- detailed visual inspection (including identification of cracks and delamination)
- reinforcement cover depth
- chloride content of concrete
- carbonation depth.

Additional properties which may be measured in specific situations include:

- half cell potential of reinforcement
- resistivity of concrete
- initial surface absorption (ISAT)
- concrete compressive strength and density
- tensile strength of steel from hardness determinations
- cement content of concrete
- water/cement ratio of concrete
- sulphate content of concrete.

5. REMEDIAL TECHNIQUES

Remedial options available to overcome the current and ongoing deterioration associated with reinforcement corrosion include:

5.1 Patch Repair Systems

Proprietary cementitious repair systems are the most commonly used remedial technique for major repairs of New Zealand concrete bridges. These systems include trowellable patching mortars as well as free flowing shrinkage compensated micro-concretes, and are entirely prepackaged apart from the mixing water. Repairs are carried out by specialist contractors approved by the material manufacturer. The variable quality of repair materials batched on site is considered to be unacceptable, and consequently they are not recommended.

Cementitious repair systems have been used for repair of a number of state highway bridges in the past five years. The cause of damage in these bridges was both chloride and carbonation induced reinforcement corrosion. Repairs are carried out on chloride contaminated structures with the understanding that future maintenance may be required to reinstate areas of continuing deterioration.

5.2 Coatings

Coatings are an integral part of many cementitious repair systems, particularly in coastal locations where ongoing chloride contamination is likely. They are commonly applied as the final stage of a major repair contract.

Coating systems used to date consist of impregnation with a silane-siloxane to block liquid water and chloride ions, followed by a solvent- or water-based acrylic coating which is often pigmented.

Coating systems should be considered in future as a preventative maintenance technique to prevent deterioration of relatively new concrete structures where the risk of chloride contamination is high.

5.3 Cathodic Protection (CP)

Impressed current cathodic protection systems have been available in New Zealand since 1987. To date, their installation has been restricted to wharves, multi-storey commercial premises and apartment buildings. There have been no installations on state highway bridges. Cathodic protection is considered as an appropriate remedial option where chloride contamination is high.

With the continuing development and refinement of different anode systems, CP systems are becoming more cost competitive relative to conventional repair techniques, especially once the long term benefits of CP installation are accounted for.

5.4 Chloride Extraction/Realkalisation

In April 1996 proprietary chloride extraction and realkalisation processes were launched in New Zealand as a remedial technique for concrete structures affected by reinforcement corrosion. To date, the techniques have not been used on state highway bridges. Chloride extraction will potentially be the most useful technique.

5.5 Replacement

The deterioration of a reinforced concrete bridge due to reinforcement corrosion or other concrete durability factors can contribute to the decision to replace a bridge, but is unlikely to be the sole reason. Transit New Zealand uses a cost/benefit analysis to determine whether a bridge needs replacing. The analysis considers factors such as regional strategic decisions, bridge age and condition, structural/seismic factors, bridge alignment and traffic volumes.

6. CONSTRUCTION STANDARDS

The criteria for design of new concrete bridges is set out in the Bridge Manual (Transit New Zealand, 1991d). The Bridge Manual calls up NZS 3101 : Part 1 : 1995 for design of concrete for durability, which considers design in terms of the compressive strength of concrete and cover depths required for given exposure conditions (see Figure 2).

An anomaly exists between the 100 year design life requirements of the Bridge Manual and the 50 year specified intended life quoted in NZS 3101 for durability purposes. The provisions in NZS 3101 require modification to provide criteria for design for a specified intended life of 100 years, and to allow for the use of alternative cement types and blends. A research proposal for this work is currently under consideration (see Section 8).

Curing is specified in NZS 3101 according to exposure classification. For members subject to inland exposure conditions, the concrete is required to be wet cured for three days under ambient conditions. For coastal and tidal exposure conditions, the members must be wet cured for seven days at ambient conditions.

Requirements for good construction practice, including adequate fixing of reinforcement and the placing, compacting and curing of concrete, are described in NZS 3109 : 1987.

The use of precast prestressed concrete beams and deck sections in recently constructed bridges has markedly improved the concrete quality, and should improve the long term durability of these elements.

7. TEST METHODS FOR DURABILITY RELATED CONCRETE ACCEPTANCE

Concrete acceptance is traditionally based around compressive strength tests using cylinders. In recent major works (e.g. Museum of New Zealand, Sky Tower), durability-related testing has been specified in the form of the rapid chloride test (AASHTO T277, 1993). In addition, shrinkage testing (AS 1012.3 : 1992) has been specified to prove the concrete in question meets a maximum prescribed shrinkage level to minimise cracking, and on the Sky Tower site a water permeability test has been specified.

8. RESEARCH

Transit New Zealand fund a significant volume of roading related research. The total value of funding in 1995/96 was $1.8 million. No concrete durability projects are currently being funded. Proposals currently under consideration for 1996/97 include:

- preparation of modified criteria for durability design (NZS 3101 : 1995) to take into account Transit New Zealand's 100 year design life requirement;

- a more comprehensive investigation of the durability of concrete bridges proposed as an extension of this brief position paper. This research would be based on consultation with Transit New Zealand regional offices to identify what concrete durability problems are encountered, how the problems were identified, what remedial measures were used to solve these problems and how they performed. This work would also address regional variations in bridge inspection, data collection and storage systems with a view to Transit New Zealand adopting a common bridge maintenance database system.

General concrete durability research is also carried out by a small number of research agencies who bid competitively for government research monies administered by the Foundation for Research, Science and Technology.

9. REFERENCES

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Standards Association of Australia (1992): "Methods of Testing Concrete. Method 13 : Determination of the Drying Shrinkage of Concrete for Samples Prepared in the Field or in the Laboratory", AS 1012.13.

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APPENDIX 13.2

Painting State Highway Bridges: Past, Present and Future

PAINTING STATE HIGHWAY BRIDGES - PAST, PRESENT AND FUTURE

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ABSTRACT

This paper examines the changes in corrosion prevention techniques employed by New Zealand's bridge engineers. The development of specifications from the Public Works Department's red lead in linseed oil applied to hand cleaned rivetted wrought iron through to today's high build heavy duty coatings is reviewed. Examples of various systems used by WORKS, including that for the Auckland Harbour Bridge is given.

The former Ministry of Works and Development's approvals scheme for bridge paints is also reviewed and the operation of the recently introduced NZ Paint Approvals Scheme (PASS) and Certified Coatings Inspectors Course is explained.

1. INTRODUCTION

Apart from a paper presented to the NZ Society of Civil Engineers by Newnham(1) in 1933 the author has been unable to find any other published paper specifically on how New Zealand's steel highway bridges have been protected against corrosion. This paper records some of the changes that have occurred in bridge painting in NZ over the last century.

New Zealand's state highway system includes 27.3 km of bridges containing steel as a principal structural element i.e. as a truss or beam supporting a timber or concrete deck. As many of these bridges are in coastal locations they are subject to very aggressive conditions due to accumulation of wind-borne marine salts not removed by rain-washing. These salts absorb moisture from our relatively humid atmosphere coating the surface with a very active and efficient electrolyte which will rapidly promote corrosion of poorly protected steelwork.

The construction and maintenance of some 2,300 state highway bridges has been carried out by a government agency that has evolved from the Public Works Department (PWD) to Ministry of Works (MOW) in 1948, then became Ministry of Works and Development (MWD) and since 1988 the state owned Works and Development Services Corporation (NZ) Ltd (WORKS).

In 1954 the National Roads Board was established to manage the state highway network and in October 1989 was absorbed into a new authority, Transit New Zealand.

2. EARLY DAYS

2.1 Nineteenth Century Bridges

The history of bridge painting probably began in England with the famous 'Iron Bridge' in Shropshire which was completed in 1779 but not painted until nine years later with a bituminous varnish. The first iron structure built over the River Tees in 1841 collapsed due to corroded chains some 60 years later. Telfords famous suspension bridge across the Menai Straits in Wales (1817) was protected with a system common at the time i.e. sections were cleaned, dipped in hot boiled oil and after erection primed with a white lead/linseed oil paint and under the deck given an additional bituminous coating(2).

The paint system used in the 1880s for the Firth of Forth bridge in Scotland became the standard for bridge painting for the next 70 years. Before erection the steel was scraped, wire brushed, and given a hot or boiled linseed oil treatment. A red

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lead/linseed oil primer was then applied in the shop where possible, and after erection, a second coat of the same paint applied. Surfaces then received two further coats of red oxide and as a result of continuous maintenance the bridge is still in use today.

Early New Zealand steel bridges built by PWD that are still in use include the Waimakariri Gorge (1877), Kurow (1879), Rakaia (1881) and the Beaumont (1884).

2.2 Early NZ Practice

The 1903 Public Works statement reported "our bridges are in most cases now built of steel instead of perishable timber, thus minimising the cost of future renewals". In 1933 Newnham stated that there was "at least 80,000 lineal feet of steel bridging" but that some bridges were in a dangerous condition due to lack of maintenance. He also wrote the following which is still relevant today.

"It is a difficult matter for local body engineers to convince their councils that the cleaning and painting of steel bridges is necessary and is economically profitable. Too often maintenance is neglected on account of alleged lack of finance. In other cases even when maintenance is attempted, local conditions or improper methods render the maintenance ineffective and costly... Steelwork properly protected has an almost indefinite life; improperly protected, its life is very short".

Removal of mill-scale was recognised in the early 1930s as being necessary to ensure applied coatings remained effective. Turner(3) in 1935 had discussed the advisability of descaling bridges by shot-blasting. The 1933 British Standard Specification for Girder Bridges (BSS 153) noted that the best practical method was to allow the steel to weather as chipping or scraping was not always effective.

Newnham reported that the usual NZ practice was to import steel unoiled and apply the priming coat after weathering but noted it was a risky practice as if left too long pitting could occur.

Sandblasting, usually carried out in fabrication shops, was regarded as the ideal but only used in special cases because of its expense.

The necessity for paint application to an absolutely dry surface was also recognised with the specification of a minimum steel temperature of 15°C, using hot air where necessary. Newnham advised that "in NZ, painting should not be done between the end of May and the beginning of November".

2.3 PWD No 2

There had been various formulations for red lead primer with early pigments containing a high percentage of lead oxide which required incorporation immediately prior to use due to early setting time. Later pigments increased the red lead (Pb_3O_4) to 94% which was finely ground and could be machine mixed with boiled linseed oil into a non-settling primer with a specified minimum weight of 32.75 lb/gal. This was the basis for PWD Formula No 1. Further testing showed that substitution of one third raw linseed oil for boiled linseed oil gave easier application with similar performance and this formula became the ubiquitous PWD No 2.

During the discussion of Newnham's paper it was noted that although France had prohibited the use of lead paint Furkert (the PWD Engineer-in-Chief in 1920) stated it was "absolutely essential for the welfare of the world, and that its use must not be forbidden by misguided or insufficiently informed people"! (Legislation had then just been introduced in NZ to restrict the use of red lead in its hazardous powdered form).

Its excellent wetting properties with good corrosion resistance over steel with little or no surface preparation made PWD No 2 an almost foolproof primer and until recently, it has been commonly used for bridge maintenance by NZ Railway gangs. Its formulation was adopted by SANZ as NZSS GP 1, with the red-oxide finishing paint being NZSS GP 16.

2.4 Gunite Protection

An interesting case study referred to in

Newnham's paper was the use of gunite to protect the plate girders of the bridge at the mouth of the Mokau River. This had been erected in 1927 and by 1932 was costing £400/yr to maintain with various paint systems but which usually lasted less than 12 months. This was attributed to the original paint having been applied over mill scale with the difficulty of achieving suitable surface preparation in-situ due to its very exposed location. The work of U R Evans at Cambridge University was noted, who in 1932 had reported the effect of salt under a coating drawing water through the film by osmotic pressure.

Due to the reserve strength of the bridge beams being able to carry the additional 20 tonnes of coating, the opportunity to test the effectiveness of a 1½ inch thickness of gunite was taken. The surface was sand-blasted, reinforced with 10g mesh, and coated in 1933 with a 3:1 sand/cement mix for £2,777.

Twenty-five years later, gunite was removed from two test pieces and found the encased RSJ section to be in perfect condition. As a result another bridge, 6 km to the south (over the Mohakatino Stream) was also protected by gunite in 1958 as its original bituminous paint had suffered rapid deterioration within six years.

2.5 Other Systems

Some early trials had been carried out on the Tauranga Bridge (1924) using a wax coating but this appears not to have been used elsewhere. Aluminium paint was used on the Hamilton Bridge (1931) with beneficial effect from reduced thermal movement. The first NZ use of the barrier-type finishing paint based on the lamellar pigment, micaceous iron oxide (MIO) was probably on the Clarence River Bridge in 1941 and has been widely used to protect many major steel bridges including the Mohaka Railway Viaduct.

3. 'POST-WAR' PAINTING SYSTEMS

3.1 Pre-1956

The standard specification for painting structural steel (PWD 138896) published in the department's 1956 Bridge Manual is included as Appendix 1, and shows bridge painting practice had altered little since Newnham's paper of 1933.

A proprietary heat-cured inorganic zinc silicate had been applied to Bailey Bridge panels in 1950 but was only partially successful due to difficulty in achieving adequate cover.

Flame cleaning after weathering of steel was recommended in 1943 as an alternative method to abrasive blasting for the removal of millscale. This employed the controlled application of a neutral oxy-acetylene flame and required application of PWD No 2 before steel temperature dropped below 27°C.

In 1953 MOW commissioned DSIR to examine various proprietary pretreatments based on phosphoric acid. After two years exposure it was reported that they had been ineffective in removing millscale and had not produced improved performance over untreated panels.

In 1955 the first magnetic thickness meters were issued to departmental inspectors. In the same year trials were carried out at Kenepuru Bridge near Porirua of a variety of different formulations of red lead primers with other proprietary systems including a zinc-rich primer. Only the zinc-rich showed better performance than the lead based primers.

Overseas, rapid advances in polymer chemistry during the fifties saw many new generic types of coating appear and paint technology began to move from an art to a science(2).

3.2 1956-1972

In 1956 there appeared the first swing away from the traditional linseed oil/red lead based primers with the publication by MOW of a specification for application of organic zinc-rich paint. This coincided with the publication of the influential 'Steel Structures Painting Manual'(4) and the availability of faster drying alkyd resins. The Hydro Division of MOW issued a specification HD 315 for an oil/alkyd red lead primer with a hard dry time of 24 hours in 1958 and this was followed in 1960 by the well known HD 441 with a 16 hour maximum dry time.

HD 441 was also an oil/alkyd red lead primer and based on the US Federal Specification TT-P-86A Type II. As PWD No 2 had a specified dry time of four days minimum, these new primers were a significant advance although they required a better standard of surface preparation to be as effective.

In 1963 the MOW recommended the use of steam cleaning as a method of removing deposited salt from steelwork, and issued its own composition specification (MOW 7062) for zinc rich paint. This was followed in 1965 by a series of standard specifications prepared by J H Fyson for protection of steelwork (MOW 11090-11094) covering application of primer and cover coats, and a composition specification for a MIO finishing paint for bridges. These specifications were the subject of a paint approvals scheme described later, and formed the basis for painting many of the steel highway bridges built over the next decade.

In 1966 MOW arranged a series of tests on the Whirokino Bridge on SH 1 over the Manawatu River, and 5 km from the coast. This included a number of the then new technology coatings available including coal-tar epoxy, chlorinated rubber and inorganic zinc silicate.

3.3 1972 to Date

This period saw adoption of inorganic zinc silicate as the preferred primer for structural steelwork with the issuing of a compositional specification MOW 17919 in 1972. This coating with its fast dry and excellent abrasion resistance overcame most of the disadvantages of red lead primers but requires a minimum of near-white metal (Sa2½) surface finish to be effective and is not well suited to field application.

After providing over a century of excellent service the use of lead based primers was discontinued in 1982 for environmental reasons with the replacement of HD 441 by a zinc chromate equivalent (to AS K211 Type 1) for use on hand prepared steelwork or as a maintenance primer over oil/alkyd systems.

This primer has proved very effective but with growing concern about possible links between hexavalent chromium and cancer its use may also be restricted in the future. To ensure proven alternative primers will have been identified before they are needed for maintenance of such structures as the Auckland Harbour Bridge, WORKS has commissioned independent trials of various chromate-free systems.

The standard coating system specified by MWD to protect new steel bridges in the 1980s has been to abrasive blast to white metal (Sa3) finish and shop prime with 75 microns of self-curing inorganic zinc silicate paint. Following erection two finishing coats of chlorinated rubber (CR) are applied to give a minimum total dry film thickness of 225 microns (5). In coastal areas this is increased to 325 microns for surfaces subject to condensation or sheltered from the beneficial effects of rainwashing. Use of MIO pigment is preferred in the buildcoat as it appears to prevent solvent blistering during subsequent overcoating, as well as ensuring good edge coverage when applied as a stripe coat.

Possibly the first use of this system was in 1972 on the Aurora Terrace overbridge over the Wellington Urban Motorway. This structure was spotprimed and repainted with CR in 1988, at a cost of $27/sq.m. and should not require further attention for at least another 15 years.

Chlorinated rubber paints are now becoming more expensive than two-pack high-build epoxies with their lower solvent content, but are still favoured due to CR's advantages for maintenance painting i.e. single pack and excellent adhesion when recoating. The so called 'epoxy-mastic' group of maintenance coatings, unfortunately possess widely varying properties and early claims of their ability to be applied over 'tight rust' appear to have been discredited in various studies (6, 7). As they are a barrier coat, it is essential that a heavy film build is achieved but this is not always possible on bridge members with rivets or bolts, or where sharp edges exist.

They have been used to economically upgrade aged red lead based systems but where rusting has occurred, its removal by abrasive blasting and spot priming with an epoxy zinc is recommended. Attempts to prepare by only water blasting and a spot prime with epoxy mastic have given disappointing results in coastal situations.

However interim results of an investigation into alternative systems for maintenance painting of aged galvanised steel bridges(8) indicate that some brands of epoxy-mastic could be effective.

4. AUCKLAND HARBOUR BRIDGE PAINTING

4.1 Introduction

This well known structure was erected between 1955 and 1959 at a cost of $16 million to provide four lane access to Auckland's North Shore. The bridge length is 1020 m and its original coat-hanger like lattice truss frame contains 5,800 tonnes of riveted and bolted steelwork supporting 6,500 tonnes of concrete deck.

The welded box girder 'clip-on' extensions added an extra four lanes costing $13.3 million in 1969 and also added another 8,600 tonnes of steel to be maintained in a very hostile environment. The bridge was managed by the Auckland Harbour Bridge Authority (AHBA) which was disestablished in 1984 and responsibility for maintenance taken up by the MWD.

4.2 Protective Coatings

The original specification called for red lead primer on wire brushed steel and overcoated with a micaceous iron oxide enamel, as it was prepared during a financial crisis in 1952 when the estimated cost of the bridge and approaches had to be reduced from 8 to 5 million pounds. Fortunately economic conditions improved allowing an amendment to what in 1956 was regarded as the "best protective treatment known at the time, i.e. grit-blasting all steelwork before erection, metallising with a sprayed zinc coating not less than 0.002 inch thick, followed up immediately with one coat of zinc chromate primer and later with two coats of Ferrodor paint"(9).

However, within a year of completion of painting serious corrosion was being reported in the local newspapers.

Apart from some areas where the second coat of Ferrodor, a MIO/aluminium pigmented phenolic paint had been omitted, the problems were attributed to the severity of the microclimate in sheltered areas being underestimated. This was exacerbated by a very rough surface profile after grit blasting which resulted in peaks of zinc metal having an inadequate cover of paint. Wind-borne salt attacked the zinc and the alkaline reaction products reacted with the aluminium pigment to produce black spots which eventually became red when the zinc was exhausted.

The AHBA took over responsibility for painting and began a second series of trials of alternative systems with the following criteria:

(a) lead free and compatible with zinc;

(b) suitable for all application techniques - i.e. able to be brushed onto rivets and bolt heads, and also capable of application by roller or airless spray to flat surfaces;

(c) able to be applied in a wide range of temperatures at up to 85% relative humidity and during a moderate wind;

(d) single pack products to minimise wastage and on site mixing errors.

The following maintenance system was selected and is still in use today:

(1) Wash surface with fresh water to remove salt followed by light abrasive blasting with a fine grade of quartz sand to remove corrosion products while minimising damage to the residual zinc spray.

(2) Within two hours of cleaning bare surfaces are primed with a brush applied oil/phenolic zinc chromate which has excellent wetting properties and allows good penetration into crevices.

(3) Within 36 to 72 hours this is followed by the first of two coats of a special phenolic zinc chromate primer (i.e. AS K211 Type 4 but with 50% zinc chromate pigment).

(4) Two complete cover coats are then applied of phenolic finish paint heavily pigmented with micaceous iron oxide (MIO).

MIO is a naturally occurring mineral in the form of microscopic platelets which overlap each other to give improved coverage to sharp edges, reduce permeability of the film and give a good key between coats when repainting. The phenolic resin has good resistance against both moisture and the alkali conditions which can occur as previously mentioned.

Repainting of the bridge with the above system commenced in 1963 and was completed by the time the extensions were in place in 1969.

The specified protective treatment for external surfaces of the 'clip-on' box sections was grit blasting to Sa 3, 25 microns of zinc spray (or in some places 65 microns of inorganic zinc silicate) sealed with a vinyl butyral etch primer and followed with two coats of the MIO/phenolic finishing paints. Internal surfaces received two coats of red lead paint(10).

4.3 Maintenance History

The extensions have been repainted twice since their erection with internal surfaces being touched up in 1982. The over-arch area of the original bridge was repainted in 1969, 1978 and 1989 as part of a continuous and ongoing maintenance programme. Sections under the deck which are more prone to condensation and increased times of wetness are currently receiving their fourth repaint with an average cycle time of eight years which is increasing as the average coating thickness increases.

When the extensions were added which aggravated the problem of salt deposition, the practice of washing the underside of the bridge was introduced. This is carried out with mains pressure water whenever conditions are unsuitable for painting and programmed so that all surfaces are cleaned at least annually. It is estimated that this has more than doubled coating life in the sheltered areas.

4.4 Organisation

As with most similar major bridge structures around the world, maintenance is performed in accordance with a long term strategy by a group specifically set up and equipped for this purpose.

Approximately 10,000 litres of paint is applied each year by a crew consisting of 20 full time painters supported by six riggers and tradesmen who maintain the custom designed access equipment.

Financial and technical management is provided by WORKS Consultancy Services and has included the recent development of a non-proprietary specification for the coating and a detailed quality plan for maintenance painting. This sets out responsibilities of the various parties involved in paint supply, preparation, application, inspection and documentation.

5. PAINT APPROVAL SCHEMES

5.1 MWD Periodic Approval Scheme

From 1963 until its corporatisation and the introduction of "user-pays" in 1988, the Ministry of Works and Development operated a 'Periodic Approvals Scheme' which covered four types of paint most commonly used on bridges. These (and their specifications) were the single-pack zinc-rich primer (CD 501), a self-curing inorganic zinc silicate (CD 502), a red lead and later zinc chromate pigmented linseed oil/alkyd (HD 441/CD 503) for priming hand prepared surfaces, and a micaceous iron oxide (MIO) pigmented alkyd finishing paint (CD 504).

The objective of the scheme as described in a circular to manufacturers by J R Bewick was to "ensure all paint applied under the department's control conformed to the specified standard known to be capable of yielding a sound protective coating when competently applied to a properly prepared surface". The four specifications above set out requirements for the quality, composition and proportioning of ingredients and qualitative requirements such as condition in the container, colour, viscosity, drying times and shelf life.

All NZ manufacturers were periodically invited to submit samples for testing which was carried out for MWD by Chemistry Division of the DSIR. Lists of approved brands were then circulated to bridge engineers and inspectors and also made available to other departments such as Electricity and Railways. It is of interest to record a few statistics extracted from the paint testing records.

In the 1972 test series invitations were sent to 36 different paint manufacturers, 14 different brands of inorganic zinc silicate (IOZ) were submitted but only seven were approved. In the test series of 1981 the list of manufacturers had reduced to 22, 27 brands were tested and nine approved. Currently, following extensive rationalisation of the coatings industry only five of these brands are still on the market.

A further indication of the variability that existed in the quality of NZ paint is illustrated by the fact that in 1971 seven out of 15 brands of HD 441 primer tested failed to meet the specification and in the 1978 test series 12 out of 16 brands were not approved. Note that these approvals were not based on samples randomly selected from suppliers but on those specifically forwarded by manufacturers for testing.

5.2 NZ Paint Approvals Scheme (PASS)

This was originally set up by the Government Stores Board in 1983 and administered by MWD as the Public Sector Paint Committee (PSPC). It became operational in April 1986 with the issuing of 20 paint specifications based on those of the Australian Government Paint Committee (GPC), on which the PSPC was modelled. In July 1987 the name was changed to "New Zealand Paint Approvals Scheme" (PASS) to reflect the involvement of Government Corporations and Local Authorities in the scheme. In March 1988 administration of the scheme by MWD was handed over to TELARC and operated as one of their QA programmes.

Members of the scheme can obtain a listing of paint brands that have been approved as meeting PASS durability and/or composition requirements and which are manufactured within a specified quality assurance regime that has been independently assessed using procedures based on the NZS 9000 series of standards.

Preference is now given by WORKS Consultancy Services to PASS approved coatings for bridge maintenance where these are available.

5.3 CBIP Certified Coatings Inspector Scheme

The Certification Board of Inspection Personnel (CBIP) was established by the NZ Heavy Engineering Research Association, to certify Welding and NDT Inspectors. In 1986 this scheme was extended to include coatings inspectors and involves a 2 day block-course of lectures and practical demonstrations midway through a 120 hour home study course of 17 modules which is followed by a 5 hour written and oral examination.

Currently some 21 inspectors have successfully completed this course and their involvement in application of protective coatings should assist in ensuring that the potential long life of modern high performance coatings is realised.

6. COATING SELECTION

6.1 The Specifiers Dilemma

The existence of such codes as AS 2312 and BS 5493, together with references such as SSPC Painting Manuals(4) and the books by Hare (2) and Munger(11) are of great assistance to the Engineer who is usually untrained in the surface protection of steel.

However as noted by Bartlett(12), "selecting the most appropriate coating system to provide long term corrosion protection for steel is a difficult and imprecise science. While broad generalisations can be made as to the system most likely to be cost effective, in reality there can be wide differences between the performance of commercial products, even of the same generic type". Robinson(13) summarising twenty-five years testing by the GPC reported that 50% of all commercial coal tar epoxy systems immersed in sea water were "exhibiting integrity failures" within four years. Hence the advantage to specifiers of an approvals system such as PASS or GPC scheme where products or coating systems approved to the C/29 specification have demonstrated their durability in a specific environment (four years to obtain interim approval and six years for full approval).

6.2 Coating Performance

The specifiers problems are usually compounded by a lack of published information on the performance of alternative systems in different environments. Care is required in translating overseas data such as reported by Brevoort et al(14), to the NZ situation because of our different environment i.e. long times of wetness resulting from high relative humidities and deposited salts combined with increased ultra-violet exposure due to clear skies which reduce the life expectancy of organic coatings.

The corrosivity zones proposed by Duncan(15) and adopted in NZS MP 2312 give some guidance but allowance must be made for local microclimate effects. Results of the current BRANZ survey(16) on atmospheric corrosivity in NZ is awaited with interest.

6.3 Coating Application

Modern economical steel structures have limited reserve strength and so corrosion that may initiate fatigue or loss of section cannot be tolerated. The principle of ensuring a good foundation applies equally to coating systems as to the bridge itself, and so ensuring primer is applied to a rust and salt free surface is vital to ensure the potential life of the coating can be achieved. Use of zinc rich primers has been proven to maximise the life of most modern high build coatings and provides protection where any defects occur until maintenance can be carried out. The risk of inadequate coating thickness can be minimised with the use of stripe coats and/or multi-coat systems. Stripe coats should be applied to all rivets, bolts, holes and edges (after rounding) prior to application of the main primer and build coat. Use of a build coat in contrasting colour will provide an early warning of the need for maintenance, and refurbishment costs will be considerably reduced if carried out before significant corrosion (i.e. 0.5% of the surface area) occurs.

The first maintenance repaint is most important to maximise the life of the system and should not be delayed as initial defects can be more easily repaired if caught early. Also any inadequacies of the original coating in coping with a local micro climate can be dealt with. The effectiveness of a shop applied priming system can rarely be reproduced in the field situation, and therefore should be preserved as long as possible. Because providing access is usually a significant cost in maintenance repainting of bridges it is important that coatings are applied right first time. This can be achieved by requiring that all components of initial and maintenance painting are carried out in accordance with sound quality assurance principles, i.e. material supply, surface preparation, application and inspection are all controlled and documented in accordance with a quality plan. With regard to protective coating systems, the following anonymous quotation is particularly relevant:

"The bitterness of poor quality remains long after the sweetness of low price has been forgotten".

6.4 Coatings in the Future

As has already occurred in parts of Europe and America, the range of available coating systems is likely to be restricted due to the regulation of permitted levels of certain pigments, solvents and catalysts. Controls on the use of quartz sand for abrasive blasting and the containment and disposal of debris from bridges painted with red lead have already had a significant impact on bridge maintenance in USA.

These challenges are being met by the contracting and coatings industries with new cleaning techniques and the development of water borne, non toxic, high solids coatings which are currently being evaluated by such bodies as the SSPC and the FHWA in their research project PACE (Performance of Alternate Coatings in the Environment).

7. CONCLUSION

Most steel bridges in New Zealand can be classed as permanent structures and therefore require effective coating systems that are well designed, applied and maintained. Engineers need to utilise past experience and use proven systems in the protection of their bridges. They should also not under-estimate the care required in both the preparation of a coating specification and the application of a coating system, to ensure that the potential life of modern protective coatings can be achieved.

Corrosion of steel, like death and taxes, is inevitable, but with a good coating system well maintained, its effects can at least be postponed during the life of the structure.

ACKNOWLEDGEMENT

The author is grateful for the opportunity to record some of the work of J R Bewick, J H Fyson and other predecessors in their attempts to ensure that the most effective methods were used to protect New Zealand's major bridges.

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APPENDIX 13.3

Transit New Zealand
Bridge Inspection Policy
TNZ S 6 2000

BRIDGE INSPECTION POLICY

1. INTRODUCTION

These requirements are for the inspection of all State Highway bridges. In this document, wherever "bridges" are referred to, this is taken to include all culverts with a waterway area greater than $3.5m^2$, and all other culverts specifically listed.

This policy document sets out the frequency of bridge inspection, the minimum reporting requirements to ensure that following the discovery of a defect appropriate action is taken, and identifies the personnel who are responsible for the inspection.

2. STANDARD OF BRIDGE INSPECTION

The standard to which inspections shall be carried out is defined in the publication *Bridge Inspection Guide*, (DOT, 1983).

3. RESPONSIBILITIES FOR BRIDGE INSPECTION

3.1 Superficial Inspections

These shall be carried out by staff who are competent to identify and report on superficial faults that may occur.

3.2 General, Detailed and Special Inspections

These shall be carried out under the control of the Bridge Inspection Engineer.

3.2.1 An individual shall be designated the Bridge Inspection Engineer. This engineer shall have experience of supervision of bridge construction, inspection and maintenance, and shall be able to interpret condition in terms of structural action.

The Bridge Inspection Engineer shall:

(a) maintain overall management and technical supervision of the bridge inspection and maintenance programme for those bridges defined in the Schedule;

(b) take responsibility for the technical competence of all personnel involved in inspections;

(c) take responsibility for the structural safety of all bridges which have been inspected under the contract; and

(d) take responsibility for consulting with specialist staff when necessary.

3.2.2 Other personnel who shall undertake inspection are defined as follows:

(a) Bridge Inspector

A Bridge Inspector shall be experienced in construction, inspection and maintenance of bridges. A Bridge Inspector may be either a professional engineer or a person who, from extensive practical experience, is competent to judge the condition of structures.

(b) Specialist Staff

(i) Design Engineer

A Design Engineer who is responsible for inspection shall be experienced in the design of bridges, and shall be able to interpret observations in terms of structural action.

(ii) Other Specialist Staff

In any situation where identification of faults in the particular material or structure is considered by the Bridge Inspection Engineer to be outside the competence of the normal inspection staff, a specialist shall be engaged to advise them. Specialist staff shall be considered for the following situations, but shall not be limited to them:

- Bridges showing significant deterioration of structural steel members, or significant breakdown of protective coatings.

- Bridges showing significant decay of timber members.

- Bridges showing alkali/aggregate reaction or carbonation of concrete.

- Bridges showing significant corrosion of concrete reinforcement.

4. CATEGORIES OF INSPECTION

The various categories of inspection and the frequency with which they are to be undertaken are listed in Table 1, and described below. Where specific personnel are referred to, they shall be as defined in section 3.

4.1 Superficial Inspection

Superficial Inspections shall be carried out in accordance with *Maintenance Guidelines for State Highways* (Transit 1991). The inspections shall identify any obvious defect which may affect the safety of highway users or anything else needing urgent attention, such as those items listed below. :

- impact damage from vehicles, especially to guardrails and handrails
- build-up of flood debris
- adequacy of signs and road marking
- erosion damage
- deck drainage function
- approach settlement and condition of road surface
- expansion joint function

Defects and shall be reported immediately to the Transit New Zealand (Transit) Project Manager, with a copy to the Bridge Inspection Engineer.

4.2 General Inspection

General Inspections shall be carried out at intervals not exceeding two years.

The procedure required is described in *Bridge Inspection Guide*, referred to in section 2. During a General Inspection, personnel shall verify that the data recorded for each bridge in the Descriptive Inventory is correct, or note any necessary changes.

On bridges which have no history of maintenance problems and are considered by the Bridge Inspection Engineer to present no specific difficulty, the inspection shall be carried out by a Bridge Inspector.

On other bridges, as decided by the Bridge Inspection Engineer, the inspection shall be carried out jointly by a Bridge Inspector and a Design Engineer together with such Other Specialist Staff as the Bridge Inspection Engineer may direct.

4.3 Detailed Inspection

Detailed inspections shall be carried out at intervals not exceeding six years.

The procedure described in *Bridge Inspection Guide* shall be followed, but inspection shall be carried out at close quarters of all external surfaces above water level and, where appropriate, all internal surfaces. In waterways where abrasion or impact damage is possible, sufficient underwater inspection shall be carried out to verify whether such damage has occurred. Where measurements indicate significant scour has occurred, its extent shall be recorded and, if necessary, underwater inspection shall be carried out.

All inspections shall be carried out by a Bridge Inspector together with such specialist staff as the Bridge Inspection Engineer may direct.

4.4 Special Inspection

Special inspections involve particular types of bridge or particular circumstances.

(a) *Posted Bridge Inspection*

This is for posted bridges, and for those which have been identified as able to operate without a posted restriction, but at a stress level or load factor other than the standard values specified in the Transit *Bridge Manual, Design and Evaluation Section.* It is to be undertaken in place of the General Inspection, and carried out at a frequency to be determined by the Bridge Inspection Engineer.

Inspection shall include close observation of locations likely to sustain damage under traffic overload. Any deterioration in such locations shall be noted.

Inspection shall be carried out by a Bridge Inspector with such other specialist staff as the Bridge Inspection Engineer may direct.

(b) *Bailey Bridge Inspection*

This is in place of the General Inspection for Bailey Bridges, and shall be carried out annually.

Inspection shall be carried out in accordance with Appendix A.

Inspection shall be carried out by a Bridge Inspector and such other staff as the Bridge Inspection Engineer may direct.

(c) *Large or Complex Bridge Inspection*

This is for bridges for which, due to size or complexity, the frequency or the scope of the General or Detailed Inspection are not appropriate. The bridges to which this applies and the criteria are defined in a separate schedule.

Inspection shall be carried out by personnel as the Bridge Inspection Engineer may direct.

(d) *Earthquake Inspection*

This shall be carried out following an earthquake which is likely to have caused damage on all bridges in the affected area. Inspection shall be carried out as for a General Inspection, on those bridge members susceptible to earthquake damage.

The criteria and the extent of the inspection shall be agreed between the Bridge Inspection Engineer and the Transit Project Manager.

The inspection shall be carried out by a Bridge Inspector and such other specialist staff as the Bridge Inspection Engineer may direct.

(e) *Flood Inspection*

This shall be carried out following a flood which is likely to have caused damage on all bridges at sites known to have a history of instability. The criteria and the extent of the inspection shall be agreed between the Bridge Inspection Engineer and the Transit Project Manager.

The inspection shall be as for a General Inspection on the waterway and all members susceptible to flood damage.

The inspection shall be carried out by a Bridge Inspector and such other specialist staff as the Bridge Inspection Engineer may direct.

(f) *Overload Inspection*

This shall be carried out on any bridge during passage of an overload which may possibly cause damage. It shall also be carried out on any bridge where it is known or suspected that an illegal overload has caused damage. The criteria and the extent of the inspection shall be as agreed between the Bridge Inspection Engineer and the Transit Project Manager.

Inspection shall concentrate on those members susceptible to damage by traffic overload.

Inspection shall be carried out by a Bridge Inspector and such other specialist staff as the Bridge Inspection Engineer may direct.

5. REPORTING

5.1 Bridge Inspection

The Bridge Inspection Engineer shall require each inspection to be reported on Form TNZ 801 or 802 as appropriate, accompanied by a written report as necessary to describe specific defects. Maintenance work or further detailed investigation shall be recommended as appropriate.

Where a posted bridge, or one which operates at a stress level or load factor other than the standard values specified in the Transit *Bridge Manual, Design and Evaluation Section*, shows deterioration, the report shall make recommendations (to the Transit Project Manager) on design checks needed, taking account of previous reports and current condition.

Each report and recommendations shall be sent:

(a) to the Transit Project Manager;

(b) to the State Highway Maintenance Management Consultant for information and eventual implementation of maintenance work, when approved.

If the results of any inspection show that emergency action is required to temporarily strengthen or to close a bridge or perform any other work, the Bridge Inspection Engineer shall immediately advise the Transit Project Manager.

5.2 Bridge Descriptive Inventory

Changes required to the Bridge Descriptive Inventory shall be reported to the Transit Project Manager quarterly, on the necessary input forms.

6. RECORDS

The Bridge Inspection Engineer shall maintain the files of bridge inspection records and maintenance, so that a continuous history of each bridge is available.

7. VERIFICATION OF MAINTENANCE

A system shall be instituted to verify that approved maintenance work has been carried out as programmed. The cost description, and timing of the completed work , other than routine maintenance, shall be recorded on the bridge files.

8. TRAFFIC CONTROL

At all times during the work or activities associated with or arising from the exercise of this specification, the Contractor shall take responsibility to ensure all traffic control is carried out in accordance with the *Specification for Temporary Traffic Control*, TNZ G/1.

9. REFERENCES

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TABLE 1: BRIDGE INSPECTION POLICY

Category of Inspection	**Minimum Frequency for Inspection**	**Personnel Involved (minimum requirements)**	**Reporting**
Superficial Inspection	In accordance with "Maintenance Guidelines for State Highways"	Clause 3.1	As required
General Inspection	2 years	Bridge Inspector	TNZ 801
Detailed Inspection	6 years	Bridge Inspector	TNZ 801 and engineering report
Special Inspections:			
Posted bridges or bridges with a known weakness or structural defect	2 years or as determined by Bridge Inspection Engineer.	Bridge Inspector	TNZ 801 and engineering report
Bailey bridges	1 year	Bridge Inspector	TNZ 801 and 802
Large or complex bridges	As agreed with the Transit Project Manager	As determined by Bridge Inspection Engineer	As required
Earthquake. All bridges in the area seriously affected	Immediately following a significant earthquake	Bridge Inspector	As required
Flood. Bridges over a waterway with a history of instability	Immediately following a flood	Bridge Inspector	As required
Overload. Where a heavy overload has proceeded without the required supervision	Immediately following the event	Bridge Inspector	As required

NOTE: Bridge Descriptive Inventory Requirement - Clause 5.2

APPENDIX A

INSPECTION OF IN-SERVICE BAILEY BRIDGES

A1 General

A thorough inspection shall be carried out by a Bridge Inspector at least once per year.

A2 Inspection

Inspection of Bailey bridges shall cover the following points:

(a) Check for tightness of all raker, bracing frame, tie plate and riband bolts.

(b) Check tightness of transom clamps.

(c) Check sway braces are taut.

(d) Check that all panel pins have safety wires installed.

(e) Examine bearing foundations with particular emphasis on erosion, foundation shear failure and uneven settlement which, if present, much be corrected immediately.

(f) Check all packing is tight and if timber is used to retain approach fill, make sure timber is sound and approach fill is not spilling through.

(g) Check the condition of the decking. (Note that for all but the most temporary of bridges, there should be a protective skin of diagonal planking nailed to the chesses C this can be of sound grade 40-50 mm thick timber which will stiffen up the whole deck system as well as protect the chesses.)

(h) Ensure that all pins are greased to prevent water entering the joints. Ensure that all exposed threads of bolts, clamps and swaybraces are greased.

(i) Inspect protective coatings. Where significant damage to the coatings has occurred, the damaged areas shall, as soon as practicable, be first washed to remove any contamination from air-borne salts and then thoroughly cleaned by wire brushing, and reprimed with an approved epoxy zinc-rich paint. (A burnished surface should be avoided as it gives a very poor surface for bonding of the new coating). If such painting obscures the test date stamped on the central gusset plate, or the service plate painted thereon, these dates shall be reinstated.

(j) Check visually for signs of cracking in both welds and parent metal, particular attention must be paid to the swaybrace slot and male lug areas illustrated in Figure A1. Where cracking is suspected, magnetic particle or dye penetrant tests shall be carried out.

A3 Crack Monitoring

(a) When cracks are located their ends shall be centre-punched to allow monitoring of crack growth during subsequent inspections.

(b) Where cracks have been located, repeat inspections shall be carried out and crack test record sheets filled out accordingly. If significant crack growth is observed the defective panel shall be replaced.

A4 Crack Test Recording

(a) The crack test record sheet shall be used for the recording of results of crack testing in the swaybrace slot and male lug areas of all in situ Bailey bridges.

(c) Tests shall be carried out using either Magnetic Particle (eg, Magnaflux) or Dye Penetrant inspection techniques.

(c) All identified cracks shall be recorded on the record sheet TNZ 802, by showing their location and length and whether they occur in welds (W) or parent metal (PM).

A5 Reporting

Inspections shall be reported using form TNZ 801 with copies to be held on the Bridge Inspection Engineer's files. Where crack testing is carried out, the results are also to be recorded on the record sheet TNZ 802.

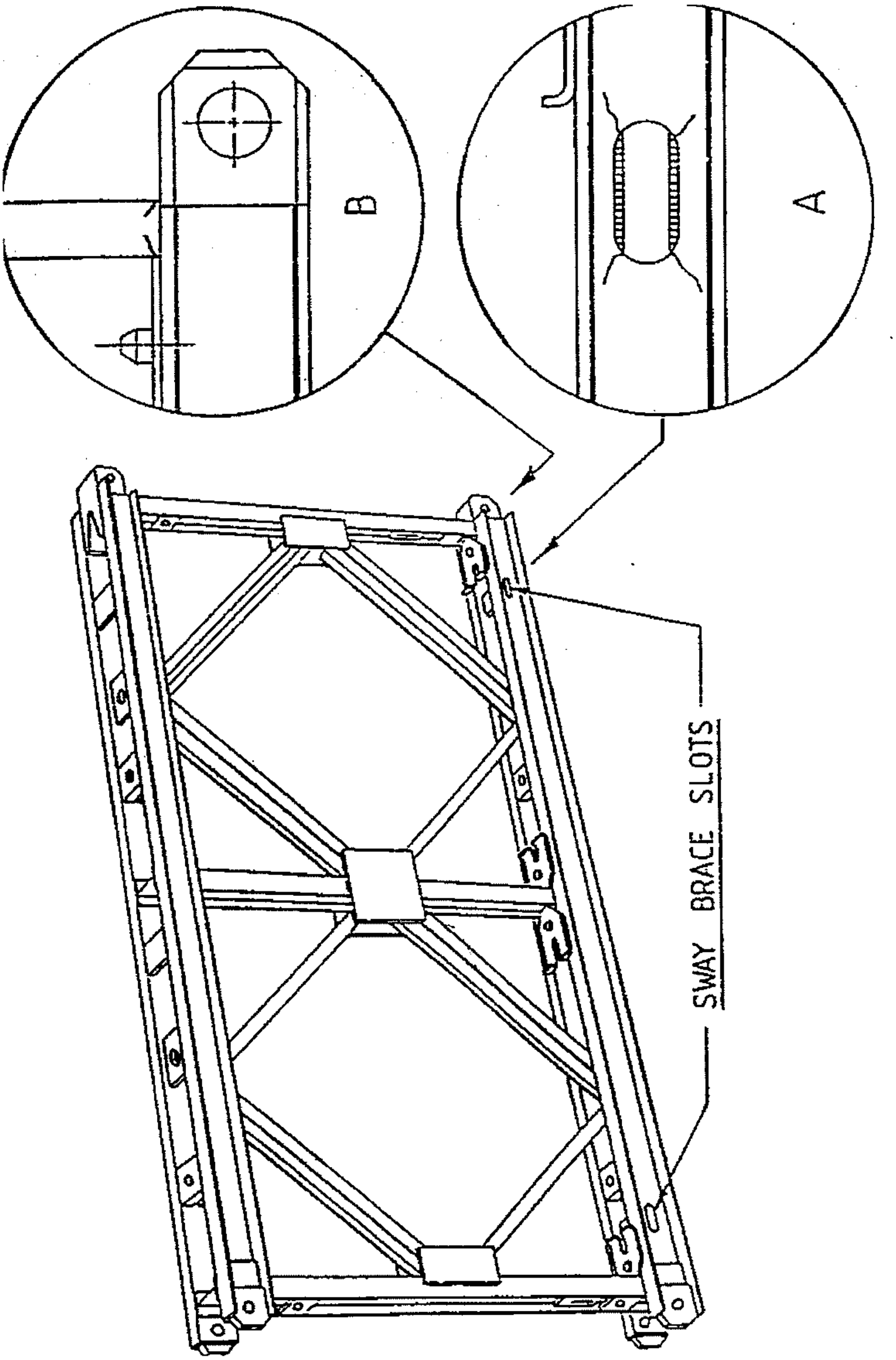


FIGURE A1

TRANSIT NEW ZEALAND
ARARAU AOTEAROA

Bridge Inspection Report

Bridge Name: .... Highway: .... R.P: ....
Spans: .... Width Between Kerbs: .... Length: ....
Type of Bridge: .... Restrictions: ....
Inspected By: .... **Date**: /...../ **Reviewed By**: .... **Date**: / /
(Bridge Inspection Engineer)

Check List

General

1	Appearance	
2	Approach adequacy	
3	Signs	
4	Vibration	
5	Bearings	
6	H.D Bolts and Linkages	
7	Expansion Joints	
8	Footways	
9	Road safety barriers and/or handrails	
10	Deck drainage	

Superstructure Concrete

		Deck	Main Member	Sec. Member
11	Cracking			
12	Spalling			
13	Reinf. Corrosion			
14	Other defects			

Superstructure Steel

		Main Member	Sec. Member
15	Condition of Paint		
16	Corrosion		
17	Joints		
18	Rivets and Bolts		
19	Other defects		

Superstructure Timber

20	Decay		
21	Warping and Cracking		
22	Deck wear		
23	Bolts and Spikes		
24	Other defects		
25	Date of last boring		

Foundations and Substructure

26	Settlement	
27	Cracking	
28	Spalling	
29	Abrasion	
30	Corrosion of Steel	
31	Other defects	

Scour and Waterway

32	River aggrading	
33	River degrading	
34	Waterway adequate	
35	Erosion of abuts/ approaches	
36	Embedment of foundations	
37	Other erosion or scour risks	

Marking Code

Not inspected	0	Routine maintenance *(provide comment)*	3
Satisfactory	1	Structural maintenance *(provide comment)*	4
Monitor next inspection	2	Not Applicable	N

Remedial work recommended last inspection has been completed: **YES** **NO** *(comment overleaf if answer is NO)*
Bridge Descriptive Inventory Changes Required **YES** **NO** *(describe change if answer is YES)*
....
(Continue over if required)

Comments and Recommendations for Maintenance/Repairs

Item	Brief Description of Fault and Recommendations for Repair and Urgency	Cost Estimate
	(Continue over if required)	

Comments and Recommendations Relating to Future Management (Transfer to Current Report)

Item	Defect/Strategy	Person (Bridge Inspection Engineer)	Date
	(Continue over if required)		

TNZ 801

BRIDGE DETAILS

S.H. ____________

R.P ____________

TYPE ________ ie–SS, DS, TS, DSCR, Etc.

DATE OF ERECTION ____________

NOTES

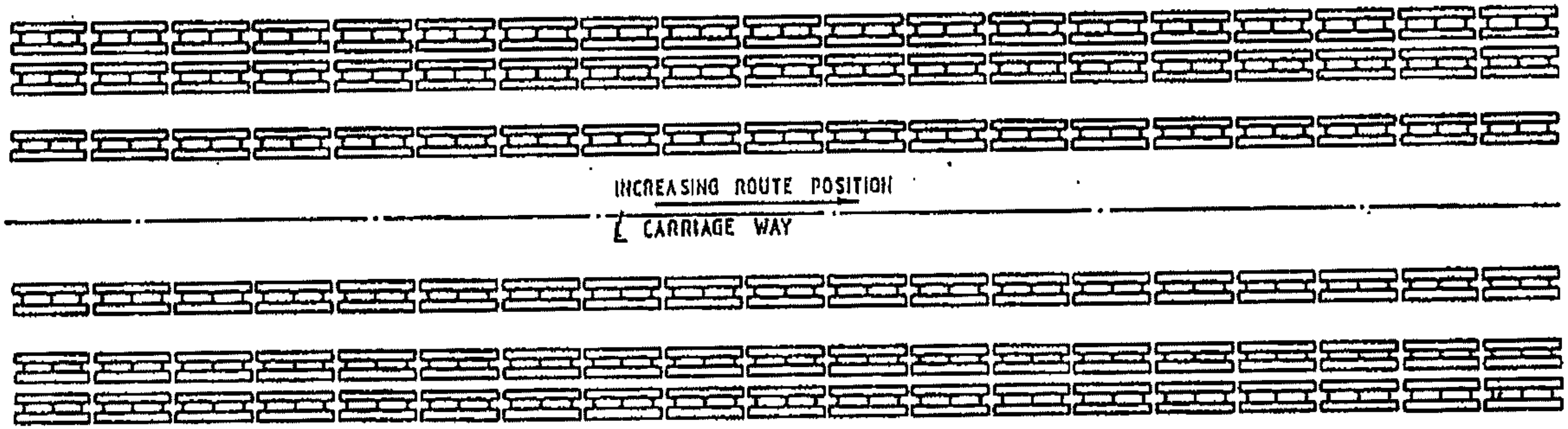
RESULTS OF CRACK TESTS CARRIED OUT AROUND SWAYBRACE SLOTS IN BOTTOM CHORD MEMBERS AND THE TRANSVERSE WELDS OF MALE LUGS. INDICATE LENGTH AND LOCATION OF CRACK AND WHETHER IT IS A WELD CRACK OR IF IT EXTENDS INTO PARENT METAL.
THIS SHEET SHOWS ONE TRIPLE STOREY OF A 19 PANEL BRIDGE. DELETE PANELS WHICH DO NOT APPLY TO THIS BRIDGE.
USE SEPARATE SHEET FOR EACH STOREY.

DATE OF INSPECTION ____________

SHEET Nº ____________

METHOD OF TEST ____________
ie–MAGNAFLUX OR DYE PENETRANT

FILE Nº ____________



GENERAL REMARKS.

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INSPECTED BY ____________

TNZ 802