

BRIDGE POLICY CIRCULAR

BPC2004/11

SUBJECT: Strategies for enhancing the durability of post-tensioned concrete bridges

No of Drawings Following	0	No of Appendix Sheets Following	4
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Background

Post-tensioned concrete has been used in Australia for more than 50 years. Two principal forms of post-tensioning are used – internal and external. Within these forms, a number of variants exist. These are determined by construction method.

Recent overseas experience in aggressive environments has highlighted questions of detailing of post-tensioned concrete structures to achieve suitable durability. In particular, the state of Florida in the United States of America, following durability failures in a number of pre-cast match-cast post-tensioned bridges, has adopted a multi-level approach to designing post-tensioned structures for durability. A similar approach is believed to be prudent for the RTA, as its coastal bridges are subject to a similar environment to Florida.

Current Position

Current projects performed under Design, Construct and Maintain (DCM) contracts have nominated the use of external post-tensioning for pre-cast post-tensioned segmental concrete bridges. Some of the detailing is only suitable for benign environments.

Recent work by the Bridge Section of RTA to revise specifications and testing for post-tensioning systems also provides the opportunity for a comprehensive statement on the protection of post-tensioned bridges against failure due to corrosion.

Policy

The following strategies for the protection of post-tensioned bridges against failure due to corrosion are to be adopted in accordance with Table I for the design of post-tensioned concrete bridges, according to the applicable environmental classification and post-tensioning system.

Table I**Protection strategies to be adopted for post-tensioned concrete bridges**

Post-tensioning system	Environment	Protection Strategy				
		1	2	3	4	5
Internal	Benign	Man.	Opt.	N/A	Man.	Man.
	Aggressive	Man.	Man.	N/A	Man.	Man.
External	Benign	Man.	Man.	Man.	Man.	Opt.
	Aggressive	Man.	Man.	Man.	Man.	Man.

Key to Table: Man. – Mandatory – protection strategy must be used
 Opt. – Optional – protection strategy may be used
 N/A – Not applicable for this post-tensioning system

Classification of environment

For the purposes of this policy, a benign environment is one that is not in water or where the exposure classification for the structural element (bridge superstructure, column, footing) is from A to B1 inclusive as defined in AS 5100 *Bridge design*. An aggressive environment is one that is in water or where the exposure classification is more severe than B1.

Protection strategies

The following are regarded as effective strategies for the protection of post-tensioning tendons and anchorages:

1. Filling of ducts, or sheathing, with properly applied protective grout;

or:

- Using coated (galvanised or epoxy), or grease-filled and individually sheathed, tendons;
2. Containment in a non-corroding duct that has sufficient strength to withstand all the construction processes and is effectively sealed against the ingress of moisture;
3. Replaceability of external tendons using existing anchorages and deviators;
4. Sealing of bridge deck and effective deck joint detailing;
5. Where erection is by match-cast segmental method, full epoxy coating of segment joints.

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The requirements for each of the above protection strategies are given in the attached Appendix.

Application

This Policy applies to all new bridge designs from the date of signature. This policy applies to all bridges not yet constructed in aggressive environments except where exempted by the General Managers, RNI Infrastructure Maintenance or Network Development.

Action Required

Project Managers, Bridge Designers, Design Reviewers, Project Verifiers and Principal's Representatives must make sure that design and detailing of post-tensioned bridges conform to the requirements of this Circular.



Gordon Chirgwin

Manager Bridge Policies, Standards & Records

Date

30/11/04

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Appendix

I. Encapsulating of tendons in protective grout or grease

Grout

Pending the revision of RTA B113 – *Post-tensioning of Concrete*, the following requirements for grout and grouting procedures shall apply.

For grout to be effective, the grout must be a low bleed cementitious grout specially formulated for the grouting process.

The duct must be tested under air pressure for leakage to at least 400 kPa.

Bleed points must be provided at the top face of anchorages, at all high points within the duct, and 1.0 m to 2.0 m beyond each high point in the direction of grouting.

Drains must be provided at all low points as contingency injection points.

Injection points must be provided at the low points of the duct and at the lower points of the anchorages.

All vents must be fitted with reusable metal valves to facilitate grouting and bleeding off.

All injection points must be fitted with pressure gauges to determine grouting pressures in the ducts.

Grouting pressures observed at the grouting pump must only be used for operational controls of grouting and not for determining grouting pressures in the ducts.

The grout must be injected from the lowest point of the duct. The duct must be grouted until grout of the same consistency as that being injected flows from the bleed tube for at least 5 seconds, as verified by flow cone measurements.

After initial grouting, the duct must be closed off at grouting pressures of up to 100 kPa for at least 5 minutes before bleeding off the high points. The high point bleed tubes must then be re-opened and bled successively in the direction of grouting using the least possible fresh grout before closing off the duct vent valves.

Within 72 hours of the setting of the grout, the upper bleed holes and anchorage bleed holes must be opened and the duct and anchorages checked for any voids in the grouting at these locations. Any voids must be filled using suitable techniques.

Note: Some cracking of the anchorage diaphragm is likely and there is potential for a void at the top of anchorages due to evaporation of bleed water following grouting.

Grease

Where grease is used for protection of tendon and/or anchorages the performance requirements of the grease must comply with Table 2 of this Appendix. Spaces filled with grease must be sealed used suitable O-ring seals.

Coated or sheathed tendons

Individual strands may be epoxy coated or galvanised, as approved by the RTA.

Strands may also be protected by encapsulating in individual grease-filled plastic sheathing conforming to RTA specification requirements.

Handling of these strands must be such that the protective coating or grease-filled sheathing remains intact and effective after installation into the structure. Special provisions and testing requirements may apply to ensure the effective gripping and protection of the unprotected length of strands at the anchorages.

2. Containment in a non-corroding duct

For Exposure Classifications A and B1, galvanised corrugated steel ducts are adequate.

For more severe exposure classifications, only approved plastic ducts must be used.

Internal plastic ducts must be corrugated and mechanically attached to the anchorages.

External plastic ducts must be of smooth HDPE tube with a minimum wall thickness 1/17 of the tube diameter positively connected to suitable steel or plastic sleeves at diaphragms and deviators.

Plastic duct design must account for creep rupture effects from the sustained circumferential stresses induced by pressure grouting, if applicable.

Duct sleeves at deviators and through diaphragms must be designed to minimise bending stresses and abrasion.

Ducts must be effectively sealed against moisture.

All tendon anchorages must be capped with permanent heavy-duty plastic caps filled with suitable protective grout or grease.

3. Full tendon replacement

For full tendon replacement the following conditions apply:

1. The structure must be able to withstand the removal/loss of a tendon under reduced live load;
2. Access to the stressing anchors for all operations must be provided without the need to close traffic lanes for more than 48 hours for each tendon, or to require the removal of any structural elements of the superstructure, abutments or piers;
3. The tendon must be fully destressable and replaceable with sufficient access and clearances to allow the installation and stressing of the replacement tendon in existing deviators and anchorages;
4. The Works as Executed Drawings must contain the design criteria for the post-tensioning system used in the bridge, as well as full construction details and procedures for destressing and replacing tendons, including any limitations on structure loading during tendon replacement operations.

4. Sealing and drainage of bridge deck and deck joint detailing

Waterproofing of the concrete bridge deck in accordance with the RTA Bridge Policy Manual requirements is deemed to satisfy these requirements where:

1. The structure is in a benign environment.
2. The prestressing tendons are contained within the webs of the girders or within the void space of the superstructure;
3. All jointing of ducts between segments is positively sealed using approved duct couplers.

Where the structure is in an environment that is aggressive, waterproofing of the concrete bridge deck must be provided in accordance with the RTA Bridge Policy Manual, and the following:

- a. Anchorages at deck joints must be located in blisters at least 500 mm away from the deck joint face.
- b. The design must detail specific deck drainage provisions.
- c. A stainless steel drainage trough must be fitted under all deck joints to prevent seepage through deck joints running down the face of the anchorage diaphragms.
- d. The grout cap at the anchorage and adjacent face of anchorage diaphragms must be coated with a waterproof membrane and suitable drip catches provided to prevent deck runoff seepage through any link slabs and deck joints from infiltrating the post-tensioning anchorage and the grout cap.

Drainage outlets must be provided in box girders.

5. Full epoxy coating of match-cast segment joints

Sealing of match cast joints must be carried out using an approved wet epoxy paste spread evenly over all of the mating surfaces at the time of erection, and applying post-tensioning across the joints before the epoxy has initially hardened.

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Table 2

Performance Criteria for Grease/Wax for Post-Tensioning

Property	Grease		Wax		Comments
	Test Method*	Requirement	Test Method*	Requirement	
Consistency	D217	265-340 dmm	D937	150-350 dmm	Application compatibility to be confirmed
Pumpability	D1092	100-200 cP at 25°C & 25 s ⁻¹	D445	15-25 cSt @ 99°C	
Corrosion protection	D1743	Pass	D1743	Pass	Test substrate to be advised.
Copper corrosiveness	D4048	1a	D130	1a	
Salt Spray corrosion	B117	1000h	B117	1000h	
Oil separation maximum	D1742	3%	FTMS 791C	0.5%	
Drop pt. minimum	D566	150°C	D127	90°C	
Flash pt. minimum	D92	Flash Pt.: 200°C	D92	Flash Pt.: 200°C	
Evaporation maximum	D972	0.5%	D972	0.5%	

*Test methods are ASTM unless noted otherwise.