Integral and Semi-integral Bridges

BTN 010

Version 1.1 12 April 2022

1 Scope and Application

Bridge Technical Note BTN 010 – Integral and semi-integral bridges – states the Department of Transport's (DoT) requirements for the design of integral and semi-integral bridges.

Bridge Technical Notes are a Code of Practice. Compliance with Bridge Technical Notes is mandatory.

Other than as stated in this document and relevant DoT/VicRoads standard specification sections, the provisions of AS5100:2017 apply. Where this document differs from AS5100:2017, its requirements override those of AS5100:2017.

The contents of this document are based on the PD 6694-1:2011 Recommendations for the design of structures subject to traffic loading to BS EN 1997-1:2004 together with the US PCI State of the Art of Precast/Prestressed Integral Bridges (2001). Where PD 6694-1:2011 refers to UK standards as a source of design requirements and material properties or other parameters, the equivalent requirements, material properties and other parameters must be obtained from AS 5100:2017 and other Victorian and/or Australian standards as appropriate.

The requirements of this BTN also apply to culverts and underpasses, except that the earth pressure in PD 6694-1:2011 may not be applied to culverts and underpasses where temperature ratcheting of soils is not expected.

2 Definitions

The terms integral bridge and jointless bridge are sometimes interchanged. However, the following meanings apply in this document:

Integral bridges, also known as 'fully integral' bridges, feature a fully continuous moment connection between the superstructure and substructure at the abutments, eliminating the need for deck movement joints or bearings to accommodate rotations and displacements at the ends of the deck.

Semi-integral bridges do not have deck movement joints but incorporate bearings at the supports to allow relative rotations between the superstructure and the abutment. This form may be adopted when ground conditions are not suitable for an integral bridge.

In both the cases, horizontal forces in the superstructure are transmitted to the abutment fill by a diaphragm that is continuous with the superstructure.

In multi-span integral or semi-integral bridges, the deck is made continuous between abutments and there are no movement joints in the deck. Pier to deck connections may be fully rigid or the deck may be supported on bearings. Provisions for thermal movements are made outside the bridge deck.

Refer to BTN 011 for definitions of underpasses and culverts.

3 General

3.1 Basis for Selection

Clause 5 of AS5100.4:2017 requires that the number of deck joints in a bridge must be minimised. The aims of that requirement are to improve ride quality and to eliminate the need for potentially hazardous and costly inspection, repair, and replacement of movement joints over the life of the bridge. Both the integral and semi-integral forms of construction eliminate the need for deck movement joints and must be considered in the following order of preference for all new bridges that meet the requirements of Section 4 of this document.

1. Integral bridges.
2. Semi-integral bridges.
3. Other bridge forms that minimise the number of deck movement joints and bearings.

The decision to adopt the integral and semi-integral forms of construction must be based on a thorough consideration of structural, geotechnical and backfill options.

3.2 Safety in Design

The Victorian Occupational Health and Safety Act 2004 places general duties on the DoT to provide a safe workplace and a specific duty on designers to ensure that the structures they design are safe and without risk to the health of people using them as a workplace so far as is reasonably practicable. For this reason, the integral and semi-integral construction are the most preferable forms of construction where they are suitable.

3.3 Foundation Type

The choice of foundation type for an integral or semi-integral bridge abutment will depend on the ground conditions and considerations of soil-structure interaction. Large stresses may be generated in piled foundations embedded in shallow rock due to cyclic thermal movements of the superstructure. A shallow footing or piles within oversized casings may be more appropriate in that situation.

4 Design requirements

4.1 Maximum Overall Length

The overall length between the rear faces of integral abutments, measured along the bridge centreline, must not exceed:

- 70m for a concrete superstructure.
- 55m for a steel superstructure.

In no case must the thermal cyclic movement at each abutment exceed ±20mm.

These limits are aimed at controlling the maximum passive soil pressure arising from thermally-induced cyclic displacements at the abutments which will, in-turn, limit the maximum stresses in the piles and, the size of the movement joint between the approach slab and approach pavement.

4.2 Structure Geometry

Integral and semi-integral bridges are only permissible for straight and curved-in-plan bridges with a skew of not greater than 30º.

Highly skewed and curved bridges tend to rotate in plan as a result of the action of thermally-induced forces in the superstructure which, in turn, mobilise passive resistance at the abutments in the form of a couple. This can lead to proportional increases in the horizontal loads on piled foundations.

4.3 Structural Design

Creep, shrinkage, temperature, and differential settlement effects are more significant for integral and semi-integral bridges than for conventional bridges. The structure including superstructure-substructure joints must be checked for stresses and stress reversals due to these and seismic effects.

Earth pressures behind the abutments must be calculated in accordance with AS5100 and PD 6694-1:2011. The structure must be designed for loads:

- immediately after construction
- long-term, after the development of passive pressures stated in PD 6694-1:2011.

The load factor for passive earth pressure in PD 6694-1:2011 must be as per Table 6.4 of AS5100.2, but must be taken equal to 1.50 where it reduces safety. Any reduction in earth pressure due to soil gapping effects or formation of voids behind the abutments must be evaluated and considered in design.

For seismic design of integral and semi-integral bridges, the requirements of AS5100 must be supplemented by other appropriate specialist literature. The effects of any excessive settlements and/or instabilities of approach embankments and increased seismic earth pressures must be determined.

4.4 Bridge Approaches

The requirements for integral and semi-integral bridge approach slabs are stated in BTN011 – Approach slabs.

The abutment backfill must possess adequate flexibility to allow bridge movements without significant restraint but have sufficient stiffness to limit settlements. The designer must assess and confirm the suitability of the abutment backfill for integral bridges.

Free draining, Type A select backfill material in accordance with DoT/VicRoads Standard Specification Section 204 must be used within a distance equal to twice the abutment wall height. The friction angle of the backfill material must be between 35º and 45º. Any in-situ material within that distance that may inhibit thermal bridge movements must be replaced with the select backfill.

4.5 Inspection and Maintenance

Consideration must be given to accessibility for inspection, maintenance and replacement of bridge components throughout the design life of the bridge, particularly where the details include items such as elastomeric bearings, bearing pads and joint fillers.

The gap between beams at the abutment and pier diaphragms must be filled up to the front face of the crosshead to eliminate a ledge. This infill must be cast integral with the fender wall/diaphragm.

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Bridge Technical Notes are subject to periodic review and may be superseded.

Document Control

This document is subject to periodic review and may be superseded. The revision date is listed in this BTN.

Note that for projects tendered prior to the revision date of this document, there are no retrospective implications of this document unless agreed otherwise with DoT.

Revision	Description	Revision	Approved by
1.0	General Amendments	17 December 2017	Principal Bridge Engineer
1.1	General Amendments Revision of Section 4 • Structural design requirements • Max. overall length • Maintenance requirements	12 April 2022	Chief Engineer - Road