Evaluation of shear connectors in composite bridges

Full report: www.nzta.govt.nz/resources/research/reports/602

New evaluation procedure should open up more routes for large vehicles

A recently published Transport Agency research report proposes a new procedure for evaluating the composite bending capacity of channel shear connectors in composite bridges.

The proposed procedure incorporates a newly developed design equation for channel shear connectors and adopts a Eurocode-based evaluation solution, which covers a wide range of applications. The procedure is an extension of the existing evaluation steps in the Transport Agency's 2014 *Bridge manual* (3rd edition).

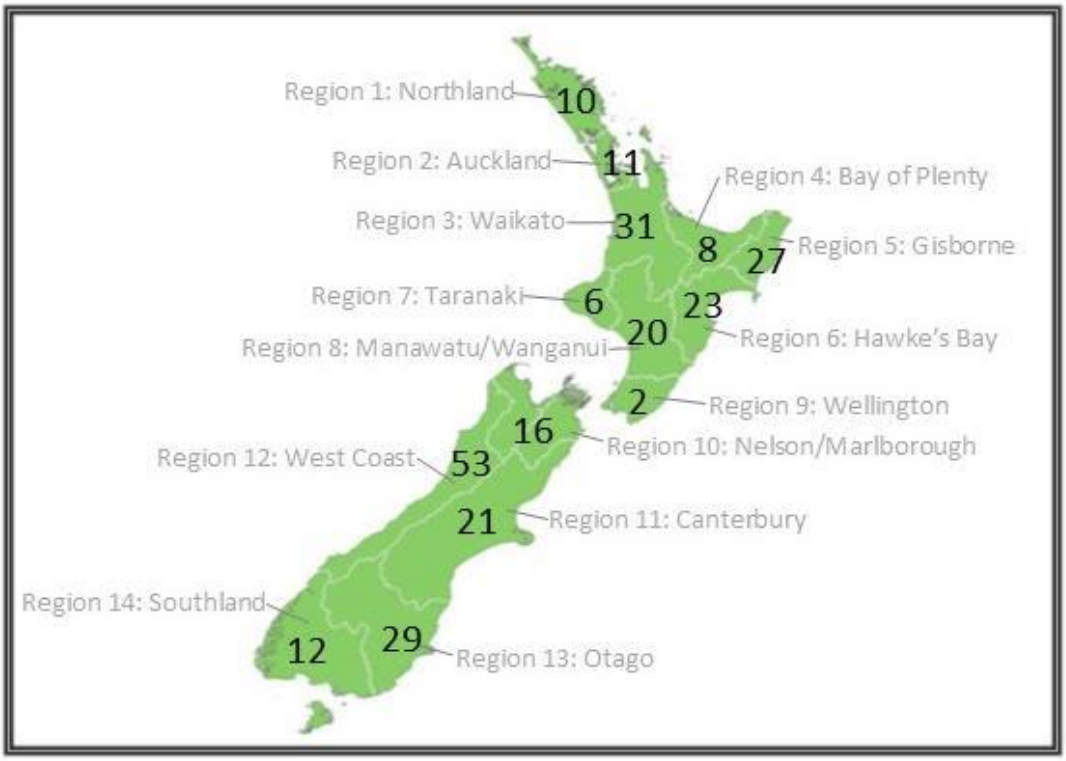
Bridge construction in New Zealand

At present, there are around 270 bridges on New Zealand's state highway network, and many more bridges on local roads with steel-concrete composite superstructures.

The figure below shows the distribution of these bridges throughout the country, with particularly high numbers evident in the central North Island and on the west coast of the South Island.

Most of these bridges have reinforced concrete deck slabs connected to braced steel I-beams, with welded channels or studs used to provide the longitudinal shear connection. Most (over 70%) were constructed between 1950 and 1970, with approximately three-quarters designed by the Ministry of Works.

Map showing number of composite bridges within each NZ Transport Agency territorial region, according to the Transport Agency's 2009 *Bridge data system structural guide*



The connectors used in these bridges play an important role in transferring the longitudinal shear force between the deck slab and girders or beams, thereby ensuring the bridge's composite behaviour. Although many different types of connectors have been used historically, the most common are welded channel (used in approximately 67% of bridges) and welded V-angle connectors (approximately 24%), with the balance comprising a mix of shear studs, bent plates and riveted angles.

Unfortunately, most of these shear connectors are not covered by the evaluation standards currently referenced in the *Bridge manual* (NZS 3404 and AS

5100.6). In particular, the design equations based on the standards are outdated and fail to take into account recent international tests (in terms of a safety margin).

This has implications for assessing the capacity of composite bridges. Although, based on their design live loadings, most of these existing bridges are expected to be capable of supporting full high-productivity motor vehicles, significant variations tend to arise in their assessed live load capacities, using existing design equations.

The aim of the research project was therefore to develop new design guidance for evaluating the capacity of existing bridges that incorporate welded channel shear connectors. (The research focused on this type of connector due to their prevalence.) It was anticipated, as a result of this study, high-productivity motor vehicles and 50MAX vehicles would be able to access more of the existing highway network.

What's in the report

The research first investigated the results of recent international experiments on shear connectors, and the design equations relating to them that had been incorporated in various international standards.

Drawing on this, the research went on to develop a new design equation for the resistance of welded channel shear connectors. The equation retained the form of that in NZS 3404; however, the capacity reduction factor was re-evaluated based on British Standard BS EN 1990. The analysis showed the design resistance of the connectors should be lower than that used in the existing equations. A method to identify the ductility of the welded channel shear connectors was also developed.

The research report introduces a proposed new design method for evaluating beam bending capacity in composite bridges, which incorporates the new equation for the connectors. The new design method is to be accepted in the forthcoming AS/NZS 2327 as a general solution for composite structures in New Zealand.

The report also sets out a proposed new evaluation procedure, which integrates the new design method. The procedure is based on the existing procedure in the *Bridge manual*, but has a broader scope, taking into account multiple design options, depending on the degree of shear connection, ductility of the shear connection, steel section compactness, minimum degree of shear connection and construction method, ie propped and un-propped construction methods.

The research report's appendices include a worked example of the new procedure, together with historic steel properties to use when the nominal material strengths at the time the bridge was designed are uncertain. The example is based on an existing New Zealand bridge and compares the results with the existing methods in the *Bridge manual*, demonstrating that the new method gives a more accurate prediction.