Title: Auckland Harbour Bridge Extension Bridge Upgrade

The Auckland Harbour Bridge (AHB) is a critical link carrying eight traffic lanes between Auckland City and North Shore City in New Zealand. The original bridge, opened in 1959, is a four lane steel truss structure. The bridge was widened in 1969 using two lane orthotropic steel box girder "extension" structures supported on steel box brackets fixed to each side of the original concrete piers.

The extension bridges were a pioneering technology in bridge design and this new technology was pushed to the limit to minimise weight and cost. As a result there have been ongoing strength and fatigue cracking issues with the bridges and ongoing repairs and retrofits have been necessary.

Extensive repairs were carried out in the early 1970’s and again in 1987 through the addition of welded steel plate in the superstructure to maintain the integrity of the bridges. A seismic assessment in the late 1990’s resulted primarily in strengthening of the box bracket substructure.

This paper outlines the challenges in carrying out a full assessment and strengthening design of the extension bridge structures in accordance with BS5400 and BD56 and the implementation in an extremely constrained working environment while maintaining daily traffic flows of over 160,000 vehicles per day.

A key feature of this project is that the geometry, detailing and tolerances of many members do not comply with current bridge standards requiring special studies and modelling to develop solutions.

A bridge specific probabilistic traffic load model was developed for live loads and wind tunnel tests were carried out to provide drag, lift and dynamic effects and consider the interrelationship between the three independent bridge superstructures.

The primary method of strengthening the box girders was by the addition of new stiffeners, plating and girders to the existing steel structure to upgrade the extension bridges to their maximum practicable capacity.

Construction has posed major challenges due to access, ventilation, fire, existing lead paint and the need to maintain traffic on the bridge. An electric railway materials handling system has been installed to handle most of the 900 tonnes of steel required for this project.
Speaker Abstract

Grafton Bridge is currently being strengthened to provide improved earthquake resistance and increased load-carrying capacity as part of the Central Connector project linking the Auckland CBD and Newmarket via a dedicated bus route. In-depth investigation into the strength of materials and structure was carried out in the assessment stage of this unique and challenging project to extend the life of the listed monument. The upgrade work will be New Zealand’s largest carbon fibre reinforced polymer bridge strengthening project.

Grafton Bridge was built in 1908 to carry horse-drawn traffic and pedestrians. At that time it was the longest reinforced concrete bridge span in the world and one of the first large concrete structures in New Zealand.

As well as being an Auckland landmark, the bridge is a vital pedestrian and traffic link. Heavy vehicles over 8 tonnes cannot currently use the bridge. The structural upgrade will mean it can carry general traffic as well as increased bus usage. The structure will also be strengthened to withstand earthquakes with an annual probability of exceedence of one in a thousand years.

Strengthening and upgrade works being completed on Grafton Bridge include:

- Strengthening the approach spans piers with additional reinforcement cored and grouted into the original columns
- Strengthening bridge deck beams with carbon fibre reinforced polymer materials
- Extending main pier foundations with piles and ground anchors tied into existing walls
- Installing shear keys and steel deck linkages
- Replacing expansion joints and bridge bearings, repairing cracks and applying an anti-carbonation coating

The presentation will address investigative work undertaken during assessment of the unusual early reinforced concrete details including material sampling, lab testing of the non-standard fish-tailed reinforcing bars, abseiling inspection of high level beams, and site investigation of ground and structural conditions.

In order to confirm analytical findings relating to the shear strength of the original structure physical load testing was carried out that successfully proved that non-standard details were capable of carrying design loads.

The project is due for completion in September 2009 in time for the 100-year anniversary of the opening of this historical piece of Auckland’s infrastructure.
Title: Upgrade of Esmonde Road Underpass

The Esmonde Interchange on the Northern Motorway, Auckland was modified to accommodate a new east to west movement, bus access to the adjacent Bus Station, and improved access for vehicles to the motorway as a part of the Northern Busway Project. It is a NZ$44M project undertaken by Transit New Zealand in collaboration with North Shore City Council to improve the public and private transport around the north of the Harbour Bridge in Auckland. The works involved construction of a new retaining wall under the western abutment spans for the northbound motorway on-ramp loop, a new motorway underpass bridge alongside the existing underpass and modifications to the existing Esmonde Road Motorway Underpass. The design and construction observation of the project was jointly provided by Opus and Beca. The project was completed and opened for public in May 2007.

This paper deals with the upgrade undertaken to the existing Esmonde Road Underpass. The underpass is a continuous three cell reinforced concrete box girder of depth 1.1m. The alignment of the bridge is on a spiral curve with varying super elevation along its length. The bridge deck needed to be widened up to 1.5m and raised by maximum 500mm to accommodate the modifications required at the motorway interchange. The original bridge was designed to H20-S16-44 loading standard and was built in the late 1950s. Thus the bridge required extensive strengthening to cater for the new alignment and current loading standards.

The main focus of the paper is on the widening and strengthening methods adopted in the light of construction challenges especially due to work adjacent to and over live motorway traffic. Structural assessments were carried out to determine the extent of strengthening required to the underpass Retaining and strengthening the existing underpass was compared with constructing a new bridge, however constructing a new bridge was found to be uneconomical.

The paper presents a summary of the findings of the structural assessments, options considered, and methods used for modifying and strengthening the underpass. Post tensioning and Fibre Reinforced Polymer composites have been adopted to strengthen various components of the underpass.
The Westgate Freeway upgrade project in Melbourne will improve traffic flow on a section of Melbourne’s main transport artery by eliminating weaving resulting from the junction of the Western Link and Westgate Freeway. Additional carriageways will be constructed to separate traffic at the existing conflicts. Much of the existing freeway is carried on two viaducts that were constructed in the mid to late 1980s as precast segmental, box girders erected by the balanced cantilever technique.

This paper describes the modifications that were carried out to the east bound viaduct. In broad terms these include alterations to the box girder span and widening of the viaduct over a length of approximately 700 m.

Part 1 of the paper will describe the alterations to the box girder and the resulting effects on its behaviour. Three and three quarter spans of the segmental structure were demolished, significantly altering the span configuration of this structure. This paper describes the effect of the change in span arrangement and the modifications required in the remaining structure. It also describes the demolition strategy and its implementation as well as widening of the deck in those areas where the widening is supported by the existing girder.

Part 2 of the paper deals with the widening of the deck where an additional steel trough girder has been used to cater for the increased width. This paper describes the philosophy adopted for the widening and some of the details that were developed. The structural analysis is described and related to the requirements of the AS5100. It also presents some design issues related to the flange slenderness limits encountered in AS5100. The construction staging and installation procedure are explained in relation to the design assumptions and the effect of temperature variation causing dimensional changes of the continuous steel spans.