NEW STANDARD BRIDGE BEAMS PROJECT

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SUMMARY

The main purpose of the New Standard Bridge Beam Project was to begin the process of updating the now largely out-of-date Ministry of Works & Development (MWD) standard bridge designs developed over 30 years ago. The original standard designs led to cost efficiencies both in design time and also the use of standard moulds by precasters led to more competitive tenders for supply of bridge beams. It is expected the new designs will lead to similar economies being realised.

INTRODUCTION

The two main task or stages of this project were as follows:
- Identify precast concrete bridge beam shapes to be adopted as industry standards for the future.
- Produce standard designs for these selected shapes for a standard two-lane carriageway configuration.

After much consultation with the industry, the following shapes were selected as the way forward in the New Zealand market place:
- Hollow core deck units (both double hollow core and a single hollow core variant)
- ‘I’ beam (a modification of the old MWD ‘I’ beam shape)
- Super ‘T’ girder (originating in Australia and now widely used in NZ)

Designs for a standard two-lane carriageway configuration have now been completed (see Figures 5 & 6 at the end of this paper). The standard designs are for simply supported bridge decks ranging in span from 16m up to 30m. Future work could include the development of the designs for a full range of carriageway configurations, as was the case with the original MWD designs.

BACKGROUND

In the mid 1970’s the MWD designed a range of double hollow-core, “I” and “U” precast concrete bridge beams and small span bridges which were adopted as NZ industry standards. These standard designs led to cost efficiencies both in design time and also the use of standard moulds by precasters led to more competitive tenders for supply of bridge beams. Probably thousands of standard beams were used in bridges all over NZ during the next 20 years.

In 1987 the then Ministry of Works and Development (MWD) ceased to be a government department and two private sector firms emerged from the MWD with Opus International Consultants taking over the copyright of the standard bridge designs. The standard MWD bridge beam designs completed in the 70’s era are now over 30 years old and out of date both with respect to design codes and higher strength materials now commonly used. In particular, changes to vehicular loading, durability, width and side protection requirements have adversely affected the current beam designs.

Discussions with a wide range of industry participants (consultants, bridge contractors, precasters and road controlling authorities [RCA’s]) have indicated strong support for producing a new range of standard beam designs which will provide long term economic benefits to RCA’s, with more efficient designs for simple bridge projects and for precasters who will be able to standardise more of their moulds for precast bridge beams.

Subsequently Land Transport New Zealand agreed to fund the New Standard Bridge Beam Project with the Cement & Concrete Association and Precast New Zealand providing financial support also.

The project’s objectives were to identify bridge beam shapes for the future and to produce detailed designs for these shapes.

Beca and Opus were commissioned to develop the new standard designs. From the outset a steering group was set up to guide the project. This group included clients, precasters, consultants, contractors, Precast New Zealand and the Cement & Concrete Association.

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STAGE 1 - BEAMS FOR THE FUTURE

Stage 1 of the project was completed in 2003.

The team researched and consulted widely during the first stage of the project and received considerable support for producing new standard designs from Road Controlling Authorities, major consultants, precasters, bridging contractors, Cement and Concrete Association and Precast New Zealand representing precasters nationally.

During Stage 1, 15 precasters (nationwide) of concrete bridge beams were consulted regarding usage of beam shapes and at the three consultation workshops nearly 40 bridge specialists attended to consider the research to date and express their view on the beam shapes that should be adopted as standard beams.

Following the Stage 1 research and consultation process the research team concluded that initially three beam types should be adopted as “standard” beam shapes and that standard designs should be prepared for Stage 2 of the project. Two existing shapes were selected to be retained and updated. These are:

- Hollow Core beams. These are currently suitable for spans up to 20 metres (650mm deep), but are to be extended for spans up to 25 metres (900mm deep)
- I-Beams for a span range of 18-24 metres

These shapes were still considered to be cost-effective and structurally efficient, in addition to being regularly used as bridging solutions. Also, the pre-cast industry has a significant investment in existing beam moulds, which it is keen to continue to utilise. Further spans/shapes could be designed as a subsequent stage.

The new shape selected (with nationwide approval) was the Super T beam based on a similar shape used in Australia. This shape is available in Australia in several depths with flange widths up to 2.5 metres. The depths selected for New Zealand standard designs were:

- 1025 mm for spans up to 25 metres
- 1225 mm for spans up to 30 metres

This shape is aesthetically more acceptable for urban situations (compared to I beams) but is still very cost effective.

The deliverable at the end of Stage 1 was a report recommending the scope and proposed cost for completing the standard designs and specifications for Stage 2 of the project.

STAGE 2 - DETAILED DESIGN

Stage 2 involved carrying out design calculations and producing construction drawings for the above beam configurations.

Stage 2 of the project started in earnest in early 2006. The project start was initially held up for a number of good reasons including pending amendments to the Transit Bridge Manual (Second Edition adopted in 2003 and subsequently amended in 2004 & 2005) followed by the recent rewrite of the NZS 3101 Concrete Structures Standard (published in March 2006).

DESIGN METHODOLOGY

The underlying philosophy was to achieve maximum efficiency in design along with good build-ability. Efficient and construction friendly outputs would also limit the scope or need for alternative designs at the tender stage of projects. All parties consulted agreed this was desirable.

Efficiency in design was achieved by:

- Grillage Analysis of the decks. Two-dimensional plane frame grillage models were used to analyse the bridge decks. This was to take maximum advantage of the transverse load spread that occurs in bridge decks. The resulting design actions are significantly smaller than what would be derived from a simple line beam approach with less prestress and or longer spans for a particular beam depth resulting.
- Cracked section or partial prestress design of beam elements. Cracked section analysis of the beams in accordance with NZS 3101 was undertaken to ensure maximum economies in design were achieved under the actions calculated by the grillage analysis.
- Calculation of prestress losses using the approach described in Appendix CE of NZS 3101: Part 2:2006. The method described in the reference is known as ‘the age adjusted effective modulus method’. This methodology accounts for the restraining effect of all bonded reinforcement (prestressed and non-prestressed) on creep and shrinkage strains. Losses calculated this way are typically smaller than those obtained by more traditional approaches.

Considerable effort was invested in the design to develop solutions that are relatively easy to construct. The adopted details were developed in liaison with precasters and constructors alike to help ensure this objective was realised.
Features include:

- A 'wide' bottom flange. Note that two different shapes of super 'T' girder are currently in use in New Zealand with one being approximately 100mm wider at the bottom of the bottom flange than the other. Because more prestressing can be added to the wider unit, it has been found that fewer beams are generally required across the width of bridges with cost savings resulting.
- A 100mm thick top flange has been adopted. Both 75mm and 100mm flanges have been used in New Zealand. The general consensus was that the thicker flange has advantages from a constructability and handling point of view hence its adoption. Note that the increase in thickness also ensures there is a reasonable covering of concrete over the top layer of reinforcing steel in the flanges, which is particularly relevant now that minimum design covers have increased with the new concrete code.
- 15.2mm strand has been adopted as standard for the prestressing. This allows more prestressing to be added to the beams and also reduces congestion of prestressing compared with equivalent areas of 12.7mm strand.
- Both the end diaphragms and intermediate stiffeners can be varied in length. This permits some standardisation in length of the inner formers.
- Four strands are located at the top of the beams to help control camber and reduce debonding in addition to providing support to the top of the reinforcing cage of the beams. It is in fact intended that the reinforcing cage will be hung from these four strands.
single hollow core units, the voids may be constructed using collapsible forms which can be withdrawn and reused.

- Transverse stressing of the units together at end, midspan and quarter span points, designed to resist the transverse flexural moments imposed by live loading on the deck or by vehicle impact on concrete barrier side protection of up to test level 4 standard. Note that the existing standard designs were designed assuming only shear transfer between the units in the transverse direction across the bridge deck, which has resulted in serviceability problems in some bridge decks with cracking of the longitudinal joints between the units occurring accompanied by break-up of the deck surfacing.

- With the single hollow core units, end diaphragms, and in the outer deck units, also quarter span point diaphragms need to be cast as secondary concrete pours following the initial construction of the units and withdrawal of the internal void former. In the outer units of the deck, these diaphragms provide anchorage for the transverse post-tensioning.

- As with the current standard designs, the outer deck units are solid over their outside half to provide fixing for concrete barriers.

- Prestressing has been standardised on 12.7mm diameter strand and reinforcement on grade 500 bars.

**'I' GIRDER DECKS**

Figure 4: I Beam

Features include:

- Standard beams that are pre-tensioned only for the full span range, 18m–24m, of units provided, with prestressing standardised on 12.7mm diameter superstrand.

- Cross-sections that are based on the existing standard design cross-sections but widened to provide the additional concrete cover required by NZS 3101:2006.

- A deck slab thickened to 250mm thick to satisfy the increase concrete cover to reinforcement required for a 100 year design and to provide for the higher barrier loads imparted to the deck by test level 4 rigid concrete barriers compared to the traditional test level three barriers.

- Diaphragms at the span ends and midspan, similar to those of the existing standard designs, have been retained.

**CONCLUDING COMMENTS**

The project has been a rewarding undertaking. The views of the industry needed to be heard prior to commencing with the designs. This collective wisdom was used to develop the designs with the many good ideas tabled being incorporated into the final product.

Although a complete document like the MWD blue and read books is not provided, a start has been made.

The project team believes that the designs produced will lead to economies all around to the obvious advantage of all parties involved in the precast bridge building industry.

**SPECIAL THANKS**

This project would not have been feasible without the contributions made by the steering group. A special thanks to the following people who have contributed through the group over the years:

**Ex Members**

Alex Grey, formally Beca (Project Instigator and former Project Leader)

Geoff Brown, formally Opus (Alex’s deputy earlier on in the project)

Helen Ferner, Beca (former Project Leader)

**Current Members** (in addition to the authors)

Paul Sweetman, Smith Bridge

John Marshall, Stresscrete

Mark Williams, Stresscrete

Ross Cato, Precast New Zealand

Alan Kirby, Cement & Concrete Association

Dene Cook, Cement & Concrete Association

Rudolph Kotze, Transit New Zealand

Ian Billings, Beca

Rob Jury, Beca
**TYPICAL BRIDGE SECTION**

Figure 5: Super ‘T’ Bridge Cross-section

Figure 6: Hollow Core Bridge Cross-section