A Bridge Strategy for the Introduction of the Next Generation of Heavy Vehicles

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SYNOPSIS

This paper discusses VicRoads’ staged approach to the introduction of High Productivity Freight Vehicles (HPFVs) as proposed by the National Transport Commission (NTC) based on Performance Based Standards (PBS). As the bridge stock has been designed to different design standards, many bridges are inadequate for the projected vehicles.

An explanation is provided of the strategies being used and the interaction with others. These strategies include the provision of initial government advice and the determination and assessment of critical freight routes to minimise the time intervals for the introduction of next generation high productivity freight vehicles. The introduction of these vehicles will require a new paragon of thinking by bridge engineers including increased surveillance of the performance of existing bridges, new methods of strengthening and accelerated construction techniques to minimise disruption to traffic.

1. History

VicRoads has practically completed a bridge strengthening and replacement program for Higher Mass Limits (HML) vehicles that commenced in the late 1990s. About 300 bridges have been strengthened or replaced at a total cost of about $70million. As a result of this program just over 99% of the declared arterial road network is now available to tri-axle 45.5t HML semi-trailers and tri-axle 68t HML B-Doubles.

In February 2006, the Council of Australian Governments (COAG) agreed to identify a suitable road network for B-Triples across Australia to “improve the safety and efficiency of freight transport”. Transport Ministers asked the National Road Transport Commission (NTC) to work with governments to identify a potential B-Triple network.

In November 2006, the NTC released a discussion paper entitled, “Adoption of a more general use of quad-axle groups in semi-trailers and B-Doubles” [1]. The paper proposed conditional new mass limits of up to 27t on these quad axles which corresponds to a gross vehicle mass (GVM) of 50t for semi-trailers and 77t for B-Doubles. The purpose of this initiative was to increase heavy vehicle productivity and more efficiently handle the national freight task.

Subsequently, COAG directed NTC to provide a national policy for the use of quad-axle groups for semi-trailers and B-Doubles and the Chairman of the NTC sought and obtained agreement from the Ministers of the Australian
Transport Council (ATC) in 2007 to the adoption of more general use of quad-axle vehicles.

The NTC initially worked with industry to develop “Blueprint” proposals [2] for HPFVs including mass and dimension details for B-Triples, 27t quad-axle Semi-trailers and 27t quad axle B-Doubles.

2. Liaison

2.1 NTC and Industry

Ongoing consultation is required with the NTC, vehicle designers, other state road authorities, local government and industry.

The initial “Blueprint” vehicles proposed by the NTC have some shortcomings which the above groups are working on to improve. For example, only a single vehicle configuration has been proposed for each HPFV type whereas a range of vehicle lengths and axle group spacing and mass will be required for different applications.

Practical limits need to be negotiated on these configurations to provide the basis for bridge assessment and strengthening programs, as was done for the HML vehicles. The broader the range of configurations for a HPFV class, the greater the number of bridges that will have to be upgraded before operation of such vehicles can be allowed on proposed networks. Non-conforming PBS vehicles will have to be assessed individually for specific networks.

A compromise needs to be reached between:

- Limiting vehicle configurations to minimise bridge strengthening and maximise network availability;
- Giving flexibility to vehicle designers to develop task specific HPFVs;
- Developing vehicles that comply with PBS vehicle standards.

2.2 AUSTROADS

The AUSTROADS Bridge Assessment Group (BAG) will be reconvened to:

- Co-ordinate bridge assessment activities at the national level with the intention of achieving consistency of approach, minimising duplication of effort and sharing knowledge and resources;
- Develop guidelines for the assessment of bridges for HPFVs using the Rating section of AS 5100 Bridge Design [3] and the BAG Guidelines [4] developed for HML vehicles as the basis;
- Identify and co-ordinate R&D projects related to bridge load capacity and the response of bridges to HPFVs.

This Group can also provide a forum for local government and consultant bridge engineers to become informed and provide an input to the process.

2.3 Within VicRoads

Assessment of bridge capacities and determining the requirement for strengthening or replacement will be done using the BAG guidelines when available.
The Structures Group, in partnership with Major Projects and Regions and in consultation with the Network and Asset Planning and Road Safety and Network Access groups, undertakes and provides advice on the assessment and strengthening of existing bridges for HPFVs.

3. PBS Vehicles

Under the current PBS provisions, the vehicle classifications and network levels are as shown in Table 1. \( L_v \) is the overall vehicle length.

<table>
<thead>
<tr>
<th>Network Level</th>
<th>Access Class A</th>
<th>Access Class B</th>
<th>Vehicle Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Access</td>
<td>Rigid Trucks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( L_v \leq 20 )</td>
<td>Single Semi-trailers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Truck &amp; Trailers</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>( L_v \leq 26 )</td>
<td>26 &lt; ( L_v \leq 30 )</td>
<td>B-Doubles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Longer B-Doubles</td>
</tr>
<tr>
<td>3</td>
<td>( L_v \leq 36.5 )</td>
<td>36.5 &lt; ( L_v \leq 42 )</td>
<td>B-Triples</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Double Road Trains</td>
</tr>
<tr>
<td>4</td>
<td>( L_v \leq 53.5 )</td>
<td>53.5 &lt; ( L_v \leq 60 )</td>
<td>Triple Road Trains</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other Long Combinations</td>
</tr>
</tbody>
</table>

Table 1 – PBS Network Levels

Current proposed PBS standards for Pavement Protection Measures are based on a summation of the effects of individual axle groups on a PBS vehicle and are not dependent upon the spacing of these groups.

Any form of Bridge Protection Measure must include both the mass and spacing of the proposed PBS vehicle axle groups.

A three tiered approach has been proposed:
- The use of traditional Axle Spacing Mass Schedules (Bridge Formulae);
- A generic approach, based on reference vehicles and bridge design capacities;
- Detailed analysis of individual bridges.

4. Nationally Proposed High Productivity Vehicles

4.1 B-Triples

Proposed B-Triples, as shown in Figure 1, include vehicles with:
- General Mass Limits (GML) axle group loads - 82.5t GVM;
- HML axle group loads - 90.5t GVM.
Figure 2 shows a generic B-Triple HPFV configuration that could form the basis for bridge assessment.

<table>
<thead>
<tr>
<th>6t</th>
<th>16.5t</th>
<th>20t</th>
<th>20t</th>
<th>20t</th>
<th>GML</th>
</tr>
</thead>
<tbody>
<tr>
<td>6t</td>
<td>17.0t</td>
<td>22.5t</td>
<td>22.5t</td>
<td>22.5t</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

An internal group spacing of 1.2m is shown to be consistent with HML bridge assessment vehicles incorporating tandem axles and tri-axles.

B-Triples complying with relevant ASMS have a minimum overall axle spacing (OAS) of 35.3m and lengths that comply with Network Level 3 Access Class B limitations shown in Table 1. Shorter B-Triples, not compliant with ASMS, would satisfy Level 3 Access Class A length criteria. Consideration might even be given to allowing “mini B-Triples”, with lengths of 30m or less, to operate on Level 2 Class B networks. These vehicles could be used to transport small volumes of high density freight, such as steel coils or similar.

Limiting X, Y and Z values to those applicable to HML B-Doubles would enable these vehicles to travel over most short to medium span bridges on HML networks as shown in Figures 9 and 10. As the difference between X, Y and Z dimensions increase, so do the effects on bridges thereby reducing access to existing networks.

B-Triples are very effective vehicles for transporting large volumes of low to medium density freight over long distances on multi-lane freeways and highways.
4.2 Quad Axle Semi-Trailers and B-Doubles

The nationally proposed quad axle HPFVs are limited to 27t on quad axle groups and HML limits on other axle groups. The limit of 27t has been determined mainly from pavement considerations. Quad axles offer minimal advantage over tri-axles in terms of loading on bridges except for short (< 6m) span bridges and culverts.

One of the principal reasons for introducing quad axles is to produce vehicles capable of transporting 12.2m (40ft) containers. A consequence of this requirement is that quad axle Semi-trailers may exceed the existing 19m overall length limit and quad axle B-Doubles may be up to 30m long compared to the existing 25m limit.

Figure 3 shows a range of generic quad axle Semi-trailer and B-Double HPFV configurations that could form the basis for bridge assessment.

<table>
<thead>
<tr>
<th>HPF Semi-Trailer – GVM=50t</th>
</tr>
</thead>
<tbody>
<tr>
<td>6t 17.0t 27.0t</td>
</tr>
<tr>
<td>O O O O O O O</td>
</tr>
<tr>
<td>A 1.25 X 3.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HPF Quad Quad B-Doubles – GVM=77t</th>
</tr>
</thead>
<tbody>
<tr>
<td>6t 17.0t 27.0t 27.0t</td>
</tr>
<tr>
<td>O O O O O O O O</td>
</tr>
<tr>
<td>A 1.25 X 3.75 Y 3.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HPF Quad Tri-axle B-Doubles – GVM=72.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td>6t 17.0t 27.0t 22.5t</td>
</tr>
<tr>
<td>O O O O O O O</td>
</tr>
<tr>
<td>A 1.25 X 3.75 Y 2.5</td>
</tr>
</tbody>
</table>

Figure 3 – Generic Quad Axle Semi-Trailers and B-Doubles

The allowable ranges of dimensions A, X and Y for bridge assessment have yet to be agreed. Reference is made to Clause 9, Generic Assessment for comparisons and comments on values of A, X and Y.

5. Principal Freight Routes

VicRoads and the Victorian Government are focussing on high priority freight routes. The Victorian Transport Plan [5], which includes “Freight Futures, Victorian Freight Network Strategy” [6], provides guidance on these routes.

The VTP estimates that by 2020 the total Victorian freight task will increase by 47% and the freight carried on key regional freight routes will increase by over 70%. It also estimates that by 2030 approximately 6.8 million 20 ft container equivalents (TEUs) will be traded through the Port of Melbourne, an increase of 210% on today.
VicRoads is addressing specific industry driven network assessment and upgrading for HPFVs where benefits are considered to justify the expenditure. Examples of these networks include:

- The Port of Melbourne and National Rail Terminal area with a specific focus on movement of 12.2m containers;
- The “Green Triangle” area in South Western Victoria with a specific focus on transport of materials to and from the Port of Portland.

Attention is also being given to other major upgrading projects such as the widening of the Western Ring Road which links the Port of Melbourne area to the Hume, Calder and Western Freeways and the upgrading of the M1 (Monash / West Gate) Freeway. These projects are all very important to the Victorian Transport Plan and the movement of freight between designated transport hubs.

6. Trial Implementation

VicRoads is implementing a trial of 30m long quad-quad axle B-Doubles on limited high priority networks in the first instance, to assess their performance and gauge public reaction to longer vehicles.

Only limited sections of the network, generally with bridges of close to T44 capacity or greater, will prove to be adequate for 27t quad axle Semi-trailers and B-Doubles in the first instance.

7. Victorian High Productivity Vehicles

A typical VicRoads Trial 30m long 27t quad axle B-Double has the following configuration:

<table>
<thead>
<tr>
<th>6t</th>
<th>17.0t</th>
<th>27.0t</th>
<th>27.0t</th>
<th>GVM 77t</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>3.7</td>
<td>1.3</td>
<td>9.8</td>
<td>3.75</td>
<td>5.0</td>
</tr>
<tr>
<td>OAS = 27.3m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4 – Typical 30m long HPFV B-Double

An example of a shorter, 25m long, 27t quad axle B-Double, proposed for transporting quarry products, as shown in Figure 5, has been included for comparison purposes. This vehicle is too short to comply with allowable configurations for the VicRoads Trial and could only be considered for specific limited routes.

<table>
<thead>
<tr>
<th>6t</th>
<th>17.0t</th>
<th>27.0t</th>
<th>27.0t</th>
<th>GVM 77t</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>3.8</td>
<td>1.3</td>
<td>4.2</td>
<td>3.75</td>
<td>5.5</td>
</tr>
<tr>
<td>OAS = 22.3m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 – A Short 25m HPFV B-Double
In addition to the NTC proposed HPFVs referred to above, several 30m long quad tri-axle Super B-Doubles, with a maximum gross vehicle mass of about 110t, have been operating on a very limited, low speed network in the Port of Melbourne area, under permit conditions, for several years now. These vehicles are used to transport 12.2m containers. Refer to Figures 6 and 7.

![Operating 110t Super B-Double](image)

**Figure 6 - Operating 110t Super B-Double**

<table>
<thead>
<tr>
<th>7t</th>
<th>27.0t</th>
<th>22.0t</th>
<th>34.0t</th>
<th>GVM 110t</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>O</td>
<td>3.2</td>
<td>1.4</td>
<td>8.7</td>
<td>3.75</td>
</tr>
<tr>
<td>A</td>
<td>OAS = 27m</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consideration may be given to allowing similar vehicles to operate under permit conditions on other localised networks for high efficiency freight tasks.

VicRoads is considering including 38t quad-quad B-Doubles in addition to the NTC 27t quad-quad B-Doubles for initial bridge assessment and strengthening considerations.

![Configuration of an Existing 110t Super B-Double](image)

**Figure 7 – Configuration of an Existing 110t Super B-Double**

<table>
<thead>
<tr>
<th>7t</th>
<th>26.0t</th>
<th>38.0t</th>
<th>38.0t</th>
<th>GVM 109t</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>A</td>
<td>1.25</td>
<td>X</td>
<td>3.75</td>
<td>Y</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8 – Possible 109t Quad Quad Super B-Double**

It is suggested that consideration be given to using tri-drive prime movers for these vehicles to reduce effects on pavements and short span bridges.

**8. VicRoads Strategy for Bridge Assessment and Strengthening**

VicRoads is implementing a strategy for the assessment, strengthening and replacement of bridges on high priority routes as part of network upgrading for
HPFVs and other commercial vehicles (such as cranes). This strategy is dynamic and subject to modification as improved knowledge, data and methods become available.

VicRoads initially undertook a generic assessment of all of its existing bridges for proposed B-Triple and 27t quad axle Semi-trailer and B-Double HPFVs to develop a broad understanding of the networks that might be adequate, the number of bridges that might have to be strengthened or replaced and some idea of budgetary requirements.

Detailed assessment of individual bridges is proceeding on the following basis:

- The assessment of bridges on high priority freight routes;
- The assessment of bridges as part of current major upgrading projects involving high priority freight routes;
- The assessment of common bridge types on high priority freight routes to expand and verify the results from generic assessment and identify potential research and development (R&D) projects;
- Review previous detailed research and analysis of individual bridges and common bridge types for HML vehicles as part of determining their adequacy for HPFVs.

9. Generic Assessment

9.1 General
Generic comparisons provide the basis for the initial review of bridges on a proposed route or network to indicate structures that are adequate, inadequate or require detailed assessment for the proposed vehicle.

Generic assessment of proposed HPFVs, including B-Triples and quad axle vehicles, predominantly consists of making comparisons of the bending, shear and reaction effects against design capacities and other vehicles.

9.2 Comparison of Single Vehicles
Figures 9 and 10 illustrate the relative effects of the following for simply supported span positive moments and two equal continuous span hogging moments as a proportion of T44 design capacity:

- 27t quad axle Semi-trailers
- 30m long, 27t quad axle B-Doubles;
- 25m long, 27t quad axle B-Doubles;
- Normal length B-Triples with HML axle groups and 90.5t GVM;
- HML Semi-trailers and B-Doubles;
- MS18 design capacity

The vehicles quad B-Double used as the basis for these graphs, were the quad axle B-Doubles shown in Figures 4 and 5, a B-Triple with an OAS of 30m and a quad axle Semi-trailer based on Figure 3 with HML Semi-trailer A and X values.
The comparisons included in this paper only show live load effects. The relative dead load and live load effects become increasingly important as span length increases, particularly for concrete bridges.

The 1.25m axle spacing shown in Figure 3 for bridge assessment vehicles is based on a practical minimum for quad axle spacing and is consistent with the SM1600 design vehicle axle spacing.

Setting A to minimum of 3m allows for a range of prime movers. The long (28 to 30m) quad quad B-Doubles used as the basis for Figures 9 and 10 assume a minimum OAS of 25.5m, minimum values of X and Y of 5m and a minimum value of (X+Y) of about 12m (the same as for HML B-Doubles).
The use of quad axle HPFVs to transport heavy quarry materials or similar would potentially require the use of shorter vehicles, such as that shown in Figure 5, and increase effects on bridges as shown in Figures 9 and 10.

Figure 9 indicates that for flexure in simply supported structures:
- HML B-Triples induce effects less than or equal to HML Semis and B-Doubles for spans up to about 33m and that exceed T44 values for spans over 25m;
- Long quad axle B-Doubles induce marginally greater or similar effects to HML for spans up to about 33m and again exceed T44 values for spans over 25m;
- 25m long quad axle B-Doubles induce significantly greater effects and exceed T44 values for spans over about 20m.

Figure 10 indicates that for hogging flexural effects in continuous spans:
- All vehicles, including existing HML vehicles, induce effects in excess of T44 for spans of about 7 to 11m;
- B-Triples marginally exceed T44 for 15 to 25m spans;
- 25m long B-Doubles induce significantly greater effects than other vehicles in about the 10 to 17m span range.

Further comments are made below under Detailed Design.

9.3 Multiple Vehicles in Same Lane
The Austroads Bridge Assessment Guidelines for HML vehicles included the provision to consider two HML vehicles in the same lane as well as multiple vehicles in adjacent lanes.

The multiple axle groups of the M1600 design loading makes provision for multiple moving freight vehicles in the same lane whilst the S1600 design loading allows for closely spaced stationary freight vehicles in the same lane.

Further consideration will need to be given to multiple vehicle loading, in both the same lane and adjacent lanes, when updating the BAG Guidelines for HPFVs.

10. Detailed Assessment
Detailed assessment of individual bridges and families of bridges for proposed PBS HPFVs is generally done in accordance with the provisions of AS5100 Bridge Design Part 7 Rating [3]. The updated Austroads Bridge Assessment Guidelines for HPFVs will also be used when available. The use of first principles and research findings are essential elements to an effective bridge assessment and upgrading program.

Assessments need to give consideration to a range of theoretical bridge capacity issues including:
- The ultimate limit state capacities of bridges and components;
• Serviceability limit state capacities with emphasis on durability and fatigue of steel and concrete that will potentially lead to structural deterioration, reduced life and increased maintenance costs;
• The capacities of existing substructures and foundations as well as superstructures;

Detailed analysis of a limited number of simply supported and continuous T44 bridges has indicated generally adequate flexural capacity for HPFVs, but sometimes marginal shear capacity and serviceability stress values and ranges in prestressed concrete structures. Continuous short to medium span reinforced concrete bridges, assessed as adequate for HML vehicles, may be prove to be inadequate for HPFV quad axle vehicles.

Detailed assessment of a number of representative prestressed concrete super tee and other bridges has indicated that bridges designed for T44 and HLP400 require minimal, if any, strengthening for B-Triples and 77t quad axle B-Doubles and even 110t Super B-Doubles, particularly if a reduced live load factor was assumed to reflect that such a vehicle would only be allowed to operate under permit conditions, most probably with on-board weighing and GPS tracking. Bridges designed for T44 only still only required relatively minor strengthening, even for Super B-Doubles. Box girders with large cantilevers are likely to require special consideration.

11. Research and Development (R&D) Activities

The potential exists to implement a similar program of R&D that was undertaken by VicRoads, other state road authorities, universities and industry as part of the NRTC / AUSTROADS Mass Limits Review for HML vehicles.

The magnitude of loading from HPFVs, particularly vehicles like the 110t Super B-Double, European cranes and similar is likely to produce previously unseen levels of fatigue damage in concrete structures as well as steel structures if this is not well understood and included in bridge assessment and the design of bridge strengthening and new structures. Loading from some current and future road vehicles introduces similar issues to railway loading.

Investigations for HPFVs will need to draw on previous research and focus on both MS18 and T44 bridges to determine the true capacities of the more common form of structures and identify any reserves of strength over and above design values.

12. Strengthening

12.1 Design Considerations

All new bridges and the widened sections of existing bridges are being designed for SM1600 design loading.

It is not always possible, nor economically justifiable, to strengthen existing bridges or the existing parts of widened bridges for SM1600 loading.
However, it is critical that strengthened structures have more than adequate capacity for vehicles that will use the structures during their remaining life.

VicRoads has generally strengthened bridges to about T44 capacity for the past 30 years. Since the introduction of SM1600 design loading and the ongoing demands to operate heavier freight vehicles, efforts are being made to strengthen to higher capacities.

Figure 11 - Comparison of Super B-Doubles for Simply Supported Spans

Figure 12 - Comparison of Super B-Doubles for Continuous Spans
It is essential that the capacity of the strengthened structure is well defined and documented for following generations of bridge engineers. It is strongly recommended that the capacity of the strengthened structure be expressed as a percentage of a design loading standard, preferably the current SM1600.

Figures 11 and 12 provide an indication of the loading induced by 110t Super B-Doubles and European cranes as a proportion of SM1600 design loading. These comparisons assume a common live load factor of 1.8 for all vehicles whereas a value of 1.6 is typically used for cranes.

These Figures also show the HLP400 design heavy load platform loading factored to allow for reduced live load factor, dynamic load allowance and occupation of 2 lanes.

The effects induced by these vehicles would generally be provided for by strengthening to the greatest of 75% of M1600 and a single M1600 axle group for simply supported spans or two M1600 axle groups spaced at 3.75m for continuous spans. Further consideration is required for multiple vehicles in the same lane but is generally covered by the above. Sections of bridges designed for HLP400 design loading, with spans greater than about 15m, have adequate capacity for 110t Super B-Doubles and 60t European cranes provided that the structure has at least 2 design lanes.

Most commonly strengthening is carried out to increase flexural and shear capacities of superstructure components. Pier crossheads also frequently require strengthening.

Strengthening of existing bridges is very often combined with widening and upgrading or replacement of existing bridge barrier systems.

Bridge aesthetic and heritage considerations may be an important issue for the more many bridges, particularly in urban areas. The type and appearance of any strengthening should be sympathetic to these requirements.

12.2 Methods of Strengthening
Strengthening of concrete beams is usually done by the addition of steel plates, fibre reinforced (FRP) strips or plates or by external prestress. In some instances where there is a shear deficiency at the ends of beams, steel supporting brackets are fitted in front of existing pier and abutment support positions. Strengthening of steel beams, similar to concrete beams, is generally achieved by the addition of steel plates to flanges and webs or by external prestress.

Strengthening of steel and cast in-situ and precast segmental concrete box girders is challenging, particularly cantilever sections. Closed box webs, soffits and deck soffits may be strengthened using steel or FRP plates or external prestress within the boxes. In some instances cantilever props that transfer load to the bottom of the web of the box section have been used. In other instances, particularly where widening is involved, cantilevers have been cut back and replaced with concrete beams or similar.
The most common form of strengthening used by VicRoads is to cast a continuous composite reinforced concrete overlay over multiple spans of precast beams. This approach generally increases the load capacity of MS18 bridges to T44 or greater capacity and eliminates all intermediate expansion joints. It also provides a method of retrofitting upgraded barrier systems, waterproofs old superstructures that are commonly cracked and corroded thus improving robustness against repeated loading by heavy vehicles.

13. Construction Techniques

Widening and strengthening bridges on major urban freeways as part of major upgrading projects can cause major traffic congestion.

It is essential to continue explore new materials and methods of strengthening and widening that minimise disruption to traffic. The addition of reinforced concrete overlays is effective but time consuming requiring the use of part width construction or side tracks.

Strengthening from the underside or within a structure are the preferable methods for heavily trafficked roads. The use of FRP drop in deck spans and other options may offer alternative solutions in the future.

14. Summary

Further work is required to develop Austroads Bridge Assessment Guidelines for HPFVs, assess and upgrade bridges to develop priority networks and monitor the ongoing performance of these bridges. Design and construction aspects of bridge strengthening present ongoing challenges. This paper has presented some information and discussion on these issues.

15. Acknowledgements

The authors wish to express their thanks to VicRoads for giving permission to present this paper. The views expressed in this paper are those of the authors and are not necessarily those of the Corporation.

16. References

1. “Adoption of a more general use of quad-axle groups in semi-trailers and B-Doubles”, National Transport Commission, November 2006.