AS5100.2 2017 – THE EFFECT ON BRIDGE BARRIERS

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ABSTRACT

The revision to AS5100 in 2017 resulted in significant changes to the design loading and impact heights for all bridge barrier performance levels. These changes have increased the requirements for on and off structure barriers and for pier protection which are then reflected into increased cost of bridge construction.

The paper will explore the impact of the changes to bridge barrier design

1 BACKGROUND

Safety to all road users is paramount. A bridge and its associated fittings, including barriers, form an integrated component of the safety systems of the road network. It is recognised that people will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of crashes and to protect people in the event of a crash.

Figure 1: Truck falling from Bridge

Bridge barrier systems should contribute to the following safe roads objectives:

- Designing, constructing and maintaining a road system (roads, vehicles and operating requirements) so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury.
- Improving roads and roadsides to reduce the risk of crashes and minimise harm. Measures for higher speed roads include dividing traffic, designing forgiving roadsides and providing clear driver guidance. In areas of large numbers of vulnerable road users or substantial collision risk, speed management supplemented by road and roadside treatments is a key strategy for limiting crashes.
- Managing speeds taking into account the risks on different parts of the road system.

This inclusive approach needs to cater for all groups using the road system, including drivers, motorcyclists, passengers, bicyclists and commercial and heavy vehicle users.

In addition, heavy vehicles are continually increasing in mass:

- Semi-trailer vehicles have increased from 42.5 tonne to 45.5 tonne higher mass limit and Truck Dog vehicles are currently travelling at 50-57 tonne.
- B-doubles have increased from the original 62 tonne to 68.5 tonne and application are received for 72.5 to 77.5 tonnes on specific routes.
- Other high performing freight applications from industry include 79-85 tonne A double, 82-90 tonne B-triple and 102.5-113 tonne AB triple.

With the ongoing trend for increased vehicle loading, and the desire to increase focus on road user safety, the publication of AS5100 in 2017 resulted in significant changes to the design of barriers.

2 BRIDGE BARRIERS

AS5100 specifies Low, Regular, Medium and Special performance level bridge barriers with a possibility of including a “no barrier” case and Special level. Table 1 below provides some general guidance where each type of barrier would typically be used:

Barrier Performance Level	Containment Properties
Low	Provided for the containment of light vehicles. Generally to be used for short, low-level structures on rural roads and areas where a very small number of mixed heavy vehicles are expected and for a low speed environment.
Regular	Provided for the containment of cars, heavy utilities and light trucks. Generally to be used on high speed main roads and highways with a mixture of heavy vehicles. This barrier is applicable and appropriate to the majority of bridge sites
Medium	Provided for the containment of most buses and medium mass vehicles. Generally to be used for high speed freeways, arterial main roads and major highways with a high volume of mixed heavy vehicles and site-specific risk situations.
Special (High)	Provided for high risk situations and the containment of heavy high centre-of-gravity vehicles. Generally to be used on routes with a higher volume of mixed heavy vehicles and maximum tolerable speeds such as freeways with variable cross slopes and reduced radius of curvature.

Table 1: Barrier performance level containment properties

In AS5100 (2004) the barrier performance levels were based on the NCHRP Report 350 test level system. The associated lateral force and effective height for each performance level is shown in the table below:

Barrier Performance Level	Vehicle Test Criteria			Lateral Force	Effective Height	NCHRP 350 Test
	Tonne	**Km/h**	**degrees**	**kN**	**mm**	**Level**
Low	2.0	70	25	125	500	TL2
Regular	8.0	90	15	250	800	TL4
Medium	36.0	80	15	500	1100	TL5
Special (High)	44.0	100	15	1000	1400	TL6

Table 2: AS5100 (2004) Barrier Design Requirements

NCHRP was replaced by MASH (AASHTO 2009) in 2009 which has for some levels increased test vehicle mass, speed, angle and impact energy. AS5100(2017) has been updated to reflect these changes as shown in the table below:

Barrier Performance	Vehicle Test Criteria			Lateral Force	Effective Height	MASH Test
Level	Tonne	Km/h	degrees	kN	mm	Level
Low	2.27	70	25	150	600	TL2
Regular	10.0	90	15	300	900	TL4
Medium	36.0	90	15	600	1200	TL5
Special (High)	44.0	100	15	1200	1500	TL6

Table 3: AS5100 (2017) Barrier Design Requirements

Figure 1: Typical barriers complying with AS5100:2004

The changes to the design loads is explained as follows:

- The severity index impact energy being proportional to half of the "mass*(speed*sin(degrees)) squared".
- The low performance force is approximated by the 2 to 2.27 tonne increase in mass
- The regular performance force is approximated by the 8 to 10 tonne increase in mass
- The medium performance force is approximated by the 80 to 90 km/hr speed increase squared
- The high-performance mass and height denote some minor changes arising from the effect of rear trailer impact at 100km/hr.

The resultant impact on design actions is quite significant as shown in Table 4 below:

Barrier Test	Bending Moment at Base of Barrier (kNm)			Shear Force at base of Barrier (kN)		
Level	2004 Code	2018 Code	% Change	2004 Code	2018 Code	% Change
Low	62.5	90	**44%**	125	150	**20%**
Regular	200	270	**35%**	250	300	**20%**
Medium	550	720	**31%**	500	600	**20%**
Special (High)	1400	1800	**29%**	1000	1200	**20%**

Table 4: Summary of Design Load action changes

3 PIER PROTECTION BARRIERS

The supports (abutments and piers) of overpass bridges are required to be structurally protected from vehicle collisions. They are considered roadside hazards and need to have safety treatments to protect road users.

AS 5100.1 (2004) typically required the following:

- *No protection* - Bridge supports located at a distance greater than the clear zone width, do not need to be designed for collision from road traffic

- *Road safety barriers* - Flexible or semi-rigid barriers may be provided to protect occupants of errant vehicles in the vicinity of bridge supports where the bridge supports are located within the clear zone.

  Bridge supports shall be designed for the collision load of 2000kN at a height of 1.2m The collision load may be assumed to vary linearly from the full load when the bridge supports are located at a lateral distance equal to the clearance required for the barrier to deflect from the edge of the nearest travel lanes, to zero load when the bridge supports are located a distance equal to the clear zone width from the edge of the nearest travel lanes.

- *Rigid barriers -* Where rigid barriers are provided, the barriers shall be structurally and geometrically designed for an appropriate performance level. The barriers shall be crashworthy, ground-mounted and structurally independent. **The bridge supports do not need to be designed for collision from road traffic.**

Figure 2: Protection barriers in front of pier at Williams Landing (designed to AS5100:2004)

AS5100:2017 is similar to the 2004 code requiring the relevant authorities to determine the minimum clearance of a pier or column from the roadway beyond which traffic barrier protection is not required. Where a pier is within the clear zone it is required to be designed to resist a minimum static load of 2700kN in any direction in a horizontal plane applied 1.2m above ground level.

The previous provision for bridge supports not needing to be designed for collision from road traffic when behind an appropriate barrier has been removed. When a pier is located within the clear zone it

must be designed for an increased collision load of 2700kN in any direction in a horizontal plane applied 1.2m above ground level.

VicRoads, in BTN003, require a reinforced concrete barrier to be provided in accordance with the detail shown in Figure 1 if site constraints do not permit the bridge supports to be positioned outside of the Clear Zone.

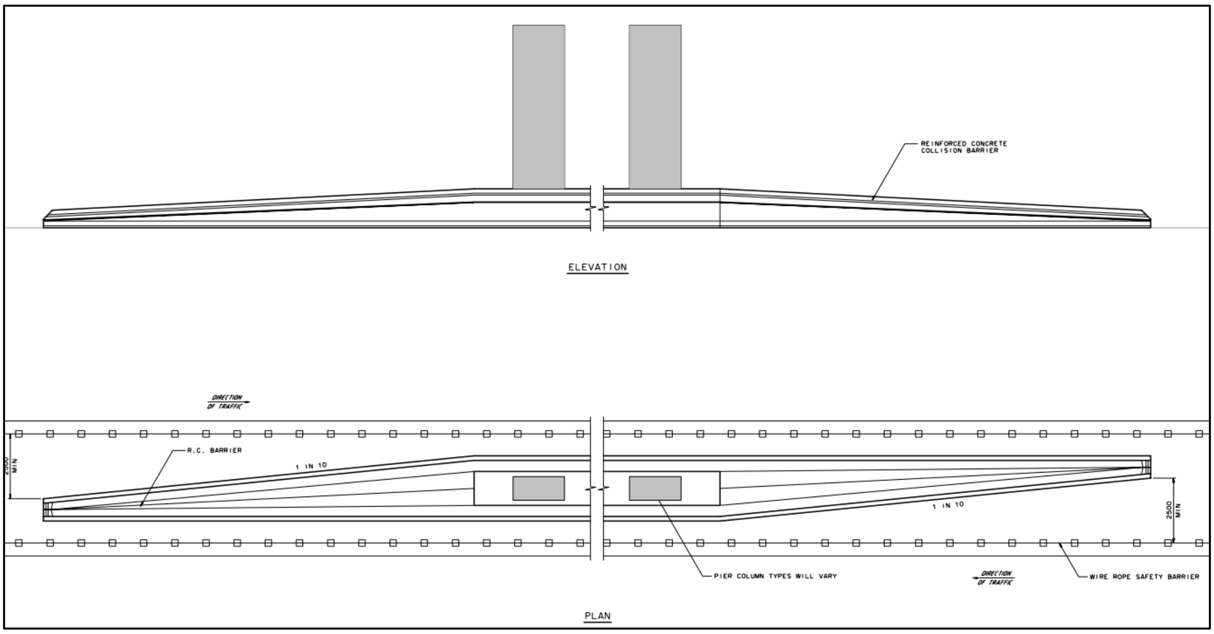

Figure 3: Typical Pier Protection Barrier (ref BTN 003)

Figure 4: Typical Pier Protection Barrier

In summary, piers in the clear zone must now be designed for a 2700kN load to be applied in any direction at a height of 1.2m. This represents a 35% increase in design loads.

4 OFF STRUCTURE BARRIERS

Where a vehicle crashes into a roadside barrier on a bridge approach, severe accelerations and the consequent high risk of injury can occur if the transition from a flexible approach barrier to a rigid bridge barrier is not properly detailed and transitioned in strength and stiffness. Such incidents represent a potentially major risk to the occupants of these vehicles.

Figure 5: Typical Off Structure Barriers

In addition, the road section in the proximity of the bridge may have the same risks as the bridge section itself. particularly in the instances where the area beneath the bridge is a major roadway or railway, highly developed area, deep waterway or similar feature. Such situations may represent a high risk to third-party persons and property if, for example, an errant heavy vehicle or high occupancy vehicle, such as a bus, impacts the bridge approach area.

AS5100:2017 has not changed in the requirements for off structure barriers, except the increases in barrier loads are reflected into the off structure barrier designs. There is a subsequent knock on effect in the design of piles or friction slabs under the approach barriers.

AS 5100.1 requires that a transition barrier be provided on the approach to all bridge traffic barriers. Strength and stiffness shall vary to provide a transition between any flexible roadside barrier and the rigid or semi-rigid bridge traffic barrier. The selection of a barrier performance level for bridge approaches and departures is based on the same procedure as for the bridge barriers. The length of each performance level provision shall consider local factors including, but not limited to, the following:

- The distance and clearance to the ROW boundary as it may affect the risk to occupants of errant vehicles and third parties
- The distance to hazards, including rigid objects and steep descents, as it may affect the risk to occupants of errant vehicles and third parties
- The risk associated with the use of the crossing underneath the bridge and the proximity of that crossing
- The risk associated with the existence of service roads or parallel walkways and the like.

VicRoads, in their document BTN002, expand on the provisions of AS 5100.1 for the design of bridge approach barrier systems for bridges on arterial road networks, on major freeways, divided highways, and on less heavily trafficked roads. BTN002 provides guidance on the approach barrier performance level lengths in Table 5 below:

Barrier PL on the bridge	Length of high PL approach barrier	Length of medium PL approach barrier	Length of regular PL approach barrier
High	LOB/3 [2]	LOB/3 [1]	LOB/3 [1]
Medium		LOB/2 [3]	LOB/2 [1]
Regular			LOB [1]

Table 5: Approach Barrier Lengths

The Austroads document, Standardised Bridge Barrier Design, provides a suggested design guideline for the design of approach barriers as follows:

- Determine the Length of Need (LON) for the bridge approach barrier to protect vehicles from a roadside hazard
- Select appropriate performance levels for different section along the required LON
- Determine transitions between different barrier types
- Select end treatments
- Determine structural solutions.

5 DISCUSSION

AS5100:2017 presents a significant change to barrier loading and will present challenges to designers and constructors. Designs will need to accommodate the increased loads with the following potential outcomes:

- Larger widths of barriers at the kerb stitch to allow for increased stitch reinforcement to installed.
- Larger and heavier barriers units making installation more difficult
- Moves to use continuous barriers in order to get improved load distribution in the barriers
- Substantially heavier foundations to off structure barriers
- Potential changes to currently standard construction - for example achieving adequate barrier connectivity into debonded link slabs
- Some designs may struggle to remain ductile as reinforcement quantities increase
- Considerably larger pier foundations to accommodate increased pier loads for piers located in the clear zone
- Potentially moving to longer span bridges to move piers out of the clear zone.
- Increasing difficulty retrofitting barriers on existing bridges to comply with the new code loads.

Figure 6: Longitudinal kerb-stitch and steel levelling bracket for precast barrier unit for AS51000/2004

All of these effects will impact on the costs of constructing bridges which will put increasing pressure on bridge owners budgets.

6 SUMMARY

The revision to AS5100 in 2017 resulted in significant changes to the design loading and impact heights for all bridge barrier performance levels. These changes have increased the requirements for on and off structure barriers and for pier protection which are then reflected into increased cost of bridge construction.

7 REFERENCES

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8 AUTHOR BIOGRAPHY

David Coe is a Senior Principal with pitt&sherry. He has over 35 years' experience in the design and construction of civil/structural engineering projects working most of which have been associated with the design, rehabilitation and management of bridges. He has considerable experience working within a large project team acting as the pivotal point between designers, contractors and the client.