Epping to Thornleigh Third Track

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Executive Summary

This submission draws on my professional lifetime of work for railways in NSW beginning with Way and Works Branch, NSWGR in 1964. I have extensive experience in the area of bridges and structures, maintenance, design, construction and safety and standards. In addition I have extensive experience in railway workshops for high standard bridge fabrication and preventative maintenance of locomotives and rolling stock. Since the beginning of NRC taking control of interstate freight in NSW in the mid 1990s I have been very concerned about the drop in standards for bridges, locomotive traction and wheel condition. This is related to the two main areas of this submission as follows:

1. Safety of the proposed track particularly considering overbridges, footbridges and other structure above the tracks

I am very concerned with safety aspects of the proposed track when considering bridges and other structures above the track. The gradient, curves and design speed of freight trains between Epping and Pennant Hills increases the probability of derailment and or collision of trains and the seriousness of the consequences. Past major derailments and collisions are discussed and their relevance to these bridges. It is essential that AS 5100 Bridge design be complied with for the design and modification of the new track's overbridges, underbridges, footbridges and above track structures. AS5100 is discussed in my paper attached. Note that the Chapman Avenue Beecroft Overbridge does not comply with the standard and is not adequate if a derailment or collision affects it either from a passenger or freight train at present. Replacement of the Chapman Avenue Overbridge and the Cheltenham Road Overbridge with a clear span similar to Copeland Road Overbridge is the first preference. If funds do not permit this, provision of sufficient redundancy to meet the requirements of the standard is the next best option. Only if this level of redundancy can not be met should pier protection be resorted to. For the Pennant Hills Road Overbidge, as the existing superstructure is continuous, provision of sufficient redundancy is the only option to consider and should be the least expensive. Sensors should be attached to the piers and a video camera attached to the new footbridge to indicate if a derailment affecting the piers occurs. If this occurs the train signals

should be set at red and the traffic lights at Yarrara Road and The Crescent controlled to remove road traffic from the overbridge until it is inspected and certified safe. Wells Street Thornleigh Overbridge should have its pier protection improved to meet the standard allowing for the freight line speed.

Provision of a train stop system compatible with CityRail's, on every freight train and light loco, is essential to reduce the probability of collisions on this section of track.

2. Diesel traction instead of electric traction and the resulting pollution causing devastating health effects on some of the residents of Sydney suburbs near the railway

The change from electric traction to diesel traction by NRC in the mid 1990s was an engineering disaster when considering conservation of energy and its devastating effect on the health of the community near the railway. *Within the CityRail System, this decision affects the health of more people in the Cheltenham to Thornleigh area than any other area because of the gradient, curvature and population density.* **The diesel fumes generated cause respiratory problems and <u>act as a depressant and carcinogen.</u>** In my case, as I am very intolerant to diesel fumes, they cause headaches and migraines (sometimes every second day), chronic fatigue and depression, loss of cognition, memory and alertness.

Once the third track is completed many freight trains will have to stop with there locos between Pennant Hills and Thornleigh and the end of the train down the grade towards Beecroft Station. For long heavy trains this will result in about four times the diesel fumes, at Pennant Hills and Thornleigh, when the train starts again, compared to the same train traveling at a constant speed up the grade at present.

It is very important to reinstate the previous electric traction for freight trains over the same CityRail tracks, as before, and this proposed track. In the long term, this should extend from Melbourne to Brisbane, with track realignment, as QR did from Brisbane to Gladstone and the Queensland coalfields. Until this occurs it is essential that all people in this area who have problems with diesel fumes, like me, can readily obtain advice of freight train running, say from a web site, so that they can put on a double filter respirator or go into high quality filtered air conditioning at that time.

Epping to Thornleigh Third Track

As a Civil Engineer working in the NSW railways from the 1960s to 2003 and continuing with the AS 5100 Bridge design standards committee until 2005, I would like to comment on the following aspects:

1. Safety of the proposed track particularly considering overbridges, footbridges and other structure above the tracks
2. Diesel traction instead of electric traction and the resulting pollution causing devastating health effects on some of the residents of Sydney suburbs near the railway

1. Safety of the proposed track particularly considering overbridges, footbridges and other structures above the tracks

I am very concerned with safety aspects of the proposed track when considering bridges and other structures above the track. The gradient, curves and design speed of freight trains between Epping and Pennant Hills increases the probability of derailment and or collision of trains and the seriousness of the consequences. The mandatory provisions of AS 5100 Bridge design, which are discussed in my paper attached, must be complied with for the design of new structures and the alteration of existing structures in this area. The critical section of this paper is given below:

4 COLLISION PROTECTION

It is very important to consider Part 1 General, Part 2 Design loads and the respective commentaries for collision protection from rail traffic, requirements.

These clauses have been revised to give more emphasis to design of bridges and structures with enough redundancy to permit a derailed train to demolish supports without collapse of the superstructure onto the train, rather than conventional pier protection. This was the recommendation of the Granville Investigation (7) section 5.12, p 22.

A tiered approach has been taken with a clear span still the preferred option. Next come bridges and structures with sufficient redundancy to permit a derailed train to remove one or more support columns without collapse of the superstructure onto the train under dead load plus 20% of live load. Only if this level of redundancy can not be met, is pier protection to be resorted to.

Between 10 and 20 metres from the track, new provisions apply. Derailments such as Concord West, where the double decker train came to rest on the adjacent road, influenced this clause.

Within 10 metres of the track, new loading of 500 kN applies to simulate collision loads such as occurred at Waterfall, NSW, following a shunting collision between two trains. This load can act in any direction and reduces above 5 metres above track level, to zero at 10 metres. It is applied as a vertically up load under superstructures. British Standards have been considered in this area. Collisions such as Beresfield, NSW, generate loads way beyond this provision.

For all bridges, below ground railways and air space developments, new provisions apply where additional superstructure dead load, fill or development occur (except on platforms); deflection walls, blade piers or continuous walls are required and the 500 kN load is increased to 1500 kN. Where the superstructure supports a dead load of more than 30 kPa the supports are to be continuous walls designed to the higher load. For all tunnels, including cut and cover construction, where roof support is required between tracks, a continuous wall will be required, allowing for a minimum of small openings to meet safety requirements for cross-passages and refuges. RIC is proposing to relax the requirement to increase the 500 kN load to 1500 kN where trains have a train stop system and those without are limited to 20 km/hr.

The Commentary indicates the relatively low speeds that the pier protection loads relate to. These loads are intended to satisfy the conditions of moderate derailments, and minor collisions, but not major derailments and moderate collisions. That is, a derailment of a 300LA train with 84 wagons derailing at slow speed, or a collision of two trains of this type at shunting speeds. (This may also represent a self propelled passenger train derailing at moderate speed, or a collision of two trains of this type at slow speed.) Wherever these speeds will be exceeded, structural redundancy, or a clear span are preferred. Where freight trains collide head on with rigid pier protection at a speed approaching 80 km/hr sufficient energy is stored to permit the locomotive to rotate end over end on to the superstructure, thus redundancy is a much better option in this case.

Past major disasters at Eschede, Germany and Granville, NSW, could have been reduced to a derailment without collapse of the overbridge until all passengers were removed from the derailed train, by the simple provision of redundancy conforming to the new requirements of the standard.

I am not satisfied that the alterations to the overbridges at Hornsby, for the new freight line, have been constructed to comply with the intent of AS 5100 (that is to do minimal work to change to blade piers) and certainly would have been of concern to Safety and Standards during the eight years I was there. On the section of line from Epping to Pennant Hills, the overbridges at Chapman Avenue Beecroft and Cheltenham Road Cheltenham (the design of which I did and was involved in, respectively) are of the most concern. This is because the gradient and curvature increases the probability of derailment or collision. The Chapman Avenue overbridge has sharper reversing curves so has the highest probability of derailment. It also has no pier protection so is not acceptable for present track and traffic conditions. This overbridge has had a column in a pier damaged previously, probably by a shifting load on a freight train. For both of these overbridges, even if the piers are converted to full height blade piers to comply with AS 5100, the commentary explains that this allows for only freight trains derailing at slow speed (not defined but not more than 20 km/hr), or a collision of two freight trains at shunting speeds. The current speed board freight train speed of 60 through the curves is well above slow speed (but after the new track is fully operational there is a possibility that some trains may exceed this) making blade piers inadequate protection. Rebuilding with clear span or three span continuous with redundancy will give the best solution. I have had some discussions with Transport for NSW staff at the information day and they are considering increasing the collision protection loads in the standard to allow for the increase in design freight train speed above slow speed. It is essential that any such strengthening be applied to both piers adjacent to both the up and down main lines. By contrast the renewal of Copeland Road Overbridge Beecroft has been done to the highest standard as one clear span from abutment to abutment over the existing tracks and proposed tracks (similar to the renewal of Bold Street Overbridge Granville.) Unfortunately this solution is by far the most expensive and this is why AS 5100 allows for modification to overbridges and other above track structures to provide redundancy so that if a support or supports are demolished in a derailment or collision, the bridge or structure will not collapse onto trains although unserviceable. This much less costly modification could have been done at Copeland Road, leaving scarce funds available for similar modifications to roughly 300 overbridges in NSW which are of the same general design to the previous Copeland Road and Bold Street Granville overbridge designs. I have only had strengthened one overbridge in this manner, however Safety and Standards was preparing for a major program (which I was managing), coordinated with the RTA, to strengthen all of these 300 odd overbridges. In the late 1990s, Rail Access Corporation abruptly stopped all this work.

The Pennant Hills Road Overbridge Pennant Hills is less of a concern as it is at the top of the steep gradient and the track is straight. This makes the probability of derailment or collision lower. The consequences of a collision similar to Beresfield however has the potential to be truly catastrophic if a peak hour passenger train is on either of the adjacent tracks, if the superstructure collapses.

A very brief observation of the superstructure indicates that it may already comply or may easily be altered to comply with the provisions of AS 5100 for redundancy, such that if a pier is removed in a derailment the deck will not collapse (but may deflect noticeably and not be servicable.) This is due to the steel and wrought iron girders being three span continuous. In this instance it may be necessary to increase the live load case to allow for the high density of semi trailer traffic. This is an ideal location to also install sensors, similar to slip detectors, to sense pier damage from a derailment then put the railway signals to stop and control the Yarrarra Road and The Crescent traffic lights to remove all traffic from the Pennant Hills Road overbridge, until it can be examined and certified safe.

Additions to the footbridge at Pennant Hills and the new footbridge at Cheltenham must comply with AS 5100 Bridge design.

It is very important to consider the type of derailment or collision that is possible on this section of track. As well as considering the derailments and collisions mentioned in the paper above, the derailment of a 2 kilometer long steel train in the Wallarobba Tunnel a few weeks before the 2000 Olympic Games, and the derailment of a coal train decades ago on the Blue Mountains following brake failure, needs to be considered. Similar incidents could occur on this section of track. Although derailments like the Blue Mountains derailment and the Concord West derailment could result in trains coming to rest in adjacent streets or beyond, the Beresfield collision is what should be designed for. Until all freight trains, including light locomotives, are fitted with a train stop system, the probability of a collision of this type will be unacceptable. The main concern is the high design speed of freight trains for this new track. At Rhodes, when I was representing Safety and Standards on this subject, for the high density development there, National Rail Corporation (NRC)/ARTC where proposing speeds in the 100 to 110 km/hr range and I was very concerned about this. For the track at Chapman Avenue overbridge I presume a design speed at the currently posted speed board of 60 km/hr is proposed (due to the curves and gradient). Even at this lower speed, incredible disasters can occur. At Beresfield the coal train was traveling at 80 km/hr when it passed signals at stop. The driver and observer missed seeing the signal as they were blinded by the sun on the horizon. By the time they saw the coal train ahead (this was on straight level track) they applied the maximum braking then jumped off because they new the train could not stop before a collision. They were both injured but survived. The collision occurred at Beresfield station, which has an island platform similar to Beecroft. Coal wagons went everywhere and one of the locos stood on end and crashed across the island platform, crushing the station masters office and breaking her arm. A passenger waiting for the late running passenger train had to jump off the other side of the island platform to avoid being hit by the falling loco. Very fortunately, the passenger train was late, if it had been on time, it would have been in the platform and would have had the loco and coal wagons fall on it with severe consequences. Imagine this happening at Beecroft at peak hour with one or two passenger trains on adjacent tracks. Worse still, if it occurred at any of the overbridges mentioned, a disaster similar to Granville is possible. Even at Copeland Road, the overbridge could not withstand a loco standing on end under it, causing a very high upward load, or falling on the deck. It should also be remembered that because of the curves, drivers do not have as much sight distance as at Beresfield, so there would be much less time to brake and for a train going down the grade the collision speed would be close to the speed before braking. In addition more freight trains will be able to run at speed with passenger trains at speed on the adjacent tracks. If trains traveling in opposite directions collide, the effective speed of collision could exceed 100 km/hr. **Only a train stop system compatible with CityRail's, on the freight line and every loco, can reduce the probability of such collisions to an acceptable level.**

Overbridges on this section of track should be designed for EP freight trains (which allow for cant deficiency correction and are permitted to run at passenger speed board speeds) at passenger train line speed, even though at present this is only allowed on sections of the North Coast Line. It has to be also considered that some freight trains will exceed these speeds and I have some experience with this in relation to bridges and bridge damage. It is critical to increase the design collision loads to reflect these higher speeds relative to the lower speeds assumed in the standard, given in the Commentary.

As stated in the extract from the section of my paper dealing with collision protection, replacement of the Chapman Avenue Overbridge and the Cheltenham Road Overbridge with a clear span similar to Copeland Road Overbridge is the first preference. If funds do not permit this, provision of sufficient redundancy to meet the requirements of the standard is the next best option. Only if this level of redundancy can not be met should pier protection be resorted to. For the Pennant Hills Road Overbidge, as the existing superstructure is continuous, provision of sufficient redundancy is the only option to consider and should be the least expensive. Sensors should be attached to the piers and a video camera attached to the new footbridge to indicate if a derailment affecting the piers occurs. If this occurs the train signals should be set at red and the traffic lights at Yarrara Road and The Crescent controlled to remove road traffic from the overbridge until it is inspected and certified safe.

Probability of derailment

This is a big topic covered in AS5100 and its commentary. For this portion of track it is important to remember that the Commonwealth took control of all interstate freight and took a 100 year lease on each states tracks and infrastructure outside the CityRail area to improve efficiencies and rationalise railway standards throughout Australia. This sounds sensible in theory however in practice standards have been allowed to fall too far.

Important factors increasing the probability of derailment and collision are the abandonment of preventative maintenance and routine inspection of locomotives and rollingstock, eliminating technical expertise by closing the Railway Technical Library (this had been the best railway specific library in the southern hemisphere), and closing the Scientific Services laboratory (which had 90 employees three decades ago). Residents within the area in question are well aware of the increase in wheel squeal which is directly related to these factors.

Railway ethos

Prior to NRC, train drivers took an interest in underbridge condition and would slow down below the speed limit on an underbridge if they thought its poor condition warranted it. NRC offered a bonus to drivers that arrived at the destination early. This meant that drivers tended to speed. I observed one freight train on an underbridge at very high speed way above the speed restriction set because of its poor condition. The underbridge deflected violently and the wagon underframes could be seen deflecting in a sinusoidal wave. This substantially increases the probability of derailment.

Consideration of the Granville Disaster

Lessons must be learnt from the Granville Disaster and applied to the design of this track and associated bridges and structures. The design of the Bold Street Overbridge Granville was prepared in 1947 following WWII. Due to the shortage of professional engineers the bridge was 'designed' by a draftsman who most probably was not allowed to visit the site. Construction started in the early 1950s and stopped once it was found that the superstructure level did not meet the approach road level. After a years delay, the railways increased the concrete deck thickness to 2'6" rather than the design 8" to 10". Of course they should have altered the steelwork to suit the road grading. This proved to be fatal as in the derailment, once the trestle was knocked out the bridge collapsed after two minutes or so. If the slab had been as designed the bridge may not have collapsed onto the train due to the limited continuity provided by the web splices (although it would not have met the redundancy provisions of AS5100) or it may have held up longer allowing more passengers or all passengers to escape, before collapsing. Thus it can be seen that unsatisfactory design and construction may not lead to collapse until decades later.

By contrast at Eschede, Germany, the continuous prestressed concrete overbridge collapsed immediately onto the high speed passenger train traveling at about 200 km/hr. The girders were accelerated towards the ground by the negative prestress at the pier that was removed by the derailment. They crushed the train with a large loss of life. (If this overbridge had been similar to the Granville one, the train would have been way past the bridge by the time it collapsed.)

The overbridges at Chapman Avenue and Cheltenham Road would not perform as well as the original Granville overbridge if a freight train derailed affecting either bridge. If a pier was demolished the bridge would collapse straight away. This actually applies to most prestressed concrete overbridges on the proposed freight corridor. Note that with the present track arrangement and the pier protection at Cheltenham Road, only Chapman Avenue overbridge is at present an unacceptable risk in a derailment.

The overbridge at Wells Street Thornleigh also has inadequate pier protection which should be improved.

Other areas of concern on the Freight Corridor

1. Air space developments at Hornsby

   There has been a discussion of air space developments at Hornsby station. In the greater Sydney area there is an unfortunate history of incredibly unsafe air space developments, when considering the possibility of derailments, such as the Goulburn Street Car Park, Hurstville and Bankstown. In Hornsby yard there are slips which are the track components with the highest possible probability of derailment, except for derailers and catch points (which are specifically designed to cause derailment to protect a main line). As the probability of derailment is so high, emergency services conduct their training here. Considering the ARTC freight traffic, it would be madness to consider an air space development at Hornsby.

2. The Hawkesbury River Bridge

   A derailment or collision of a freight train on the Hawkesbury River Bridge affecting a passenger train on the adjacent track has the potential for the gravest of consequences if a passenger train enters the water. Considering the depth of the water, any passenger that can not get themselves above water level, will drown. In the past this bridge has been given the highest priority for maintenance. A high level of bridge maintenance is of no consequence if ARTC allow freight train standards to drop so much that the possibility of derailment or collision on the bridge increases above an acceptable limit. I have similar concerns about the Parramatta River Bridge at Meadowbank.

2. Diesel traction instead of electric traction and the resulting pollution causing devastating health effects on some of the residents of Sydney suburbs near the railway

One of the first things NRC did when they took control of the interstate freight tracks was to discontinue the use of electric locomotives for freight trains throughout the CityRail system. The use of electric locos for freight trains began in the early 1950s. On the Cowan bank (Cowan to Hawkesbury River) and over the Blue Mountains, trains were timetabled so that freight trains descending the steep grades would use their regenerative braking to put power back in the overhead wiring system to power trains going up the steep grades at the same time. Diesel electric locos also have regenerative braking but the amount of power stored is limited by their battery capacity and most is dissipated through resistor banks so electric locos gave a far greater conservation of energy on these long steep grades. From 1976 to 1980, Alan Reiher, as Chief Commissioner of PTC, NSW, was improving engineering aspects of railways and lobbying the Federal Government for funds for railway improvement to all states. His work was so effective that I thought in a few decades we would see electrification from Melbourne to Brisbane.

The change from electric traction to diesel traction by NRC was an engineering disaster when considering conservation of energy, particularly because we are past peak oil, and its devastating effect on the health of the community near the railway. This was an indication of the many poor engineering decisions NRC and ARTC have made since, some of which I have informed the ICAC and the Rail Safety Regulator of. Some of these bad decisions have affected the safety of the traveling public and the surrounding community.

Within the CityRail System, this decision affects the health of more people in the Cheltenham to Thornleigh area than any other area because of the gradient, curvature and population density. **The diesel fumes generated cause respiratory problems and <u>act as a depressant and carcinogen.</u>** In my case, as I am very intolerant to diesel fumes, they cause headaches and migraines (sometimes every second day), chronic fatigue and depression, loss of cognition, memory and alertness. If I go to the country or other areas of Sydney where there are no diesel fumes, I am much better. Returning from a week in the country it takes only two days at Pennant Hills to return to my usual poor health. For the last decade I have been searching for a remedy by seeing many specialists and professors and the most highly qualified in various disciplines throughout the state. I have found no medication that will eliminate this problem, however folinic acid gives some relief. The best recommendation is to use a double filter respirator, which is not practical to use all the time. To walk from Thornleigh to Pennant Hills along Pennant Hills Road I need to wear a double filter respirator and I sometimes use one to shop or drive in this area. (I prefer not to drive in Sydney as on most main roads I should wear a double filter respirator. Going North I wear one to Wyong; going South I wear one to Heathcote, then drive from there; I wear one to Picton on the Hume and going West use back roads and the Bells Line of Road to avoid most semi trailers.) Ducted air conditioning at home would help but is too expensive for us to purchase and run. We purchase a second hand European car with an effective pollen filter but we found it too expensive to maintain so had to sell it. Neither of our older Japanese vehicles can be fitted with such a filter, at reasonable cost. I have an expensive herbal mixture which is a partial help. The most useful assistance I find is to do 2.2 km of very hard and steep, fast cycling every day, in all weather. Without this, headaches and migraine increase dramatically. When headaches and migraines occur I find wearing silk clothes against the skin a good remedy. It normalises serotonin and probably dopamine levels.

Once the third track is completed many freight trains will have to stop with their locos between Pennant Hills and Thornleigh and the end of the train down the grade towards Beecroft Station. For long heavy trains this will result in about four times the diesel fumes, at Pennant Hills and Thornleigh, when the train starts again, compared to the same train traveling at a constant speed up the grade at present.

The Pennant Hills Station Manager does not get advised when freight trains will run on the DOWN track (up the grade from Epping to Pennant Hills). All other trains, including XPT and all freight trains on the UP track (towards Sydney) are no problem. **IT IS ABSOLUTELY ESSENTIAL THAT ALL PEOPLE IN THIS AREA WHO HAVE PROBLEMS WITH DIESEL FUMES, LIKE ME, CAN READILY OBTAIN ADVICE OF FREIGHT TRAIN RUNNING SO THAT THEY CAN PUT ON A DOUBLE FILTER RESPIRATOR AT THAT TIME AND FOR THE NEXT HOUR SAY, DEPENDING ON WHERE THEY ARE AND THE WIND DIRECTION AND STRENGTH, OR GO INTO HIGH QUALITY FILTERED AIR CONDITIONING AT THAT TIME. ONCE THE THIRD TRACK IS IN OPERATION IT WILL BE MUCH MORE IMPORTANT TO HAVE THIS INFORMATION, TO PREVENT *POTENTIAL FATALITIES* , IF THESE TRAINS STOP AND RESTART BEFORE REJOINING THE MAIN LINE AT THORNLEIGH**. Even a range of possible times with probabilities of freight trains would be better than the present lack of any information.

It is essential that all preschools, schools and high schools from Cheltenham to Thornleigh be advised of this information so that they can have all children indoors, in high quality filtered air conditioning, at these times.

The staff of the Allergy Unit at RPA advises that people with high sensitivity and intolerance, like mine, are often those who achieve 100% at university. In my case, in 1963, I was the only engineering student from all engineering disciplines at UNSW, out of just under 1000 students, to achieve 100% in Structures. (By contrast I had a deferred in English.) I am sure there are other academic high achievers that are similarly affected by diesel fumes in this area.

Most people in this area assume that trucks on Pennant Hills Road are the main problem but my health symptoms did not become a major problem until after NRC changed to diesel traction on the CityRail System. Where we live we are closer to a much longer length of the railway from Cheltenham to Pennant Hills than to Pennant Hills Road through Pennant Hills and Thornleigh. (See attached map -- Distance to stations: Cheltenham 0.77 km, Beecroft 1.43 km, Pennant

Hills 1.50 km and Thornleigh 2.0 km. Distance to Pennant Hills Road footbridges: Observatory Park 2.2 km, Railway Street 1.47 km; and Station Street 1.96 km.) Recently when waiting on Pennant Hills station, a very long freight train with five diesel locos ascended the grade from Beecroft. I was so badly affected by the diesel fumes that I was unwell for the rest of the day despite going on a long Probus walk. In September 2011 I was exposed to a large amount of diesel fumes at the Grand Parade at the Rusty Iron Rally at Macksville. In this case the wind blew the diesel fumes into the grandstand where the roof trapped it and I felt very unwell. Once I left the grandstand and walked around the showground in the fresh country air, to our car, I felt much better. The difference at Pennant Hills is that if I am exposed to large volumes of diesel fumes at the station, the background diesel fume level at home, particularly through the night, is significant and prevents rapid recovery.

Conclusion

It is essential that AS 5100 Bridge design be complied with for the design and modification of the new track's overbridges, underbridges, footbridges and above track structures. Note that the Chapman Avenue Beecroft Overbridge does not comply with the standard and is not adequate if a derailment or collision affects it either from a passenger or freight train at present. Replacement of the Chapman Avenue Overbridge and the Cheltenham Road Overbridge with a clear span similar to Copeland Road Overbridge is the first preference. If funds do not permit this, provision of sufficient redundancy to meet the requirements of the standard is the next best option. Only if this level of redundancy can not be met should pier protection be resorted to. For the Pennant Hills Road Overbidge, as the existing superstructure is continuous, provision of sufficient redundancy is the only option to consider and should be the least expensive. Sensors should be attached to the piers and a video camera attached to the new footbridge to indicate if a derailment affecting the piers occurs. If this occurs the train signals should be set at red and the traffic lights at Yarrara Road and The Crescent controlled to remove road traffic from the overbridge until it is inspected and certified safe. Wells Street Thornleigh Overbridge should have its pier protection improved to meet the standard allowing for the freight line speed.

Provision of a train stop system compatible with CityRail's, on every freight train and light loco, is essential to reduce the probability of collisions on this section of track.

Reinstate the previous electric traction for freight trains over the same CityRail tracks, as before, and this proposed track. In the long term, this should extend from Melbourne to Brisbane, with track realignment, as QR did from Brisbane to Gladstone and the Queensland coalfields. Until this occurs it is essential that all people in this area who have problems with diesel fumes, like me, can readily obtain advice of freight train running, say from a web site, so that they can put on a double filter respirator or go into high quality filtered air conditioning at that time.

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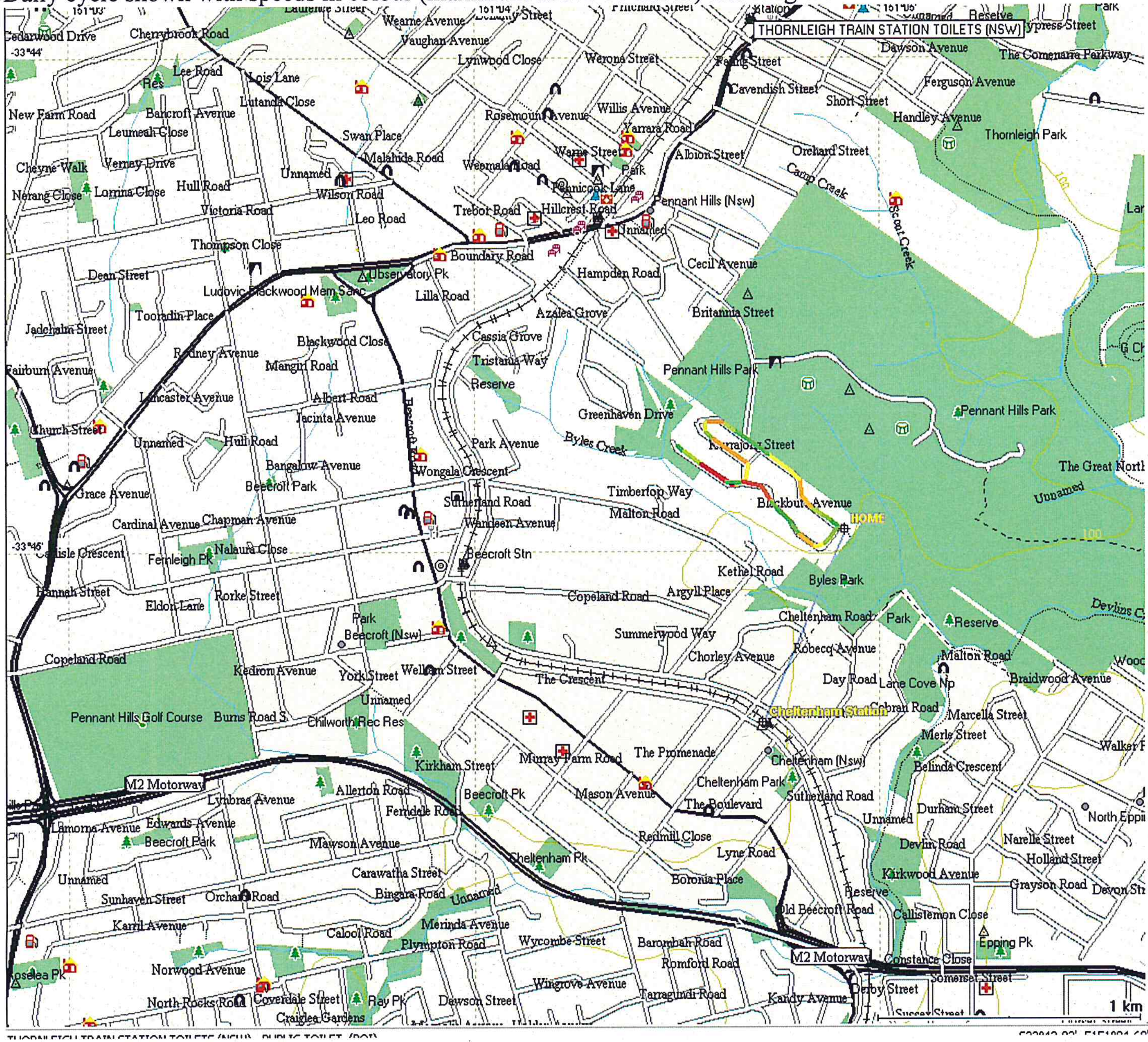
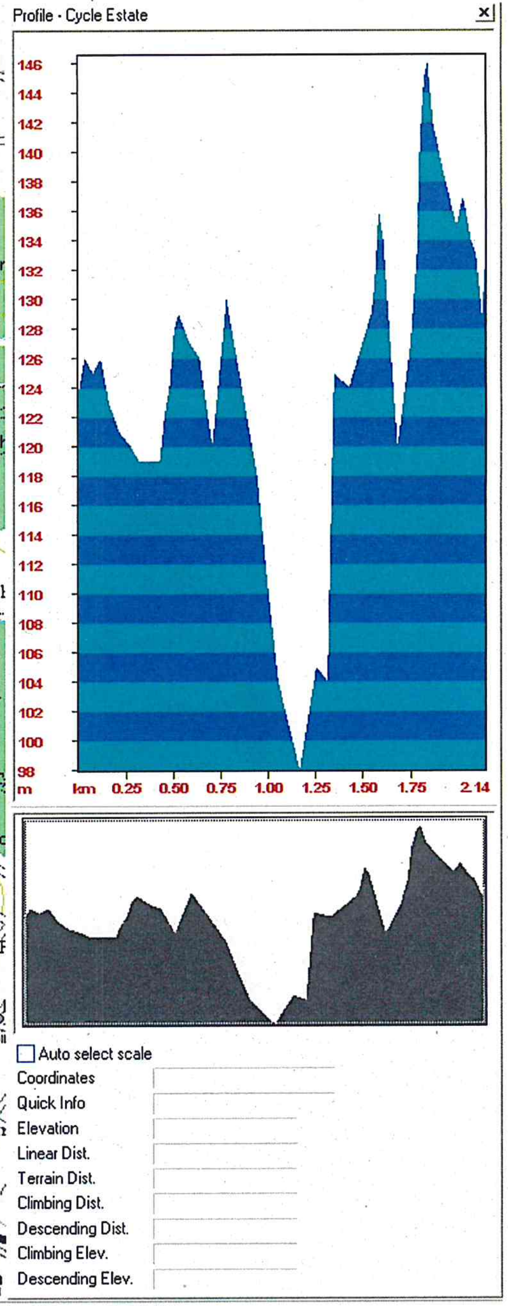
Map attached: Train Stations and Location of Home

Reference attached: J R MARCER “Revised Railway Provisions of the new Bridge Design Standard” Conference on Railway Engineering” Nov 2002, EA, RTSA

TRAIN STATIONS AND LOCATION OF HOME AT SQUARE.

Daily cycle shown with speeds in colour (maximum above 60 km/hr) and longitudinal section of route.





REVISED RAILWAY PROVISIONS OF THE NEW BRIDGE DESIGN STANDARD

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The Australian Bridge Design Code (ABDC) has been revised as an Australian Standard to be published in 2003 as AS 5100. Many of the railway provisions of the ABDC have been expanded, revised, and refined.

The railway revisions to be discussed in this paper fall into the following categories.

1. Dynamic load allowance
   The history of railways in Europe, America and Australia, related to dynamic load is first explained showing why Australia followed American standards rather than European standards in the past. Dynamic load allowance has been revised using strain gauging from many different types of transom top underbridges in NSW, then compared with similar testing with ballast top underbridges in USA and Canada. The basic European approach has been maintained, as it is superior to the ANZRC approach, which was based on AREA. The changes are required to allow for the lower standard of track and wheel condition in Australia, USA and Canada compared to Europe. The lower standard is due to the former countries constructing their systems as "pioneer lines", whereas Europe had the population density and short distances to afford higher standard lines.

2. Railway loading
   A simple but necessary change has been made to simulate coupled six axle locomotives on medium length spans.

3. Protection from collision
   Many alterations have been made to the provisions to protect bridges and structures from train collisions following derailments and collision between two trains. Most of these relate to allowing for structural redundancy rather than conventional pier and column protection.

4. Steel underbridges
   Many changes have been made related to fatigue prevention, fatigue assessment and corrosion protection of steel underbridges. Examples are the ANZRC limits on slenderness ratio have been reinstated and fatigue life enhancement, which has been used on NSW underbridges for 35 years, but not mentioned in Australian standards, only overseas standards, has been addressed and referenced.

5. Rating of underbridges
   The rating provisions have been amended to give appropriate rules for underbridge assessment.

1 INTRODUCTION

In 1922 NSWGR had the "Grey Book" as the code for the design of bridges and track. Decades later AREA became the code for bridge design. In 1974 an Australian and New Zealand version of the AREA code was metricated as the ANZRC code and used the SAA concrete standards for concrete bridges. In 1995 the RoA code was written covering railway bridge design and steel bridge design. Austroads published this in 1996 as an addition to their bridge design code, to become the Australian Bridge Design Code. The ABDC has now been comprehensively revised as an Australian Standard, AS 5100 Bridge Design. This work has extended over five years but much of the testing and research began ten years ago.

The following sections present some of the most important aspects of the railway revisions covering Part: 1 General, Part 2: Design loads, Part 6: Steel and composite construction and Part 7: Rating of existing bridges.

2 DYNAMIC LOAD ALLOWANCE

2.1 History of Railways in Europe, America and Australia, Related to Dynamic Load

At the beginning of the railway age at the middle of the 19 th century, railways in Great Britain and Europe had developed a high demand for their services, over relatively short lengths of track, due to the high population densities. Because of this high utilisation it was not difficult to justify the cost of maintaining track to a high standard. By contrast, in America and Australia railways had to service a vast area which was sparsely populated and would generate minimal traffic. Under these conditions, pioneer lines built to low track standards, were all that could be afforded or justified. A good example is the North Coast Line in New South Wales, which is still on the winding, minimum cost alignment selected early in the 20 th century, for most of its length.

The first railway carriages and wagons had four wheels. These performed satisfactorily on the high standard European tracks, but performed poorly on low standard pioneer lines in America and Australia, requiring severe speed restrictions. The first bogie vehicles were developed in America in the 1830's, and were found to operate safely at speed on the poor quality track of pioneer lines. It was found that bogie vehicles could also tolerate worse wheel defects than four wheel wagons, and still travel safely at speed. Similarly, in Australia, bogie vehicles were found to be best on our pioneer lines, so as soon as railway systems could afford them, bogie passenger vehicles were purchased. These passenger trains were permitted to run at a reasonable speed. By contrast, bogie freight wagons could not be afforded until well into the 20 th century, in most cases. Four wheel freight wagons such as S, U and K trucks were limited to about 30 mph maximum.

Europe stayed with four wheeled vehicles for a long time. In 1835, locomotives with leading bogies were invented in the USA. These tracked better and had significantly reduced lateral load. Some were imported into Britain. It was not until 1870 that the British built their own locos of this type.

Thus there were two district world standards for track, vehicle type and wheel condition. One being European and the other American. In Australia we followed the American standards, as this was the closest type to our system. It was then logical that we also follow the American standard for underbridge design. The American Railway Engineering Association (AREA) was adopted for bridge design, to be metricated as the Australian and New Zealand Railway Conferences (ANZRC) Railway Bridge Design Manual in 1974.

It is significant that the greater majority of early underbridges and later steel underbridges were transom top, rather than ballast top. The inherent disadvantage of bad bridge ends ensured that our track standard remained below that of Europe where ballast top underbridges were common.

2.2 Recent History

Track standards and wheel standards have remained poor in NSW throughout our history. The problem of bad bridge ends has been addressed to some extent by progressive embankment stiffening with geogrids, but many significant problems remain. The most serious one is the inability to run dynamic stabilisers up to the face of most abutments due to insufficient factor of safety against sliding and overturning of both abutments and wing walls. Thus the most critical portion of our formation is the worst, resulting in settlement causing extreme dynamic load at ends of underbridges as well as significant fatigue cracking and connection failure. In Queensland, on the standard gauge line, bad bridge ends also occur frequently.

Wheel condition has continued to be poor. In the late 1970's and early 1980's there was a concerted effort to implement preventative maintenance to eliminate this problem. Unfortunately this effort was not maintained and now we have evidence of a continued deterioration of wheel condition with significant and frequent exceedence of the standard. The situation has been such with high speed country trains that some disc braked wheels were not turned at bogie change, but were simply replaced, because of severe wear.

This is in contrast to the European situation. There, high speed intercity trains have their wheels inspected after every run, and where necessary, are turned in under floor lathes in depots before the next run. In this way, only a small amount of metal needs to be removed, leaving the majority of the work hardened wheel surface intact. In NSW, the equivalent wheels are often so worn that all of the work hardened steel has to be removed to obtain a satisfactory profile. This exposes softer steel, which in turn will be worn at a much faster rate.

From the early 1970's some design engineers at the Structural Design Office, Way and Works Branch, Dept of Railways NSW, realised that for very short spans impact was of the order of 100%. This was well above the impact given by AREA. The underbridges involved were subway girders of 4.6m span. Their very premature fatigue cracking indicated the higher impact was appropriate.

2.3 Pilbara Railways

Pilbara iron ore railways in Western Australia, by contrast, are maintained to exacting track and wheel standards, and in no way can be compared to the NSW or other state systems. This results in the very low dynamic load recorded on that system. In addition, the poor standard of welding of steel underbridge superstructures in the Pilbara would not survive in the NSW system for any length of time without significant fatigue cracking due to high dynamic load.

2.4 The Nature of Wheel Defects

Wheel flats are the most commonly thought of wheel defect. See Figure 1 showing class 4 skidded wheel. This is because they are very audible, with a regular annoying impact on every revolution, and are easily measured. Because wheel flats are so easily identified they are removed from service in relatively quick time. These and other defects concentrated at one point on the wheel circumference are the most significant defects on conventional tread braked vehicles.

***Figure 1* Wheel Flat close to 100 mm – Class 4 skidded wheel**

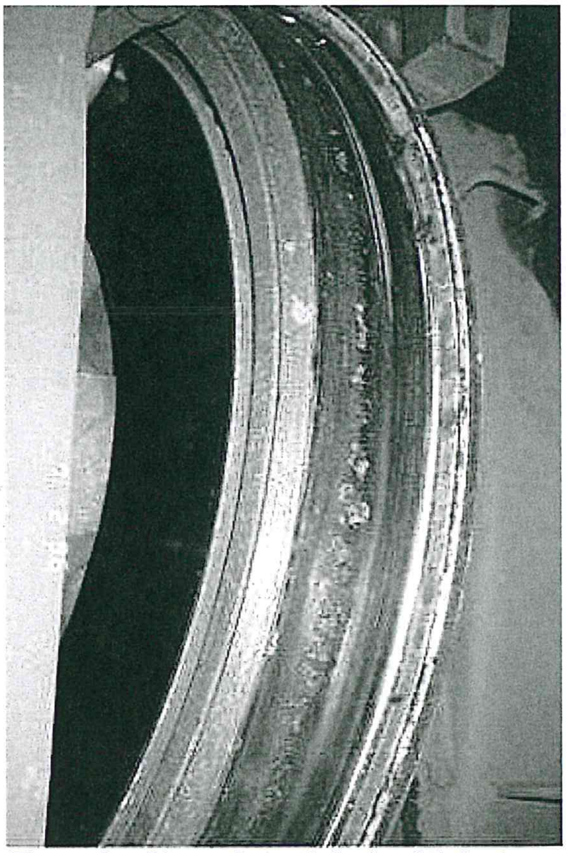

***Figure 2* Circumferential wheel defect**

Defects located around the wheel circumference are of many types. See Figure 2 showing Tangara wheel spalling. (Tangaras have disc brakes without tread breaks.) These tend not to be as readily identified, as they may not be as audibly annoying and are not as easily measured as wheel flats. Out of round wheels are a particular example that may not give any audible or visible indication of their presence, yet strain gauging (4) has been reported that indicates higher dynamic load than with wheel flats. In the NSW system disc braked wheels on suburban and country passenger vehicles develop a significant type of circumferential defect if not regularly turner. If they are also fitted with tread brakes, as XPT power cars are, this type of defect does not occur. These defects are caused by the disc braked wheel picking up pieces of metal from the rail surface, which are not wiped off by the next brake application, as with tread brakes. The pieces of metal embed themselves in the wheel tread, all around the circumference, causing an indentation which is visible once the metal falls out. These defects all around the circumference cause very high frequency excitation in rails and underbridges. Susceptible underbridge members such as slender members, bracing, stringer and cross girder end connections, the bottom termination of welded stiffeners, and all truss members may respond in an undesirable manner, compared to the assumptions in the Australian Bridge Design Code. It is very significant that this high frequency excitation is often not audible. In the case of Lewisham Viaduct Suburban (3) during strain gauging, the laboratory staff recorded those trains with audible flats, there being 4 such trains recorded out of 46. The extreme strain gauged response shown in Figure 7 of (3) was from a train not recorded as having audible flats, and it is assumed that the defects affected the whole wheel circumference.

2.5 Amendments to Dynamic Load Allowance

The following amendments have been made to Part 2 Design Load, for railway dynamic load allowance. A comparison between the new and old dynamic load curves can be seen in Figure 3. In the ABDC the general shape of the dynamic load allowance curve is acceptable, particularly for short spans. The curve is low for long transom top spans. In the new standard the existing curve is used for ballast top, still limited to α of 1.0; and another curve 0.1 higher has been adopted for transom top with α now limited to 1.6.

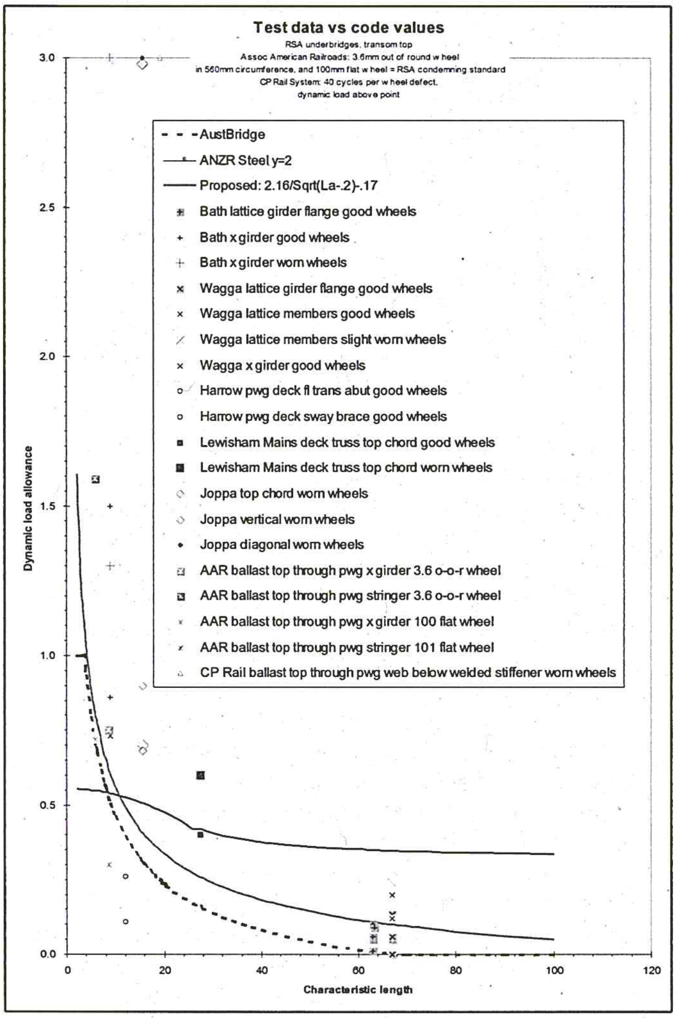

Figure 3

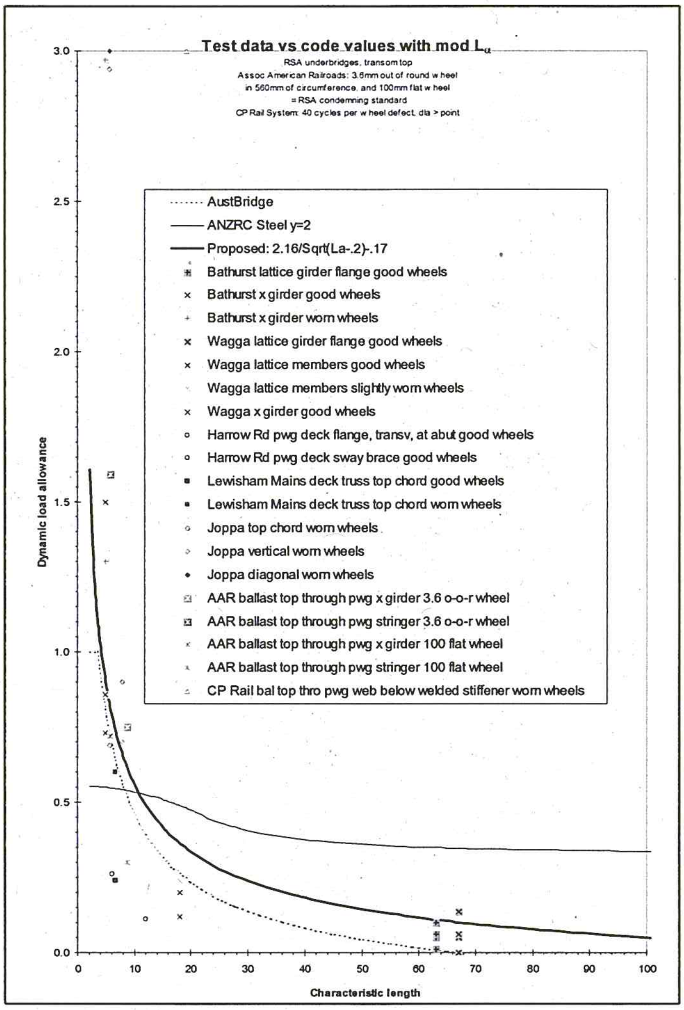

Figure 4

It is also significant that the trains that recorded the highest dynamic load in the stringers was different to that recording the highest dynamic load in the truss diagonal to top chord connection, which in turn was different to that causing the highest dynamic load in the truss diagonal to bottom chord connection.

Figure 3 shows the curve with strain gauged points plotted from tests of five RIC underbridges (1, 2, 3 and 6) along with those of American underbridges from USA (4), and Canada (5). All RIC underbridges tested were steel or wrought iron transom top and the American underbridges were steel ballast top with concrete decks.

The following comments on dynamic load can be made in relation to RIC strain gauging of five underbridges (1, 2, 3 and 6). The number of underbridges strain gauged are limited but they still provide a valuable check of the provisions of the standard.

In order to obtain a better fit for the test results than the scatter in Figure 3, it has been necessary to amend the calculation of the characteristic length L_{α}. The amendments result in the replotting of the test results as shown in Figure 4, which gives a better fit. The American test results also correlate well with this replotting as shown.

Samples of the reasons for some of the amendments are given below related to ABDC clause numbers:

Table 2.4.6.2 FLOOR MEMBERS

4. Provision for cross girders loaded by continuous deck elements was checked against two transom top underbridges, (1 and 2), which indicate the ABDC provisions are satisfactory or conservative for good wheels when considering centre moment; but far too low when considering end moment. A check against the simply supported stringer case shows that it is better for end moment with good wheels. With worn wheels this case is exceeded for end moment, but taking the characteristic length as twice the cross girder spacing and allowing the dynamic load allowance to exceed 1.0 gives more accurate results.

   The AAR experimental work referred to in (4) is very significant here as it uses 4 inch flats as well as out of round wheels on a captive train. As 100 mm is the limiting flat on the RIC/SRA/Freight Corp standard, at which vehicles must not move, underbridges must be designed for this load. Dynamic loads up to 1·1 for stringer end shear was reported, and it is assumed that end moment would be about 50% higher.

   Stringer and cross girder end moment dynamic load is very important in fatigue assessment, as in the NSW system, as elsewhere, fatigue cracks are frequently found in end connections. It is also significant that the majority of all cracking at end connections appears to be moment related rather than shear related. By contrast, the first crack found at the centre of a stringer or cross girder, other than from very bad design, fabrication, corrosion or damage, was found by removing flange angle rivet heads from a cross girder replaced for end connection cracking. In this case the crack from the bottom flange angle web connection rivet hole had just passed the edge of the rivet head, and would have been difficult to detect without removing the rivet head. The end connection cracking problem is so significant that 375 cracks have been found, with the aid of magnetic particle testing, in this area of cross girders in three major underbridges in a six months period. It is considered that high dynamic load applied very rapidly, by worn wheels at speed is a major factor in this fatigue cracking. The other major factor is non-dynamically balanced steam locos at speed, prior to 1930.

MAIN GIRDERS

9. For truss members L_{α} reduces to three times the length of the individual member between panel points taken as a horizontal or vertical projection, whichever is the shorter. Where diagonals intersect the multiplier is six.

   Strain gauging of Joppa Junction (1) and Lewisham Viaduct Mains (3), has been used to formulate this amendment. It is clear from these examples of strain gauging that worn wheels at speed cause individual truss members to oscillate in a manner dependent upon each individual member's properties. Even with strain gauging of captive trains with good wheels the dynamic results were well above those given in the ABDC.

   There is a possibility that the multiplier should be 2 rather than 3 to more correctly match oscillation with worn wheels. Further strain gauging of various trusses is required to evaluate this.

2.6 Commentary on Dynamic Load Allowance

The Commentary will provide explanation of how to apply the dynamic load allowance to railway bridge design.

3 RAILWAY TRAFFIC LOADING

Where underbridges on new lines have been designed for the minimum A-12 loading, to only match the axle loads running at present, the effects of coupled six axle locomotives, on spans at and close to 20 metres come close to the design provisions of the ABDC. Away from this span length there is a reasonable reserve of capacity. Figure 5 shows the comparison of wheel positions on various length spans. It is easy to see why the loading is inadequate for spans around 20 metres.

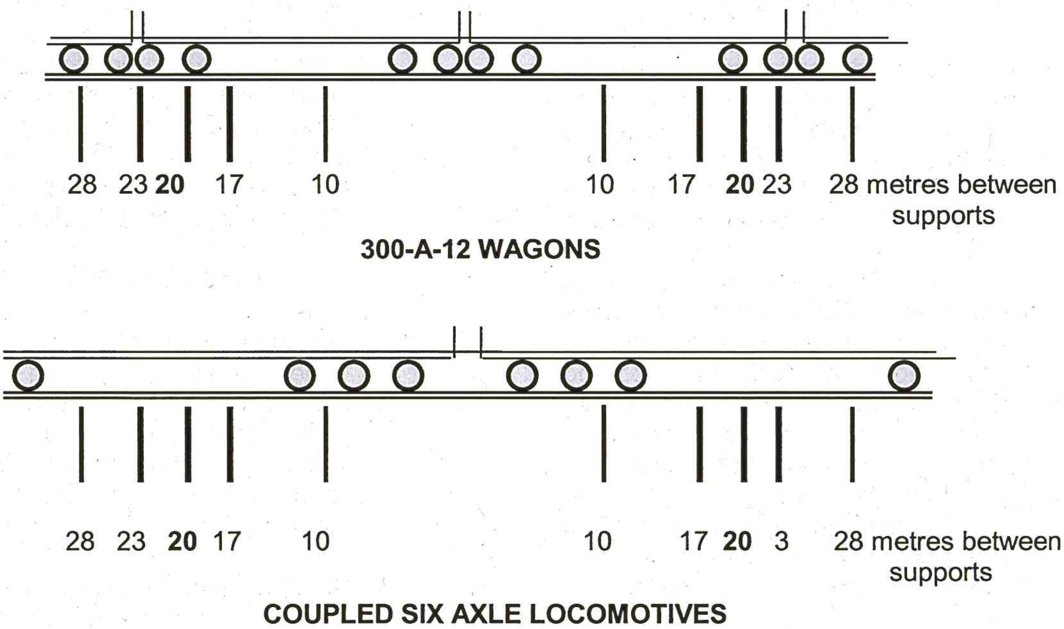

Figure 5 300-A-12 Wagons Compared with Coupled Six Axle Locomotives both with Couplers on C/L Span

In order to overcome this and other problems in a simple manner, the 300LA loading in the new standard combines the two load cases of the 300-A-12 loading from the Australian Bridge Design Code, by adding the 360kN single axle load 2 metres in front of the vehicle loading. This is to simulate six axle coupled locomotives and better represent their loading in the 15 to 22 metre span range. This combination produces a moment envelope more nearly proportional to that of existing trains.

The graph in Figure 6 shows a comparison of the A-12 loading with existing and proposed trains. The 180 tonne T1 locomotive, proposed in the early 1990s for the Hunter Valley coal traffic, is shown to exceed 300-A-12 in the span range 18 to 22 metres. The existing 90 class locomotives may have kentledge added to be equivalent to the 180 tonne T1 locomotive. Other locos with less favourable spacing of the six axles of 300 kN will have worse effect. The 300LA loading retains a good reserve above the 180 tonne T1 locomotive. For 300-A-12 loading there is not a 20% reserve above the heaviest NSW train (90 class loco and NHRH, RCGF) and National Rail interstate train, in the 5 to 25 metre span range.

With the 300LA loading the 20% reserve is maintained throughout the span range.

4 COLLISION PROTECTION

It is very important to consider Part 1 General, Part 2 Design loads and the respective commentaries for collision protection from rail traffic, requirements.

These clauses have been revised to give more emphasis to design of bridges and structures with enough redundancy to permit a derailed train to demolish supports without collapse of the superstructure onto the train, rather than conventional pier protection. This was the recommendation of the Granville Investigation (7) section 5.12, p 22.

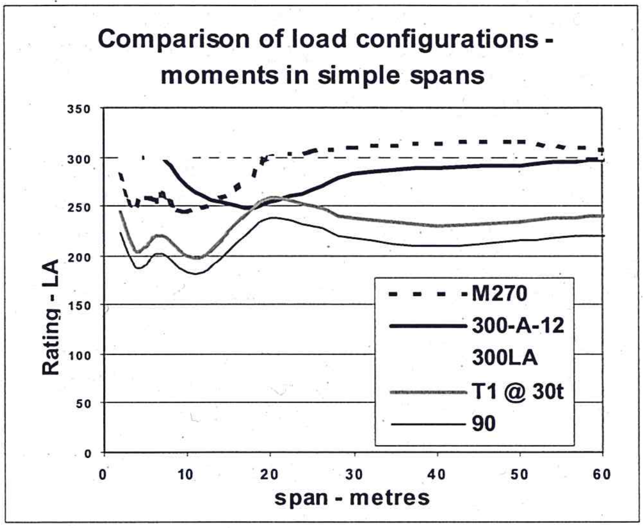

Figure 6

A tiered approach has been taken with a clear span still the preferred option. Next come bridges and structures with sufficient redundancy to permit a derailed train to remove one or more support columns without collapse of the superstructure onto the train under dead load plus 20% of live load. Only if this level of redundancy can not be met, is pier protection to be resorted to.

Between 10 and 20 metres from the track, new provisions apply. Derailments such as Concord West, where the double decker train came to rest on the adjacent road, influenced this clause.

Within 10 metres of the track, new loading of 500 kN applies to simulate collision loads such as occurred at Waterfall, NSW, following a shunting collision between two trains. This load can act in any direction and reduces above 5 metres above track level, to zero at 10 metres. It is applied as a vertically up load under superstructures. British Standards have been considered in this area. Collisions such as Beresfield, NSW, generate loads way beyond this provision.

For all bridges, below ground railways and air space developments, new provisions apply where additional superstructure dead load, fill or development occur (except on platforms); deflection walls, blade piers or continuous walls are required and the 500 kN load is increased to 1500 kN. Where the superstructure supports a dead load of more than 30 kPa the supports are to be continuous walls designed to the higher load. For all tunnels, including cut and cover construction, where roof support is required between tracks, a continuous wall will be required, allowing for a minimum of small openings to meet safety requirements for cross-passages and refuges. RIC is proposing to relax the requirement to increase the 500 kN load to 1500 kN where trains have a train stop system and those without are limited to 20 km/hr.

The Commentary indicates the relatively low speeds that the pier protection loads relate to. These loads are intended to satisfy the conditions of moderate derailments, and minor collisions, but not major derailments and moderate collisions. That is, a derailment of a 300LA train with 84 wagons derailing at slow speed, or a collision of two trains of this type at shunting speeds. (This may also represent a self propelled passenger train derailing at moderate speed, or a collision of two trains of this type at slow speed.) Wherever these speeds will be exceeded, structural redundancy, or a clear span are preferred. Where freight trains collide head on with rigid pier protection at a speed approaching 80 km/hr sufficient energy is stored to permit the locomotive to rotate end over end on to the superstructure, thus redundancy is a much better option in this case.

Past major disasters at Eschede, Germany and Granville, NSW, could have been reduced to a derailment without collapse of the overbridge until all passengers were removed from the derailed train, by the simple provision of redundancy conforming to the new requirements of the standard.

5 STEEL AND COMPOSITE CONSTRUCTION

Many changes have been made related to fatigue prevention, fatigue assessment and corrosion protection of steel underbridges. The most important of these is the reinstatement of ANZRC limits on slenderness ratio. Strain gauging of a NSW 27 metre truss underbridge (3 and 6) has shown that tension members with slenderness ratios greater than 200 have dynamic load of 1.5 and with 26 cycles instead of one, when comparing trains with worn wheels at approximately 100km/hr, with trains with good wheels at slow speed. Premature fatigue of members and connections is well documented and common in the NSW system. Many such trusses have now been replaced or had members stiffened. In the Queensland standard gauge track there are a number of similar trusses dating from 1930.

Fatigue provisions from Eurocode (the source of the existing provisions) which most closely match railway underbridges have been added to the standard. Previously, no mention was made of fatigue life enhancement in any Australian standard or code, but now that has been addressed. NSW underbridges have been successfully using fatigue life enhancement since the mid 1960s. The fatigue life enhancement treatment at the base of stiffener welds is specified at the time of fabrication, rather than only during repair, because fatigue cracking is visible within one year in new CityRail underbridges, and repair and fatigue life enhancement in the field is about 10 time more expensive than fatigue life enhancement at the time of fabrication. In addition, where traffic is high, after detection of cracks requiring repair, it may take one year to obtain a suitable possession for repairs. This may be unacceptable on safety grounds if the fatigue crack is propagating at a rapid rate. The principal trains causing the damage are Tangaras and XPT trailer cars with worn wheels at speed, the induced member vibrations are of such high frequency, resulting in very high rates of strain, that critical welds accumulate fatigue damage rapidly, if not fatigue life enhanced. As well as at the termination of stiffener welds, cross girder flange welds also crack at their termination. On the other hand, bridges with similar weld details have shown no similar cracking when loaded with heavier slower coal trains over more than thirty years. Similarly, acoustic emission testing has shown XPT at speed with worn wheels causes crack propagation but heavier freight trains do not. The reason relates to the rate of strain. Disc braked wheels on these passenger trains have defects which induce higher rates of strain in underbridges than tread braked freight train worn wheels, at speed. No account of this greater rate of fatigue due to higher rate of strain has been made in the standard. This is understandable as a literature survey by the CRC for Welded Structures through the University of Wollongong did not find any standard world wide that allows for this. The reason probably is because the cost and time involved in testing underbridges for the rate of strain with various worn wheels, is very high. Designers still need to keep this in mind.

Specific provisions for underbridges have been added covering web to flange welds, beam restraint at supports and intermediate locations, for bracing an allowance of double the calculated cycles for fatigue, similarly 1.4 times for trusses and lattice girders, end connections of floor members, minimum moment on end connections, welded stiffeners and cross girder to through girder connections, transom top underbridges and thickness of material for underbridges.

To limit crevice corrosion the maximum edge distance for bolting has been reduced closer to the ANZRC provisions as 0.5 times the square of the thickness of the thinnest outer connecting ply under consideration or 100 mm.

Four acceptable systems for locking of bolts and fasteners to withstand underbridges dynamic load have been provided.

6 RATING OF EXISTING BRIDGES

Methods of testing for dynamic load allowance and fatigue response of underbridges have been given.

Information related to identification, inspection and rating of cast iron and wrought iron bridges has been provided.

7 CONCERNS OF FUTURE REVISIONS TO THIS STANDARD

A great deal of research, and documented experience, over more than ten years, is behind many of the revised or new provisions. Unfortunately many of the state railway systems do not today support this type of research and input by highly experienced railway bridge design, construction and maintenance engineers. Only Queensland Rail is properly supporting the revision of the standard today.

One state system, once their design office was privatised, no longer participated on the committee. Other state systems already privatised, were extremely difficult to obtain any feed back from when written to and contact was only made after many phone calls. Another state system withdrew one of their representatives and replaced him with another who did not attend meetings. This situation is not adequate for an Australian Standard on bridge design.

A further problem for future revisions of the standard is the loss of specialist expertise in railway bridge design, construction and maintenance within the railway systems. The detailed knowledge base that was available to "in-house" design teams, who could draw on well qualified professionals with extensive past experience of successes and failures in the specialist field of bridge design for rail applications, is fast disappearing. This is not helped by the more frequent use of professionals of other disciplines and non professionals for work traditionally done by specialist railway bridge designers. The Institution of Engineers should pursue this disturbing trend and discuss it at the highest levels of state and federal government. If this trend continues, future revisions of the standard will be very difficult to accurately implement.

8 CONCLUSION

The new SAA bridge design standard incorporates a high level of expertise in railway bridge design, particularly in the parts discussed. Emphasis has been placed on providing sufficient detail and explanation, especially in the commentary, for the use of design engineers not experienced in the railway bridge design area.

A great deal of research and documented experience is behind many of the revised or new provisions. The support necessary for future revisions of this standard will be difficult to find as only one state system is now providing adequate support to the SAA committee and subcommittees.

ACKNOWLEDGEMENTS

Mr Don Hagarty, the last Chief Civil Engineer of the State Rail Authority of NSW, contributed much of 2.1 History of Railways in Europe, America and Australia. RIC has provided the facilities for testing of underbridges for more than ten years, the data from which has been used for the standard. In particular the Scientific Services testing engineers and metallurgists have made a significant contribution. Mr Ted Bain, Structures Engineer Standards, has provided a large amount of data for the standard. The CRC for Welded Structures through the University of Wollongong checked the fatigue provisions against many overseas standards.

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