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Aspec Newsletter

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ASPEC ENGINEERING PTY LTD
ABN 22 105 267 016

Level 3, 349 Coronation Drive
Milton QLD 4064

PO Box 1843
Milton QLD 4064

T (07) 3842 3114
F (07) 3371 7300

www.aspec.com.au

INSIDE THIS ISSUE

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Introduction

This is ASPEC Engineering's annual newsletter for 2005. In July this year ASPEC successfully completed two years of operation. We are very pleased with our success and the continuing support from our valued clients, staff and supporters.

We have focussed on providing quality engineeringto mining companies and ports in design,plant integrity assessment, engineering analysis and risk assessment and currently havea compliment of 15 engineers and drafters as well as relationships with leading industry experts.

ASPEC has continued to gain recognition as a leader in materials handling machines and knowledge of the requirements of Australian Standard AS4324.1 as evidenced by current projects including refurbishment design of Shiploader SL2 at the Hay Point Coal Terminal, stockyard machines upgrade for Babcock Brown Infrastructure (DBCT) and proof audits on new machines at Dalrymple Bay, Abbot Point and Port Waratah.

The objective of this newsletter is to share knowledge and experience gained during the course of our work. This edition contains articles on crane rail and mounting system selection, loadings from mine haul trucks, and a scorecard for asset management of materials handling machines. We would be pleased to receive suggestions from readers, via email, as to the subjects and types of articles of interest.

by Frank Gatto *(fgatto@aspec.com.au)*

Crane Rail Mountings

Crane rail sections are used in a variety of applications in heavy industrial, materials handling, mining and port industries. Large rail mounted machines such as shiploaders, stackers,reclaimers, ship-unloaders and container cranes require reliable rail systems in order to operate effectively. The runway rails carry the load of the whole machine which may be many hundreds of tonnes. Other rail systems are used for secondary motions such as shuttling and traversing. Factories and workshops use gantry cranes for operations and maintenance and many of the same issues apply.

Rail and Wheel Selection

Some of the crane rail sections used in Australia for stackers, reclaimers and shiploaders are shown in Table 1 below. Design aspects of crane rail selection are covered in Australian Standard AS1418. The FEM Rules which are commonly used internationally adopt a similar methodology.

Table 1: Crane Rail Sections

Designation	Weight (km/m)	Head Width B (mm)	Head Width H (mm)	Base Width P (mm)
BSC164	166	150	140	230
A150	150.3	150	150	220
CR100	100.2	120	150	155
CR73	73.3	100	135	140
MRS87A	86.8	102	152	153
MRS86	85.53	102	102	165
MRS73	73.63	70	157	146

Wheels and rails need to be considered together in the design process. Generally wheels with a wider tread have a larger load capacity than wheels with a narrow tread. Increasing the diameter of the wheel also increases the load capacity. Thus if large loads are required on a small wheel diameter, it is advisable to choose a crane rail with a wide head. Wheel failure often manifests itself as excessive wear and spalling of the surface of the wheels rather than a catastrophic fracture. Commonly used standards such as AS1418 and the FEM rules base the selection of the wheel material on material strength with no account for the effects of heat treatment and surface hardening which is commonly used on such wheels. For wheels with hardened surfaces AS1418 and the FEM rules may be over conservative. The American Iron and Steel Engineers Technical Report No 6 allows for surface hardening and may be more applicable when specifying and selecting wheels of this type.

In addition to vertical loads, crane rails may be subject to lateral loading, eg wind loading, abnormal digging, travel skew and lateral collisions. These actions can cause large horizontalforces on the rail which need to be resisted by both the rail and its mounting system. This may be applied by friction on the rail/wheel interface, by horizontal guide rollers if fitted or directly from wheel flanges. Allowance for correct clearances, tolerances and provision for expansion and contraction are important considerations for good performance in respect to lateral load resistance.

Rail Splices

Rails normally require splicing, although in some cases, where the duty is not onerous and the mounting is rigid, the rails are simply butted together. Common methods of splicing include "thermit" welding, arc welding and use of bolts and "fish" plates.

Thermit welding relies on a reaction to produce molten steel which solidifies to produce a butt weld. A mould is used to contain the molten metal during the thermit welding process. One of the disadvantages of the process is that it does not produce a flush joint and grinding is required.

Arc welding of crane rails with arc welding processes has been carried out in many cases. This may involve a complete penetration butt weld or an incomplete penetration butt weld. Because of the shape of crane rails it may be difficult to achieve a suitable weld preparation, hence if a complete penetration weld is not required for strength or fatigue performance, the use of partial penetration welding is a good option. Considerable attention needs to be paid in selecting the type of welding consumables, preheating and welding procedure which will suit the rail steel type.

Bolts and "fish" plates should generally only be used on light duty applications. Care needs to be exercised in providing adequate clearances to wheel flanges where "fish" plates are used. They may also interfere with rail clamps, where these are to be fitted to the machine or crane.

Crane Rail Mountings

Many mounting systems have been used on continuous bases and numerous problems have occurred. Our experience is that the best performance is gained by using a system with the following features.

a. Continuous steel base plate which can be levelled and grouted in place.
b. Continuous elastomeric underlay to rail.
c. Rail clips welded to the steel mounting plate with provision for horizontal adjustment.
d. Rubber nosings to rail clips to allow for resilience and for longitudinal expansion and contraction.

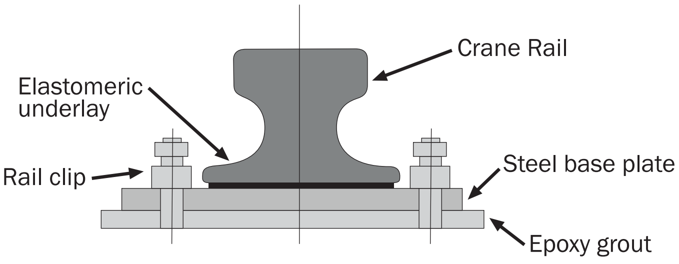

Figure 1: Crane Rail Mounting Detail

Holding down bolts are set into the concrete or stud welded to the steel girder. It is desirable to weld the clip bases onto the steel base plate in the shop and to galvanize the whole assembly to give long term corrosion protection. The base plate is levelled using jacking screws or other methods. Once the rail is spliced and aligned, further vertical adjustments can be made with the levelling system under the base plate. Only then should grouting take place.

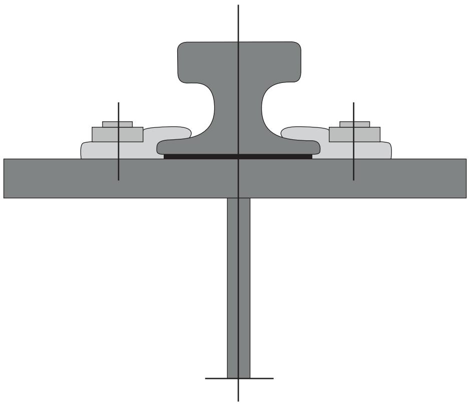

Figure 2: Mounting on Steel Girders

For mounting on a concrete beam a commercially available cementitious "non shrink" grout is often adopted as the underlay to the steel base plate. This is installed by pouring from one side or by pumping so as to eliminate air pockets. For heavy duty applications and for steel bases it is desirable to use an epoxy grout.

Crane rails are commonly mounted directly on steel girders for elevated crane runways or on steel framed wharves. A proprietary rail clip system attached to the steel girder by means of welding or by using through bolts or resistance welded studs is used to retain the crane rail. Such clips allow horizontal alignment of the crane rail. Correct selection of the clips and corrosion protection of the clips and top flange of the steel girder need close attention particularly in a marine environment. It is desirable to incorporate a continuous elastomeric underlay to the rail in order to reduce vibration anddynamic effects on the crane or machine and on the supporting structure. One of the main problems with this type of system is obtaining and subsequently maintaining the correct vertical alignment as there is limited scope for adjustment. Particular attention needs to be given to fabrication and installation tolerances.

Lateral Design Forces

Older designs often had clips spaced at very close intervals at the storm park down position then at quite wide spacings for the operational range as shown on Figure 3 below. With the application of Australian Standard AS4324.1 it has been found that high lateral loadings can occur on the rail over the full length of travel, thus in these cases it may be necessary to use heavy duty clips at close centres over the full length of rail.

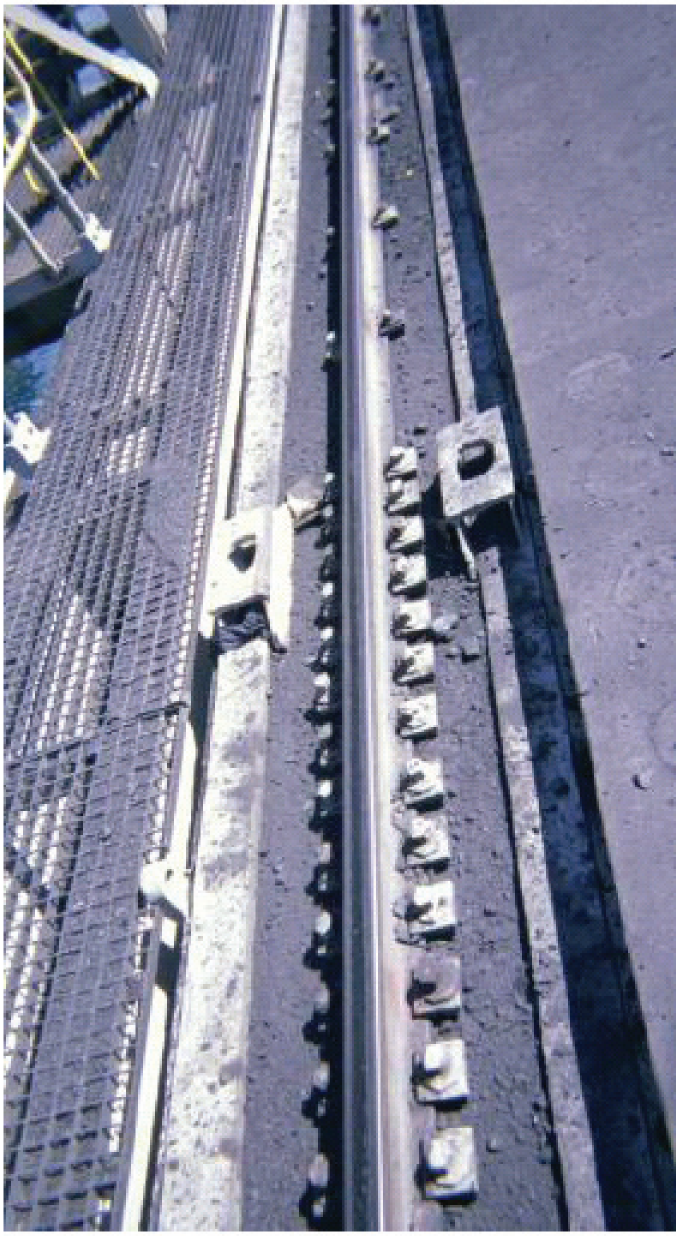

Figure 3: Photograph of typical crane rail

Design Loads on ROM Bridges

The payload capacity of trucks used in any material handling operation has a significant affect on the overall material handling cost per tonne. For an existing facility considering upgrading their mining trucks, the potential benefits in terms of moving higher volumes of material has to be weighed against the possibility that the infrastructure that the trucks use may have to be upgraded. Mining trucks today are designed to carry much larger loads and more commonly have a rear dumping action. These are now being used for coal hauling as well as overburden stripping whereas previously bottom dump trucks were used for coal hauling.

For example, consider a run of mine (ROM) bridge which has been designed for a 380 tonne loaded CAT 784 or Eucilid CH210 bottom dump truck. If the mine is considering upgrading to a Komatsu 930E rear dump truck, then the increase to the design load is approximately 30%. If they are upgrading to a CAT 797 the design load increases by more than 65%. An increase in load of these magnitudes is likely to result in overloading of the bridge structure hence retrofitting or replacement of the structure may be required. This article investigates these type of issues and presents some of the important aspects relating to the design loads imposed by mining truck on ROM bridges.

Truck Loading

The loaded mass of a mining truck is specified by the truck manufacturer and is referred to as the Gross Vehicle Weight (GVW). This is the manufacturer's recommended total loaded vehicle weight and consists of the empty weight of the truck, plus the maximum weight of the material allowed to be carried. Figure 4 presents a selection of mining vehicles and their GVW.

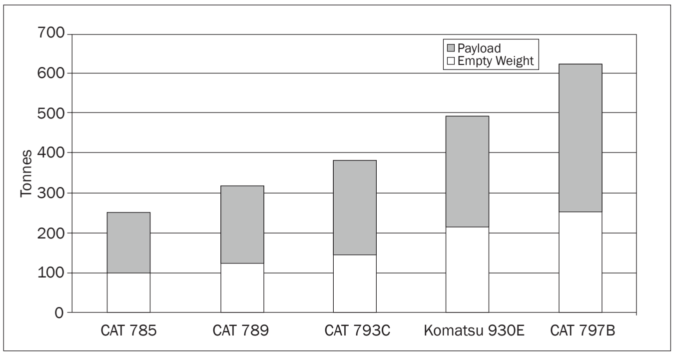

Figure 4: Comparision of Mining Trucks GVW

The GVW is often based on the tray filled with overburden with a density between 1.6-2.0 t/m3. For example, the CAT 793C has a payload of 237t and when fitted with a standard tray can handle 129 m3 based on a heap struck at 2:1. The GVW is therefore based on a material density of 1.84 t/m3. For a structure handling CAT 793 trucks carrying raw coal (typical density between 1.0-1.2 t/m3), the design loading used to assess the capacity of the bridge structure can be reduced.

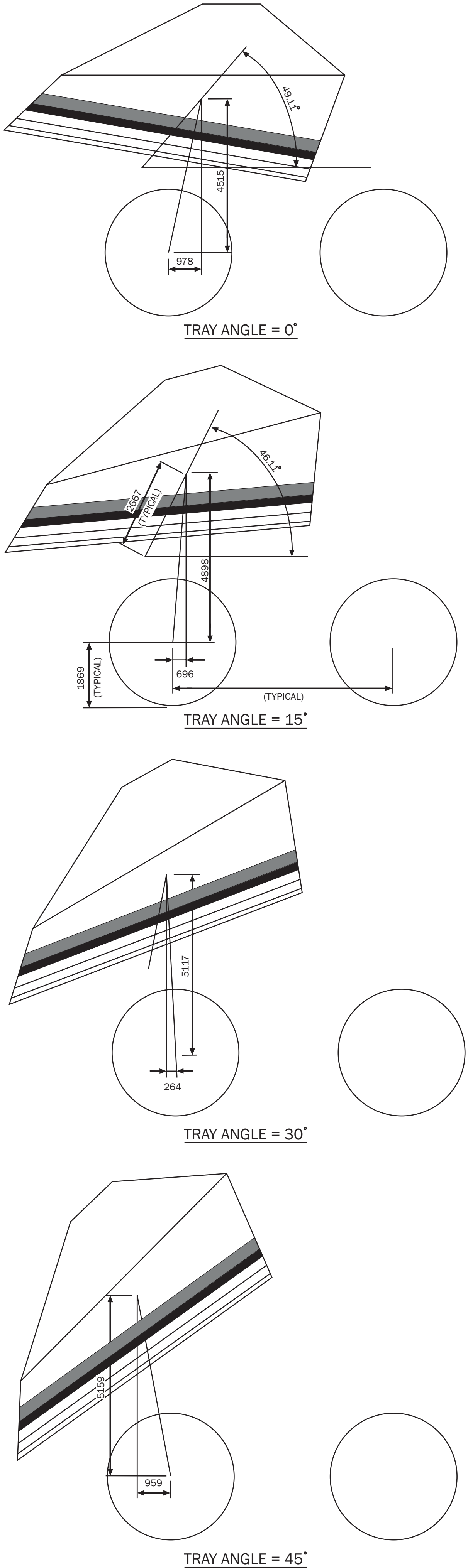

Figure 5: Centre of Mass of Payload as Tray is Rotated

Payload Discharge

For rear dump trucks the rear wheel reaction can potentially increase as the load is discharged. As the tray is rotated, the centre of mass of the payload moves towards the rear wheel. A study of a Komatsu 930E truck with 217 m3 of material in the tray shows that when the tray rotates by 24 degrees, the centre of mass of the payload is directly above the rear axle. The location of the payload centre of mass for various rotation positions is presented in Figure 5.

Table 1. Summary of Wheel Reactions at Various Tray Positions for a Komatsu 930E truck (assuming no material discharge)

Angle of Tray Rotation (degrees)	Rear Wheel Load (tonnes)	% Increase
0	334	-
15	361	8
30	391	17
45	423	26
60	454	36

The increase in rear wheel loads during the tipping cycle has been verified at the BMA Goonyella Riverside mine for a Komatsu 930E truck. These trucks can be fitted with a payload measuring system that can measure wheel strut pressures. Figure 6 presents data recorded by Komatsu for a truck carrying overburden. When the truck speed reaches zero and unloading begins, a 30% increase in the rear axle load has been recorded.

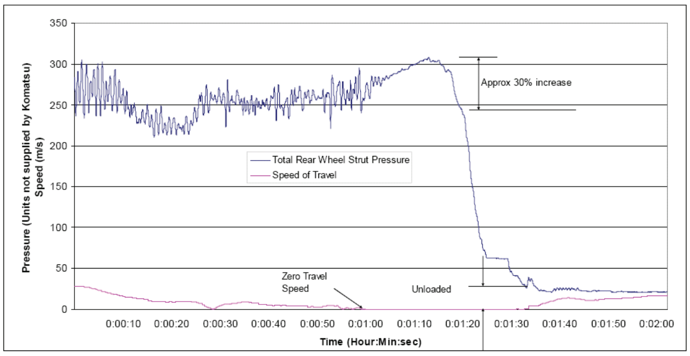

Figure 6. Rear Axle Pressure for Komatsu 930E

The angle at which the material begins to fall from the tray is influenced by several variables including:

a. Material properties
b. Geometry and condition of the tray
c. Speed of tray rotation
d. Inclination of ground

Each of these variables can influence the 'hang up' of material in the tray and an assessment should be based on local site information.

Design Loading

Design loads should generally be based on the GVW of the truck, except where it can be proven that this is unreasonably high for the material that is being carried. For the design check of ROM Bridge deck girders, the two load cases to consider for each truck are:

• The GVW of the truck travelling over the ROM at the design speed. The wheel loads are factored up by live load and dynamic factors.
• The GVW of a stationary rear dump truck with the tray rotated at the maximum angle without material being discharged.

The axle configuration and distribution of axle loads can affect the level of stress in the bridge structure. The truck with the largest GVW may not necessarily cause the worse effect. The ROM structure needs to be assessed for each type of vehicle that may travel across it.

Conclusion

For an existing facility considering upgrading their mining trucks, the possibility that the structure may require retrofitting or replacement should be considered. When undertaking a structural assessment of a ROM bridge the following points require consideration:

• Design loads should be based on the GVW of the truck, except where it can be proven that this is unreasonably high for the density of material that is being carried.
• For rear dump trucks the rear axle loads can increase during the tipping cycle. The increase in load should be based on the properties of the material being carried and other local factors that may influence the 'hang up' of material in the tray.
• The axle configuration and distribution of axle loads can affect the level of stress in the bridge structure. The structural capacity of the bridge needs to be assessed for each type of vehicle that may travel across it.

Bulk Materials Handling Machine Scorecard

Equipment and facilities for bulk materials handling in the mining industry incorporate rail mounted machines such as stackers, reclaimers stacker/reclaimers and shiploaders rely on appropriate design, ongoing inspection of the structure and correct installation and maintenance of mechanical and electrical equipment to limit loads and ensure safe operation. ASPEC has developed a scorecard for operators to assess if they are addressing important issues affecting the safe operation of bulk materials handling machines.

Protection Devices

• Critical machine protection devices are identified and documented (with settings)
• Critical machine protection devices are tested and calibrated within nominated intervals
• Critical protection systems are multiple and independent - independent disciplines and separate from operation systems
• Defeating safety devices is strictly controlled and, if permitted, is subject to rigorous control with the defeat log displayed

Design

• Well-engineered and built to current industry standards – working within the design envelope
• Design check carried our by a qualified engineer familiar with the design loads, load paths and operation conditions - typically senior engineer from OEM, industry specialist consultant or industry recognised site/business expert
• Machine balance is documented and checked regularly
• Critical items and items which need to be custom built or have long lead times are clearly identified
• There are no notable structural flaws awaiting rectification or further investigation
• The design audit program is identified in readily available equipment life plans or machine books
• Design is subject to cyclic (at least every 5 years) risk review to identify creeping changes
• There is a high level of in-built redundancy such that failure of these items has little impact on production

Condition

• Programme of regular inspections in place – visual and NDT
• Qualified and experienced inspector - typically from OEM, industry specialist consultant or industry recognised site/ business expert
• Access to all areas - machine was thoroughly cleaned for inspection
• Traceable inspection system - results of the last audit are available in electronic/written report for review - the pro gress of actions identified in any audit report can be easily tracked and the status readily established
• The machine condition reflects a high standard of care - no obvious damage, clean - little or no spillage, free from corrosion and well painted

• Guards are in place and fixed correctly, drive belts are correctly adjusted, machine components are aligned, hold-down bolts are firm, foundations do not show signs of cracks
• Machine is not prone to unusual or damaging modes of vibration

Human Elements

• Documentation management - equipment history, drawings, specifications, test certificates are available
• Change management - written change management procdure - this procedure enables registering and tracking of changes
• Risk management - machine has been formally assessed for risk and appropriate risk reduction/protection measures taken
• Risk management - proposed changes to machine including protection settings, maintenance procedures and operating procedures are assessed for risk
• Awareness - incident reporting system is in use
• Awareness – operators are experienced in this type of equipment and are required to conduct regular inspections or checks according to written guidelines to identify and report any defects
• Awareness - maintenance personnel conduct routine visual inspections of the machine and report unacceptable conditions