Pandrol Rail Fastening for High Speed Track

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Pandrol Rail Fastening for High Speed Track

Over the last twenty years, the maximum speed of trains running on track with Pandrol rail fastenings has more than doubled, to over 300 kph.

Les attaches de rail Pandrol pour voies à grande vitesse
Ces vingt dernières années, la vitesse maximale des trains rouliant sur les voies équipées des attaches de rail Pandrol a plus que doublé, dépassant maintenant les 300 Kmph.

Pandrol-Schienebfestigungen für Hochgeschwindigkeitsgleise
Im Laufe der letzten zwanzig Jahre hat sich die Höchstgeschwindigkeit von Zügen, die auf Gleisen mit Pandrol-Schienebfestigungen fahren, mehr als verdoppelt, und zwar auf über 300 km/h.

Fijaciones de carriles Pandrol para vías de alta velocidad
En los últimos 20 años, se ha duplicado la velocidad máxima de los trenes que circulan por vías con fijaciones de carriles Pandrol, hasta superar los 300 Km/hora.
Track Maintenance by Stoneblower

by P.L. McMichael, Project Manager, Network South East, British Rail

British Rail has ordered an initial fleet of Stoneblowing machines from Pandrol's subsidiary, Pandrol Jackson. The machines are being designed and built at Pandrol Jackson's factory in Michigan, USA. When these machines are fully established as BR's principle maintenance technique large financial savings in the cost of maintaining track geometry are anticipated.

After one and a half centuries of railways, ballasted track is established as the preferred method of construction. Track ballast allows free drainage of water, the distribution of loads to the ground below and allows for the geometry to be adjusted. It is the maintenance of geometry by the adjustment of the ballast support and the cleaning or replacement of this ballast when it is no longer responsive to the maintenance techniques that represents the major cost of ballasted track.

With the passage of traffic, ballast is vibrated and consolidated. The particles lock together and form a relatively stable structure.

Unfortunately for railways which require a high geometrical standard (i.e. passenger railways and particularly high speed passenger railways) the geometry which the track adopts when the ballast has been fully consolidated by traffic is not always commensurate with the geometry required. If a great deal of attention is paid to the geometry at installation this deficiency of the ballasted track can be alleviated. However, with an intensively used network like British Rail the commercial pressures on track occupation time mitigate against great geometrical precision and consolidation during the relaxing process - although better control of relaying equipment, using lasers, and the use of dynamic track stabilisers is helping in this area. BR like most administrations worldwide relies on the tamping process to provide the fine adjustment of track surface geometry both after the relaxing process and in the maintenance process when the geometry has deteriorated after the passage of traffic. When used after the relaxing, or ballast relaying process the tamping machine is working with relatively large lifts and with un-consolidated material. In this instance it is very effective at adjusting sleeper height by moving fresh material from the crib area under the sleeper. When working in a maintenance process the lifts are smaller and the machine is much less effective at moving material. In fact for lifts below 20-25mm it has been shown that a tamping machine simply dilates the consolidated ballast under the sleeper. This has the effect of raising the sleeper, due to the increase in the apparent volume of the stone under the sleeper, but when this dilated ballast is consolidated by traffic it simply packs down to its original, pre-maintenance, shape. This is illustrated in Figure 1, on page 6, which shows the geometrical shape of a section of track before tamping and at various stages after tamping. It can be clearly seen that the track settles to a geometry which is nearly identical to that which existed prior to maintenance. This phenomenon is known as ballast memory. All track maintained by the tamping process, if maintained with a small lift, suffers from this phenomenon. The ballast memory or the geometry at which the track is fairly stable is largely the one that was built in at the time the track was ballasted but is also influenced by the straightness of the rails themselves.
Tamping with a large lift can, to some extent, combat this ballast memory and many railway administrations use this as a method of tamping. Larger lifts require ballast consolidation before traffic can be allowed to run at speed, requiring yet further resources or the imposition of temporary speed restrictions following maintenance. The process is also slower than small lift tamping, has an exorbitant ballast consumption and can only be used in small areas where the overhead clearances will allow the large lifts involved. The technique is therefore of limited values on BR.

Between tamping cycles the track can be subject to rapid local geometry deterioration, particularly around deeply worn, fishplated joints and areas where the tamping process was restricted by track furniture (laboratory, signal cables etc) and will require attention between tamping cycles. This is generally carried out manually.

Also the tamping process requires the ripping and regulating of make up ballast to replenish that moved from the cribs under the sleeper and that destroyed by the process itself. On BR track around 60 tonnes of replacement ballast are required for every mile of track tamped. On heavy haul railroads with larger lifts the ballast requirements can reach 400-600 tonnes per mile per tamp. Research Engineers at British Rail Research (BRR) realised that the key to a durable maintenance process lay in a method of adjusting sleeper height which introduced extra material under the sleeper without disturbing the consolidated ballast. The method of measured shove packing, widely used before the introduction of tamping machines, where measured quantities of stone chippings were placed under the sleeper soft in a shovel did just this and had an excellent reputation for durability. However, the method was slow, labour intensive and, hence, uneconomic. Attempts to mechanise this technique by blowing stone under sleepers down tubes inserted on the face a sleeper proved successful. An experimental machine was built by converting an obsolete tamping machine. Experimental sites were set up comparing this method to tamping over a wide variety of BR's tracks. The Stoneblower never failed to produce a more durable result than tamping. Figure 2 shows the improvements in maintenance durability obtained. The process was very effective at removing the faults impressed on the ballast by poor welding and joint geometry. The system also showed considerable potential when used on track where the ballast was reaching the end of its useful life. Also, the tracks treated by the process were found to require far less make up ballast.

The compromises forced by the machine conversion made the original experimental machine slow and cumbersome to use. The next stage of the development was to commission a prototype machine which, after a protracted development period, proved that a viable working speed could be achieved, confirmed the effectiveness of the system and verified the advantages when maintaining worn out ballast. It was also shown that by careful machine design sleepers that were normally difficult to access for maintenance could be maintained.

However, this prototype machine proved very unreliable and its performance on good quality track proved erratic when compared to the experimental machine. BR instigated a development programme which established conclusively the reasons for the erratic performance on good quality track and established how consistent good quality could be achieved. An analysis of the breakdown statistics showed that the reliability problem could be cured by a careful design process involving reliability engineers.

By this time the successful development of the continuous action tamping machine appeared to threaten the economic advantage offered by the stoneblowing technique. However, as was now analysing data from a lot of track maintained by the process and other significant benefits had emerged and could be quantified.

It was always suspected that the tamping process was damaging to the ballast in rubbing the particles against each other. Measurements of this effect have established that for a typical BR track loading and maintenance frequency the maintenance process itself was responsible for half of the damage to the ballast (Figure 3A). A similar analysis from stoneblowing showed that the process itself was far less damaging to the ballast and since the requirement for maintenance is far less frequent the contribution to the ballast damage from the maintenance process becomes almost negligible (Figure 3B). This result surprises many track engineers who at first find it difficult to accept a technique which actually aims to put small amounts of chippings under a sleeper. However, once the damaging effect of conventional tamping is realised then the premise that the ballast on track maintained with stoneblowing will have a longer life is accepted.

While it will take many years and a full ballast life to prove practical the theoretical calculations, use of the prototype machine on tracks with ballast approaching the end of its useful life has already delivered gains in ballast life exceeding the calculated values.

As track ballast wears and the individual particles lose their angularity, impairing its interlocking qualities, the ability to retain the shape geometry after tamping is reduced. The required tamping frequency for a given geometry increases. The fine material generated from the rounding of the ballast (and from material deposited on the track) tends to block the pores in the ballast structure which allow the drainage of surface water.

The track will develop wet spots where the presence of water lubricates the movement of the ballast particles leading to more rapid settlement following maintenance. Also, once the track has settled and a void has developed the pumping action when traffic passes causes an abrasive slurry to cause further damage to the ballast and sleepers. If the track is to continue in use, then the maintenance frequency increases.

At this, this extra maintenance takes the form of manual attention for spot maintenance, additional back filling and digging out of wet spots etc. Thus, the costs of maintenance increase dramatically. Eventually, it becomes more economic to rehabilitate the track and start the cycle again. A typical time/maintenance cost curve is shown in Figure 4.

The use of the Stoneblower on near life expired ballast has been found to be extremely beneficial. The fresh stone chippings are placed on the worn out but consolidated ballast in a more durable mechanism and is achieved to the extent that the pumping action of traffic is reduced and the wet spots have a chance to dry out. There are many examples where track which had been subject to speed restrictions and was awaiting ballast renewal has had the speed restriction lifted and the planned ballasting cancelled following maintenance by Stoneblower. Thus BR has found many benefits from stoneblowing. The method provides a far more durable maintenance process with the ability to repair the track, it reduces the potential ballast life is increased. A comparison of the effect on maintenance cost of changing to a stoneblower maintenance regime is shown in Figure 4.

Pandrol Jackson's first machine is due for delivery in 1994 and will enter revenue service on the Intensively used track of BR's Network South East in 1995. The initial fleet will comprise of eight machines and BR has the option to increase this to eleven. It is expected that eventually BR could require over twenty machines.
The design of trackwork for the Metrolink, Manchester's new light rail system, is interesting not least for the variety of trackform in use. These are summarised in Figure 1. The 33km network was designed and constructed in 2½ years as part of a Design-Build-Operate-Maintain (DBOM) contract, but was preceded by a hectic tender stage.

During this tender stage we realised that the street-track for the first new street running light railway in the UK for many years needed to achieve four main characteristics:

- quiet
- virtually maintenance free
- electrically insulated from the ground
- construction cost, while

These four requirements return to the street through the running rails

MINIMUM CONSTRUCTION COST, WHILE

 metaLINK TRACK TYPES

complying with the other characteristics and the specification

For the new track in the city centre we therefore conceived a design in which grooved rails are entirely encased in a resilient polymer, with no metal fastenings and no tie bars between rails, even for radii down to 25m. The logic for trying to eliminate tie bars included both construction and maintenance reasons, in straight track, lateral forces are very small anyway, so why tie the rails together mechanically; in the curved track in the city centre, the radii of 25m to 40m pointed to a very uneven rate of wear between inside and outside rails.

The ability to replace a heavily worn outer rail, without disturbing its inner equivalent, was thought to be of great advantage in limiting road traffic disruption during rail replacement. After award of the contract the initial concept was refined into the system shown in Figure 2. The detail design specified 2mm vertical movement of the rail under load but limited the horizontal movement to a maximum of 1mm, with the object of getting as high a vibration isolation as possible whilst maintaining a stable rail position. We ran a 3-dimensional finite element analysis of the wheel load distribution as transmitted through the rail to the polymer and slab below, to determine the stiffness characteristic of the polymer.

Two types of polyurethane polymer with different flexing details have been installed. Recent measurements have confirmed the design calculations and show a high degree of vibration isolation from the support slab both vertically and laterally. At 50Hz, vertical vibration acceleration is attenuated by about 65% but over the rest of the frequency range between 90% and 99% is achieved. Laterally, there are no appreciable peaks in the response, with reduction averaging about 95%.

These results are confirmation of the general perception of a quiet, vibration free system which, in normal daytime hours, is completely "drowned" by the road traffic. At other times, the general "tractions" sounds seem to dominate, but appear to be at acceptably low levels.

An even higher degree of noise and vibration isolation was judged necessary by the developers of the new concert hall, particularly for the low frequencies. For this we developed a floating road slab, building on our successful designs for Canary Wharf Station on the Docklands Light Railway. There are significant problems in ensuring that reflections under rail loading are optimal. In order to provide the vibration damping at sufficiently low frequencies -20 to 50Hz - while limiting deflections at the edge of the slab under the point load of a commercial road vehicle, a valid

FIG 1

MANCHESTER METROLINK
CONCEPTION DES VOIES
PAR NEIL AYNALL ET ROGER HALL, WS ATKINS CONSULTANTS

De manière à répondre aux exigences locales, diverses formes de voies, à la fois nouvelles et remises en état, composent le nouveau réseau ferroviaire à voile étroite de 33 km de Manchester. Les conceptions de WS Atkins Consultants pour les nouvelles voies ainsi que pour l'interface route/voie sur les voies existantes sont décrites. Cela faisait partie du projet. Conception-Construction-Exploitation-Entretien réalisé en 2 ans et demi.

Pour la section en ville notament, on a mis de plus à satisfaire aux autres exigences et à la spécification, la conception présentait quatre caractéristiques principales: une marche silencieuse, une exploitation quasiment sans entretien, une isolation électrique du sol et un coût de construction minimum.
outline design was developed, but concern over vibration from sources other than the railway persuaded the developers to isolate the concert hall building within its own foundations. The polymer embedded track has proved to provide electrical resistance exceeding the local authority’s requirement of 100 ohm/m. As a further safeguard against stray current, a welded-mesh grid was built into the supporting concrete slab in discrete lengths, and each length of mesh connected to the sub-station via continuous cable and diode. The new G-Mex viaduct, which carries the Metrolink from street level up to the old railway formation, is some 240 metres long including a 42m span steel boxstring arch. The reinforced concrete approach spans have 80A rail set in polymer, in similar fashion to the grooved rail in the street. For the bowstring arch bridge, however, we felt that more rigorous isolation was required to prevent drumming of the steel structure. We therefore designed two levels of vibration isolation: longitudinal concrete way beams supporting 80A rails encased in polymer, whilst the waybeams themselves are resiliently mounted at 5m intervals on the steel bridge cross-members. The bridge itself is also supported on neoprene bearings. This has proved very effective in service - there is no discernible difference in noise/vibration levels when an LRV is on the bridge. During these deliberations, we also prepared an outline design for a third level of isolation to achieve the very high standards that the nearby concert halls require. This comprised a floating top section of the abutments at each corner of the bridge - effectively a 1m cube of concrete, resiliently supported on five sides with the bridge bearing on top. Like the floating road slab, this effort was rendered redundant by the concert hall’s own foundation design.

To the south of the new viaduct is the one kilometre long, previously disused Combrook viaduct, which used to serve Central Station (now converted to the G-Mex Centre). This generally has BR style track with 113A rail held on concrete sleepers by Pandeled ‘e’ clips with 5mm moulded rail pads. However, there are three impressive Victorian wrought iron truss bridges within the length of the brick viaduct, all with limited width. The provision of a walkway, a requirement for new railways in the UK, did not leave sufficient space for the kinematic envelopes required for ballasted tracks. A 300m length of slab track was designed which with the reduced construction and maintenance tolerances enabled twin tracks and walkway to be accommodated to the satisfaction of the Railway Inspectorate. The 113A rail sits on resilient concrete baseplates with thick studded baseplate pads. Construction tolerances were reduced by providing continuous longitudinal plinths under each rail, as a second concrete pour. A similar slab track design is used in the new station underneather BR main line Piccadilly station, and at Victoria station where very close tolerances (75mm) between kinematic envelope and reinforced concrete containment wall are required to restrain any derailed LRV. The pre-existing BR tracks on the line from Manchester Victoria to Burry were taken over in a very variable condition. Some sections had been upgraded by BR prior to handover, others had not. Commercial considerations dictated that the existing point and crossing work could not be replaced. However, the standard wheel profile of the LRVs does not interact correctly with the standard BR design of switches. We also considered it desirable to maintain the existing track such that BR freight trains could use it if required in the future. A compromise design was therefore produced in conjunction with the vehicle suppliers in which the LRV wheels are shaped to provide a relatively thin flanged BR profile with a thickened section above rail level such that the BR wheel back-to-back dimension is maintained.

At the new tram line, the check rails on the existing P & C were raised by 5mm, with changing their plan position, so that they act on both the thickened section of the LRV wheels and standard BR wheels. This satisfied the needs of both types of rolling stock at a very modest cost to our clients.

Transitions from the slab track to ballasted track have generally been designed with transition slabs. Two lengths of transition slab have been used depending on the LRV speed, with the intention of providing a gradual change of stiffness of the support structure. With the high degree of resilience available in the slab track fastening, we must admit to some scepticism regarding the need for such transition slabs. The design of the wheel-rail interface is very important, not only for the reasons mentioned above. The braking performance of steel wheels on steel rails compares poorly with rubber tyres on asphalt, and in the city centre it is the latter with which the public are familiar. It was therefore essential to provide the best possible braking properties by careful consideration of the wheel tyre/rail interface. However we have to recognise that the majority of the mileage runs by the LRV wheels will be over the pre-existing track with its varying rail condition. In consultation with GEC- Alsthom and the rolling stock manufacturers, it became apparent that the LRV specific type profile required the rail head to be presented at 1:20 inclination to achieve the optimum braking traction contact. The grooved rail in the city centre had been set with vertical webs for ease of construction, due to the difficulty of providing coincident low radii horizontal and vertical bends, and so the rail head was ground fin-situ to provide the required profile. In the depot at Queens Road, considerations of economy led to the use of second-hand rail, both flat bottomed and bullhead, except for the approach tracks where we considered the extra reliability of new track components to be desirable. A reduced, more appropriate specification for ballast was permitted for the stabling sidings.

As explained earlier, this was a DBOM contract working to a fast-track programme. Our client for track design was Mowlem Civil Engineering, a member of the GMA consortium. GMA built the Metrolink for GMML who will operate it for a period of 15 years for the GMPT which is the public sector transport executive.
When Pandrol International Ltd purchased a share of the Spervo Rail Services Company in 1981, it acquired a fleet of eight 90 stone grinding units. These units were hauled by motive power provided by the user railway. The grinding motors were mounted in pairs in frames which allowed for angular adjustment by bolting into preset positions. Changing the motor angle was a laborious, manual operation.

The joint venture was charged with designing a new grinding project to develop a new grinding train which was well propelled, where the motor angles could be remotely adjusted from a control unit within the train and where all the operational and control systems were electronically sensed and computer managed. The result was RMS 1, a 120 grinding stone train, propelled by two diesel electric units with the grinding heads mounted in five articulated trucks. A sister train RMS 2 closely followed the design of RMS 1 but had an additional vehicle in the articulated group. The design improvements developed from experience gained in the operation of RMS 1.

Together these two trains have ground well over 60,000 tons of track and remain in service.

In 1989, Pandrol International acquired the whole of the equity in Spervo Rail Services and also purchased Jackson Jordan Inc, the leading U.S. manufacturers of points and crossings grinding machines and a major manufacturer of rail-bound track maintenance equipment to form a new company, Pandrol Jackson Inc. The benefits of rail grinding were becoming increasingly realised while at the same time the needs of railways with established grinding programmes were changing. Initially substantial volumes of metal needed to be removed to reshape the rail and remove surface anomalies like corrugation and scaling. Once the rail shape or profile had been restored, the need became one of maintenance which required far less removal of material but more accurate control of grinding facets.

The reduction in rate of metal removal required during the maintenance phase of grinding allows the same grinding train to travel faster and become substantially more productive but introduces larger dynamic forces and requires a very stable grinding platform.

With these needs in mind, Pandrol Jackson Inc embarked upon a design programme for a new generation of grinding units. It was decided to move away from the concept of a train with separate motive power units and a dedicated consist to a modular system where each grinding unit was fully independent with its own power generation, its own drive system and its own control system but where any number of units could be linked together and work centrally from any of the units as required.

The characteristics of the module designed and built for use on U.S. railroads are:

- **Weight:** 108 tonnes
- **Length:** 24 metres
- **Height:** 4.3 metres
- **Travel speed:** 72 Kph max
- **Grinding speed:** 20 Kph max
- **Grinding angle:** +50° to -45°

The 30 HP grinding motors are mounted in pairs in hydraulically operated adjustable cradles but each is individually adjustable for angular position and load control within the cradle. Four cradles, two on each rail, are mounted in wheeled frames, or buggies, three of which are articulated to provide the grinding platform. Lateral adjustment is provided to enable an angled motor to be positioned normal to the surface it is grinding and the lateral position of each buggy on the track is hydraulically controlled to maintain the locational accuracy of the ground facet. Power for both the 680kW generator and for the hydraulic pumps is provided by a 1950 HP Cummins diesel engine.

To meet environmental requirements, the unit is fitted with a vacuum dust collector system which draws dust through a plenum running the full length of the grinding buggies into filters from which it can be discharged, via an auger, to a suitable collection point.

Each module has an on-board computer which controls all the grinding and transit functions. Up to 60 grinding patterns (60 sets of predetermined stone angle positions) can be retained in memory with each angular position having a predetermined automatically applied (hydraulically) loading level. The control system includes a monitoring system covering all the main mechanical functions and behaviour. If required all the automatic controls can be manually over-ridden. For multiple unit operation, the computers on each unit are networked and a supervisory SCADA computer takes over most operating functions in addition to diagnostics and record keeping.

To avoid grindstones following corrugation patterns on a rail, a servo system on the hydraulic load control encourages the stones to attack the peaks while controlling their rate of descent into the troughs. To avoid obstructions the lift control on the grindstones can be manually directed or programmed to operate through a given ground zone where each stone will be automatically lifted on entering the zone and lowered on departure.

The modules have been named Magnum and the first Magnum train comprising 3 units (72 grindstones), a 20,000 gallon water tank bogie and a tool/utility bogie vehicle has just entered service.

The control and monitoring systems on the grinding trains are being constantly upgraded as the development and particularly the operating speeds of computers allows. The next major advance will be in the very accurate measurement of rail profile, both before and after grinding which will provide essential data for planning and controlling the grinding operation. An optical system using lasers is in development to measure cross sectional rail profile to supplement a mechanical contacting system, already developed, which measures the longitudinal profile. Ultimately, one can look forward to a completely integrated measurement and control system where, using pattern recognition techniques, rail measurements can be translated directly into optimum grinding patterns to achieve the desired profile and the grinding control will be directed, without manual intervention, accordingly.
The Sydney City Underground System is a focal point for the whole rail network. It consists of a dual track system totalling approximately 16 track kilometres of which 11.7 kilometres is on a concrete track bed. The underground includes Town Hall, Wynyard, Circular Quay, St. James and Museum Stations. The running time Central to Central via the underground network totals 9.35 minutes on the City Inner and 8.41 minutes on the City Outer.

The City Underground network was constructed and commissioned in 3 stages, 1972, 1973 and 1975. The alignment followed the existing street lines to avoid massive resumption costs and costs involved in the underpinning of buildings. The ruling grades are based on 1 in 30 with 1 in 40 against the load. The design criteria was as follows:

(i) Maximum design speed: 75 km/hr
(ii) Curves range from 160 metres, most curves 400 metres.
(iii) Design speeds on curves = 0.32 R, where R is radius in metres and speed in km/hr
(iv) Curves less than 400 metres transitioned by parabolic formula $y = \frac{x^2}{a}
(v) Vertical curves were calculated using $y = \frac{x^2}{b}$
(vi) Superelevation = 11.9573 x $\frac{S}{R}$, $S$ speed in km/hr $R$ = radius in metres
(vii) Maximum superelevation = 11.5m

The capacity criteria was as follows:

(i) 30 Sec. train stop, maximum speed of 50 km/hr, continuous overlap of signalling and automatic train stops, allowing for maximum 36 trains/trk/hour.
(ii) Passenger capacity estimated at 50,000/hr during peak System was designed to be adequate for a population of over 2 million.

The philosophy adopted in the track bed design was to provide a maintenance-free first class track system. This consisted of Ironbark timber half sleepers embedded in a concrete road bed. A G.E.O. steel baseplate providing a rail cant of 1 in 20 was attached to the half timbers by four 24mm diameter 150mm long screws/pkgs. Screws/pkgs were used in preference to the usual dog spikes to further reduce the maintenance of the track bed. The rail was held to the plates by a system of rail clamps and bolts. The general arrangement can be seen in Figure 1.

The Sydney City Underground System has served Sydney well over the past 60 years, but the system has now reached the stage that major maintenance and upgrading works are required. Due to the fact that maintenance criteria were never designed into the original infrastructure, there are many constraints on upgrading works. These include limited access to upgrading sites, passenger transport during track possession, environmental/health standards, and limited maintenance adjustment possible to the permanent way.

At present CityRail is upgrading the City Underground to world class standard. This involves the replacement of failed sections of track bed, installation of sub-soil drains, repairs to the tunnel vault, upgrading of the drainage system, realign and grade the geometric properties of the track to facilitate the operating requirements of modern rolling stock, and standardise and upgrade the rail fastening system and rails. The remainder of this article looks into the realignment and regarding of the track and the upgrading and standardisation of the fastenings.

Prior to the commencement of the upgrading project there were 8 different types of fastening systems used in 13 varying combinations, including G.E.O. (KE, 44D, 430, Cologne Eggs) and various modifications of these.

The primary reason for the proliferation in fastening systems used is that the ongoing maintenance during the life of the track (i.e. isolated regarding, timber and fastening renewal, rail welding and rail renewal) has left to constant replanning throughout the entire system. In order to eliminate the occurrence of spike-killed timbers during these maintenance activities, a variety of fastening systems (as outlined above) was used, so as to eliminate the costly

Planches d’assile allongées du métré de Sydney

Le métro de la ville de Sydney est le point de metro du réseau complet de City Rail. Il comporte en un système à deux voies totalisant quelque 16 kilomètres de voies dont 11.7 kilomètres sur une distance 20 de bêton remontant à certains endroits à plus de 65 ans. En 1989, le métro utilisait de nombreuses combinaisons d’attaches et de plaques de voies différentes. De ce fait, et en raison du fréquent déplacement des constructeurs de systèmes de dehors, le remplacement s’avérait coûteux. Les défaillances semblent découler d’un ensemble de raisons : mouvement excessif dans la combinaison de plaques, attache non standard, mouvement vertical de supports sur rails et manque de géométrie de voie adéquate.

L'utilisation de plaques allongées fabriquées par Pandrol a aidé à surmonter ces problèmes. Ces plaques furent fabriquées en guidage sur une plaque d'acier laminé standard de Pandrol. À la fin 89, CityRail et Pandrol perfectionnèrent ce système en introduisant la plaque allongée et plus coûteuse de la plaque en fonte S.G. utilisant d'autres éléments des produits de 22mm. Ceci permet de résoudre tous les problèmes d'entretien et fut adopté par la S.R.A comme méthode d'entretien préférée.

FIG 1

Erweiterte Unterlegscheiben bei der St-Bahn in Sydney


Placas de asiento prolongadas en la S-Bahn de Sydney

El Metro de la Ciudad de Sydney es el punto final de toda la red CityRail-Sydney. Su sistema de vía doble con un total de unos 16 km de vía, de los cuales 11.7 km están tendidos sobre un lecho de hormigón que, en ciertas áreas, tiene más de 65 años.

En 1989 se empleaban muchas combinaciones diferentes de placas y placas de asiento de los carriles en el ferrocarril que pasaba el metro. Debido a esto y a que gran parte de las traviesas de madera estaban "azaballadas" por las trabas de madera de las placas de asiento.

Los fallos resultaban de una combinación de movimiento inadecuado en las combinaciones de placas de asiento originales, placas no normales, movimientos incorrectos las cumbres y carencia de una geometría adecuada de la vía.

El empleo de placas de asiento prolongadas Pandrol ayudó a superar los problemas. Las placas de asiento se construyeron soldando una placa de asiento a una placa de asiento estándar de acero laminado. A finales de 1989, CityRail y Pandrol desarrollaron más el sistema con la introducción de placas de fundición extendida de acero esfuerzo más económicas, con varios tipos de tramos de 22 mm. Esto solucionó todos los problemas de mantenimiento y fue adoptado por S.R.A como el método preferido de mantenimiento.
The Olifants River Bridge

This article is an abridged version of a paper ‘Forces in the Railway Track Structure on the Olifants River Bridge’ by Hannes Marre (Spornet) and David Rhudes (Pandrol), presented at the International Heavy haul Association Special Technical Session on Bridges, Aarslund in Norway on 7th July 1992.

Le pont de la rivière Olifants by Hannes Marre (Spornet) et Dr. David Rhudes

La ligne de trafic lord transportant le minerai de fer de Sishen-Saldanha traverse la rivière Olifants sur un viaduc d’un kilomètre à tablier de balancier qui comprend un rail double continu, non posé de point en point. Une série d’essais a été effectuée pour déterminer l’effet de changements de températures sur les forces agissant sur le tablier. Pour la réalisation de ce programme informatique spécialisé à éléments finis (‘Proils’) a été utilisé pour calculer les forces en flexion et en cisaillement s’exerçant sur le tablier, prenant en compte l’effet de la charge verticale sur les caractéristiques du tablier. Cette analyse a montré que lorsque d’importants changements de température interviennent sur des voûtes équipées d’attaches de rail conventionnelles, un glissement du rail peut se produire entre les traverses et le tablier. L’utilisation d’attaches à force longitudinale suffit dans les zones critiques pour permettre aux rails de suivre la traverse et à la traverse de rester fixe sur le tablier.

The Olifants River Bridge, at Vredendal, Republic of South Africa, is one of the major bridges of the Sishen-Saldanha Heavy Haul Iron Ore line. The bridge is unique in that it carries continuous welded rails over its entire length of just over one kilometre. The first diagram, on page 19, shows in simplified form the construction of the bridge. It consists of two 495 metre long continuous side spans fastened at the abutments, and a simply supported 45 metre long other span at mid-span. There are piers at 45 metre intervals, but the long decks are free to expand and contract in an effort to reduce the central deck by means of expansion joints. The rails have no expansion joints, and are fixed to concrete sleepers on a ballasted steel bridge deck. The rails are therefore subject to high interaction forces. Concern for the development of these forces resulted in the development of a system for their measurement. On September 7th 1982, shortly before the measurement system was put into operation, a derailment took place in the centre of the bridge, as a result of a ‘kickout’ of the track caused by excessive longitudinal forces. In October 1983, the measurement system was finally put into service so that track and structure forces could be monitored continuously. Other measures were also taken to improve the lateral stability of the track, including the adoption of ‘wing’ sleepers, and improved sidewalks to contain the ballast shoulders. Derailments later changed, on

El puente sobre el río Olifants by Hannes Marre (Spornet) et Dr. David Rhudes

La línea de transporte pesado de mineral de hierro Sishen-Saldanha cruza el río Olifants sobre un viaducto con tablero de balancio de 1 km de longitud, con carriles soldados continuos sin juntas de expansión. Se realizó una serie de pruebas para determinar los efectos de los cambios de temperatura en las fuerzas que actúan en la vía. Más recientemente, se implementó un programa de ordenador ‘Proils’ de elementos finitos, ex profeso, para calcular las fuerzas longitudinales en la vía, teniendo en cuenta los efectos de las cargas verticales en las características del tablero. Como resultado de estas pruebas, se demostró que cuando se producen grandes cambios de temperatura en las vías, los carriles soldados variarían continuamente en los carriles. Se produciría eventualmente desplazamiento del carril entre las 'bandas' y en el balancio. El empleo de juntas globales de longitud nula en estas críticas permitirá que el carril se deslice sobre la vía. Esa permanezca fija en el balancio.

Timber removal underlong standard cast Pandrol basplate

vertical and horizontal realignment of the track

The choice of fastening system adopted in the upgrading project was governed by the following constraints:

(i) Uniform fastening system removed.

(ii) No increase in noise and vibration to adjacent properties.

(iii) Limit rail movement in place to reduce load transfer to timber and track bed.

(iv) Fastening to timber to avoid spike-killed timber zones.

(v) Ease of installation and removal to minimise maintenance costs.

(vi) Track to be ruggedged to new vertical and horizontal alignment.

(vii) Be economically the best solution.

The use of resilient Pandrol fastenings has reduced the effect of rail movement in the plate and when used in combination with an extended baseplate welded to a rolled standard Pandrol plate and attached to the timber via a 22mm diameter 175mm long screw-rib, the spike killed zones in the existing timbers could be straddled.

To increase the economic viability of the product, Pandrol Australia in conjunction with Cityrail, developed a series of extended cast Pandrol baseplates. The various baseplate designs incorporated the following:

(i) A variety of thicknesses in the baseplate construction to allow for a number oframping alternatives. This allows field construction to suit vertical alignment tolerances.

(ii) A variety of spike hole configurations and plate lengths to allow the placing of the plates to correct horizontal alignment whilst allowing adequate boring of screwspikes into fresh timber.

(iii) The use of achieved and installed over 4000 of a standard rolled Pandrol plate with an extended baseplate welded to it. In addition a weight reduction of the plates allows for improved replicating production rates as well as a more efficient way of stacking the plates due to their new integrated shape.

References:

(i) The 60 Year Old City Underground Railway, B.F. Howes, CityRail

(ii) City Underground Upgrade - Report on the Findings of the Definition Study. R.S.M.

Wing sleepers for improved track stability

November 17th 1983, a 16mm over a 9 metre chord was reported over the Sishen side alignment bridge deck expansion joint due to an incorrect reset after an alarm occurred.

Rail fastenings with zero longitudinal restraint (ZLR or ‘rail free’) have now been proposed, and are to be tested in track.

The fastening system is similar to that which has been developed by Pandrol for shorter bridges, and has been used successfully in the USA, Scandinavia and the Middle East. For the much longer Olifants River Bridge, Pandrol have used a special purpose finite element computer program, ‘PROILLS’, to calculate the longitudinal forces in track, and to study the effects of using ZLR fastenings on short lengths of track around the deck expansion joints, rather than using them for the entire bridge length. Another novel feature of the ZLR fastening system proposed for this application is that the ‘rail free plates’ will be made from reinforced nylon, in order to maintain insulation of the rails in all previous applications. Pandrol ZLR fasteners have been used on baseplates on timber bearers, and it has been possible to use metal plates.

Track Force Measurements

The sidings permanently on the bridge uses encapsulated strain gauges, stuck to the rail web, and connected to a
At that time the distressing temperature was only 38°C, and this combination would have resulted in a deck expansion joint movement of 53mm and longitudinal force in the two rails of just over 3500 kN. At that force an alignment error of 12mm would have been sufficient to cause a kickout under a passing train.

Z.L.R. Proposal and "PROLIS" Analysis

Although ZLR fastenings are very successful in reducing rail and bridge structure stresses in most circumstances, the use of ZLR fastenings on long bridges leads to the possibility of excessive gaps opening up in the event of a rail break. It is therefore desirable to optimise the length of track over which there is no longitudinal restraint in order to balance the conflicting requirements of avoiding track bucking or structural failure on one hand, whilst retaining the ability to contain a broken rail safely on the other.

In order to predict the effect of applying ZLR fastening assemblies to the Olifants River Bridge, a special purpose non-linear finite element computer programme "PROLIS", was used. This program was developed by the Delft University of Technology in the Netherlands to calculate longitudinal forces in track and bridge structures and can take into account the effect of vertical loading on the ballast characteristics. For example, the analysis does take into account the fact that under the influence of thermal forces a sleeper will slip much more easily in the ballast when the track is unloaded than when the weight of a train is holding it down. The latest version of the software, "PROLIS 2.1", was developed in Delft, specifically for Pandrol, and can also take into account the non-linear creep resistance of the rail fastening system.

Both versions of PROLIS have been used to calculate the longitudinal force distribution in the central spans of the bridge, and the results were compared with the available experimental data, and the results of earlier theoretical studies which used the ICES STRUDL structural analysis software. The analysis predicts that the deck expansion joints would cause by almost 4mm per degree C increase in deck temperature, and that this would result in a force of almost 4000N per degree C in the two rails, i.e. the 53mm joint movement calculated for the 1982 derailment which resulted in a force of 3270kN in the rails - putting the PROLIS prediction within 8% of the prediction based on track measurements. The deck temperature, which would have been needed to create these conditions is predicted by PROLIS to be about 8°C.

Having established that PROLIS could predict track forces to this accuracy, the analysis was carried with various sections of track having ZLR fasteners. If ZLR fasteners were to be used throughout the bridge structure, the thermal forces in the rail were shown to be reduced to less than one tenth of the current levels. But it was also shown that in the event of a rail break at a typical night time temperature of 10°C, the gap in the rail could match the movement of the deck expansion joint and be as much as 168mm - an unacceptable high figure. However, with a group of about 40 ZLR sleepers evenly spaced across each deck expansion joint the peak force could be reduced significantly without causing any concern about the effects of rail breaks.

It has also been shown that for large temperature changes, where conventional rail fastenings are used, slip will eventually occur between the sleeper and the ballast. However, with ZLR fastenings in the critical areas, the rail slips easily on the sleeper, and the sleeper remains stationary in the ballast. Thus with repeated thermal cycles, the ZLR fastening has a further beneficial effect because it reduces degradation of the ballast under the sleeper which would otherwise lead, eventually, to a loss of the ability of the track structure to contain longitudinal forces.
Rail Flaw Detection

In 1989, the Pandrol Group acquired a majority interest in Dapco, a provider of ultrasonic flaw detection products and services. In May 1992, Dapco was divided into three separately owned entities, each with Pandrol's interests reorganized and a new company formed, called Pandrol-Jackson Technologies which took over all of its railways activities formerly carried out by the Pandrol Partnership.

PIT provides ultrasonic rail flaw contract test services to most of North America's major railroads. Many of these railroads also use PIT technology in their own testing fleets. In recent times, PIT has also become involved in world markets as a leading vendor of high speed rail flaw detection cars and systems.

Three generations of test systems - Systems 100, 300 and 1000 have now been built. Each represented a major step forward in rail testing technology and the latter two types are currently manufactured to serve the specific needs of very diverse railroads. System 100 will remain the backbone of our North American contract testing fleets as it has features specific to the practice of interrupted testing followed by immediate hand verification. The high验收 type vehicles used are ideal in an environment where the customer wishes to verify defects immediately and clear the track quickly. Furthermore, many railroads now consider it increasingly desirable not to have to supply the contractor with fuel, water and maintenance services.

System 1000 which in its current incarnation is installed only in rail bound vehicles was developed primarily for world markets where the regulatory environment and legal environments encourage non-stop high speed continuous testing. PIT has now sold a 100 system to Tamper Australia for use on their recently built Singapore multi function vehicle. In addition, we have built two rail bound test cars for the Chinese National Railway and another for three Chinese car builder for three further cars.

Before comparing the three generations of systems - 100, 300 and 1000 - one should look at the basic elements of any ultrasonic testing system applied to in situ rail.

Ultrasonic energy must be coupled with the rail while sensors then measure and record the response obtained. The next element is usually high speed processing and sorting of the data to provide real time feedback. With the refined data thus generated, an element of decision making is then applied followed by defect location, categorization and marking. Finally, some form of report is generated and increasingly, it is therefore required that the data be transmitted directly by modem to the railroad.

In evaluating the three systems types developed, System 100 serves as a base case first generation system as it was not unlike other ultrasonic test systems of its era. Despite their major differences, all three generations have common elements. These include a pulsing ratio proportional to distance travel. Transducers are parallel pulsed and all systems have the capability of automatically painting marks into the track. In all cases, PIT has chosen to use wheels as ultrasonic transmitters/receivers rather than slugs to work in the environment in which many railroads operate - uneven rail surface, high/low joints, grease, ice, snow - where they are usually the more appropriate choice.

The base case 100 system had the widest standard configuration of three transducers oriented at 0, 45 and 70 degrees. Over time, it was realized that this was inadequate in achieving high quality performance. The idea of using a 70 degree array of transducers was then introduced with each element looking at discrete but overlapping portions of the rail head. It is developed and highly successful and quickly became standard on all our contracting cars and test track systems most universally by our customers. In recent years, a large increase in the number of specially designed and optimized split head types defects was noticed in heavily worn rail particularly towards the field side. This led PIT to develop a new configured transducer to assist in finding such defects more efficiently.

This is a side looking unit which sends its signal across the head of the rail. This highly successful modification adds one extra channel per wheel giving six in place of the usual three. Hence with two wheels per rail, there are now twelve testing channels on each side and the enhanced detection sensitivity that accompanies such complete coverage.

The older 100 type systems used manually adjusted potentiometers to set the testing parameters. All our newer systems use computer controlled and thus all setups can be stored and called up instantly when - as is inevitably the case - similar test conditions arise again. Furthermore the test parameters used at any given moment can be recalled later and examined.

Another area where a major change has occurred is that of the basis system architecture. Their 100 type systems were composed solely of fixed hardware elements and were very hard to update as new components became available. This is particularly important nowadays and the pit's product life cycle typical of electronic components.

PIT's current systems are all software driven and are much more amenable to continuous improvement as newer better components becomes available. All software is also menu driven thereby providing a highly user-friendly environment.

Early systems had no Central Processor Unit and relied entirely on fixed hardware elements. With rapid advances in standard PC hardware, it became highly desirable to make use of the ever cheaper faster and more powerful processors available. System 3000 uses 2–386/20 MHz CPUs while System 1000 uses 5–486/33 MHz units. The advantages of using standard PC type items is that as improvements are made and newer, faster processors become available, they can be immediately integrated into existing designs with minimal modification.

Early systems used paper tape with ink pens and PIT have now eliminated that again by recording totally. Paper tape are bulky, hard to store, awkward to check and are open to damage and deterioration. The system has two Bernoulli removable hard disk as recording media and a 20 Meg Floptical to which all data in primary storage is automatically transferred. In operation, the data is generated, handles and stores vastly more data and is configured with a 500 Meg hard drives and a 2.2 Gigabyte capacity tape.

There is also a major difference in the type of data display used. Early systems used event markers on paper tape only System 3000 used a colour video event marker along with a numerical listing showing accurate counts, starts, walks, etc. Storage and examination is much easier than with paper tapes and the resulting information can be recalled easily. The associated numerical display is multi layered and the operator can call up many different screens with pertinent data, etc. There are also highlights exceptions in a contrasting colour thereby assisting the operator in more precisely.

System 1000 uses a Biscan type representation. This is a profile representation of the actual defect which can be shown on the video screen in real time. This enhanced level of detail is a major breakthrough in high speed real time systems. Furthermore, the system also calls the actual defect with an icon clearly highlighted on the screen.

This development is the greatest change of all from prior practices. The introduction of objective testing has long been promised and System 1000 has finally delivered that advantage and is now available with the actual creation.

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This development is the greatest change of all from prior practices. The introduction of objective testing has long been promised and System 1000 has finally delivered that advantage and is now available with the actual creation.
PIT’s latest version has a seven layer structure with five levels of pattern recognition functions. What is unique about this approach is that while each of the individual techniques are commonly used in other fields, PIT have now managed to integrate them in a comprehensive package suitable for real time usage. It has not been an easy task as there is absolutely no way to achieve a quality pattern recognition capability with any single processor based system. Only by using the System 1000 does, a relatively enormous on board computing capacity combined with a highly sophisticated system architecture and shared memory at all levels, can it be achieved in real time.

Where does all this increased capability take us in terms of testing speeds? System 100, 100 and 1000 have maximum testing speeds of 20, 35 and 55 kph respectively. Much has been claimed over the years in respect to high speed testing. In our experience, there are many variables involved - all of which mitigate against higher speeds. On perfectly maintained high speed passenger oriented tangent track with few defects, high quality rail and good track possession, high production rates can always be attained.

In the world of freight railroading with heavily worn and transposed rail, trackside lubricators, cogs, splinters, engine burns, adverse climatic conditions and intermittent track possession, the reality may be considerably more prosaic.

Higher speeds for their own sake without a concurrent improved testing capability can be wholly counterproductive. The whole focus of PIT’s recent efforts has been to try to make ever more certain that we first improve the underlying basis of the technology. This is being done by taking full advantage of the major advances in the past few years in the fields of electronics, sensing technology and software. We are totally committed to the philosophy that you must first get better before you get faster.

With this in mind, System 1000 has also been specifically designed with a very open architecture to facilitate the seamless integration of new features and add-on products at future dates. Hence, even higher maximum speeds will be attainable as major PC hardware improvements inevitably become available.
Maintenance of the Permanently Way on the Forth Bridge

Permanent Way

The Future of the Special Metre Gauge Railways

The improvement programme on the Edinburgh to Dunbar railway included the installation of a new standard-gauge track. The new track was required to cater for increased traffic volumes and to meet the needs of the railway's future development. The programme was divided into two stages. The first stage involved the installation of the new track on the through line, while the second stage involved the installation of the new track on the freight line. The new track was laid on a bed of concrete, which provided a firm and stable base for the rails. The concrete bed also provided a smooth surface for the wheels to ride on, which reduced wear and tear on the railway vehicles.

The new track was laid using a combination of mechanical and manual tools. The rails were laid in sections, which were then joined together using special mechanical clamps. The ties were also installed using mechanical tools, which allowed for a high degree of precision and accuracy. The new track was tested extensively to ensure that it met the required standards. The testing included checking the alignment of the rails, the level of the track, and the condition of the ballast.

The installation of the new track was a major undertaking, but it was completed successfully within the planned time frame. The new track provided a significant improvement in the railway's capacity and reliability, which benefited both passengers and cargo shippers.

The Future of the Special Metre Gauge Railways

The future of the special metre gauge railways is uncertain. The limited demand for the special gauge service has led to a decrease in the number of trains operating on the railway. As a result, the railway has been forced to reduce its workforce and to sell off some of its assets. The railway is currently considering options for the future of the special gauge service, including the possibility of transferring it to another operator or shutting it down altogether.

The Future of the Special Metre Gauge Railways

The special gauge service has been in operation for over 100 years, and it has played a vital role in the transportation of coal and other materials. The service has also been an important source of employment for the local community. However, the limited demand for the service has led to a decline in its profitability, which has forced the railway to consider alternatives for the future.

The Future of the Special Metre Gauge Railways

The future of the special gauge service is uncertain, but the railway is committed to exploring options for its continued operation. The railway is currently considering a range of options, including the possibility of transferring the service to another operator, selling off some of its assets, or shutting it down altogether. The railway is committed to working with the local community to ensure that the special gauge service is considered in any decision-making process.
Conversion of RN Sleepers

CVG Ferrominera Orinoco is a large iron ore mining and pelletising company based in Puerto Ordaz, which is situated on the Orinoco river in the east of Venezuela. A purpose built heavy haul railway connects the mine to the Orinoco river port.

Track and sidings extend to some 270km. The rail section is 1335mm, and is laid on concrete sleepers and held in place by an RN threaded fastening system. The single track railway transports 4tn gross tonnes per annum of high grade iron ore employing passing loops and is in constant use; three locomotives with 160 cars, grossing over 15,000 tonnes per train, 6 full and 6 empty trains per day. Axle load is 22.5 tonnes.

During a visit by Pandrol representatives, Ferrominera’s track engineers voiced concern that their trackmen needed to check and re-torque nut and bolt fastenings on a four-monthly basis, and this was leading to very high maintenance costs. The were looking for a more cost effective method to reduce maintenance.

Pandrol offered to convert a trial number of the concrete sleepers to accommodate a Pandrol fastening system. Ferrominera’s engineers supplied full details of their concrete sleeper and track conditions, which were studied by Pandrol and a conversion solution designed.

During March 1992 with the help of Ferrominera, 33 concrete sleepers were converted to the Pandrol system, using a proven method of “gelling” in cast malleable iron shoulder bolts. The existing sleeper holes, using an epoxy resin grout. On completion, the converted sleepers were placed in Ferrominera’s track at Km 12. The whole operation was completed in a few days.

After eight months and over 1.4tn gross tonnes, the performance of the Pandrol conversion was assessed with excellent results. Ferrominera also advised that to date they have experienced no problems with the converted section of track, requiring no maintenance at all. Both Ferrominera’s and Pandrol’s engineers will continue to monitor this trial.

Conversión de travesaños RN

CVG Ferrominera Orinoco estaba experimentando crecientes costos de mantenimiento en sus ferrocarril pesado destinado al transporte de mineral de hierro de sus minas. Los ingenieros de la vía en la mina expresaron su preocupación a los ingenieros de Pandrol, que ofrecieron convertir cierto número de travesaños de hormigón para llevar un sistema de fijaciones Pandrol y demostrar cómo podían reducir los costos de mantenimiento.

Estas travesaños convertidos llevan ya más de 8 meses en servicio y han soportado unos 14 millones de toneladas de mineral de hierro sin efectos perjudiciales. Los ingenieros de la vía en Ferrominera Orinoco reportan que la sección de vía convertida no ha requerido ningún mantenimiento.