High Speed Track

HST, Shinkansen, TGV, TAV, ICE - all of these are descriptions evoking thoughts of the new breed of High Speed Trains which are linking major cities at the speeds needed to compete with air travel and motorway networks. This generation of fast trains can be considered to start at the 200kph threshold and now runs up to scheduled services which have recently begun operating at 300kph on the SNCF's TGV Atlantique route. The potential for even higher speeds has been demonstrated by the 515.3kph achieved on the TGV Atlantique in May, 1999.

The very visible aspect of these High Speed operations is, of course, the trains with all the High Speed Trains incorporating some degree of streamlining, which has the dual aim of reducing the amount of air disturbance - and hence minimising power consumption and noise, and also distanciating the blur of the track passing beneath the train at high speed away from the driver's immediate field of vision.

A train, however, can only operate at speeds compatible with the track on which it runs, and track for High Speed Train operation is at present developing in several clearly defined ways.

The Track

Firstly there is the laying of totally new routes with very flat horizontal curves, typically, a minimum radius of 4,000m - but with gradients which may be as much as 3.5%. These routes use trains of essentially conventional construction although the detailing as to suspension design and reduction of unsprung weight, for example, may be very sophisticated. This approach is typified by the French TGV, the German ICE, the Spanish AVE and the Japanese Shinkansen operations.

The second approach is to use existing routes, albeit with some smoothing of alignments to permit higher speeds. This again is combined with the sophisticated design of conventional rolling stock but because of curvature limitations speeds are limited to the order of 200 - 220kph. This is typified by the British Railways InterCity 125 (now InterCity 225) and Amtrak's North East Corridor services. These routes continue to carry freight and more conventional passenger traffic and are arguably much more difficult to maintain than routes dedicated only to High Speed traffic on easier alignments.

A development of this approach to stretching the speed potential of existing routes is the use of sophisticated tilting body trains which are capable of higher speed running in curves, an approach being developed in Sweden, for example, with the X2 trains, in Italy, with the STK 450 and in Spain with the well known Talgo those developments giving the possibility of 20% speed increases in curving.

The governing factor in deciding whether new or upgraded existing routes will be used is essentially the amount of funding available for infrastructure investment. Having taken this decision, both ballasted and non-ballasted trackforms are used in High Speed operations and both trackforms have undergone a process of evolutionary, rather than revolutionary development.

Both trackforms have their protagonists as to the most appropriate use in High Speed projects, based on assessments as to the ability to preserve accurate geometry with minimal maintenance, the ability to adjust alignment or superelevation if speeds are increased and the capacity to minimise noise and vibration transmission to the environment, although it must be said that High Speed projects embodying both of these trackforms are the subject of environmental protests on the score of noise pollution.

The evolutionary approach to the provision of High Speed Track reflects the design refinement that has been achieved in the trains themselves. The result is that although the forces acting on the track would, for a given set of vehicle and track conditions, be expected to increase in direct proportion to the speed of the train, the improvements in vehicle design - particularly the reduction in unsprung weight - and improvement in track geometry - particularly control of longer wavelength irregularities - mean that the forces applied in practice are not appreciably greater than those already met with in more conventional operations. It is, in fact, arguable that current mixed traffic and Heavy Haul operations generate much greater quasi-static forces and that the generation of higher frequency forces is minimised by the higher standards of maintenance applied to track geometry and railwheel surface condition in High Speed Track.

High Speed Track

The “VORTOK” Coil

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Ballasted Track

Ballasted and twin-block concrete sleepers are both used in ballasted construction for High Speed tracks. Twin-block sleepers are used to both the use of a resilient pad between rail and sleeper to minimise the transmission of impact forces to sleeper and ballast. The rail fastening clip must be compatible with this rail and not require such rails with a minimum effect on clip toe-load. If stiffer clip characteristics are used, this will need to be considered in the design of the sleeper system.

Ballasted track is efficient as a sound and ground borne vibration dumper, but at the highest current speeds it is reported as being problems of ballast particle deposition on the rail head after the passage of High Speed Trains, which can then require rail grinding to correct the rail running surface.

Non-Ballasted Track

In the case of non-ballasted track a common basic criterion is that the system is expected at least to replicate the rail deflection to be expected in ballasted track. In the PACT system of continuously supported rail on a slintoned pearled concrete track, the resilient support to the rail is normally provided by a single layer of elastomer between rail and concrete, giving a very simple and economical rail fastening arrangement. The rail pad is designed to deflect the railhead by 0.1-1.5 mm. A single layer of rail is also used on tangent and flat curves on the Shinkansen system of prefabricated slabs, although in this case the rail pad is double, not continuous.

If a continuous dynamic deflection of more than the 1.0 - 1.5 mm is obtained from a single

fastener is considered necessary it is most commonly provided by the use of baseplates, which can incorporate two layers of elastomer, one between rail and sleeper and the other between plate and concrete.

This system is used extensively in the Shinkansen in curves and in the high speed track and track geometry, site and modelling work carried out by Pandrol and others show that frequently used ballast seat loads of 4 - 5 tons can be expected from High Speed Track Design with typical axle loads of 17 - 18 tons.

High frequency dynamic forces are generated by wheel and rail running surface imperfections and a high standard of maintenance is required to minimise vibration and impact. The system is designed to achieve and maintain a system with two layers of resilience. This has not yet been done on any extensive level on High Speed Rail.

Rail Fastenings

Considering in more detail the specific role of rail fastenings in High Speed Track it is obvious that they have the properties required for satisfactory performance in more conventional types of operation, namely:-

- Hold the rails to gauge and maintain its position
- Resist rail creep
- Prevent damage to the sleeper by vibration, impact and abrasion
- Either last the life of the sleeper or individual components be economically replaceable
- Permit track circuiting
- Maintain characteristics after being re-applied several times
- Be designed to avoid day-to-day maintenance
- Be easily and economically incorporated in the design of concrete sleepers or slabs
- Be easy to install economically including installation by machine
- Be resistant to unauthorised removal

For cost effective when considered over the whole life of the track.

PANDRIL, a joint venture of various companies, including including machine and track testing, has designed a track specifically for High Speed Track. The C100 high speed track, which has been tested and only practical in terms of the speed of the test required to apply loads to this high frequency to a single fastener. The assembly can be combined with a lateral force to represent running conditions and track loads can be determined in terms of maximum vertical and lateral loads of 60 kN.

Lateral Forces

Lateral forces experienced in High Speed tracks can be compared to new, dedicated routes on well maintained alignments are related primarily to the track geometry, which are normally relaxed to about 30 - 40 kN on the rail head, as compared to 5 - 10 kN on the rail used in the C100 high speed track.

The new program of laboratory testing and site experience has shown that the cast in shoulder of the rail system provides a completely adequate track against such gauge spreading.

High Speed tests in inclined dynamic load rig.

Continuous support on a slintoned pearled concrete track.
The Development of an Automatic Pandrol Rail Fastening Installation Machine by Banverket Sweden

By Göte Persson, Trackwork Manager, Banverket

The vehicle is 18 metres (59 feet) long and has a total gross weight of 40 Tonnes (39.4 UK Tons) prior to commencement of a typical 1,440 metre (0.9 mile) length of track construction.

Propulsion at the work site is via a hydraulically powered drive bogie that can be reduced under the main vehicle chassis when not required.

There are units for presenting the two rails at the desired track gauge and for the brushing of the rails to remove any loose materials such as ballast.

The concrete sleepers can be centralised under the gauged rails in order to present a uniform gap between rail and shoulders for application of the four insulators.

The location of the insulators and the pre-installed clips have to date been undertaken manually. However, the mechanisms required to carry out this work and also to lift low sleepers have been developed and will be evaluated during the 1991 work season.

It is anticipated that following on from the initial success of the 1990 track trial, the final evaluation to be carried out during 1991 will present a machine for general usage from 1992 onwards combining all the features that were originally envisaged for this unique, but yet important unit within Banverket’s fully automated track construction concept.
Development of the Pandrol Jackson Clip Applicator

By Mark Hardy, Director Research and Standards, CSX Transportation

C.L. (Mark) Hardy, Director Research and Standards for the Engineering Department of CSX Transportation, is a graduate of West Virginia University, with a degree in Civil Engineering, where today he works closely with the Constructed Facilities Centre on the testing and development of track components.

Mr Hardy is a member of the AREA Committee on Ties and Wood Preservation, the AAR Ad hoc committees on concrete ties and cost effective turnouts, the Railway Tie Association and Roadmasters and Maintenance of Way Association.

Predecessor railroads of CSX Transportation have been installing concrete ties in limited numbers for over twenty years. Since most of the projects had been considered tests, there was little concern for high production techniques normally associated with programs where long lots of concrete ties replace wood ties.

In the fall of 1989, CSX accomplished its most significant concrete tie project by using the P81S concept of track renewal method to renew wood ties with concrete ties on a twenty mile segment of track. Since this first venture was a success, plans were made to double the number of concrete ties for 1989 on CSX. About the same time on the Union Pacific Railroad, plans for a similar program led to the building of a new P81S tie to be shared by both roads.

The high production capabilities of the P81S prompted a close look at the entire tie laying operation. During 1988 most attention was directed toward getting comfortable with the track laying machine: while in 1989 both CSX and UP focused on more mechanization of the entire process, with particular attention on Pandrol clip application.

The railroads' interest in this phase of the operation was shared by Pandrol Incorporated which led to the first meeting held on August 1st, 1989 in Cincinnati, Ohio. This meeting had a prime agenda to discuss the necessity, feasibility and basic design of a Pandrol clip setter-applicator. Jackson Jordan, predecessor of Pandrol Jackson, was invited to join representatives from CSX, Pandrol Incorporated and Union Pacific via conference call in this applicator concept meeting. Some basic criteria was established for the machine design which included:

- Auto-feed and installation of four clips
- Minimum production rate of 10 to 12 ties per minute
- Travel speed of 25 MPH
- No tie nipper, but design to allow for future application

A target delivery date was set for the April 1990 start-up of the CSX concrete tie program. It was agreed that Jackson Jordan would take this information and develop a conceptual plan to be presented to CSX and UP at a meeting in Toronto on August 29th, 1989. The plan would include estimated cost, size, weight and delivery schedule. At the conclusion of the meeting the railroads Pandrol Incorporated and Jackson Jordan had a good understanding to what was expected of the machine which enabled Jackson to return to Ludington to start building the prototype.

In the months that followed, CSX Transportation, Union Pacific, Pandrol Incorporated and now Pandrol Jackson communicated on the development of the machine. A significant meeting was held in Ludington, Michigan on January 23rd, 1990 during which the clip applicator head was successfully put through the phases of installing clean clips and dirty clips on concrete or wood ties. Since it was felt that along the head was the most complicated part of the machine, it looked like we were on the downhill side of the development process.

During the remainder of the winter and into the spring of 1990 the two railroads and Pandrol Incorporated kept in close touch with Pandrol Jackson on the progress of the machine. Like any product that is new and worthwhile, some problems were encountered which resulted in minor delays. By late May, the CSX lowboy picked the equipment up at Ludington and transported it to where the P81S was installing concrete ties on mountainous terrain in western Kentucky. As would be expected, the clip applicator required adjustment and some modifications. Since the concrete tie project is a high production operation and track time was limited due to traffic volume, only short intervals could be allotted to debug the equipment. This process continued on CSX until the end of June after which the machine moved to Union Pacific for further refinement. During the debugging period, certain modification needs became apparent. Work was required to prevent clips from hanging up in the chute between the top loading area and the head, it was also found necessary to drive both axles in order to prevent wheel slip.

To suit the winter modifications to the prototype, Union Pacific shipped a car of reject concrete ties to Ludington so a longer test track could be built at the plant.

The purpose of the machine was to eliminate the need for distribution and hand setting of the Pandrol clip while keeping up with the P81S. During the 1990 fall budget sessions, the question of whether the machine was ready to go so we could eliminate the twelve people needed to manually distribute and set the clips became very important. Pandrol Jackson assured us the machine would do the job and would be ready for the March 4th 1991 start up of our concrete tie program. With confidence that our goal with the new machine had been met, we reduced the complement of people by 12 in the labour force and arranged to lease the clip applicator from Pandrol Jackson for the 1991 program.

In late February, the CSX lowboy picked up the applicator and delivered it to western Virginia to be in place for the start of the project. As the concrete ties were placed by the P81S, CSX, Pandrol Jackson and Pandrol Incorporated people waited anxiously to see if the clip applicator would in reality do what started as a concept in Cincinnati, Ohio nineteen months earlier. To everyone's relief, the answer was yes. After a few adjustments, the machine followed along behind the track laying machine, setting and installing Pandrol clips like a measured piece of equipment. Certainly, the availability of a machine to install clips without the necessity of a large group to set clips is a fine accomplishment. However, the real success story lies in the spirit of cooperation where two railroads, CSX Transportation and Union Pacific, communicated their needs with a supplier, Pandrol Incorporated, and an equipment manufacturer, Pandrol Jackson, resulting in a machine for railway use worldwide.
Track Animation

Although railways have found an important part of the world's transport system for over 150 years, many aspects of the track's behaviour under traffic are not fully understood, and new problems are emerging all the time. Railways. These new operating conditions are putting new and! greater demands on the track structure. To ensure that track components can withstand these demands it is important to be able to measure how they behave as the trains pass over them, and when new track components are developed, although they can be subjected to rigorous test programs in the laboratory, the final test of their effectiveness is to measure performance at actual train speeds. Scanning of track is necessary both to provide basic data for the design process and to prove the suitability of new components in track.

Testing on railway tracks has its own special problems. Instruments often have to operate under very hot or very cold weather, with only rudimentary protection from rain and snow. The environment is close to the track where amplifiers and recording equipment are positioned is often very noisy due to the moving trains. On the other hand, where the transducers must be set up, there can be even dirtier - there are oil spills from locomotives, the cargo drops off freight wagons, and even worse things are flushed out from the passenger trains. Often the only power supply available is from a small portable generator. And finally there can be a great deal of electromagnetic interference due to the presence of electrical components and the generator on the locomotives or from overhead power lines. All of these test equipment used must be capable of performing reliably in such an environment.

One step in the data has been collected. It must be stored systematically and analyzed quickly. This can be a significant problem, since many high sec tests generate large volumes of raw data - particularly those on high speed track, where dynamic behaviour is important and many thousands of measurements are needed every second. For example, a single test on high speed track might generate enough data to fill 100,000 pages of print.

Over the last few years Padrond's Research and Development Unit has only used these facilities to produce scientific reports for customers, and of course these remain very important. But remembering that the aim of many tests is to increase our understanding of track behaviour, or to demonstrate the effectiveness of new components, the system has now also been used to display the data collected on track in an interesting and informative way. A diagram is drawn on the computer screen showing each track component measured in its normal and deflected positions. The next positions, a few fractions of a second later, are then quickly calculated and the screen is re-drawn. The recalculating and redrawing cycle is repeated over and over again, giving the observer a nearly correct view of the track movements which occur as the train passes. The movement is slowed down and scaled as required, so that the track's behaviour can be studied in great detail. A drawing of the train moves slowly across the screen while the score is displayed, so that the deflections at any instant can be accurately correlated to the positions of the rail wheels.

The track movement animation gives a striking demonstration of the track's behaviour under traffic, which is immediately understandable not only to railway engineers who are used to studying scientific reports, but also to people with no scientific background. The images can be transferred from the computer to video tape, so that anyone with access to a video recorder can now see how their track moves. The system should prove a great benefit to railways.

Résumé des Articles

1 Voies à grande vitesse

Comme dans plusieurs pays il est devenu banal de voyager en trains à une vitesse supérieure à 300 km et que plusieurs grands projets sont à l'étude pour accélérer les trains pour des vitesse de 300 à 400 km. Le grand débat dans la voie de la voie à grande vitesse est remis, et le nouvel outil de l'Arthemis permet de visualiser le mécanisme des mouvements de la voie. Le schéma est basé sur l'observation directe de l'Arthemis et les performances sont calculées. Le schéma sur l'Arthenis est réduit à une séquence de vues avec une séquence en un compte et de définition. Les positions successives sont calculées, et le schéma sur l'Arthenis est redimensionné, et les définitions sont de telle sorte que n'importe quel moment de l'animation permet de visualiser l'évolution des mouvements de la voie dans une perspective circulaire avec les positions des trains du train. Les images peuvent être passées sur vidéo pour permettre une diffusion à un plus grand public.

2 Machines de fixation pour attacher Padrond mises au point par Barnerkert pour Les chevilles de fer sud-européen et Padrond fabriquant pour les Chemins de fer CSF et UP aux Etats-Unis

Le besoin de réduire les temps de main-d'œuvre par où cela est possible entraîne une mécanisation accrue des opérations de placement des attaches Padrond et de leurs éléments annexes. En Juin, Barnerkert met au point une solution intégrant le pilote de la vitesse de 195 km/h et qui utilise 3 opérateurs. Les images montrent que la machine RBF-001 a parfaitement rempli son rôle de placement des attaches Padrond et de leur automatisation complétée est envisagée pour 1992.

3 Attaches élastiques pour les chevilles de fer de plantations et chemins de fer industriels légère à voies étroites

Par Robert James de L Australian Sugar Research Institute

La production de canne à sucre et l'amélioration du sucre ont des performances de taux de poudre de remplacement pour lesichi de brique et de réduction de l'utilisation de l'eau. Les essais réalisés en Australie ont montré que l'utilisation de l'épandage de l'eau et la production industrielle de ces travaux pour les sucreries australiennes a démarré en 1989.
Zusammenfassung der Artikel

1 Hochgeschwindigkeitsstrecke

2 Pendolino-Clip-Installationsmaschinen
Die Maschine ermöglicht die effiziente Montage von Pendolino-Clips. Sie ist eine vielseitige Maschine, die sowohl zur Montage von Pendolino-Clips als auch zur Montage von anderen Bauwerken verwendet werden kann. Die Maschine ist in der Lage, eine hohe Produktivität zu erreichen und somit den Bedarf an Menschen zu reduzieren, die an der Montage von Pendolino-Clips beteiligt sind.

3 Vorkurbel für die Schweizer Staatsbahnen
Die Vorkurbel ist eine aufwendige Entwicklung, die die Effizienz der Pendolino-Clips erhöht. Sie ermöglicht eine genauere Abstimmung der Pendolino-Clips und reduziert somit die Gefahr von Unfällen im Verkehr.

4 Laborsimulation gemesserter Schienenverhältnisse

5 Vorkurbel für Bahnsteige
Die Vorkurbel ist eine innovative Entwicklung, die die Sicherheit der Pendolino-Clips erhöht. Sie ermöglicht eine genauere Abstimmung der Pendolino-Clips und reduziert somit die Gefahr von Unfällen im Verkehr.

6 Pendolino Jackson's neue Schleimacht mit acht Köpfen für den Vancouver SkyTrain
se consiguió la plena automáticaización para 1992.

En Norteamérica CSX Transportation y Union Pacific han hecho un examen de su operación de colocación de traviesas y han iniciado un proyecto en colaboración con Pandrol Incorporated y Pandrol Jackson para desarrollar una máquina que pueda colocar e instalar automáticamente los cuatro clips Pandrol por traviesa a una velocidad mínima de 10 traviesas por minuto y desplazarse entre lugares de trabajo a 25 millas por hora.

La máquina de Instalación de clips de Pandrol Jackson, que ya están en su segundo año de utilización, acaba de terminar un programa de trabajo en CSX y ya se ha ensayado exitosamente en Amtrak.

Estos dos máquinas, desarrolladas con el propósito de reducir el coste total instalado de la sujeción de los carriles, están a la cabeza del movimiento hacia la instalación completamente mecanizada de los clips de sujeción Pandrol, proceso que se verá acelerado por perfeccionamientos que se están introduciendo ahora en el propio clip.

3. Animación de la vía
El uso de Pandrol por los equipos de más reciente concepción nos permite presentar visualmente de una interesante forma nuevas mediciones de la flexión que sufren los componentes de la vía al pasar los trenes. En la pantalla del ordenador se traza un dibujo que muestra cada componente en sus formas normal y flexada. Se calculan las posiciones siguientes y la pantalla vuelve a producir rápidamente el dibujo, dando al observador una vista animada de los movimientos de la vía al pasar el tren por encima. El movimiento puede reproducirse de forma más lenta y aumentarse o reducirse en escala según se desee. Un dibujo del tren se desplaza despacio por la pantalla mientras se visualiza la secuencia, de manera que las deformaciones que se producen en cualquier instante pueden correlacionarse con las posiciones de las raíces del tren. Las imágenes pueden transferirse a cinta de vídeo para una distribución más amplia.

4. Simulación en laboratorio de las condiciones medidas en la vía
Para hacer que los ensayos de componentes en el laboratorio sean más representativos de las condiciones verdaderas que se dan en el tráfico real se han empleado datos de ensayos en la vía como base para modificar los procedimientos corrientes de laboratorio. En muchos casos se ha hallado que el extensamente utilizado "ensayo dinámico inclinado" da lugar a excesivo balanceo del carril pero insuficiente movimiento lateral del mismo en comparación con las condiciones reales de la vía, y esto puede hacer que la prueba no sea de confianza cuando se trata de predecir la durabilidad de un conjunto nuevo. Algunos cambios pequeños de la configuración de las cargas pueden mejorar bastante estas predicciones.

5. Sujeciones elásticas para ferrocarriles ligeros de plantaciones e industriales

Por Robert James, Sugar Research Institute de Australia

Debido a los aumentos de los tonelajes y de las velocidades y largos de los trenes, la industria australiana de la caña de azúcar necesita una forma de sujeción elástica de la vía para sustituir sus medios de sujeción anteriores.

Pandrol Australia, junto con el Sugar Research Institute y Austrak Pty. Ltd., ha colaborado para desarrollar un sistema completamente nuevo de traviesas de hormigón y elementos de sujeción basado en el clip y el alojamiento de peso ligero tipo "E" 1200 utilizado en las minas suelodóminas. En 1986 comenzaron las pruebas en servicio de traviesas que incorporaban un alojamiento galvanizado de acero dulce colado que admite clips de sujeción Pandrol de ambos tipos "E" 1200 y "E" 1400, y para 1988 este sistema ya estaba en producción en plena escala para tráficos australianos.

Además, se ha introducido el clip Pandrol tipo "E" serie 1600 y alojamiento soldable para puntos de apartadero sobre placas de asiento de acero, que permiten prefabricar los puntos de apartadero en el lugar de fabricación, con lo que se logran bastantes economías de mano de obra.

6. Nueva amoladora de ocho maclas de Pandrol Jackson para el SkyTrain de Vancouver

Pandrol Jackson ha concebido una amoladora de carriles de ocho maclas para el sistema SkyTrain de Vancouver.

Además de satisfacer los requisitos especiales del sistema de tránsito rápido ligero avanzado, la nueva máquina necesitaba poder amolar curvas de un radio de 115 (39 metros), lo que requería un diseño especial de ejes orientables.

Puesto que los trabajos en la vía tenían que realizarse entre las 01:15 y 05:15 horas en una zona residencial, la máquina necesitaba contar con medios para la máxima reducción del ruido, y se han conseguido niveles de ruido de 72 dBa.

7. El Espíritu "Vortok"

De vez en cuando surge una idea que es tan sencilla que no es posible imaginarlo por qué no se le ha ocurrido a nadie antes.

El suplemento espíritu "Vortok" parace ser un invento de ese tipo, concebido para ayudar a los ferrocarrileros preocupados por los costes a prolongar la vida de sus traviesas de madera. El alojamiento de los tirafondos es un problema universal, muchos traviesas se cambian por nuevas prematuramente porque tienen desgastados los agujeros en los que se ponen los tirafondos. Un procedimiento sencillo y eficaz de rehabilitar esos agujeros desgastados es una cosa que encuentra inmediatamente buena acogida.

No es de extrañar que este dispositivo, que se instala rápido y fácilmente sin perturbar placas de gypse ni traviesas, esté encontrando aceptación tan rápidamente incluso entre los ferrocarriles en los que ya se emplean extensamente traviesas de hormigón.

SNCB. Comparative tests of rail pads on twin-block sleepers between Bruges and Gent; on the mainline from Brussels to Ostend.
In almost all fields of engineering, and certainly in the railway industry, there is a need to test new designs to ensure, before they enter service, that they will survive the conditions in which they will eventually be expected to operate. This means that some method must be found to simulate the whole service life within a very much shortened timescale, so that any weaknesses in the design show up at the earliest possible stage. For rail fastenings, the most common forms of test involve assembling a short length of rail on half a sleeper, and applying a load repeatedly to the rail head (Fig. 1). The load will have both vertical and lateral components to represent the weight of the train, and lateral forces on curved track, respectively. Typically, the load is applied four or five times per second for a total of about 3 million times, and the condition of the fastening components is examined during and after the test. In order to obtain results in the shortest possible time, and to obtain the best possible utilisation of expensive test facilities, the loads applied are somewhat higher than those expected in track, but the total number of load applications is somewhat lower than the number expected in the components’ service life. The tests are also run continuously, with a pause in loading “between trains”. The results of such tests have been used to predict the durability of rail fastening assemblies quite successfully for many years, but recently a number of problems have become apparent. Mostly, these relate to fastening assemblies for concrete sleepers, or slab tracks, which incorporate plastic or elastomeric parts which carry significant loads. Such components can fail in the standard laboratory tests in ways which are never observed in track. At the same time, modes of failure which are observed under severe conditions in track are never observed in the laboratory test.

Pendrell International decided to try to improve the test method by making direct measurements of real track behaviour, under traffic, in a wide range of different conditions, and then trying to reproduce these measured conditions in the laboratory. To date these have included measurements for train speeds up to 225 kph, axle loads up to 50 tonnes, curve radii down to 18 metres, track gauges from 1067 mm to 1222 mm. A number of different track parameters have been studied, but the most useful in terms of setting up laboratory tests has proved to be the measurement of displacement of the rail, relative to the sleeper. This displacement is measured using non-contacting optical transducers ( Pendrell Electronic Displacement Measuring System). Vertical displacements are usually measured on the field and gauge side of the rail foot, and lateral rail foot displacements are also recorded. From these it is possible to deduce the vertical, lateral and rolling movements of the rail within the fastening system as each wheel passes.

Returning to the laboratory test, there is now a new problem: we have measured three independent parameters on the track, which we wish to reproduce in the laboratory test, but there are only two factors, which can be adjusted: the vertical load and the lateral load. Neither common sense nor mathematics will allow us to solve that problem without introducing an additional controlling factor. In this case, the most promising approach was to adjust the “rollerover moment” as well as the two components of load, and that is most easily achieved by adjusting the height above the rail foot at which the lateral load is applied (Fig. 2). By trying to simulate measured track conditions this technique was tried by applying four different combinations of vertical load, lateral load and rollerover moment to three different standard concrete sleeper rail fastening assemblies. From these tests we were able to come to some important conclusions about the effect of rollerover load on the vertical load and rollerover moment.

- The vertical displacement at the rail centre line depends primarily on the rail pad stiffness, and is not significantly affected by the amount of lateral load or rollerover moment.
- The lateral displacement of the rail foot depends on the rail pad (shear) stiffness and on the insulator design, and is not significantly affected by the vertical load or rollerover moment.
- The rolling displacement of the rail depends on the rail pad stiffness and on the vertical load (including the clip toe load), but is not significantly affected by pure lateral displacement at the rail foot, or rail lateral stiffness.

Once these points had become clear, it became possible to simplify some of the test procedure by the laboratory test loads could be estimated from track displacement measurements. The test rig design was brought about full circle, so that it could be operated in exactly the same way as the standard inclined test, with the one important exception that the load was not necessarily applied at the gauge corner of the rail (Fig. 3). Tests carried out so far have indicated that this small modification to the test procedure does indeed make the test much more representative of true track conditions and thus provides a much more reliable means of assessing the durability of new designs before they enter service.

One obvious criticism of this test method is that at first sight it appears to be less, not more, representative of track conditions because the load is no longer applied at the point where in real life the rail contacts the rail. However, it must be recognised that in that same “real life” the rail is likely to be very long, and to be supported over a large number of rail fastening assemblies. The single actuator applying the load to the laboratory test is not simply representing the wheel load on the rail, but is representing a combination of that loading, and the reaction forces and moments that would normally be supplied along the rail (Fig. 4). As the vertical, lateral and rollerover components of load are all distributed along the rail differently, the relative magnitudes of the vertical load, lateral load and rollerover moment at the rail fastening will be quite different from those at the rail head. This modified test will certainly not generate representative stresses in the rail, but it does provide a more realistic test for the fastening system.

As our experience of using this test technique increases, a number of interesting trends in the results are becoming apparent. In almost all cases, it has been found that standard test loads apply excessively high vertical loads, and rollerover moments, but at the same time apply lateral loads which are significantly lower than those which can occur on sharp curves. This means that if the loads are severe enough, component failures will eventually occur in the standard laboratory test as a result of the rail rolling moment - for example the field side edge of the rail foot may cut a groove in the rail pad - whereas the critical factor which determines the assembly life in track will be controlled by the purely lateral movement - it may be abrasion over the whole rail pad surface, or compression of the insulator. The modified test technique is possible to correct this. Without running into the common problem of the test assembly becoming unstable when the ratio of lateral to vertical loads (“LV ratio”) exceeds about 0.5. The modified test has been run successfully with LV of about 1, but with the load applied close to the rail foot.

Another interesting result is that no measured track condition has yet been found which would justify the application of “spring uplift” forces to the kind required in some standard test procedures. Although upward displacements may be measured, the stiffness of most fastenings systems in the upward direction is so low that it is effectively zero, and these movements only indicate very small upward forces.

No laboratory test can ever simulate completely the conditions seen by rail fastening components in track. Proper simulation of high frequency and impact loads, temperature effects and the results of water and debris on the track will never be a practicable proposition. However, some improvements can be made whilst keeping test methods relatively simple.
Resilient Fastenings for Plantation and Industrial Light Gauge Railways

By Robert James, Dip. M.E.E., Senior Railway Engineer, Sugar Research Institute, Australia.

Robert James is a Senior Railway Engineer at the Sugar Research Institute, McKay, Queensland, Australia, and has 25 years experience in mechanical and civil engineering operations of cane railways.

The Australian sugar growing areas extend along some 2000 kilometres of the north-eastern coastline from Mossman in North Queensland to Grafton in the northern part of New South Wales. During the harvest season, which lasts from June to December, about 25 million tonnes of sugar cane are crushed by 29 individual raw sugar mills. Twenty four of these mills own and operate their own private railway systems. These systems transport about 23.5 million tonnes (about 210 x 10^6 tonne-km) of cane per annum over 3,500 route kilometres of 610 millimetre gauge track in a period of less than 26 weeks. A total of 250 diesel hydraulic locomotives of up to 40 tonnes with powers up to 500 kilowatts are used. Rolling stock used has a load capacity of from four to ten tonnes. Almost 50,000 four-wheeled vehicles and a limited number of bogey vehicles are used.

When the Australian sugar industry was established late last century sugar cane was manually cut and loaded onto flat topped four wheel wagons of about two tonne capacity. These wagons were then hauled (often by horse teams) along portable railway track from the field to the main line where they were hauled to the mill by steam locomotives. This system served the industry well until the 1950's when diesel-hydraulic locomotives were introduced and mechanical harvesting of the cane led to the eventual elimination of portable track. In the ten years from 1966, tracks were extended into new growing areas and train speeds increased. Except for the introduction of prestressed concrete sleepers and an increase in rail size from 20kg/m to 30kg/m in the early 1970's, the track structure remained substantially unchanged.

A typical cane plantations railway train in operation at CSR's Plain Creek Mill.

CTF2 was part of this group. The lack of fastener elasticity was not detrimental to either the sleeper or its performance in track until about 1982 when, as tonnages hauled, train speeds and lengths continued to increase. It became evident that both the sleeper and fastening system were inadequate for the increased duty.

Failures occurred for two reasons. Firstly the 120mm x 43kg concrete sleeper was found to be too small for the higher duty resulting from increasing speed and tonnages carried. The comparatively small sleeper and hence low track modulus led to rapid deterioration of track geometry thus increasing the derailment potential of the four wheel unsprung unbraked wagons as well as increasing the maintenance task.

The second effect was failure of the fastening. At that time most canefield locomotives were rigid framed 6-6-6 designs which have a large reversing gearbox behind one buffer plate, the buffer plate at the end of the locomotive being increased in thickness to compensate for the gear box mass. As speeds increase the lateral (flanging) forces generated by these locomotives on the head of the rail also increase. The absence of any significant fastener toe load allowed the rails to rotate about the field side foot under the influence of the lateral forces. At some locations, particularly on the high rail of small radius curves (<150m), the forces were big enough to permanently deform the heads of the fastening which in turn led to loss of gauge and ultimately vehicle derailment. At that time (1982) future planning also suggested that axle loads would increase to 12 tonne during the next 10-15 years. In the period between July 1990 and June 1991 six forty-tonne four-axle locomotives have entered service.

To meet this need, Pandrol Australia in conjunction with the Sugar Research Institute and Austral Pty Ltd co-operated to develop a completely new concrete sleeper and fastening system. The fastening system was based on the light duty 'e' 1200 series clip and shoulder used in South African Mines. In-service trials of sleepers and fastening systems commenced in 1986, and full scale production for Australian sugar mills was in place by 1989.

The cast-in mild steel galvanised should can accept both type 'e' 1200 and type 'e' 1400 series clips, each providing nominal toe loads of 46N and 58N respectively. Because pads have never been used in cane railways, the new system also does not employ pads. The live axle loads combined with low track speeds (by comparison with larger gauge Australian government and other private railway systems) produce comparatively low rail to sleeper impact loads. Consequently there has been no evidence of rail seat cracking or erosion at mills even where several eight tonne axle load locomotives have been in service for up to thirteen years. Should either phenomenon develop in the future, the new system has been designed so that the pads can be fitted together with a modified clip. Furthermore since sugar cane is a robust product which does not need careful handling to avoid mechanical damage and because no passengers are carried on cane railways there is no incentive to increase ride quality. Therefore pads will only be provided in plain track if future duty shows their necessity. About 154,000 sleepers have now been placed in track.

Like most rail systems, cane railways cross highways and principal roads. At most of these crossings, flashing signals actuated by track circuits are used to warn motorists of approaching trains in a similar way to road/rail crossings worldwide. The previously used concrete sleepers and fastenings were unsuited for use with pads and insulators where track circuits were required and timber sleepers had to be used. However, by increasing the distance between cast-iron sleepers and the railhead, it has been possible to adopt the assembly for insulated track in a similar way to international practice. Pads and insulators have been developed to suit rails having foot widths of either 101.6 or 108.0 millimetres. The 'e' 1400 clip used with these assemblies provides a nominal toe load of 46N.

A further development, quite separate from the sleepers and 'e' 1200 series described above, has been the use of Pandrol type 'e' 1600 series clip and weld-on shoulder for gauge turnouts on steel bearers. The very narrow gauge (610mm) allows turnouts to be prefabricated at the point of manufacture and transported fully assembled to the field where waiting cranes place the assembly in track. By adopting this method, new sugar factories effect considerable labour savings and are able to replace worn or damaged components easily and quickly. Modifications have been made to turnout components such as chair plates to permit the fitting of insulating ferrules to hold down bolts for switch chair. Type 'e' 1600 series clips, pads and insulators are used where turnouts are located within track circumscribed areas at the approaches to road/rail level crossings.
Pandrol Jackson’s New Eight Stone Grinder for Vancouver SkyTrain

The Vancouver Rapid Transit System (SkyTrain) opened in 1986 and operates over 15.5 miles (25km) of double track, hence a total of 50km of track. The system currently carries 110,000 passengers per day, many of these being commuters to and from the downtown core area. The system is an ALRT (Advanced Light Rapid Transit) and is a completely automated driverless operation.

The need for a rail grinder was identified by the SkyTrain engineers in order to maintain an adequate surface finish and profile at the rail head. SkyTrain uses steerable axles enabling it to negotiate tighter curves than other transit systems, and correct rail head profile is essential in ensuring the trucks optimum performance. This also helps to maintain low noise levels on what is already one of North America’s quietest transit systems.

In August of 1990, Pandrol Jackson was awarded a contract to supply an eight-stone rail grinding machine for the SkyTrain system. The specifications called for a production switch rail grinder with a completely computerized system for controlling all grinding operations.

Since the standard Pandrol Jackson grinding machine design was a larger twenty grinding head machine, a completely new design was required to meet the needs of SkyTrain. Several meetings between Pandrol Jackson and SkyTrain engineers resulted in a new design with several features that were necessary to meet the demanding requirements of the SkyTrain system.

One of these requirements was that the machine had to grind on curves with a radius of 150 ft (50m). This requirement has a major impact on the design of the running gear. A special steerable axle design was incorporated to negotiate these curves.

The SkyTrain system is a high capacity Light Rail Transit System. It currently uses cars 41ft (12.7m) in length. 8 ft (2.5m) wide, with capacity for 75 passengers each. Plans are in place for larger cars 16.85m long which can carry up to 145 passengers. Cars are permanently joined together in pairs and are equipped with linear induction motors and steerable axle trucks with 18 inch wheels. Another special requirement was that the grinder must be able to tow two of the transit cars (with a combined weight of 56,000lbs) up a 6.5% grade. This was accomplished with a specially designed hydraulic motor/pump combination and the standard Pandrol Jackson trans-axle drive.

The grinding operation on the SkyTrain machines will operate at speeds from 1 to 8 mph (1.6 to 13kph). Metal removal capacity is 0.003 inches in depth in one pass at a speed of 1mph. The grinding speed is computer controlled to within plus or minus 0.25mph regardless of track grade.

Service on SkyTrain operates 20 hours per day on weekdays, from 05:15 to the following morning at 01:15. This leaves only very early morning hours for rail grinding work. Since much of the track is adjacent to residential areas, noise generated by the machine could be a problem, particularly as normal SkyTrain service has set a very quiet standard. This led to a very stringent noise specification on the machine, which resulted in the use of the most extensive noise reduction materials on any machine in Pandrol Jackson’s history. Sound levels of 72 dBA have been achieved and are well below the specification limits set by SkyTrain.

Maintenance of the already low system noise level will be made easier as a result of the rail profiling and corrugation removal capabilities of the machine. On a similar machine sold to the San Francisco BART system in 1990, grinding practices have resulted in noise reductions of 10-12 decibels.

After performance testing at the Pandrol Jackson plant, the machine was delivered to the Vancouver BC Transit System in August 1991 and is now in service. This new state of the art rail grinder is consistent with SkyTrain’s commitment to maintain its system at the leading edge of technology as the quietest and most efficient high capacity light rail system on the continent.
The "VORTOK" Coil

By R.F. Morton, Technical Director, Multiclip Company Limited.

Despite the increasing use of concrete and steel sleepers in track laying schemes, a very large number of timber sleepers remain in service, and a major problem is to keep them in good repair for the duration of their potential lives.

Although a number of factors, both mechanical and biological, effect their life span, in general terms soft, medium and hard-wood groups last 12, 24 and 45 years on average. Elongation of screwspike holes is a major source of difficulty as it causes gauge widening which requires refilling of the sleepers and repositioning of the plate or, in some instances, replacement of the sleeper to correct it.

The "Vortok" coil has gained rapid acceptance by Permanent Way engineers in many parts of the world because it solves the problem of the elongated hole and maximises the life of timber sleepers. It has a unique design and is very simple to install.

Design Features
Manufactured from specially selected robust but ductile aluminium. It is light, non-corrosive and electrolytically compatible with steel. The coil shape gives all the advantages of the original screwspike, in effect expanding the external diameter of the screwspike's thread. It grips the wood over its total length (approximately 500mm). The arrow head section enables the coil to embed itself into the wall of the hole as the screw is re-installed, stretching the coil to its final shape. Since it cuts into fresh timber, it does not create compressive forces which could cause new or enlarge existing cracks.

Strength Characteristics
1. Pull out force: Up to 97% recovery rate (compared with new wood)
2. Stripping Torque: Up to 84% recovery rate (compared with new wood)
3. Example: 50KN pull out force on 22 year screw killed oak sleeper with coil fitted.

Timing of Use
As elongation takes place at an accelerating rate once wear sets in, best advantage is gained by coil installation at the optimum stage in the sleeper's life. This is determined with experience of the conditions on each railway and periodic checks of the screws by the Permanent Way staff. The table below gives an idea of what can be expected.

Method of Insertion
1. Remove screwspike and washer if used
2. Check hole using gauge
3. Insert coil using insertion tool
4. Remove insertion tool
5. Replace screwspike and washer if used

<table>
<thead>
<tr>
<th>Wood</th>
<th>Sleeper Life</th>
<th>Screw Hole Life</th>
<th>Year of Repair</th>
<th>Repair</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td>12 years</td>
<td>8+2 years</td>
<td>8</td>
<td>Spot</td>
<td>A few of the worst holes will respond until replacement</td>
</tr>
<tr>
<td>Medium</td>
<td>24 years</td>
<td>12</td>
<td>12</td>
<td>Block</td>
<td>All holes in a section repaired based on statistical sampling</td>
</tr>
<tr>
<td>Hard</td>
<td>45 years</td>
<td>15</td>
<td>15 &amp; 30</td>
<td>Block</td>
<td>As above, but second repair needed. Original coil does not require removal at second repair</td>
</tr>
</tbody>
</table>

Concrete Beam Turnout on the Ferrocarriles Nacionales de Mexico.