Innovative application of rail fastenings for HS2

This article was first published in Railway Gazette International in May 2018.

AUTHOR:

Steve Cox
Technical Director
PANDROL

High speed tracks around the world have been built with ballasted and non-ballasted track forms. Both are proven and can work well, but the characteristics of HS2 in the UK have led to the selection of a non-ballasted track form for the plain line sections of phase 1 construction. HS2 will operate up to 18 trains per hour, at speeds of 330 km/hr, with traffic amounting to >60 MGTPA.

The further decision has been reached that the track will be built with pre-fabricated slab panels, which are usually between 5 and 6.5 metres long and typically pre-fitted with 16 or 20 fastenings. Panels can be built off-site in a controlled, factory environment, so the labour required at the construction site and the risks to the workforce are reduced. Damaged panels can be replaced, so that track repairs or renewals can be implemented quickly and efficiently. The ground conditions along the HS2 route are such that significant levels of settlement and heave can be anticipated. While adjustment of individual slabs is possible, the simplest way to re-establish alignment is by adjusting the fastening systems. The requirement on HS2 is that the fastenings need to provide for up to 70mm of vertical adjustment.

In a non-ballasted track form, the resilience otherwise given by the ballast needs to be provided elsewhere. HS2 has specified a track stiffness of 64 kN/mm as seen at the rail head. On rigidly mounted slab, all the resilience in the track must be provided by the rail fastenings. With typical fastener spacings and a 60kg rail section, this leads to the conclusion that each fastener must have a stiffness in the range 20-25 kN/mm.

All the above are basic requirements of HS2. A reliable supplier with a good track record on high speed is also a necessity for a major project of this nature. But against that background, how can proven technology be configured to provide the very best possible track fastening to meet the particular needs of HS2? And is there any scope for innovation? These are questions that Pandrol has been addressing. The Pandrol High Speed FASTCLIP baseplate is well suited to the task.

Adjustment is a fundamental requirement, and there are several aspects. The range over which adjustments can be made in both the vertical and lateral directions; the accuracy with which this can be done; the ease and speed of adjustment and the number and complexity of any additional or exchange parts are all important.

Adjustment figures at least twice. Firstly, on curved track made up of short straight panels, the positions of the fastenings to achieve a smooth alignment will clearly need to be offset. This applies particularly to the lateral baseplate position and becomes more of an issue the tighter the curve. The fastenings must be positioned very accurately to achieve the tight tolerances on track gauge required on high speed track.

The FASTCLIP baseplate is infinitely adjustable in the lateral direction. It can be tightened down and held firmly in position at the exact location required. The baseplates can also be slewed slightly relative to the axis of the slab, so that each baseplate is aligned exactly towards the centre of the curve that the particular slab to which it is fixed will form a part. This means that every slab can be identical to every other slab, and every fastening is identically configured relative to every other fastening on initial track construction. Only the exact positions of the baseplates fitted to any one slab differentiate it from other slabs in the track. So ‘spare’ slabs needed for repairs are universal, and do not need to be purpose constructed with the associated difficulties and lead times. Nor are any bespoke fastening configurations required to achieve exact track alignment.

The combination of universal slabs with universal fastenings is extremely attractive – but is not new. However, what is new and innovative is the proposed way to fit the baseplates to the slabs. Transferring the expertise that it has built up from their use in its clip manufacturing production lines, robots will be used to pick baseplates and place them in the exact positions and orientations required. The combinations of baseplate positions on a given slab can be selected at the touch of a button. Scanning assists and confirms the baseplate positioning, and the configuration of each slab (and which end is which!) is coded into an RFID tag that is affixed to the slab before it leaves the factory, so that the curve or transition where it is destined to be installed can be recalled at any time. This robotic installation increases the reliability and quality of the installation on which the ultimate quality of the track alignment depends. It also increases the rates of production and reduces the risks of delays or interruptions.

Robotic installation of baseplates is greatly facilitated by the fact that the Pandrol baseplate can be largely pre-assembled before it is installed on the slab in the factory, **see image 1**. That’s an advantage too when it comes to the second area where adjustment is essential. This is to maintain the track over its operating life. A damaged baseplate could be replaced as a self-contained unit. There is no need to dismantle the fastening on track, and no need to then know how to correctly reassemble it. Lateral adjustments are particularly advantageous. The baseplate just needs to be loosened off, moved to the correct position and retightened. No additional replacement parts are required and there is no need to largely disassemble the fastening. Vertical adjustments too are simple. The baseplates are loosened off, any additional shims required are slid into place and the baseplate is retightened. The height adjustment shims themselves are a very simple planar design, easily manufactured to whatever precise thicknesses are required. There is no danger associated with assembling shims of different thicknesses in the wrong order.

While high speed lines built in earthquake zones such as Japan and Taiwan have in the past led to a need for relatively high levels of vertical adjustment – typically +50 mm – the HS2 requirement for +70mm is a little greater. The difference may not seem large, but the overturning moment that acts on the fastening is greater and any concrete upstands provided to react lateral loads are further distant from the top level of pre-stressing or reinforcement in the base slab. Pandrol has tested the new maximum height adjustment requirement very thoroughly. We conducted a very successful test against the relevant European CEN requirement, running 15 million load cycles with a block configured so we could test adjacent assemblies at installation heights of +0 mm and +70 mm (**see image 2**), and have even tested for a further 3 million cycles at heights of +70 mm and +140 mm (**see image 3**). On slabs with rail seats, as vertical adjustments are made, the lateral position of the gauge face of the rail changes too. In order to maintain close control of track gauge, vertical adjustments may mean that the components that determine lateral alignment need to be replaced unless the position of the baseplate itself can simply be adjusted. A +70 mm height adjustment on a 1:20 rail inclination as is the case for HS2 results in a 7 mm change in gauge, much greater than the 2.5 mm change that results from a +50 mm maximum height adjustment on a 1:40 track, as, for example, in China.

Speed of construction and maintenance are important and the FASTCLIP system allows machines to be used to switch the clips between the parked and installed positions to allow for rail change and de-stressing. The rates at which the clips can be applied and extracted are exceptionally high and well known in the UK. Train mounted optical track inspection systems that allow the positions and surety of non-threaded FASTCLIP system to be verified are readily available, and can operate at relatively high speeds – typically up to 160 km/hr. As well as speed, these maintenance and inspection systems also help to keep the workforce off the track and increase safety. As has been noted, the global stiffness of the track has been specified by HS2, and this controls several aspects of the behaviour of the vehicle-track system. But most track fastenings used on high speed lines incorporate at least one baseplate or steel plate, so that in principle at least two resilient layers can be introduced – one below and one above the plate. Even for a predetermined and specified global stiffness of the whole fastening, the selection of the stiffness of these two individual elements can affect overall dynamic performance. This in turn may influences level of wayside airborne noise, as well as the mechanical behaviour of the system in response to the loads applied to it – rail roll, dynamic gauge widening, and so on. To confirm that its designs provide the best possible mitigation of airborne noise within the given constraints, Pandrol is working closely with the Institution of Sound and Vibration Research (ISVR) in Southampton to test different detailed design options (**see image 4**).

Steve gave a presentation on Application of Baseplate Technology to Slab Track Construction & Operation at the NW technical seminar in March.

More detail on the above can be found in his presentation in the Technical Hub: **https://www.thepwi.org/technical_hub/presentations_for_tech_hub/190306_nw_seminar_innovation_research_rail/10_steve_cox_application_of_baseplate_technology_to_slab_track_construction_and_operation**

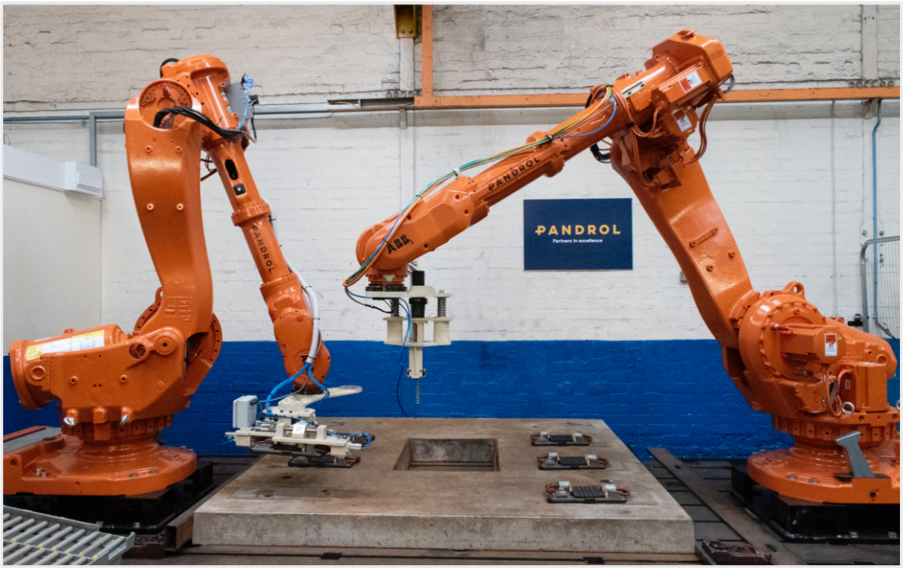

Image 1: Robots Installing baseplates


Image 2: Baseplates under test at +0 mm and +70 mm adjustment


Image 3: Baseplates under test at +70 mm and +140 mm adjustment


Image 4: Baseplates installed at Doncaster High Speed College waiting for decay rate measurements carried out by ISVR