Heat changes everything: PTV track structure and maintenance

Track structure and heat buckling

The railway track consists of rails, sleepers, ballast and track formation. Ballast is a bed of gravel or coarse stones that supports the rails and sleepers. The steel rail on a railway track is a very long piece of metal that can expand or contract significantly in the summer and winter. In hot weather the temperature of a steel rail could be significantly higher than air temperature. This generates forces that try to push and pull the rails out of shape, which is known as misalignment or buckling. On straight tracks the buckle is typically 'S' shaped, while on corners it is normally a 'C'-shaped buckle. The mass of the sleepers is tied to the rail by using specially engineered clips, and the ballast profile (height, depth and extent of the ballast beyond sleeper edge) is designed to contain the forces and prevent the rail line from buckling.

Train speeds and track forces

The movement of trains also generates forces in the track. The higher the speed, the greater the force exerted by a train. When heat expansion forces are high, trains deliberately slow down to reduce the additional forces they apply to the rail line. Likewise, forces will be greater for longer and heavier trains such as V/Line trains with locomotives or goods trains than lighter Metro trains running through the suburbs. This means that there are different temperature limits for different types of rail network. The need to prevent problems by reducing speed in hot weather also means there will be fewer trains, but this is better than causing a bigger problem such as a train derailment and being unable to run any services.

Prestressing and rail tensors

To prevent buckling from happening, hydraulic machines called rail tensors are used to artificially stretch rails as they are newly placed. This stretching means that even if the rails heat up they won't expand. However, there's a limit to how much a rail can be stretched. Too much stretching risks rails cracking during cold winters. How much a rail is stretched is therefore a careful balancing act. Ongoing monitoring of rail movement is conducted every six months, which is called creep monitoring.

Maintenance and prevention

To prevent rail buckling, ongoing maintenance is required, which includes:

- Regular monitoring of rail temperature variations at critical locations such as bridges or approaches to tunnels
- Introducing speed restrictions when weather is hot beyond certain limits set out by railway operators such as V/Line and Metro Trains in Victoria
- Removing foul ballast and inserting clean ballast to improve track stability
- Introducing heavy concrete sleepers on old timber-sleeper rail tracks
- Monitoring the condition of the fastening clips that hold rails to sleepers and replacing damaged clips when required
- Like roadways, mud spots may exist in the track and require treatment to prevent track being springier and prone to buckling.
- Internal cracks or defects in steel rails exacerbate buckling behaviour. It is extremely important to detect these faults and repair the section of defective rail. There are various ways of finding faults in rails. One of the popular ways is to run an ultrasound testing car on the track to find such defects.
- If the rail line is buckled, rails are cut in the affected zone and welded again with the help of rail tensors to stretch to appropriate lengths. The extent of stretching is calculated based on temperature and the coefficient of thermal expansion of the steel rail.