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Track bed total route evaluation for track renewals and asset management "a Network Rail perspective"

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ABSTRACT

Over the last 10 years there have been significant developments and improvements in the understanding of railway track bed in the UK and its relationship and impact on track quality, ballast life and maintenance following track renewals. This paper aims to describe the process adopted by Network Rail for track bed investigation and design which offers Network Rail optimum design solutions and value for money from an investigation and construction perspective, balancing design with possession availability to maximise construction output. It also describes innovative investigation and construction techniques that have been developed over the last 5 years maximising the use of rail mounted asset condition data collection systems which run at line speed, allowing targeted investigations and in some case removing the requirements for physical site investigation. It also allows Network Rail to predict sections of track bed which may be affected by line speed increases which would cause the track bed to fail prematurely or, retain its ability to maintain good track geometry post line speed increase. These problems can manifest themselves as stiffness related problems such as critical velocity issues (Surface Wave Velocity, Rayleigh Wave Velocity) or, sub-grade erosion resulting in high rates of deterioration in the vertical track geometry. The paper also describes the development and installation process for Enhanced Axial Micropiles to address stiffness related track bed problems whilst leaving the track in-situ a technique which is new to the UK railways.

1. Part 1 – Introduction to railway track bed

Over the last 10 years there have been significant developments in the understanding of railway track bed, its relationship and impact on track quality and maintenance following track renewals. This paper aims to describe the process developed by Network Rail for track bed investigation and design of the track bed which offers whole life of track bed and optimum cost efficient design solutions from an investigation and construction perspective. It also describes innovative investigation and construction techniques that have been developed over the last 5 years.

The quality of a ballasted track system, i.e. its ability to retain good geometry and its response to mechanical maintenance (tamping, stone blowing) is directly related to the design and condition of the track bed, drainage and earthworks on the railway.

The track bed is normally considered to consist of two elements from a track renewal point of view, ballast and formation see figure below:

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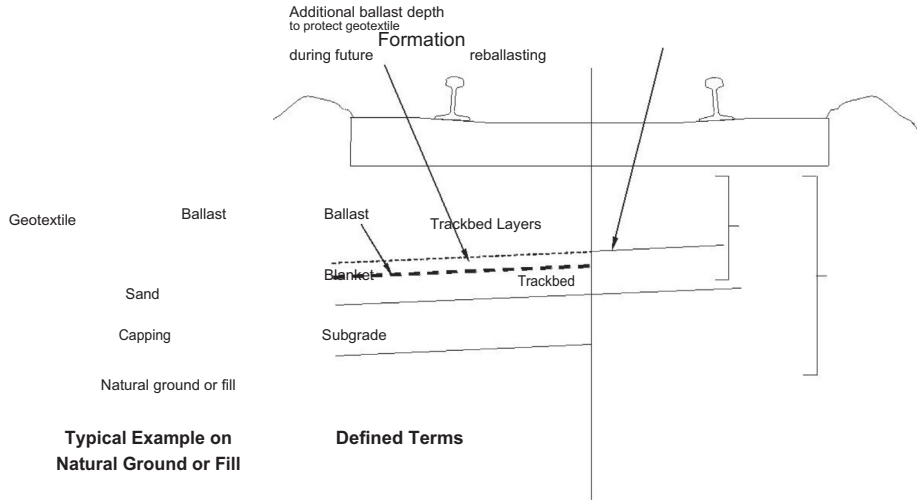

The ballast allows for adjustment of the line and level of the track. Ballast deteriorates with traffic and maintenance activities and therefore requires periodic replacement. The required depth of ballast gives the desired life before it needs to be replaced and should not be confused with the total depth of track bed which includes the formation layer (typically a sand blanket), this combination distribute the dynamic load over the sub-grade. The typical design life of track ballast on a well constructed formation layer and good sub-grade is approximately 25 years on a high speed main line and up to 50 years on secondary rural lines with appropriate maintenance interventions during its life cycle.

The formation layer typically consists of sand known as the blanketing layer this overlays the sub -grade, upon which the required depth of ballast is placed. The formation layer is permanent, and should not require replacement or maintenance providing the track drainage system is adequate.

The Capping Layer (prepared sub-grade) consist of suitable imported material whose purpose is to enhance the properties of a poor sub-grade prior to placing the blanket in particular where there are poor stiffness qualities associated with the natural ground.

On a well built formation with adequate drainage the only track bed treatment required should be ballast replacement. However, in the UK there are many locations where the formation does not provide the ideal support conditions resulting in the reduction of the service life of the track bed and poor track quality. It is therefore important that adequate and accurate investigation of the track bed is undertaken to determine the required remedial measures. Track bed stiffness is an important factor to consider when investigating the track bed because this influences track quality and the frequency of subsequent maintenance intervention [maintenance tamping reduces the life of the ballast]. On a well constructed mainline railway with a stiff track bed, tamping should normally be required only at a 3 yearly cycle. This will gradually increase over time as the ballast breaks down until the frequency of tamping is greater than once a year and it becomes economic to replace the ballast.

When new, the ballast layer is clean, free draining, resistant to settlement and responds well to tamping. As it ages it breaks down gradually under the action of traffic and mechanical maintenance until the voids eventually become filled with fines. While this will reduce the effectiveness of tamping, the performance of the ballast is not significantly affected until the fines reduce permeability to the point at which pore pressures cannot dissipate under train loading, particularly when the ballast becomes saturated during heavy rainfall. This normally occurs first beneath a rail irregularity, such as a dipped weld, where dynamic loading is higher and damaging to the ballast. The onset of this type of failure is characterised by the appearance of "wet spots" and rapid deterioration of track geometry measured as a standard deviation (SD).

In addition to the products of ballast breakdown, fines may be deposited from the environment (e.g. wind blown) or from freight vehicles (e.g. open topped coal wagons). This type of failure (dirty ballast failure) is the most common failure mode and should not be confused with sub-grade pumping.

1.1. Types of track bed failure

Track bed failure or inadequacy relates to its ability to retain good vertical geometry. The point of failure is not always clearly defined, unlike earthwork failures where movements are often large and rapid.

Various mechanisms can result in poor track geometry due to failure of the track bed. These can be divided into three main categories:

(a) Ballast deterioration (dirty ballast failure) as described above
(b) Sub-grade erosion (pumping)
(c) Poor stiffness characteristics

1.2. Sub-grade erosion (pumping)

The symptoms of sub-grade erosion are similar to those caused by extensive ballast breakdown (dirty ballast failure), i.e. poor track geometry accompanied by the appearance of wet spots.

Sub-grade pumping occurs when slurry rises into the ballast under the pumping action of dynamic train loading because there is no adequate blanket present to filter the fine particles and prevent them from entering the lower ballast layer. Slurry is normally formed by erosion of a fine-grained sub-grade, such as silt, clay or fine sand, although weakly-cemented sedimentary rocks and poorly-graded blanket layers can also be susceptible.

Small amounts of slurry in the base of the ballast layer have no effect. The problem becomes serious only when the slurry migrates upwards towards the base of the sleepers and affects the load bearing properties of the ballast. Soon afterwards the characteristic