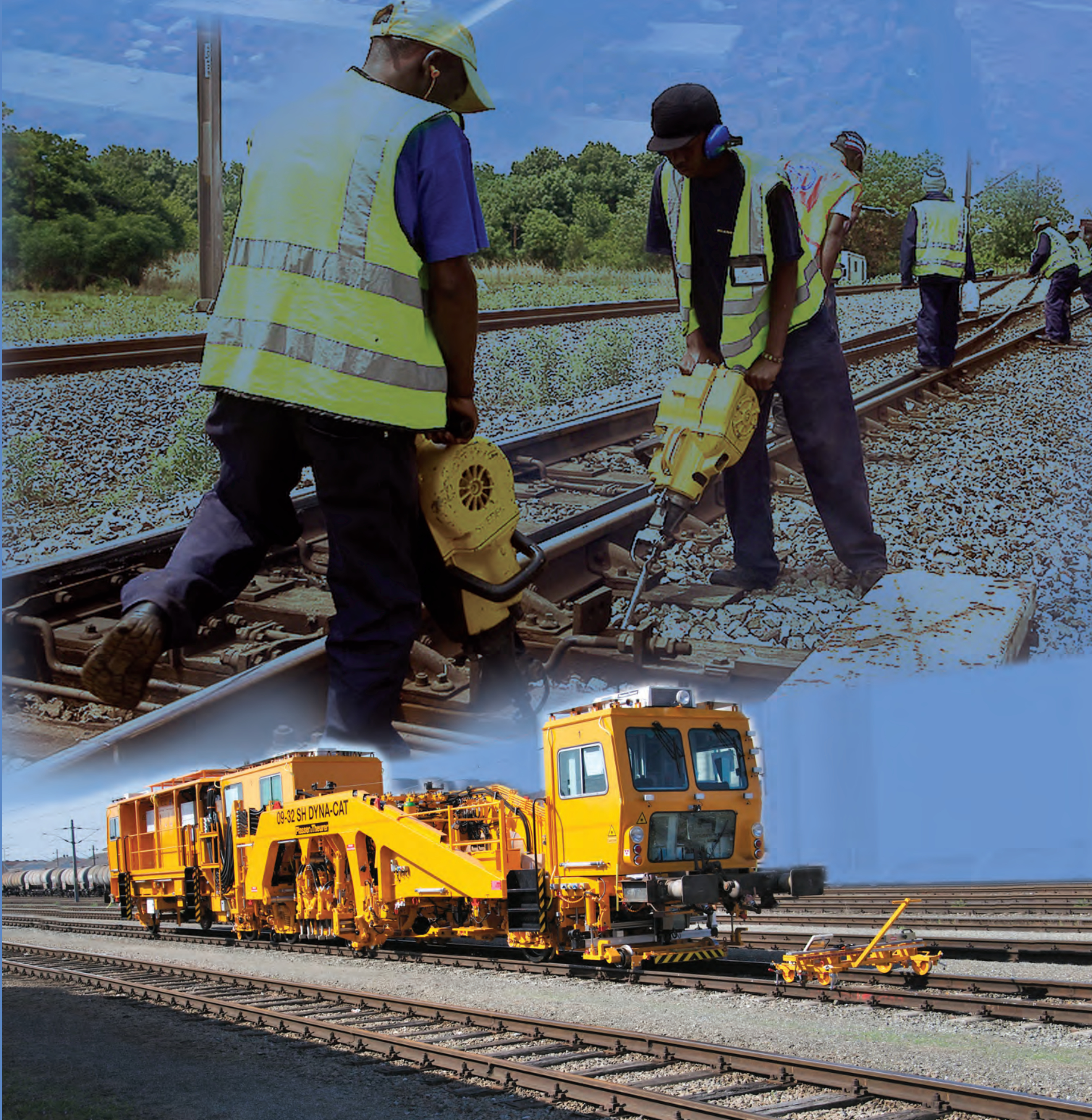
THE BASIC PRINCIPLES OF MECHANISED TRACK MAINTENANCE

Leon Zaayman



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2.14.3. Mobile Lubrication

Lubrication equipment may have been installed during the initial construction of a line, but is often neglected and very seldom will one find a working unit in many developing countries. The theft of the grease is often part of the problem. Where these problems are encountered it is recommended that a road/rail vehicle be used with equipment to pump grease onto the rail in curves. It is also particularly cost effective for low traffic lines.

It is usually done using a light delivery vehicle specially fitted with the lubrication equipment and road/rail steel and rubber wheels. The vehicle often doubles as an inspection and light emergency repair vehicle. The vehicle lubricates the track at intervals determined by the depletion rate of the grease applied to the line. The applicator system can be operated by the driver of the vehicle, although automatic systems based on GPS data are also available.

The lubrication equipment applies a thin bead of grease (about 0,4 mm) under high pressure on an intermittent basis to the side of the rail. The equipment consists of a grease reservoir, a unit to pressurise the grease, a grease pump and supply lines culminating in an application nozzle sitting in the shade of the wheel flange so as not to be damaged by obstructions like crossing noses or axle counters on the track. Grease application rates are pre-set for a trip and can usually not be adjusted from the cab while the vehicle is running. The vehicle is usually equipped with two cameras, each aimed at one nozzle and two monitors in the cab, showing the driver how the grease is being applied.

Figure 50: Two Types of Rail Lubricators

Figure 51: Road/Rail Rail Lubricating Machine (Transnet)

2.15. Closure Rails

It is often required to install a short section of rail after cutting out a rail break or rail defects. Poor maintenance practice to install a very short section (Figure 52) is common and probably due to ignorance, a lack of training and unavailability of maintenance standards. The shortest length of closure that should be installed is 4,2 metres (South African standards).

2.16. Check Rails and Guard Rails

Check/guard rails are provided on the low leg of curves to prevent excessive wear of the high leg but they increase the curve resistance. Curves of 150 metre radius or less in main or running lines must be check railed. In yards they must be provided where excessive side wear occurs on the high leg or where other conditions call for their provision e.g. where trains tend to derail. On bridges guard rails are installed to keep derailed rolling stock from falling off the bridge, striking the structure or piling up in a tunnel.

Check/guard rails may have to be removed to permit mechanised tamping and replaced again depending on conditions and tamping unit design.

The area between the check rail and the running rail is called the flangeway. This area must be kept clear of ballast.

2.17. Introduction to Rail Defects

Rail defects develop for many reasons such as rolling contact fatigue, dynamic loading, external impacts due to, for example, damaged wheels and ballast imprints which may cause a stress raiser from where cracks can develop.

It is not always possible to establish or categorise rail defects by visual inspection alone and even if the cause and type of defect can be established by visual or laboratory investigation, it is no simple task to group types together since there is a subjective element to it. Spalling for example which is visible as a surface defect may rather be as a result of a subsurface crack that developed due to a manufacturing defect.

Grouping and categorising of rail defects consistently according to a coding system is very important for statistical and rail maintenance management purposes.

In the absence of a system the classification of rail defects proposed by the International Union of Railways (UIC) publication UIC 712 can be used. It will still however require the opinion of an expert in this field.

Rail defects in this manual is however broadly divided between rail wear (paragraph 2.18), rail cracks (paragraph 2.19), damaged rail (paragraph 2.20) and broken rail (paragraph 2.21). These can be defined as follow:

Figure 52:
Poor Maintenance Practice

- Rail Wear – Wear takes place as a consequence of the relative motion between the wheel and the rail and involves the loss of material from either or both.
- **Cracked Rail** – A crack can be defined as a gap in the rail material, visible or not, and has the potential to rail fracture if the gap grows in length. Rail cracks can be caused by thermal loading or mechanical loading.
- **Rail Damage** – In the context of this manual rail damage refers to any rail defect that that cannot be classified as wear or a crack and is mostly related to dynamic loading.
- **Broken Rail** – Rail is said to be broken/fractured if it has separated in two or more pieces, or a piece of the rail becomes detached, causing a gap of more than 50 mm in length and more than 10 mm in depth in the running surface.

Figure 53 illustrates the location of some of the typical defects that will be discussed in the following paragraphs.

2.18. Rail Wear

Wear (loss of material) takes place as a consequence of the relative motion between the wheel and the rail (see Fundamentals of Rail and Wheel Interaction in CHAPTER 4). The following wear mechanisms on the rail can be identified:

- Adhesive Wear – This type of wear takes place as a result of wheel burns where extreme high heat is created.
- Surface fatigue – This is the most common form of wear between wheel and rail due to relative slip and creep forces. The fatigued material will eventually lift off the rail surface.
- Traffic Loading – In this context corrugations are listed as a form of wear due to traffic loading.

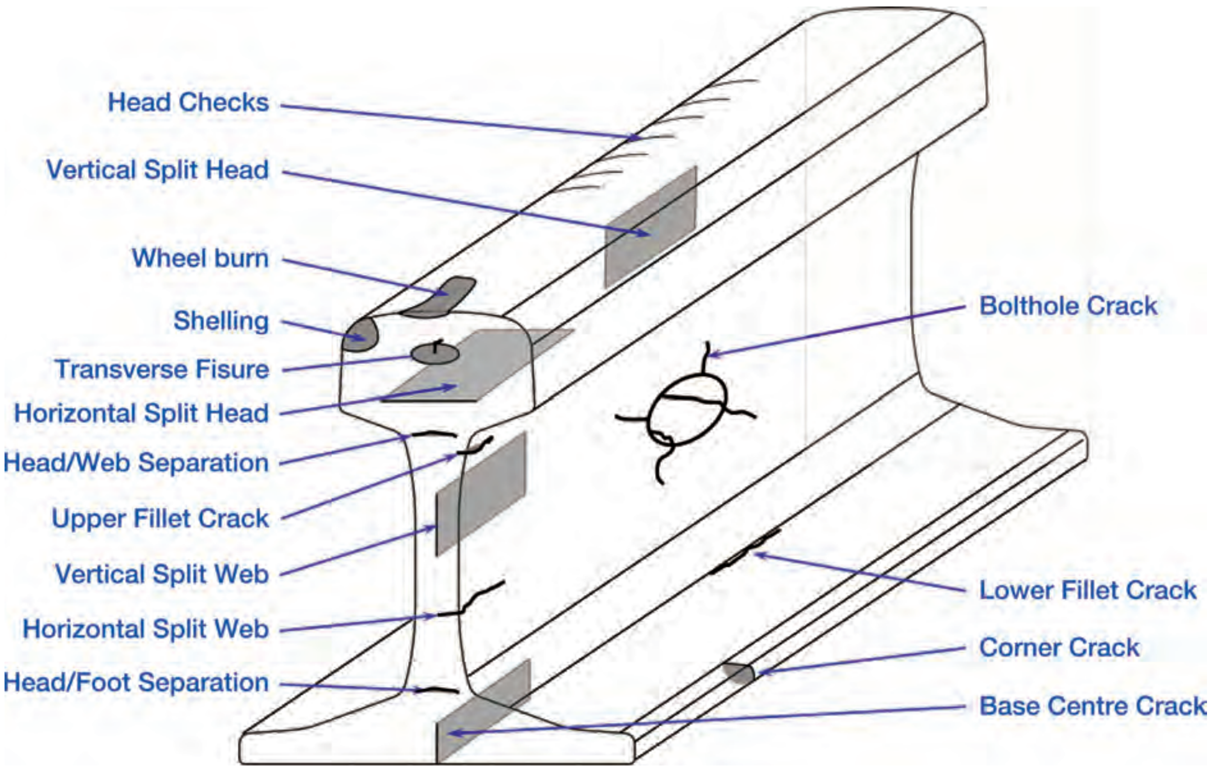


Figure 53: Typical Rail Defects

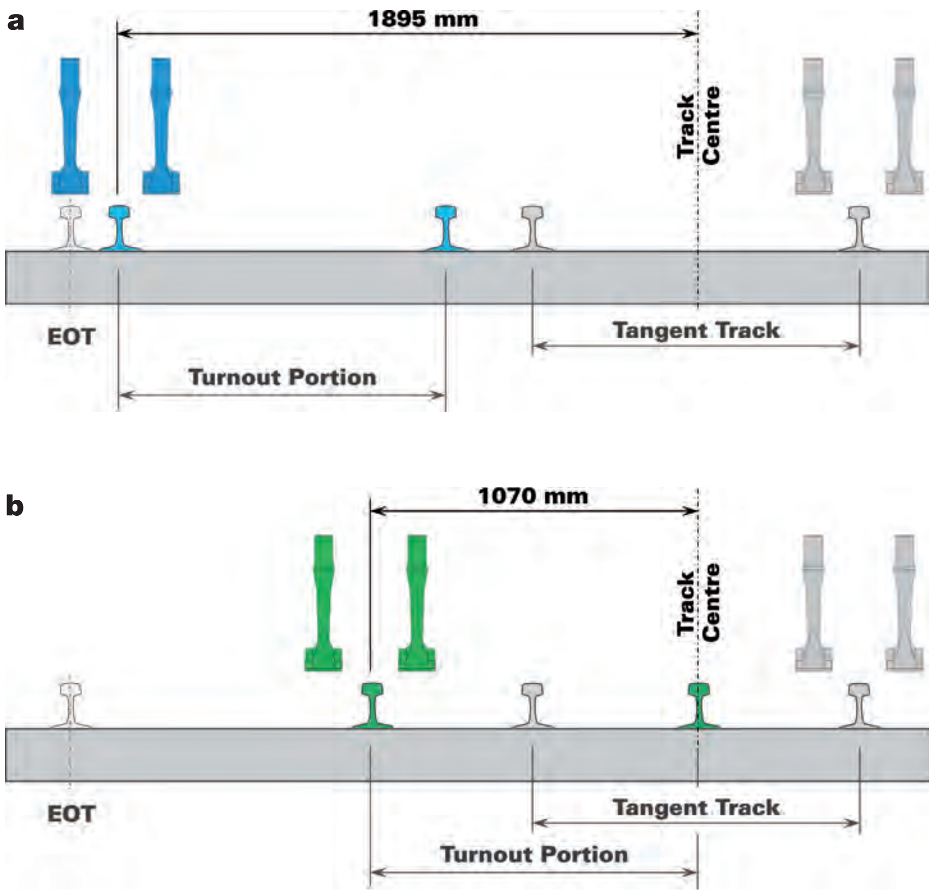


Figure 363: Typical Maximum Reach of Universal Tamping Machines to the Turnout Section while Standing on the Tangent Section
(a) Double Slewing Reach and
(b) Single Slewing Reach

Note: EOT denotes the end of the turnout. The illustration shows how close the 2 tamping unit frames can get to the end of the turnout while the machine is standing on the tangent (straight) section.

4.5.2. Rotating Tamping Unit Frames

An additional feature of modern universal tamping machines is that of rotating the tamping units through the angle of the skew sleepers of the turnout.

These tamping units are mounted to a turntable that ensures right angles to the sleeper when the turnout portion is tamped. This avoids potential squaring of the skew sleepers and improves production times.

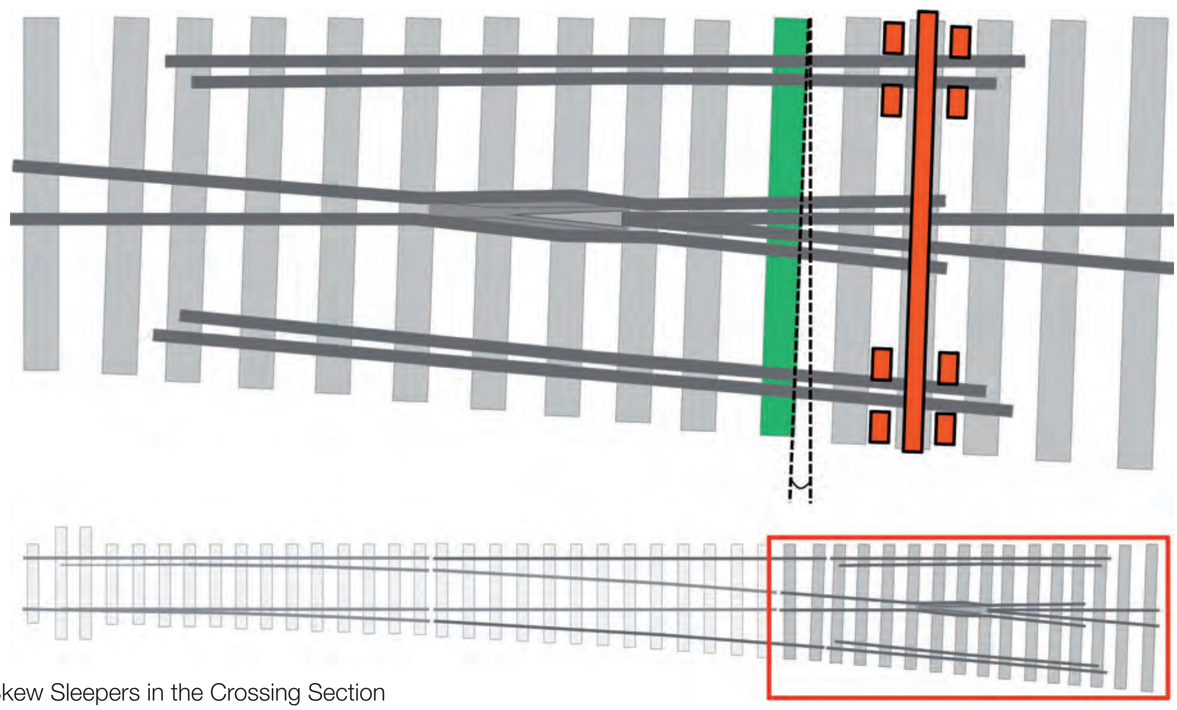


Figure 365: Skew Sleepers in the Crossing Section

4.6. Auxiliary Satellite Frame for Continuous Action Tamping

A conventional tamping machine must move from sleeper to sleeper for the tamping operation. The machine must therefore accelerate and brake again between sleepers and is referred to as index tamping. Though this principle is still used on many modern tamping machines, its production capability is limited due to the acceleration and braking limitations of heavy on-track machines using steel wheels on steel rail. The acceleration and braking is also very uncomfortable for the operator of the machine and causes fatigue to set in very quickly at higher tamping rates. The limit for index tamping using a 2-sleeper tamping machine is around 33 sleepers per minute. Therefore, only lower production, lower cost and specialised tamping machines use index tamping.

In 1983 Plasser & Theurer introduced the first continuous action tamping machine, the 09-32 CSM (see Figure 366) which tamped two sleepers per insertion and produced 30% more than the fastest machine available at the time. This was achieved by the separation of the main frame and an auxiliary satellite frame on which the tamping units where mounted. This allows continuous motion of the main frame while the cyclic braking and acceleration for the tamping action is performed by the auxiliary frame. Only around 20% of the machine mass must therefore be braked and accelerated.

machine tamps four sleepers per cycle and achieves a production rate of more than 70 sleepers per minute.

The continuous action principle was traditionally only used on plain track tamping machines. The plain track tamping speed of universal tamping machines were therefore always limited to that of single-sleeper index tamping machines. However, with the introduction of the DYNA-CAT (refer to Figure 330) and the 09-4S universal tamping machine series (Figure 367), continuous action tamping with two-sleeper split tamping units and integrated dynamic stabilisation were combined in one machine to provide the best possible production rates on turnouts while it achieves high production rates on plain track as well. The continuous action tamping principle has the following advantages:

- Increased output compared to indexing machines.
- Lower energy costs because a lower mass (just the satellite) must be accelerated from insertion to insertion.
- Reduced wear on the brakes.
- Reduced strain on the machine frame and drive system, which reduces maintenance costs and increases reliability.
- Ergonomic advantages for the operator/s of the machine.
- Other continuous-action work processes such as ballast regulating and dynamic stabilisation can be incorporated into the machine.

Figure 366: The 09-32 CSM Continuous Action Tamping Machine with the Tamping Units Mounted to a Separate Auxiliary Frame

Figure 367: 09-4S Universal Tamping Machine

The different formation rehabilitation materials are discussed in the following paragraphs.

2.1. Subsurface Drains and Geo-Pipes

Subsurface drains, as with all formation rehabilitation activities, must be properly designed by a professional in the field. Subsurface drains can also have various designs and depths, depending on the subsurface flow characteristics. To facilitate the effective flow of water in the drain, these drains are often lined with geo-textiles, filled with ballast and may also contain a geo-pipe.

2.2. Geo-Synthetic Materials

“Geo-synthetics” is a generic name for a variety of synthetic materials used in the field of soil mechanics. The most common geo-synthetic materials are:

2.2.1. Geo-Textiles

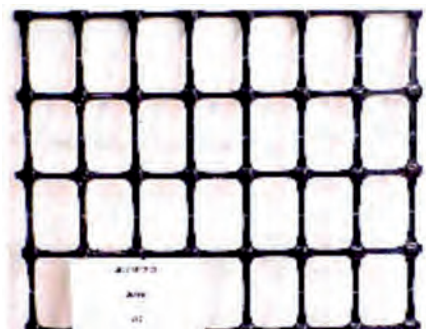
Geo-textiles are made of polymers such as polyester or polypropylene and are either used as a filter or as a separation layer between two different soil types, thereby maintaining the integrity and functionality of the soils.

Non-woven geo-textile fabrics are used for their permeability which allows the passage of water but prevents the passage of granular material, whereas woven geo-textiles are less permeable and will avoid the passage of water.

Geo-textiles are rolled out on top a soft subgrade to prevent the intermixing of the subgrade material and the placed backfill material, especially where a high water table or subsurface seepage is encountered. Geo-textiles should not be directly underneath the ballast since the stones will puncture holes in the material and when the track has to be ballast cleaned, the geotextiles will interfere with the cutting chain.

Figure 557: Geo-Textiles Being Rolled Out over the Prepared Formation

Figure 558: Geo-Grid Being Rolled Out over the Prepared Formation



2.2.2. Geo-Grid

Geo-grid is a mesh like polymer structure which is rolled out on top of a weak subgrade to strengthen it. It is also used in fin drains.

2.2.3. Geo-Cells

Geo-cells are honeycomb-shaped cells that are filled with backfill material to create the structural strength required on which to construct the new formation. The strength that the cellular confinement provides may reduce the depth of the required excavation.

2.3. Fin Drains

A fin drain is a prefabricated filter comprising a geo-grid core sandwiched by geo-textiles. The core acts as a drainage conduit along which water flows freely after it has been filtered by the geo-textile skin. This is referred to as a geo-composite for it combines the use of two different types of geo-synthetic materials to benefit from the features of both.

2.4. Backfill Material

The number of layers, layer thickness and selection of backfill material type and grading will depend on the formation rehabilitation design which is, to a large degree, based on the axle loading and traffic density of the line and the condition of the formation. The layers are, depending on the specification, graded according to the following:

- Plasticity
- Ballast grading
- Minimum compaction percentage of modified AASHTO density (American Association of State Highway and Transportation Officials)
- Minimum CBR strength after compaction

Each layer is compacted to a specified density. The specified moisture content must also be observed. Geo-textiles will generally be used together with layer work to prevent intermixing of the in-situ material and the layer work.

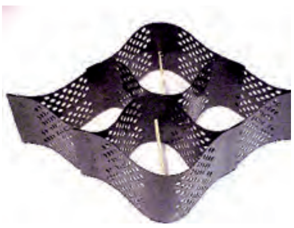
2.5. The Formation Protective Layer (FPL)

If the formation does not meet requirements, it may be necessary to install an appropriately thick formation protective layer (FPL) consisting of a graded gravel-sand mixture (backfill material). This can be reinforced by adding a membrane of geo-synthetic material.

The installation of a formation protective layer is an effective and well-proven method of raising the bearing strength of the substructure as it reduces the soil pressure tensions. Consequently, this constructional measure brings an enormous reduction of the costs for track maintenance. The installation of an FPL is associated mostly with mechanised methods of formation rehabilitation. See Figure 594.

The thickness of the formation protective layer depends above all on the bearing strength of the earth formation. On the other hand, the required bearing strength of the FPL depends on the maximum line speed. Normally, an FPL with a thickness of 30–50 cm is installed.

Figure 559: Geo-Cells Being Used Together With Geo-Textiles and Filled with Backfill Material



3. INVESTIGATION OF THE SUBSOIL

Before any rehabilitation of the subsoil is undertaken, the actual nature of the subsoil should be established by soil mechanic investigations to determine the type of subsoil rehabilitation that should be performed.

3.1. Preliminary Investigations

3.1.1. Measurements Taken by Track Recording Vehicles

The state of the subsoil for a railway network can be determined by the measuring results obtained by a track recording vehicle. Long-wave faults in the twist measurement over a long base (approximately 16 metres) indicate poor subsoil (Figure 560).

3.1.2. Geo-Radar Measurements

The principle of geo-radar measurement is the time taken by the emitted electromagnetic pulses to reflect back from the borders of different density materials which provides information about the depth and progression of the separate layers of soil. Geo-radar can identify:

- fouling inside the ballast bed (e.g. loam rising up from the subsoil);
- the location of ballast pockets; and
- the water content of the subsoil.

This method can be used to compare rehabilitated and unrehabilitated sections to provide valuable information about the subsoil.

The assessment of radar grams can only be performed by specialists.

Geo-radar measurements are the first stage of investigation of subsoil condition. Very moist and a severely fouled ballast bed will hinder the penetration depth. The technique should generally only be applied in conjunction with a detailed visual investigation.

3.2. Detailed Investigation

The final decision on the rehabilitation measures to be undertaken can only be made after detailed soil investigations, including one of the following:

3.2.1. Inspection Trench

Inspection trenches are pits dug into the ballast bed down to the subsoil either at the sleeper end or as a crosswise trench through a sleeper crib. By studying these it is possible to identify the composition of the layers and particularly to take undisturbed samples and perform bearing-strength measurements using a plate load device. Making of the trench must follow very strict procedure to ensure that the material for investigation is not contaminated with material that caved in.

Figure 560: Long-wave Twist Fault Clearly Visible – Close-up Inspection Reveals White spots on the Ballast which is Further Indication of Formation Failure

Large on-track maintenance machinery will not be cost-effective for this type of maintenance and smaller vehicles, such as the light duty machine shown in Figure 597, will be more affordable and suitable.

These smaller machines may be fitted with any type of platform. Refer to paragraph 2.3.1 below that deals with the types of platforms available.

2.2.1.2. Corrective Maintenance

Corrective maintenance is defined as work (repairs) of a non-emergency nature, identified during the performance of routine maintenance, and is required to prevent in-service functional failures and restore the operational state of the asset to the required level. This work is condition-based and is triggered by the identification of potential failures, wear and tear and deterioration of the assets, etc. Corrective maintenance can be broken down in:

- Light maintenance – This task requires the use of hand tools for replacing defective or worn components on the OHE after they have been identified during routine maintenance. These may include replacing insulators, clips and other small components on the OHE.
- Heavy maintenance – This task requires the use of large machinery, such as cranes, low bed vehicles, etc. for replacing defective large components. This may include replacing mast poles and mast foot insulation.

Figure 599: Distribution of Workload (Metrorail South Africa)

The machine in Figure 597 would generally be too light for this type of maintenance, since more storage and work space would be required as typically offered by a heavy duty machine similar to the machine in Figure 598. In addition, if the machine does not have a crane, additional vehicles would be required.

2.2.2. Unplanned Maintenance

Unplanned maintenance is defined as work of an emergency nature required to repair equipment damaged through functional failures, vandalism, theft, sabotage, derailments, etc. To determine if this type of work warrants a dedicated machine, an analysis of the workload must be done.

Figure 599 shows a typical workload study that was carried out on Metrorail in South Africa.

It reflects the distribution of the workload between the three maintenance tactics measured in hours per kilometre per year. From the figure it is clear that most of the maintenance time is spent on routine maintenance and that emergency work only accounts for 9% of the workload. It would therefore make economic sense (in this instance) to share a machine between corrective maintenance and emergency work.

Figure 598: Heavy Duty OHE Maintenance Machine