Latest Developments in Track Rehabilitation and Maintenance

High capacity, precision, reliability are the essential requirements for the development of machines for rehabilitation, repair and maintenance of the track. Tracks need to be available primarily for production. However, the maintenance should not be neglected, even though it hinders rail services, otherwise there will be irreparable damage or even a total failure of this essential means of production.

High capacity and reliability of the machines guarantee that the track closures can be kept short and that available closures can be utilised to the full extent. Precision of the work performed is essential for a good result in economic terms and for a long-lasting success of the maintenance operations. Therefore these are the essential factors which serve to keep the tracks available without interruptions for rail services at a feasible cost.

Early in the planning phase it is particularly important to designate the appropriate high capacity machines so as to keep the operational hindrance costs and the additional costs of large-scale worksites as low as possible.

Correction of track geometry

Track maintenance

For correcting the track geometry, either in the course of track maintenance or in conjunction with large-scale repair measures, the technology of the "Tamping Express" is in a class of its own. Following the success of the 09-3X continuous action 3-sleeper tamping machine, the first 4-sleeper tamping machine, the 09-4X Dynamic Tamping Express (Figure 1) has now been introduced. The 09-4X Dynamic Tamping Express is based on the working principle of the 09 series, i.e. the subframe is separate from the main frame. The main frame of the machine travels forward continuously while the track is corrected and tamped in static state and therefore with optimum quality. The forward motion of the work units is performed with maximum acceleration.

The machine has already proven its reliability in practical operation and produces an output of up to 2600 m/h. Multi-sleeper tamping machines not only have a high output, they also offer optimum quality of the work because a larger section of track is lifted, lined and tamped in one operation. Since putting the 09-3X into service on their main lines, for example, Austrian Federal Railways (ÖBB) have noted a rise in quality of 20 %.

During work the tamping units of the 4-sleeper tamping machine can be changed over to two sleeper or single sleeper tamping at any time (Figure 2).

The machine leaves behind an excellent track geometry immediately after the lifting, lining and tamping pass. This is followed by the application of the stabilising units to compact the ballast which raises the track's resistance to lateral displacement and perfects the track geometry. The result is absolute uniformity in the work performed by the 09-4X dynamic tamping express. Dynamic track stabilisation is therefore an indispensable feature of every track maintenance operation. If this work process is "left out", the reduced stability of the tracks will generate higher follow-up costs which will result in shorter durability of the track geometry and reduced resistance to lateral displacement (stability preventing rail buckling). To enable low cost operation for the machine operator, track stabilisation was integrated in the machine trailer on the Dynamic Tamping Express series.

The technical data of the 09-4X Dynamic Tamping Express can be seen in Table 1.

Switch Maintenance

Continuous working action is state of the art not only on the track tamping machines but also on the universal track and switch

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Figure 1: Continuous action four-sleeper tamping machine with integrated track stabilisation

Figures 2: Work positions of the four-sleeper tamping unit

four-sleeper tamping *two-sleeper tamping* *single-sleeper tamping*

Total mass	approx. 158 t
Length over buffers	34 040 mm
Height over top of rail	4200 mm
Width	2900 mm
Distance between bogie pivots Bogie 1 – bogie 3 Bogie 3 – bogie 4 Bogie 4 – bogie 5	 17 300 mm 5 600 mm 12 000 mm
Engine output Tamping machine Power unit and stabilising car	 440 kW 440 kW
Travelling speed under own power/towed, max.	 100/120 km/h

Table 1: Technical data of 09-4X Dynamic Tamping Express

tamping machines. With the Unimat 09-32/4S Dynamic the development is already so far advanced that two sleepers can be treated in each work cycle with 3-rail lifting and 4-rail tamping. Like on the Tamping Express, the track stabilising units are incorporated in the machine trailer and can be applied not only in the track but also in the switches.

The newly developed Unimat 09-475 4S is a continuous action single sleeper tamping machine for tracks and switches now operating in Austria. This machine is built in compact design and offers good value for money (Figure 3).

On high-capacity tracks and switches it is absolutely necessary to perform track geometry corrections using the precision method and not only the compensation method. Two to six weeks before the tamping machine is scheduled, the EM-SAT is deployed to carry out a laser-assisted track geometry survey to determine the deviations from the target track geometry together with the lifting and displacement values. If several consecutive tamping passes are necessary in the course of track laying or track maintenance operations, surveying must be carried out shortly beforehand, that is to say, just ahead of the machine. The CAL laser system for curves, which measures the versines and fixed points with the help of a laser front trolley and a receiver on the machine, was developed for this purpose. The CAL-SAT, shown in Figure 3 together with the Unimat, is a further development of this system, offering the operator a protected workplace.

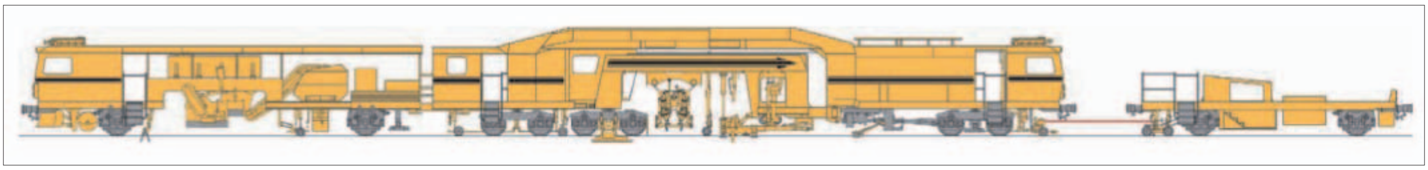
Ballast management

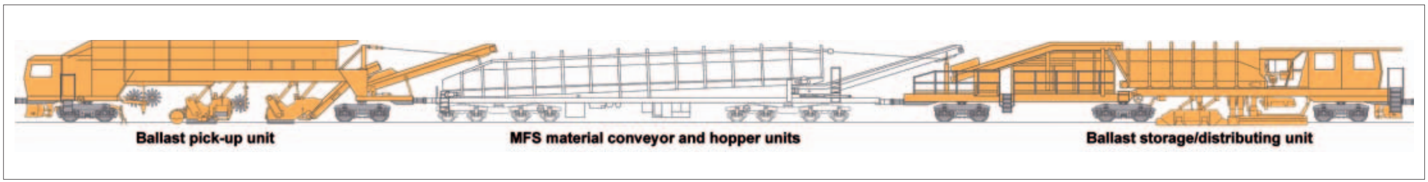
The optimum ballast cross-section is of great importance for the safety of the track geometry against track buckling and for the durability of the track geometry itself. Too much ballast in the track causes unnecessary hindrances and costs when performing maintenance. Too little ballast reduces the stability of the track and gives rise to faults in the track geometry. There is around 3000 to 5000 m³ of ballast in every kilometre of a double-track line depending upon the type of track and track spacing. The cost-efficient handling and management of these enormous quantities of material presents a great challenge for track maintenance engineers.

On most main lines there is sufficient good ballast available but it is often distributed unevenly. Ballast profile measurements on the ÖBB using the EM-SAT have confirmed this impression. If the existing ballast in the track could be distributed uniformly, it would be possible to save large quantities of new ballast in conjunction with track maintenance operations.

This finding has led to the fact that since 2005 the ÖBB has been using two BDS

Figure 3: Continuous action switch tamping machine with measuring trolley (CAL-SAT)





2000 systems in conjunction with the mechanised maintenance trains (Figure 4).

These ballast distributing and profiling machines have a powerful ballast pick-up system to collect surplus ballast from the track and store it in a large hopper. The machine has two sweeper and collecting units positioned one behind the other to be able to keep pace with the high-capacity machines of the Tamping Express series. If a great deal of ballast has to be stored, the system can be extended at any time by adding MFS material conveyor and hopper units. In conjunction with the ballast profile measurement developed by Plasser & Theurer using the EM-SAT survey car, metered quantities of ballast can be returned to the track wherever there is too little. With consistent application of the machine to save ballast, and only used in conjunction with track maintenance, the machine can pay for itself within a period of two years.

On high-speed lines it is particularly important to carry out thorough sweeping of the sleeper surfaces and the sleeper cribs in order to prevent ballast stones swirling up due to the high speeds. For this reason, the ÖBB – and many other railways – specify so-called „deep sweeping“ wherever speeds over 200 km/h are permitted. In this case the BDS sweeps the ballast out of the sleeper cribs 4 to 6 cm below the top of the sleeper.

The front section of the machine is fitted with ballast distributing devices for exact placement of the ballast, the plough for work on the ballast crown and the two shoulder ploughs. The integrated ballast hopper has a storage capacity of approx. 20 m^3.

Only profiling machines in heavy-duty design can shift large quantities of ballast in one pass, a principle that was first made possible in the SSP series and today has been perfected in the machines of the SSP series and USP 2010. The continuous working action during ballast profiling has also become reality in the BDS system. The ballast profiling devices themselves consist of steplessly adjustable shoulder ploughs, followed by an X plough for work on the ballast crown. Due to this combination, ballast can be displaced from one side to the other in one pass and the X plough enables exact placement on the ballast crown and especially in the tamping zone. The sweeper units following behind have rotating brushes (fitted with rubber hoses or rubber elements) with a large diameter, which is a basic requirement to achieve a high sweeping output.

Figure 4: Machine system for ballast management

Ballast bed cleaning

The ballast bed fulfils an important function in the track system as a load-distributing and shock-absorbing element. It must also be water permeable in order to ensure good drainage. These properties are present only when there is not too much fine material in the ballast, that is to say, when pollution of the track bed is at a reasonable level.

However, in the course of time, traffic loading and environmental influences cause fine material to be deposited in the ballast bed which generally builds up from the formation upwards and is largest in the carrying area under the sleepers (Figure 5). On poor subsoil there is also the rising of cohesive material. Tamping, on the other hand, scarcely contributes towards the formation of fine grain; ballast fines of only around 2.5 to 4 kg are generated per tamping cycle and sleeper. That is equivalent to 25 to 80 kg (10 to 20 tamping cycles) for the life cycle of a track – a very small quantity in comparison to the entire ballast volume.

If the ballast bed is polluted, it will not be possible to achieve any long-lasting track geometry and the track materials wear out prematurely due to the increased moisture and the higher dynamic forces. Studies carried out by ERRI have shown that this condition occurs as soon as more than 30 % of the ballast has a diameter smaller than 22.5 mm. When such a degree of pollution has been reached, ballast cleaning is recommended and this is absolutely necessary when this figure is higher than 40 %. The deciding criterion for the necessity of ballast cleaning is mainly the track geometry deterioration in the course of time and modern track data banks supply the respective data and evaluations.

Ballast cleaning is a cost-intensive maintenance measure, therefore the technologically correct execution is very important and will save a considerable

Figure 5: Track ballast after 27 years of operation with approx. 500 million load tons

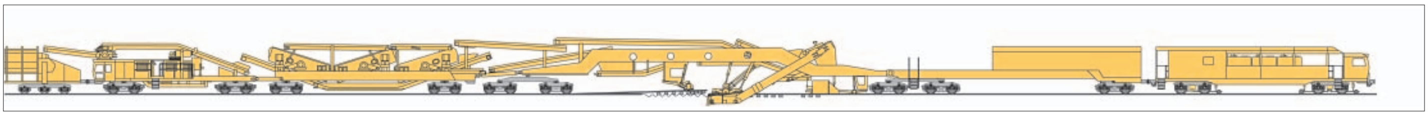


Figure 6: Ballast cleaning machine with triple-layer screening unit

amount of money in the long term. Basic principles for ballast cleaning are:

- ▷ The ballast bed must be excavated over its entire width. If polluted clumps of ballast remain on the shoulder, the drainage will not function later.
- ▷ The ballast excavation must be performed with a straight cut to produce a formation with the correct crossfall and a uniform course in longitudinal direction of the track.
- ▷ The entire depth of the ballast under the sleepers must be excavated because the greatest pollution is found in the lower area.
- ▷ Partial cleaning (for example shoulder cleaning) normally has little success, because a large proportion of the ballast attrition occurs in the area underneath the sleepers.
- ▷ The excavated material must be cleaned in vibration screening plants specially developed for track ballast, with few remaining fine particles and no excessive loss of usable ballast.
- ▷ The screened-out spoil must be evacuated to the front end so that the cleaned track is not polluted by spilled material.
- ▷ Re-ballasting must be carried out evenly and allow variation of the track height.

Practical construction of the RM 80 US ballast cleaning machine

For many years the ballast cleaning machines of the RM 80 series have been setting standards for high-quality ballast cleaning with high output. The RM 80 US now operated by the ÖBB is the latest development from this series. Like all Plasser & Theurer ballast cleaning machines, this machine has a transverse chain guide for the excavating chain to produce a smooth, straight formation which can be set exactly to the required excavating depth and formation cross-fall. During work this can be controlled and adjusted from the workplace or automatically by the measuring unit.

These special measuring and monitoring units consist of roller transducers, an electronic pendulum, the processing electronics and display instruments in the work cabin. The constant angle of the chain cutter bar is adjusted automatically with the help of the electronic pendulum. An optional rotation laser transmitter, which is set up at a distance of up to 300 metres, produces a laser beam sighting plane which hits the laser receiver (mounted on the outer side of the cutter bar). This laser unit performs automatic control of the excavation depth of the excavating chain to produce a straight formation.

A six-channel recorder is available for exact monitoring of the working quality which records the main parameters: excavation depth, formation crossfall, superelevation of the old track and of the cleaned track, twist of the cleaned track as well as track height and track lowering.

Excavation to a width of 7700 mm and a depth of 1000 mm enables ballast cleaning in switches without having to dismantle the switch. The excavating width can be varied by inserting intermediate links 500 mm wide in the cutter bar. Snap closures enable fast execution of this work. The four speed settings of the chain allow ideal adaptation to different ballast situations.

The triple-layer screening unit of the RM 80 US has been optimised with regard to screen angle, mesh size and vibration, is equipped with large-stone separation and achieves excellent results. The automatic superelevation compensation prevents one-sided distribution of the material on the screen surfaces.

Frequently it is necessary to add new ballast, due to the high percentage of spoil. The RM 80 US not only places the cleaned ballast coming from the screening unit evenly in the track using hydraulically adjustable baffles and slewing distributing conveyor belts, but also distributes new ballast via ballast chutes directly in the track, with an optional new ballast supply unit.

The spoil is loaded into MFS material conveyor and hopper units standing at the front using a slewing spoil conveyor belt in the area where the ballast has not yet been cleaned, or the spoil material is deposited at the side of the track. To ensure that overhangs and visibility comply with UIC regulations, the RM 80 US was equipped with a third cabin which supports the transfer conveyor belt for the spoil. For working movements this machine is in articulated design.

The new output category RM 800 Super 3S

Essentially the output capacity of a ballast cleaning machine is determined by the size of the screening unit and the excavating chain. In 1989 the RM 800 was the first ballast cleaning machine to be built with two screening units and one excavating chain steplessly adjustable to the excavating width. Outputs of up to 1000 m^3/h were achieved. This concept has prevailed and today machines with a double screening unit are already standard equipment on many railways because they enable full utilisation of the track possessions.

Due to the dense traffic situation on high-speed lines, even higher outputs will be needed in the future and this requirement will be met by a new category of machines fitted with three screening units.

The RM 800 Super 3 S (Figure 6) is a fully hydraulically powered multi-car machine with 10 powered axles consisting of drive unit, screening car, excavating car, power unit and tank and measuring trailer. All cars, except the tank and measuring trailer, are linked together by pivot coupling. The machine consists of the following sections:

Drive unit with conveyor belts for spoil, slewing spoil transfer conveyor belt that can also be turned for transit, one drive engine, diesel and water tanks, cabin at front and measuring axles to measure the track geometry before cleaning.

Screening car with three eccentric vibrating screens, conveyor belts for excavated material, cleaned ballast and spoil.

Excavating car with endless excavating chain, fully adjustable excavating width up to 5330 mm (with feeder plates), track lifting and slewing devices, conveyor belts for transport of excavated material to screening car, return transport of cleaned ballast, ballast hopper for cleaned ballast, ballast distributing conveyor belt and profiling plough, cabin in front of the excavating chain and behind the ballast distributing and profiling devices.

Power unit with two drive engines.

Tank and measuring trailer carrying three diesel tanks and measuring axles to measure track geometry after cleaning. Cabin with driver's control desk, workshop cabin and measuring recorder.

Measuring, guiding and recording devices plot the parameters excavating depth, formation crossfall, versine and superelevation, twist and lowering of the cleaned track.

Another machine with three screening units and two excavating chains, the **RMW 1500**, has been operating successfully in Germany since 2005.

Combination of ballast bed cleaning and track renewal

In order to utilise track possessions as fully as possible the trend is going towards combination machines which means that several stages of work are combined in one machine. Track renewal and ballast bed cleaning are nearly always carried out as a joint project because the new permanent way material should be installed on a perfect track bed. Up until now these jobs were performed in two separate operations using high-capacity machines and frequently it was necessary to perform a stabilisation tamping pass between ballast cleaning and track renewal in order to allow the track to be re-opened for traffic in between. The RU 800 S is the world's first combination machine for continuous track renewal and simultaneous ballast bed cleaning with supply of new ballast.

Figure 7: RU 800 S – picking up sleepers, picking up ballast, laying sleepers

Composition and function of the RU 800 S

The heart of the machine is the actual track renewal machine with integrated ballast bed cleaning (Figure 7). During work the middle bogie is raised by turning a spindle and the two four-axled bogies are displaced by 4.5 metres to the front or to the rear to obtain a clear working space 45 m long. This free working space ensures a gentle bending line for the rails during removal and laying.

The old-sleeper pick-up unit lifts up the old sleepers in continuous working action and conveys them on conveyor belts to the old-sleeper transfer platform. Then the ballast is excavated using an excavating chain. The excavating depth can be as much as 700 mm below the top edge of the sleeper. The old ballast is carried on conveyor belts to the double screening unit. There the spoil is separated from the reusable ballast. After this, the cleaned and the new ballast is taken back for insertion. A plough distributes the ballast in the ballasting area, taking care that the area in the centre of the track is lower in order to avoid centre-bound sleepers. Then the inserted ballast is compacted using plate consolidators. Immediately after this, the new sleepers are placed at the correct sleeper spacing. Due to the limited space available, the new sleepers are transported through the machine parallel to the track axis. For that reason the new sleepers are turned inside the machine, in pairs, the first time after the transfer platform and the second time before the laying unit.

The supply of new sleepers and evacuation of old sleepers is carried out by two gantry units which can pick up 30 sleepers at a time. The gantry units run on rails mounted on the sides of the cars. For transfer travel two 4-axled wagons with arched frames are used to transport the gantry units. During work the remaining rail fastenings are loosened underneath the frame of the first wagon. The drive engines are also mounted on this wagon. The second wagon carries the measuring equipment and a water tank.

Figure 8: RU 800 S – picking up ballast from the shoulder

Figure 9: RU 800 S – double screening unit

The shoulder excavation car (Figure 8) follows behind the relaying machine. Two shoulder cutters pick up the remaining ballast and pass it to conveyor belts for transport to the screening car. The excavating width of each cutter can be varied between 600 mm and 1250 mm.

The ballast storage and ballast distributing car following behind is equipped with a 30 m^3 buffer store for new ballast and/or cleaned ballast. The floor of the hopper is designed as a conveyor belt. Ballast distributing devices for the shoulders and for the sleeper cribs are mounted behind the hopper. In addition to this, an automatic action eight-spindle power wrench is mounted on the ballast hopper car which is suspended on the main frame so that it is longitudinally displaceable and tightens the rail fastenings in cyclic action. When Fastclips are used, the eight-spindle module is replaced before start of work by a Fastclip clipping unit.

The ballasting and power wrench car is followed by the screening car. Two eccentric vibratory screens (Figure 9) are in operation, as already used on other high-capacity ballast cleaning machines. The screens separate the re-usable ballast from the spoil. A total screening area of 46 m^2 guarantees the required output.

Material conveyor and hopper units are used to transport the spoil and the ballast. These are coupled to the end of the machine. The new-ballast MFS is equipped additionally with a conveyor belt to transport the spoil.

The advantages of the machine are the cost-efficient utilisation of track possessions due to the combined execution of track renewal and ballast bed cleaning, the avoidance of “lost work passes” and the technologically correct sequence of work: cleaning before renewal. It is even possible to perform ballast cleaning in restricted areas such as station platforms. Quality and costs in track renewal and track upgrading are further optimised thanks to the application of the RU 800 S.

Summary

In general, decisions concerning the project costs are made in the planning phase and only slight adjustments can be made in the implementation and operation phase.

It is therefore very important for the planning engineer to have full information about cost-saving methods of construction and they should already be laid down in the specification. This article presents newly developed machines and systems which are designed to improve the availability of the track for rail services. Therefore they offer high working speed and excellent quality and combine several working operations in one machine. Great attention is also given to the economical use of material resources such as track ballast.

Unimat 09-475/4S