

WITHOUT WELL BEARING FORMATION AND CLEAN BALLAST-BED NO STABLE RAILROAD

Poor Quality Rail-Tracks in Sri Lanka

By Dr. Frank Wingler, August 2018



Modern well ballasted High Quality, Rail-Track; Union Pacific "Sunset-Route", California, USA; Pict. by EK Verlag, www.eisenbahn-kurier.de

The Railway-Tracks of **Srilankan Railways** are a shining teaching sample that a long-lasting well aligned rail-track, matching the traffic load it has to carry, is not possible without a well drained and well bearing Formation, a thick Formation Protective Layer (FPL, "Blanket" or "Sub-Ballast") and a proper and clean Ballast-Bed. The memory for the track misalignments in Sri Lanka is mostly buried in the poor bearing, damaged or even missing formation. The biggest obstacle for the Colombo Suburban Railway Project, to make the track fit for faster and more frequent commuter service, are not the current 90 pound rails but the poor bearing, yielding and unstable formations, or even the missing formation, and the improper and poor ballasting. Envisaged long welded UIC 60 rails alone will not do the job. See: **COLOMBO BACKS RAIL TO TAKLE CONGESTIONS** by Keith Barrow, in International Railway Journal, August 2018, page 30, and **SIGNS OF PROGRESS IN ISLAND REVIVAL**, by Rohan Gunasekera, in Railway Gazette International, August 2018, page 62.

Envisaged electrification will not bring alleviation for the current low route capacity and low train speed, if not the rail-tracks from Kalutara up to Negombo and Rambukkana will face comprehensive formation reengineering, rehabilitation and strengthening, as well proper ballasting. The current poor quality rail-tracks on weak formation need constant and costly

maintenance and repair – *“nearly as every train goes”* = former GMR Mr. Priyal De Silva - ; see Fig. 1:



Fig. 1: Typical poor Quality Srilankan Rail-Track with nearly no Ballast on poor bearing Formation; Pict. from Ceylon Railway Forum

Due to poor quality tracks, train Derailments, especially on the Upcountry or Uva-Line, are frequent; Fig. 2a/b:



Fig. 2a: Train Derailments on Srilankan un-ballasted Rail-Tracks, especially on the Upcountry (Main) Line (Uva-Line) are frequent; Night Mail Derailment on un-ballasted Rail Track with Concrete Sleepers near Kotagala; Pict. by Daily Mirror



Fig. 2b: S11 Power-Set Derailment on poor ballasted Track of SLR Northern Line

On the poor ballasted and poor aligned “bumpy” SLR tracks on poor bearing formation the train-speed and the riding comfort are low.

Quotations for Fundamentals of Rail-Track Technology:

- ◆ A rail-track is only as good as what is underneath.
- ◆ Without well bearing and well drained formation (subsoil, subgrade, blanket) no stable rail-track.
- ◆ Water is the enemy of a rail-track.
- ◆ The longevity depends, if the water can be taken out and kept away from the track-bed.
- ◆ Ballast is the blood of a rail-track.
- ◆ Without a well dimensioned and clean ballast-cushion no alignment-stable rail-track.



Fig. 3: Cross-Section of a Rail-Track; Pict. by F. Piereder

What does Ballast do?:

Ballast is a key part of the track system.

- ◆ It supports and arrests the sleepers against both vertical and lateral movements under traffic load;
- ◆ it spreads the loading from the sleepers onto the formation;
- ◆ provides a drainage path for precipitation;
- ◆ it facilitates to adjust and align the geometry of the track.

Those tasks can only be fulfilled, if there is a 30 to 35 cm thick well packed and clean ballast cushion under the sleeper-sole, if the space between the sleepers is boxed up with ballast and if there is a wide ballast shoulder at the end of the sleepers.

On Long Welded or Continuous Welded Rail-tracks (LWR/CWR) without fishplate joints, the ballast has not only to spread the load equal on the formation to avoid formation damage, but has also to arrest the longitudinal forces created by expanding or shrinking rails with the temperature.

In Sri Lanka there is no much difference between hot and cold, and hence the rails develop only little expansion and shrink forces with temperature variation. Rails are clamped onto the sleeper base-plate by their weight and in addition by the clamping force of elastic rail clips. This means that if the sleepers are properly arrested in a proper and well packed/tamped and un-fouled ballast bed over a well bearing formation, fishing rail-joints with fish-plates are not needed. Up to a curve tightness of 7 Degree all the rails could be continuously welded by Alumino-Thermic (AT) welding or better by electric flash-but welding.

Presently only the IRCON refurbished and rebuild rail tracks from Matara to Kalutara and north of Omanthai are laid on a proper ballast-bed and therefore allow long or continuous

welded rails providing a better long-living alignment and reducing drastically the maintenance expenditures.

Wooden sleepers are elastic and therefore gentle to ballast and formation. The contact area between ballast stones and the sole of wooden sleepers is in the range of 30 to 35 % since edges of ballast stones can penetrate into the sleeper sole.

Concrete sleepers are rigid and not elastic. The contact area between ballast stone edges and the sole is in the range of only 10 to 12 %. Therefore concrete sleepers are unfriendly to ballast and formation. Modern railways provide nowadays concrete sleepers with a rubber under-sleeper pad prolonging the life-time of ballast up to 3 times and prolonging the tamping cycles; see **Fig. 4a/b**:



Fig. 4a: New laid Concrete Sleepers with Under-Sleeper Pads; Pict. by Getzner, Austria



Fig. 4b: Increased Contact Area with Under-Sleeper Pads; Sketch by Getzner, Austria

When replacing wooden sleepers by concrete sleepers the bearing properties of the formation components and the thickness of the ballast cushion have to be increased to compensate the loss of elasticity. If not done, ballast degradation and formation damage will be the result; see **Fig. 5**:



Fig. 5: Formation and Ballast Damage caused by Concrete Sleeper on poorly ballasted Track after Replacing Wooden Sleeper; UVA Railway; Pict. by F. Wingle

Trough steel-sleepers have the advantage that they tolerate a thinner ballast cushion with only marginal ballast shoulders, provided the trough is filled inside with clean and unfouled ballast stones, which interlock for crib with the stones of the ballast-cushion. They do not tolerate, if they are laid without a proper ballast cushion on muddy and wet earth, as on the UVA Line in Sri Lanka; see **Fig. 6**:



Fig. 6: Result of Laying new Steel-Sleepers without clean Ballast on UWA Line, Rozella-Hatton; the “dancing and tilting” Steel-Sleeper crush the Formation Material into Mud and submerge; Pict. by F. Wingle

What does a Formation Protective Layer or Blanket do and what happens if the Ballast depth is insufficient?:

There is a strong correlation between ballast problems and problems in maintaining good track geometry, alignment and quality.

For a single line broad-gauge track the top formation should have a width of 7800 mm to enable a proper geometry of the substructure components. Between the top of the formation with a width of 7.80 m and the ballast-bed of 30 to 35 cm depth there should be a 25 to 50 cm thick Formation Protective Layer (FPL), also called Blanket or Sub-Ballast, of a fine grain rock material of a particle size distribution from 0.02 to 30 mm with a maximum at 4 mm. Suitable is an Aggregated Base Course, ABS, used also for road constructions. A Geotextile layer between the top formation and the FPL prevents ABC and formation material to penetrate into each other. The FPL has in addition the task to distribute the forces onto the formation avoiding formation damage; **Fig.7/8:**

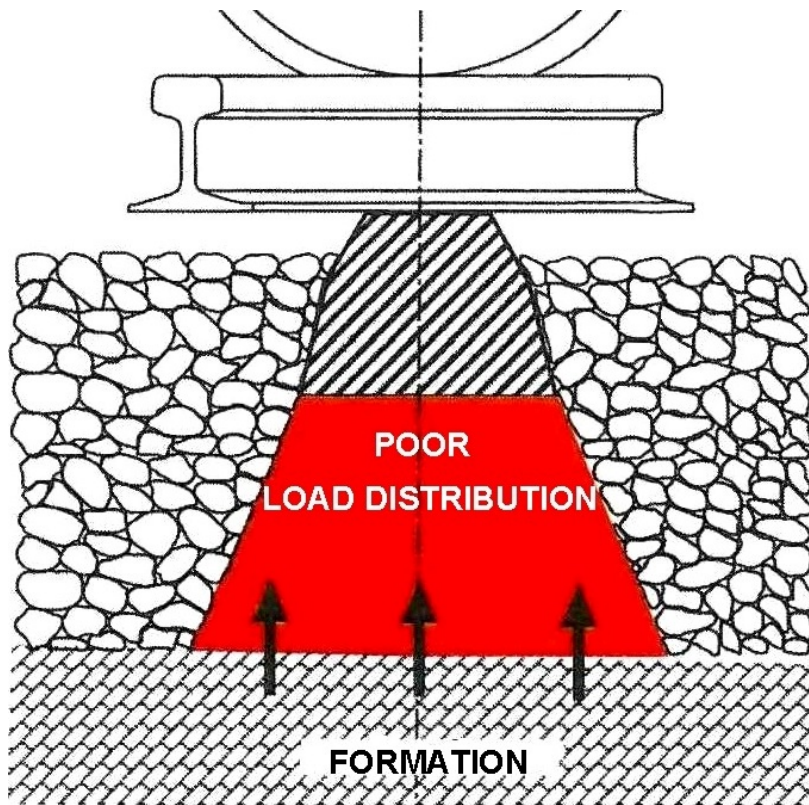


Fig. 7: Unfavorable Load Distribution and higher Formation Pressure on Track without Formation Protective Layer (FPL); Formation Material can penetrate into the Ballast Bed thus fouling the Ballast; Diagram by B. Lichtberger, Track Compendium

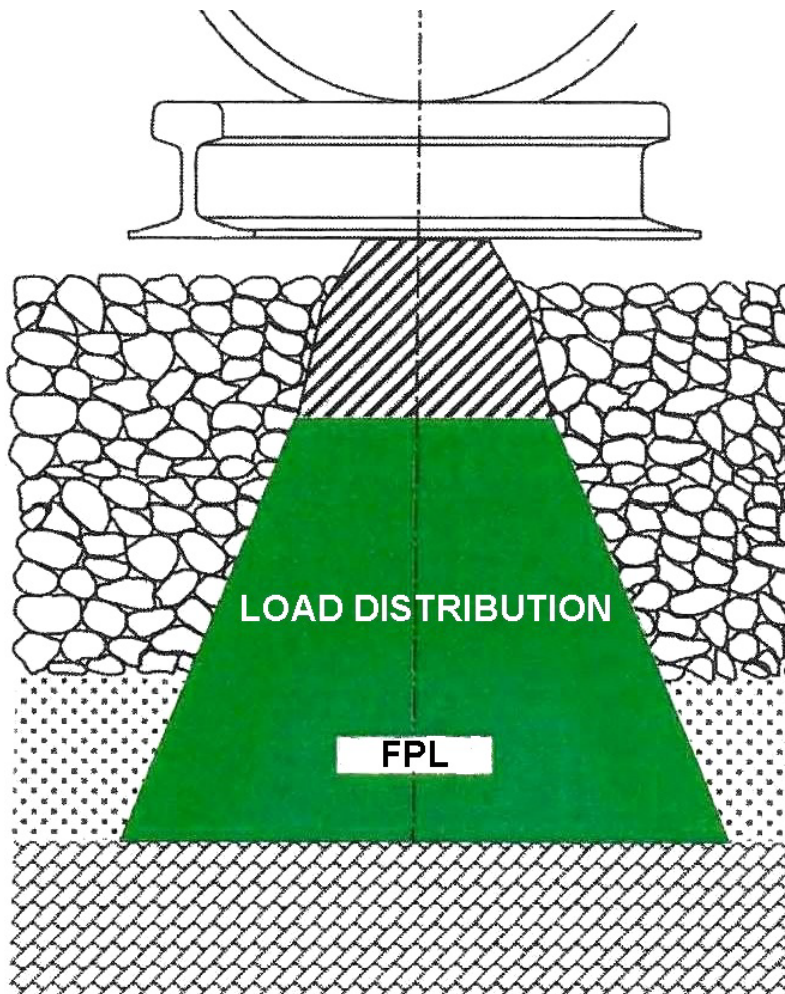


Fig. 8: A FPL spreads the Load on a wider Area and prevents Formation Material and Ballast from mixing; Diagram by B. Lichtberger, Track Compendium

If there is nearly no ballast or only marginal ballast and hence the Load Distribution not sufficient, the concrete sleeper will “dance” under dynamic traffic load, hammer the few ballast stones into the formation, formation material will pop up, and the marginal ballast stones get either crushed to dust or submerge in the formation. Overloading of formation due missing ballast and missing formation protective layer cause soil to penetrate into ballast vice versa. Formation material and ballast are mixing. This happens all over insufficient ballasted SLR Tracks. Water cannot be drained any more out and forms with the fouling materials a mud-slurry. Such tracks need high expenditures for “*maintenances nearly as every train goes*”, see Fig. 9a,b/10/11/12:

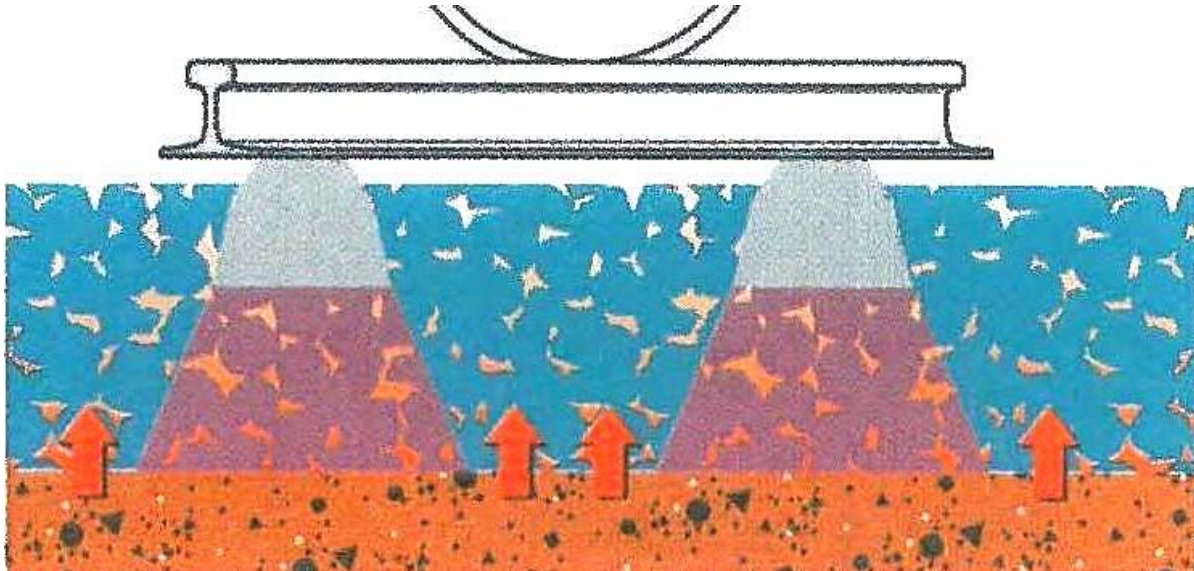


Fig. 9: Destruction of Formation and Fouling of Ballast due to insufficient Load Distribution with fouled Ballast; Diagram by B. Lichtberger, Track Compendium



Fig. 9b: Ballast and Formation-Material are mixing due to insufficient Ballasting and missing Formation Protective Layer, Pict. by Plasser&Theurer



Fig. 10: Result of insufficient Ballast Depth and fouled Ballast causing Formation Damage on SLR Track; Slurry rises up through the Ballast and Ballast-Stones submerge into the Formation; Pict. by F. Wingle

Loose and “dancing” concrete sleepers moving under traffic in an insufficient packed/tamped ballast-bed crush the stones to dust. In dry season such spots can be detected by white marks on the sleepers and rails; **Fig. 11a/b:**



Fig. 11a: White Marks on “dancing”/badly packed Concrete Sleepers caused by Ballast Abrasion



Fig. 11b: White Ballast Stones created by “dancing” Sleepers in poor packed Ballast-Bed: Pict. by IBES Baugrundinstitut GmbH

During rainy season the mud forms slurry and during dry season the mud gets cemented and creates dust. During dry season one can see SLR tracks “fuming” when a train runs.



Fig. 12: Typical “Mud-Pump” of “dancing Sleepers” on SLR Track; Pict. by F. Wingle

During rainy season the mud forms slurry and during dry season the mud gets cemented and creates dust. During dry season one can see SLR tracks “fuming” when a train runs.

Best Practice in Ballast and Formation Management/Maintenance:

Ballast must be kept clean and free from impurities, and the correct profile must be maintained.

Vegetation along the track (trees, bushes) fouling the ballast by falling leaves/foliages must be pruned or removed.

Advanced railways clean the ballast-bed in intervals after 4 to 10 years and replace of missing ballast; nowadays with heavy duty on-track ballast cleaning machinery; **Fig. 13a/b/c:**



Fig. 13a: Plasser&Theurer Ballast Cleaning Machine, RM 802; Pict. by Plasser&Theurer



Fig. 13b: Plasser&Theurer PM 200 2R on-Track Rehabilitation Train; Pict by Plasser&Theurer



Fig. 13c: Schematic Presentation of Track Rehabilitation Train; Sketch by Plasser&Theurer

A simpler tool to excavate contaminated soil, mud and fouled ballast is an Off-Track Under-Cutter mounted to a caterpillar backhoe-loader with an excavating under-cutting blade; **Fig. 14/15:**



Fig. 14: Off-Track Blade Under-Cutter, Hulder, USA; Pict. by Hulder



Fig. 15: Removing Mud and Muck from under the Sleepers with Off-Track Under-Cutter; Pict. by Hulder

For formation and blanket/sub-ballast rehabilitation modern railways use heavy duty and high performance on-track rehabilitation machineries; **Fig. 16/17:**

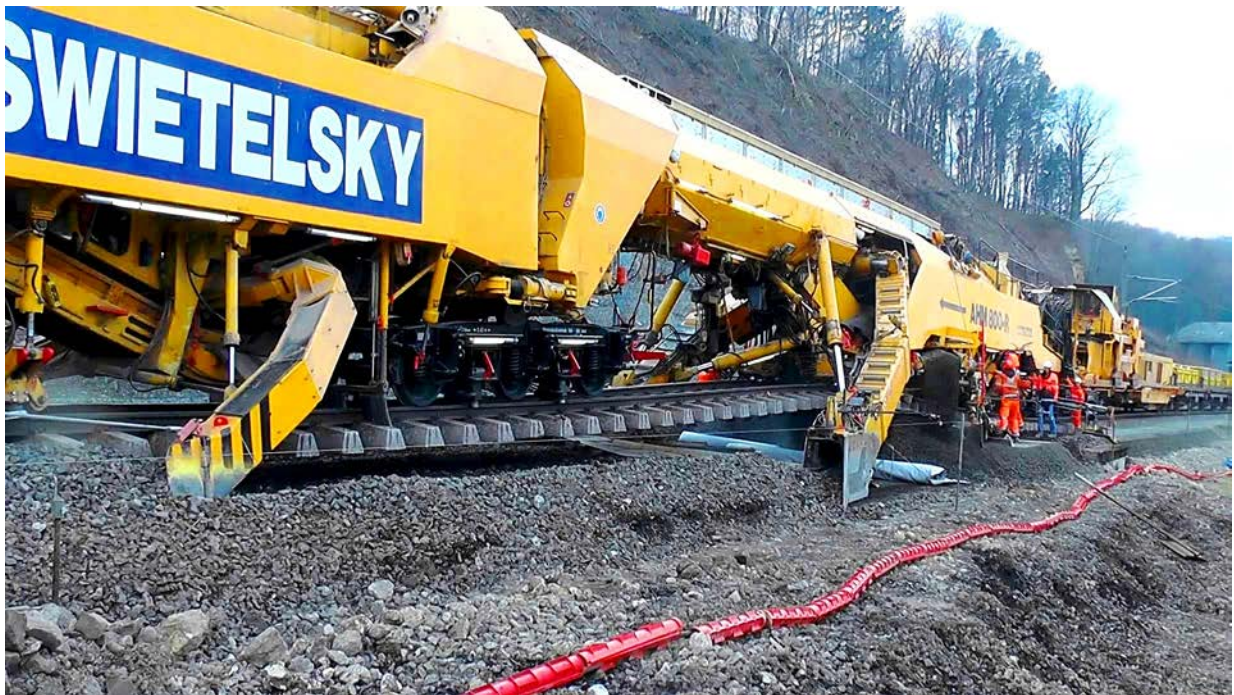


Fig. 16: Formation and FPL Rehabilitation with Geotextile through on-Track Machinery; Pict. by Plasse&Theurer

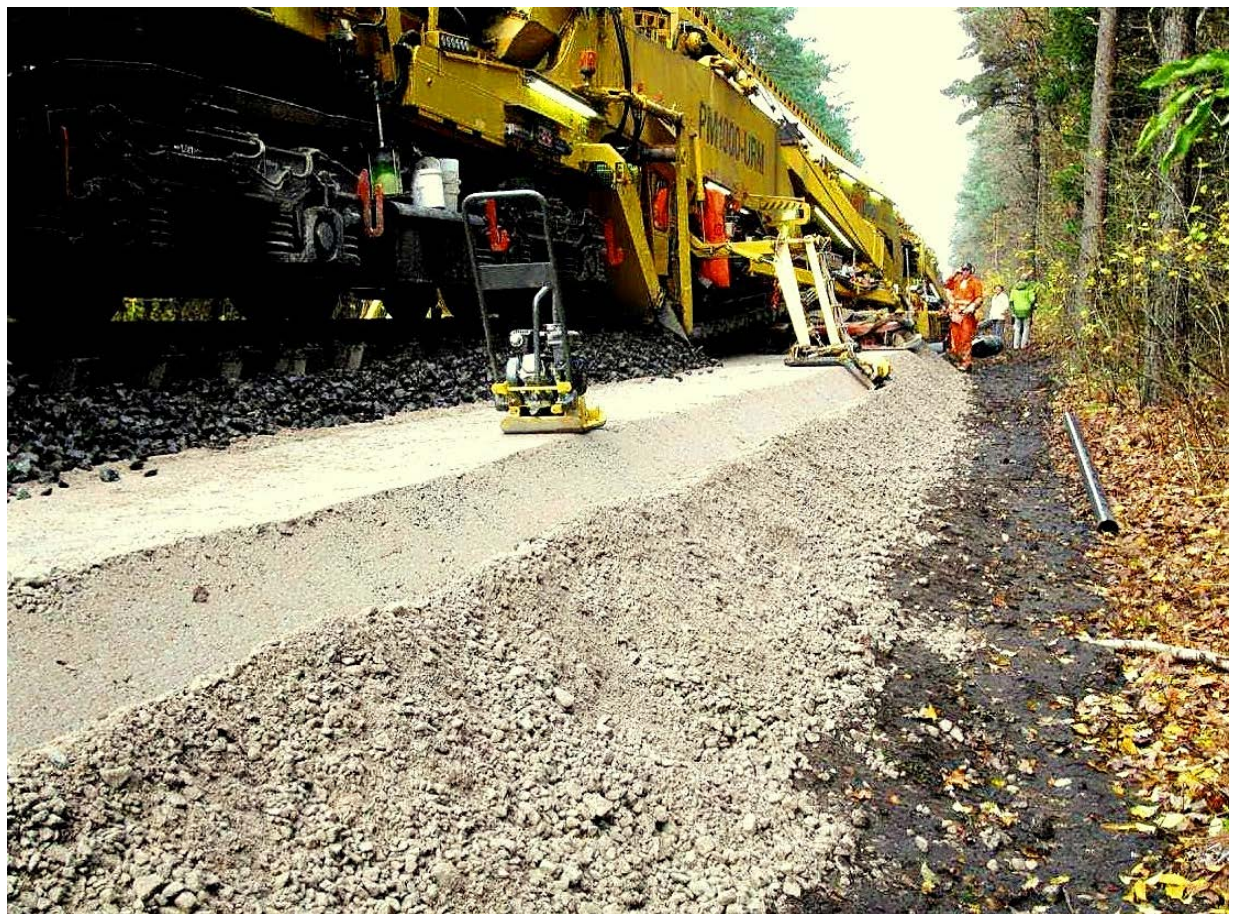


Fig. 17: Formation, FPL and Ballast Rehabilitation with on Track PM 1000 URM Machinery; Pict. by Plasser&Theurer

The top of a rehabilitated Formation Protective Layer (FPL) should have a slope of 1 in 20 to 1 in 40 to both sides in order to allow water to be drained to the sides; **Fig. 18:**

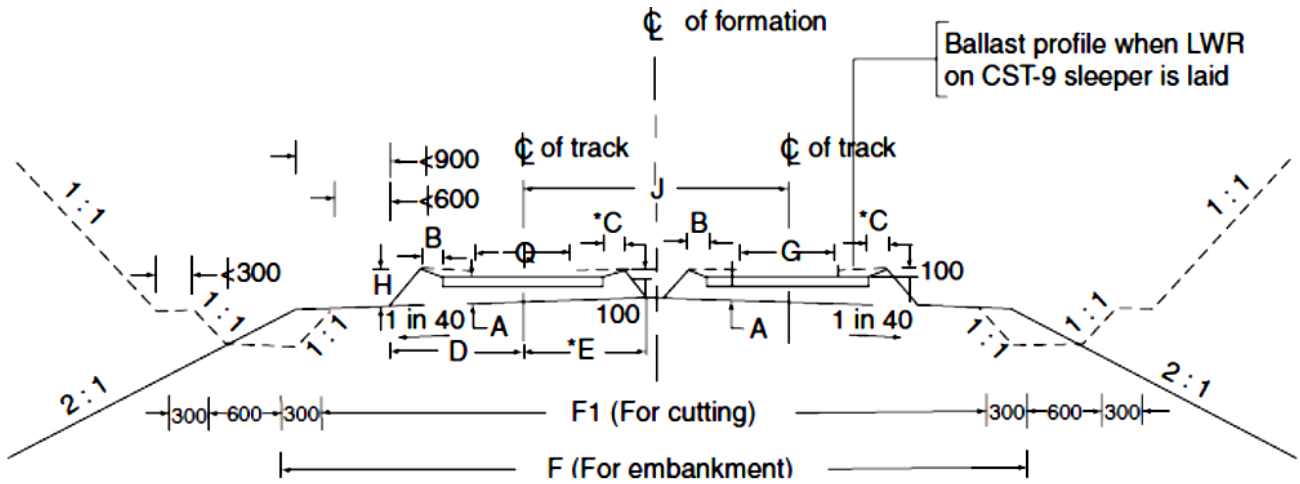


Fig. 18: Cross Section/Profile for a BG Double Track; Fig. by RDSO, India

Indian Railways have shown that in a traffic block of 4 hours 125 m of track can be completely removed, ballast and bad formation material excavated, core material (moorum) filled and compacted, a blanket and a fresh ballast cushion provided and finally the stabilized track re-laid; see **Fig. 19:**



Fig. 19: Formation Rehabilitation with conventional Off-Track Machinery under Traffic Block with complete Track-Removal; see paper No. 23 on **Formation Treatment with Moorum....**, presented by T. Anil Kumar, S. Veerama and U. Sarath on IPWE International Seminar, 23-24th Febr. 2018, at Guwahati, India

In lieu of such machineries ballast can also be conventional cleaned by manual "Deep Screening", working from sleeper to sleeper; **Fig. 20:**



Fig. 20: Ballast Cleaning through manual “Deep-Screening”; Pict. by Andy Franklin, Carillion Rail, UK

For lifting, aligning and leveling and as well for packing of ballast on tracks, where there is a sufficient ballast depth, SLR has two computerized heavy duty on-track Plasser&Theurer Tamping Machines; **Fig. 21:**



Fig. 21: New Sri Lanka Railway Plasser&Theurer on-Track Lifting, Aligning and Tamping Machine; Pict. by Primal Madusanka

Hydraulic driven and vibrating tines pack the ballast stones under the lifted and aligned rails cum sleepers; **Fig. 22:**

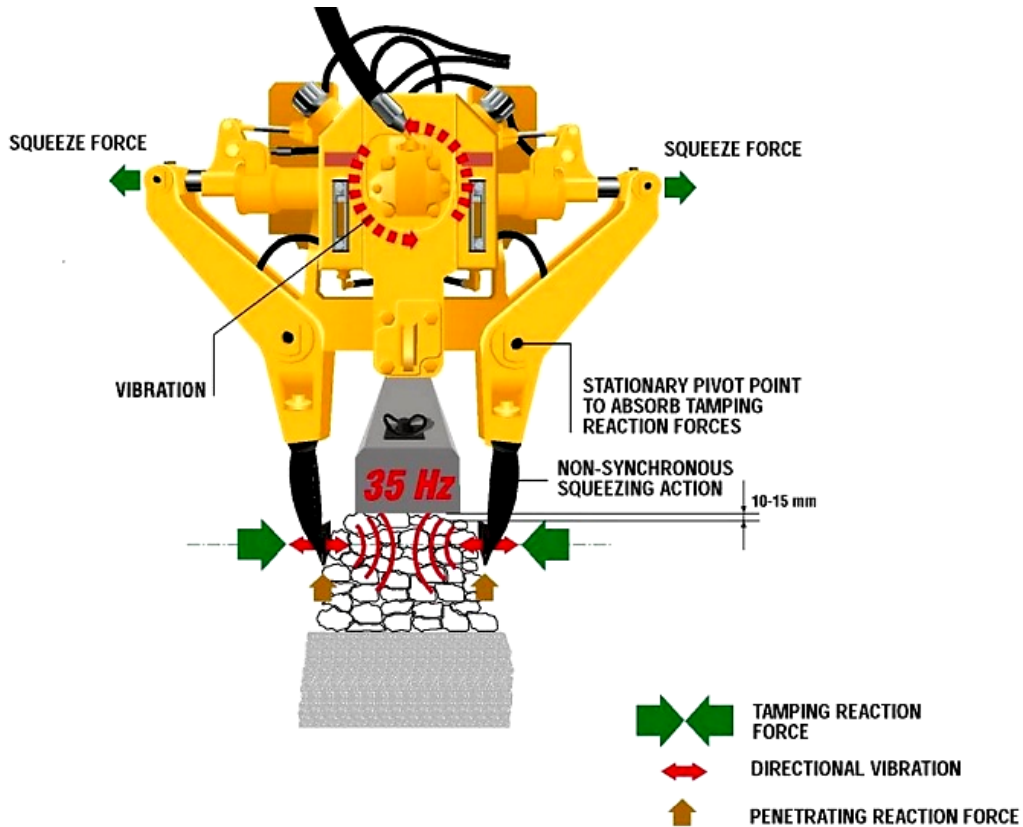


Fig. 22: Schematic Presentation of Tamping Tool Functions; Pict. by Plasser&Theurer

After tamping advanced railways consolidate the track with a vibrating Dynamic Track Stabilizer to allow using after aligning and tamping the track immediately with booked train speed. Through dynamic stabilization the stones get orientated in denser packing. Without dynamic stabilizer the consolidation by train traffic needs some weeks at reduced train-speed; **Fig.23/24:**



Fig. 23: Pl&Th Dynamic Track Stabilizer DGS 62 N; Pict. by Plasser&Theurer

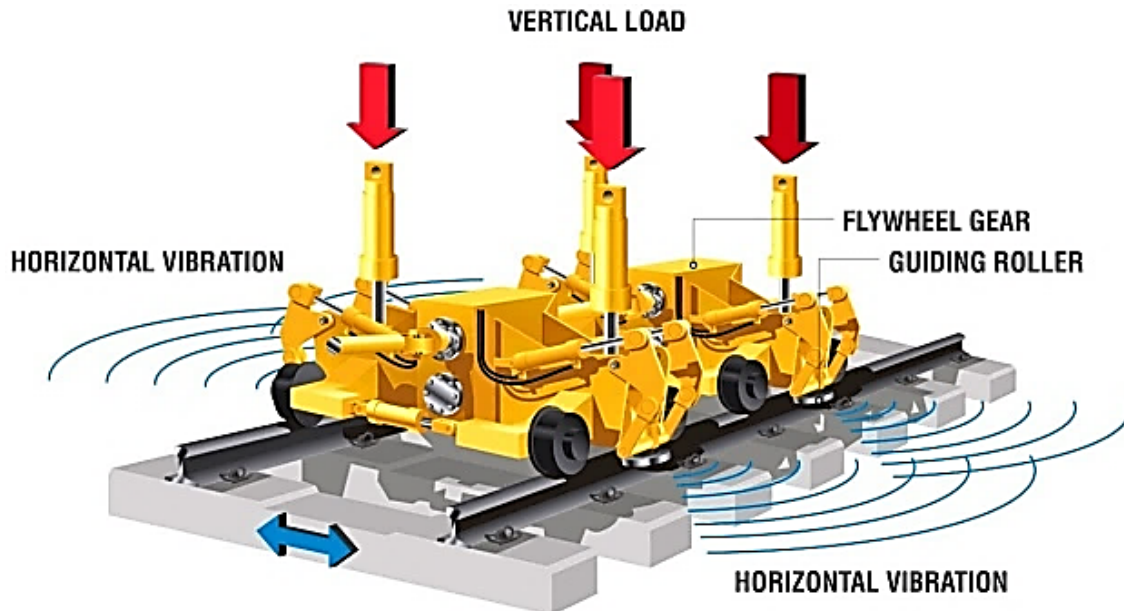


Fig. 24: Working Principle of dynamic Vibration Unit; Pict. by Plasser&Theurer

FAZIT: To be stingy with Ballast and Formation-Rehabilitation is not only uneconomical; it has also a disastrous Track destroying Effect, increases the Derailment-Proneness and causes high Maintenance Expenditure. Investment in Drainage- and Formation-Rehabilitation and in proper Track Ballasting is no Luxury. It cuts overall Life Cycle Costs, allows to increase the Train-Speed and Route Capacity, it increases the Safety and reduces the Derailment-Proneness. Formation reengineering and rehabilitation, drainage improvements, provision of formation protective layers and track ballasting should be given top priority in the envisaged modernization program for Sri Lanka Railways; see: Final Report on *URBAN TRANSPORT SYSTEM DEVELOPMENT PROJECT FOR COLOMBO METROPOLITAN REGION AND SUBURBS, URBAN TRANSPORT MASTERPLAN*, Japan International Cooperation Agency, August 2014; Rohan Gunasekera *SIGNS OF PROGRESS IN ISLAND REVIVAL*, Railway Gazette International, August 2018, p. 62.



Fig. 25: Srilankan Main-Line „BALLAST-LESS“ Rail-Track; Pict. by F. Wingler



Fig. 26: Srilankan "EARTH-WORKS" for "BALLAST-LESS" Rail-Track; Pict. by F. Wingle



Fig. 26: The only Broad Gauge Main-Line Track around the Globe with Concrete Sleepers laid on a poor bearing Formation with nearly no Ballast Cushion; SLR Upcountry/Uva Line; Pict. by Ceylon Railway Forum

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