MODERN RAIL TRACK TECHNOLOGY helps to cut LIFE CYCLE COSTS.

LIFE CYCLE COSTS CONSIDERATIONS are tools for economical TRACK STRATEGIES. Under such Considerations modern Track-Technologies have been pushed up.

University Professor JOHN RUSK, Oxford, UK, 1819-1900, gave a quotation, which can be evaluated as a summing-up for economical proof on basis of QUALITY, LIFE CYCLE COSTS and LIFE CYCLE COSTS CONSIDERATIONS:

“In this world there is nearly nothing, which someone can manufacture with some lower quality and sell it cheaper. And the people, who are only orientated towards the price, consequently will get captured by such machinations. It is unwise to pay too much, but it is worse to pay too little.

If you pay too much, you might lose some money on the long run. On the other hand, if you pay too little, you might lose everything on the end, because the purchased item cannot fulfil the task for which it is meant.

The rule of economics and commerce do not allow obtaining higher value for smaller money. If you accept the lower bit, you will have to take precautions for a risk cover and for additional risk induced costs. And if you behave accordingly the rule of economy and commerce than at the beginning you have also enough money left to pay for something better!”

Private mining corporations with their own HEAVY-HAUL rail-roads in Africa, Australia, Brazil and Norway/Sweden have a sense for OVERALL LIFE CYCLE COSTS inclusive the AGGREGATED HINDERANCE COSTS, generated when the trains can only run under speed restrictions, under lower traffic density or cannot run at all. The private undertakings know about the importance of INITIAL TRACK QUALITY, STATE-TO-THE ART RAILROAD TECHNOLOGY and the all-important WHEEL-RAIL INTERFACE. They have learned to manage the wheel-rail interface at its optimum by looking out for track friendly rolling stocks (bogies), by target profiling both wheel treats and rail heads for low friction and wear and by rail and wheel-flange lubrication. This is called “Friction Management”. The economy has pushed the technology already to the performance with 43.5 t axle-load. Developments are under way to increase the axle-load up to 45 t; see Keith Borrow, PILBARA’S HEAVYWEIGHT CHAMPION FLEXES ITS MUSCLES in IRJ, International Railway Journal, November 2015 Volume 55, Issue 11, page 20ff.

Private heavy-haul operators know:

Without a well bearing, well drained and stable blanket, sub-soil, sub-grade and formation there will no stable rail track under given traffic load.
In state owned railways mostly one section feels responsible only for the track and the other section only for the rolling stocks. There is often a lack of mutual understanding, responsibility and cooperation between the disciplines. This has the result that often rail tracks do not match the traffic load they have to carry vice-versa. The developments of Tracks and Rolling Stocks when running apart are not in compliance.

Fundamentals of Rail-Road Technology in a Nutshell:

“WATER IS THE ENEMY OF THE RAIL TRACK AND RAIL-ROAD”;  
“BALLAST IS THE BLOOD OF THE RAIL TRACK”;  
”TRACK QUALITY IS NO LUXURY”;  
”A LOWER QUALITY TRACK DETERIORATES FASTER THAN A HIGH QUALITY TRACK”;  
“WITHOUT PROPER WELL BEARING AND WELL DRAINED BLANKET, SUBSOIL, SUBGRADE AND FORMATION NO STABLE RAIL-ROADS”;  
“ONE HAS TO MANAGE EFFECTIVELY THE ALL-IMPORTANT WHEEL - RAIL INTERFACE”.  
“POLITICAL INTERFERENCE AND CORRUPTION CAN WRECK QUALITY”;

A railway consists not only of individual components viewed separately, but of an ENTITY of the "ROLLING STOCK/WHEEL - TRACK" System. Rail-Road and Rail Vehicle interact actively. Defective tracks ruin rolling stocks and ruined bouncing, yawing, rolling and
pitching rail vehicles distort and deteriorate the already poor tracks further in an **INTERACTIVE MUTUAL SELF DESTROYING SYSTEM.**

The individual components of a rail-road, sub-soil, sub-grade, formation, sub-ballast (blanketing, formation protective layer (FPL), ballast, sleepers, rails and fastening materials behave interactive and have to be treated as an entity. Strategies must be based on treating the track as a whole structure rather than treating the individual elements or components. Each of the components interacts with the other components individually. Strengthening only one component to a level well beyond the strengths of the other components will provide only incremental and inefficient overall strength improvements.

As an typical example: Sri Lankan Track Policy and Strategy of the last decades has clearly demonstrated, that the "**SOLO FIDDLE ON THE SUPERSTRUCTURE COMPONENTS**" (sleepers, rail fastenings, rails) without a proper appropriate sub-grade, sub-soil and formation strengthening and without taking the water out and keep the water away from the track-bed by a proper surface water drainage management led only to a further degradation of the rail-roads; see also Mike Knutton and Malcom Owens in IRJ, International Railway Journal, August 2004, p. 25.

**The track must:**

- guide vehicles in a smooth way without risks of derailments and without excessive wear and tear of rails, wheels and rolling stocks,
- take up vertical and horizontal vehicle forces,
- off-load these forces via the track grid and ballast/sub-ballast bed onto the bearing formation, sub-grade and sub-soil,
- ensure high riding comfort, passenger comfort, satisfaction and safety,
- high availability for train traffic under low **OVERALL LIFE CYCLE COSTS** and low **AGGREGATED HINDERANCE COSTS** (costs generated, when the trains are not running or only with speed and traffic load restrictions).

**The RAIL-WHEEL SYSTEM** transmits vertical and horizontal forces onto the track. Furthermore the track is subjected to the influence of longitudinal forces arising because of changes in temperature. It gets stressed by the acceleration and brake deceleration efforts of the rail vehicles. The track is also stressed by quasi-statistic, low frequency and dynamic force components of high frequencies (wheel roaring on corrugated rails).

**The figure below schematically represents the WHEEL-TRACK-SYSTEM.** The individual parts of this system are linked by components exerting elastic and damping effects. The elastic and damping elements between vehicle bodies, as well as between bogie and wheel set, are well known, and their behaviour can be very well expressed mathematically.
Schematic Demonstration of the Wheel-Track System

The track itself with its elasto-plastic properties cannot be expressed by an exact analysis because of the inhomogeneous behaviour of the ballast bed, the formation protective layer (FPL) or blanket material/sub-ballast on top of the bearing formation, sub-grade and sub-soil. Empiric parameters and connections found out by experiments are used for this purpose.

The strength of these forces is a function of the axle-load, of changes in wheel loads when negotiating curves or in case of unequal loading, of braking and starting forces and the rolling of ovalized unbalanced wheels on a defective track.

The track grid has to distribute these forces in such a way that the maximum admissible values for ballast compression below the sleepers and the admissible compressive strain on the bearing soil will not be exceeded.

A rail track on rigid concrete sleepers needs therefore a better bearing and wider formation and a thicker damping ballast cushion with harder ballast stones under the sleepers than a rail track on wooden or timber sleepers. This means that when changing from wooden sleepers to concrete sleepers the bearing formation has to be strengthened, widened, and a thicker ballast spreading, best with harder ballast stones on a sub-ballast bed, provided, otherwise the formation will be damaged. Steel-Sleepers have the advantage of longevity and toleration of troublesome and narrow formations with less ballast; but they do NOT TOLERATE WET MUD.

The bottom of concrete sleepers touches the ballast stones only by an area of 10 to 11 %. Moving or “dancing” concrete sleepers crush the ballast edges to dust, forming a slurry with water and fouling the ballast bed and its elasticity. With under-sleeper pads the
contact-area can be increased from 10 to 35 % and the tamping intervals prolonged by 2.75 times.

In Austria lacing the sole of the concrete sleepers with a rubber pad has become standard. This increases the life-time of the ballast and the track by up-to 38 % and reduces maintenance expenditures:

![Diagram of Under-Sleeper Pads for Concrete Sleepers cutting Life Cycle Costs; Drawings by Getzner, Austria](image)

It must be considered by all railway men, engineers inclusive the top management that in order to run the traffic at appropriate speed, the rail-wheel and track-rail vehicle interactive forces have to be well understood.

“**It is urgently necessary to remind the responsible persons repeatedly about the mechanism of wheel-rail interactivity in order to secure the safe rail-wheel contact**”. = **Prof. Dr. Klaus Rießberg, Technical University of Graz, Austria, in ETR 10/2007, Eurail press, Hamburg, page 621.**

It has to be well understood that without comprehensive drainage and formation/sub-grade rehabilitation, reengineering and strengthening a moribund track cannot be brought to a level matching the traffic load in order to render a smooth, risk free and overall economical train service.

It must be understood, that the main track structure is provided by the ballast, sub-ballast (blanket) and the well-drained compact broad and well bearing formation. A Broad Gauge concrete sleeper single track needs a 7.5 to 7.80 m wide top formation. The solo fiddle on the superstructure only with rail, sleepers and fastenings provides only a short lasting and jugglery cheaper alleviation.

The **QUALITY** can be estimated by the **DETERIORATION RATE** under given Traffic Load, by the loss of Alignment Parameters and Track Support Modulus with the time under given traffic load; *(see the contributions of Prof. P. Veit and Dr. B. Lichtberger in RTR Special,)*
The **LONGIVITY** of a Track Rehabilitation depends, if the water has been taken out and kept away from the track bed, and if the bearing capacity of the formation had been strengthened. The formation is by 40% responsible for the elasticity of a rail-road.

**DRAINAGE** of the track is the single most important factor for proper maintenance. Proper drainage is vital as excess water reduces the bearing capacity of the sub-soil as well as its resistance to shear. Water in the sub-grade or sub-soil is mostly the cause for a misalignment-memory effect; see M.M. Agarwal in *INDIAN RAILWAY TRACK*, 15th revised edit., reprint 2007, Prabha & Co., Delhi, India, ISBN: 81-900613-1-3, page 461, 229, 233.; Dipl. Ing. Dr. P. Veith in RTR Special MAINTENANCE & RENEWAL, July 2007, ISBN 978-3-7771-0367-9, Eurail press, Hamburg, page 11.

Track engineers should be aware that very often the memory for track defects, misalignments and settlements is buried in the uneven and faulty formation, sub-grade and sub-soil with fluctuations of the bearing capacity subjected to climate seasons and rain down fall patterns. Seasonable fluctuations of the ground water level can contribute to the **MEMORY EFFECT**. An appropriate surface-water management is therefore essential.

The intervention threshold for formation rehabilitation is given, when the support modulus falls below 10 MN/m². Given norms, parameters and values for the **BEARING CAPACITY OF THE FORMATION** (measured by the plate load bearing test or by the dynamic plate load method; see Chapter 18) as well for the characteristic soil parameters as compaction ratio, water content, plasticity parameters, shear strength, the tensional and expansion behaviours, effective tension should be known (see Dr. B. LICHTBERGER in *TRACK COMPENDIUM*, 2nd edition, ISBN 978-3-7771-0421-8, Eurail press, Hamburg, Germany, 20011, Chapter 7/8; RDSO Pamphlet “Guidelines and Specifications for Design of Formation for heavy Axle-Load.; Report No. GE: 0014, 2009, Lucknow, India).

The specific tracks should be determined by their **TRACK SUPPORT MODULUS** in the unit [N/mm²] or [MN/m²] or [MPa], measured as deflection of the track under given load. According Prof. A. Kerr, *FUNDAMENTALS OF RAILWAY TRACK ENGINEERING*, Simmons- Boardman, Books, Inc. Omaha, NE 68102, USA, ISBN: 0-911382-40-2, page 89, for a wooden sleeper track with dog spikes a Modulus of approx. 6 N/mm² is sufficient whereas for a track with the stiff concrete sleepers the Modulus should be in the range of 40 N/mm². The stiffer concrete sleepers transmit to the sub-grade a higher pressure and may create sub-grade failures where none existing when wooden sleepers were used.

By physical laws the track stability, stiffness parameters and moduli have to be increased by 62%, if one wants to increase the train velocity from 80 to 100 kmph under the same traffic load. The necessary increase of stiffness and strength goes logarithmic with the velocity. With increase of the train speed not only the short wave length misalignments but also the long wave misalignments have to be rectified to a minimum of few millimetres.

The strength of a rail track is determined by the bearing capacity of the well-drained formation. The fatigue of a low quality track under increasing train load stress can be proportional to the 4th or 5th power (exponent) of the load, as can be the damage to the ballast. The damage inflicted by the traffic load onto a poor quality track is by exponents higher than onto a good quality track. **A bad quality track deteriorates much faster than a good quality track.** The quality of a track can be measured in physical terms by the deterioration rate, by the loss of alignment and the track support modulus under given traffic load with the time.
The loss of quality under traffic stress of a track, which is not in compliance with the traffic load, causes an immense increase in routine-maintenance expenditures. Since a poor quality track deteriorates much faster than a high quality track under the same traffic load stress, a poor quality track needs much higher maintenance costs, which can be 10-fold higher. It is highly uneconomical to render a railway service on a poor quality track not matching the traffic load; see Prof. R.A. Smith, Vice President of Institution of Mechanical Engineers, London, UK, in IRJ Vol. 949, Issue 2, Feb. 2009, page 9; A. Beck et al. in Permanent Way Technology Management, Netz AG, German Federal Railway, in ETR, Vol.4, page 159, 2009; B. Lichtberger in DER EISENBAHN INGENIEUR (EI), 06/09, page 11, 2009.

The INITIAL TRACK QUALITY after track renewal is of the highest importance for the low TRACK DETERIORATION RATES and LONGIVITY (low LIFE CYCLE COSTS, LCC). The deterioration rate is dependent on the current quality. The original initial track quality can never subsequently be reproduced by maintenance and certainly never exceeded. A high quality track deteriorates slower than a low quality track. Track quality can be measured in physical terms by the deterioration rate, the loss of alignment with the time under the given traffic load. Therefore TRACK QUALITY is no LUXURY, but it is an economic necessity; see Prof. Dr. P. Veit, TRACK QUALITY – LUXURY or NECESSITY? In RTR SPECIAL Maintenance & Renewal, Eurail press, Hamburg, ISBN 978-3-7771-0367-9, July 2007, page 8, and Dr. B. Lichtberger, THE TRACK SYSTEM and its MAINTENANCE, ibid., page 14.

It should be realized that it is uneconomical to run a rail service on the lowest possible track quality level at the threshold next to accidents and derailments with numerous speed precautions and under heavy wear and tear inflicted onto the rolling stocks – on a rail-road not matching in its quality the traffic load it carries, in order just to keep the trains running, - and on a track, which needs maintenance “nearly as every train goes”.

“For successful implementation of a TRACK MANAGEMENT SYSTEM (strategic planning, track policy) it is essential that detailed guidance lines are available for the maintenance units to carry out all track operations in an appropriate manner. Thus there is a need for track maintenance manuals, which describe the methodology for carrying out all track maintenance operations. Most of the world wide railway systems have track maintenance manuals, which incorporate all the technical information required by the track man for maintenance of tracks in a safe and efficient manner”; see contribution technical paper APPROPRIATE TECHNOLOGY FOR RAILWAY TRACK CONSTRUCTION AND MAINTENANCE by J.S. Mundrey to the conference of the heads of the Railway Organisation of BIMSTEC/GANGA MEPKONG DELTA COUNTRIES, held in BANKONG on 3-4th Dec. 2007.

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See also the “MEDIA LIBRARY” in *PLASSER&THEURER MACHINES&SYSTEMSMOBILE RAIL RECTIFICATIONS (-TAMPING)”...


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