COLOMBO SUBURBAN RAILWAY PROJECT (CSRP); PART I
- an ambitious Project with a long Way between actual and Target Quality of Rail-Track

The Evolution of sound and healthy high Quality Tracks for Suburban Commuter Rail-Service

Electrified High Quality Rail Track fit for mixed Suburban and Long-Distance Train Service, Germany, near Frankfurt - a Track Quality Target for CSRP; Pict. by German Federal Railway, DB

By Dr. Frank Wingler, September 2018
In Sri Lanka, the majority of passenger transport is by road.

The ambitious Colombo Suburban Railway Project (CSRP) aims to increase the share of rail transport from the current 5% to 10%. The success of the project will depend on whether it will be possible to bring the dilapidated rail-tracks up to the latest standards. The substructure of the railway-tracks is still at the level of the turn from the 19th century to the 20th century.

The upgrading of the railway-tracks will become the most difficult task within the programme. The technical paper deals with the current affairs, the role of the bearing substructure/formation and drainage, and it points out the tasks/difficulties of strengthening, reengineering, revamping and upgrading.
Colombo Suburban Railway Project - an ambitious Project with a long Way between actual and Target Quality of Rail-Track

Looking at the Project through the Spectacles of Rail-Track Engineering and Technology

The Evolution of sound and healthy high Quality Tracks for Suburban Commuter Rail- Service

BACKGROUND

The Colombo Suburban Railway Project (SRP) was created on 7th of July 2016 with the commencement of Pre-feasibility Study in the Colombo Suburban Region of Sri Lanka Railway Network. Considering the Japan International Cooperation Agency , JICA, funded Colombo Urban Transport Master-Plan (ComTRANS) study carried out by the Ministry of Transport & Civil Aviation, and the Western Region Transport Master Plan prepared by the Ministry of Megapolis & Western Development, the Pre-feasibility Study of CSRP was focused towards passenger and freight demands for Sri Lanka Railways by 2025 and 2035. This included identifying requirement of Infrastructure Development, Passenger Needs, Hauling Power transition from Diesel to Electric, Business Processes etc. Now, the project has moved from pre-feasibility stage to detailed design stage. In this, construction of 105 km of additional tracks, rehabilitation of 210 km of existing tracks, development of railway stations and multi-modal hub-centres, replacing signalling system,
development of maintenance facilities and acquisition of new rolling stock will be considered and designed.

During this time, the interest of all sectors was focused to the Kelani Valley (KV) Line because this would ease off traffic congestions in Malapalla, Horana and Avissawella corridors.

Consequently, additional studies were entrusted to the Consultancy Team of M/s. egis International, France; a French engineering group involved in the areas of infrastructure and transport systems, planning, water and environment. Those were, Kelani Valley (KV) Line alternatives study and Long Distance Services of Railway. In addition, it was decided to carry out four or five of small scale projects, and the consultancy team prepared evaluation reports for those.

The Consultancy was completed and Draft Final Report was issued in November 2017. The Stakeholder Workshop was also held in November 2017.

The detailed design consultancy for the Development Initiatives identified by Pre-feasibility study was initiated in February 2017, and the procurement was completed, and the detailed design consultants were mobilized on 10.01.2018.

This was initiated through Asian Development Bank (ADB) loan of USD 10.0 million. The Scope of the consultancy was to carry out feasibility studies and detailed designs for

- Kelani Valley Line: Double track construction from Maradana to Padukka and single line rehabilitation from Padukka to Avissawella.
- Main Line: Four tracks from Maradana to Ragama, three tracks from Ragama to Veyangoda and double track rehabilitation from Veyangoda to Rambukkana.
- Coastal Line: Three tracks from Colombo Fort to Panadura and double track rehabilitation from Panadura to Kaluthara South.
- Puttalam Line: Two tracks from Katunayaka to Negambo and Airport. Rehabilitation of existing two tracks from Ragama to Katunayake.
- Development of railway stations to cater multi-model operation, park and ride and other facilities for public.
- Replacing signalling system of the entire project area, Colombo to Rambukkana, Colombo to Kalutara, Maradana to Awissawella and Ragama to Negambo.
- New Colombo Train Control Center (CTCC) with power control center for electrification.
- Electric multiple units with 6 cars having passenger capacity of 1200.
Electrification Network consisting of grid sub stations, catenary & electric feeders.

Development of existing maintenance (heavy and light) facilities for rolling stocks including maintenance sheds at Dematagoda and Maligawatte and workshops at Ratmalana. In addition, construction of level–1 and Level–2 maintenance sheds at Ratmalana, Maradana etc.

In addition to above:

- Detailed Design Consultants are to attend to: Surveys needed for engineering designs such as land surveys, topographic, hydrological, geological surveys etc.
- Social surveys and resettlement plans.
- Financial analysis of each development intervention.
- Training of railway engineers/officials.

The average speed on the Matale Line in KMR during peak traffic periods is around 25 kmph. The poor track condition contributes to long delays. Sri Lanka Railway implemented a project to install Block Signalling in the section from Peradeniya to Kandy to reduce capacity limitations, which were experiencing during peak traffic, and then launched a project to double track on the section from Peradeniya to Kandy. The preliminary work is now in progress. SLR’s plan is to improve the triangle section from Kadugannawa to Peradeniya, Peradeniya to Kandy and Peradeniya to Gampola. The objectives of the Kandy Suburban Railway Project are, to avoid the bottlenecks in the section from Kadugannawa to Katugastota, (possibly by double tracking), rehabilitate the section from Katugastota to Matale and to explore the possibility of increasing traffic capacity in the gradient section from Rambukkana to Kadugannawa.

The project will improve the capacity and operating speed of the railway network in the KMR by modernizing and upgrading track, signalling, communication and potentially electrifying the suburban railway lines to operate suburban train with electric traction. The project will also support procurement of fast and modern commuter trains, modernization of maintenance facilities, constructing new railway tracks and upgrading railway stations to improve intermodal connectivity, park-and-ride facilities at selected stations etc. The project will increase the capacity and attractiveness of the railway system, thus increasing its market share and reducing road congestion by shifting passenger preference to rail transport. The project will be designed on a modular basis to allow future expansions. The project will include three sub projects for:

- Double tracking the section from Kadugannawa to Katugastota,
- rehabilitating the section from Katugastota to Matale and
- a pre-feasibility study to explore the possibility of increasing traffic capacity in the gradient section from Rambukkana to Kadugannawa.
Present Status:

The Procurement for consultancy commences in October 2017, and the Expression Of Interest (EOI) has been called. Twenty-one consultancy forms submitted their interests. The evaluation has now been completed and six shortlisted organizations will be issued with “Request for Proposal” documents. It is expected to mobilize consultants in June 2018.


DESIGNING OF RAIL-TRACK STRUCTURES AND WORKING PROCEEDURES TO UPGRADE EXISTING TRACKS

A main factor in this project will be the DESIGNING of the RAIL-TRACK STRUCTURES and the WORKING PROCEEDURES to make the current rail-tracks fit to match with the future traffic load, volume and speed.

High Quality Rail-Tracks with low deterioration rate under given traffic-load, -volume and -speed are a prerequisite for a modern High Capacity Rail Transport System.

Railways run with steel wheels on steel rails on a nearly inelastic and undamped contact area of less than 3 cm². Elasticity has to be provided by the suspension of the rolling stocks and, following the Newton’s Law Mechanics, by the components or constituents of the rail-track in their entity. The components acting with each others, have to be fit to withstand the dynamic forces exerted by the running trains, their axle-load, speed and traffic volume.

There are two fundamental laws about the dependence of the Inherent Track Quality under given traffic load:

- A track is as good, as what is underneath: Substructure consisting of subsoil, subgrade, formation-materials, formation protective layer and ballast-cushion.

- The longevity and deterioration rate depend in a high extend, if the water can be taken out and kept away from the track bed.

This means, the track-quality, fit for the traffic load it has to carry, depends in a large extend on the well bearing FORMATION and BALLAST BED and as well on the DRAINAGE; see technical paper on “WITHOUT
The technical quality of the current rail tracks are far away from modern standards. The alignments had been that time laid predominantly to transport plantation products from inland to the Colombo harbour by a light railway with steam locomotives of an axle-load of 12 tonnes – later of 14-16 tonnes. Several lines have been laid on earth instead on ballast, or had been laid on the plain ground. For the Main-Line from Colombo to Rambukkana all kind of available materials had been used to fill the embankments. Since long, the bearing capacity and stability (track support moduli) of the embankments and heaved up formations do not fulfil the requirements of the present traffic load and volume.

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. This had not been considered, when SLR exchanged timber sleepers by concrete sleepers with the result, that formations got damaged further.

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 millimeters.

When rehabilitating the winding coast line from Matara to Kalutara South, IRCON had to make compromises because the grabbed railway land, which could not be anymore reclaimed, the tightness of the curvatures could not be eased and no proper surface water management provided. The line had been fully closed for month, the track superstructure dismantled, what had been left of the sub-structure had been compacted, a blanket or subballast layer with aggregated base course laid, a ballast cushion provided, in India manufactured concrete sleepers laid with flash-but welded rails composed of 13 m revised British standard 90 A rails, imported from AFERPI-LUCCHINI, Italy, and fastened with Indian RDSO designed MARK III Elastic Rail Clips (ERC). Due to irreversible land-grab a compromise had to be engineered
concerning the drainage with masonry walls functioning also as ballast retaining walls, but with the result, that in rainy season the water level in the track bed is sometimes higher than in the drains, leading to a memory-effect for coming up alignment defects.

Nevertheless, the result is much better than before. Trains now run smooth on the Long Welded Rail Track (LWR) with 60 to 80 kmph and on short straight sections with up to 90 kmph. But this is far away from what we are used from the quality of rail tracks in Central European Countries.

IRCON rebuild with the same technical features the Northern Line from Omantai to Kankesanturai and Talaimannar with the advantage, that the superstructure had been already dismantled by the insurgents during the civil war.

When SLR replaced the worn elastic dog-spiked timber sleeper by inelastic and heavy concrete sleepers with Pandrol Clip rail-fastenings, there had been no formation rehabilitation as required violating fundamental procedures of rail-track engineering with the result, that the formation got further damaged. And there is up to now no proper ballasting and no formation protective (blanketing/subballast) layer (FPL). The ballast bed is shallow, with the result that ballast stones mix with the formation materials and get lost in their support and stabilization of the sleepers. Despite frequent maintenance and repair works and tamping, the correct alignment cannot be kept. The alignment deterioration rates (loss of geometry under given traffic load over the time) are uneconomically high.

The low track quality and high deterioration rates slow down the train speed (on some lines to an average speed of 20 to 22 kmph) and make frequent and costly attendance by repairs and maintenance necessary “nearly as every train goes” (= press-release by former GMR Mr. Priyal de Silva).
TRACK QUALITY had been defined by the works and publications of the Technical University, Graz, Austria, Prof. P. Veit, and by Dr. B. Lichtberger, Plassser&Theurer. Advanced and modern Railways around the globe are following this wisdom about the advantage of **Track Quality under overall Life Cycle Costs Considerations**; see my technical railway papers published on the website [http://www.drwingler.com](http://www.drwingler.com).

If the **TRACK QUALITY** is not matching the traffic load it has to carry, the deterioration-rates (loss of alignment and geometry parameters under given traffic load) will be high, the train speed will decrease and the maintenance expenditures will increase by up to 8 times. This means, an envisaged train speed of 120 km and a high traffic load cannot be kept, if not the track with its substructure components and the drainage systems got adjusted.

All the existing SLR lines, which will be incorporated into the envisaged rail-traffic schemes, will need comprehensive reengineering, strengthening and rehabilitation of the substructure components; as well proper new drainage systems (surface as well undersurface).

Besides two Plasser&Theurer tamping machines, SLR has no other heavy duty and high performance on-track machinery for Ballast Stabilization,

There are also no private track-infrastructure and rail-track managing companies, corporations or undertakings to do the rehabilitation job as in other advanced countries around the globe. With the available technology in Sri Lanka such required formation rehabilitation and drainage engineering will become a severe bottleneck for the CSRP, and it will become a high expenditure and labor intensive work under long line closures or long traffic blocks, hampering, disturbing and disrupting the current rail traffic for coming years.

Malpractises committed in recent times:
♦ The single and dual rail-track from Ragama via Negombo to Putalam had been laid without any formation works on plain ground.
♦ For the recent line doubling from Panadura to Kalutara the track had been laid also on the plain strata without any drainage, formation, substructure components and ballast bed.
♦ The triple track from Demadegoda to Ragama had been laid on organic material containing earth embankment fill with the result, that despite frequent overhaul the alignment parameters cannot be kept and the train speed cannot be increased on this roller-coaster line over 50 kmph. To make use of this third track within a modern high capacity suburban rail traffic scheme, the line has to be closed, the track dismantled and the whole embankment material excavated and replaced by new core compacted material. As it is now, this third track is totally unfit for a modern high capacity suburban rail transport system.

One should be aware that the memory for track misalignments is mostly buried in what is underneath. Weak and yielding formation cannot be compensated by stronger rails!
♦ To construct the second track between Kalutara and Payagalla SLR took nearly 10 years with a poor result due to insufficient formation work. After few months in service, the author could observe that this new laid line is starting already to become warped. Presumably, the Srilankan Permanent Way Engineers, providing "NON-PERMANENT WAYS", know, why they did not go for continuous welded rails on this poor bearing and narrow substructure, and why they laid only short gas-pressure welded rail panels linked with un-supported fish-plate joints, which started already to hog.
One should be aware that the memory for track misalignments is mostly buried in what is underneath. **Weak, yielding and badly drained formation, what cannot be compensated by stronger rails!**

For a modern single line track the land to be taken must have a width of 15 m and for a double line about 20 m. To reclaim lost railway land will become a difficult task.

The question had been left open, from where to take the lost railway land for a line doubling between Pyagalla South and Aluthgama in the section of Beruwela?, or for a line quadrupling and tripling on the main-line up to Veyangoda and for a line tripling on the Colombo urban section of the Coast Line.

**Regarding the KV Line, the Author has his own Opinion:**

It had been a major mistake to convert the winding NG line up to Avissawella to Broad Gauge laying the BG track on the same winding trace without any formation work and to abandon the trace up to Ratnapura. On the tight broad gauge curvatures, with tightness of up to 18 degree, trains cannot run faster than 35 kmph. The poor quality track with its tight curvatures and without any stable formation and nearly no ballast allows no faster average station to station travel velocity than 22 kmph, which is much too slow for a modern urban and suburban Rapid Mass Transit System in the highly populated outskirt area. The trace from Avissawella to Ratnapura and the railway-land are once and forever lost and cannot any more be revitalized.
KV Line with a BG Rail-Track laid on the narrow Alignment of the former NG Trace without any Formation Engineering; Pict by Google
The KV line terminates at Maradana and caters no long-distance through-traffic beyond. A gauge-brake would not have created trouble. The track should have been converted to **Meter Gauge (MG)**. India has ample reconditioned meter gauge locomotives to be exported. Nowadays with **modern meter gauge light weight rail cars** and continuous welded rails on Y steel-sleepers laid on a well bearing formation and with sufficient ballasting, **MG Rail Cars** could negotiate the tight curvatures with over 60 kmph and on straight sections up to 120 kmph. Y steel-sleepers have the advantage that they tolerate a shallow ballast-cushion and a narrow formation top-width. Y steel-sleepers retain excellent the curve geometry. Y steel-sleepers allow even to lay on 45 meter (36.5 Degree) tight MG curves continuous welded rails. Switzerland has demonstrated on the Räthic Railway, what is nowadays possible on winding MG with Rail Cars of Swiss Stadler design and on tracks with ThyssenKrupp Schulte GmbH Y steel-sleepers:

![THYSSENKRUPP Y Steel-Sleeper](image)

Long Welded Rail (LWR) on 18 Degree, 45 m, Curve with Y Steel-Sleepers and without Curve Check-Rails on Bernina Railway, Switzerland


13
In Sri Lanka, it will be not understood, why a MG track on the KV trace is advisable having many advantages compared with BG.

Stadler in Switzerland has engineered a 2 ½ feet NG railcar with middle traction module for Greece, which run for a test on a German NG track with 80 kmph. This demonstrates that for an urban and suburban commuter service the NG track could have been left on the KV trace.

The value of the KV trace is, that it crosses twice the Highway, at Malapalla and near Wattala/Enderamulla. The route of the highway has the disadvantage, that it touches only outskirts of Colombo, and the gain of journey time on the highway gets lost on the congested roads into or from the town. At Malapalla a highway-railroad hub intermodal road-rail station is under construction. Perhaps a second intermodal hub will come later at Enderamulla enabling to interlink highway bus service from and to the south with rail service from and to Colombo over the Main.Line.

On the current winding KV rail trace with a poor quality track and a broad gauge without any proper well bearing formation and drainage system a rail shuttle service linking the Malapalla intermodal hub station under construction with the town centre will have only a low capacity and will be relatively slow. The Colombo Megapolis plan to bring a dual BG track on an elevated structure up to Malapalla will become highly costly and will need a lot of space. With Meter Gauge the required space would be less and the task easier. See F. A. Wingler DESIGNING A LIGHT WEIGHT MODEL RAIL CAR FOR THE “LANKA ECONO RAIL” PROJECT; published on: July 15, 2016 August 23, 2016, free to download from http://www.drwingler.com.

As a Signalling System for the KV line one should think about the deployment of COMMUNICATION BASED TRAIN CONTROL (CBTC); see https://www.cbtcsolutions.ca/about/

A bottleneck on the way to Kandy is the low route capacity of the Balana incline section between Rambukkana and Katuganawa with its low permissible speed of 35 kmph. This line is predominantly laid on the plain strata without a well bearing and well drained formation, formation protective layer and without any proper ballast bed. The whole substructure components and drainage systems have to be reengineered. For this winding section the most advisable sleepers will be Y-shaped Thyssen/Krupp Steel-Sleepers, keeping in a perfect way the curve geometry parameters. On a proper subgrade-structure with proper ballasting it will be technically feasible to provide LONG WELDED RAILS without fishplate-joints on Y-Steel Sleepers. But track upgrading under running traffic without mega-block will become a Herculean task. On such a track the speed could be increased from presently from 35 kmph to 60 kmph. A shining teaching sample for such a track structure is the winding 1 in 35 incline section of the VINSCHGAU Railway in
North Italy, on which Swiss Stadler build **Light Weight Rail Cars** with middle Module Traction run up and down with 65 kmph.

_Viceroy Special on ailing and weak Track near Lion’s Mouth, Balana Incline near Katuganawa; Pict. by courtesy of Bernd Sailer, from TAILS OF ASIEN STEAM_

_ThyssenKrupp Y-shaped Steel-Sleepers on tight Curvatures of the 1 in 35 Incline Section of the Vinschgau Railway, North Italy; Pict. by F. Wingler_
When going for **Electrification** one should be aware, that with comprehensive formation rehabilitation or reengineering, with the provision of a formation protective layer (FPL) (sub-ballast, blanketing material) and with a proper ballast cushion = prerequisite for a viable rapid and high capacity/performance urban and suburban rail service = the existing rail tracks will come approx. 2 feet higher. This has consequences not only for the height of the catenary but also for over-bridges.

Electric traction needs a reliable power supply and an electric grid with enough redundancy in case of power plant failures. The envisaged section for electrification from Panadura to Veyangoda serves a mixed traffic scheme with long-distance and urban commuter trains. The long-distance trains will not harvest the benefits of electric traction. Even with electrification there will remain a mixed traffic scheme of Diesel and electric hauled or propelled trains. The slower trains will block the faster trains.

For track revamping, the KV line up to Avissawella could be closed down for one year, and the current track superstructure could be taken out in order to provide a stable formation, proper drainage system, a formation protective layer and proper track ballasting, and as far as possible, to ease of the tightness of curvatures to less than 5-6 Degree. If the line has to be closed and the current rails and sleepers taken out anyway, the line could also be rebuilt in **Meter Gauge** offering many advantages. But latter will nobody understand in Sri Lanka, since it had become a sacrilege to challenge the 1676 mm Broad Gauge conversion under Priyal de Silva.

But the other tracks catering a mixed traffic schemes of suburban commuter trains and long-distance trains cannot be closed down for formation and drainage rehabilitation, unless temporary extra side tracks are laid. Otherwise track revamping has to be performed under traffic blocks. Upgrading will hamper and disturb the rail-traffic over years. Such difficulties and constraints should be properly taken into account in the relevant studies and plans.

It will be a long, tedious and expensive way to make the existing lines fit for the Colombo Suburban Railway Project with High Quality Tracks. There will be a lot to do, starting with **comprehensive Formation Works**. The scope of necessary track-engineering works should not be underestimated.

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