Project # GTZ-GNR-001
Doubling of Ganden to Eber Rail Line

Project Overview

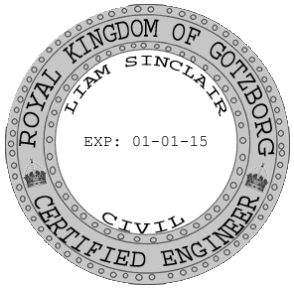
On May 5, 2013, the Royal Chancellor of Gotzborg, Lord Montin, announced that the Royal Government would seek to double the existing single-track rail line from Ganden, Courland, to Eber, Kendal, in response to Kendal's growing export economy in the areas of agriculture and aquaculture. This would allow for an increase in product reaching the major ports of Gotzborg, destined for overseas buyers. The expansion would also serve to increase passenger capacity along one of the most congested rail routes in the Royal Kingdom.

As the Engineering and Design Contractor for the Gotzborg National Railway, Montin Constructors' subsidiary engineering firm, Montin Engineering Consultants, was tasked with the design development and cost estimating associated with this project.

This final report to the General Manager of the Gotzborg National Railway for this project includes:

1. Route Survey;
2. Environmental Impact Assessment;
3. Material Specification;
4. Material Quantity / Project Length Estimate;
5. Construction Cost Estimate;

We trust that this is satisfactory.



Regards,

Liam Sinclair

Liam Sinclair, C.Eng.
CEO, Montin Constructors GmbH

Route Survey

The existing single-track rail line from Ganden to Eber runs generally from Eber at an elevation of approximately 1,500 metres, reaching 1,650 metres through the hills to the west, and culminating at an elevation of approximately 100 metres north of Ganden at the local rail yard. The existing route of the rail line is shown in Figure 1 while its topography is shown in Figure 2.

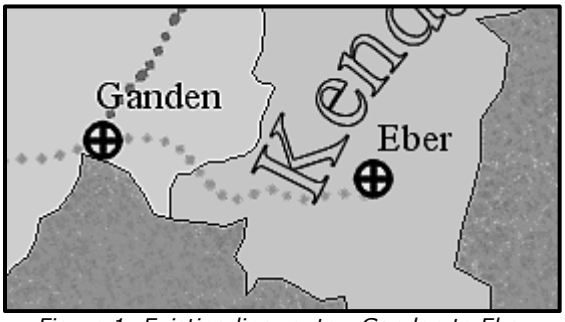


Figure 1: Existing line route - Ganden to Eber

The double-track rail line will follow the same route to minimize construction costs by taking advantage of an already cleared and defined right-of-way. This means that the new rail line length required is estimated to be that of the existing line at 55.8 kilometres.

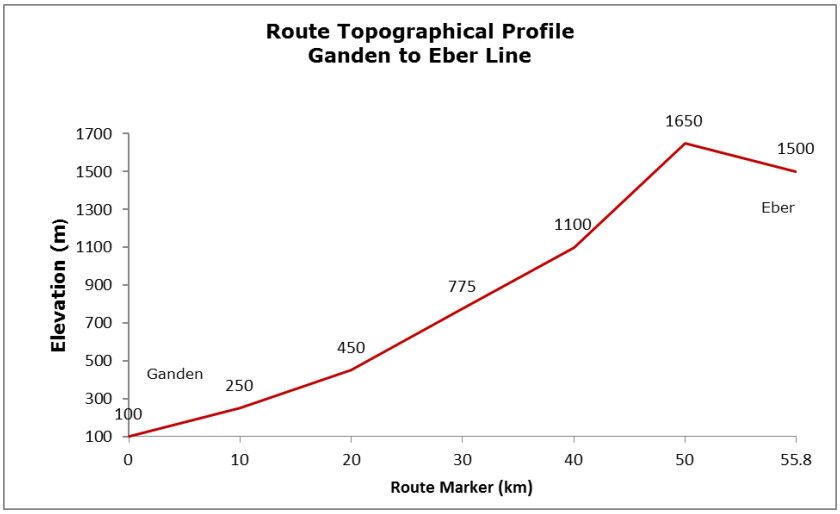


Figure 2: Route Topographical Profile

Environmental Impact Assessment

As the new rail line to be laid is a doubling of the existing single-rail line, the environmental impact from construction activities is inherently minimized, as it will take place within the confines of the existing right-of-way. Regardless, the presence of work camps along the route as construction progresses will increase human interaction with local wildlife and this interaction may lead to unintended environmental consequences.

The Contractor must be required by the Gotzborg National Railway to take steps to minimize the interaction between workers and wildlife, and to locate work camps away from natural habitats. Any

environmental damage caused beyond the confines of the right-of-way should be the subject of a holdback on the contract until satisfactorily remediated by the Contractor.

The operation of the new rail line will increase the frequency of train versus wildlife collisions and the locations of such collisions should be monitored by the Gotzborg National Railway so that future mitigation efforts can be explored to ensure the safety of employees, equipment and local wildlife.

Material Specification

The following specification data is designated by the Gotzborg National Railway Master Specification in 2006 to detail the crosstie and rail track characteristics necessary to support the Railway's use of locally manufactured rolling stock.

Standard Crosstie

Wood Type:	Pine softwood
Wood Density:	455 kg/m^3
Standard Dimensions:	178 mm x 229 mm x 2591 mm
Wood Engineering Properties:	Static bearing capacity of 0.61; Dynamic bearing capacity of 0.80
Standard Crosstie Spacing:	508 mm centre-to-centre
Crossties Per Kilometre:	1969
Tonnes of Crosstie Per Kilometre:	98.45

Crossties have three purposes in a railway: (1) to secure the two lines of rails transversely and hold them to the correct gauge; (2) the axle loads are borne and transmitted with diminished unit pressure to the ballast; and, (3) the crosstie embedded in the ballast anchors the track against lateral, longitudinal, and vertical movement.

The choice of the Gotzborg National Railway to utilize softwood as the crosstie material has both advantages and disadvantages for the maintenance regime required along the route. Softwoods more readily absorb treatment chemicals meant to prevent rapid decay compared to hardwoods. The softwood crosstie will, on the other hand, become worn much quicker than a hardwood due to the load and forces induced upon it by rolling stock.

A crosstie must possess hardness and toughness, resistance to the abrasion of the rails, tie plates, and ballast, resistance to decay, and freedom from splits, shakes and knots. It is important that any structurally defective wood be discarded as its inclusion in the production of crossties would pose a safety and environmental risk, as well as a financial liability for Gotzborg National Railway.

The disqualifying conditions for a length of wood intended for use as a crosstie are specified as follows:

Cut:	A crosstie must be perfectly straight from end-to-end.
Decay:	No decay which extended further than 6.3 mm into the wood.
Holes:	No hole more than 12.5 mm in diameter and 76 mm deep; or, covering more than one-fourth the width of the surface on which it appears and 76 mm deep; or, not between 508 mm and 1016 mm from the middle of the crosstie. Note that numerous small holes may be equivalent to a large hole.
Knots:	Large knots with diameter exceeding one-fourth the width of the surface are not permitted, but may be allowed if outside the area ranging from 508 mm to 1016 mm from the middle of the crosstie. Numerous small knots are considered to be equivalent to a large knot.
Shakes:	One shake not over one-third the tie width is permitted.

Splits: One split not more than 127 mm long is allowed if an anti-splitting device is used.

The crosstie will be affected by several factors which ultimately contribute to its service life. These limiting factors are: natural causes, the drying process, service wear, and abuse. Pine softwood will shatter, split or develop dry rot when subjected to wear. The source of service wear includes the rolling stock that travel along the line, as well as ballast particulars which come into abrasive contact with the crosstie due to vibrations, etc. As with any construction materials, the method by which it is installed is critical to the service life: trackmen should take care installing each crosstie, and not subject it to impacts, such as beating it with a spiking hammer to set it square with the rails or to poke it in place with a lining bar.

Some crossties are expected to fail within the first 5 to 10 years of service, while others may last for up to 50 years depending on the local climatic and service conditions affecting the crosstie. For the crosstie used on this route, we predict a safe tie life of 30 years. This means that by the 30-year mark, 50% of the crossties along the new Ganden to Eber line are expected to require replacement, and by the 35-year mark, 85% of the original crossties will need to be replaced.

Industry custom dictates that all crossties be inspected twice annually to ensure that they are in acceptable condition for operations.

Standard Rail

Rail Material:	Steel
Rail Style:	Flat Bottom ‘Jointed’
Gauge:	1435 mm
Gauge on Bends > 6°:	1441 mm
Rail Weight:	49.61 kg/m (mainline)
Rail Length:	11.89 m

All new Gotzborg National Railway rail line installed since the Lonenberg to Bellelay project in 2006 utilize mainline-weight rail steel. The heavier weight of the mainline rail increases the moment of inertia (i.e. the stiffness) of the line, reducing rail deflection and contributing to the stability of the line. It further provides redundancy against failure in locations where wear and tear on the line may have caused it to become weaker.

The existing line from Ganden to Eber predates this change and consists of rail steel weighted for branch line use. The existing line will not be replaced within the scope of this project to conform to the new specification.

The mainline rail weight is designed to support a concentrated wheel load of 13,608 kg, with normal crosstie spacing. It is strongly recommended that the Gotzborg National Railway not exceed this load rating with its rolling stock during use on the new Ganden to Eber line. Other engineering properties of the steel to be used in the mainline rail for this route are to be specified by the manufacturer to meet the performance requirements above.

Rail life is generally measured in millons of gross tonnes (mgt) carried along the line. The total million gross tonnes divided by annual traffic density provides a measure of rail life in years. The service life of a rail varies with traffic, the amount of curvature, gradient, subgrade and ballast support, and the standard of maintenance. Rail life may be determined by wear and fatigue observed through inspections. It is recommended that rails be replaced when the cumulative gross tonnage travelled reaches 500 mgt.

Rail Spike

Rail spikes are a critical anchoring component of the railway system. It is recommended that all rail spikes conform to the "cut spike" hold-down device design, with each cut spike being 178 mm long, with a spike head width of 31.8 mm and a weight of 0.38 kg.

Ballast

When selecting ballast material for a rail line, two behavioural characteristics are important to consider: the short-term elastic response, and the long-term plastic (permanent) deformation and degradation. The characteristics affecting ballast are strength, toughness, durability, stability, drainability, cleanability, workability, availability, resistance to deformation, minimum purchase price, and overall economy. Good ballast will emulate the positive end of each of these individual characteristics, though some compromise may be required as not every characteristic listed can be well-achieve in unison.

It is recommended that ballast used on the Ganden to Eber line be of a No. 5 (4.00 mm) well-graded nature to resist plastic deformation. Ballast should be chosen and installed such that rail deflection, including the deflection of the subgrade on which the ballast is installed, does not exceed 6.3 mm.

Track Cross-Section

A cross-section of the constructed standard rail line for the Gotzborg National Railway is currently available via the Public Records Office Archival Library and has not been reproduced within the scope of this report.

Material Quantity / Project Length Estimate

For the 55.8 kilometre length of rail line to be installed under this project, the amount of gross materials required has been estimated as follows:

Aggregates:	165,172	m^3 required
Steel:	3,068,238	kg required
Lumber:	5,493,510	kg required

The amounts indicated above are the absolute minimums for the work. Additional material orders may be required based on unforeseen circumstances arising during construction.

Based on a typical construction rate of 1.2 km of line per day presently being achieved by Gotzborg National Railway contractors, the total estimated construction timeframe for this project is approximately **75 days**, including commissioning.

Construction Cost Estimate

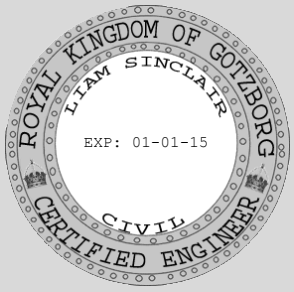
The following is a summary of the engineering-related cost and the estimated construction material, labour and equipment cost for the work.

Engineering:	Design Development Fee (8% of Construction Cost*)	25,134 Th
	Contract Services Fee (5% of Construction Cost*)	15,709 Th
	Total	*40,843 Th*
Construction:	Labour Cost	122,180 Th
	Equipment Cost	104,725 Th
	Material Cost	87,271 Th
	Overheads (10%)	34,908 Th
	Contingency (10%)	34,908 Th
	Total	*383,992 Th*
Total Project		**424,835 Th**

* Excluding Overheads and Contingency.

The Engineering Design Development Fee portion is due upon submission of this report.

This document has been certified for use as a work specification for the development of Gotzborg National Railway project "Doubling of Ganden to Eber Rail Line" by a certified engineer registered with the Royal Kingdom of Gotzborg. Additionally, all work done by the contractor firm shall be supervised and certified by a registered certified engineer, else the work shall be considered void and the contractor required, at own expense, to perform any corrective measures.



Signed --

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2014-02-05
Final Report

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