STATE RAILWAY OF THAILAND

Consulting Service
for Feasibility Study and Detailed Design
The Construction of Double Track Railway on
Surat Thani - Hat Yai Junction - Songkhla Route

Executive Summary Report of Detailed Design

August 2016 (2559 B.E.)

PARSONS BRINCKERHOFF
CHOTICHINDA
Span

บริษัท เอ็ม เอ เอ คอนซัลแตนท์ จำกัด
MAA Consultants Co.,Ltd.

บริษัท พีบี เอเชีย จำกัด
PB Asia Ltd.

บริษัท โชติจินดา คอนซัลแตนท์ จำกัด
Chotichinda Consultants Co.,Ltd.

บริษัท ปัญญา คอนซัลแตนท์ จำกัด
PANYA Consultants Co.,Ltd.

บริษัท สแปน จำกัด
Span Company Limited

บริษัท ยูทิลิตี้ ดีไซน์ คอนซัลแตนท์ จำกัด
Utility Design Consultants Co.,Ltd.

Executive Summary Report of Detailed Design
For the Construction of Double Track Railway
on Surat Thani – Hat Yai Junction – Songkhla Route

Content Page

Content (cont.)

Page

Content (cont.) *Page*

Content of Figure *Page*

Content of Figure(cont.) *Page*

Content of Figure(cont.) *Page*

Content of Table

Page

Content of Table (cont.) *Page*

Chapter 1 Introduction

CHAPTER 1

INTRODUCTION

1.1 Project Background

On April 27, 2553 B.E., Thailand's Cabinet had a resolution to acknowledge the resolution from the Economic Minister Meeting No.5/2553 on April 26, 2553 B.E to approve the infrastructure investment plan by the State Railway of Thailand (SRT). The investment plan included the development of double track railway on northern, north-eastern, and southern routes.

In addition, according to the resolution by Thailand's Cabinet No 3/2555 dated on March 20, 2555 B.E. in Phuket which agreed to the meeting resolution obtained among public and private sectors for solving regional economic problems No 3/2555 on March 19, 2555 B.E. as proposed by the Joint Standing Committee on Commerce, Industry and Banking, Tourism Council of Thailand, Federation of Thai Capital Market Organizations, and the representatives from private sectors in 5 southern provinces on Andaman side (Phuket, Phangnga, Krabi, Trang and Ranong). The proposal consisted of 8 topics and was assigned to the Ministry of Transports for undertaking the feasibility study on the development of double track railway project in the South (Bangkok- Chumphon – Su Ngai Kolok and Padang Be Sar) in accordance with the development plan on high speed train previously studied by the Ministry of Transports. It also asked to accelerate the implementation of the infrastructure investment plan for the first phrase during 2553-2557 B.E. from the Thai cabinet's resolution on April 27, 2553 B.E.

In order to support the development of double track railway network, cabinet resolution, and government policy for promoting investments on important projects of the nation which includes continuous and high potential projects, the study on the construction of double track railway on Surat Thani – Hat Yai Junction – Songkhla route is then an important project of the Ministry of Transports in railway infrastructure development for enhancing the capacity of freight and passenger transports, as well as tourism potential of the nation.

The development of double track railway shall result in the increase of railroad capacity, the decrease of travel time and energy consumption in transport sector of the nation, the decrease of pollution to the environment, the enhancement of public transport efficiency in both suburb and urban areas, as well as internationally. It shall be convincing to people for shifting their travel modes to railway system, resulting in the decrease of road accidents. In the project, the service on freight transport, as well as the enhancement on tourism potential of the South and efficiency of railway freight transport network, was also in consideration.

Figure 1.1-1 shows the route in the construction project of the double track railway on Surat Thani – Hat Yai Junction – Songkhla.

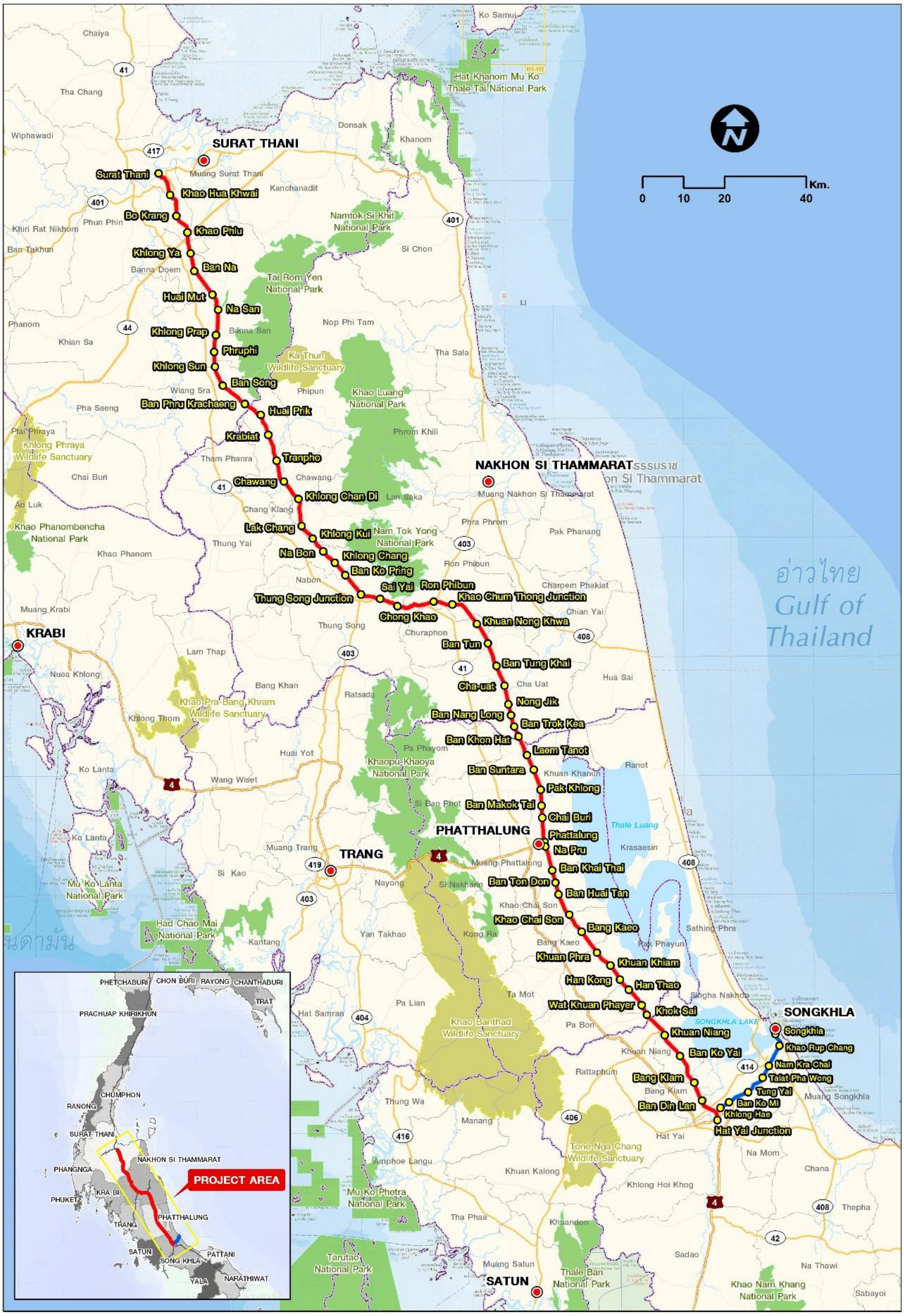


Figure 1.1-1: Project Location and Railway Route

1.2 Objectives

The objective of this project was to carry out a feasibility study, engineering detailed design, and a report of Environmental Impact Assessment (EIA) for the construction of double track railway on Surat Thani – Hat Yai Junction – Songkhla route with the approximate distance of 323 kilometers.

1.3 Scope of Work

The scope of work in this project consists of 3 sections, as follows.

1.3.1 Section 1: Feasibility Study on Engineering, Economic, Social, Finance and Optimal Investment Plan

The feasibility on engineering, economics, socials and finances shall be made by selecting route alignment, specifying right of way, defining building structures at the locations intersecting to other projects, proposing infrastructures necessary for current topographical condition and environment, proposing guideline for suitable investment plan, and preparing feasibility study report for the project.

1.3.2 Section 2: Detailed Design and Tender Document

The preparation of detailed design, construction cost estimates, and tender document needs to efficiently connect project infrastructure to other transportation systems, and ready to be used in tendering process.

In this section, the Consultants shall carry out survey and detailed design for the construction of double track railway, train station, and related components, as well as provide tender documents and construction drawings to SRT for further implementation.

1.3.3 Section 3: Study and Preparation for Environmental Impact Assessment (EIA), Public Relation and Public Participation

Study the Environmental Impact and the Environmental Impact Assessment (EIA) in according to the latest updated standards by the Bureau of Natural Resources and Environmental Policy and Planning (ONEP), Update and prepare the report in according to the requirement of state agencies related to environment. Implement the project in accordance with the ministerial regulation of public participation by Prime Minister's Office in 2548 B.E., and the Enhancement and Conservation of the National Environmental Quality Act 2535 B.E.

1.3.4 Related duties as assigned by SRT

1.4 Work Schedule

The Consultants have thoroughly considered the details according to the Scope of Work, methods and procedures as mentioned above, and determined work plans in each section. According to the study defined by the Consultants corresponding to the completion timeline of 12 months after notified by SRT, the operational method was defined by the Consultants.

1.5 Submission of Reports, Drawings and Related Documents

The Consultants started working on August 3, 2558 BE within 30 days after the date specified in the Contract or informed on the Notice to Proceed by SRT. Due dates for the submission of reports, drawings and related documents to SRT are shown as follows.

(1) Inception Report consists of maps, data related to the Project, work plan, schedule of timeline, concept and guideline, implementation procedures, techniques and methods, and working staffs and experts to carry out the work, including plan for public hearing. This shall be made in Thai language for 20 copies, together with CD or DVD, and submitted within 1 month from the first day of operation.

(2) Progress Report No-1 consists of the review on secondary data and details, physical condition of project areas, including plans and work progress of the operation, obstacles, solutions and suggestions. This shall be made in Thai language for 20 copies, together with CD or DVD, and submitted within 3 months from the first day of operation.

(3) Interim Report covers the operations and the progress, study plans and offered methods which consist of survey, check, details collection, analysis and implementation of public participation, including suggestions, obstacles and solutions during the operation, etc. This shall be made in Thai language for 20 copies with CD or DVD, and submitted within 6 months from the first day of operation. In addition, the preliminary design as in the Scope of Work on 1.3.2 shall be proposed with 20 copies.

(4) Draft Report of Feasibility Study covers the review and further study on feasibility as in the Scope of Work on 1.3.1. This shall be made in both Thai and English languages with 20 copies of CD or DVD each, and submitted within 6 months from the first day of operation.

(5) Final Report of Feasibility Study and Executive Summary Report shall be made in Thai for 70 copies and in English for 30 copies with 70 copies of both languages on CD or DVD, and submitted within 30 days after SRT has approved the draft report.

(6) The Report on Environmental Impact Assessment (EIA) to be proposed to the Expert Committee shall cover issues and comprehensive details, according to the rules, procedures, regulations and guidelines for preparing EIA.

(6.1) Draft Report of EIA shall be made in Thai for 20 copies with CD or DVD, and submitted to SRT within 6 months from the first day of operation for approval.

(6.2) Within 30 days after approved by SRT, the Report of EIA shall be proposed to the Bureau of Natural Resources and Environmental Policy and Planning (ONEP). This shall be made in Thai for 40 copies with CD or DVD.

(6.3) Final Report of EIA after approved by ONEP shall be made in Thai for 40 copies. And, 40 copies of Executive Summary Report of EIA shall be made in Thai language with 40 CD or DVD within 30 days after informing the approval from the ONEP to the SRT.

(7) Progress Report No-.2 composes of the work plans and progress, obstacles, solutions and suggestions. This shall be made for 20 copies in Thai language with CD or DVD, and submitted within 9 months from the first day of operation.

(8) Draft Final Report to be submitted within 10 months from the first day of operation shall consist of:

(8.1) Draft Report of Detailed Design from the result of 1.3.2 in the Scope of Work shall be made in Thai and English for 20 copies, with CD or DVD.

(8.2) Draft of Drawings for Detailed Design from the result of 1.3.2 in the Scope of Work shall be made on A3 paper size for 20 copies with CD or DVD.

(8.3) Draft Report on Bill of Quantity and Construction Cost Estimate from the result of 1.3.2 (11) in the Scope of Work shall be submitted for 20 copies, together with CD or DVD.

(8.4) Report on Estimate of Land and Building Compensation Cost, List of Land Owner, other details, as well as maps and layouts as of 1.3.2 (2) and (12) in the Scope of Work shall be made for 30 copies, together with CD or DVD.

(8.5) Draft of Tender Document shall be made in Thai for 20 copies, together with CD or DVD.

(9) Final Report and Executive Summary Report to be submitted within 12 months from the first day of operation shall consist of reports after further updated and edited from (8), as follows.

(9.1) Final Report of Detailed Design and Executive Summary Report shall be made in Thai for 70 copies and in English for 30 copies.

(9.2) Final Drawing of Detailed Design on A3 size shall be made for 50 copies.

(9.3) Final Report on Bill of Quantity and Construction Cost Estimate shall be make for 50 copies.

(9.4) Final edition of Tender Document shall be made in Thai and English for 50 copies each.

(10) The reports in (9) shall be written on CD or DVD with a proper container for 100 copies.

(11) The Consultants shall collect all work and project operation beneficial for later use, written on CD or DVD for 100 copies in the form of editable Digital File with description in the appropriate box to send to the SRT, including details, documents, brochures, public relation poster of public hearing session.

(12) The Consultants shall provide project details for presentation in form of Video which covers background, project main point, and operations. In addition, simulations, procedures construction methods and train operation along the route shall be included by using computer animation and recorded on DVD for 100 copies in Thai and English each.

Chapter 2

Passenger and Freight Demand Forecast

Chapter 2

Passenger and Freight Demand Forecast

2.1 Primary and secondary data collection

2.1.1 Current transport demand

The Consultants has collected data and statistics of getting trip and transport of goods related to the operation of existing projects, according to the education authorities and the various sources of information, including statistics derived from the train of the Governor, this is the information for the passenger volume up-down at various stations in the project path displayed in the **Table 2.1.1-1.**

Table 2.1.1-1 Passenger volume up-down in 2014 (B.E. 2557)

Code	Station	Passenger (pcu/year)			
		Up (Bangkok)		Down (South)	
		Up	Down	Up	Down
4239-สุราษฎร์ธานี	Surat Thani	239,409	106,997	68,171	280,508
4241-เขาหัวควาย	Khao Hua Khwai	190	259	911	137
4243-*บ่อกรัง	Bo Krang	0	973	0	695
4245-เขาพลู	Khao Phlu	427	919	1,349	299
4246-*คลองยา	Khlong Ya	0	223	0	156
4247-บ้านนา	Ban Na	7,688	4,587	5,893	7,454
4249-ห้วยมุด	Huai Mut	1,182	2,155	3,363	910
4250-นาสาร	Na San	34,095	11,884	12,960	29,625
4252-คลองปราบ	Khlong Prap	0	438	0	243
4253-พรุพี	Phruphi	2,784	2,131	2,741	2,523
4254-*คลองสูญ	Khlong Sun	0	16	0	38
4255-บ้านส้อง	Ban Song	57,002	17,050	19,821	55,410
4257-บ้านพรุกระแชง	Ban Phru Krachaeng	849	1,811	2,369	608
4258-ห้วยปริก	Huai Prik	5,657	3,923	5,365	5,372
4259-กระเบียด	Krabiat	3,215	2,694	3,396	2,578
4261-ทานพอ	Tranpho	18,136	8,556	9,724	16,312
4262-ฉวาง	Chawang	13,981	5,311	5,910	13,199
4264-คลองจันดี	Khlong Chan Di	57,039	13,946	15,946	58,660
4266-หลักช้าง	Lak Chang	1,181	1,899	2,330	1,017
4267-*คลองกุย	Khlong Kui	50	241	3	253
4268-นาบอน	Na Bon	9,162	5,051	6,335	7,902
4269-คลองจัง	Khlong Chang	1,422	1,512	1,940	1,101
4270-ชท.ทุ่งสง	Thung Song Junction	164,396	38,705	39,515	173,258
4295-ใสใหญ่	Sai Yai	1,978	1,925	3,752	1,739
4297-ช่องเขา	Chong Khao	256	104	208	171
4299-ร่อนพิบูลย์	Ron Phibun	13,178	3,564	14,977	3,726
4300-ชท.เขาชุมทอง	Khao Chum Thong Junction	16,341	19,821	22,727	13,279
4310-ควนหนองคว้า	Khuan Nong Khwa	1,410	2,190	2,728	1,219
4312-บ้านตูล	Ban Tun	5,837	4,240	5,786	3,209
4315-ชะอวด	Cha-uat	51,928	38,637	44,004	43,975

Code	Station	Passenger (pcu/year)			
		Up (Bangkok)		Down (South)	
		Up	Down	Up	Down
4316-**หนองจิก	Nong Jik	8	725	11	677
4317-บ้านนางหลง	Ban Nang Long	6,235	5,072	5,634	5,693
4318-บ้านขอนหาด	Ban Khon Hat	10,991	12,896	12,957	10,048
4319-แหลมโตนด	Laem Tanot	5,564	16,257	15,788	4,303
4320-*บ้านสุนทรา	Ban Suntara	0	340	5	100
4321-ปากคลอง	Pak Khlong	16,689	19,918	19,057	14,772
4323-*บ้านมะกอกใต้	Ban Makok Tai	5	1,119	9	213
4324-*ชัยบุรี	Chai Buri	4	1,878	7	143
4325-พัทลุง	Phattalung	119,024	123,972	77,716	113,359
4326-*นาปรือ	Na Pru	0	308	55	237
4327-**บ้านค่ายไทย	Ban Khai Thai	0	287	2	508
4328-บ้านต้นโดน	Ban Ton Don	4,502	4,450	6,268	5,198
4329-**บ้านห้วยแตน	Ban Huai Tan	0	1,461	13	1,202
4330-เขาชัยสน	Khao Chai Son	12,301	13,183	14,626	11,657
4331-บางแก้ว	Bang Kaeo	23,207	25,663	25,081	22,234
4333-*ควนพระ	Khuan Phra	34	6,320	160	3,353
4334-ควนเคี่ยม	Khuan Khiam	5,364	8,973	9,772	5,129
4335-**หารกง	Han Kong	1	627	12	599
4336-หารเทา	Han Thao	18,743	21,556	23,857	16,699
4337-**วัดควนเผยอ	Wat Khuan Phayer	1	240	3	227
4338-โคกทราย	Khok Sai	5,309	14,024	13,595	4,586
4340-ควนเนียง	Khuan Niang	18,377	9,870	10,919	14,806
4342-บ้านเกาะใหญ่	Ban Ko Yai	3,396	3,572	3,865	2,536
4344-บางกล่ำ	Bang Klam	3,069	2,251	2,256	2,081
4345-บ้านดินลาน	Ban Din Lan	4,767	2,242	3,300	2,210
4347-ชท.หาดใหญ่	Hat Yai Junction	406,591	324,747	215,078	423,867

Source: SRT

2.1.2 Mid-Block Counts

The Consultants have conducted survey, the number of passengers on the vehicle (Occupancy Survey) surveys in the same position, quantity survey, and traffic on the road range to use that information to calculate the passenger volume on the road in the area, the study interval

The results of the data collection, traffic quantity and quantity of passengers. Traveling on the road network in the presently Traffic volume on the highway in the project area, as follows:

- Highway 4, Phang Nga-Ranong, traffic volume on the road range approx19,000 PCU/day
- Highway 41 Chumphon-Surat Thani, traffic volume on the road range approx 40,000 PCU/day
- Highway 4 Krabi—Trang, traffic valume on the road rang approx 30,000 PCU/day
- Highway 41 Surat Thani—Nakorn Si Thammarat, traffic valume on the road rang approx 32,000 PCU/day
- Highway 41 Nakorn Si Thammarat - Phatthalung traffic valume on the road rang approx 28,000 PCU/day
- Highway 4 Phatthalung-Hat Yai, traffic valume on the road rang approx 40,000PCU/day
- Highway 407 Hat Yai—Songkha, traffic valume on the road rang approx 30,000 PCU/day
- Highway 4 Hat Yai-Sadao, traffic valume on the road rang approx 31,000 PCU/day
- Highway 4 Songkha-Pattani, traffic valume on the road rang approx 16,000 PCU/day

The Consultants have collected information on passengers travelling on the current road network. By quantity of passengers travelling in and out project boundary can be summarized as follows:

- Passenger volume on highway 4 travels into space, Ranong with passenger volume of approximately 26, 000 people per day. On the part of the passenger volume at the trip to Phangnga province has estimated passenger volume 28, 000 people per day
- Passenger volume on highway 41 travels into space, Chumphon with passenger volume of approximately 61, 000 people per day. On the part of the passenger volume at the trip to Surat Thani province has estimated passenger volume 57, 000 people per day
- Passenger volume on highway 4 travels into space, Krabi with passenger volume of approximately 67, 000 people per day. On the part of the passenger volume at the trip to Trang province has estimated passenger volume 66, 000 people per day
- Passenger volume on highway 41 travels into space, Surat Thani with passenger volume of approximately 33, 000 people per day. On the part of the passenger volume at the trip to Nakhon Si Thammarat province has estimated passenger volume 35, 000 people per day
- Passenger volume on highway 41 travels into space, Nakhon Si Thammarat with passenger volume of approximately 45, 000 people per day. On the part of the passenger volume at the trip to Phatthalung province has estimated passenger volume 40, 000 people per day
- Passenger volume on highway 4 travels into space, Phatthalung with passenger volume of approximately 41, 000 people per day. On the part of the passenger volume at the trip to Hat Yai has estimated passenger volume 43, 000 people per day
- Passenger volume on highway 407 travels into space, Hat Yai with passenger volume of approximately 39, 000 people per day. On the part of the passenger volume at the trip to Sadao has estimated passenger volume 37, 000 people per day
- Passenger volume on highway 4 travels into space, Hat Yai with passenger volume of approximately 39, 000 people per day. On the part of the passenger volume at the trip to Sadao has estimated passenger volume 37, 000 people per day
- Passenger volume on highway 4 travels into space, Songkha with passenger volume of approximately 21, 000 people per day. On the part of the passenger volume at the trip to Pattani has estimated passenger volume 22, 000 people per day

2.1.3 Surveys, data collection and problems in the study area

2.1.3.1 Study the product is suitable for rail transport

Detailed statistical data freight traffic and volume* the distance of each type of goods transport between 2008-2012 (B.E. 2551-2555) shown in **Table 2.1.3.1-1.**

Table 2.1.3.1-1 Rail transport statistics (Unit: Million Ton)

NO	Product	Freight traffic (Unit: Million Ton)					Freight traffic* Distances (Million ton - Kilometer)				
		Budget year					Budget year				
		2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
1	Container	9.312	7.483	7.561	7.121	7.009	1522.50	1103.70	1055.0	988.3	n/a
	east	7.453	6.408	6.970	6.615	6.596	879.5	756.2	822.5	780.6	n/a
	other	0.631	0.385	0.348	0.349	0.285	258.2	167.4	150.0	147.5	n/a
	Landbridge	0.612	0.293	0.205	0.157	0.129	335.1	148.0	79.4	60.2	n/a
		0.616	0.398	0.038	-	-	49.8	32.2	3.1	-	n/a
2	crude oil	1.299	1.349	1.371	1.276	1.267	583.3	601.8	610.9	574.3	n/a
3	The cement powder	1.281	1.149	1.111	1.099	0.899	315	283	286.6	273.9	n/a
4	LPG	0.625	0.674	0.834	0.818	0.806	296.5	315.2	396.9	389.9	n/a
5	Other products	0.173	0.091	0.66	0.123	0.473	80.5	70	47.4	43.4	n/a
6	Oil products	0.694	0.662	0.579	0.561	0.468	393.7	312.7	259.1	252.8	n/a
7	ash lignite	0.065	0.061	0.054	0.043	0.023	39.4	36.6	32.2	25.5	n/a
8	The cement powder	0.045	0.029	0.042	0.036	0.017	17.9	9.9	12.1	14.3	n/a
9	Gypsum	0.012	0.006	0.004	-	-	3.4	1.6	1.1	-	n/a
	Total	**13.508**	**11.505**	**11.623**	**11.076**	**10.961**	**3252.30**	**2734.40**	**2701.3**	**2562.5**	**n/a**

Source: SRT

2.1.3.2 The Study are important to economic growth along the path train

- Review the education border trade / Thailand -Malaysia- Singapore

International Trade Thailand -Malaysia there is a continuous increase in trade value every year as export and import in a similar proportion and compared with the border trade between Thailand-Malaysia Overall, found that 60-75 percent of the value of trade between the Thailand-Malaysia as border trade, as the import more exports every year but there is a tendency to export via border is reduced and is more likely to lead to increased bored ,which contains information on international trade and the value of trade between the border 2011-2014 (B.E. 2554-2557) shown in **Table 2.1.3.2-1.**

Table 2.1.3.2-1 Value of international trade and the border trade Thailand -Malaysia 2011-2014

Unit: Million Baht

Item	Internation trade				The border trade			
	2011	2012	2013	2014	2011	2012	2013	2014
Export	373,614.58	383,674.62	393,568.51	410,287.25	379,364.17	303,019.53	288,051.23	274,992.19
Import	376,183.48	409,623.46	406,576.27	414,464.25	181,291.23	212,903.94	213,350.78	232,663.27
Total	749,798.06	793,298.08	800,144.78	824,751.50	560,655.40	515,923.47	501,402.01	507,655.46

Source: Department of foreign trade by customs cooperation

Export products, according to the Thailand-Malaysia border trade include rubber and rubber product, computer, electronics, car and engines, shown in **Table 2.1.3.2-2.**

Imported goods, according to the Thailand-Malaysia border trade important is the majority of the product is radioactive waste electrical and electronic equipment shown in **Table 2.1.3.2-3.**

Table 2.1.3.2-2 Types and value of goods export trade Thailand-Malaysia border 2011-2014

Unit: million baht

No.	Item	2011	2012	2013	2014
1	Rubber	207,324.41	139,382.45	123,044.69	91,325.33
2	Computer	29,780.03	19,373.19	25,669.91	25,851.68
3	Other rubber products	25,908.19	26,175.65	20,472.17	16,419.81
4	Boards	12,387.11	12,743.25	15,107.31	14,280.18
5	Car accessories and parts	4,948.19	6,807.25	9,469.69	9,381.19
6	Fax telephone teletype equipment	N/A	N/A	N/A	8,488.65
7	Cutting machine and electric circuit protection	1,932.41	1,726.55	2,167.81	7,108.36
8	Motors and generators	8,104.06	6,196.79	5,489.93	6,332.55
9	Rubber gloves	6,117.98	6,283.97	5,693.39	5,881.15
10	Internal combustion piston engines	1,598.48	1,651.32	2,129.11	4,809.16
Other		81,263.31	82,678.77	78,807.21	84,574.13
Total		**379364.17**	**303,019.53**	**288,051.23**	**274,992.19**

Source: Department of foreign trade by customs cooperation

Table 2.1.3.2-3 Types and value of the imported goods trade Thailand-Malaysia border 2011-2017

Unit: million baht

No.	Item	2011	2012	2013	2014
1	Sound recording media	23,473.22	12,124.71	19,403.83	23,557.62
2	Magnetic tape. Magnetic plate for computer	17,129.33	9,638.35	19,194.83	22,536.76
3	Computer	20,128.81	N/A	28,365.48	20,280.17
4	Computer components	17,382.39	31,182.09	16,656.09	18,417.58
5	Industrial machinery	9,215.44	11,356.00	11,549.11	17,648.56
6	Circuit boards	6,572.10	8,744.62	10,599.13	12,865.70
7	Printed circuit board	1,398.38	1,744.10	5,763.42	9,135.28
8	Other electrical machinery and components	5,394.24	33,940.83	4,497.44	8,727.48
9	Telegraph tv, telephone radio receiver	5,358.24	6,981.37	6,879.44	8,171.24
10	Aluminum and products	2,098.84	2,955.40	4,967.99	5,892.97
	Other	73,140.03	92,236.47	85,473.91	85,429.90
	Total	**181,291.23**	**212,903.94**	**213,350.78**	**232,663.27**

Source: Department of foreign trade by customs cooperation

- **To collect cargo data and the demand for transport with a train**

Currently on shipping conditions and domestic shipments, road transport is the main because of the road system is a transportation service that is convenient to access to source productions and items directly, not to change the transport. Road transport is also the most effective system for transport during the short distance. The volume of domestic goods transport classified by model of transportation in 2007-2011 (B.E. 2550-2554) is shown as **Table 2.1.3.2-4.**

Table 2.1.3.2-4 Volume of domestic goods transport classified by transportation mode in 2007-2011

Unit: thousand of ton

Forms of transport	2007	2008	2009	2010	2011	% 2011
Road	428,123	424,456	423,677	420,449	406,538	82.17
Rail	11,055	12,807	11,133	11,399	10,864	2.20
River	47,229	47,687	41,561	48,185	46,130	9.32
Coastal	31,216	29,615	29,311	29,004	31,071	6.28
AIR FREIGHT	110	106	103	121	131	0.03
Total	517,733	514,671	505,785	507,916	493,536	100

The volume of highway transportation

Road freight in 2012 (B.E. 2555) Freight volume in the maximum weight of product units product categories include sugarcane as secondary categories and types of sandstone soil minerals, respectively, but when you consider the total transport volume with distance (in million tons-km) Found to have the highest rice as miscellaneous items and metal construction, respectively

The volume of rail freight

Data from the Center for Information and Communication Technology, Ministry of transport Office found that freight train, there is a very small proportion, when compared to the carriage of goods by road and combined transport volume decreased continuously. By a group item with a quantity of transport most petroleum products, cement and miscellaneous items, respectively.

2.2 Transport Demand Modelling

National Model (NAM)

The Consultants applied the National Model (NAM) developed by Office of Transport and Traffic Policy and Planning (OTP) for our transport demand forecast. The model has been developed in Cube Voyager and been applied to several transport studies for OTP, EXACT, DOH, SRT, BMA, etc.

NAM is composed of 4 main hierarchic procedures as shown in **Figure 2.2-1**

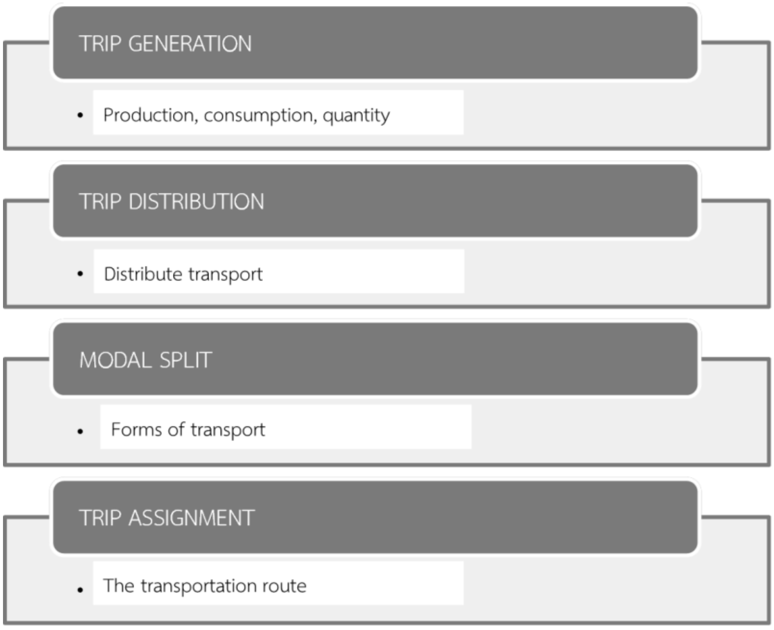


Figure 2.2-1 Four-Step Model

All 4 main procedures in NAM can be briefly explained as the followings:

(1) Trip Generation Model

Trip generation model is the first step of the forecast. Trip generation will estimate total number of trips in and out traffic zones in term of "Trip End" by using the equation stated below.

$$TRIP = (0.0262 * Pop) + (0.0763 * GPP) + 2{,}373$$

where:

TRIP = Total number of trips (Person trips/day)

Pop = Population by traffic zone

GPP = Gross Provincial Product at a constant price in 1988 (2531) by traffic zone

(2) Trip Distribution Model

Trip distribution model is the next step of the forecast. Trip distribution will estimate total number of trips between each pair of traffic zones by using "Gravity Model" as its equation is stated below.

$$T_{ij} = a_i \times b_j \times P_i \times A_j \times F(C_{ij}) \times K_{ij}$$

where:

T_{ij} = Trip from $zone_i$ to $zone_j$

P_i	=	Trip from $zone_i$
A_j	=	Trip to $zone_j$
$a_i\ b_j$	=	Adjustment Factor
$F(C_{ij})$	=	Cost Deterrence Function from $zone_i$ to $zone_j$
K_{ij}	=	K Factor Adjustment from $zone_i$ to $zone_j$ for $F(C_{ij})$
		where $F(C_{ij})$ is calculated from
$F(C_{ij})$	=	C_{ij} 1.556 exp (-0.000635C_{ij})
C_{ij}	=	Generalised Cost from $zone_i$ to $zone_j$

The end result is "Trip Matrix" from all provinces with a trip length distribution curve as shown in **Figure 2.2-2.**

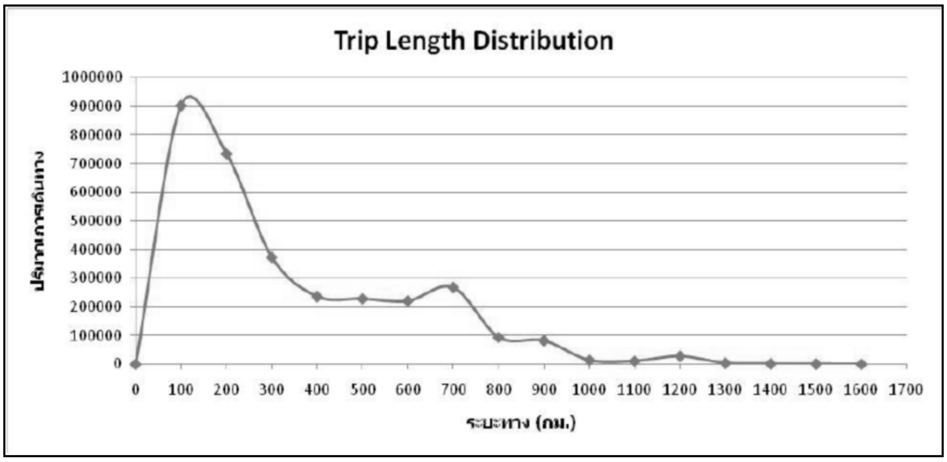


Figure 2.2-2 Trip Length Distribution Curve

(3) Modal Split Model

After trip distribution model, the next step is to evaluate choices of transport by mode which is by far the most complex procedure in transport modeling. Evaluation of proportion of trips by each mode of transport can be done by applying utility function. The type of utility function in NAM is "logit model" as written in the equation state below.

$$P_i = \frac{e^{Ui}}{\sum_m e^{Ui}}$$

where:

P_i	=	Probability of choosing $mode_i$
e	=	Natural logarithm value (2.718)
U_i	=	Utility Function
m	=	Total number of modes

Figure 2.2-3 shows the Logit Curve of the model.

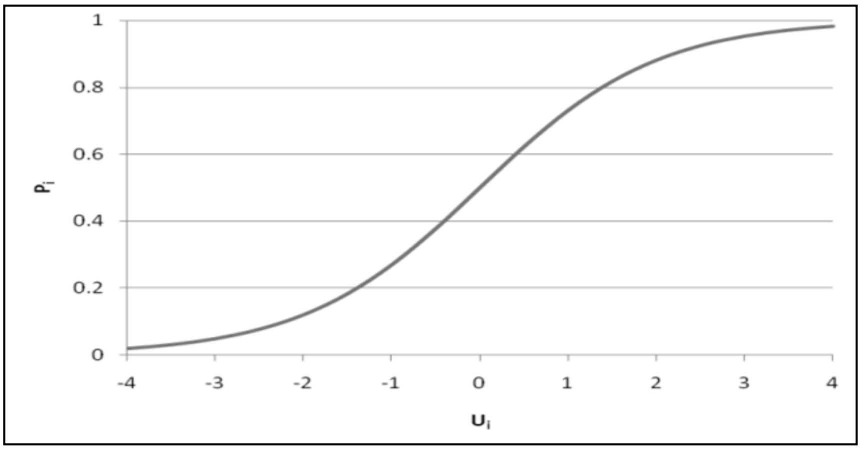


Figure 2.2-3 Logit Model

Utility Function is used to describe trip characteristics by mode as it is written as:

$$Ui = Ai + (Bi * GCi)$$

where:

GC_i = Generalised Cost of $mode_i$

B_i = Coefficient Parameter of Generalised Cost

Ai = Mode Specific Constant of $mode_i$

Generalised Cost by each mode can be calculated in such manner in term of travel time and travel cost. **Table 2.2-1** shows parameters used in modal split of NAM model.

Table 2.2-1 Parameters of NAM Modal Split

Mode of Transport	A_i	B_i
Private vehicle	0.00	-0.0015
Bus	-0.03	-0.0015
Rail	-1.70	-0.0015
Airplane	-3.50	-0.0015

Those parameters are approved by OTP as they underwent a calibration in order to be applied for this forecast. The Consultants later used these parameters in our evaluation of modal split.

They are other free parameters that can be cross checked for modal split validation to represent actual trip pattern and mode share. These are parameters required in the utility function, in vehicle time, fare, wait time, and transfer/walk time.

(4) Trip Assignment Model

There are several types of modes, but eventually they are grouped into 2 sets of trip matrices of private and public transport modes. Number of buses can be estimated from line frequency (or headway) and it was then added to the road network as a “Preload” volume.

Later a technique called “incremental loading” was applied for the highway assignment.

Modification of NAM

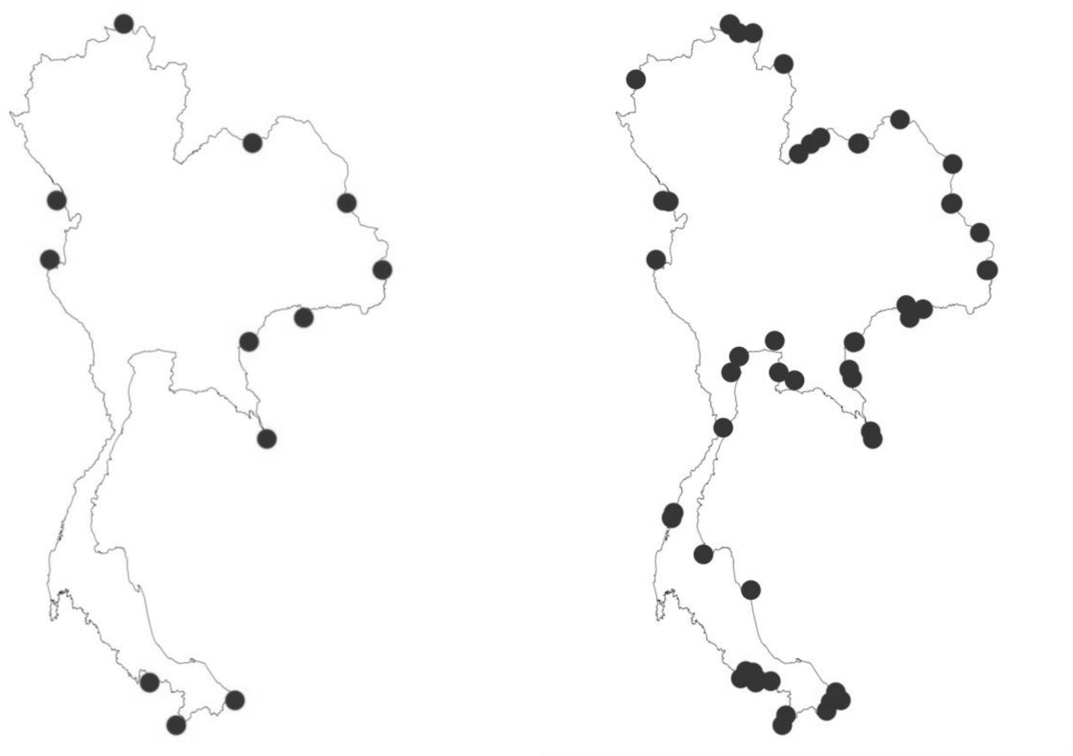
The Consultants did some update and modification to NAM as the followings:

- Update NAM with the present and the future networks according the latest implementation plans.
- Perform model validation using traffic data from DOH and all related agencies.
- Update and improve the trip generation model using the latest survey data.
- Update and improve the trip distribution model using the latest primary & secondary survey data.
- Update and improve the modal split model for all types of transport modes (road, rail, and water)

(1) Traffic Zone

Since the traffic zone system in NAM is based on district level (Amphor), while stations are located in sub-districts level (Tambon). Therefore, a modification of NAM traffic zoning system was required to make a model more robust for the study. Modification was done to trip assignment module as the Consultants performed a fine tuning to the traffic zoning system along the project corridor as it is referred to as “the influenced area” or “potential area”

In addition, the Consultants added more locations of border crossing (custom borders) from 12 to 46 as shown in **Figure 2.2-4**



12 External Zones (Original NAM) **46 External Zones (Improved NAM)**

Figure 2.2-4 Border Crossings as External Zones

(2) NAM Transport Network

NAM transport network are from several agencies in different Geographical Information System (GIS) with different formats. The data was then stored in the database and converted to a node & link base. Transport network is in a "link" format. Each transport link represents a transport route (as a section of route). An intersection of links is called "node" with node coordinates. There is also one type of link called "centroid connector" from each traffic zone. It represents a link connecting network and a traffic zone as "centroid" represents the location where trip generation/attraction in the traffic zone.

NAM transport network (or link) is composed road & public transport network with attributes as follows:

- Network (classified by road, rail, water, and air), length, capacity, speed, etc.
- Public transport network (rail, river, coastal, and air), service policy (frequency or headway), mode, company, fare table (or fare structure), location of station, capacity, speed, etc.

The Consultants updated all types of NAM transport networks for road, rail, water, and air with all important transport nodes in such as rail stations, LCD, ports, airports, etc. as shown in **Figure 2.2-5**

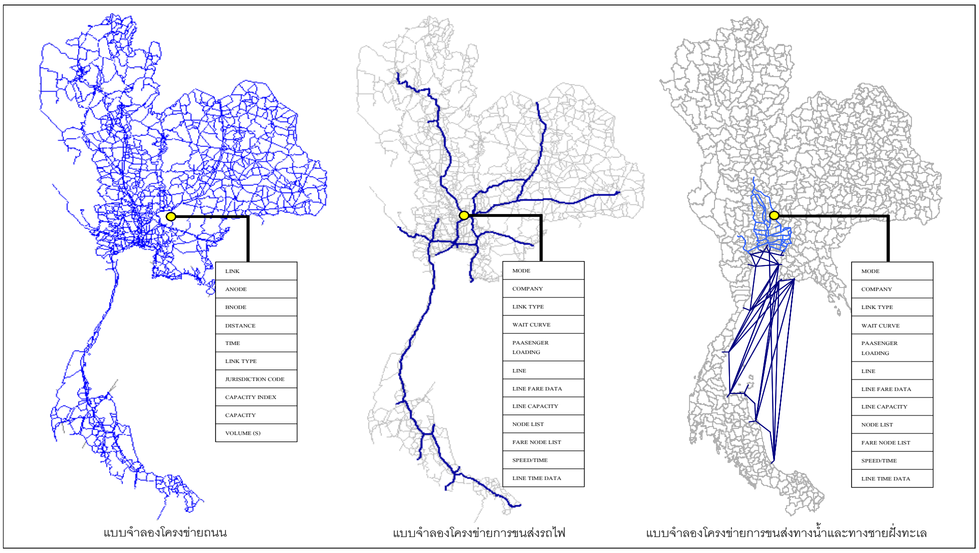


Figure 2.2-5 Different Types of NAM Transport Networks

(3) Location of Train Stations

Location of rail station from Surat Thani – Hat Yai is shown in **Figure 2.2-6** with all 59 stations (large, medium, and small station). From Hat Yai – Song Khla, there are 7 stations as shown below.

- Khlong Hae
- Ban Ko Mi
- Thung Yai
- Talat Pha Wong
- Nam Kra Chai
- Khao Roop Chang
- Songkhla

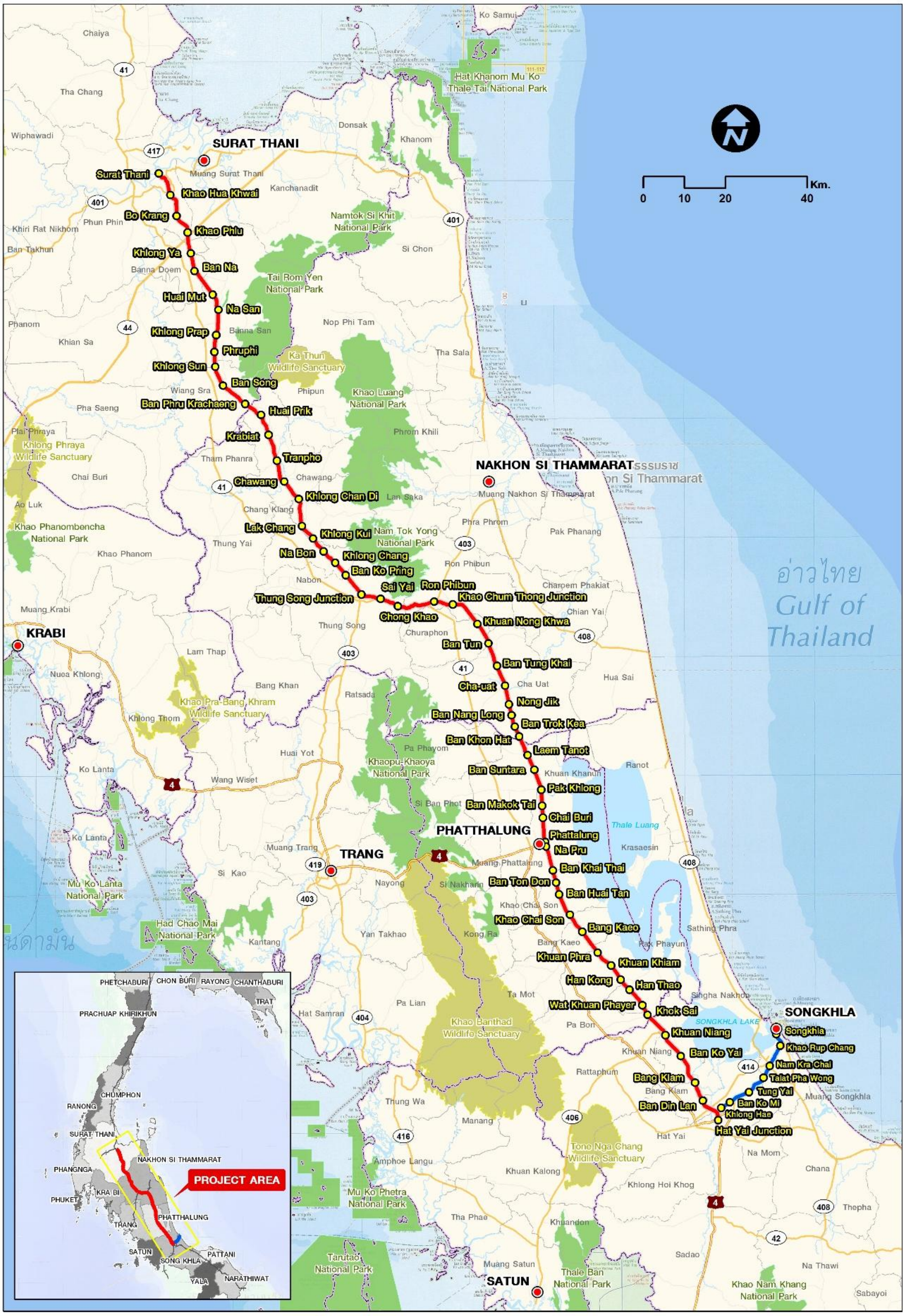


Figure 2.2-6 Location of Train Stations

Model Validation

Model validation is a procedure to adjust the model results to the observed volumes by each screenline location by using several sources from DOH and related projects. Nonetheless, discrepancies between 2 sets of volumes are allowed but within an acceptable range by using criteria issued by U.S. Department of Transport (1997) as shown in **Table 2.2-2** The result of our model validation is shown in **Table 2.2-3** as the difference between observed and estimated volumes is within 10% range.

Table 2.2-2 Allowable Discrepancies between Modeled & Observed Volumes

Type of Road	Allowable Discrepancies (%)
Expressway	± 10
Major Arterial	± 15
Minor Arterial	± 25
Traffic Volume (PCU/day)	**Allowable Discrepancies (%)**
0 - 5,000	± 36
5,000 - 10,000	± 29
10,000 - 25,000	± 25
25,000 - 50,000	± 22
>50,000	± 21

Source*: Travel Model Improvement Program, Federal Highway Administration, U.S. Department of Transportation*

Table 2.2-3 Result from Model Validation

No	Direction	Observed Volume (PCU/day)	Modeled Volume (PCU/day)	Discrepancies (%)
MB-1	Highway no 4 Ranong – Phang Nga	19,392	20,518	5.8%
MB-2	Highway no 41 Chumporn – Surat Thani	40,207	41,723	3.8%
MB-3	Highway no 4 Krabi - Trang	30,754	33,629	9.3%
MB-4	Highway no 41 Surat Thani – Nakhon Sri Thammarat	32,434	34,711	7.0%
MB-5	Highway no 41 Nakhon Sri Thammarat - Patthalung	28,407	30,512	7.4%
MB-6	Highway no 4 Phattalung – Hat Yai	40,612	41,723	2.7%
MB-7	Highway no 407 Hat Yai – Song Khla	30,007	32,862	9.5%
MB-8	Highway no 4 Hat Yai – Sa Dao	31,994	30,265	-5.4%
MB-9	Highway no 4 Song Khla - Pattani	16,709	17,527	4.9%

2.3 Passengers and freight volume forecast

Many reports that involving in this project have been studied in order to make this estimation as realistic and up-to-date as possible. This is because this estimation will be used as a database for further studies in this project such as the planning in engineering, economic, social, finance and funding, designing, and environmental impact

According to U.S. Bureau of Public Roads, the estimation of future demand of commuting can be classified into 4 types

1) The current traffic of the new construction project – this refers to the changing of citizen commuting behavior that they will change the route they used to travel to be the new one from the project. The number of passengers in this case can be calculated from the number of passengers who commute in this route before the launch of this project plus the number of passengers who will use this route when this project finished

2) Normal growth traffic – this refers to the growth of traffic due to the expansion of economic and changes of social. This factor will not be affected from the existence of the project.

3) Generated traffic – this refers to the growth of traffic because of the new construction or developing of the project. The generated traffic can be categorized into 2 types

- Induced Traffic – the traffic from the better accessibility from the project
- Converted Traffic – the traffic from the change of the mode of transportation to use the one from the project

4) Development Traffic – the future commuting demand will be changed according to the changes of lands. The guideline on how to estimate the number of passengers can be seen in **Figure 2.3-1**

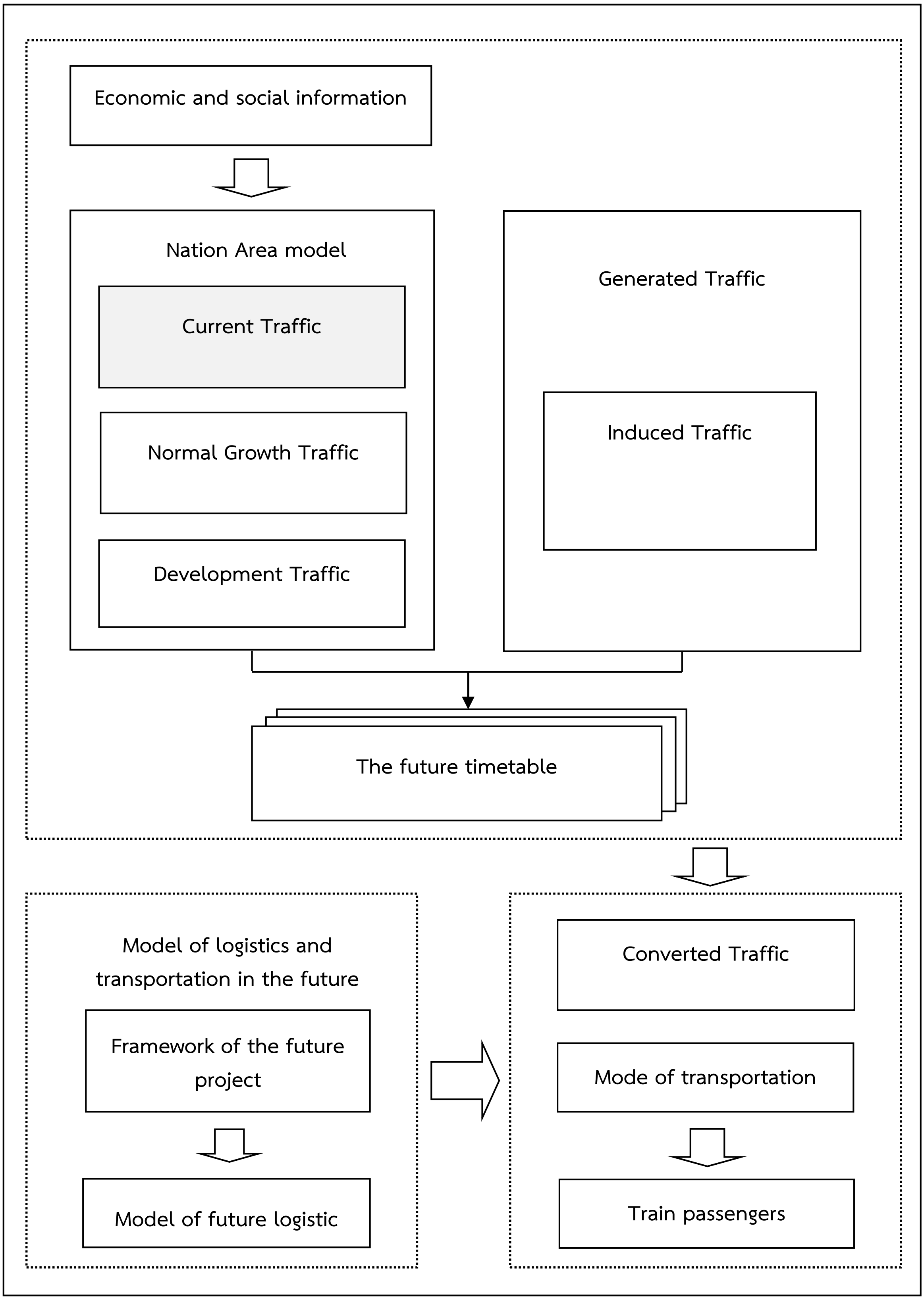


Figure 2.3-1 Guideline on estimation of the number of passengers

2.3.1 Assumption for estimating the number of passengers

Assumption for estimating the number of passengers can be found in **Table 2.3.1-1.**

Table 2.3.1-1 Assumption for estimating the number of passengers

1. The database of the model of traffic and logistic	
The traffic model	Model traffic and transport: NAM (National Model)
2. Train information project	
- To continue the project	Open 2021
- Speed of service	- Rail passenger train double standard, aver. 160 km./hr. (max. 200 km./hr.) - Rail passenger train double the size of one metre aver. 100 km./hr. (max. 160 km./hr.) - Rail passenger train one single size (ST/MG) aver 60 km./hr.
- Station number of railway projects	Main station list station list sub district and sub-district
- Basic fares	SRT Floor 3 aver 0.40 baht/km. SRT Floor 2 aver 1.16 baht/km SRT Floor 1 aver 1.96 baht/km Personal cars aver 3.00 baht/km Bus aver 1.20 baht/km Plane (standard) เฉลี่ย 5.60 baht/km Plane (Promotion) เฉลี่ย 2.88 baht/km
3. Rail network system	Schedule network development partner via rail system rail system both in size and standard rail 1 meter according to the development plan of the Ministry of transport
4. Road network system	Road development schedule based on the master plan

Source: The Consultants

2.3.2 Result of Passenger Demand Forecast

Result of Passenger Demand Forecast

Result of passenger demand forecast is shown in **Table 2.3.2-1** In 2021 the amount of passenger trips will be 3,009.42 thousand person trips/day and will increase to 3,748.90, 4,750.84, and 5,872.07 thousand person trips/day in 2031, 2041, and 2051, respectively. Growth rate is 2.2% per annum increasing from 2,660.40 thousand person trips/day in 2015 (B.E. 2558).

Table 2.3.2-1 Passenger Demand Volumes by Modes

(Unit: thousand person trip/day)

Mode	2015	2021	2031	2041	2041
Private vehicle	1,404.21	1,544.53	1,899.74	2,384.68	2,851.78
Bus	1,060.35	1,186.72	1,443.11	1,807.05	2,132.27
Rail	99.40	169.46	251.97	341.97	520.77
Airplane	96.44	108.71	154.08	217.14	367.24
Total	**2,660.40**	**3,009.42**	**3,748.90**	**4,750.84**	**5,872.07**

Source: The Consultants

2.3.3 Result of Passenger Demand Forecast

There are 2 cases in our transport forecast as follows:

Case1: Construction of the whole project from Surat Thani – Song Khla

Case 2: Construction of a section from Surat Thani – Hat Yai Junction

The result of the forecast is shown on the next page.

Case1: Construction of the whole project from Surat Thani – Song Khla

The result of case 1 is shown in **Table 2.3.3-1** Ridership in 2021 will be 21,416 passengers/day and will increase to 28,760, 37,342, and 45,950 passengers/day in 2021, 2031, and 2041, respectively.

Considering passenger boarding figures as shown in **Table 2.3.3-1,** the maximum passenger boarding will occur at Hat Yai Station in 2041 since it is a junction station and also the largest one with passenger boarding at 8,811 passengers/day or equivalent to 19% of the total daily ridership.

Song Khla Station comes in the 2nd place as it will accommodate 6,773 passengers/day. Most trips will be from Hat Yai – Song Khla.

Surat Thani Station comes in the 3rd place with 4,249 person trips/day or equivalent to 9% of the total daily ridership. Passenger boarding at Tung Song Station and Patthalung Station will be 3,056 and 3,002 passengers/day, respectively or equivalent to 9% of the total daily ridership.

Passenger line load figures for all sections are shown in **Table 2.3.3-2**. In 2021, maximum passenger line load will occur at the section of Surat Thani – Hat Yai at 16,393 passengers/day/direction. It will increase to 20,654, 26,138, and 33,120 passengers/day/direction in 2031, 2041, and 2051, respectively.

In 2021, maximum passenger line load from Hat Yai – Song Khla will 3,371 passengers/day/direction. It will increase to 4,619, 5,856, and 7,139 passengers/day/direction in 2031, 2041, and 2051, respectively.

Table 2.3.3-1 Daily Ridership

Case 1: Surat Thani – Song Khla

Person Trips/Day

Station	2021		2031		2041		2051	
	In	Out	In	Out	In	Out	In	Out
Surat Thani	2,506	3,158	3,113	3,922	3,638	4,597	4,249	5,382
Khao Hua Kwai	9	4	16	7	25	10	39	16
Bo Krang	3	14	5	24	8	39	12	63
Khao Plu	13	11	23	19	37	31	60	50
Khlong Ya	5	3	9	5	15	8	24	13
Ban Na	102	91	151	134	223	198	403	358
Huai Mut	33	23	49	34	57	40	67	47
Nasan	353	313	522	463	702	622	825	730
Khlong Prap	5	8	7	10	10	17	15	25
Phru Phi	46	38	62	51	100	83	162	136
Khlong Sun	3	2	4	3	7	5	11	8
Ban Song	576	543	853	803	1,192	1,122	1,456	1,371
Ban Phru Krachaeng	23	18	31	24	50	39	82	64
Huai Prik	81	71	109	95	183	150	292	255
Kra Biat	50	40	68	54	110	88	180	144
Tran Poh	213	186	315	275	466	407	690	602
Chawang	148	138	232	217	364	340	571	533
Khlong Chan Di	548	545	859	855	1,271	1,265	1,553	1,545
Lak Chang	27	22	36	29	58	47	94	76
Khlong Kui	5	6	7	8	11	14	18	22
Na Bon	116	98	156	132	254	215	414	350
Khlong Chang	23	18	30	24	49	39	80	63
Ban Ko Pring	4	5	5	6	8	9	12	14
Tung Song Junction	1,599	1,681	2,091	2,200	2,610	2,748	3,056	3,222
Sai Yai	41	26	55	34	90	56	147	92
Chong Kao	6	2	18	4	36	8	71	16
Ron Phibun	257	113	406	170	630	239	802	295
Khao Chum Thong Junction	293	246	477	401	777	654	1,006	847
Khuan Nong Khwa	31	27	43	37	63	54	93	80
Ban Tun	86	58	120	81	168	113	234	157
Ban Tung Kai	1	2	1	2	2	3	3	4
Cha-uat	723	624	1,018	880	1,367	1,181	1,638	1,414
Nong Jik	2	10	3	14	4	18	5	24
Ban Nang Long	88	81	119	109	160	147	215	198
Ban Khon Hat	179	174	241	234	324	314	435	421
Laem Tanot	158	156	213	209	287	281	386	377
Ban Suntara	2	3	3	4	4	5	5	7
Pak Khlong	269	261	421	408	659	639	774	750
Ban Makok Tai	2	11	3	15	4	20	7	36
Chai Buri	4	14	5	18	6	24	10	43

Table 2.3.3-1 Daily Ridership
Case 1: Surat Thani – Song Khla (cont.)

Person Trips/Day

Station	2021		2031		2041		2051	
	In	Out	In	Out	In	Out	In	Out
Ban Trok Kae	5	7	7	9	8	11	11	14
Phattalung	1,702	2,067	2,128	2,584	2,579	3,147	3,002	3,677
Na Pru	6	7	7	9	8	11	14	19
Ban Kai Thai	4	6	5	8	6	10	11	18
Ban Ton Don	81	71	159	140	313	276	367	324
Ban Huai Tan	6	18	7	22	8	26	14	47
Khao Chaison	204	187	279	256	382	351	465	427
Bang Kaew	363	361	498	494	683	677	833	825
Khuan Phra	7	73	10	100	14	137	17	167
Khuan Khaim	115	106	158	145	216	198	279	256
Han Kong	7	10	10	14	14	20	19	28
Han Thao	318	288	457	414	657	596	827	750
Wat Khuan Phayer	6	7	8	9	11	13	27	33
Khok Sai	140	140	207	207	306	306	385	385
Khuan Niang	221	188	327	278	484	411	609	517
Ban Ko Yai	55	48	90	79	147	129	266	234
Bang Klam	41	36	66	58	107	94	134	118
Ban Din Lan	61	37	99	59	161	95	202	119
Hat Yai Junction	4,972	5,540	6,217	6,887	7,448	8,217	8,811	9,699
Khlong Hae	413	398	566	545	717	691	874	843
Ban Ko Mi	237	216	324	296	411	375	501	457
Thung Yai	135	132	185	181	234	230	285	280
Talad Pha Wong	241	185	330	254	419	322	511	392
Nam Kra Chai	158	107	216	146	274	185	334	225
Kao Roop Chang	86	78	118	107	150	136	183	166
Song Khla	3,199	3,346	4,383	4,585	5,556	5,812	6,773	7,085

Table 2.3.3-2 Maximum Passenger Line Load
Case 1: Surat Thani – Song Khla

Passengers/Day/Direction

Section	Maximum Passenger Line Load (Person/Day/Direction)			
	2021	2031	2041	2051
Surat Thani – Tung Song	120	20,654	26,138	33,120
Tung Song Junction - Patthalung	13,900	17,276	21,642	27,597
Pattalung – Hat Yai	14,407	17,971	22,511	28,620
Hat Yai – Song Khla	3,371	4,619	5,856	7,139

Case 2: Construction of a section from Surat Thani – Hat Yai Junction

The result of case 2 is shown in **Table 2.3.3-3**

Ridership in 2021 will be 15,237 passengers/day and will increase to 20,236, 26,617, and 32,955 passengers/day in 2021, 2031, and 2041, respectively.

Considering passenger boarding figures as shown in **Table 2.3.3-3**, the maximum passenger boarding will still occur at Hat Yai Station in 2041 since it is a junction station and also the largest one with passenger boarding at 6,219 passengers/day or equivalent to 18% of the total daily ridership.

Passenger boarding at Tung Song Station and Patthalung Station will be 2,934 and 2,623 passengers/day, respectively or equivalent to 7-9% of the total daily ridership.

Passenger line load figures for all sections are shown in **Table 2.3.3-4.** In 2021, maximum passenger line load will occur at the section of Surat Thani – Tung Song at 15,911 passengers/day/direction. It will increase to 19,923, 25,041, and 31,656 passengers/day/direction in 2031, 2041, and 2051, respectively.

Table 2.3.3-3 Daily Ridership
Case 2: Surat Thani – Hat Yai

Person Trips/Day

Station	2021		2031		2041		2051	
	In	Out	In	Out	In	Out	In	Out
Surat Thani	2,303	2,903	2,835	3,574	3,331	4,198	3,913	4,931
Khao Hua Kwai	8	3	14	5	23	8	37	13
Bo Krang	2	13	4	23	7	38	11	61
Khao Plu	13	11	23	19	37	31	60	50
Khlong Ya	5	3	9	5	15	8	24	13
Ban Na	101	90	150	133	222	197	402	356
Huai Mut	33	23	49	34	57	40	67	47
Nasan	353	313	522	463	702	622	825	730
Khlong Prap	4	6	5	8	8	14	13	22
Phru Phi	46	38	62	51	100	83	162	136
Khlong Sun	3	2	4	3	7	5	11	8
Ban Song	576	543	853	803	1,192	1,122	1,456	1,371
Ban Phru Krachaeng	23	18	31	24	50	39	82	64
Huai Prik	80	70	108	94	181	148	290	252
Kra Biat	50	40	68	54	110	88	180	144
Tran Poh	213	186	315	275	466	407	690	602
Chawang	148	138	232	217	364	340	571	533
Khlong Chan Di	548	545	859	855	1,271	1,265	1,553	1,545
Lak Chang	26	21	35	28	57	46	93	75
Khlong Kui	5	6	7	8	11	14	18	22
Na Bon	116	98	156	132	254	215	414	350
Khlong Chang	23	18	30	24	49	39	80	63
Ban Ko Pring	3	4	4	5	7	8	11	13
Tung Song Junction	1,525	1,588	1,990	2,073	2,498	2,603	2,934	3,058
Sai Yai	41	26	55	34	90	56	147	92

Table 2.3.3-3 Daily Ridership
Case 2: Surat Thani – Hat Yai (cont.)

Person Trips/Day

Station	2021		2031		2041		2051	
	In	Out	In	Out	In	Out	In	Out
Chong Kao	6	2	18	4	36	8	71	16
Ron Phibun	211	56	344	92	561	150	727	194
Khao Chum Thong Junction	293	246	477	401	777	654	1,006	847
Khuan Nong Khwa	30	26	42	36	62	53	92	79
Ban Tun	86	58	120	81	168	113	234	157
Ban Tung Kai	1	2	1	2	2	3	3	4
Cha-uat	718	618	1,012	872	1,360	1,172	1,630	1,404
Nong Jik	2	10	3	14	4	18	5	24
Ban Nang Long	88	81	119	109	160	147	215	198
Ban Trok Kae	3	4	4	5	5	7	7	9
Ban Khon Hat	178	173	240	233	323	313	434	420
Laem Tanot	158	156	213	209	287	281	386	377
Ban Suntara	2	3	3	4	4	5	5	7
Pak Khlong	268	260	420	407	658	638	773	749
Ban Makok Tai	2	11	3	15	4	20	7	36
Chai Buri	3	13	4	17	5	23	9	42
Phattalung	1,473	1,780	1,814	2,191	2,233	2,697	2,623	3,168
Na Pru	5	6	6	8	7	10	13	18
Ban Kai Thai	4	6	5	8	6	10	11	18
Ban Ton Don	81	71	159	140	313	276	367	324
Ban Huai Tan	6	18	7	22	8	26	14	47
Khao Chaison	203	186	278	255	381	350	464	426
Bang Kaew	363	361	498	494	683	677	833	825
Khuan Phra	7	73	10	100	14	137	17	167
Han Kong	7	10	10	14	14	20	19	28
Han Thao	318	288	457	414	657	596	827	750
Wat Khuan Phayer	5	6	7	8	10	12	26	32
Khok Sai	140	140	207	207	306	306	385	385
Khuan Niang	221	188	327	278	484	411	609	517
Ban Ko Yai	55	48	90	79	147	129	266	234
Bang Klam	41	36	66	58	107	94	134	118
Ban Din Lan	60	36	98	58	160	94	201	118
Hat Yai Junction	3,836	4,618	4,596	5,533	5,346	6,436	6,219	7,486

Table 2.3.3-4 Maximum Passenger Line Load
Case 2: Surat Thani – Hat Yai

Passengers/Day/Direction

Section	Maximum Passenger Line Load (Person/Day/Direction)			
	2021	2031	2041	2051
Surat Thani – Tung Song	15,911	19,923	25,041	31,656
Tung Song Junction - Patthalung	13,006	16,007	19,955	25,452
Pattalung – Hat Yai	13,209	16,266	20,302	25,897

2.3.4 Forecasted product volumes for domestic and international transportation

From the survey and the collected data of factors for selecting transportation modes and its demand in the previous study, it was found that the potential and suitable goods for rail transportation in the southern routes between Surat Thani station and Hat Yai junction including the connection to Padang Besar Customhouse for the connection to Malaysia are the following 3 products; 1) Rubber products 2) Rubber wood products and 3) Wood-made fiberboard products, either through Padang Besar Customhouse or the northbound route to Bangkok port or Laem Chabang port while other miscellaneous or consumable goods are not high in volume for domestic transportation comparing with international transportation. As for some construction materials such as cement, gypsum and energy related products, although the consumption was relatively high in the studied area, but they were usually transported by ships and also their warehouses/distribution centers were located near the coastal ports of Surat Thani already. In addition to the above mentioned, goods contained in parcels or packages by many small entrepreneurs also required transportation by train, but the volume was not so high. The transportation for these kinds of goods was different from the first three main groups whose transportation was directly performed by freight trains, but these products were by contrast performed by passenger trains for which the senders and the receivers had to pick up their goods to and from the trains at the stations by themselves.

Goods those could be potentially transported by train in each studied route are varied in term of transportation behavior including the growth trend under different factors. Nevertheless, some hypothesis for the forecast of volumes in the future as well as the volumes of goods that tend to switch from other modes to rail transportation mode for any kind of goods can be identically specified as follows;

- The analysis is made only for the transport of goods from their factories which are located not over 50 kilometers from the railway.
- The State Railway of Thailand (SRT) owns sufficient engines, bogies, staff, discharge area, and space for storing containers in both origin and terminal stations.
- SRT can provide services for several customers in one trip (not specify that a customer must take the whole service individually)
- SRT has a supporting measure for rail transportation to serve small and medium entrepreneurs.

Moreover, from the transportation demand data obtained from the survey, comments from all entrepreneurs and logistics providers on rail transportation according to the studied routes can be significantly divided into 2 major opinions which are 1) The Transportation on the old route between Surat Thani Station and Padang Besar Station for which all of them agreed that double-track railway improvement project was necessary and 2) The transportation between Hat Yai junction-Sonkhla for which the majority of them considered unreasonable according to the actual demand. Therefore, our forecasted volumes of goods to be transported in the future are divided into 2 parts; 1) The transportation between Hat Yai junction-Songkhla connecting to Padang Besar, and 2) The transportation between Songkhla-Hat Yai Junction connecting to the main railway. The details are also individually specified for each station and type of goods as follows;

2.3.4.1 Transportation of goods between Surat Thani and Hat Yai Junction connecting to Padang Besar

From the survey of transportation demand, the entrepreneurs, logistics providers as well as the related organizations showed similar opinions that the transportation demand along the route from Surat Thani to Padang Besar had a potential for future growth. The entrepreneurs needed rail transport to connect with Malaysia where double-track railway had already been developed up to the border of

Padang Besar. Although the studied routes did not cover Padang Besar Station, it was found that in the actual situation, the transportation demand in the route Surat Thani-Hat Yai junction-Padang Besar was higher than that in the route to Muang Songkhla. Moreover, the transportation by train of the Southern route was likely to be international than domestic. Also, there were many containers appeared in the origin stations and terminal stations which were out of the scope in this study, but they were partly transported across the studied routes. Therefore, the forecasted volumes of goods based on this study must take the volumes occurs in Padang Besar Station into account too so that it can be used as the data for future decision.

In order to understand the whole picture of transportation from Bangkok and Perimeter areas to Padang Besar, diagram for the illustration of transport for which the origins and terminals are indicated as well as the types of goods and transportation modes according to the present situation are made and shown in **Figure 2.3.4-1**

Considering the present situation of goods transport at Hat Yai Junction, many problems and limitation were found such as the intensity of the surrounded community which resulted in limited accessibility of big trucks or time restriction for accessing the area. Moreover, it was found that Hat Yai Junction was the transition station for containers from Ban Thung Pho and Thung Song Junctions before delivering to Padang Besar, but unloading and reloading activities of containers could not be found like in the past. However, the entrepreneurs and logistics providers mutually agreed that some nearby railway station should be improved to be a new rail transportation center of Songkhla. From industry conditions in the area, it was found that Bangklam Station was suitable as a candidate for the replacement of Hat Yai junction whose space was limited for the expansion. Therefore, the forecast in this study consists of 2 stations which are “Thung-Song” and “Bangklam”, and 2 stations out of this studied, “Thung Pho”, “Badung Besar”.

The forecast of volumes in this study is based on the following conditions;

- In case of normal growth by economic situation and SRT does not invest for any infrastructure or facilities.
- In case there is no implementation of double track railway, but SRT increases the number of engines and bogies and adjust the train timetable.
- In case double-track railway is implemented

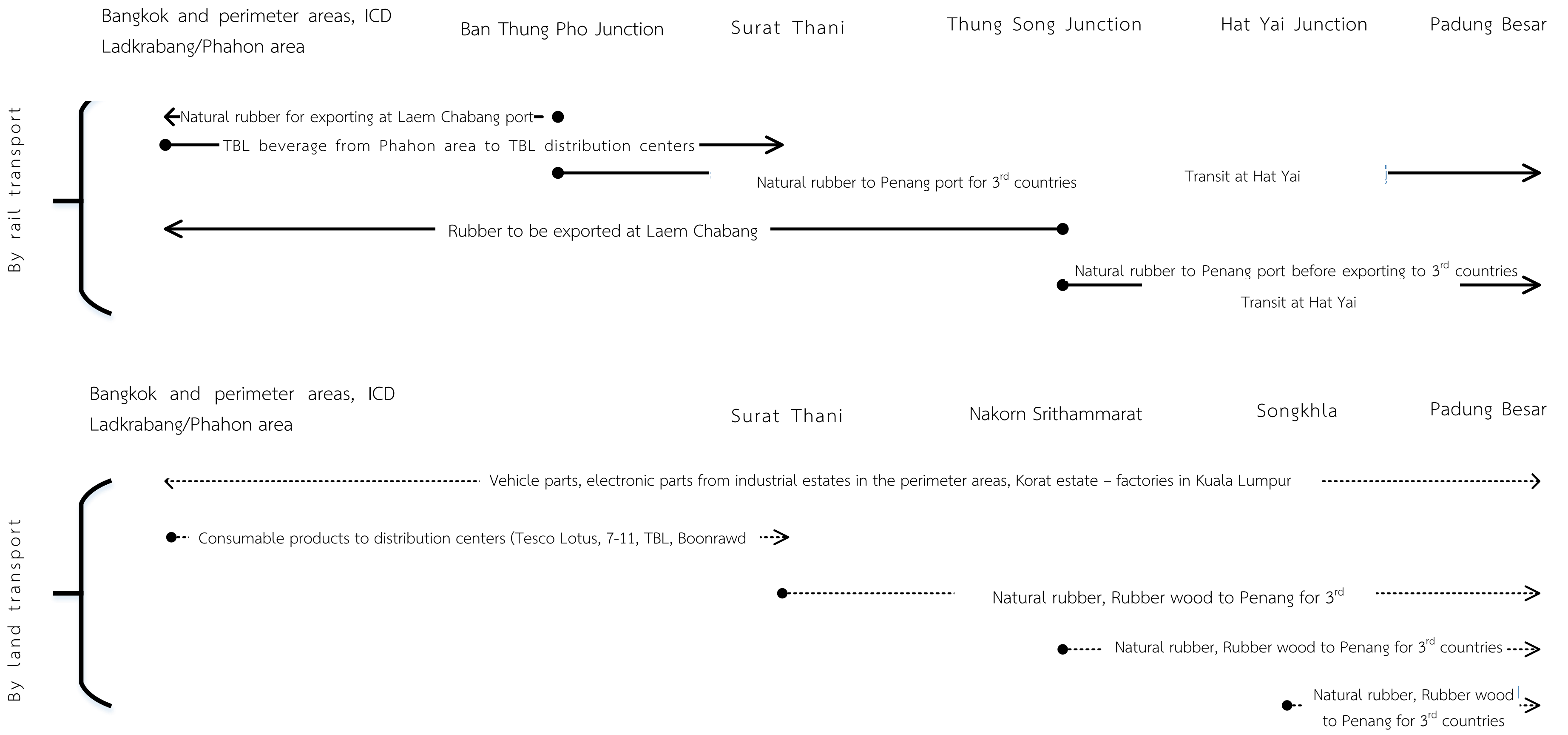


Figure 2.3.4-1 Origin-Terminal stations, types of goods, modes of transportation which are potentially performed by trains in the studied area.

From the above figure and the data given by Badang Besar Customhouse, it was found that there were 3 potential types of goods whose destinations were different. Rubber products are the first rank in term of volume and transported to both northbound and southbound, while Rubber wood products and Wood-made Fiberboard products were only transported to the southbound for Badang Besar only.

From the volume data in all three types in 2014 and economic growth rate under the following assumption, the forecasted numbers of goods in the studied area are shown in **Table 2.3.4-1**

- The average growth rate of exported rubber products volume is 4.3% per year.
- The average growth rate of exported rubber wood products is 5.5% per year and expected to be the same rate until 2019, after that the growth rate drops to 3% per year because the main customer 'China' can finally consume its own domestic rubber trees.
- The average growth rate of exported Fiberboard products volume is 5.5% per year.

Table 2.3.4-1 Forecasted product volumes in the studied areas (unit: ton)

Year (B.E.)	Year	Rubber Products	Rubber Wood Products	Fiberboard Products	Total
2557	2014	2,096,035	656,622	151,126	2,903,783
2564	2021	2,896,652	910,441	219,839	4,026,932
2569	2026	3,649,655	1,055,451	287,321	4,992,427
2574	2031	4,598,407	1,223,558	375,518	6,197,483
2579	2036	5,793,792	1,418,439	490,786	7,703,017
2584	2041	7,299,925	1,644,360	641,438	9,585,723
2589	2046	9,197,587	1,906,264	838,333	11,942,184
2594	2051	11,588,560	2,209,884	1,095,667	14,894,111

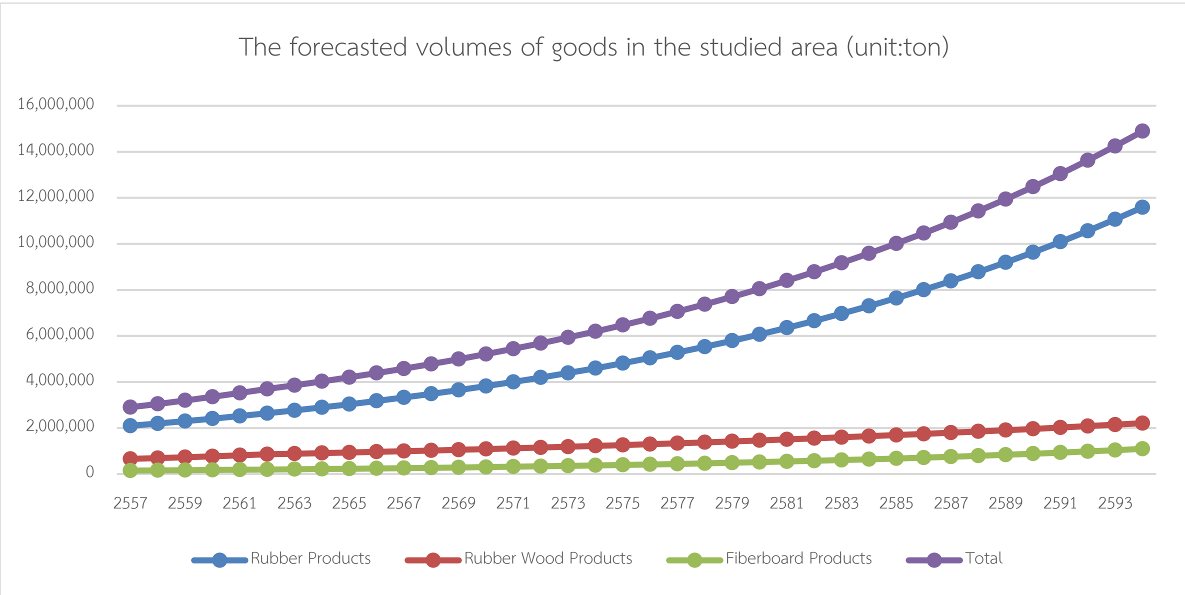


Figure 2.3.4-2 Forecasted product volumes in the studied area (unit: ton)

So, the volume in term of TEUs according to loading capacity (in case of transportation by train) can be calculated as follows;

- Rubber products: 25 tons/TEUs (in short-typed container)
- Rubber wood and Fiberboard products: 14 tons/TEUs (in long-typed container)

The result of calculation in TEUs is shown in **Table 2.3-7.**

Table 2.3.4-2 Forecasted product volumes in the studied area (unit: TEUs)

Year (B.E.)	Year	Rubber Products	Rubber Wood Products	Fiberboard Products	Total
2557	2014	83,841	46,902	10,795	141,538
2564	2021	115,866	65,032	15,703	196,601
2569	2026	145,986	75,389	20,523	241,898
2574	2031	183,936	87,397	26,823	298,156
2579	2036	231,752	101,317	35,056	368,125
2584	2041	291,997	117,454	45,817	455,268
2589	2046	367,903	136,162	59,881	563,946
2594	2051	463,542	157,849	78,262	699,653

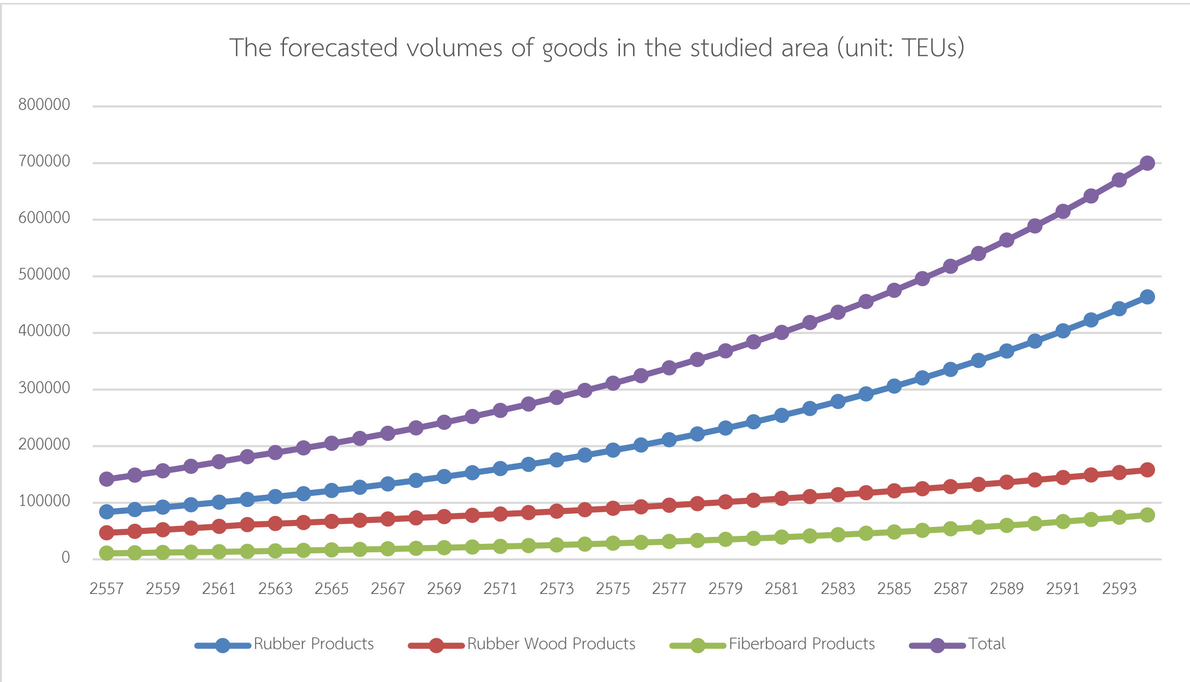


Figure 2.3.4-3 Forecasted product volume in the studied area (unit: TEUs)

The forecast of volumes to be transported by trains in the studied area is made based on the following circumstances;

- Case No. 1: If SRT does not improve anything.
- Case No. 2: If SRT invests for additional bogies and engines in response to the users' demand. The proportion of transportation by trains is expected to increase to 15% which was once the number that the southbound trains could reach in the past.
- Case No. 3: If SRT invests on double-track railway and completes within 2564, and the transportation capacity expands to 2 times of the existing capacity (the proportion of train transportation increases to 30%).
- Case No. 4: If SRT invests on double-track railway and completes within 2564, and the transportation capacity expands to 3 times of the existing capacity (the proportion of train transportation increases to 45%).

The details are shown in the **Table 2.3.4-3.**

Table 2.3.4-3 Forecasted product volumes on rail transport in the studied area for different cases

unit: ton

Year (B.E.)	Year	Case No. 1	Case No. 2	Case No. 3	Case No. 4
2557	2014	145,189	145,189	145,189	145,189
2564	2021	201,347	604,040	1,208,080	1,812,119
2569	2026	249,621	748,864	1,497,728	2,246,592
2574	2031	309,874	929,622	1,859,245	2,788,867
2579	2036	385,151	1,155,453	2,310,905	3,466,358
2584	2041	479,286	1,437,858	2,875,717	4,313,575
2589	2046	597,109	1,791,328	3,582,655	5,373,983
2594	2051	744,706	2,234,117	4,468,233	6,702,350

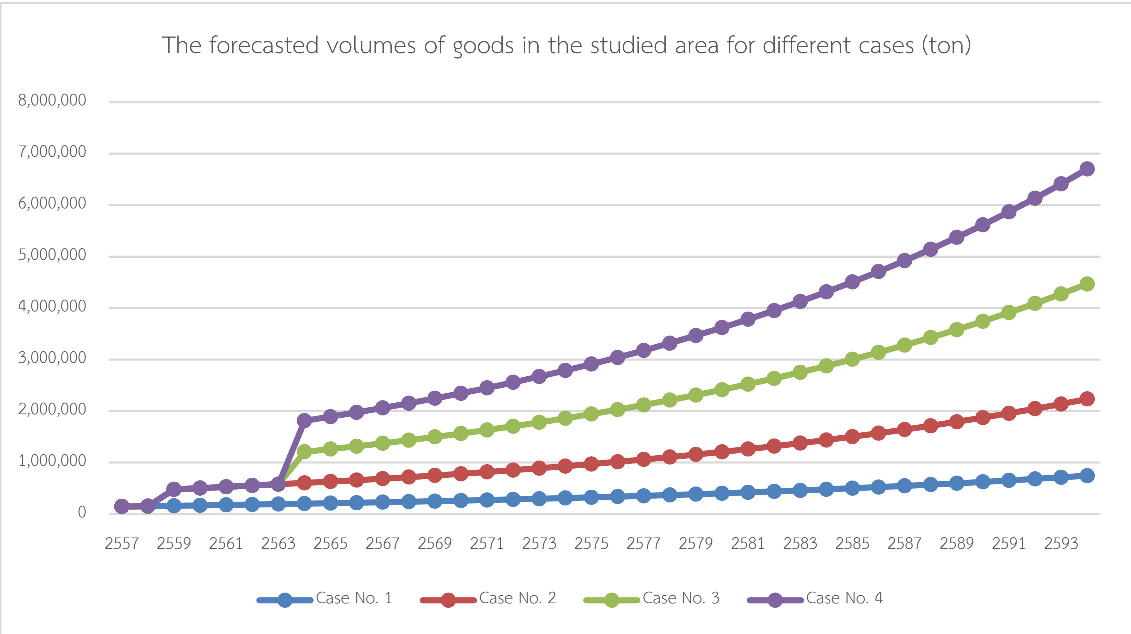


Figure 2.3.4-4 Forecasted product volumes on rail transport in the studied area for different cases (unit: ton)

Table 2.3.4-4 Forecasted product volumes on rail transport in the studied area for different cases

Unit:TEUs

Year (B.E.)	Year	Case No. 1	Case No. 2	Case No. 3	Case No. 4
2557	2014	7,077	7,077	7,077	7,077
2564	2021	9,830	29,490	58,980	88,470
2569	2026	12,095	36,284	72,570	108,854
2574	2031	14,908	44,723	89,447	134,170
2579	2036	18,407	55,219	110,438	165,656
2584	2041	22,764	68,291	136,580	204,871
2589	2046	28,197	84,592	169,184	253,776
2594	2051	34,982	104,947	209,897	314,844

Remark: Construction has not started yet in 2014 (B.E. 2557)

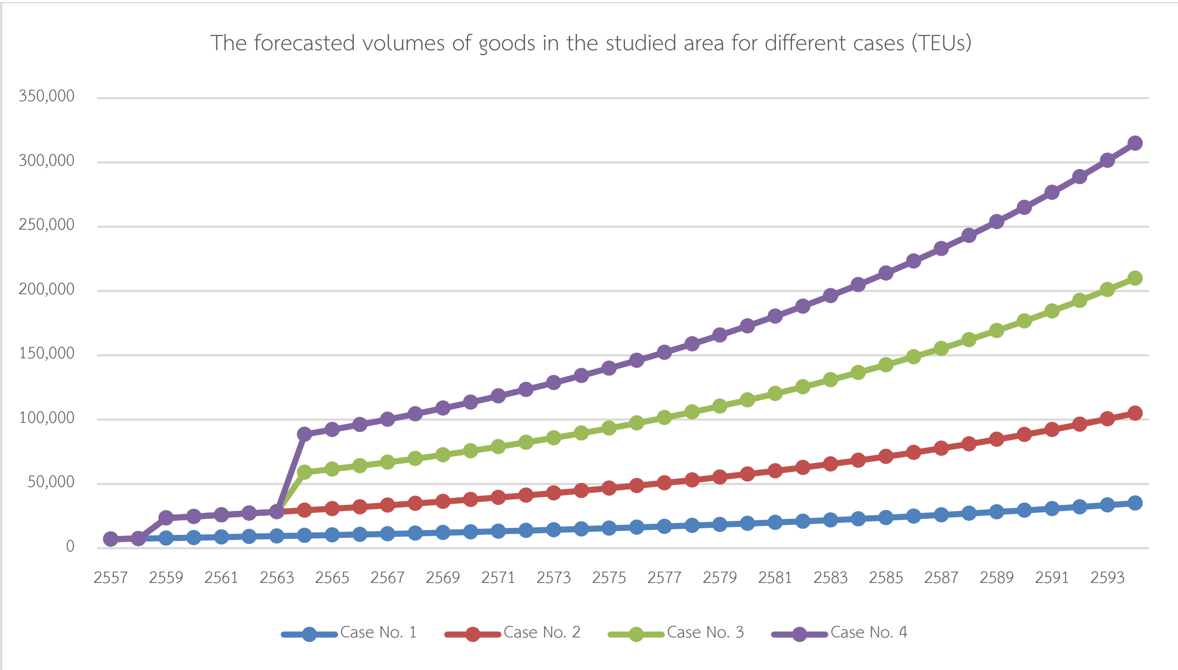


Figure 2.3.4-5 Forecasted product volumes on rail transport in the studied area for different cases (unit: TEUs)

From the data as a whole, volumes of goods by types at each station in different situations can be classified as follows;

Rubber products

The main sources of rubber processing factories in the Southern region are located in Surat Thani, Nakorn Srithammarat, Songkhla and Trang (not in the scope of this studied). The export of rubber products to overseas is made through Bangkok port, Laem Chabang port and Penang port in Malaysia (by land transportation through Sadao Customhouse and Padang Besar Customhouse). Considering the present conditions of the transportation, it shows that Rubber products from Trang are delivered by land transport to the border customhouse and then by marine transport from the coastal port of Kantang to Penang port. As for rubber products from Songkhla which is also a studied area, most factories are located in Sadao and Jana districts for which the land transport by trailer trucks are mostly used between factories and border customhouses because the distances are short, it is easy to control the delivery time and more flexible as well as cheaper cost than train for which loading and unloading has to be made several times in a trip. Therefore, data from Hat Yai Junction is not taken into account for the forecast of volumes of rubber products (in case there is no relocation) or Bangklam Station (in case of relocation).

Rubber Wood Products

Rubber Wood processing sources can be found all over the southern region, they account for around 70% of the total production capacity of the country. The main production sources are located in Surat Thani, Songkhla, Nakorn Srithammarat, Trang and Yala. If considering only in the studied area, the total production in the area accounts for around 35% of the total production capacity of the country. In 2555, the export volume of rubber wood products was 2888674 cubic meter or around 1,925,782 tons and the biggest market was China which accounted for around 96% of the total export volumes. The second biggest market was Malaysia for which 3.5% of the total volumes were sent to them. In 2557, the export of rubber wood products through Padang Besar Customhouse was 656,622 tons in total or 45,848 TEUs which accounted for around 30% of the total export of the country and through Songkhla port for 366466 tons or 26,176 TEUs. From the site survey for transportation behavior, it was found that there was no transport of rubber wood products to Padang Besar Customhouse by train. All of them were delivered by trailer trucks to the customhouse after that by rail to Malaysia until arrived at Penang port. Also, from the interview with some entrepreneurs and logistics providers, they were interested in rail transport, but due to the limitation of trains which could not meet their demand, land transport was always their choice.

Considering from the locations of factories and the present limitation of the stations, it shows that rubber wood products are similar to rubber products. Thus, the analysis on Hat Yai junction is abandoned. However, according to the survey, many entrepreneurs accepted that rail transport became more interesting if Bangklam station was improved to facilitate their product containers because many rubber wood processing factories were located near the station.

Wood-made fiberboard products

Fiberboard products are made from rubber wood. They are a processing of rubber wood of which the main processing factories are located in Songkhla and Surat Thani. The production ratio between two provinces is around 70%:30%. In 2557, the export of wood-made fiberboard through Padang Besar Customhouse was 151126 tons in total or 10795 TEUs. From the result of site survey for transportation behavior, it shows that there is no wood-made fiberboard transported to Badang Besar Customhouse by train. All of them are transported by trailer trucks and then transferred to rail at Padang Besar Customhouse to Penang Port in Malaysia which is similar to the case of rubber wood products. From the interview with logistics providers, they show the interest on the rail transport, but due to the limitation of SRT which cannot meet their demand, they still strict to the use of land transport as their choice.

Considering from the locations of factories and limitation of the stations, it shows that fiberboard products and rubber wood products whose factories are located in Bangklam are similar in term of transportation mode. In addition, the entrepreneurs are interested in the use of rail transport if the area in Bangklam is improved to facilitate product containers properly.

2.3.4.2 Goods transport in the area of Hat Yai junction-Songkhla

From the site survey on industry conditions, the transportation behavior of the area nearby the old Hat Yai junction-Songkhla which was closed in 2521 and the interview with logistics providers, it was found that there was very little chance for rail transport along the route because there was no any big factory in the surrounded area of Muang district of Songkhla as well as the route along the way between Hat Yai-Songkhla (only CP group that used land transport and had a huge negotiation power over the logistics providers). Also, the land along the railway has been trespassed in many areas which resulted in the difficulty of expansion for transportation zone. Moreover, if considering on the connection to Songkhla port, it is only 35 kilometers away from the center of Hat Yai and only 40 kilometers from Bangklam station (in case transportation zone is developed in this station), the distances are considered very short. Currently, land transportation is convenient by the use of Lopburi Rames road to the center of Hat Yai, it is also connected with Petchkasem road to access to factories in other districts. While, the use of rail transport requires several loadings and unloading which results in higher cost in total comparing with land transportation. The result of interview shows that there will not be any product switch their existing transportation mode to rail mode along the route of Hat Yai junction-Songkhla. Therefore, the investment on this route should be reconsidered in term of feasibility aspect.

2.4 Proper position for container Yard

Considering the current condition of the cargo at Hat Yai station found that there are several issues and limitations in the community around congestion causes a large cargo truck cannot reach the space station, or is there a limit to the time-space-pickup station. It also found that in the current Hat Yai junction station will operate in a manner of shipping containers parked convoy came from Ban Thung Pho junction and Thung Song junction to wait for the convoy to transport cycles to Badang Besar but there is no container transport up and down the Hat Yai station area like in the past. Anyway entrepreneur comment that the nearby train station, should be developed as a centre of rail freight in Songkhla province from consideration in the area of industrial conditions, the Consultants found that Bangklam station suitable for the development of rail freight is a point the substitute Hat Yai junction station with limited space and urban expansion

Chapter 3 System Operation Plan

CHAPTER 3

System Operation Plan

3.1 Working Process

Carrying out the system operation plan aims of preparing suitable primary train service schedule for Surat Thani – Hat Yai - Songkhla Double Track railway Project, and estimating railroad line capacity, as well.

Forecasted demand for passenger and freight movement carry on the project's route with the developed alignment and system design would be necessary input to perform the appropriate service operation plan. Focus group meeting is needed to gather recommendations from the operator and to confirm applicability of the final plan stated in the report. Primary output of operation plan would had been proposed to SRT's Service Operation Department including; capacity, train schedule, train diagram, required train number, and rolling stocks. Process achieving service operation plan has briefly described as shown in **Figure 3.1-1**.

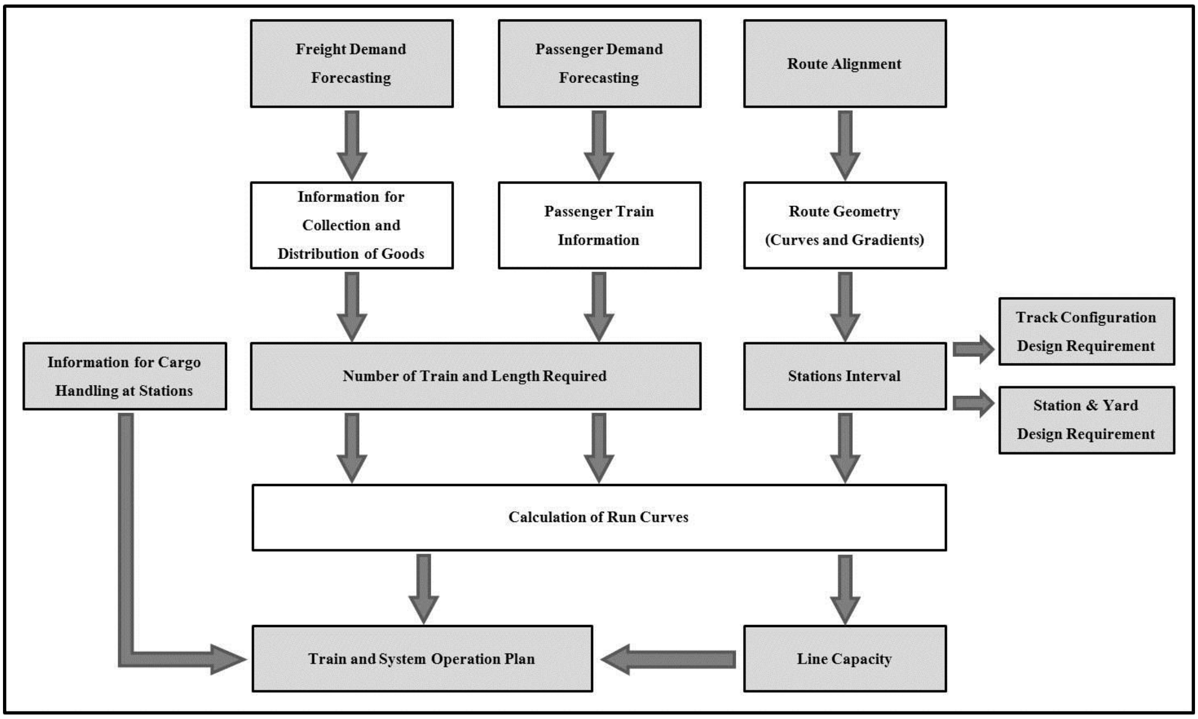


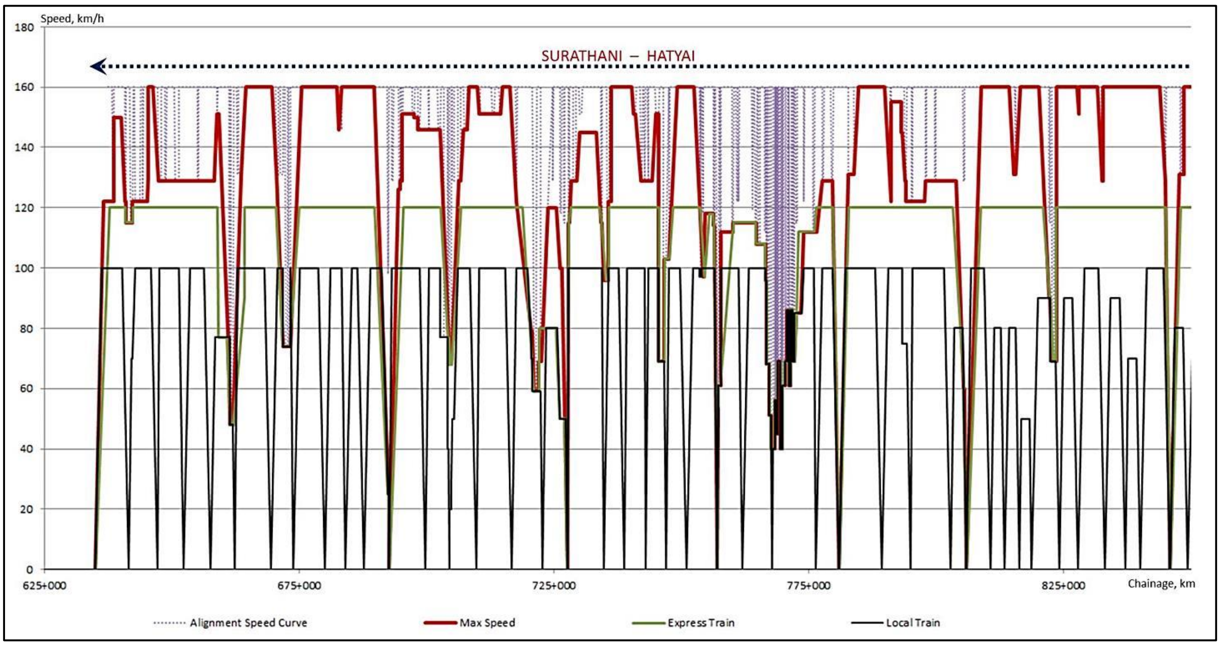
Figure 3.1–1 Flow chart showing Service Operation Plan Process

3.2 Railway Alignment and Distance

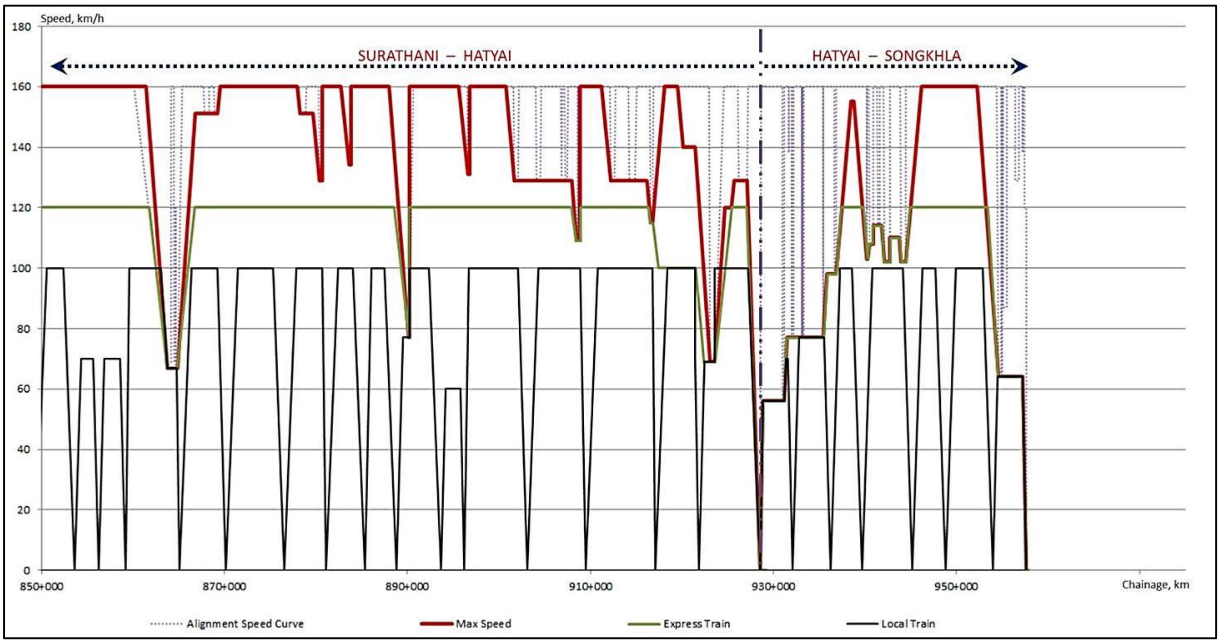
This section of the southern railway line included in this design project is 322.649 km in total consist of:

- 1st section: from Surat Thani station to Thung Song Junction with distance of 122.080 km
- 2nd section: from Thung Song Junction to Hatyai Junction with distance of 171.410 km
- 3rd section: from Hatyai station to Songkhla station with distance of 29.159 km

The existing railway alignments are re-designed to achieve design speed of 160 kph requirement. However there are some curves that could not be realigned to reach the mention requirement with its physical constrains, these sections' alignment are remain the existing. Many sections are limited to achieve 160 kph as required; however overall distance is sufficient for maximum operation speed at 120 and 100 kph of express train and local train services respectively. Speed profile for the designed alignment in this project is shown in **Figure 3.2-1**.



(a) Speed profiles for Surat Thani - Hatyai Section



(b) Speed profiles for Surat Thani – Hatyai - Songkhla Section

Figure 3.2-1 Alignment speed profiles for infrastructure speed limit and operation speed ranges

3.3 Types of Passenger and Freight Train Service

Firstly, train service needs to be identified as inputs to carryout operation plan and calculate required capacity. There are 6 types of trains in this study as shown below.

1) Special Express Train is a long distance locomotive train set coupling with 1st – 3rd class passenger coaches and restaurant cars. It would stop for taking passenger at only large and important station.

2) Express Train is a long distance locomotive train set coupling with 2nd – 3rd class passenger coaches and restaurant cars. It would stop for taking passenger at more station than a special express train.

3) Rapid Train is a long distance locomotive train set coupling with 2nd – 3rd class passenger coaches and restaurant cars. It would stop for taking passenger at more station than an express train.

4) Heavy Freight Train is a locomotive train set coupling with longer number of container bogies to carry large amount of freight.

5) Light Freight Train is a locomotive train set coupling with short number of container bogies to carry less amount of freight than heavy freight train. Types of freight bogies and containers will reflect the exact size of train, and it can be changed again after the result of forecasted freight forwarding demand.

3.4 Passenger Train Service Stopping Pattern

Passing trains will be set to stop on the mainline track; only the overtaken train has to make its stop on siding. Freight train will be required to stable on the dedicated freight yard. Train service stopping pattern for this project is shown in **Table 3.4–1**.

Table 3.4–1 Train service stopping pattern for each service type

No.	Station	Chainage	Distance	Special Express	Express	Rapid	Commuter	Freight
Surat Thani – Hatyai Junction								
1	Surat Thani	635.025		x	x	x	x	x
2	Khao Hua Kwaii	641.478	6.453				x	
3	Bor Krang	647.175	5.697				x	
4	Khao Ploo	652.382	5.207				x	
5	Khlong Ya	657.675	5.293				x	
6	Ban Na	662.317	4.642			x	x	
7	Huay Moot	669.432	7.115				x	
8	Na Sarn	673.805	4.373		x	x	x	
9	Khlong Prab	680.005	6.200				x	
10	Pru Pee	683.985	3.980				x	x
11	Khlong Soon	687.620	3.635				x	

No.	Station	Chainage	Distance	Special Express	Express	Rapid	Commuter	Freight
12	Ban Song	692.635	5.015	x	x	x	x	x
13	Ban Pru Kra Seang	699.708	7.073				x	
14	Huay Prig	704.532	4.824				x	
15	Kra Biat	709.725	5.193				x	
16	Tarn Por	716.680	6.955			x	x	
17	Chawang	722.670	5.990			x	x	
18	Khlong Jaan Dee	727.575	4.905	x	x	x	x	
19	Lak Chang	734.675	7.100				x	
20	Khlong Kui	738.780	4.105				x	
21	Na Born	742.930	4.150			x	x	
22	Khlong Jang	746.997	4.067				x	
23	Ban Koh Pring	751.062	4.065				x	
24	Thung Song Junction	757.105	6.043	x	x	x	x	x
25	Sai Yai	761.996	4.891				x	x
26	Chong Khao	767.756	5.760				x	
27	Ron Piboon	776.390	8.634			x	x	
28	Khao Chum Thong Junction	780.989	4.599	x	x	x	x	x
29	Kwan Nong Khwa	789.360	8.371				x	
30	Ban Toon	794.875	5.515				x	
31	Ban Thung Khai	802.800	7.925				x	
32	Cha Oaud	805.925	3.125	x	x	x	x	
33	Nong Jik	810.600	4.675				x	
34	Ban Nang Long	813.437	2.837				x	
35	Ban Trok Khea	816.340	2.903				x	
36	Ban Khon Hart	818.983	2.643			x	x	x
37	Leam Tanode	824.095	5.112			x	x	
38	Ban Soon Tra	827.825	3.730				x	
39	Pak Khlong	833.135	5.320		x	x	x	
40	Ban Makok Tai	837.050	3.905				x	
41	Chai Buri	839.970	2.920				x	
42	Pathalung	845.870	5.900	x	x	x	x	x
43	Ban Na Prue	849.250	3.380				x	
44	Ban Khai Thai	853.665	4.415				x	
45	Ban Ton Done	856.255	2.590				x	x
46	Ban Huay Tan	859.175	2.920				x	
47	Khao Chai Son	865.080	5.905			x	x	

No.	Station	Chainage	Distance	Special Express	Express	Rapid	Commuter	Freight
48	Bang Keaw	870.150	5.070		x	x	x	
49	Kwan Pra	876.575	6.425				x	
50	Kwan Kiam	881.140	4.565				x	
51	Harn Kong	885.310	4.170				x	
52	Harn Thao	888.775	3.465		x	x	x	
53	Wat Kwan Payer	893.670	4.895				x	
54	Kok Sai	896.245	2.575			x	x	
55	Kwan Niang	903.070	6.825			x	x	
56	Ban Koh Yai	909.505	6.435				x	
57	Bang Klum	917.100	7.595				x	x
58	Ban Din Larn	921.870	4.770				x	
59	Hatyai Junction	928.515	6.645	x	x	x	x	x
Hatyai Junction – Songkhla								
1	Hatyai Junction	928.515				x	x	
2	Khlong Hae	932.100	3.585				x	
3	Ban Ko Mi	936.200	4.100				x	
4	Thung Yai	939.653	3.453				x	
5	Tarad Pa Wong	945.200	5.547				x	
6	Nam Kra Jai	948.800	3.600				x	
7	Khao Roop Chang	954.000	5.200				x	
8	Songkhla	957.674	3.674			x	x	

3.5 Design Rolling Stocks for the Project

Trains running in this route can be categorized into 2 types;

1) Passenger Trains: Locomotive train sets and/or diesel multiple units (DMU) with diesel rail cars are chosen and considered to run at 120 km/h maximum speed.

2) Freight Trains: Diesel locomotive with container bogies are chosen and considered to run at 80 km/h maximum speed.

The alignment design criteria for track doubling projects have been assigned to set at 160 km/h as maximum speed. While maximum running speed for power rolling stocks requirement of 120 km/h has obtained. In several track doubling projects, power rolling stocks chosen as design models for taking performances to be input of design and planning variables are the following models;

1) Diesel-electric Locomotive: GENERAL ELECTRIC (GEA), No. 4523 – 4560, begin running in SRT system since 1995, Maximum Axle Load of 15 tons, Maximum Speed of 100 km/h with pure air-brake system

2) Diesel Rail Car: Daewoo, Type APN.60APD (APD 60), No. 2525 – 2544, begin running in SRT system since 1996, Maximum Axle Load of 14 tons, Maximum Speed of 120 km/h with pure air-brake system

3) Diesel-electric Locomotive: CSR Qishuyan, begin running in SRT system since 2014, Maximum Axle Load of 20 tons, Maximum Speed of 120 km/h with AC-AC traction power transferring system

3.6 Train Running Simulation

To perform train running simulation running properties such maximum train speed, acceleration, and deceleration are compulsory to be assigned. Other needed sets of data to correctly perform running simulation model are alignment, speed profile, rolling resistance, dwell time, etc. The more accurate will be described in the next section.

3.7 Forecasted Passenger Demand

Passenger demands as volume of alighting and boarding passengers to be planed and operated for this project, described in **Table 3.7–1**.

Table 3.7–1 Alighting and Boarding Passenger Volume via Service Stopping Pattern

Station	Passenger Volume				Special Express	Express	Rapid	Commuter
	2021	2031	2041	2051				
Surat Thani – Hatyai Junction								
Surat Thani	5,664	7,035	8,235	9,631	x	x	x	x
Khao Hua Kwaii	13	23	35	55				x
Bor Krang	17	29	47	75				x
Khao Ploo	24	42	68	110				x
Khlong Ya	8	14	23	37				x
Ban Na	193	285	421	761			x	x
Huay Moot	56	83	97	114				x
Na Sarn	666	985	1,324	1,555		x	x	x
Khlong Prab	13	17	27	40				x
Pru Pee	84	113	183	298				x
Khlong Soon	5	7	12	19				x
Ban Song	1,119	1,656	2,314	2,827	x	x	x	x
Ban Pru Kra Seang	41	55	89	146				x
Huay Prig	152	204	333	547				x
Kra Biat	90	122	198	324				x
Tarn Por	399	590	873	1,292			x	x
Chawang	286	449	704	1,104			x	x
Khlong Jaan Dee	1,093	1,714	2,536	3,098	x	x	x	x
Lak Chang	49	65	105	170				x
Khlong Kui	11	15	25	40				x
Na Born	214	288	469	764			x	x
Khlong Jang	41	54	88	143				x
Ban Koh Pring	9	11	17	26				x
Thung Song Junction	3,280	4,291	5,358	6,278	x	x	x	x
Sai Yai	67	89	146	239				x
Chong Khao	8	22	44	87				x
Ron Piboon	370	576	869	1,097			x	x

Station	Passenger Volume				Special Express	Express	Rapid	Commuter
	2021	2031	2041	2051				
Khao Chum Thong Junction	539	878	1,431	1,853	x	x	x	x
Kwan Nong Khwa	58	80	117	173				x
Ban Toon	144	201	281	391				x
Ban Thung Khai	3	3	5	7				x
Cha Oaud	1,347	1,898	2,548	3,052	x	x	x	x
Nong Jik	12	17	22	29				x
Ban Nang Long	169	228	307	413				x
Ban Trok Khea	12	16	19	25				x
Ban Khon Hart	353	475	638	856			x	x
Leam Tanode	314	422	568	763			x	x
Ban Soon Tra	5	7	9	12				x
Pak Khlong	530	829	1,298	1,524		x	x	x
Ban Makok Tai	13	18	24	43				x
Chai Buri	18	23	30	53				x
Pathalung	3,769	4,712	5,726	6,679	x	x	x	x
Ban Na Prue	13	16	19	33				x
Ban Khai Thai	10	13	16	29				x
Ban Ton Done	152	299	589	691				x
Ban Huay Tan	24	29	34	61				x
Khao Chai Son	391	535	733	892			x	x
Bang Keaw	724	992	1,360	1,658		x	x	x
Kwan Pra	80	110	151	184				x
Kwan Kiam	221	303	414	535				x
Harn Kong	17	24	34	47				x
Harn Thao	606	871	1,253	1,577		x	x	x
Wat Kwan Payer	13	17	24	60				x
Kok Sai	280	414	612	770			x	x
Kwan Niang	409	605	895	1,126			x	x
Ban Koh Yai	103	169	276	500				x
Bang Klum	77	124	201	252				x
Ban Din Larn	98	158	256	321				x
Hatyai Junction	7,555	9,052	10,528	12,248	x	x	x	x
Hatyai Junction – Songkhla								
Hatyai Junction	6,033	8,266	10,480	12,775			x	x
Khlong Hae	811	1,111	1,408	1,717				x
Ban Ko Mi	453	620	786	958				x
Thung Yai	267	366	464	565				x
Tarad Pa Wong	426	584	741	903				x
Nam Kra Jai	265	362	459	559				x
Khao Roop Chang	164	225	286	349				x
Songkhla	6,545	8,968	11,368	13,858			x	x

3.8 Forecasted Freight Forwarding Demand

Forecasted freight forwarding demand data in term of freight line load volume per day shown in **Table 3.8–1** had been included in the analysis for train operation planning as described in the next section.

Table 3.8–1 Freight Line Load on the project rail route

Station	Railway Freight Line Load (Ton/Day)							
	Year 2021		Year 2031		Year 2041		Year 2051	
	To Hat Yai	To BKK	To Hat Yai	To BKK	To Hat Yai	To BKK	To Hat Yai	To BKK
Surat Thani - Thung Song	1,211	696	1,810	1,810	2,735	1,755	4,132	2,786
Thung Song – Bang Klum	2,061		3,104		4,727		7,177	
Bang Klum - Hatyai Junction	2,279		3,465		5,331		8,190	

3.9 Basic criteria for performing system operation

System operation plans has been carried out to provide sufficient service for the forecasted railway passenger and freight demand follow the SRT major design rules in Thailand Track Doubling Master Plan. The following briefly describes basic conditions in order to perform system operation for this project.

1) Design criteria for passenger train operation

- Maximum service operation speed for passenger train will be set as 120 kph (100 kph average)
- Passenger train will mix operate on the same line for freight train
- Expected siding track length will be set of 500 meter if possible
- Platform length for passenger of 350 meter will be design if possible

2) Design criteria for passenger train operation

- Maximum service operation speed for freight train will be set as 80 kph (50-70 kph average)
- Heavy crane or lifting equipment is needed in freight yard for future development
- Expected siding track length for freight train will be set of 650 meter if possible

3.10 Operation Service Pattern

In the current SRT Train Services, there are several types for passenger such, special express trains; express train; rapid train; ordinary train; commuter train; suburb train; and DRC train. Only 4 types are included in this project's design report, special express trains; express train; rapid train; and ordinary train.

The following discussed general concepts to be kept on planning the train service operation in this project, there are several issues as described below. Very important concept to set up train schedule is to prioritize each train type about to wait or to pass by a station for trains' double-entry in the same time.

There are around 32 trains per day, including 6 special express trains; 4 express trains; 8 rapid trains; 12 commuter trains; and 2 freight trains, operate on the project railway nowadays as shown in **Table 3.10–1**.

Figure 3.10–1 Current service route for Surat Thani – Hatyai – Song Khla railway

No.	Train ID.		Type	Route	Time
1	447	448	Commuter	Surat Thani - Sungai Kolok	06:13 - 18:00
2	451	452	Commuter	NakornThammarat - Sungai Kolok	06:00 - 14:50
3	463	464	Commuter	Pathalung - Sungai Kolok	06:02 - 12:10
4	445	446	Commuter	Chum Porn – Hatyai Junction	06:30 - 16:50
5	455	456	Commuter	Nakorn Si Thammarat - Yala	09:58 - 17:10
6	457	458	Commuter	Nakorn Si Thammarat - Pathalung	14:15 - 16:55
7	171	172	Rapid	BKK - Sungai Kolok	13:00 - 10:45
8	35	36	Special Express	BKK - Butterworth	14:45 - 12:55
9	37	38	Special Express	BKK - Sungai Kolok	15:10 - 11:20
10	169	170	Rapid	BKK - Yala	15:35 - 11:20
11	83	84	Express	BKK - Trang	17:05 - 08:05
12	173	174	Rapid	BKK - Nakorn Si Thammarat	17:35 - 09:55
13	167	168	Rapid	BKK - Kantang	18:30 - 11:20
14	85	86	Express	BKK - Nakorn Si Thammarat	19:30 - 10:55
15	41	42	Special Express	BKK - Yala	22:50 - 14:30

3.11 Passenger and Freight Train Formation

Passenger Train Services running on this project are classified into 4 Types:

- Special Express Train is a longest distance train running overnight from BKK with limited stop service pattern.
- Express Train is a longer distance train running from BKK with limited stop service pattern, more stop stations than special express train.
- Rapid Train is a long distance train running from BKK with limited stop service pattern, more stop stations than express train.
- Local Commuter Train is a short distance train service with all stop service pattern.

3.12 Required Passenger and Freight Trains

To design the railway systems such trackwork and signalling, as long as operating and maintenance costs estimation for each projection year, required train numbers prepared for proper operation have to be calculated.

Train running simulations based on proposed rolling stocks' properties and railway systems configurations had been primarily modeled. Effective train formation and running properties (speed, acceleration, deceleration, and rolling resistance) have been assigned to execute running model.

Train schedules can be set by those simulation models. And then the amount of trains required to ride the plan can be estimated while each of the trains' cycle time per one round trip was input. Number of Trains desired for each type and each projection year in case of passenger service and freight service is clarified in **Table 3.12–1**.

Table 3.12–1 Required passenger trains

Required Passenger Trains / Day / Direction	Year	2021	2031	2041	2051
Surat Thani - Thung Song Junction (119.58 km) Average Speed 88.54 kph	Special Express	6	6	6	9
	Express	4	6	10	11
	Rapid	8	10	13	17
	Commuter	4	4	4	6
	Passenger Train	22	26	33	43
	Passenger Cappacity (Passengers/Day/Direction)	17,640	20,880	26,512	34,500
	Max Lineload (Passengers/Day/Direction)	16,393	20,654	26,138	33,120
	Heavy Freight Train	1	1	2	3
	Light Freight Train	0	1	0	0
	Freight Train	1	2	2	3
	Freight Capacity (Tons/Day/Direction)	1,485	2,385	2,970	4,455
	Max Lineload (Tons/Day/Direction)	1,211	1,810	2,735	4,132
Thung Song Junction - Khao Chum Thong Junction (23.94 km) Average Speed 72.43 kph	Special Express	6	6	6	9
	Express	3	5	8	8
	Rapid	7	9	11	14
	Commuter	4	4	4	6
	Passenger Train	20	24	29	37
	Passenger Cappacity (Passengers/Day/Direction)	16,060	19,300	23,352	29,760
	Max Lineload (Passengers/Day/Direction)	14,691	18,321	22,999	29,187
	Heavy Freight Train	1	2	2	4
	Light Freight Train	1	1	3	2
	Freight Train	2	3	5	6
	Freight Capacity (Tons/Day/Direction)	2,385	3,870	5,670	7,740
	Max Lineload (Tons/Day/Direction)	2,061	3,104	4,727	7,177
Khao Chum Thong Junction - Pathalung (65.05 km) Average Speed 87.62 kph	Special Express	6	6	6	9
	Rapid	4	4	4	6
	Commuter	9	14	21	23
	Passenger Train	19	24	31	38
	Passenger Cappacity (Passengers/Day/Direction)	14,384	17,728	22,204	27,804
	Max Lineload (Passengers/Day/Direction)	13,889	17,262	21,623	27,563
	Heavy Freight Train	1	2	2	4
	Light Freight Train	1	1	3	2
	Freight Train	2	3	5	6
	Freight Capacity (Tons/Day/Direction)	2,385	3,870	5,670	7,740
	Max Lineload (Tons/Day/Direction)	2,061	3,104	4,727	7,177
Pathalung - Hatyai Junction (82.52 km) Average Speed 86.27 kph	Special Express	6	6	6	9
	Rapid	4	4	4	6
	Commuter	9	15	22	25
	Passenger Train	19	25	32	40
	Passenger Cappacity (Passengers/Day/Direction)	14,468	18,496	23,056	29,340
	Max Lineload (Passengers/Day/Direction)	14,407	17,971	22,511	28,620
	Heavy Freight Train	1	2	2	5
	Light Freight Train	1	1	3	2
	Freight Train	2	3	5	7
	Freight Capacity (Tons/Day/Direction)	2,385	3,870	5,670	9,225
	Max Lineload (Tons/Day/Direction)	2,279	3,465	5,331	8,190

Required Passenger Trains / Day / Direction	Year	2021	2031	2041	2051
Total Passenger Travel for Surathani – Hatyai Section	Total passenger-km per day	2,554,745	3,320,273	3,671,805	5,173,595
Hatyai Junction - Songkhla (26.05 km) Average Speed 92.14 kph	Rapid Commuter	4 2	5 3	6 4	8 4
	Passenger Train	6	8	10	12
	Passenger Cappacity (Passengers/Day/Direction) Max Lineload (Passengers/Day/Direction)	3,714 3,371	4,857 4,619	6,000 5,855	7,428 7,138
Total Passenger Travel for Hatyai – Songkhla Section	Total passenger-km per day	189,241	259,286	328,691	400,712

3.13 Costs for Operation and Maintenance

Several numbers of cars by various rolling stock types obtains form service operation plan are taken to compute approximate costs for operation and maintenance in this section. Unit costs as core value for calculation are referred from Den Chai – Chiang Rai – Chiang Khong Double Track Railway Report (2012).

Values are converted to present by external and socio-economic effects. **Table 3.13–1** illustrates annual maintenance cost for various types of rolling stock in each focused year.

Fuel consumption unit cost for locomotive input for operation cost calculation is 112.71 baht/kilometer. This value had been estimated by statistical data from SRT's Commercial Department. At this stage of study, total operation and maintenance costs have been estimated and shown in **Table 3.13–1**.

Table 3.13–1 Maintenance cost for each type of rolling stock in Year 2021 – 2051

	Amount				Unit Cost (baht / year)	Annual Maintenance Cost (baht)			
	2021	2031	2041	2051		2021	2031	2041	2051
DRC	31	38	53	62	0.50	11,268,654	13,813,188	19,265,763	22,537,308
Locomotive	101	131	181	230	0.81	119,060,384	154,424,854	213,365,638	271,127,606
Container Bogie	308	455	706	1,131	3,014.71	928,529	1,371,691	2,128,382	3,409,632
Brake Van	11	15	26	37	8,123.22	89,355	121,848	211,204	300,559
1st Coach	24	24	24	36	2,372,524.18	56,940,580	56,940,580	56,940,580	85,410,870
2nd Coach	392	472	612	783	326,364.93	127,935,054	154,044,249	199,735,340	255,543,744
3rd Coach	717	935	1,242	1,550	326,391.42	234,022,651	305,175,982	405,378,149	505,906,707
Restaurant Car	91	117	156	195	83,822.96	7,627,889	9,807,286	13,076,381	16,345,477
Total	**1,675**	**2,187**	**3,000**	**4,024**		**557,873,097**	**695,699,679**	**910,101,437**	**1,160,581,903**

Table 3.13–2 Fuel cost for operation in Year 2021 – 2051

	Annual Fuel Cost for Train Running Operation				
(baht / year)	Fuel cost per km**	2021	2031	2041	2051
Diesel Railcar	19.62	34,015,697.99	40,885,743.68	59,575,955.14	68,031,395.99
Locomotive	112.71	653,103,765.77	827,724,824.31	1,060,932,457.12	1,359,558,706.23
Total		**687,119,463.76**	**868,610,568.00**	**1,120,508,412.26**	**1,427,590,102.22**

* Values for 2021 adjusted from Banphai - Nakhon Phanom Track Doubling Report (SRT, 2557)

** Contingency = 20%

Table 3.13–3 Annual operation and maintenance costs in Year 2021 – 2051

	Annual Operation and Maintenance Costs			
(baht / year)	2021	2031	2041	2051
Rolling Stocks Maintenance Cost	557,873,097.06	695,699,678.88	910,101,437.18	1,160,581,903.27
Service Operation Cost	687,119,463.76	868,610,568.00	1,120,508,412.26	1,427,590,102.22
Total	**1,244,992,560.82**	**1,564,310,246.88**	**2,030,609,849.44**	**2,588,172,005.49**

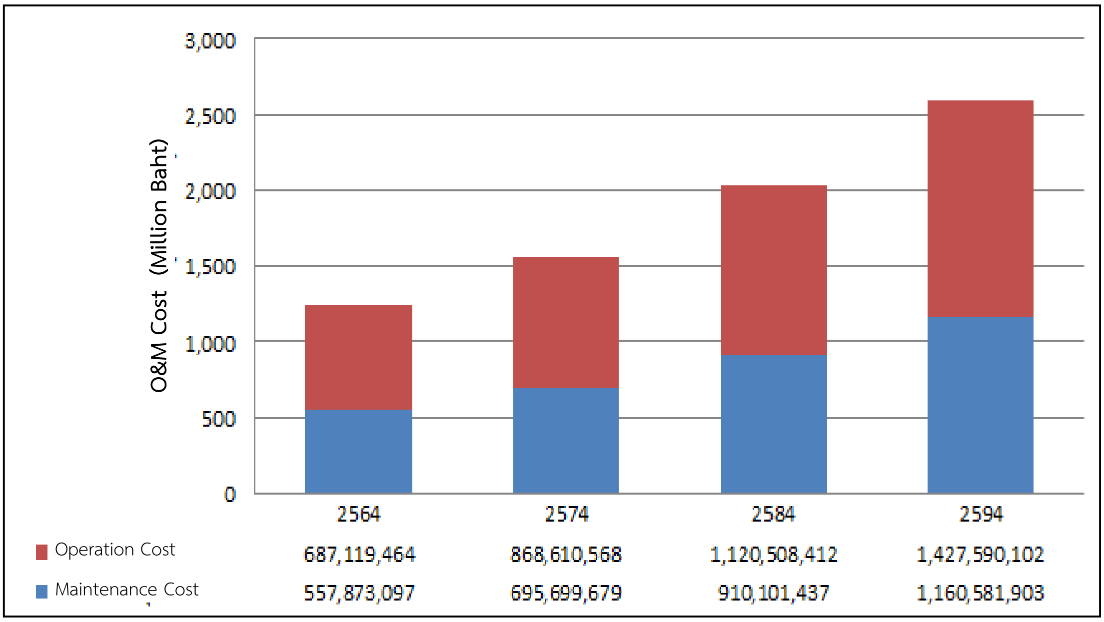


Figure 3.13-1 Estimated O&M Annual Costs for 2021 - 2051

Chapter 4 Field Survey and Mapping

Chapter 4

Field Survey and Mapping

4.1 Topographic Survey of Project Route and Mapping

4.1.1 Aerial Photographs and Base Map

Aerial photographs were obtained from Sensefly's fixed wing unmanned aerial vehicle (UAV), model eBee. The images were taken with the resolution of approximately 20-centimeter pixel size/GSD, corrected for geometric precision using the same coordinate system as the project survey, and exhibited to be the original or the base map of scale 1:4,000. Sample aerial photographs obtained from the UAV at Thung Song station and Songkhla station are presented in **Figure 4.1.1-1.**

Figure 4.1.1-1 Aerial Photographs from UAV at Thung Song Station and Songkhla Station

4.1.2 Ground Control Points

The survey to lay ground control points refers to the vertical and horizontal control points of the Royal Thai Survey Department. Nineteen control points were included, which are illustrated in **Tables 4.1.2-1 and 4.1.2-2**

Table 4.1.2-1 Horizontal Ground Control Points Included in the Project

Control Point	Location	Easting	Northing
GPS3375	Ranod School, Ranod District, Songkhla	646,607.598	859,739.160
GPS3667	Mapring Temple, Wat Pradoo Sub-district, Muang District, Surat Thani	531,329.559	1,007,690.045
GPS3668	Baan Nanang Checkpoint, Moo 5, Baan Song Sub-district, Wiang Sa District, Surat Thani	541,384.156	957,276.619
GPS3669	Baan Kuan Tang School, Khao Pun Sub-district, Huay Yod District, Trang	573,946.900	860,524.312
GPS3670	Provincial Land Office, Sadao Branch, Sadao District, Songkhla	660,520.121	743,919.854
GPS3673	Baan Thung Yai Sub-district Health Promotion Hospital, Muang District, Songkhla	680,709.628	791,810.847

Table 4.1.2-2 Vertical Ground Control Points Included in the Project

Control Point No.	Location	EL.MSL
P1979	Hat Yai District Office, Hat Yai District, Songkhla	6.9442
S10234/51	Irrigation Canal Bridge Km.31+950, Highway 4, Pa Bon District, Phatthalung	23.7533
S10253/51	Prak Suwan Canal Bridge, Highway 43, Rattaphum District, Songkhla	17.8853
SBM16102 (previouslyS9512)	Tinsulanonda Bridge (Koh Yo – Songkhla)	3.8146
P1949-1	Baan Nong Wa School, Thung Song District, Nakhon Si Thammarat	50.6171
P1951	Suwan Rangsi Temple, Ron Pibun District, Nakhon Si Thammarat	33.3670
P1956R	Khan Temple, Chulabhorn District, Nakhon Si Thammarat	12.4485
P1964R	Indrawas Temple, Muang District, Phatthalung	11.6919
S10203/51	Mai Canal Bridge, Km.49+300, Highway 41, Cha Oad District, Nakhon Si Thammarat	18.1253
P1946R	Baan Nong Dee School, Na Bon District, Nakhon Si Thammarat	40.7328
PBM1780	Surat Thani Highway District, Highway 401, Muang District, Nakhon Si Thammarat	3.3104
PBM1935	Na Derm Hospital, Na Derm District, Surat Thani	20.9008
SBM15395	Tan Lang Canal Bridge, Km.064+197, Highway 4009, Wiang Sa District, Surat Thani	23.4841

4.1.2.1 Primary Horizontal Control Survey

The primary horizontal control survey included 84 ground control pairs that were laid 3-5 kilometers apart, with each control point being 100-400 meters apart. The primary horizontal ground control points were measured with the global positioning system (GPS), static dual-frequency type. The coordinate system is UTM WGS 84 Zone 47N, the same that is used by the Royal Thai Survey Department. The data were corrected for accuracy by detailing the coordinate network to determine the location of the primary horizontal ground control points. The coordinate standard passed Level C of terrestrial based survey of the Royal Thai Survey Department. The baseline deviation is less than 10 PPM (part per million), or the accuracy is more than 1:100,000. **Figure 4.1.2-1** shows sample horizontal control points.

Figure 4.1.2-1 Sample of Primary Horizontal Control Points

4.1.2.2 Primary Vertical Control Survey

The primary vertical control survey employed the primary horizontal control points to direct vertical orientation. Vertical control points were installed every 2.5 kilometers on a strong and permanent surface, which does not move and is not easily destroyed. Screws were used to hold the control points to tree trunks or old bridge structures. Links and alignment checks were made with control points of the Royal Thai Survey Department every 20-40 kilometers. The control points are based on the mean sea level (MSL), with Third-Order accuracy level according to the Royal Thai Survey Department. The deviation is less than 12 mm. $\sqrt{K}$ (K=distance in km.).

4.1.2.3 Secondary Horizontal Control Survey and Traverse

The secondary horizontal control survey and the traverse are necessary to gather geological information. Secondary horizontal control points were laid every 100-300 meters. The traversing employed a closed traverse total station to measure the degree and the distance of secondary horizontal control points, by linking and combining with the primary control points of the project. The accuracy passed the Third-Order Level of the Royal Thai Survey Department. The deviation is less than 1:10,000, and the angle deviation is less than 10”$\sqrt{N}$ (N=number of control points). Sample traverse calculations are presented in **Figure 4.1.2-2.**

Figure 4.1.2-2 Secondary Horizontal Control Points

4.1.2.4 Secondary Vertical Control Survey and Traversing

The secondary vertical control survey was based on the secondary horizontal control points. Control points were added in every waterway on a strong and permanent surface or tree trunks, which does not move and is not easily destroyed. The accuracy passed the Third-Order Level of the Royal Thai Survey Department. The deviation is less than 12 mm. $\sqrt{K}$ (K=distance in km.).

4.1.3 Topographic Survey along Railway Route and Levelling

The topographic survey along the railway route and the leveling included the existing railway route and additional 10 meters on the left and the right side. The survey was completed with a total station. The topographic survey included buildings and structures, utilities, roads, passageways, alleyways, canals, bridges and others within the project area. Existing ground level, waterway cross-section, water levels, highest and lowest water level, and flow direction were also observed. Survey of the waterway extended 100 meters on the upstream and the downstream side from the center of the railway route. The topographic survey process along the project route is presented in **Figure 4.1.3-1.**

Figure 4.1.3-1 Topographical Survey along Project Route

4.2 Survey of Structures and Encroachment of Land Owned by the State Railway of Thailand

The survey examines the structures that have to be removed, and the encroachment upon the land owned by the State Railway of Thailand. Most encroachment occurs between Hat Yai train junction and Songkhla station, the length where trains have been discontinued since 1978. Thousands of people have intruded the area still belonging to the State Railway of Thailand. Information from the survey contributes to the listing of structures to be removed and owners of those structures, along with estimated cost of structure removal on the land owned by the State Railway of Thailand.

4.2.1 Survey of Structures on Land Owned by the State Railway of Thailand

The survey starts with the initial estimation of structures and field inspection plan. The survey is carried out in 3 main sections, as well as the cord line:

- Section 1 Km.637+500 - Km.783+000
- Section 2 Km.783+000 - Km.929+150
- Section 3 Km.930+000 - Km.957+860
- Section 4 Chord Line

Then, meetings are arranged with community leaders in the area owned by the State Railway of Thailand, from Hat Yai junction to Songkhla station (km.930+000–km.958+460), adding up to 14 communities, on September 3-4 and October 13-14, 2015. The purposes of the meetings are to notify them of the objectives and process of the survey, and to decrease community resistance, shown in **Figures 4.2.1-1 and 4.2.1-2.**

Figure 4.2.1-1 Meeting with Community Leaders, September 3-4, 2015

Figure 4.2.1-2 Meeting with Community Leaders, October 13-14, 2015

4.2.2 Encroachment upon Land Owned by the State Railway of Thailand

The survey of the encroachment upon the land owned by the State Railway of Thailand was carried out simultaneously with the survey to examine structures on the land. The encroachment survey gathers ownership status, details of buildings and structures, and information on violators, including name and last name, registered address or contact address, and telephone number, to put together a listing of violators. Photographs of buildings and structures were taken, and a survey questionnaire was given out to violators to complete. A briefing session to train officials and explain the work process took place prior to the survey in front of Hat Yai station on October 18, 2015. Badges and team uniforms were distributed to survey officials. The briefing session is presented in **Figure 4.2.2-1.** The survey took place on October 19, 2015, shown in **Figure 4.2.2-2.**

Figure 4.2.2-1 Briefing Session to Train Officials and Explain Work Process

Figure 4.2.2-2 Buildings and Structures on Land Owned by the State Railway of Thailand

The findings of the encroachment survey on the land owned by the State Railway of Thailand are divided into 4 sections.

Section 1 From km.637+500 to km.783+000: There is a total of 3,647 structures. Of these, 272 structures are legally leased with the State Railway of Thailand, 91 structures are belong to other state agencies, 501 structures are belong to SRT, and 2,783 structures are encroachments, as presented in **Table 4.2.2-1**.

Table 4.2.2-1 Total Number of Structures on Land Owned by the State Railway of Thailand Section 1 From km.637+500 to km.783+000

No.	Item	Number of Structures (Item)		
		In required operation zone	Outside required operation zone	Total on land owned by the State Railway of Thailand
1	Structures leased with SRT	115	157	272
2	Structures belonging to other state agencies	62	29	91
3	Structures belonging to SRT	488	13	501
4	Structures that are encroachments	1,622	1,161	2,783
	Total	**2,287**	**1,360**	**3,647**

Section 2 From km.783+000 to - km.929+150: There is a total of 2,906 structures. Of these, 530 structures are legally leased with the State Railway of Thailand, 66 structures are belong to other state agencies, 618 structures are belong to SRT, and 1,692 structures are encroachments, as presented in **Table 4.2.2-2**.

Table 4.2.2-2 Total Number of Structures on Land Owned by the State Railway of Thailand Section 2 From km.783+000 to - km.929+150

No.	Item	Number of Structures (Item)		
		In required operation zone	Outside required operation zone	Total on land owned by the State Railway of Thailand
1	Structures leased with SRT	267	263	530
2	Structures belonging to other state agencies	41	25	66
3	Structures belonging to SRT	400	218	618
4	Structures that are encroachments	694	998	1,692
	Total	**1,402**	**1,504**	**2,906**

Section 3 From km.930+000 to - km.957+860: There is a total of 6,618 structures. Of these, 4,022 structures are legally leased with the State Railway of Thailand, 176 structures are belong to other state agencies, 10 structures are belong to SRT, and 2,480 structures are encroachments, as presented in **Table 4.2.2-3**.

Table 4.2.2-3 Total Number of Structures on Land Owned by the State Railway of Thailand Section 3 From km.930+000 to - km.957+860

No.	Item	Number of Structures (Item)		
		In required operation zone	Outside required operation zone	Total on land owned by the State Railway of Thailand
1	Structures leased with SRT	1,395	2,627	4,022
2	Structures belonging to other state agencies	20	156	176
3	Structures belonging to SRT	-	10	10
4	Structures that are encroachments	1,386	1,094	2,480
	Total	**2,801**	**3,887**	**6,688**

Section 4 Chord Line: There is a total of 224 structures that are encroachments, as presented in **Table 4.2.2-4**.

Table 4.2.2-4 Total Number of Structures on Land Owned by the State Railway of Thailand Section 4 Chord Line

No.	Item	Number of Structures (Item)		
		In required operation zone	Outside required operation zone	Total on land owned by the State Railway of Thailand
1	Structures leased with SRT	-	-	-
2	Structures belonging to other state agencies	-	3	3
3	Structures belonging to SRT	-	-	-
4	Structures that are encroachments	-	221	221
	Total	**-**	**224**	**224**

4.3 Estimation of Compensation for Land and Structures

4.3.1 Compensation for Affected Land

The compensation estimation for affected land is based on the compensation regulations Article 21 of the Immovable Property Expropriation Act 1987 (B.E.2530), taking into account the land value appraisal to assess fees for right and juristic act registration (2016-2019) (B.E.2559-2562), along with the survey of current land buying and selling price.

The affected land was resulted from realignment in 3 locations, namely KM.642+575–KM.644+085, KM.650+385-KM.651+685, and KM.744+175-กม.746+388, as well as from new design of overpass for railway crossing in 8 locations, namely KM.720+982, KM.790+871, KM.807+316, KM.816+376, KM.838+151, KM.907+166, KM.916+132, and KM.917+628. The estimated compensation for affected land is presented in **Table 4.3.1-1.**

Table 4.3.1-1 Estimated Compensation for Affected Land

No.	Section	Land Area (Plot)	Affected Land Area			Compensation (Baht)
			Rai	Ngan	Wah	
1	Section 1 km.637+500-km.783+000	47	85	3	58.3	11,214,592
2	Section 2 km.783+000-km.929+150	148	29	0	49.0	26,518,787
3	Section 3 km.930+000-km.957+860	-	-	-	-	-
	Total	110	195	115	0	7.3

4.3.2 Compensation for Affected Structures

The compensation for affected structures includes the compensation for structures, structure removal and transport, and opportunity loss due to the disruption in living, buying and selling or legal business (according to Article 21 final section). The estimated compensation for affected structures is exhibited in **Table 4.3.2-1.**

Table 4.3.2-1 Estimated Compensation for Affected Structures

No.	Section	Quantity (Count)	Compensation (Baht)
1	Section 1 km.637+500-km.783+000	13	12,333,215
2	Section 2 km.783+000-km.929+150	27	30,575,661
3	Section 3 km.930+000-km.957+860	-	-
	Total	40	42,908,876

4.3.3 Compensation for Affected Standing Timbers

The compensation estimation for affected standing timbers is based on the cost and benefit of standing timbers, with reference to government agencies, namely the Department of Agricultural Extension, and the Office of Agricultural Economics. Affected standing timbers include rubber trees and oil palms. **Table 4.3.3-1** demonstrates the estimated compensation for standing timbers that are expropriated.

Table 4.3.3-1 Estimated Compensation for Standing Timbers

No.	Section	Quantity (Parcel)	Affected Land (Rai)	Compensation (Baht)
1	Section 1 km.637+500-km.783+000	31	75.82	14,317,992
2	Section 2 km.783+000-km.929+150	36	10.38	1,904,555
3	Section 3 km.930+000-km.957+860	-	-	-
	Total	50	86.20	16,222,547

Table 4.3.3-2 Summary of Estimated Compensation

Section	Land (Baht)	Structure (Baht)	Standing Timbers (Baht)	Contingency 30%	Sum (Baht)
Section 1 km.637+500-km.783+000	11,214,592	12,333,215	14,317,992	11,359,740	49,225,539
Section 2 km.783+000-km.929+150	26,518,787	30,575,661	1,904,555	17,699,701	76,698,704
Section 3 km.930+000-km.957+860		-	-	-	-
Total	**37,733,379**	**42,908,876**	**16,222,547**	**29,059,441**	**125,924,243**

4.4 Estimation of Compensation for Structures on Land Owned by the State Railway of Thailand

The compensation for structures legally leased with the State Railway of Thailand and the structures belonging to other state agencies includes the compensation for structures minus the depreciation. On the other hand, the compensation for structures that encroach upon the land owned by the State Railway of Thailand includes only the cost of structure removal and transport. The compensation for structures belonging to SRT shall not paid due to the fact that those structures are being replace with new construction already included in the project.

The estimation of compensation for structures on land owned by SRT (only in construction zone) was divided into 4 sections as the survey is carried out in 3 main sections, as well as the cord line, as follows:

- Section 1 Km.637+500 - Km.783+000
- Section 2 Km.783+000 - Km.929+150
- Section 3 Km.930+000 - Km.957+860
- Section 4 Chord Line (Not in construction zone, then no compensation was estimated.)

Tables 4.4-1 shows the estimated figure for the compensation for structures on land owned by the State Railway of Thailand summarized in each section.

Table 4.4-1 Compensation for Structures on Land Owned by the State Railway of Thailand

No.	Item	Compensation for Structures (Baht)			
		Section 1	Section 2	Section 3	Sum
1	Structures leased with SRT	128,562,241	92,266,863	1,086,825,689	1,307,654,793
2	Structures belonging to other state agencies	18,542,014	7,977,843	19,955,039	46,474,896
3	Structures belonging to SRT	-	-	-	-
4	Structures that are encroachments	117,794,246	48,518,771	113,670,858	279,983,875
Total		**264,898,501**	**148,763,477**	**1,220,451,586**	**1,634,113,564**

Chapter 5 Detailed Design

CHAPTER 5

DETAILED DESIGN

5.1 Route Alignment

5.1.1 Project Route

The Surat Thani-Hat Yai Junction-Songkhla project is a double track railway construction, in which a new railway will be installed in parallel to the existing rail along its 80 meters right of way from Pun Pin station (Surat Thani) to Hat Yai Junction, and new construction of double tracks from Hat Yai Junction to Songkhla station where it has no longer operated since 1978. The rail route passes through 80 Tambons of 23 Amphoes in 4 Provinces, as summarized in **Table 5.1-1**.

Currently, the Surat Thani-Hat Yai Junction section is single track railway all the way from Surat Thaini to Hat Yai consisting of a total distance of 292 km and 58 railway stations (excluding Surat Thani station). Among these stations, there are 3 railway junctions at Thung Song, Chum Thong, and Hat Yai. In addition, there are 2 maintenance depots along this route which are Thung Song maintenance depot and Hat Yai maintenance depot.

The second section, Hat Yai Junction station to Songkhla station, is currently inoperative. The existing route alignment diverge from Hat Yai Junction to Songkhla, had a total distance of 29 km with 14 railway stations and stops (excluding Hat Yai station), passing through two districts, Hat Yai district and Songkhla district. It began the operation in King Rama 6 period, on January 1, 1913 (2456 BE). However, in 1978 (2521 B.E.), the Cabinet made a resolution to the State Railway of Thailand to stop Songkhla station operation since July 1, 1978 (2521 BE) but maintain its right of way as it was. Presently, the route is in poor condition and there are some buildings were established along the railway right of way, particularly in Songkhla Municipality.

5.1.2 Design Criteria and Standard

For the criteria for the design of railway alignment in the project, it was designed by accounting for convenience, fast and safety, and avoiding additional land expropriation. In addition, the design was made by aiming to support passenger and freight trains to be added in the future as forecasted and support separated grade railway crossings and railway fencing. The new rail line was also designed to avoid the impact on current operating routes during construction phrase.

Additionally, the following design criteria were applied:

- Compliance to SRT's standards
- Safety on train operation and convenience of train users
- Compliance to other related projects
- Avoiding additional land expropriation for minimizing impact on communities which could be an obstacle during construction
- Difficulty in construction and construction cost
- Impacts on related environment which may occur during construction and afterward.

Table 5.1-1 List of administrative district through which the rail route passes

Surat Thani Province	Nakhon Si Thammarat	Phatthalung	Songkhla
<u>Amphoe Phunphin</u> Tha Kham Khao Hua Khwai Tha Sathon	<u>Amphoe Chawang</u> Huai Prik Kapiat Na Khliang Mai Riang Na Wae Chawang Sai Ra Chan Di	<u>Amphoe Khwon Khanun</u> Laem Tanot Pan Tae Phanang Tung Makok Nuea	<u>Amphoe Khwon Niang</u> Khwon So Rattaphum Bang Riang
<u>Amphoe Ban Na Doem</u> Tharuea Na Tai Ban Na	<u>Amphoe Chang Klang</u> Lak Chang Chang Kklang	<u>Amphoe Mueang</u> Chai Buri Prang Mu Phaya Khan Khuha Sawan Khwon Maphrao Tamnan	<u>Amphoe Rattaphum</u> Khwon Ru
<u>Amphoe Ban Na San</u> Na San Khlong Prap Phru Phi	<u>Amphoe Na Bon</u> Kaeo Saen Na Bon	<u>Amphoe Khao Chaison</u> Han Pho Khwon Khanun Khao Chaison	<u>Amphoe Bang Klam</u> Bang Klam Tha Chang
<u>Amphoe Wiang Sa</u> Wiang Sa Ban Song	<u>Amphoe Thung Song</u> Nong Hong Cha Mai Na Saen Luang Pak Phraek Tham Yai	<u>Amphoe Bang Kaeo</u> Tha Maduea Khok Sak Na Pa Kho	<u>Amphoe Hat Yai</u> Khlong U Taphao Khlong Hae Kho Hong Hat Yai Nam Noi Thung Yai Tha Kham
	<u>Amphoe Ron Phibun</u> Ron Phibun Khwon Koei Khwon Chum	<u>Amphoe Pa Bon</u> Pa bon Wang Mai Khok Sai	<u>Amphoe Mueang</u> Phawong Khao Rup Chang Bo Yang
	<u>Amphoe Chulaphon</u> Khwon Nong Khwa Sam Tambon Cha-Uat	<u>Amphoe Pak Phayun</u> Falami Han Thao Don Pradu Don Sai	
	<u>Amphoe Cha-Uat</u> Ban Tun Khwon Nong Hong Cha-Uat Tha Pra Cha Tha Samet nang Long Khon Hat		
Passing through 4 Amphoes, 11 Tambons	Passing through 7 Amphoes, 30 Tambons	Passing through 6 Amphoes, 23 Tambons	Passing through 5 Amphoes, 16 Tambons

For the standard for the design of railway alignment, the following rules were applied.

1) **Standard of permanent way:** In the design of railway alignment, the standard of permanent way as shown in **Table 5.1.2-1** was used.

Table 5.1.2-1 Standard of permanent way

Track Gauge	1,000 mm
Rail	UIC54
Sleeper	Prestressed concrete with 600 mm spacing
Ballast	300 mm beneath sleeper
Axle load	20 tons (U-20)
Max. Speed	160 km/hr
General min. horizontal radius	1,600 meters
Absolute min. horizontal radius	900 meters
General min gradient	1.00%
Absolute min gradient	1.20% (1.10% in curve)

2) **Structure Gauge:** Regarding the various requirement of side track equipment and envelope of train movement, the Consultants have proposed the use of structural gate as shown in **Figure 5.1.2-1.**

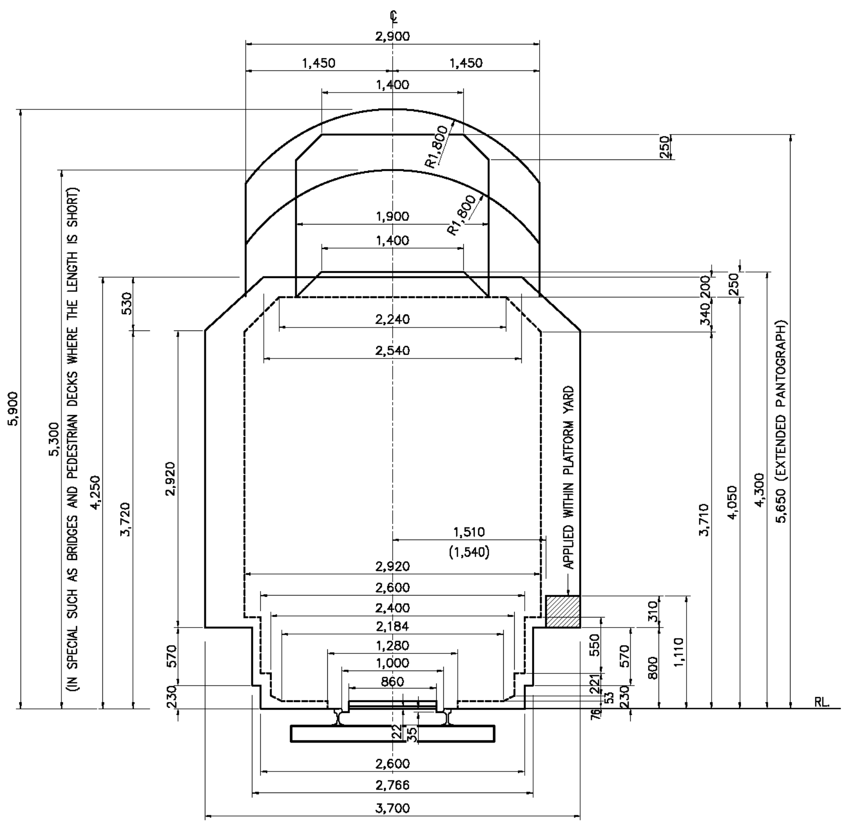


Figure 5.1.2-1 Structural and loading gauges

3) **Track Spacing:** The distance between tracks generally in the range of 4-10 m. For this project, the distance between track centerline for each section of project route is shown in **Table 5.1.2-2**.

Table 5.1.2-2 Distance between track centerline

Section	Distance between track centerline (m)
Surat Thani – Hat Yai (Track doubling)	6
Hat Yai - Songkhla (New double tracks)	5

4) **Vertical Clearance:** For a new structure in the project, the Consultants have specified the vertical clearance height at 6 m and more to prepare for electric train system in the future even though the general requirement of safety distance relative to the height of the overhead electrical distribution system is just 5,655 mm above the rail level.

5.1.3 Design Result of Route Alignment

The construction project of Surat Thani-Hat Yai-SongKhla double track railway was divided into two sections as follows.

The first section is Surat Thani-Hat Yai, starts from km.637+500 which is the end of Chumphon-Surat Thani Double Track Project. The railway continues south to Thung Song, Nakhon Si Thammarat via Phatthalung to Hat Yai at km.929+150, with total distance of 291.65 km, 40 stations, 18 train stops (excluding Surat Thani station). This section is desgined to have one additional railway track parallel to the existing one, as shown in **Figure 5.3.3-1**.

Due to very lengthy section, there are 140 curves. At some curves in which the speed of 120-160 km/h cannot be reached, the Consultants then realigned the route in 51 curves, resulting in additional 3 areas of land expropriation for route alignment modification.

The second section, Hat Yai Junction-SongKhla station route, has the total distance of 29.217 km but no longer service since 1978 (2521 B.E.). As a result, it is redesigned entirely with double tracks, starting from Hat Yai Junction at km.928+643 to Songkhla station at km.957+860 in which there are 7 new stations established (excluding Hat Yai Junction) from the previous 14 stations since 1978 (2521 B.E.). Since there are many people in Songkhla, living on the railway right of way, including the governmental bodies, temples, school, the Consultants have redesigned the route as elevated train at some parts along the route alignment. Then, the required area for train operation is reduced from 80 m of the existing R.O.W. to 30 m for the ground train and to 20 m for the elevated train, just sufficient for the train operation plan (as shown in **Figure 5.1.3-2**). However, the remaining right of way may be allowed for local people to continue living based upon the rental registration from the State Railway of Thailand in order to mitigate to potential impact during construction.

As a result, the project route has the total distance of 321 km with 65 stations as shown in **Figure 5.1.3-3.**

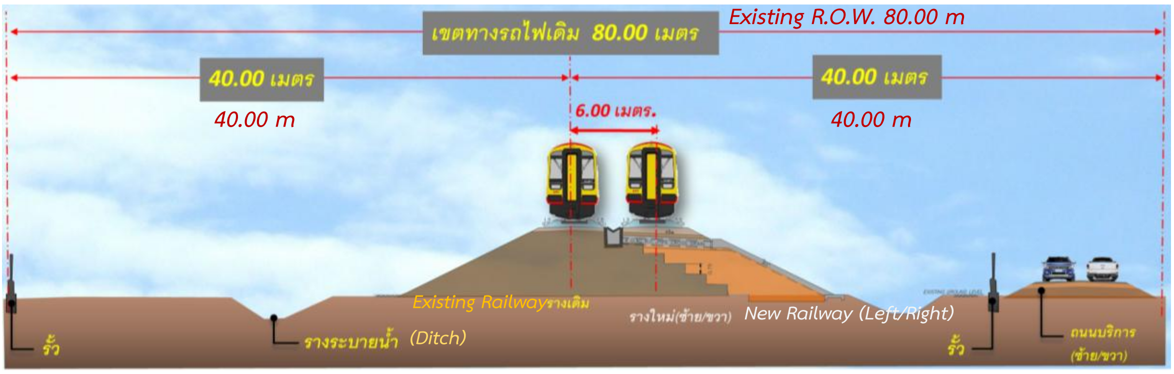


Figure 5.1.3-1 Typical cross section of Surat Thani-Hat Yai Junction

Figure 5.1.3-2 Typical cross section of Hat Yai Junction-Songkhla section

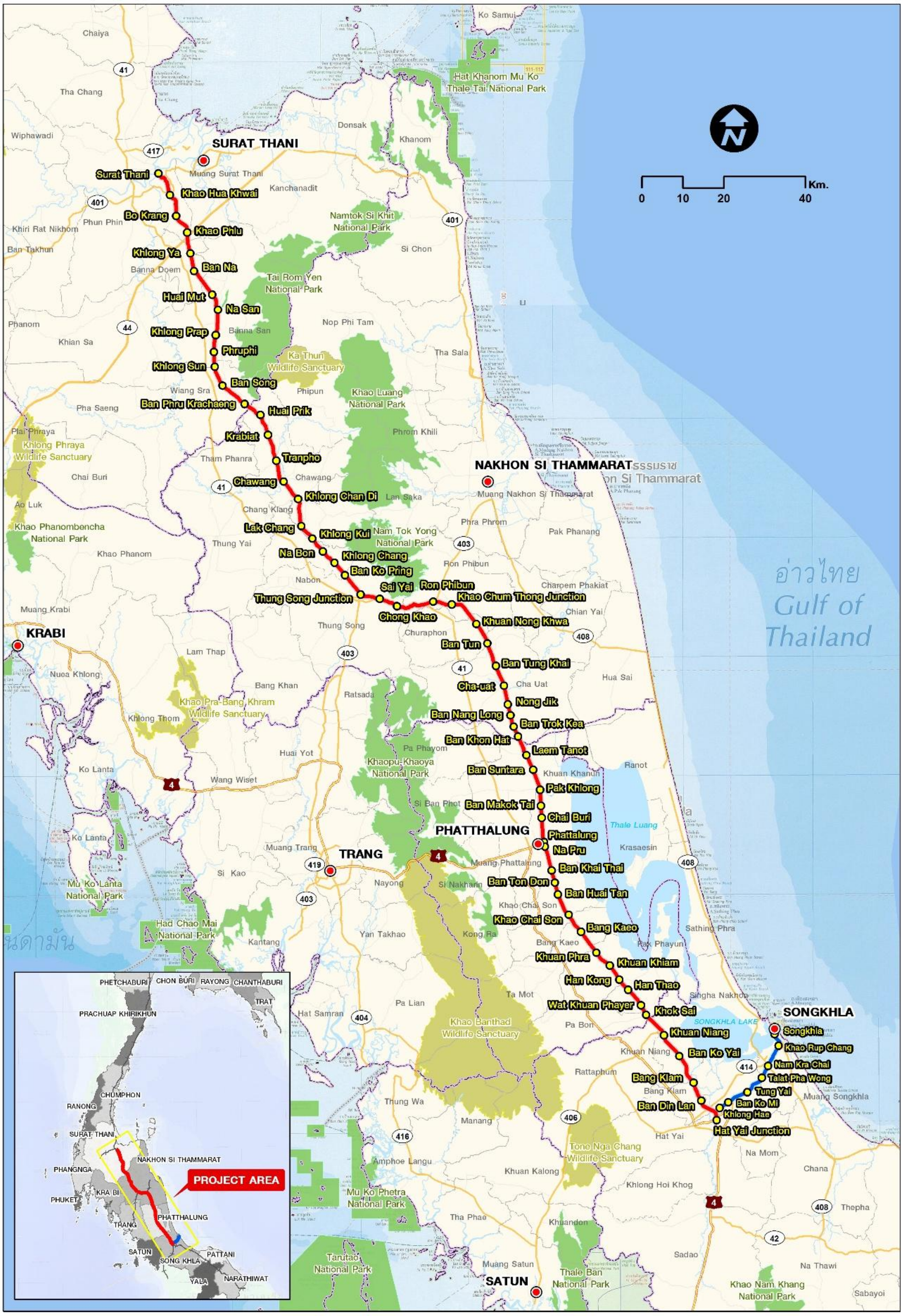


Figure 5.1.3-3 Project Railway Route

5.2 Geotechnical and Railway Embankment

5.2.1 Soil Profile

Soil survey at foundation has been made for collecting soil property data. Along the project route alignment, 330 boreholes have been drilled to provide cross-section showing soil profile.

Soil survey has been made by the rotary and percussion drillers with 100 mm. (4 inches) of drilling head. Wash boring method was used in drilling process.

Soil sampling has been made by 2 methods, which are undisturbed sample by Shelby Tube, and disturbed sample by Spilt Spoon.

Laboratory test on soil samples consists of the physical properties test of the representative soil samples, as follows:

- Test of water content in the natural soil mass
- Test of the Atterberg's Limits
- Test of density of soil
- Test of particle-size Analysis
- Test of unconfined compression

To describe soil conditions and classify soil types, the standard of Unified Soil Classification System (USCS) developed by American Society of Testing and Materials (ASTM D 2487) was used.

The properties of soil, such as color, continuity, soil type and other physical characteristics, have been gathered into the results of various laboratory tests, presented in the form of borehole logs and layers of soil profile.

5.2.2 Survey on Source of Construction Materials

Survey on source of construction materials includes representative construction material sampling and laboratory testing. The materials included millstone, crashed rock, fill sand, concrete mixed sand, and embankment fill material. This has been made to obtain high quality materials for embankment design, cost estimate and construction.

- Nine sources of embankment filling materials have been considered.
- Two sources of ballast have been considered.
- Eight sources of sand have been considered.
- Seven sources of millstone have been considered.

5.2.3 Design Concept, Principle and Standard

In geotechnical design, it has been related to the designs of embankment, foundation for supporting embankment, structures for improving settlement of soil at shallow and deep layers, slope protection, etc. Several international standards, such as UIC 719R : Earthworks and Trackbed Layers for Railway Lines, AREMA 2014, NAVFAC DM7.02 Foundations and Earth Structures, were used.

The following types of force load were accounted by the Consultants:

- Live load from standard train weight of SRT with the maximum axial load P = 20 tons (U20).
- Impact load
- Load from earthquake

5.2.4 Embankment Design Result

In the design of embankment structure, the criteria in UIC-719R standard have been used for determining thickness and quality class of blanket layer which includes subballast and subbase. According to the quality class of subgrade and the recommendation from AREMA, it is shown that approximately at 1.5 m from subballast is the area with significant effect from impact load. For the layer above subgrade at the approximate thickness of 0.6 m, selected material with high drain capacity is recommended. In addition, the standard on the quality of subgrade for highways by the Department of Highways, Thailand, in which many contractors are familiar, has been accepted. As recommended by AREMA, the embankment side slope of 2 (H) : 1 (V) was also adopted.

From soil profile and overall engineering properties, the soil has been complied into several groups of soil parameters**.** The summary of analysis on embankment stability of cut and fill works is shown in **Table 5.2.4-1.**

In addition, referring to USC719R, the qualities of construction materials were classified as QS0-QS3 for subgrade material, and as P1-P3 according to bearing capacity class for prepared subgrade used to support blanket layer.

The typical cross sections of at grade embankment are shown in **Figures 5.2.4-**1 to **5.2.4-3**.

Table 5.2.4-1 Summary of Analysis on Embankment Stability

Typical Soil Group	Max. Height of Embankment (m)	Side Slope (V:H)	Depth of Replacement (m)	Temporary Loading		Permanent Loading		Seismic Loading
				Flood Level (m)	FS	Flood Level (m)	FS	FS
1	9.0	1:2	-	+2.0	1.561	+0.0	1.701	1.634
2	7.0	1:2	1.5	+2.0	1.540	+0.0	1.630	1.565
3	5.0	1:2	-	+2.0	1.345	+0.0	1.574	1.512
4	6.0	1:2	2.0	+2.0	1.362	+0.0	1.563	1.504
5	8.0	1:2	-	+2.0	1.397	+0.0	1.533	1.458

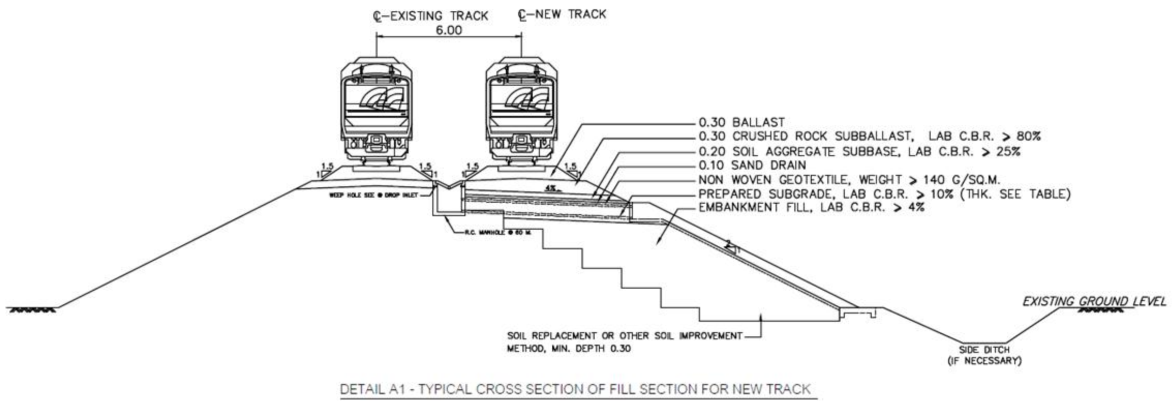


Figure 5.2.4-1 Typical section of embankment: Surat Thani – Hat Yai subsection

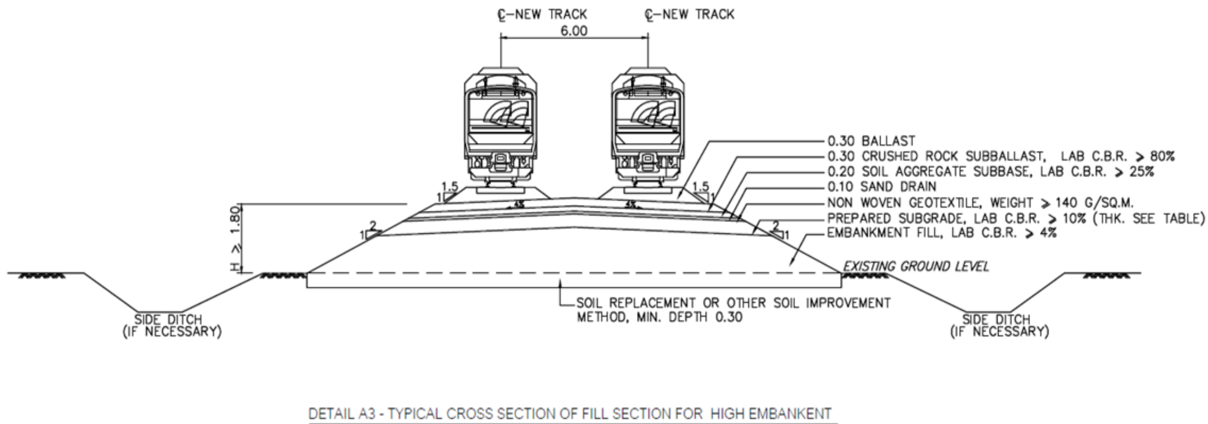


Figure 5.2.4-2 Typical section of embankment: Surat Thani – Hat Yai subsection

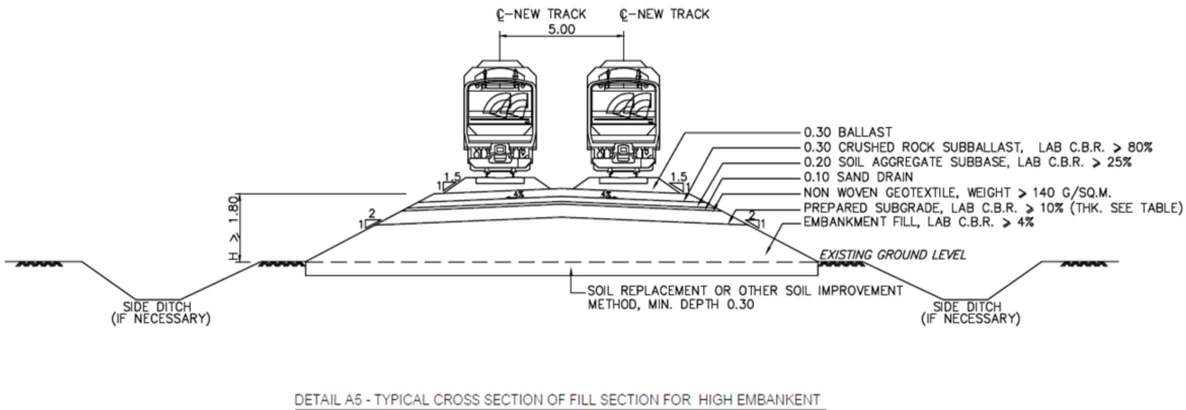


Figure 5.2.4-3 Typical section of embankment: Hat Yai – Songkhla subsection

5.2.5 Protection System for Soil Slope Failure and Erosion

The slope failure or sliding is the behavior where the soil mass moves from high to low under gravity force, which causes damage to life, assets and structure.

Soil slope stability analysis is normally considered using Limit Equilibrium method. The soil stiffness is determined based on the maximum acceptable soil stiffness. It is then be compared the ratio between the maximum soil friction per unit force that creates the soil slope (Factor of Safety, F.S.). The randomized trial of F.S. was conducted in different scenarios by varying the characteristics or the possible slope position, until the lowest F.S. was obtained.

In the design of filled soil embankment at bridge approach and tunnel tomb with high raised fill in limited space, the Consultants have considered the embankment design with reinforcement to improve shear resistance capacity. Soil reinforcement is the method to utilize tensile resistant capacity of the reinforcement and compressive resistant capacity of soil at the same time. The introduction of tensile reinforcement materials, such as metal strips, geosynthetics, into soil structure allows engineers to control soil settlement and soil movement, resulting in steeper side slope than usual.

For cut embankment in area with limited space, soil nail for earth reinforcement is normally used. In addition, it can be used in soil retaining structure which can be applied to the construction on hillside where slope is steeper than usual.

Problem from surface slope failure may be found when the installation of drainage system is insufficient for the amount of water. When water infiltrates into the slope surface, it results in instability of the slope. To prevent this kind of problem, the best location to install a drainage system is at the top of slope above where is at risk of the movement to intercept surface water before flowing to critical area.

To protect erosion for back slope, bench method is one of the methods for erosion protection and slope stability improvement, as shown in **Figure 5.2.5-1**. This shall help in reducing water flow velocity, storing water, intercepting sediment, increasing slope stability in steep areas which can be later used for construction and maintenance.

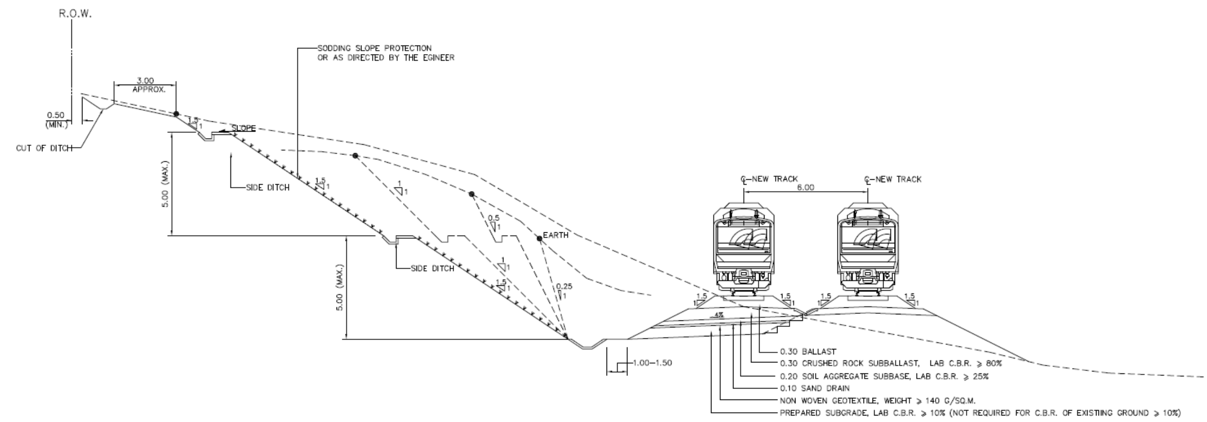


Figure 5.2.5-1 Erosion protection by back slope benching

5.2.6 Railway Tunnel

In the construction of double track rail of Surat Thani – Hat Yai Junction – Songkhla, an existing tunnel with 240 m in length is located near Chongkhao station in Ron Phibun district, Nakhon Si Thammarat province. By selecting a tunnel construction, the route distance is shortened with less impact to environment.

The configuration of tunnel in this project is a Multi-Centric Tunnel as shown in **Figure 5.2.6-1**. As a short type with the approximate distance of 240 m, the tunnel was designed to be constructed with drill and blast method for the best result with a wide section of tunnel for railway and any grade of rock hardness. This construction method may be called the conventional tunneling method in which the procedures for excavation and tunnel support may vary corresponding to geological and groundwater conditions for save and safety. However, this method may spend more time in construction than the modern tunnel drilling method with tunnel boring machine.

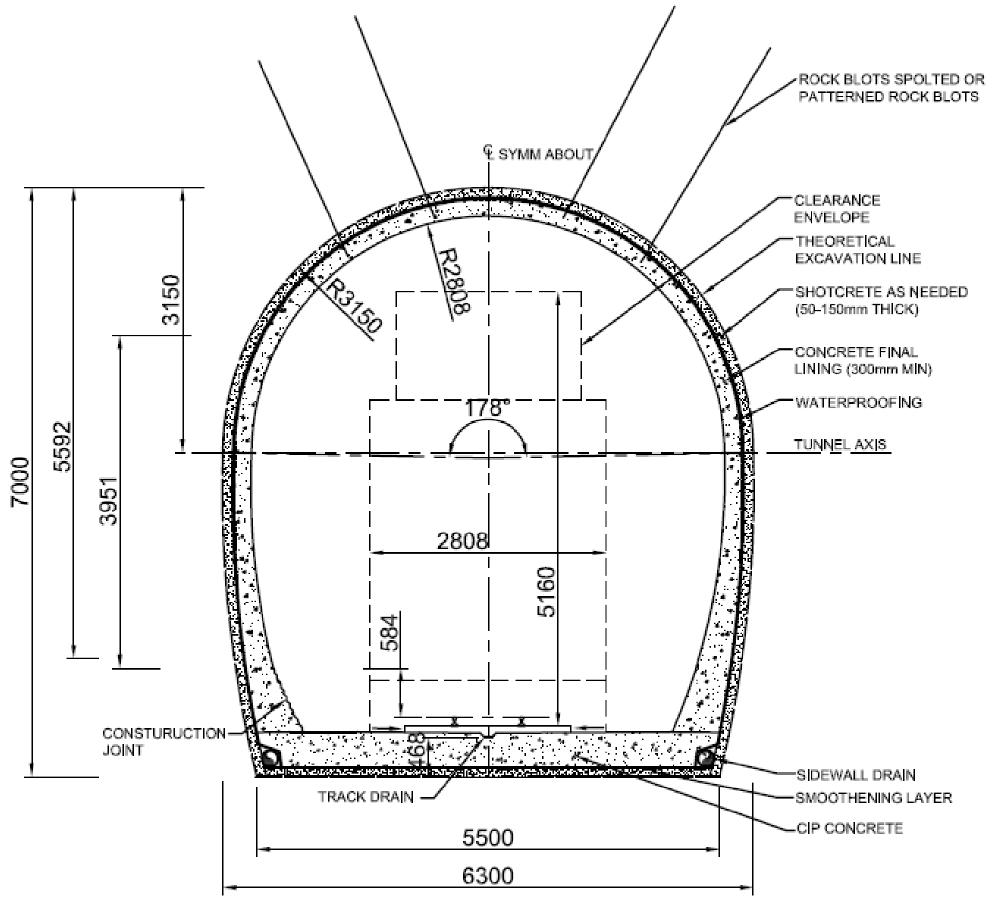


Figure 5.2.6-1 Cross section of semicircle tunnel constructed by drill and blast

In designing the tunnel of this project, the existing international standard and criteria for tunnel structure and safety have been adopted and updated for the project suitability. The following list was the standard used for tunnel design in the project:

For structural design:

- Eurocode 0-Basis of Structural Design
- Eurocode 2 Design of Concrete Structures Pt. 1-1 general rules and rules for buildings

- Eurocode 2 Design of Concrete Structures Pt. 1-2 general rules-structural fire design
- Eurocode 7 Geotechnical Design Pt. 1 general rules
- BS EN 14487 Part 1 Sprayed Concrete Definitions, specifications and conformity
- BS EN 14487 Part 2 Sprayed Concrete: Execution
- Austrian Guideline of Sprayed Concrete
- The Joint Code of Practice for Risk Management of Tunnel Works in the UK

For the requirement on safety

- NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems
- Relevant national and international railway codes and guidelines

5.3 Railway Crossing and Fencing

Since the southern line has more than 1,000 rail crossing points, more than 300 rail crossing points are located in the Surat Thani-Hat Yai Junction-Songkhla double track construction project. The majority are at grade railway crossing. This has caused lower average train speed and accidents easily. To prevent accidents which may occur, the fence was designed along both sides of the railroad in order to protect people and livestock from any train accident and electric shock, as well as maintaining the train speed. The designed fence along the route alignment is a clear fence with spacing for drainage, as shown in **Figure 5.3-1**.

However, if there is a public road near the railway, the fence is designed to be placed along the inner road so that people can still use such public road.

Figure 5.3-1 Example of fence installation

5.3.1 Conceptual Solution for Railway Crossing

With the concerns on the accident at the rail crossing or the ground level road, the rail crossing was entirely designed to be the grade-separated rail crossing. The design of thoroughfare or the roads, which the rail is crossing, has considered how people are normally using the existing roads and can be well connected between the two sides of the rail according to the road standard such as Department of Highways (DOH) standard, Department of Rural Roads or local authorities, as well as cooperate with the road authority. The recommendations and suggestions from public participation conference were also considered as part of the highway design

For such design, the road network connecting two sides of the Rail crossing area were considered according to the existing road crossing design standard as well as collaborate with the responsible parties so that the design will be based upon the same database.

5.3.2 Types and Forms of Grade Separated Railway Crossings

The type of rail crossing must align with the development plan of State Railway of Thailand. Based on the field survey at every rail crossing point, the Consultants have used this information to screen and categorize appropriate Rail crossing type for the rail crossing design. From the above criteria, the rail crossing type can be categorized into 5 types as follows:

Type 1 - Railway bridge over highway: This was considered where there is high rail embankment with the congested vehicle road passes underneath or when rail crossing points passing through many main roads. Therefore, for those cases, the railway was design to be elevated across those roads as shown in **Figure 5.3.2-1.**

Figure 5.3.2-1 Railway bridge over highway

Type 2 - Overpass over railway: In case there is very high traffic highway with sufficient right of way, it will be considered to design an overpass over railway as shown in **Figure 5.3.2-2.**

Figure 5.3.2-2 Overpass over railway

Type 3 - U-shape and H-shape turn bridge: This type was applied when the rail crossing passes through the highly populated zone or there is some restrictions on the existing connected road, insufficient right of way, land expropriation in nearby area which consequently impact to local people. Therefore, it is necessary to design the grade-separated way on the existing route in order for road connection and reduce the impact to the people using passing it. This provides convenient and safety to the users. The Consultants have categorized the bridge turning into two types which are U-Shape and H-Shape U-turn Bridge as shown in **Figure 5.3.2-3.**

Figure 5.3.2-3 U-shape and H-shape turn bridge

Type 4 – Underpass: This type was applied where the rail crossing point passes through the low traffic loads roads, on the agricultural zone or the fencing area causing the separation area issue. With this design, the railway embankment must be sufficiently high to construct the underpass, so that it does not affect the local people for passing through such underpass. In addition, the underpass can also be used as the drainage during flooding period as shown in **Figure 5.3.2-4.**

Figure 5.3.2-3 Underpass

Type 5 - Service road: This type was designed beside the railway. This is suitable for the area where the Rail crossing points passes through number of nearby roads, and the soil condition is too poor to construct separation grade rail crossing or underpass. This was designed beside the railway as a service road, connecting to the local roads and builds either an underpass/overpass or a link to existing underpass/overpass so that the two side of the rail can be connected as shown in **Figure 5.3.2-5.**

Figure 5.3.2-4 Service road

In addition, to mitigate the problem due to land separation, small crossing bridges for pedestrians and motorcycles were designed, as shown in **Figure 5.3.2-6**, and placed in appropriate areas such as community, temple, school, or the area requested by local people from the meetings in public participation program of this project.

Figure 5.3.2-6 Crossing bridge for pedestrians and motorcycles

5.3.3 Location of Grade Separated Railway Crossings

From the preliminary survey and inspection the Rail crossing along the project route alignment with total distance of 321 km. For both sections, it was found that there are several existing railway crossings, including grade-separated rail crossing, at grade rail crossing with and without the fences, as well as many illegal crossings. The Consultants have reconsidered on the type of rail crossing and specified the detail design pattern, as follows:

The first section is from Surat Thani station to Hat Yai Junction station. It was found that there are 253 rail crossing points with different road pavement and operational purposes such as the dirt road access to the agriculture zone or between villages, the asphaltic concrete road to connect between province and district, concrete road for local people. Some of them are under the responsibility of Department of Highways, Department of Rural Roads, Irrigation District Administrative Office, Tambon Administration Organization, and Provincial Administration Organization, as show in **Table 5.3.3-1**.

The second section is from Hat Yai Junction station to Songkhla. It was found that this route is in the process of operation discontinuity without rail dismantlement. The rail condition is in very poor condition, and there are many housing and buildings being built on top of railway right of way. Particularly in Songkhla Municipality zone, there are 50 rail crossings along its existing route alignment, as summarizied in **Table 5.3.3-1**.

In addition, the Consultants have summarized the position of rail crossings including 5 main types, small crossing bridges for pedestrians and motorcycles, and small underpass for farmers and livestocks, as presented in **Table 5.3.3-2**.

Table 5.3.3-1 Summary on number of existing road-railway crossings

Response Agency		Surat Thani – Hat Yai	Hat Yai – Songkhla
1)	Department of Highways	22	7
2)	Department of Rural Roads	10	3
3)	Royal Irrigation Department	10	-
4)	State Railway of Thailand	1	-
5)	Local Administration Agencies and Others	210	40
Sum		253	50

Table 5.3.3-2 Summary on number of new railway crossings

Crossing Type		Surat Thani – Hat Yai Section				Hat Yai – Songkhla Section	Sum
		Surat Thani	Nakhon Si Thammarat	Phatthalung	Songkhla	Songkhla	
1)	Railway bridge (only for road crossing)	6	16	7	8	42	79
2)	Overpass	2	6	5	4	1	18
3)	Turn bridge						
	- U-turn	18	28	20	4	7	77
	- H-turn	3	1	-	-	-	4
4)	Service road	5	5	1	3	32	46
5)	Underpass	12	14	5	5	-	36
6)	Small underpass for agriculture	1	14	20	5	-	40
7)	Pedestrain bridge	14	22	15	5	-	56

5.4 Railway Bridge and Crossing Structure

5.4.1 Design concept and design standard and criteria

5.4.1.1 Standard and design consideration for railway bridge structure and railway crossing.

In the detailed design process of railway bridge, the Consultants consider the following factors

(1) Strength of structure

(2) Difficulty in construction

(3) Period of construction

(4) Complexity in quality control

(5) Harmonious desigh with surrounding environment

(6) Environmental impact both during and after construction

(7) Cost of construction

(8) Aestheticity of the structure

(9) Cost of maintenance

5.4.1.2 Railway birdge design loads

In the design of railway bridge design, the Consultants consider loads and load combination in accordance with the following design standards and specifications

AREMA : American Railway Engineering and Maintenance-of-Way Association

PCI : Prestressed Concrete Institute

ACI : American Concrete Institute

- ACI 224R-01, Control of Cracking in Concrete Structures
- ACI 318-05, Building Code Requirements for Structural Concrete
- ACI 435R-95 (Re-approved 2000), Control of Deflection in Concrete Structures

UIC : The Union International des Chemins de Fer

EIT : The Engineering Institute of Thailand under H.M. the King's Patronage

TIS : Thai Industrial Standard

5.4.1.3 Elevated railway bridge design load

In the design of elevated railway bridge, the Consultants consider loads and load combination in accordance with Standard Specifications for Highway Bridges AASHTO (LRFD, Load and Resistance Factor Design) ultilised HL-93 class vehicle on every bridge span. While other specifications presented in the project which is not included in AASHTO, the Consultants follow reccomendaition given in other relevant standards such as ACI "Building Code Requirements for Reinforced Concrete" (ACI 318-95), Department of Highway Design's codes etc.

5.4.1.4 Railway bridge design provision for seismic load

All railway bridge design is perfromed in accordance with the design methologies and calculations outlined in Mor.Yor.Por.1302 standard. Each structural member is subject to acceleration derived from responsecturm given for each provinces as shown in Mor.Yor.Por.1302.

5.4.1.5 Design consideration to provide for structure settlement

In design of railway bridge and elevated railway structure including crossing, the Consultants design in accordance with relevant engineering standard including AREMA, AASHTO which require designer to consider load resulted from settlement of structure as shown in **Figure 5.4.1-1** for AREMA's requirement and **Figure 5.4.1-2** for requirement presented in AASHTO.

Group	Item	Allowable Percentage of Basic Unit Stress
I	D + L + I + CF + E + B + SF	100
II	D + E + B + SF + W	125
III	Group I + 0.5W + WL + LF + F	125
IV	Group I + OF	125
V	Group II + OF	140
VI	Group III + OF	140
VII	Group I + ICE	140
VIII	Group II + ICE	150

Figure 5.4.1-1 Group Loading combination – service load design with settlement (OF) consideration as specificed in AREMA (2014)

Load Combination Limit State	*DC DD DW EH EV ES EL*	*LL IM CE BR PL LS*	*WA*	*WS*	*WL*	*FR*	*TU CR SH*	*TG*	*SE*	Use One of These at a Time			
										EQ	*IC*	*CT*	*CV*
STRENGTH I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
STRENGTH II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
STRENGTH III	γ_p	—	1.00	1.40	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
STRENGTH IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—
STRENGTH V	γ_p	1.35	1.00	0.40	1.0	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
EXTREME EVENT I	γ_p	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—
EXTREME EVENT II	γ_p	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00
SERVICE I	1.00	1.00	1.00	0.30	1.0	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—
SERVICE II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—
SERVICE III	1.00	0.80	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—
SERVICE IV	1.00	—	1.00	0.70	—	1.00	1.00/1.20	—	1.0	—	—	—	—
FATIGUE—*LL, IM & CE* ONLY	—	0.75	—	—	—	—	—	—	—	—	—	—	—

Figure 5.4.1-2 Load combination and load factors with settlement (SE) consideration as specified in AASHTO

5.4.2 Bridge structure

In the design process of railway bridge, the Consultants consider volumn of water flowing under the bridge and topography of the area while maintain adequate level of engineering standard such as strength and durabilityin accordance to relevant international standards. Furthermore, the Consultants also emphasize on mitigrating enirvonmental impact and design aesthetic by allowing minimal pier to be constructued in the river as outlined in topic 5.4.1 during the design process.

Superstructure of the bridge is suit for different range of span length. Consultants choose cast in-situ reinforced concrete slab for relevatively short span bridge (10m and shorter) clearance between bottom of structure and water level is adequate. In special loction where clearance is limited and longer span, U-girder and steel bridge is preferred due to thier lower head room space requirement. In general railway bridge type choose can be summaired in **Table 5.4.2-1**

Table 5.4.2-1 Railway bridge structure type

Span length (m)	Structure type
10	Cast In-situ Reinforced Concrete Slab
15, 20, 25, 30	Prestressed concrete I-girder or U-Girder or Steel Bridge
Over 40	Steel bridges

The Consultants select bridge types according to particular topographic conditions. The selected bridge types shall not obstruct river flow and the bridge span length should be longer than the width of the river. The bridges are also orientated to be parallel with existing bridge. Thus, it will not obstruct the water flow. Cast in-situ reinforced concrete slab is selected for short span bridge. Pre-stressed concrete girder is selected for modulate span and steel bridge is selected for long span bridge. The structure has been designed considerating that the vertical clearance must higher than the vertical clearance. Bridge structure configurations are shown in **Figure 5.4.2-1** to **5.4.2-3**

In sum, railway bridge within the project can be summed as shown in **Table 5.4.2-1**.

Table 5.4.2.-1 Summary on distance and number of railway bridge

Railway Bridge	Surat Thani – Hat Yai	Hat Yai – Songkhla	Sum
Steel Bridge			
Distance	6,440 m	140 m	6,580 m
Number	183	6	189
Concrete Bridge			
Distance	1,710 m	-	1,710 m
Number	111	-	111
All			
Distance	8,150 m	140 m	8,290 m
Number	294	6	300

Remarks: The Number shown represents the location of the bridge, and some locations may contain more than one bridge due to vertical profile adjustment or realignment.

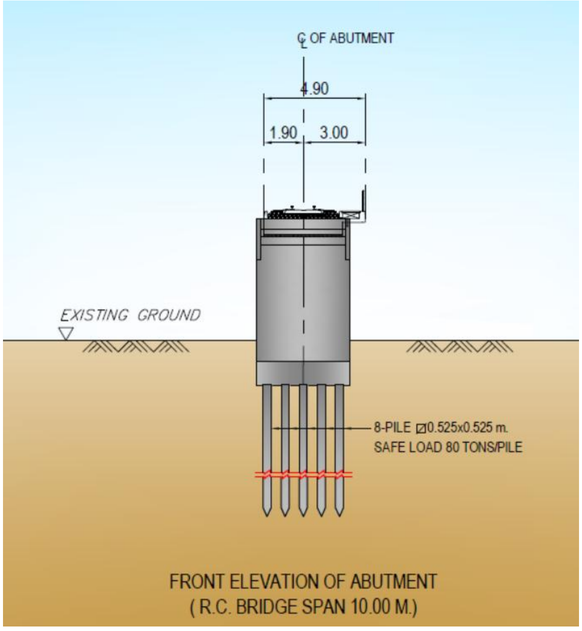


Figure 5.4.2-1 Cast In-situ Reinforced Concrete Slab bridge

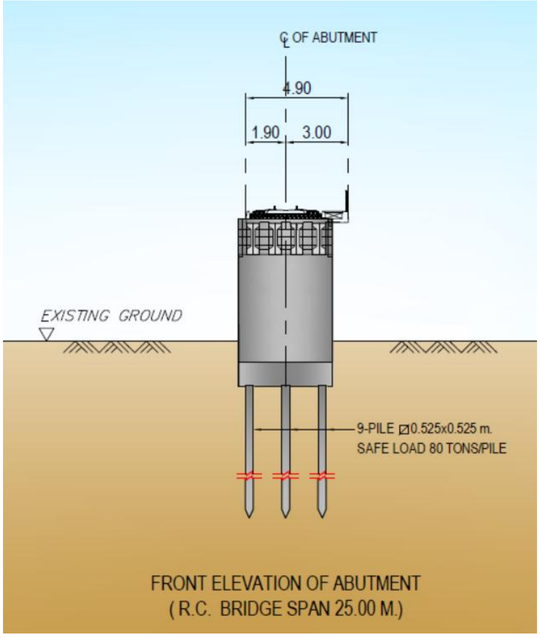


Figure 5.4.2-2 Prestressed concrete girder bridge

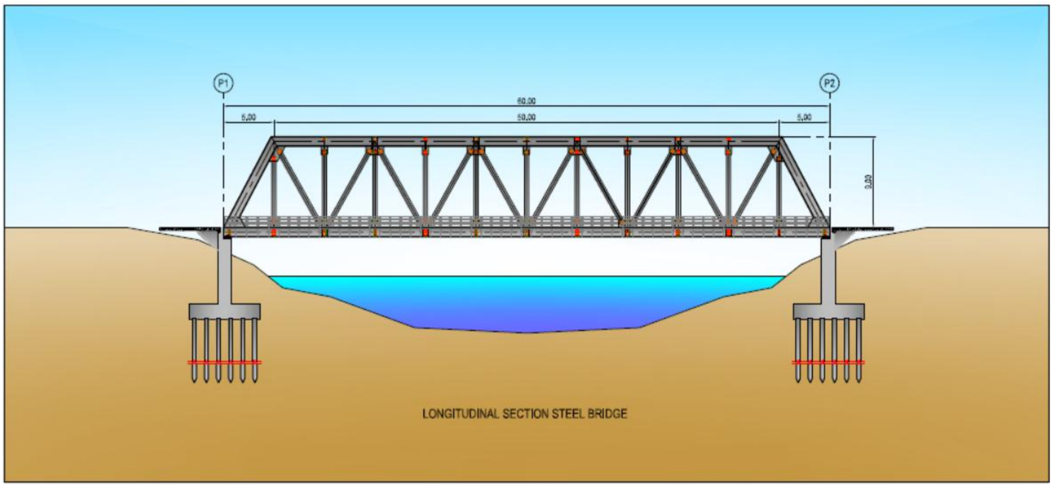


Figure 5.4.2-3 Steel bridges

5.4.3 Elevated railway structure

In general where elevated railway structure is neccessary for example intersection of main roads in urban area, the Consultants shall proceed in accordance with international standard and code of practise. Altough structure configuration is being influenced by many factor such as length of bridge, clearance requirement, transportation route etc. For short span bridge, the Consultants decided to use Cast In-situ Reinforced Concrete Slab bridge while in longer span bridge Pre-stressed concrete girder or Steel Bridge is preferred. Illustration of elevated bridge type is shown in **Figure 5.4.3-1.**

In sum, the project’s elevated railway bridge structure can be summaried as follows:

Surat thani – Hat Yai section: No elevated railway bridge to be constructed

Hat Yai – Songkla section required 3 elevated railway bridges:

1) chainage 930+873.055 to 941+616.418 total distance of 10.74 km,
2) chainage 950+404 to 951+831 total distance of 1.43 km, and
3) chainage 925+485.056 to 957+860.000 total distance 5.38 km.

The total length of elevated railway bridges is 17.545 km.

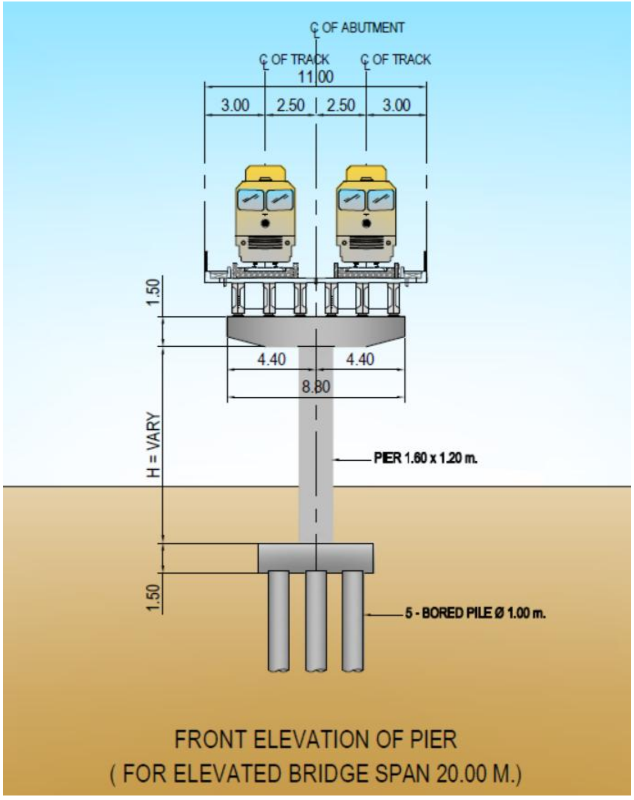


Figure 5.4.3-1 Illustration of an elevated railway bridge

5.4.4 Overpass

Overpass structure is required where there is an interection between train track and medium traffic road. The Consultants propose overpass configuration as shown in **Figure 5.4.4-1** and **5.4.4-2.** typically overpass consist of 2 with lanes of traffic but in some case 4 traffic lanes shall be requiered to serve higher traffic volume.

Majority of enginereing aspect of overpass design is done in accordance with Standard Specificatios for Highway Bridges AASHTO (LRFD, Load and Resistance Factor Design). Where AASHTO is not applicable or not cover, the Consultants shall design in accordance with other relevant standards such as ACI"Building Code Requirements for Reinforced Concrete" (ACI 318-95 or Department of Highway design manual.

In sum, the number of vehicle overpass structures in this project can be summaried as follows:

(1) Surat Thani – Hat Yai section requires 17 overpass to be built.

(2) Hat Yai – Song khla section requires 1 overpass to be built.

Figure 5.4.4-1 Overpass

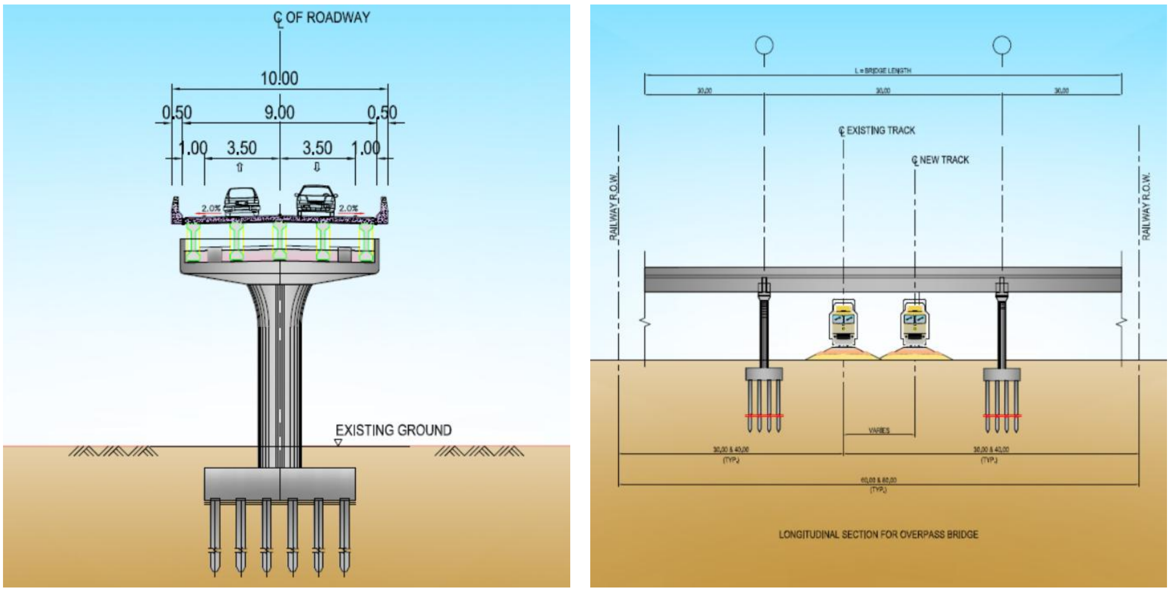


Figure 5.4.4-2 Cross section and long section view of Overpass

5.4.5 Underpass

Three types of underpasswere used in the project 1) 35 reinforced concrete box culvert underasses for small vehicle, as shown in **Figure 5.4.5-1**, 2) 40 small reinforced concrete box culvert for agriculture and animal crossing, and 3) Single Large Underpass at KM 757+585, as summaried in **Table 5.4.5-1**.

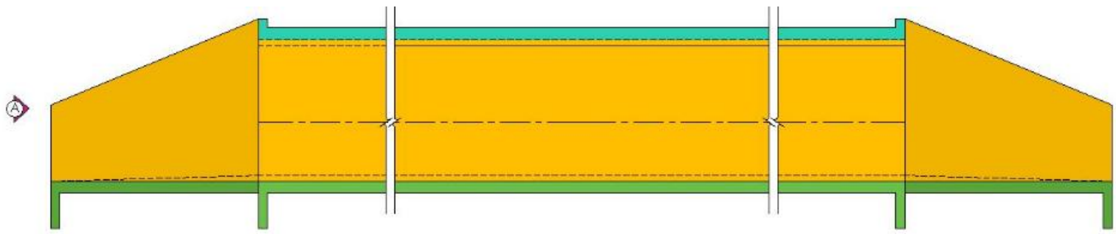


Figure 5.4.5-1 Reinforced Concrete Box Underpass type

Table 5.4.5-1 Summary on the number of underpasses

Type of underpass	Surat Thani – Hat Yai	Hat Yai – Songkhla
For all types of vehicles	1	-
For small vehicles	35	-
For agriculture and animals	40	-

5.4.6 Turn Bridge

Apart from bridge crossing over the rail mentioned above, the intersection between the rail and the secondary road which has low traffic loads. The Consultants shall solve this issue by designing the U-shape or H-shape Turn Bridge as shown in **Figure 5.4.6-1** and **Figure 5.4.6-2**. The advantage of H-Turn Bridge is to minimize the impact from land expropriation. In this project, 77 U-turn bridges and 4 H-turn bridges were designed, as summaried in **Table 5.4.6-1**.

For a Turn Bridge structure design, the Consultants shall study various structure type by considering not only the strength to the truck weight but also the effect from earthquake. The architectural design and landscape architecture will also be taken into the consideration in order to maintain a unique structure characteristic. The design must follow accordingly to the project objective in term of cost saving, compliance to the area condition, constructability and the operational efficiency. The structural type to be considered will be the Pre-cast concrete I-girder with cast-in-situ deck. The superstructure consists of a concrete I-girder deck (I) while the deck will be a Cast in-situ concrete deck. The typical length of concrete girder is around 20-35 meter, in which it will be cementing in order for the whole pre-cast concrete girder to be an entire system. In case of minimizing the problem when cementing without the wooden frame, the precast floor can be placed on top of pre-cast concrete girder and then cementing over it again. This method will affect the road with little cross sectional area as the contractor is familiar with this method and can shorten construction time.

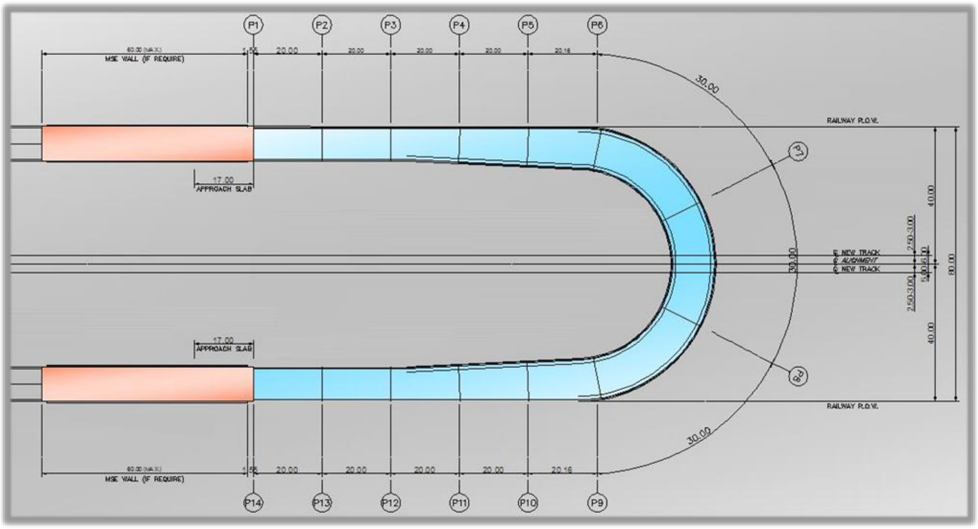


Figure 5.4.6-1 Typical Plan of U Turn Bridge

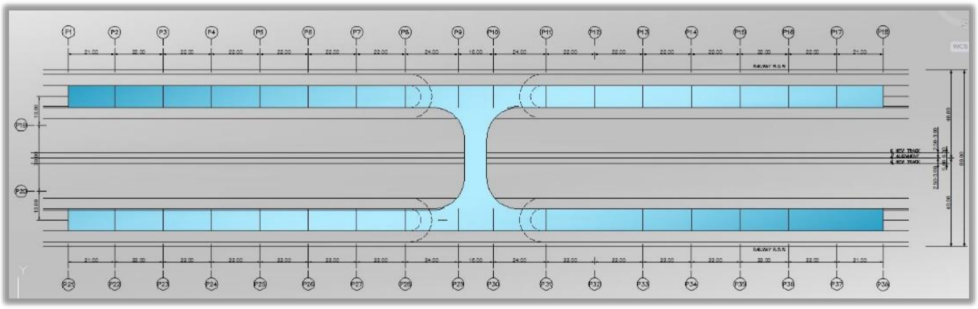


Figure 5.4.6-2 Typical Plan of H Turn Bridge

Table 5.4.6-1 Summary on the number of U- and H-turn brigdes

Type of turn bridge	Surat Thani – Hat Yai	Hat Yai – Songkhla	Sum
U-turn	70	7	77
H-turn	4	-	4
All	74	7	81

5.5 Station, Station Yard and Related Components

5.5.1 Station Location and Re-location

Currently, on the Surat Thani-Hat Yai Junction-Songkhla line, with the total distance of 321 km, the Consultants have divided the number of stations into 2 sections; the stations from Surat Thani-Hat Yai Junction Station and Hat Yai Junction Station-Songkhla station.

Along the Surat Thani-Hat Yai Junction station route, there are 58 stations and stop signs (excluding Surat Thani station) as shown in **Table 5.5.1-1**. They can be categorized into levels of the station, as follows:

- 18 train stops
- 25 small stations
- 9 medium stations
- 6 large stations

However, the station design has been categorized into 4 categories by referring to the forecasted daily ridership in 2051 or B.E. 2594 (30 years after commercial operation) and by considering the station position and its importance and the system operation plan design, as follows:

- Train stops need to serve less than 100 persons/day (estimated figures).
- Small stations need to serve less than 1,000 persons/day (estimated figures).
- Medium stations need to serve between 1,000-3,000 persons/day (estimated figures).
- Large stations need to serve more than 3,000 persons/day (estimated figures).

For Hat Yai Junction station-Songkhla station where it has been no longer operated since 1978 (2521 B.E.), the Consultants have determined the number and the position of the stations to appropriately align with the physical characteristics of the location and community. The name and location of stations are listed in **Table 5.5.1-2.**

Table 5.5.1-1 List of station name and position in Surat Thani-Hat Yai Junction

#No	Station Name (TH)	Station Name (EN)	Station Type	Platform Side	Building Development	Location
0	สุราษฎร์ธานี	Surat Thani	Large	Right	-	Tha Kham, Phunphin, Surat Thani
1	เขาหัวควาย	Khao Hua Khwai	Small	Right	Renovated	Khao Hua Khwai, Phunphin, Surat Thani
2	บ่อกรัง	Bo Krang	Stop	Right	Newly Constructed	Tha Sathon, Phunphin, Surat Thani
3	เขาพลู	Khao Phlu	Small	Right	Renovated	Tha Sathon, Phunphin, Surat Thani
4	คลองยา	Khlong Ya	Stop	Right	Newly Constructed	Na Tai, Ban Na Doem, Surat Thani
5	บ้านนา	Ban Na	Small	Left	Renovated and Newly Constructed	Ban Na, Ban Na Doem, Surat Thani
6	ห้วยมุด	Huai Mut	Small	Right	Renovated	Na San, Ban Na San, Surat Thani
7	นาสาร	Na San	Medium	Left	Newly Constructed	Na San, Ban Na San, Surat Thani
8	คลองปราบ	Khlong Prap	Stop	Right	Newly Constructed	Khlong Prap, Ban Na San, Surat Thani
9	พรุพี	Phruphi	Small	Right	Renovated	Phru Phi, Ban Na San, Surat Thani
10	คลองสูญ	Khlong Sun	Stop	Right	Newly Constructed	Phru Phi, Ban Na San, Surat Thani
11	บ้านส้อง	Ban Song	Large	Right	Renovated and Newly Constructed	Ban Song, Wiang Sa, Surat Thani
12	บ้านพรุกระแชง	Ban Phru Krachaeng	Small	Left	Newly Constructed	Ban Song, Wiang Sa, Surat Thani
13	ห้วยปริก	Huai Prik	Small	Left	Newly Constructed	Huai Prik, Chawang, Nakhon Si Thammarat
14	กระเบียด	Krabiat	Small	Right	Renovated	Krabiat, Chawang, Nakhon Si Thammarat
15	ทานพอ	Tranpho	Medium	Right	Newly Constructed	Mai Riang, Chawang, Nakhon Si Thammarat
16	ฉวาง	Chawang	Medium	Left	Newly Constructed	Chawang, Chawang, Nakhon Si Thammarat
17	คลองจันดี	Khlong Chan Di	Large	Right	Newly Constructed	Chan Di, Chawang, Nakhon Si Thammarat
18	หลักช้าง	Lak Chang	Small	Right	Renovated	Lak Chang, Chang Klang, Nakhon Si Thammarat
19	คลองกุย	Khlong Kui	Stop	Left	Newly Constructed	Chang Klang, Chang Klang, Nakhon Si Thammarat
20	นาบอน	Na Bon	Small	Left	Newly Constructed	Na Bon, Na Bon, Nakhon Si Thammarat
21	คลองจัง	Khlong Chang	Small	Left	Renovated	Na Bon, Na Bon, Nakhon Si Thammarat
22	บ้านเกาะปริง	Ban Ko Pring	Stop	Right	Newly Constructed	Nong Hong, Thung Yai, Nakhon Si Thammarat
23	ชุมทางทุ่งสง	Thung Song Junction	Large	Right	Renovated and Newly Constructed	Pak Phraek, Thung Song, Nakhon Si Thammarat
24	ใสใหญ่	Sai Yai	Small	Left	Newly Constructed	Tham Yai, Thung Song, Nakhon Si Thammarat
25	ช่องเขา	Chong Khao	Small	Left	Renovated	Tham Yai, Thung Song, Nakhon Si Thammarat
26	ร่อนพิบูลย์	Ron Phibun	Medium	Left	Renovated and Newly Constructed	Ron Phibun, Ron Phibun, Nakhon Si Thammarat
27	ชุมทางเขาชุมทอง	Khao Chum Thong Junction	Medium	Left	Renovated	Khwon Koei, Ron Phibun, Nakhon Si Thammarat
28	ควนหนองคว้า	Khuan Nong Khwa	Small	Left	Renovated	Khwon Nong Khwa, Chulabhorn, Nakhon Si Thammarat
29	บ้านตูล	Ban Tun	Small	Right	Renovated and Newly Constructed	Ban Tun, Cha-Uat, Nakhon Si Thammarat
30	บ้านทุ่งค่าย	Ban Tung Khai	Stop	Right	Newly Constructed	Cha-Uat, Cha-Uat, Nakhon Si Thammarat
31	ชะอวด	Cha-uat	Large	Right	Renovated and Newly Constructed	Cha-Uat, Cha-Uat, Nakhon Si Thammarat
32	หนองจิก	Nong Jik	Stop	Right	Newly Constructed	Nang Long, Cha-Uat, Nakhon Si Thammarat
33	บ้านนางหลง	Ban Nang Long	Small	Right	Newly Constructed	Nang Long, Cha-Uat, Nakhon Si Thammarat
34	บ้านตรอกแค	Ban Trok Kea	Stop	Right	Newly Constructed	Khon Hat, Cha-Uat, Nakhon Si Thammarat
35	บ้านขอนหาด	Ban Khon Hat	Small	Left	Newly Constructed	Khon Hat, Cha-Uat, Nakhon Si Thammarat
36	แหลมโตนด	Laem Tanot	Small	Right	Newly Constructed	Laem Tanot, Khwon Khanun, Phatthalung
37	บ้านสุนทรา	Ban Suntara	Stop	Right	Newly Constructed	Pan Tae, Khwon Khanun, Phatthalung
38	ปากคลอง	Pak Khlong	Medium	Right	Newly Constructed	Makok Nuea, Khwon Khanun, Phatthalung
39	บ้านมะกอกใต้	Ban Makok Tai	Stop	Left	Newly Constructed	Chai Buri, Mueang, Phatthalung
40	ชัยบุรี	Chai Buri	Stop	Right	Newly Constructed	Chai Buri, Mueang, Phatthalung
41	พัทลุง	Phattalung	Large	Right	Renovated and Newly Constructed	Khuha Sawan, Mueang, Phatthalung
42	นาปรือ	Na Pru	Stop	Left	Newly Constructed	Khwon Maphrao, Mueang, Phatthalung
43	บ้านค่ายไทย	Ban Khai Thai	Stop	Left	Newly Constructed	Tamnan, Mueang, Phatthalung
44	บ้านต้นโดน	Ban Ton Don	Small	Right	Newly Constructed	Khwon Khanun, Khao Chaison, Phatthalung
45	บ้านห้วยแตน	Ban Huai Tan	Stop	Left	Newly Constructed	Khwon Khanun, Khao Chaison, Phatthalung
46	เขาชัยสน	Khao Chai Son	Small	Right	Newly Constructed	Khao Chaison, Khao Chaison, Phatthalung
47	บางแก้ว	Bang Kaeo	Medium	Right	Newly Constructed	Khok Sak, Bang Kaeo, Phatthalung
48	ควนพระ	Khuan Phra	Stop	Left	Newly Constructed	Falami, Pak Phayun, Phatthalung
49	ควนเคี่ยม	Khuan Khiam	Small	Left	Renovated and Newly Constructed	Falami, Pak Phayun, Phatthalung
50	หารกง	Han Kong	Stop	Left	Newly Constructed	Falami, Pak Phayun, Phatthalung
51	หารเทา	Han Thao	Medium	Left	Newly Constructed	Han Thao, Pak Phayun, Phatthalung
52	วัดควนเผยอ	Wat Khuan Phayer	Stop	Left	Newly Constructed	Don Pradu, Pak Phayun, Phatthalung
53	โคกทราย	Khok Sai	Small	Left	Newly Constructed	Khok Sai, Pa Bon, Phatthalung
54	ควนเนียง	Khuan Niang	Medium	Left	Newly Constructed	Rattaphum, Khwon Niang, Songkhla
55	บ้านเกาะใหญ่	Ban Ko Yai	Small	Left	Newly Constructed	Bang Riang, Khwon Niang, Songkhla
56	บางกล่ำ	Bang Klam	Small	Left	Newly Constructed	Bang Klam, Bang Klam, Songkhla
57	บ้านดินลาน	Ban Din Lan	Small	Right	Renovated and Newly Constructed	Tha Chang, Bang Klam, Songkhla
58	ชุมทางหาดใหญ่	Hat Yai Junction	Large	Left	Renovated and Newly Constructed	Hat Yat, Hat Yai, Songkhla

Table 5.5.1-2 List of station name and position in Hat Yai Junction-Songkhla

No.	Station Name (TH)	Station Name (EN)	Type	Platform Side	Location
1	คลองแห	Khlong Hae	Elevated		Hat Yai, Hat Yai, Songkhla
2	บ้านเกาะหมี	Ban Ko Mi	Elevated		Kho Hong, Hat Yai, Songkhla
3	ทุ่งใหญ่	Tung Yai	Elevated		Tung Yai, Hat Yai, Songkhla
4	ตลาดพะวง	Talat Pha Wong	At-grade	Right	Phawong, Mueang, Songkhla
5	น้ำกระจาย	Nam Kra Chai	At-grade	Left	Phawong, Mueang, Songkhla
6	เขารูปช้าง	Khao Rup Chang	Elevated		Khao Rup Chang, Mueang, Songkhla
7	สงขลา	Songkhla	Elevated		Bo Yang, Mueang, Songkhla

5.5.2 Design Concept, Standards and Criteria

1) Major Rules for the design

The major criteria for station design are as follows:

- **Station type**
  - The stations in Surat Thani-Hat Yai Junction are at-grade stations.
  - The stations in Hat Yai Junction station-Songkhla station are 2 at-grade stations and 5 elevated stations.
- **The distance between the center line of railway track**
  - Rail's center line at Surat Thani-Hat Yat Junction, the double track shall be placed 6 meters away from each other.
  - Rail's center line at Hat Yat Junction-Songkhla station, the double track shall be placed 5 meters away from each other.
- **Size and height of the platform**
  - For train stops and small station, the size is 6.00x210 meter (length x width) with the minimum width of 3.00 meter for train stopping.
  - For medium station, the size is 6.00-7.40x500 meter (length x width).
  - The height of the platform from the rail head is 1.10 meter. This was designed to support elderly and disabled passenger for new fleet trains in the future since the floors of the train and platform shall be at the same level.

2) Design concept for architectural station building and other buildings

- It shall be a universal design.
- It shall be designed in such a way that users can easily understand and utilize the area, with the procedure for accessing the area thoroughly.
- It shall have a unique architectural pattern, blending the Local identities into such building so that the users can feel the locality

3) Design Criteria and Standards

- The Building Control Act 2522 B.E. (1979) with related ministerial regulations.

- Ministerial Regulations on the requirement in providing the facilities, equipment or any form of services in building, vehicles and transportation services for disabled people to access and utilize the building, 2556 B.E. (2013), by Empowerment of Persons with Disabilities Act.
- Design criteria for international standard facilities: Universal Design Code of Practice, by Institute of Siamese Architect, The Association of Siamese Architects under the Royal Patronage of His Majesty the King
- International Standard and Reference Standard abroad
  - NFPA 130: Standard for Fixed Guide way Transit and Passenger Rail System and
  - NFPA 101: Life Safety Code
- City Planning requirement according to the station location
- Other related standards such as Structural Gauge Standard, Platform Layout, Train Operation Management, etc.

5.5.3 Architecture of Station Building and other buildings

1) Station Building

Most of the station buildings on Surat Thani – Hat Yai Junction route are currently old and decadent even though some are in good condition. Accordingly, the design work for this section was to either renovate or newly construct the station building. For Hat Yai – Songkhla section, all the stations were designed with all new construction.

For the building with new construction, it is designed to facilitate and serve the passenger, officer operation, station building and platform. The size of the station building can be divided into 3 sizes which are the small, medium and large station building, based upon the forecasted demand which need to prepare the spacing as Passenger area, Operational zone, and Platform area.

2) Other Buildings

As the majority of the stations with existing buildings, the buildings have been designed to additionally fulfill the needs in that particular station, which can be categorized into the following

- Passenger service building includes 3-size public restroom according to the station design, commercial area for restaurants, shops, book stores, etc. This area is separated from the station building but with connecting path to one another to facilitate and manage and future expansion of station building.
- System operation building includes engine system building which consists of relay room, battery room and generator room
- Office building for civil works and maintenance, communication work, other system works is designed accordingly to serve the needs of such station.
- Officer accommodations are divided into detached house, attached houses, town house and flat. This has been considered properly to serve the needs and in proportional to the man power in that station
- Maintenance depot building

3) Architectural Pattern

- Applying the uniqueness of the train station building which is Thailand's architecture heritage color (ripe areca color).
- Using the southern location and land uniqueness which align with its environment and climates.
- Value creation to station building and location, via the unique architecture of the station building for local people to be proud in their origins, as well as reducing the conflicts in the applied architecture, as shown in **Figure 5.5.3-1**.

The tipical architectrual pattern of new train stations and stops designed is shown in **Figure 5.5.3-2**, and the architectural patterns for Hat Yai station and Songkhla station are shown in **Figure 5.5.3-3** and **5.5.3-4**, respectively.

Figure 5.5.3-1 Existing station building in Surat Thani – Hat Yai section and local architecture

(a) Train stop

(b) Small station

(c) Medium station

(d) Large station

(e) Elevated station (Hat Yai - Songkhla)

Figure 5.5.3-2 Typical architecture of station buildings

Figure 5.5.3-3 Architectural pattern of Hat Yai station building

Figure 5.5.3-4 Architectural pattern of Songkhla station

5.5.4 Layout of Station Yard and Building

The Consultants have completed the study and analysis on the station layout. The study was done based upon the considerations, such as the alignment between traffic system and train operation, facilities and infrastructures, comply with the environmental act and the existing and future development of the station. The study was also considered the land utilization and the station development to serve nearby communities, as well as to develop the transportation network. The loayouts for position of station building, platforms and other buildings are examplified as shown in **Figures 5.5.4-1 to 5.5.4-4.**

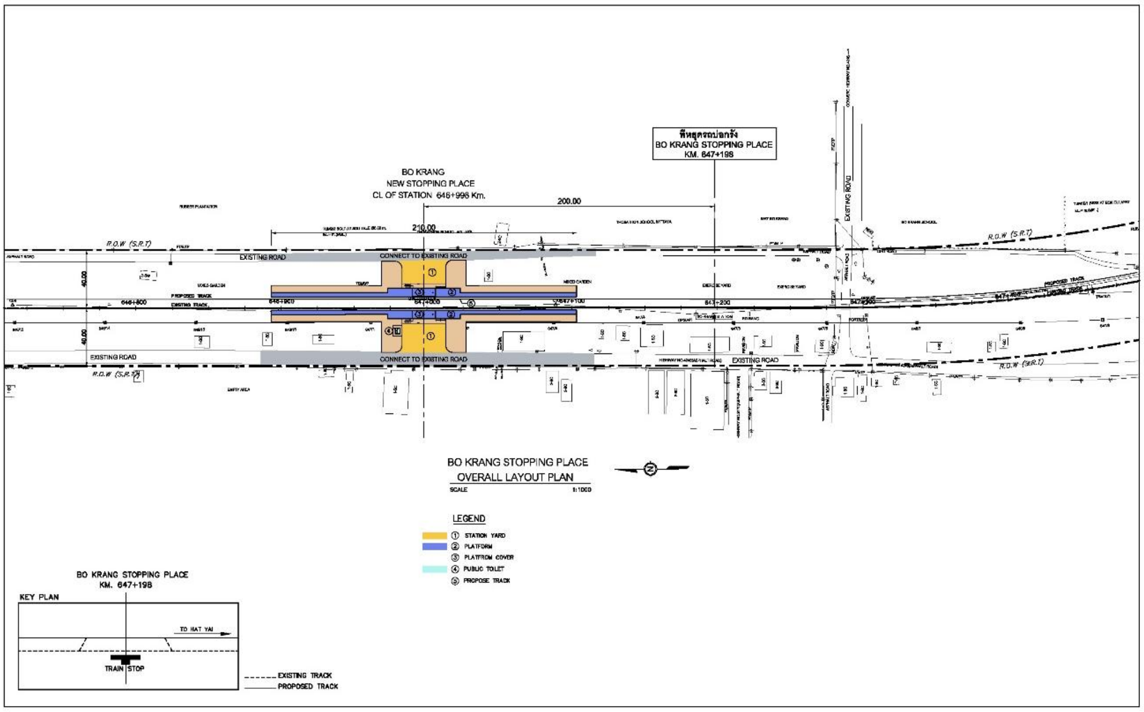


Figure 5.5.4-1 Sample of train stop layout – Bor Krang

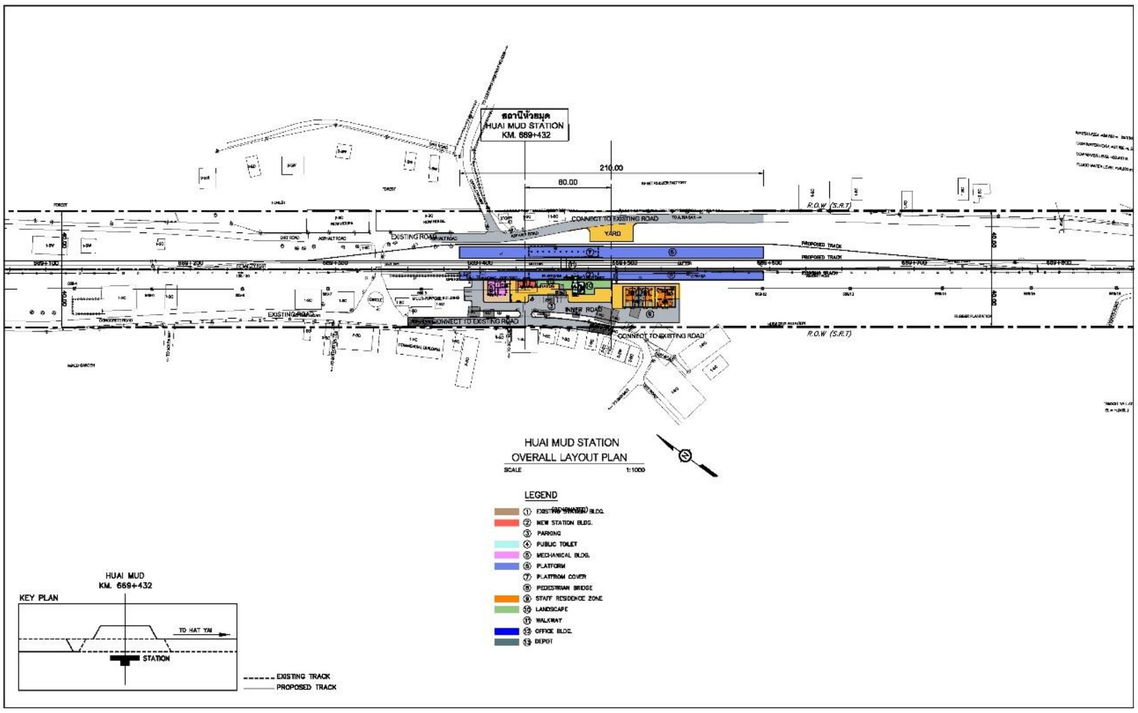


Figure 5.5.4-2 Sample of small station layout – Huay Mut

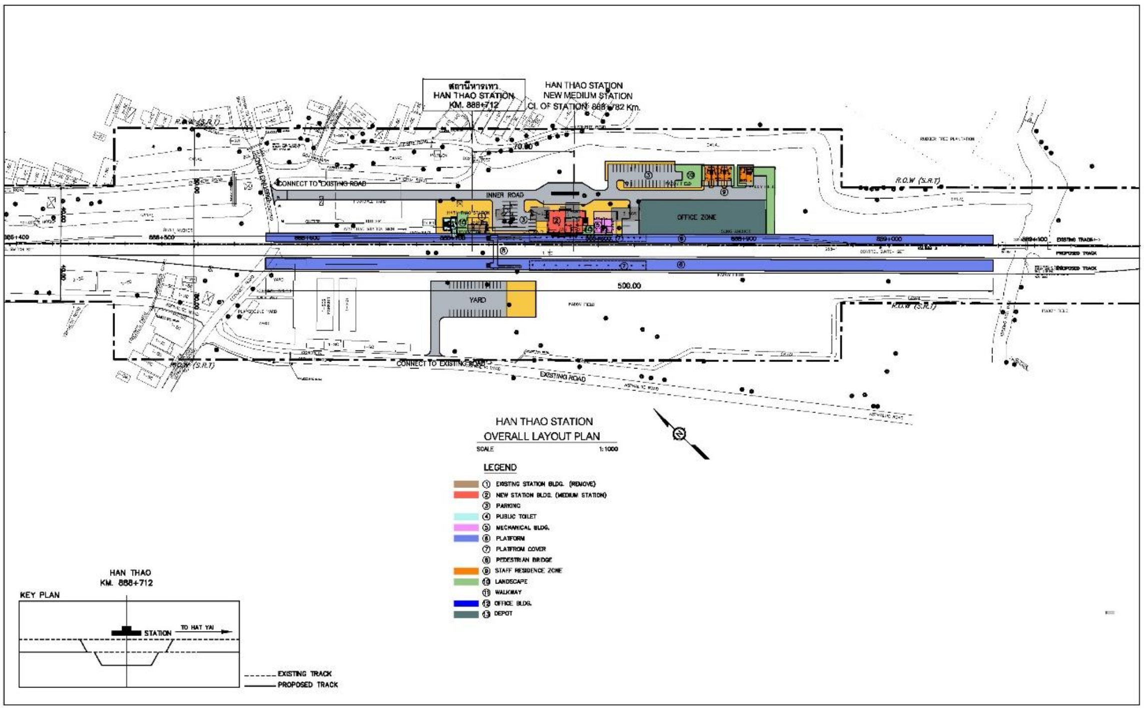


Figure 5.5.4-3 Sample of medium station layout – Han Thao

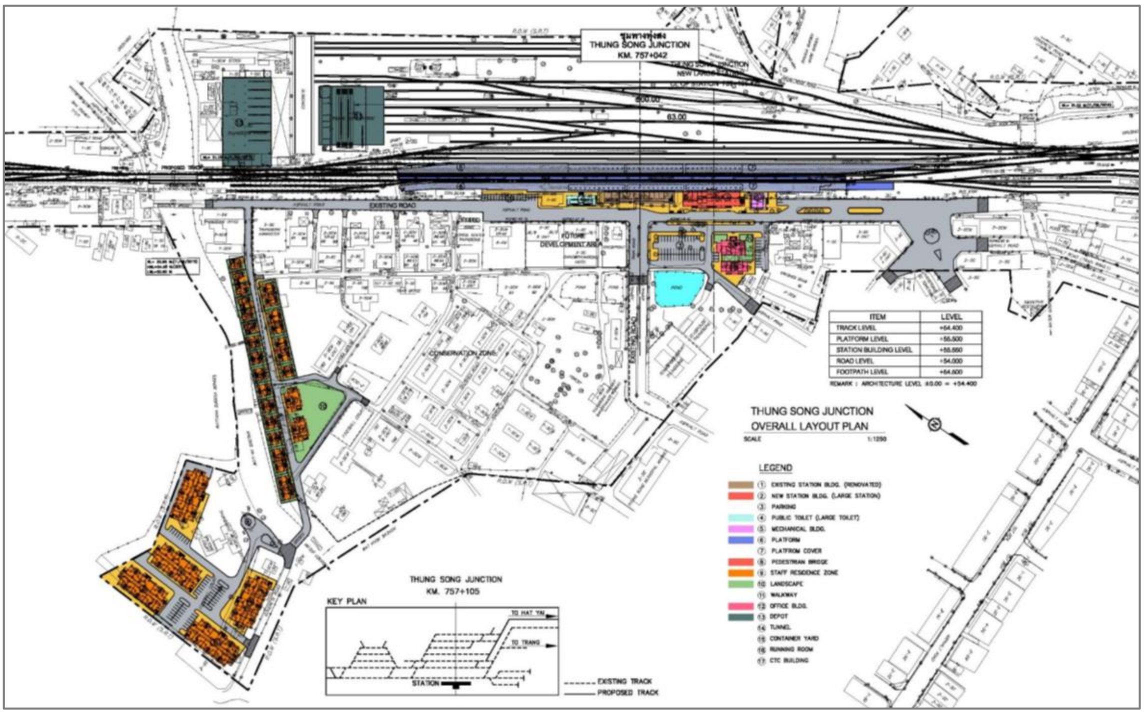


Figure 5.5.4-4 Sample of large station layout – Thung Song

5.5.5 Recommendation for area development to promote SRT's activities

From the study and survey, there are six potential station areas which can be commercially utilized, namely, Ban Na, Na Sarn, Cha-Uoad, Bang Kaew, Hat Yai, and Songkhla in each of which the layout are presented in **Figures 5.5.5-1** to **5.5.5-6**.

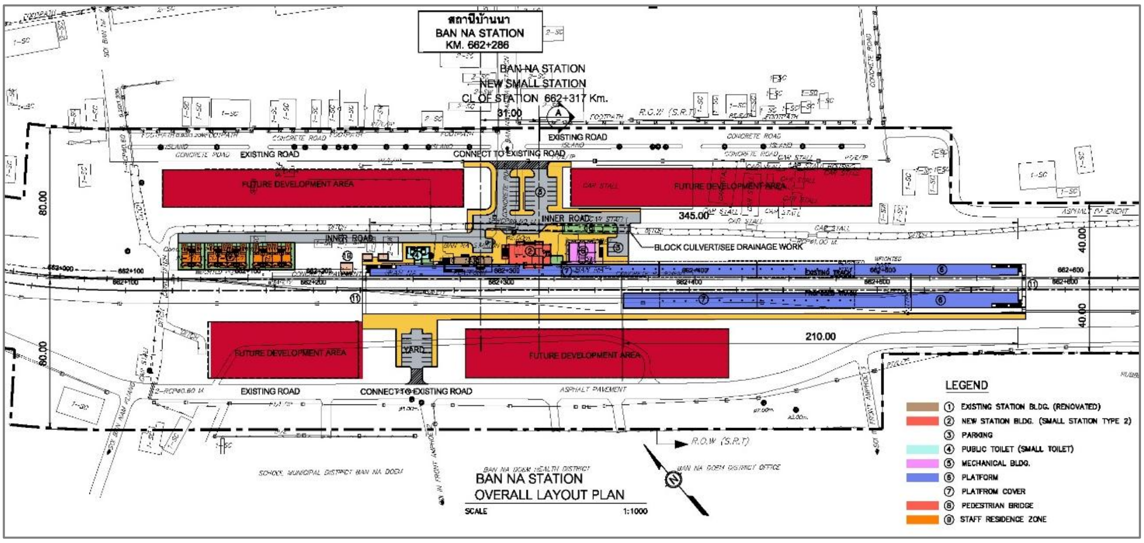


Figure 5.5.5-2 Ban Na station layout showing future development area

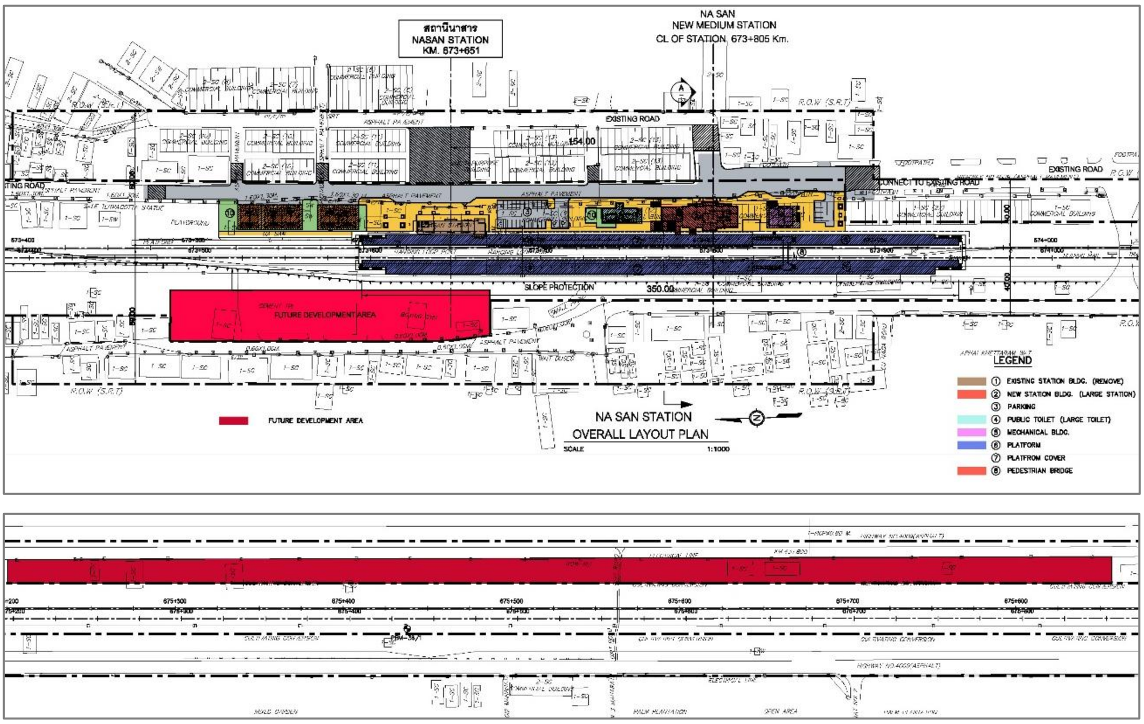


Figure 5.5.5-4 Na Sarn station layout showingr future development area

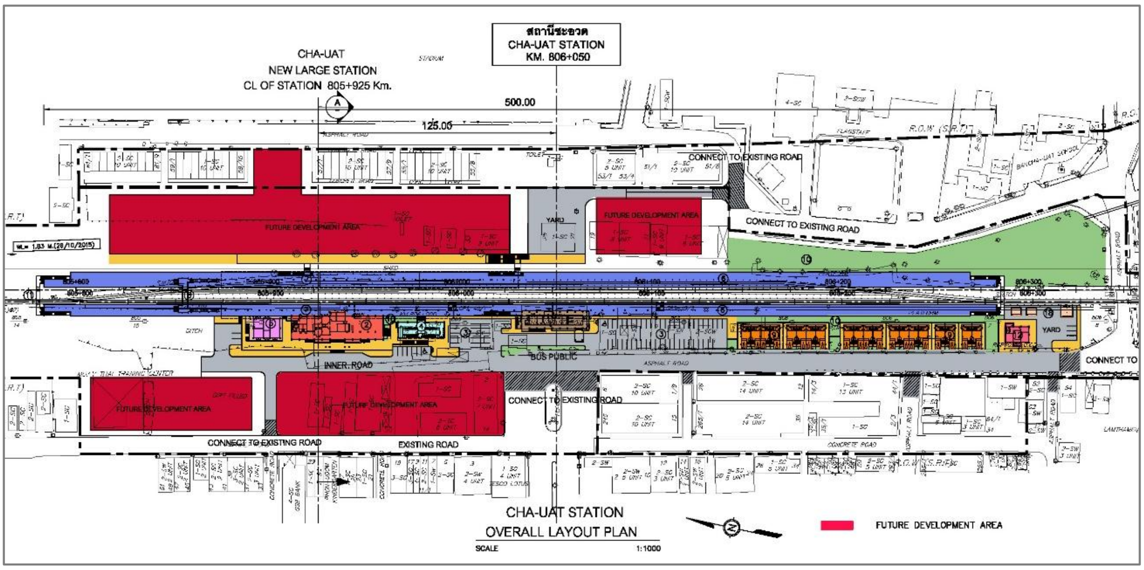


Figure 5.5.5-6 Cha-Uoad layout showing future development area

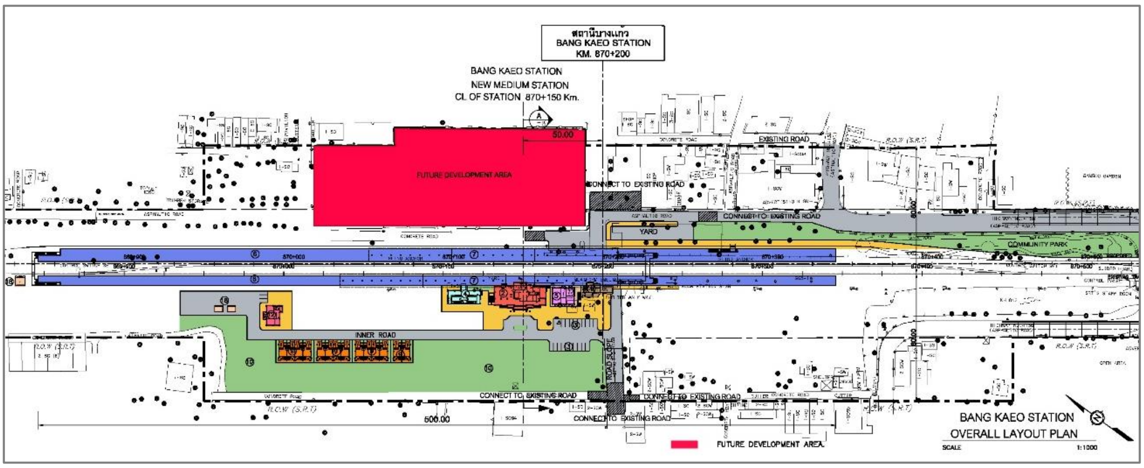


Figure 5.5.5-8 Bang Kaew station layout showing future development area

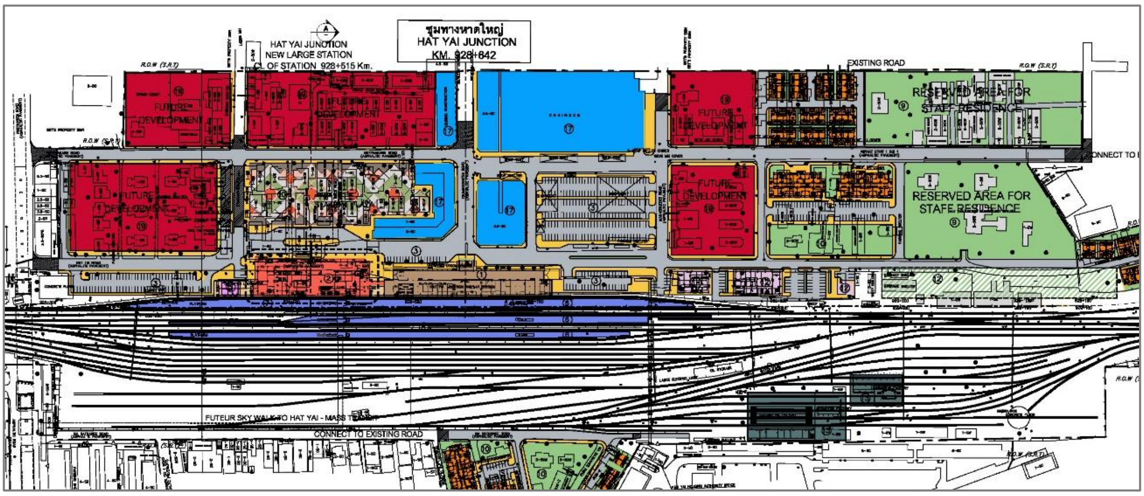


Figure 5.5.5-10 Hat Yai station layout showing future development area

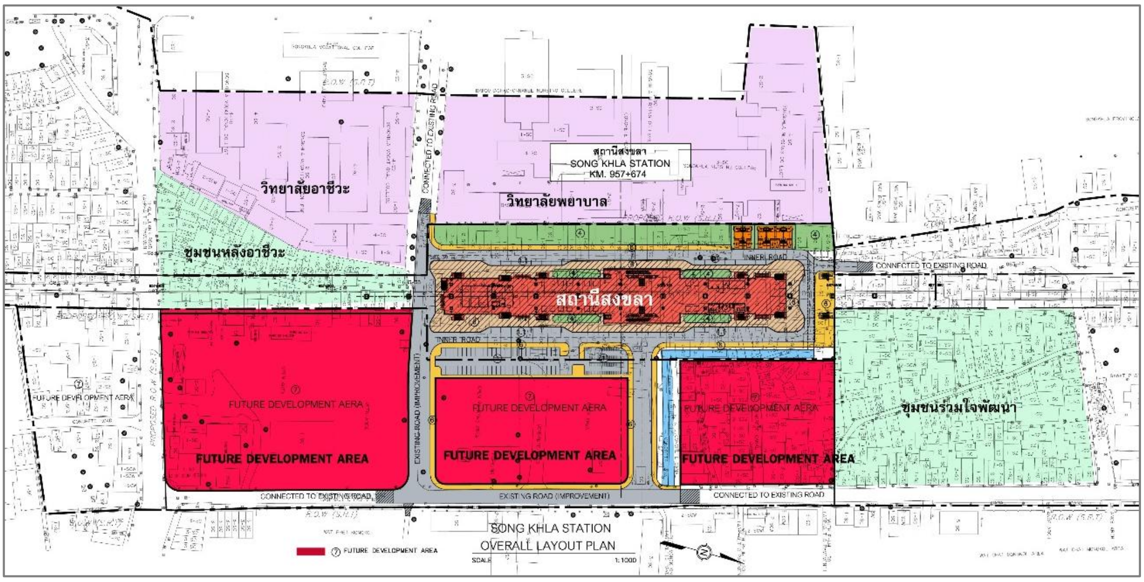


Figure 5.5.5-12 Songkhla station layout showing future development area

5.5.6 Road and Station Access

After the field survey at entrances/exits of 58 stations along the Surat Thani-Hat Yai and 7 stations along Hat Yai- Songkhla, it was found that some stations or areas are needed to be revamped on the road network which connects to the station, so that it can appropriately be utilized to serve more traffic loads as forecasted in **Figure 5.5.6-1**

Figure 5.5.6-1 Example of the entrance and exit condition of train stop to be revamped.

The Consultants have considered the feasibility study and the related infrastructure design to serve the interconnection service between rail system and the roads. The design for access roads from the station entrance and exit to the main route has considered the major components as follows;

- The design for road condition improvement in the station according to the international standard shall consider number of parameters such user comforts, driving safety, preparation for parking lots and its access, location for the station or previous dwelling platform, and necessary location where the new station is located.
- The design for the interconnection improvement at the station entrance and exit shall consider the existing road network, the type of main route link to the station, the traffic loading so that it is safe to enter / exit the station, as well as not impacting to the main route traffics.
- The design and installation of road marking and signs. This shall consider the installation location at the dangerous zone such as at curve and intersection. This has to be done so that the traffic is flown safely with comforts, as well as directing the users to their destination in an effective way
- The design for the electrical system and drainage system of the road network at the station is to serve the users and prevent the flooding issues in the station and nearby areas.

5.5.7 External Water Supply System

The design of External Water Supply System was to place the water supply system for the buildings at the station and maintenance depot area. The water pipe network system shall be connected to the system by Provincial Waterworks Authority, before distributing to the water storage tank of the buildings. For the remote area or the area without any water system, the ground water pumping system shall be installed with water storage tower tank in order to supply water to the building. However, it mainly depends on the readiness of the utilities system in such area. At large stations, water taps were provided along the platform in order to be used for filling to storage tank on the train.

(1) Design Codes and Regulations

- Regulations issued under the Building Control Act
- Standard Design Engineering Institute of Thailand
- Thai Industrial Standard
- Provincial Waterworks Authority Standard
- British Standard (BS)
- National Plumbing Code (NPC)
- American Society of Testing Materials (ASTM)
- American National Standard Institute (ANSI)
- American Water Works Association (AWWA)

(2) Design Criteria

Water supply at the station and maintenance depot area is divided into 2 scenarios as follows;

- For the area with a Provincial Waterworks System nearby, it shall receive water from Provincial Waterworks Authority by connecting from the main water supply pipe through water metering in the area to water storage tank of the building. The water supply distribution system was designed as underground water piping system using HDPE to prevent the problem from ground settlement.
- For the remote area without Provincial Waterworks system, the underground water drilling rigs shall be installed at the nearby area to pump the underground water and store at the raw water storage tank in order to improve the water quality through softener process to qualify with the Provincial Waterworks Authority Standard before pumping into tower tank and supply to the building via gravity flow. The water supply distribution system was designed as underground water piping system using HDPE to prevent the problem from ground settlement.

5.5.8 Power Supply System

The design of power system for utilities at stations and railway crossing shall include high and low voltage power systems, landscape lighting system. The design standard used was referred on Building Control Act, Design Standard by Engineering Institute of Thailand, International Standard and other related standards.

The conceptual design of power system for utilities emphasized on safety, engineering, reliability, energy saving, flexibility for future expansion, as well as ease of operation and maintenance. The scope of work and design standard are shown as follows:

Scope of Work

(1) High voltage power distribution system
(2) Low voltage power distribution system
(3) Landscape lighting system in station yard
(4) Street lighting system at railway crossing

Design reference standard

(1) Standard for electrical and communication installation and design:

(a) Engineering Institute of Thailand

- Electrical Installation for Thailand, 2545 B.E. (2001-56)
- Lightning protection standards for buildings (2007-53)

(b) Provincial Electricity Authority (PEA)

(2) Materials and electrical equipment Standard

(a) Thai Industrial Standard

(b) International Electrotechnical Commission (IEC)

(3) Parameters for specification and calculation

(a) Maximum outside temperature at 40°C and the annual average temperature at 36°C

(b) Utilization System

- Medium Voltage: 33kV, 3 phases, 3 lines, 50 Hz.
  19kV, 1 phase, 1 line, 50 Hz.
- Low Voltage: 230/400V, 3 phases, 4 lines, 50 Hz.

(c) Voltage Drop

- Power feeders: less than 2 %
- Branch circuits: less than 3 %
- Main service line to load: less than 5%

(d) Power factor of the system is not less than 0.9.

(e) Resistance to ground is not more than 5 Ohms.

(f) Luminance on corridor:

- General corridor: 1-5 Lux
- More crowded corridor: 10-20 Lux
- Most crowded corridor: 30-50 Lux

(g) Luminance on roadway:

By referring to the standards from the Department of Highways and Illuminating Engineering Society (IES)

5.6 Container Yard

From the prediction of freight and cargo, the location for container yards shall be at Thung Song Junction and Bang Klum station. The container yard at Thung Song is currently during construction under the responsibility of the Office of Public Works and Town & Country Planning at Nakhon Si Thammarat and Thung Song Municipality. Covering the area of 85.43 rai of the land leased from SRT, the project is located near Muat Sila between Tambon Pak Phraek and Tambon Cha Mai and planned to be a distribution center of Southern Region-Thung Song. With the construction cost of 832 million Baht, the project is expected to complete in 2560 B.E. (2017).

Figure 5.6-1 Distribution Center of Southern Region-Thung Song

At Bang Klum station, the area in the station yard on the right side of the railway track was designed to be used for container yard with the approximate total area of 12.25 Rai, as shown in **Figure 5.6-2**.

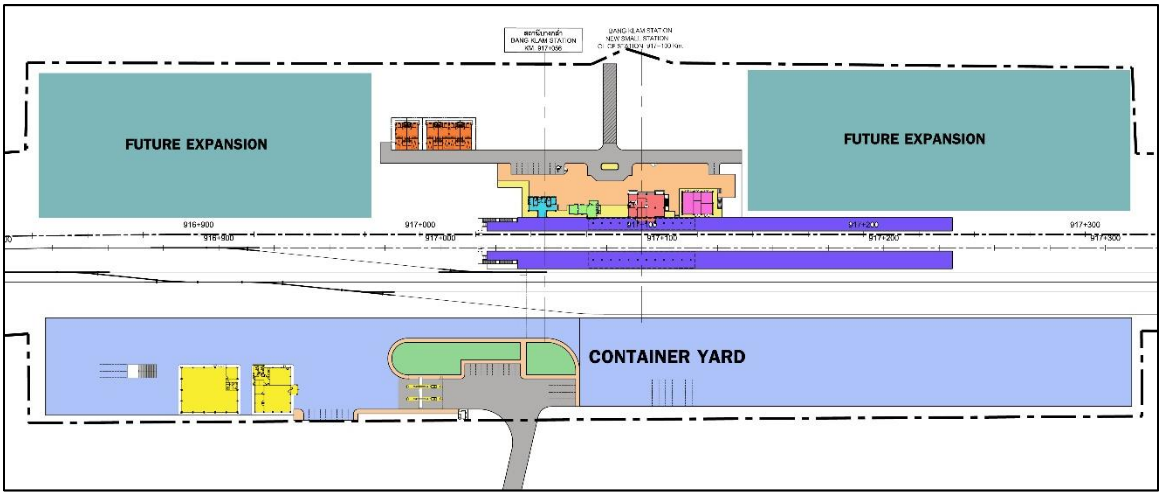


Figure 5.6-2 Site Layout Container Yard at Bang Klum Station

5.7 Building Structure and Service System

5.7.1 Station Structure Design

Main structures of buildings and structures in the project are cast-in-situ reinforced concrete. Precast reinforced concrete and structure steel are used for some structures. The structural system consists of the following components:

1) Foundations are cast-in-situ reinforced concrete. The type of foundation is designed based on the result of soil investigation in the area. Two (2) types of foundations are considered:
   - Shallow foundations for the area where allowable soil bearing capacity is not less than 20 tons per square meter
   - Piled foundation, if the allowable soil bearing capacity is less than 20 tons per square meter.

   Piled foundation may be either driven pile or bored pile. Driven pile is recommended first if pile driving operation does not have impact on the surrounding. Otherwise bored pile will be used for piled foundation.
2) Beams are cast in situ reinforced concrete structure, except Elevated Station (Platform floor) where I-Girder is used. Box Girder is used for Pedestrian Bridge.
3) Slabs are both cast-in-situ reinforced concrete and precast reinforced concrete structure, depending on the application.
4) Staircases are cast in situ reinforced concrete or steel structures.
5) Roof is a steel structure, the purpose is to provide lightweight and facilitating construction work.

5.7.1.1 Design Standard and Regulation

The following Codes and Standards are used in the design of building structural work.

- Building Control Act BE 2522 and the Ministerial Regulation issued under this Act.
- The Standard of the Engineering Institute of Thailand. (EIT)
- Department of Public Works and Town Planning Standards (Mor Yor Por).
- American Concrete Institute (ACI)
- American Institute of Steel Construction (AISC)
- Prestressed Concrete Institute (PCI)
- Post – Tensioning Institute (PTI)

5.7.1.2 General Materials

Structural materials shall meet the requirements of applicable Thai Industrial Standards (TIS). If there is no TIS standards for any materials, ASTM Standard shall be used.

5.7.1.3 Design Load

Follow ASTM Grade A185 E70

1) Dead Load: Dead load shall be the weight of materials forming structural members, such as slab beam, column, footing and include other internal loads in the building.

2) Live Loads: Live load shall be in accordance with Ministerial Regulation No.6 issued under Building Control Act BE 2522.

3) Wind load: Wind load used in the design is in accordance with Ministerial Regulation No.6 issued under Building Control Act BE 2522. or using the Standard for calculation of Wind Resistance and Building Response Standards (Mor Yor Por 1311-50).

4) Earthquake load: The structure is designed to withstand earthquakes, according to The Ministerial Regulation, resistance and durability of the building and foundation for seismic vibrations (2550), Building Design Standard, Seismic Resistance Mor Yor Por 1301-54 and Building Design Standard, Seismic Resistance Mor Yor Por 1302-52.

   Calculated by the equivalent static wind load method follow Building Design Standard, Seismic Resistance Mor Yor Por 1302-52.

5) Surcharge Live Load

For road	1.0	ton / sq.m.
For railroad	5.0	ton / sq.m.

5.7.1.4 The design of reinforced concrete structure

The design calculation uses Ultimate Strength Design method in accordance with Ministerial Regulation No.6 issued under Building Control Act BE 2522 and American Concrete Institute, "Building Code Requirement for Reinforced Concrete" (ACI 318-14)

According to Ministerial Regulation BE 2550, the maximum stress caused by earthquake or the effects of wind loads on structural components, whichever is higher shall be used in the calculation.

5.7.1.5 The design of steel structure

Design by Allowable Stress Design in accordance with American Institute of Steel Construction "Manual of Steel Construction" (AISC 1989)

According to Ministerial Regulation BE 2550, the maximum stress caused by earthquake or the effects of wind loads on structural components, whichever is higher shall be used in the calculation.

5.7.2 Building Services

Building services comprise 2 major systems, namely electrical system and mechanical system.

5.7.2.1 Building Electrical System

Building electrical system comprises 8 subsystems as follows:

1) Lighting and Power System
2) Lightning Protection system
3) Telephone system
4) Structure Cabling system
5) Fire Detection and Alarm system
6) Public Address system
7) Closed Circuit Television system
8) Access Control system

Design Standard and Specification

The design of building electrical system including materials and installation standards are in accordance with the following codes and standards.

- Building Control Act BE 2522 and the Ministerial Regulation issued under this Act.
- Energy Conservation Act.
- Building Design Standard, Department of Public Works and Town & Country Planning
- Thai Industrial Standard
- The Engineering Institute of Thailand
- National Fire Protection Association (NFPA)
- International Electro technical Commission (IEC)

Following is design description of electrical subsystems

1. **Lighting and Power System**

   1) Wiring in new buildings shall be in conduits, concealed in ceiling and walls. Wiring in renovated existing building is to be in conduits, concealed in ceiling but exposed on walls.

   2) Building electrical system is 230/400V, 3 Ø, 4 W or 230V, 1 Ø, 2 W, depending on rating and type of loads to be supplied.

   3) Lighting illumination used in the design is based on the value specified in Ministerial Regulation issued by the Ministry of Labor in Standard for Administration and Management of Safety, Health, Environment in the Work place on Heat, Light and Sound BE 2549.

   4) LED tubes will be used in luminaires replacing fluorescent lamps.

   5) Non-current carrying metal part of equipment shall be grounded.

2. **Lightning Protection system:** Lightning Protection System comprises 2 systems, i.e., 1) protection against direct lightning strike to building structure, and 2) protection of electrical/electronic equipment in building from voltage surge caused by lightning occurring in the nearby area. Lightning protection system for each type is as follows:

   1) Lightning protection system for building is a conventional system, designed in accordance with EIT Standards, NFPA 780, IEC 62305 which based on the same approach. This system will be provided to protect all Stations, regardless of sizes.

   2) Protection against damage to electrical/electronic equipment from voltage surge is by installing Surge Protective Device (SPD) at the incoming feeder of each building at Main Distribution Board or Panelboard.

3. **Telephone and Structured Cabling System (LAN Wiring):** The telephone system in the project is Voice over Internet Protocol (VoIP) Telephone System and Structured Cabling System (LAN Wiring System) use the same type wiring system. A twin outlet, 1 telephone + 1 LAN, will be provided at each location.

4. **Fire Detection and Alarm System:** Fire Protection System is a convention, multi-zone, supervised, pre-signal system. System wiring for smoke detector/heat detector/manual station circuit

shall be copper conductor, PVC insulated, installed in IMC conduits. Wiring for alarm bell, strobe light circuit shall be fire resistant cable (FRC)

5. **Public Address System:** Public Address System is provided only for all stations to announce information to passengers in the stations, platforms and the toilet nearby.

6. **Closed Circuit Television System:** CCTV will be provided for all Stations (all sizes).

7. **Access Control System:** Access Control System is provided in the building where there is an area in the building assigned as "Controlled Area". The Access Control System is provided at the access door to the controlled area. The system will be integrated with CCTV System.

5.7.2.2 Building Mechanical System

The mechanical system comprises 4 subsystems as follows:

1) Air Conditioning System
2) Ventilation System
3) Plumbing and Sanitary System
4) Fire Protection System

<u>**Design Standards and Specification**</u>

The design of building mechanical system including materials and installation standards are in accordance with the following codes and standards.

- Building Control Act BE 2522 and related regulations.
- Energy Conservation Act.
- Thai Industrial Standards (TIS).
- Engineering Institute of Thailand.
- American Society of Heating, Refrigerating and Air Conditioning Engineers. (ASHRAE)
- Air-conditioning, Heating and Refrigeration Institute. (AHRI)
- Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA)
- National Fire Protection Association (NFPA)
- Department of Public Works and Town & Country Planning
- The Engineering Institute of Thailand.
- Standard of Provincial Waterworks Authority
- Factory Mutual. (FM)

1. Air Conditioning and Ventilation Systems

1) Design Conditions:
   - Outdoor temperature : 36.1°Cdb, 28.1°Cwb
   - Indoor Condition: 24±2°Cdb, <65% RH
2) Air Cooled Central Type -Variable Refrigerant Flow (VRF) System will be used for air conditioning in large building.
3) Air Cooled Split Type System will be used for air conditioning for medium and small size buildings.
4) Signaling and Relay Room requires air conditioning continuously. The room will be provided with a redundancy air conditioning system which consists of two (2) sets of air conditioning unit (1 duty / 1 stand by) for each room.

5) Circulating fans are provided to generate air movement in the area where natural ventilation has been provided in the architectural design. Such areas are Waiting Area in the stations and Toilet Buildings.
6) The Ventilation Rate per ASHRAE Standard 62.1-2007 Indoor Air Quality (IAQ) shall not be less than the rate specified in the Building Control Act.

2. Plumbing and Sanitary Systems

1) Design Rates
   - <u>Water Demand</u>
     Passenger: 30 liters/person/day
     RST Staff: 60 liters/person/day
     Canteen: 10 liters/person/time
   - <u>Wastewater Rate</u>
     Wastewater rate: use 80% of water supply rate
   - <u>Rainfall Density</u>
     Designed Rainfall Density: 150 mm./ hr.
2) Each station will be provided with 2 days water storage tank. Water booster pump, constant pressure type, will supply water to points of use..
3) For large buildings a package booster pump set with 2 pumps and 1 pressure tank will be provided.
4) For small building or building with a few points of use, provide a package booster pump set controlled by pressure switch with pressure tank.
5) Minimum design pressure at each fixture or point of use is 1 bar.
6) Wastewater from building will be directed into a wastewater treatment tank before discharging into public sewer. Wastewater treatment package is provided for each building. The system shall be aerobic treatment system.

3. Fire Protection System: 3 types of Fire Protection System are provided:

1) Portable fire extinguishers: Fire extinguishers will be installed at easy-access locations. Dry chemical extinguisher type shall be used for general area. Carbon Di-oxide type shall be used for electrical room and machine room
2) Clean Agent Fire Extinguishing System is provided for the following rooms:
   - Signaling Console Room in Station Building
   - Telecom. & Signaling Room in Elevated Station Type B
   - Control Room & CTS Room in LACC Building
3) Dry Stand Pipe system and smoke exhaust system will be provided for Staff House Type 4 and New Hatyai Junction Building.

5.8 Drainage System

5.8.1 Survey and Inspection of Catchment Area (Canal, River, Reservoir)

The Consultants have surveyed waterway intersections to inspect the natural discharge condition, reservoir, irrigation canal, marsh, flooded area along the project route from end to end. The survey is done to collect physical information such as hydraulic dimension, flow condition and direction, existing drainage building design (if any) and erosion condition. The related information for the drainage system design was also collected such as rainfall in the project area, the physical characteristic of the discharge, current condition of hydraulic structure, the flow condition, 1:50,000 map which shows its contour, watershed divide, natural discharge, irrigation canal, reservoirs, and the current aerial images. This was prepared and analyzed accordance to hydrology and hydraulic principal to design and modify the appropriate opening channel for the drainage building to serve the discharge in this project.

With the data from field survey and from 1:50,000 geographical map, L7018 from Royal Thai Survey Department, the boundary of each catchment area at waterway intersections was determined for calculating the maximum runoff through the project area via hydrologic study, as well as to design the drainage structure via hydraulic study. The total number of 376 intersections or catchment areas were found as shown in **Figure 5.8.1-1**.

5.8.2 Hydrologic Study

Hydrologic study was performed to determine maiximum discharge for the design of sufficient opening space of drainage structures which is appropriate and compliance with SRT's standard.

The meteorological and hydrological data, such as historical rainfall and runoff, which were monitored by government agencies, such as Meteorological Department, Royal Irrigation Department, Marine Department, were complied. Data which have been collected from every 15 minutes to 24 hours for more than 10 years were used to determine the relationship among rainfall intensity, duration, and frequency by plotting Intensity-Duration-Frequency Curve or IDF curve.

From the information obtained from IDF curve, together with data on topographic condition, the boundary and size of water catchment, the maximum discharge was estimated based on the criteria as shown below:

1) When the watershed area is less than 25 sq.km, the rational formula has been applied.
2) When the watershed area is more than 25 sq.km, the Snyder's unit hydrograph method has been applied.

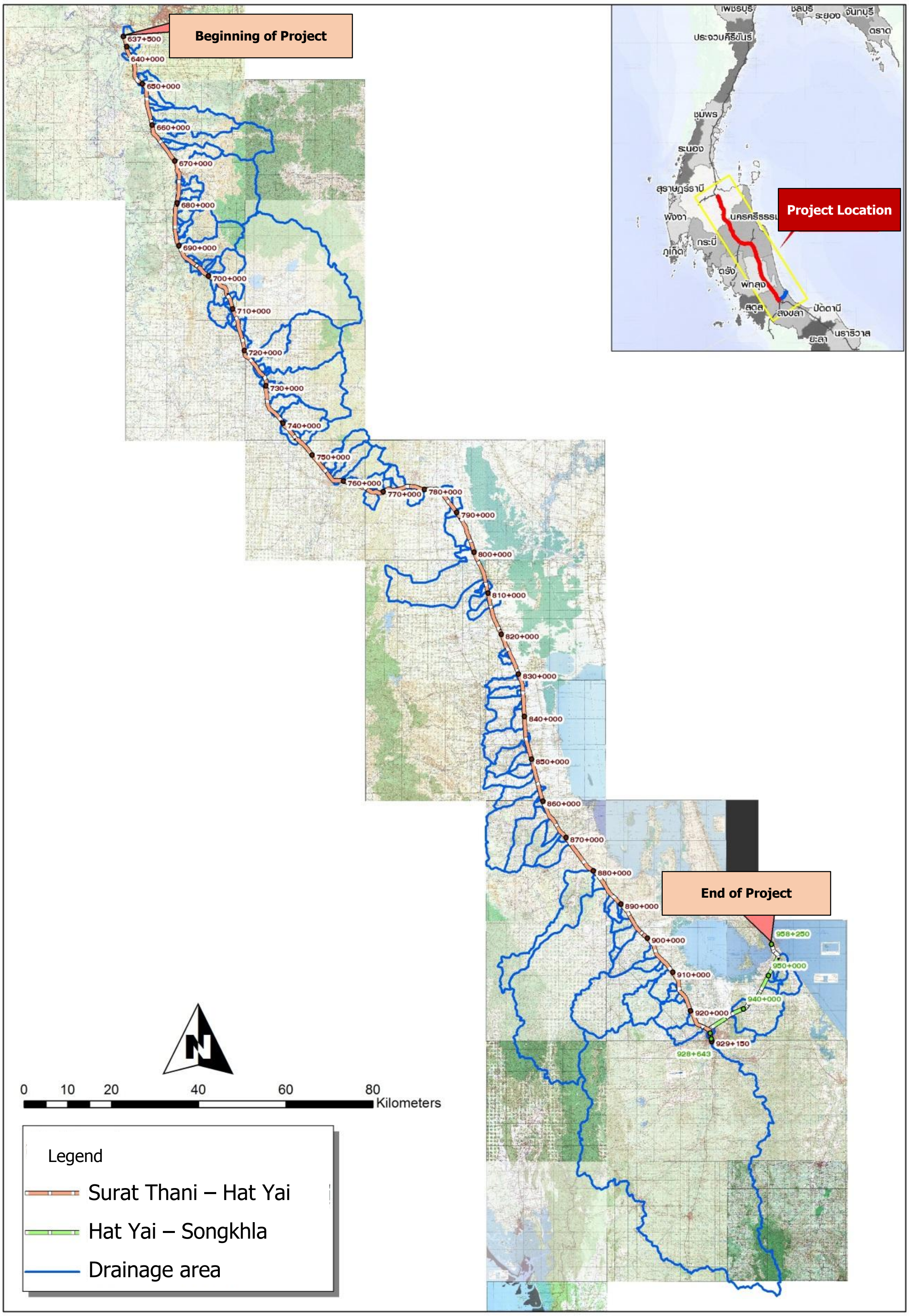


Figure 5.8.1-1 Watershed drainage area of the watercourse intersection along the project route

5.8.3 Hydraulic Study

The hydraulic study work is the analysis on the natural discharge characteristics via the drainage structure. Such characteristic is an open channel by the gravity flow, therefore the discharge analysis is based upon the fundamental concept of the uniform discharge continuity equation. The hydraulic study was conducted after the hydrology study. After obtaining the maximum discharge, the hydraulic design and inspection was made in order to calculate the suitable size of drainage structure.

The analysis is to calculate the size of the orifice of the drainage building which is sufficient and suitable for the drainage discharge. The drainage structure is the hydraulic structure in the form of bridge, culvert, intake channel or the drainage at both side of the railway to discharge into public drainage system which consider from the following components:

- The requirement for Horizontal & Vertical Clearance
- Geographical condition of the watercourse and obstacles
- The width of the orifice for watercourse crossing bridge must be sufficient for the discharge and suitable to the area along the watercourse

Typical requirements are:

- The drainage is the rainfall from the railway surface, the water from the watershed passing along the railway.
- The rainfall from the railway surface will be discharged along the railway alignment to the existing drainage or the newly built one.

The selection of drainage structure type was made between the circular and rectangular concrete box on which the rail is placed. At the deck of the box, the earthfill, stone embankment or ballast may be placed on. In case of large opening, the river crossing bridge was considered. The number of openings depends on the volume, width, depth of drained water and also the water traffic and other flow obstruction. The configuration of drainage structure was designed based on the standard by the State Railway of Thailand.

From the maximum discharge obtained from hydrological study, Manning's Equation was applied for determining the suitable size of drainage building along the route in order to serve an open channel flow by gravity flow. The safety level can be examined by adopting the safety factor of 1.5, as follows:

$$\frac{A_d}{A_{rq}} \geq 1.5$$

where A_d = Designed cross-sectional area of drainage structure (sq.m)

A_{rq} = Required cross-sectional area of drainage structure (sq.m)

5.8.4 Design Criteria, Standard and Requirement

In addition to the hydraulic study for determining appropriate opening of drainage structures sufficient for maximum rainfall, additional criteria and requirements were adopted, as follows:

1) Design Criteria for Drainage Channel

- The design flooded level which determines the height of an embankment or the ground level in the project area. It can be determined from the maximum discharge level that caused by the repetitive annual maximum rainfall from the past 50 years

- Minimum and maximum discharge velocity are 0.6 m/s and 3.5 meter/second, respectively.
- The drainage level is not less than 0.6 meter from the ground level.
- For the train drainage system which consists of circular concrete pipe, steel-reinforced box culvert and the bridge. The selction of size and type of drainage building depends on the discharge rate, geography and its position that does not block other traffic route alignment. The criteria of drainage building is as follows:

Steel-reinforced circular concrete pipe:	Not less than 0.8 m in diameter, not more than 5 rows at each location.
Steel-reinforced box culvert :	1.2 x 1.2 m to 3.6 x 3.6 m in size, not more than 4 rows at each location.
Concrete bridge :	Based on the standard, there are two types of concrete bridges, steel-reinforced concrete bridge and pre-stressed concrete from 5 to 30 meter long. For the length more than 30 m, the structure needs to be designed using the pre-stressed concrete.

2) Design Criteria for Drainage Channel

- Drainage channel alignment is placed along the railway alignment by considering the drainage direction based upon the geographical condition as much as possible, and by considering the maximum efficiency of the drainage and discharge from the street inlet.
- The type and cross section of the channel are designed as unlined trapezoid section (except some specific area which is required to be concrete lining). For determining the side slope, it depends on the type of cut or filled materials.
- Drainage level in the channel is maintained in the same level as natural ground level during the drainage at the design maximum rate
- Flow velocity in the channel is specified to be between 0.6-0.3 meter/second at which the sedimentation or erosion would not occur.

3) Design Criteria for Culvert: The culvert is generally a straight section in which water is under free flow condition. The pipe could be circular or rectangle box from one row onward. The culvert design has the hydraulic design criteria, as follows;

- Water flow is with free surface condition inside the box.
- Discharge velocity is between 0.6 – 3.0 meter/second.
- The difference in water surfce upstream and downstream of the culvert is not more than 0.3 m.
- Pipe diameter is not smaller than 1.0 m.
- Inlet invert of the culvert is specified to be the same level or lower than existing ground level of the gutter, or lower than the bottom of gutter.

4) Design Criteria for Bridge: For bridge design, the maximum discharge and ability of the watercourse drainage were compared at the construction location, and the Manning equation was applied.

In case the watercourse is sufficiently drained, the bridge is designed so that the impact to existing watercourse cross section is minimal. However, in case of insufficient draining capability, the watercourse section must be adjusted to enable better draining capability before designing the size for the opened area.

5) Design Criteria for Elevated Railway Structure

The drainage system on the elevated structure is designed as side gutters on both sides of railway. The size of gutter and spacing of drained spots with roadside ditches or the drained pipe depend on the grade slope and cross slope of road surface. The rainfall intensity is estimated by using return period of 10 years.

6) Drainage system design along the railway

In case the area to the side of the rail is hilly slope or flooded area, it was designed to be the drained canal along the side of the rail by using the right of way area so that such discharge then flows to the nearest natural water.

7) Drainage system design in station yard

The civil design in the drainage system at the station mainly considers the station plot plan and the geography of the area. The drainage system was designed accordingly to align with the station area and properly drain without any flooding. The drainage system and its structure consist of reinforced concrete structure in circular pipe, rectangular box or U-shape, and other drainage ditches. The requirements in designing drainage system at the station can be shown as follows:

- Consider the geographical condition and inspect the design plot plan of the station which was newly designed in this project, as well as the existing drainage system.
- Consider the area alignment, buildings location and other parameters that correlate with the elevations of railway, road and the existing drainage system in order to design and manage the drainage system to align with the drainage system outside the building and other waterworks and sanitary system.
- Evaluate the maximum discharge and other parameters at the design point in accordance to the drainage system requirement as previously mentioned.
- Estimate the suitable size of drainage structure and compare the size of opened space on the existing drainage structure to the newly estimated. The new estimation should be larger than the existing one.
- Design the drainage system in detail in accordance with the criteria and State Railway of Thailand standard in order to develop the detail design for a complete construction work.

5.9 Depot Work Shop Maintenance Design

At the present time the Southern Line consists of three maintenance depots located along the line, such as Chum Porn Depot, Thung Song Depot, and Hatyai depot, respectively. However, Track doubling project (Surat-Hatyai-Song kha) will not be considered the Chum Porn Depot because it's out of feasibility study scope. The location of depot is demonstrated in the **Figure 5.9-1**

Figure 5.9-1 Location of the Southern Line Depot

Table 5.9-1 Southern Line maintenance performance in each depot

Depot	Type	Location	Maintenance Schedule
Thung Song Loco. Depot	Depot	Nakhon Si Thammarat	**Locomotives**
			(CM / Daily/M1 /M3 /M6)
			Wagons
			(CM/ Daily/ M8)
Thung Song Workshop	Workshop	Nakhon Si Thammarat	**Passenger Coaches (Mild Steel)**
			(CM/ M4/ M20/ M40)
			Wagons
			(CM/ M8/ M24/ Y6)
Hat Yai Loco. Depot	Depot	Songkha	**Locomotives**
			(CM / Daily/M1 /M3 /M6)
			Passenger Coaches (Mild Steel)
			(CM/ Daily/ M4)
			Wagons
			(CM/ Daily/ M8)
Chum Porn Loco. Depot	Depot	Chum Porn	**Locomotives**
			(CM / Daily/M1 /M3 /M6)
			Passenger Coaches (Mild Steel)
			(CM / Daily/M4 /M20)
			Wagons
			(CM/ M8/ M24/ Y6)
Suratthani Department 10		Suratthani	**Loco./DRC/Passenger Coach/Wagon** (CM/Daily)

5.9.1 Depot Work Shop Evaluation

The depot capacity evaluation of the Southern Line will be considered on many factors, such as Southern Line timetable, target of depot maintenance, predicted maintenance downtime, additional rolling stock, planning and strategy of Mechanical Engineering department, staff working time, depot operation, and etc.

According to the depot capacity evaluation in this project which consists of Hatyai Depot and Thung Song Depot, they could be maintained 10 locomotives per month (In average). The target maintenance and Planning and strategy of Mechanical Engineering department are demonstrated in the **Table 5.9.1-1** and **Table 5.9.1-2**, respectively. At the present time the Mechanical Engineering Department has several projects for refurbishment the existing depots and construction new depots. These projects also is including the purchase of new equipment and instrument, such as train lifting jack, overhead crane, measuring device, and etc. In order to support the additional rolling stock that will be served the service in future. Moreover, these projects also are increasing the highest efficiency so as to correspond the track doubling project network which will be held on the future, too.

Table 5.9.1-1 Target maintenance of Thung Song Depot and Hatyai Depot

Task	Plan	Downtime	Hatyai Locomotive Maintenance Depot											
			December 2015			January 2016			February 2016			March 2016		
			Target	Done	INS.	Target	Done	INS.	Target	Done	INS.	Target	Done	INS.
500 hourly (M1)	A	4 hrs/unit	8	N/A	N/A	8	15	2	8	8	0	8	5	1
1,500 hourly (M3)	B	4 hrs/unit	3	N/A	N/A	2	2	0	2	1	0	2	2	2
3,000 hourly (M6)	C	3 days/unit	2	N/A	N/A	1	1	0	1	2	1	1	1	0
6,000 hourly (Y1)	D	5 days/unit	0	N/A	N/A	0	0	0	0	1	0	0	0	0
12,000 hourly (Y2-Y3)	*E	25 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
24,000 hourly (Y5-Y6)	*G	25 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
Total Locomtives Maintenance per month			13	N/A	N/A	11	18	2	11	11	1	11	8	3

Task	Plan	Downtime	Thung Song Locomotive Maintenance Depot											
			December 2015			January 2016			February 2016			March 2016		
			Target	Done	INS.	Target	Done	INS.	Target	Done	INS.	Target	Done	INS.
500 hourly (M1)	A	4 hrs/unit	9	N/A	N/A	9	4	1	7	4	0	7	4	2
1,500 hourly (M3)	B	4 hrs/unit	1	N/A	N/A	1	1	0	3	1	0	3	0	0
3,000 hourly (M6)	C	3 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
6,000 hourly (Y1)	D	5 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
12,000 hourly (Y2-Y3)	*E	25 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
24,000 hourly (Y5-Y6)	*G	25 days/unit	0	N/A	N/A	0	0	0	0	0	0	0	0	0
Total Locomtives Maintenance per month			10	N/A	N/A	10	5	1	10	5	0	10	4	2

Table 5.9.1-2 Strategy and Planning of Mechanical Engineering Department

No.	Project Planning	Budgets (Million Baht)	Fiscal Year (B.E.)	Remark
1	Makkasan Relocation Planning			
	• New passenger Coaches Depot	1,021.24	2559 – 2561	Consulting process (FS+DD)
2	115 Passenger Coaches Workshop Construction at the terminal station	10.896	2559 – 2561	Detailed design and auction by Civil Engineering Dept.
3	Workshop Construction at Suratthani	1.80	2559 – 2560	
4	Workshop Construction at Chumporn	11.00	2559 – ปี 2560	
5	The existing depots refurbishment project (The roof / Lighting system)			
6	The improvement of equipment which is including machine, measuring device as well as purchasing new equipment			
	• Improvement Planning, such as Overhead Crane, and etc. • Purchasing Planning, such as Overhead Crane, Lifting Jack, Testing instrument, and etc.			

The capacity evaluation for both depots will be considered on the relevant factors which are comprised of Southern Line timetable, target of maintenance, predicted maintenance downtime, additional rolling stock, planning and strategy of Mechanical Engineering department, staff working time, depot operation, and etc.

Regarding to the assessment and recommendation by a Depot Work Shop Specialist, both depot workshops will be able to serve the additional rolling stock in future. Therefore, it is not necessary to building a new depot which is making the highest cost for project construction. Whatever, the existing depots need to be refurbishment and improvement, such as equipment and instrument because the existing equipment are obsolete and out of date. In addition, the working time of staff need to be improved from the previous only one shift into two or three shifts as possible in order to correspond the additional rolling stock in future. The example of depot capacity calculation is demonstrated in **Table 5.9.1-3** as follow;

Table 5.9.1-3 Example of depot capacity calculation at Thung Song Depot

Thung Song Locomotive Maintenance Depot

Depressed track	2	tracks	2	positions	4	locos/DRC				
Pit track with 1 set jacks + Flat track	2	tracks	2	positions	1	locos/DRC	Lifting	3	locos/DRC	Flat
Plain track	2	tracks	2	positions	4	locos/DRC				

DRC	Daily Inspection	0.25	hr	On depressed track	Shunting	0.17	hr	Total	0.42	hr
	1-monthly Inspection	2	hr	On depressed track	Shunting	0.17	hr		2.17	hr
	3-monthly Inspection	3	hr	On depressed track	Shunting	0.17	hr		3.17	hr
	6-monthly Inspection	2		Depressed track	Shunting	0.17	hr		2.17	hr
	6-monthly Inspection	22	hr	Pit track or plain track					22.00	hr
	1-yearly Inspection	2		Depressed track	Shunting	0.17	hr		2.17	hr
	1-yearly Inspection	38	hr	Pit track 1 position w/ 4 lifting jacks + gantry flat track 1 position					38.00	hr
LOCO	Daily Inspection	0.50	hr	Depressed track	Shunting	0.17	hr	Total	0.67	hr
		1.5	hr	Flat track or pit track				Total	1.50	hr
	1-monthly Inspection	4	hr	Depressed track	Shunting	0.17	hr	Total	4.17	hr
	3-monthly Inspection	4	hr	Depressed track	Shunting	0.17	hr	Total	4.17	hr
	6-monthly Inspection	2		Depressed track	Shunting	0.17	hr	Total	2.17	hr
	6-monthly Inspection	22	hr	Pit or plain track				Total	22.00	hr
	1-yearly Inspection	2		Depressed track	Shunting	0.17	hr	Total	2.17	hr
	1-yearly Inspection	38	hr	Pit track 1 position w/ 4 lifting jacks + gantry flat track 1 position				Total	38.00	hr

Per DRC	1	DRC						
Total Nbr insp/year								
Nbr daily/year	353	insp	time needed	#####	hr			
Nbr monthly/year	8	insp		17.36	hr			
Nbr 3 months/year	2	insp		6.34	hr			
Nbr 6 months/year	1	insp		24.17	hr			
Nbr 1 year/year	1	insp		40.17	hr			
Total needed depressed track time/year/DMU				171.96	hr	Nbr DMU	15	DRC in 2564
Total depressed track time/year needed for ultimate fleet				2644.5	hr			

Per locomotive	1	loc			
Total Nbr insp/year					
Nbr daily/year	353	insp	time needed	766	hr
Nbr monthly/year	8	insp		33.36	hr
Nbr 3 months/year	2	insp		8.34	hr
Nbr 6 months/year	1	insp		24.17	hr
Nbr 1 year/year	1	insp		40.17	hr
Total depressed track time/year needed per loc				282.6	hr

	Total depressed track time available		Remaining capacity after DRC insp		Nbr extra Locs in daily, 1 & 3 months on pit track	
1 shift	11680	hr	9036	hr	31	locs
2 shifts	23360	hr	20716	hr	73	locs
3 shifts	35040	hr	32396	hr	115	locs

Total track occupancy flat track		Time needed M6 Inspection	Time needed Daily Inspection	Total time needed Locos	Time needed M6 DRC	Total needed on flat track	Total time provided *	Remaining time flat flat track available	
31	locos	682	16414.50	17096.50	330	17,426.50	21,544.73	4118.2	OK
73	locos	1606	38653.50	40259.50	330	40,589.50	43,217.59	2628.1	OK
115	locos	2508	60363.00	62871.00	330	63,201.00	64,930.62	1729.6	OK

Total lifting track time/ year needed	1 Year inspection locos				1 year inspection DRC	Total needed	Total pit time provided		Remaining time pit available			OK
	31.00	locs	1245	hr	570	1815.27	2920	hr	1104.73	hr	OK	
	73.32	locs	2945	hr	570	3515.11	5840	hr	2324.89	hr	OK	
	115	locs	4605	hr	570	5175.49	8760	hr	3584.51	hr	OK	

* includes remaining time on lifting track

5.9.2 Proposed solution for depot workshop expansion

According to the capacity evaluation for both depot by depot workshop specialist, the solution and methodology are totally described as follow;

- *Man Power and Working flow for depot workshop operation*
  In nowadays the SRT has been used the working time for maintenance the locomotives only one shift (eight hours) per day. For additional rolling stock that will be operated for service in future, the SRT need to add two or three working times if possible, because it will be increasing the working time for maintenance rolling stock. Thus, the depots will be able to contain the additional rolling stock. In addition, it can cause to reducing the down time and also increasing the availability of rolling stock respectively. In part of maintenance operation, the depots should be improved and refurbished the maintenance area in depots in order to be easy for maintenance and obtaining the highest efficiency as much as possible.
- *Depot Workshop Equipment*
  For both depot workshops need to be improved and provided the new equipment and instrument for supporting rolling stocks so as to increase the efficiency. For example, the existing overhead cranes need to replace a new type instead because it is very old and out of date. Therefore, the consulting will be suggested to replacing a new overhead crane (Single girder type) for traveling along the workshop. Moreover, the SRT need to be added more train lifting jack so as to increase more efficiency in rolling stock maintenance, and etc. However, Mechanical Engineering Department has a strategy and planning for improvement the existing equipment and instrument already. It is including the purchase of new equipment, such as overhead crane, lifting jack, and other instruments, and etc.
- *Proposing the existing depots improvement for CSR-U20*
  According to the feasibility study of track doubling project (Surat-Hatyai-Song kha) for transportation of freight container in the Southern Line, the container forecast will be increasing gradually in the future. Thus, the operation consulting would like to propose CSR-U20 Locomotives for hauling the Heavy freight train from Inland Container Depot (ICD) to Padang Besar Container Yard in future. Whatever, the limitation of CSR-U20 service consists of the maintenance workshop and the incomplete track rehabilitation along the Southern Line. These reasons will be effect to operating the CSR-U20. Thus, the operation will not be set CSR-U20 in service on the Southern Line. Whatever, the consulting would like suggest that both depots need to be improved the performance in order to support CSR-U20 maintenance in future. The recommendation is described as follow;
  - The Southern Line need to be improved the track for suitable supporting the axle load 20 tons
  - The depot track in the yard territory need to properly rehabilitate for supporting the axle load 20 tons

- The inspection level in depot need to separate into three levels for checking the underbody equipment, the equipment on car level, and air conditioning system and filled cooling water, respectively.
- The equipment and instrument in workshop need to improve and refurbish, such as overhead crane, lifting jack (30 tons), measuring device, and etc.

- *Construction the daily maintenance workshop for 115 passenger coach trainset*

  The proposed daily maintenance depot will be located at the south side of Hatyai Station (**Figure 5.9.2-1**) The primary workshop dimension has the length approximately 300 meter long and the height is 6 meter, respectively. The typical workshop is divided into two levels for maintenance. It is comprised of the pillar track for maintenance underbody and the height level for maintenance air condition unit. This project is now belonging to Civil Engineering Department.

Figure 5.9.2-1 Proposed location of daily maintenance workshop for passenger coach trainset

5.9.3 Depot Facilities Design

Regarding to the site survey for both depots which are comprised of Hatyai Depot and Thung Song Depot, the depot territory has many rolling stock which was out of service were parking long time ago, such as Diesel Locomotives, Freight Wagons, and etc. It could be obstacle the shunting operation. In order to increase the highest efficiency, the consulting would like to suggest that the SRT need to eliminate their rolling stock out of depot territory because the territory will be useful for being the depot yard or shunting track, and etc. However, the consulting would like to propose the new track alignment the track for both territories as follow;

- **Thung Song Depot Yard**

  The consulting will be proposed the new track alignment in depot territory for parking the rolling stock after service or maintenance because Thong Song Depot has the huge area which is very useful to design the new track alignment. The new alignment layout is demonstrated as follow;

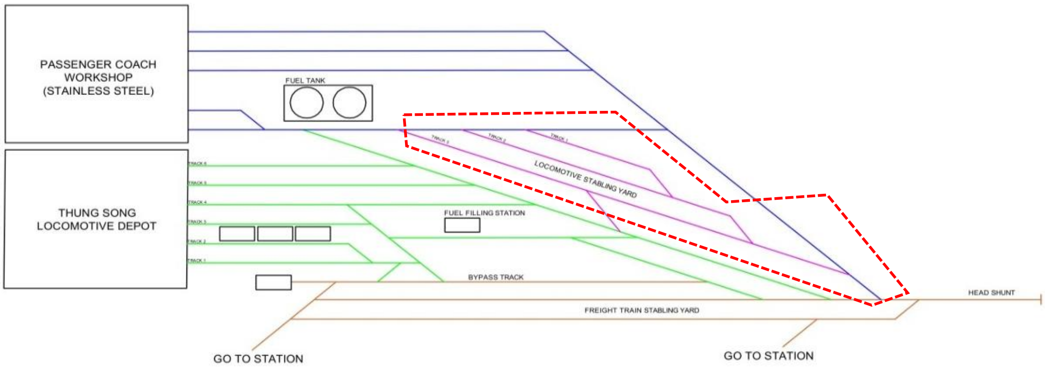


Figure 5.9.3-1 New track alignment schematic of Thung Song Depot Yard

- **Hatyai Depot Yard**

  According to the shunting operation in Hatyai Depot territory, a locomotive need to be used stopping point almost three times for shunting from depot work shop to train station. Thus, this situation could be effect to shunting time delay. In order to reduce time delay for shunting the locomotive, the consulting would like to propose the new track alignment in depot territory because the new alignment will be reduction the stopping point from three points into one point. The new alignment layout is demonstrated as follow;

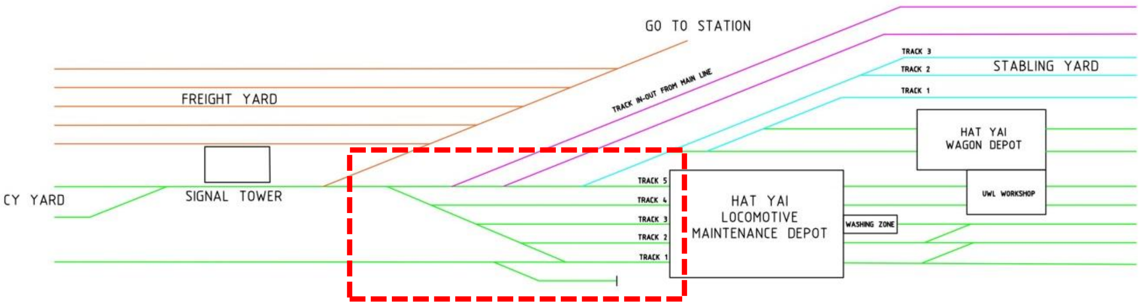


Figure 5.9.3-2 New track alignment schematic of Hatyai Depot Yard

5.10 Trackwork

Trackwork is considered an essential part of the rail transportation contributing the train operational ability such as operation speed, efficiency, schematic track layout and safety including low maintenance required. To achieve these attributes, the rail, trackform, and its component shall be strong, durable, and compatible following Thailand and International Standard design of Trackwork.

5.10.1 Schematic Track Layout

The concepts of schematic track layout are summarized as follows:

- New track alignment should have least impact to the existing building or structure. Any demolition to the existing should be avoided.
- In consideration of new track to be install whether it would be up track or down track, the location of existing building such as building station, the suitability of geography of the area are the main consideration. In case of connecting new track to existing track or vice-versa, it should generally be done at curve.
- In general, station will be designed to contain siding track (loop track) not more than 1 track. Such track would be design to be at the opposite side of the existing station to avoid the demolishing of existing structure. Installing siding on the same side with the existing station would not be normally possible unless the existing station is removed.
- There are many streams and canals along the project and also within the vicinity of the station which limits the area of track. As a consequence, siding tracks are sometimes not be able to install at such stations. In that case, siding tracks would be install to the next available station.
- The concept of single track would normally requires the siding track at the interval of 5 – 10 kilometers in order to provide the passing ability to the train to increase the capacity. Such requirement would not be required in the double track system. Therefore, the station with siding track would be less as appropriated. However, the siding will be considered in the matter of synchronizing with the system operation plan for passing, shunting, reverting and accommodating the system in the emergency situation.

Some stations may be designed with non-typical design, as shown in the following details.

1) Surat Thani – Hatyai Section

- Thung Song Junction

There will be platform at this station which will serve the train to Hatyai and Kantang. Series of crossover and turnout are proposed to install inside the station area to provide the flexsibility of the system for both 2 route. Besides, some of existing depot tracks are to be removed to provide the space for the third platform and the depot track configuration is revised slightly.

- Khao Chum Thong Junction

This is a junction type station which allows the train to go to either Hatyai or Khok Khram. The platform to serve Khok Khram route is already at the siding track which could be retained to serve the operation. For the platform for Hatyai direction, there are 3 platforms. In total, there are 4 stations for this junction.

- Han Thao Station

In normal situation for this project, the platform is design to be able to serve the mainline stopping. However for this station, the platform is design to serve at siding tracks. Due to the limited area of extending, constructing the island type platform to serve both mainline and siding tracks is not feasible.

- Ban Din Lan Station

This station is designed with series of siding track with the purpose to serve as the train stabling yard for Hatyai junction. Due to the limited space at Hatyai junction, it is not viable to upgrade or revise the junction configuration to provide sufficient space for stabling train. Therefore, Ban Din Lan station, adjacent station, is design with addition stabling tracks as a reserve to Hatyai.

2) Hatyai – Songkla Section

There are 2 stations with siding for the overall length of approximately 25 kilometers for this Hatyai – Songkla section. Most of the tracks in this section are tracks on elevated structure which is not suitable in case of building those siding on the elevated. Therefore, only 2 station which are at at-grade type station are equipped with siding. These siding will provide the flexibility to this 25-kilometer long train system.

Project track schematic layouts are shown in **Figure 5.10.1-1 to 5.10.1-3.**

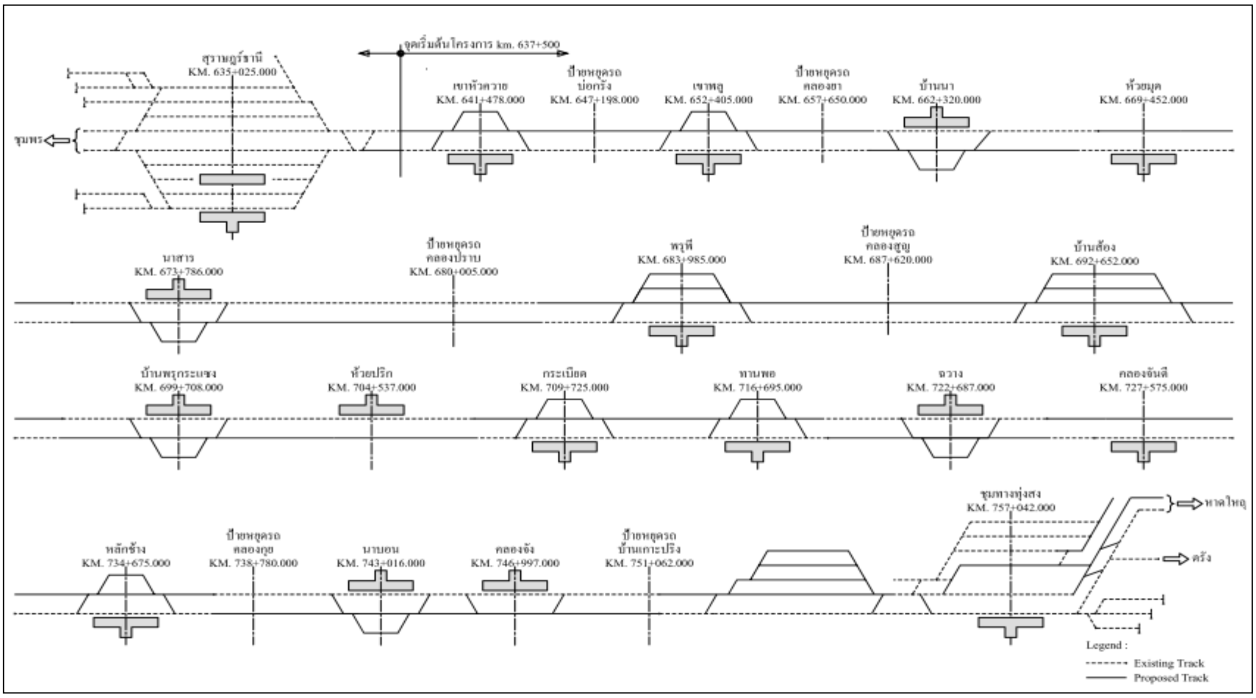


Figure 5.10.1-1 Track Schematic Layout: Suratthani – Thung Song Junction

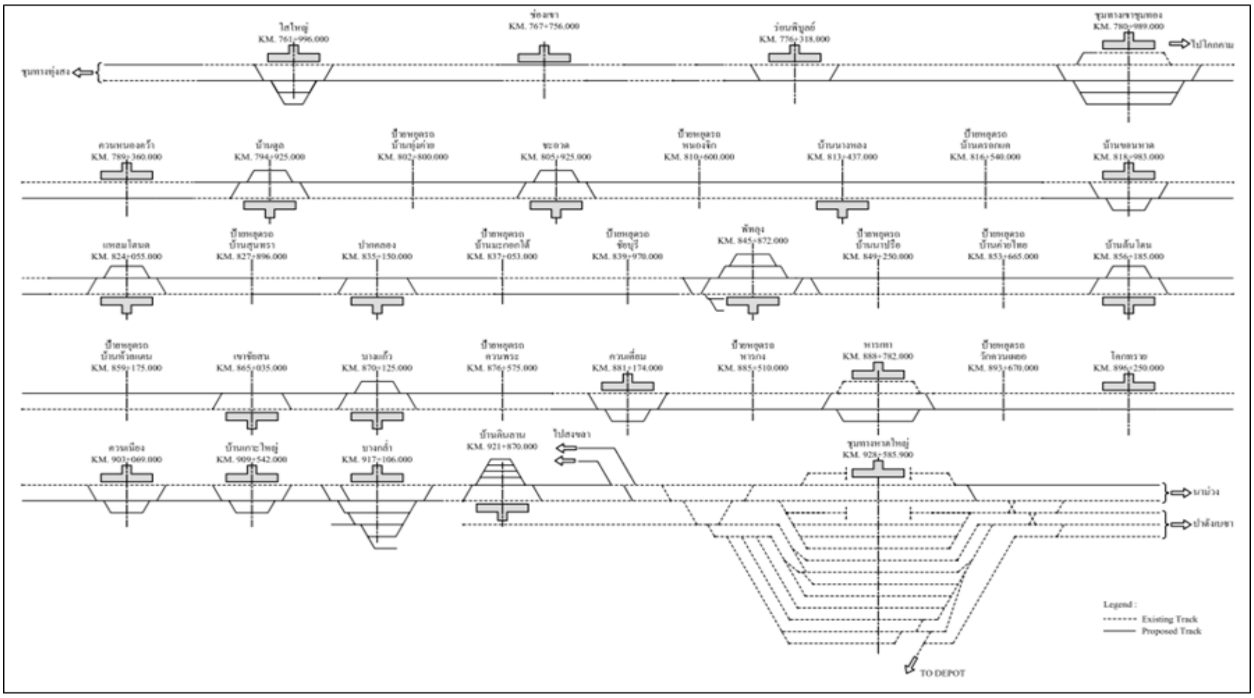


Figure 5.10.1-2 Track Schematic Layout: Thung Song Junction – Hatyai Junction

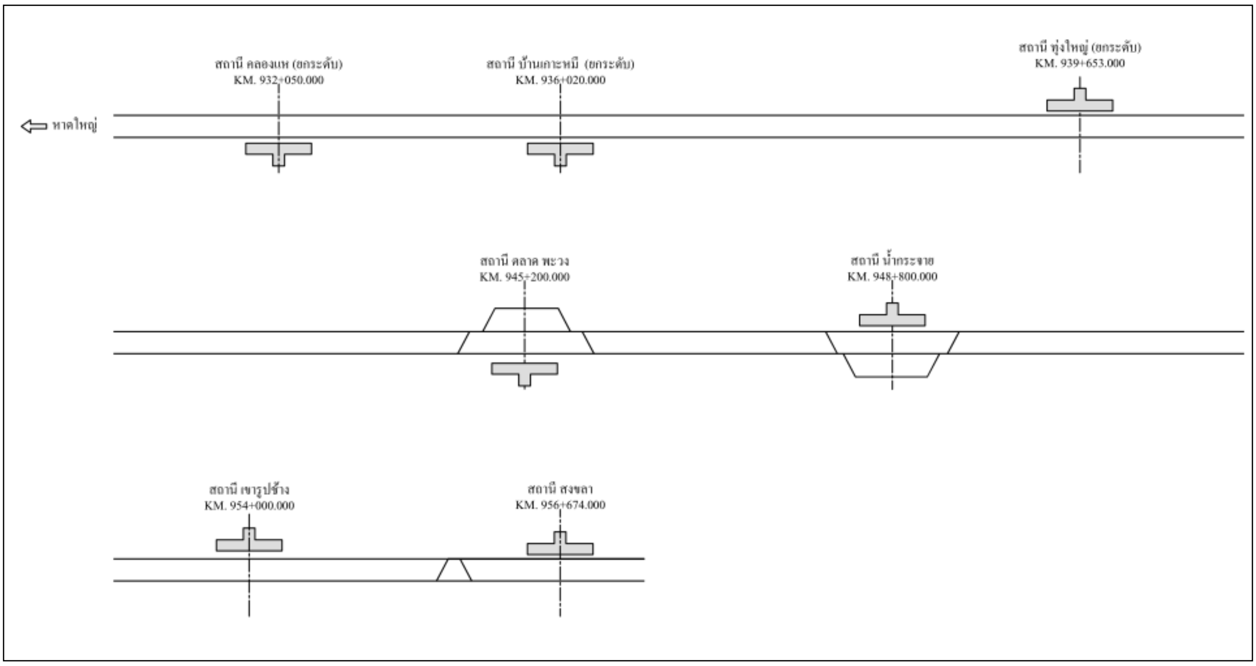


Figure 5.10.1-3 Track Schematic Layout: Hatyai Junction – Songkla

5.10.2 Concept Standard and Requirement

Generally, the trackwork is consisting of track support design and its component to obtain the strong and durable track system which shall normally follow these standards:

- British Standard (BS),
- Union International des Chemins de Fer (UIC),
- European Standard (EN),
- American Railway Engineering and Maintenance-of-Way Association (AREMA),
- American Society for Testing and Materials (ASTM) และ
- Japan Industrial Standard (JIS)

Besides those standards, another requirement for the design is for structure gauge which is the train profile to clarify the limit of the train when in service to provide safety for the system. The gauge for this project is referred from the previous project studies from OTP and SRT. The gauge is shown is **Figure 5.10.2-1**.

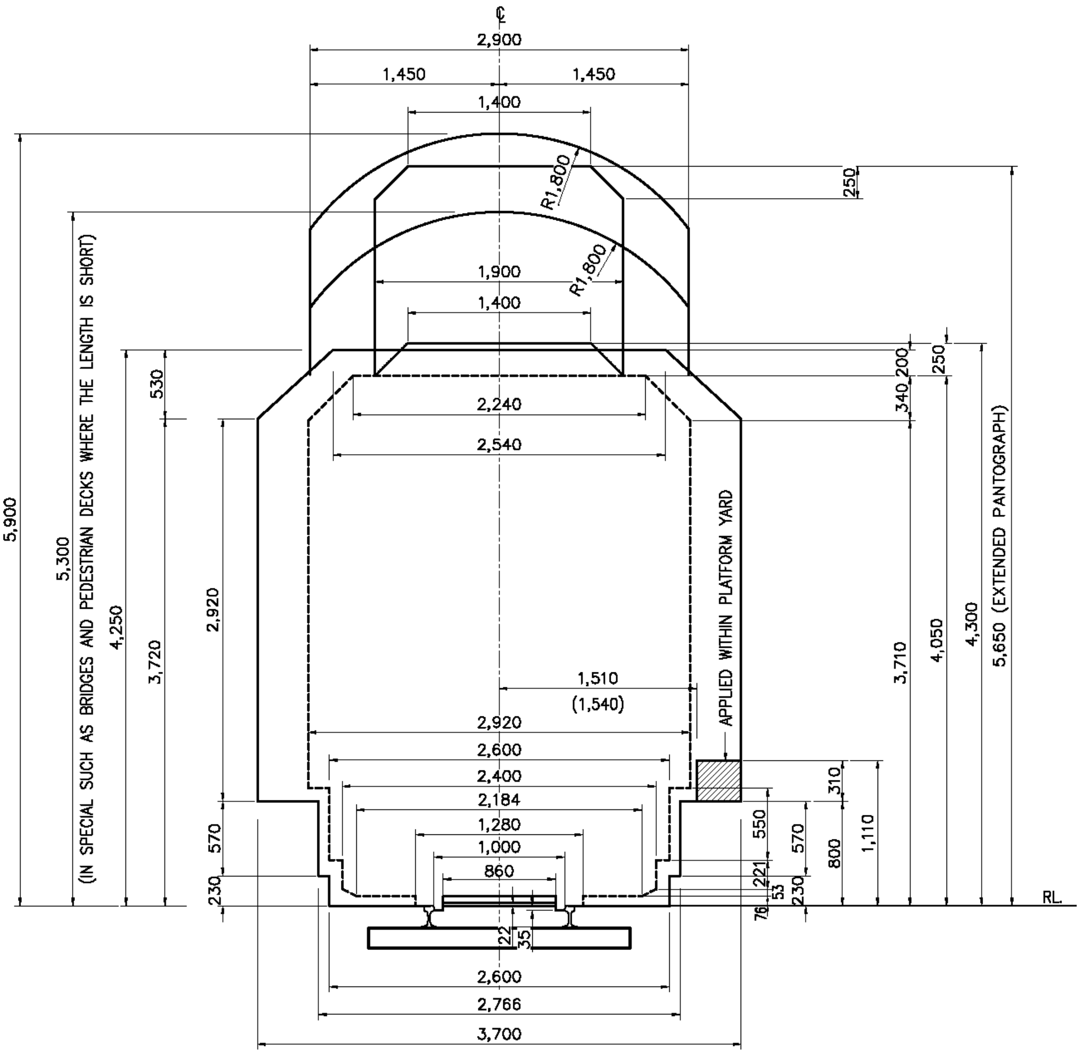


Figure 5.10.2-1 Loading gauge and structure gauge

The concept of design for each component of trackwork is shown in **Table 5.10.2-1.**

Table 5.10.2-1 Requirement of trackwork design

No.	Items	Descriptions
1	Design Axle Loads	• Axle Load 20 tonnes
2	Track Gauge	1,000 mm
3	Maximum Design Speed	160 kph
4	Rail profile	54E1 (UIC 54)
5	Rail Inclination	1:40
6	Ballast minimum thickness	300 mm
7	Sleeper	• Prestressed Monoblock Concrete Sleeper • Steel Sleeper • spacing 600 mm
8	Track Spacing • Between mainlines • Between mainline and siding	 Approximated 6.00 m 11 m
9	Turnout	• 1:12 for Mainline • 1:10 for Siding • 1:8 for Maintenance Area

5.10.3 Trackwork components

5.10.3.1 General

- Ballasted track is considered for at grade, and elevated track.
- For track on steel structure such as steel bride, the ballastless track is considered. The steel sleeper is used instead of traditional prestressed monoblock concrete sleeper and connected directly to the steel structure. The steel sleeper shall have dynamic response similar to ballasted track.
- In the area with the variation in track stiffness, the transitional structure should be constructed to provide the smooth transition between the varying track stiffness lessening the impact damage on trackform.
- Running Rail Profile 54E1 (UIC54) to be used in the project for both ballasted and ballastless track for all. Since the existing track is currenly laying with BS100A rail, therefore at the connection between new track and existing track the compromise rail will be installed to provide the smooth the connection easing the abrup change and avoid track deteriorated.
- Rail inclination shall be 1:40 to provide the self-steering and move the vertical loads away from the rail head corner.
- Typical track spacing shall be 6 m. to avoid the effect from the construction of new track to existing track. Besides, the 6-meter-spacing is also provide sufficient space for build small bridge crossing small streams along the project route. Where the track has

to run across the river, the track spacing will be increased to allow the extra space for railway bridge and construction.

5.10.3.2 Components and their requirements

1) Running Rail

Running Rail of 54.77 kg/m (54E1) is considered for the project for all tracks. Running Rail shall be investigated for any defect by non-destructive test. The minimum requirements of rail shall be as follows:

- Ability of guide the wheel smoothly and continuously.
- Ability to withstand the wheel load and transfer it to the sleeper with an acceptable deflection.
- Provide the electrical connectivity for signaling system.

2) Fastening System

The fastening system with the elastic spring clip should be used. All of fastening system components shall be manufactured from factory. Any damage during the transportation and construction shall be strictly prevented. The minimum requirements of fastening system shall be as follows:

- Ability to attach the rail in desired position within the acceptable positional rail tolerance.
- Ability of withstanding high temperature environment.
- Ability to allow rail longitudinal movement due to the temperature change and rail deflection from wheel load.
- Provide flexibility to the trackbed and sleeper.
- Provide electrical insulation between rail and sleeper
- Ability to reduce the noise and vibration within the acceptable level.
- Easy to install
- Low maintenance required

3) Sleeper

The typical prestressed monoblock concrete sleeper is considered for the project. The sleeper shall be laid perpendicular to the rail with the spacing of 600mm. Sleeper dimension should be 2m. long, 250 mm. wide at the sleeper base, and provide adequate space to position 54 kg./m rail and fastening system. The design consideration for operation requirement is maximum speed of 160 kph and maximum static wheel load of 20 tons. The rail inclination shall be 1:40. The minimum requirement of sleeper shall be as follows:

- Ability to withstand the rail loads and transfer them to ballasted bed.
- Ability to provide support and fixing the rail and fastening.
- Ability to preserve the track gauge and rail inclination

4) Ballast Bed

Ballasted bed shall consist of coarse grained material such as granite, basalt, and andesite. Typical thickness beneath the sleeper is 300 mm. measured directly below the rail seat.

The minimum shoulder width measured from the edge of sleeper shall be 400 mm. with the side slope of 1:1.15. The minimum requirement of Ballast base shall be as follows:

- Ability to sustain all forces from sleeper to maintain the track in desired position
- Provide flexibility and adsorb forces induced from track.
- Provide the ease maintenance
- Provide the good drainage system
- Ability to reduce the stress beneath the sleeper and transfer them to the bottom layer within the acceptable level.

5) Turnout

Turnouts are used to guide the train from one track to another following the train operation. Turnout of the project shall be installed on sleepers which ease the installation since the sleepers are conveniently performed quality control during the manufacture process.

Turnout type for the project shall be follow the state railway of Thailand standard and are listed below:

- Turnout Tg 1:12 – For mainline track (between mainlines), Maximum speed 39 kph.
- Turnout Tg 1:10 – For siding tracks (between mainline and siding, sidings), Maximum speed 30 kph.
- Turnout Tg 1:8 – For light maintenance and yard area, maximum speed 30 kph.

5.10.3.2 Transition Structure

At the interface point between the different types of track support structure such as the soil embankment and concrete structure, track stiffness are an abrupt change which cause the damage to the track support. To minimize the damage, the design of transition structure is employed to provide the gradual change in track stiffness and modulus reducing the impact at the interface zone.

5.11 Signalling and Telecommunication System

5.11.1 Signalling Train Control

Signaling system of the State Railway of Thailand. Designed according to the conditions and rules of operation. The signaling and telecommunications department, which summarizes the principles of the signaling system on the basis of the system. The Interlocking system from the traditional to a Computer Base Interlocking (CBI), modern, easy to maintain, repair, which is used in the design, supply and install signaling light. Since the project partners ST1 ST2 ST3 and ST4 is implemented in the current SRT.

The signalling system is designed to adapt to accommodate the European Train Control System (ETCS) Level 1 in the future, and can support the running of trains at speeds up to 160 km/hr. and is an open technology. It shall be connected to the existing network more effectively now and in the future of SRT. The signaling system that is designed to take into account security is important.

The first phase of the signaling system design is set to upgrade the existing signalling system into 3-aspect. Later, the level of protection will be gradually improved by establishing the Automatic Train Protection system (ATP) to secure higher safety.

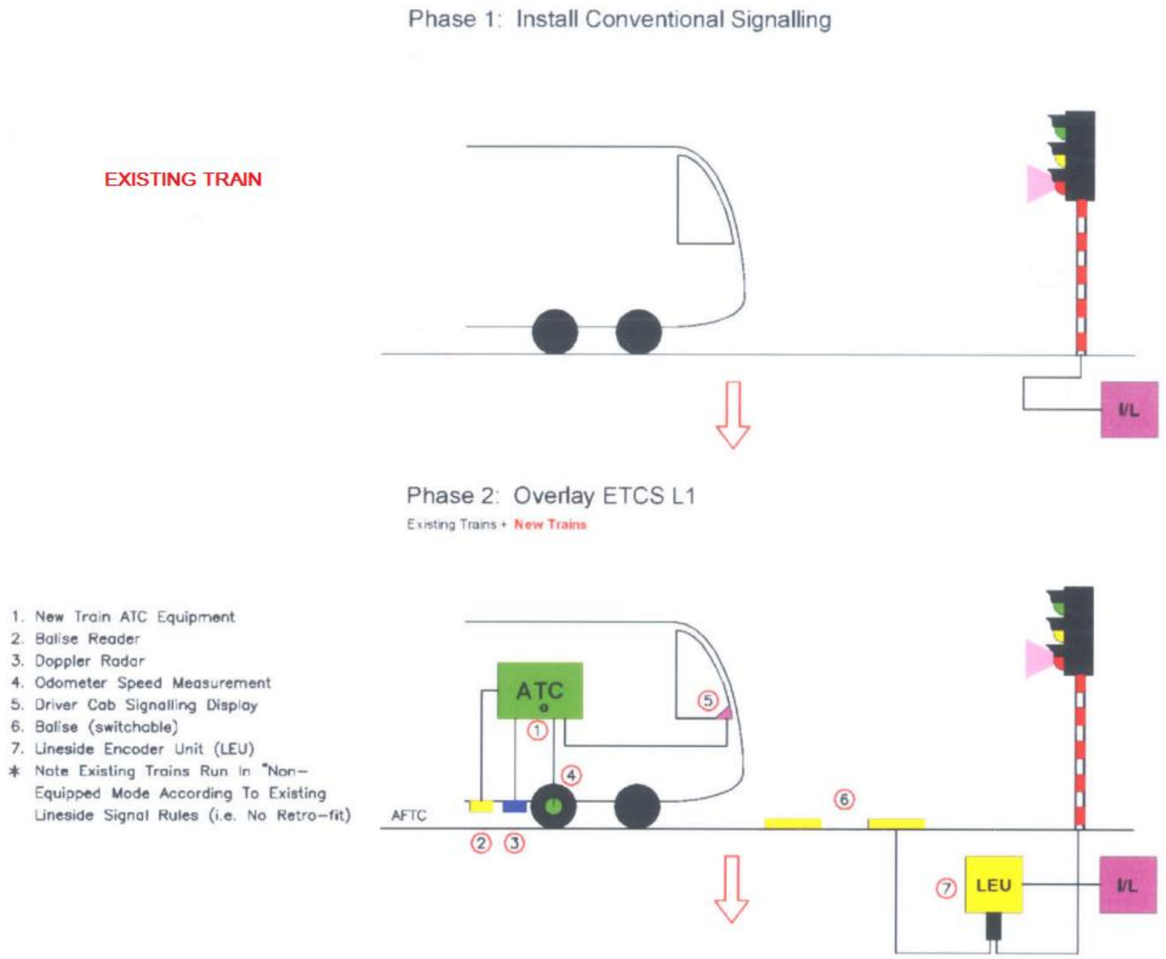


Figure 5.11.1-1 Phasing of Signalling System Development

5.11.2 Telecommunication System Design

The project requires the installation of PABX operated by personnel who are not related to the safety communication. The general of the PABX are as follows:

(1) Backbone Transmission Network System (BTN)

The BTN system shall provide sufficient capacity to transport all Project voice and data of the various systems between sites without any restriction being placed on the maximum required through put between such systems. The system functional and requirement are as follows:

- The BTN system shall provide the transmission media for the following systems:
  - PABX telephone system
  - Radio communication (RC) system
  - Master Clock (MC) system
  - Signalling System (Provide optical fibre core only, transmission system will be provided by Signalling system)
- The BTN will require technology that has been proven such as Synchronous Digital Hierarchy Technologies (SDH) etc.
- To secure reliable communication, network should contain defensive systems in the Sub-Network Connection Protection or protection ring which prevents the multiple used by

several sectors. Time to change should not exceed 50ms as specified in ITU-T G.783 standard.

- All communication circuits along the entire route shall use a fiber-optic cable; two separate sets of fiber-optic cable shall be used.
- The connectivity to the existing SRT network shall be prepared at Surat Thani station to create voice and data communication system between the new projects with the existing SRT projects.
- The communication network (BTN) should be STM-4 capable of performing technology upgrade in the future following SRT's investment plan to achieve maximum benefit. The BTN shall at least support the connection with the sub-system as follows:
- 2 Mbps E1 (ITU-T G.703 and G.823)
- Ethernet 10/100 base-TX (IEE 802.3)
- STM-4 (622Mb/s, ITU-T G.957/8)
- Synchronization Clock Source
- Interface with other systems required.

Regarding the design the Backbone Transmission Network System, the main consideration is the voice and data capacity. Such information is required to be effectively compatible with the main network system to maximize the benefit in term of safety and operation.

(2) PABX Telephone System

The project requires the installation of PABX operated by personnel who are not related to the safety communication. The general of the PABX are as follows:

- Core network should connect to the network automatically present the State Railway of Thailand. As well as the network of TOT Public Company Limited (Thailand).
- All PABX are installed as the PABX extensions which are very precise and exact without the blocking between control centers and stations.
- All Telephone DTMF are Dialing keypad.
- DLT phone system will be a 100 percent. Without any blocking.
- Establish a direct connection between the pre-assigned.
- All position of the direct line phone requires having individual phone. Sharing phone with PBAX is prohibited.
- Plans call between the groups assigned as follows.
  - Individual call
  - Group call
  - All group call
  - Call to the landline network.
  - All Direct Line Telephone calls shall be recorded on the Central Voice Recorder

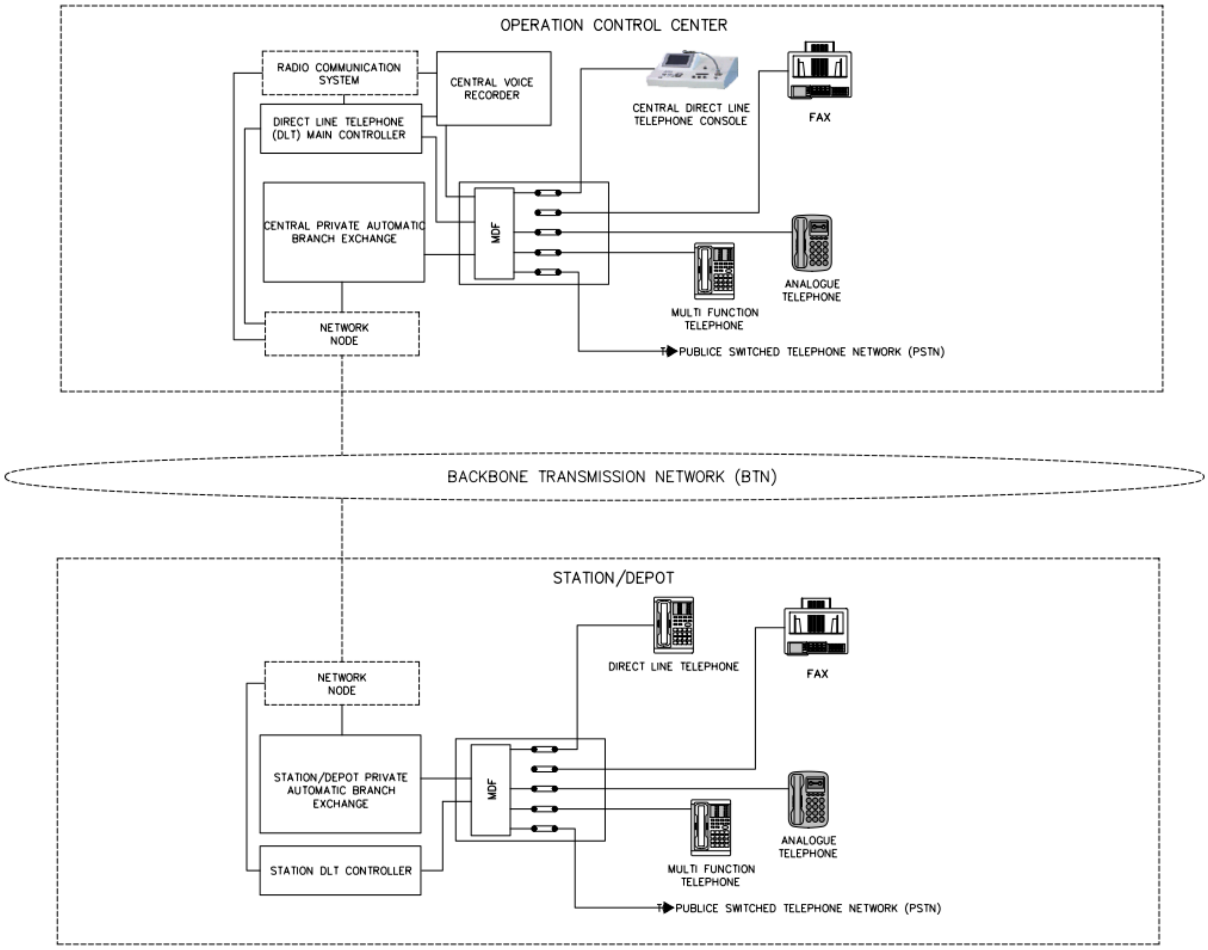


Figure 5.11.2-1 PABX Telephone System

(3) Radio Communication System

The Radio Communication systems and wireless voice communication channels are to accommodate the needs of train operation and maintenance on railway. Wireless voice communications channels are provided between the following parties.

- Traffic Controller (TC) in LACC and the Train Operators (TO) for train operation control purpose in the running lines
- Station Master (SM) and TO
- Engineering Controller (EC) and Railway Staff (mainly maintenance staff) at track side
- Depot Controller (DC) and Tran Operators (TO) within depot area
- DC and Railway staff equipped with hand-portable radio set in the deport area
- Operating and Maintenance staffs (O&M) equipped with hand-portable radio sets at station, trackside and depot area

In addition, radio communications must be designed to accommodate other work with the rules to cover areas along the route, including inside the station, tunnel and depot. It shall not be the monopoly of technology.

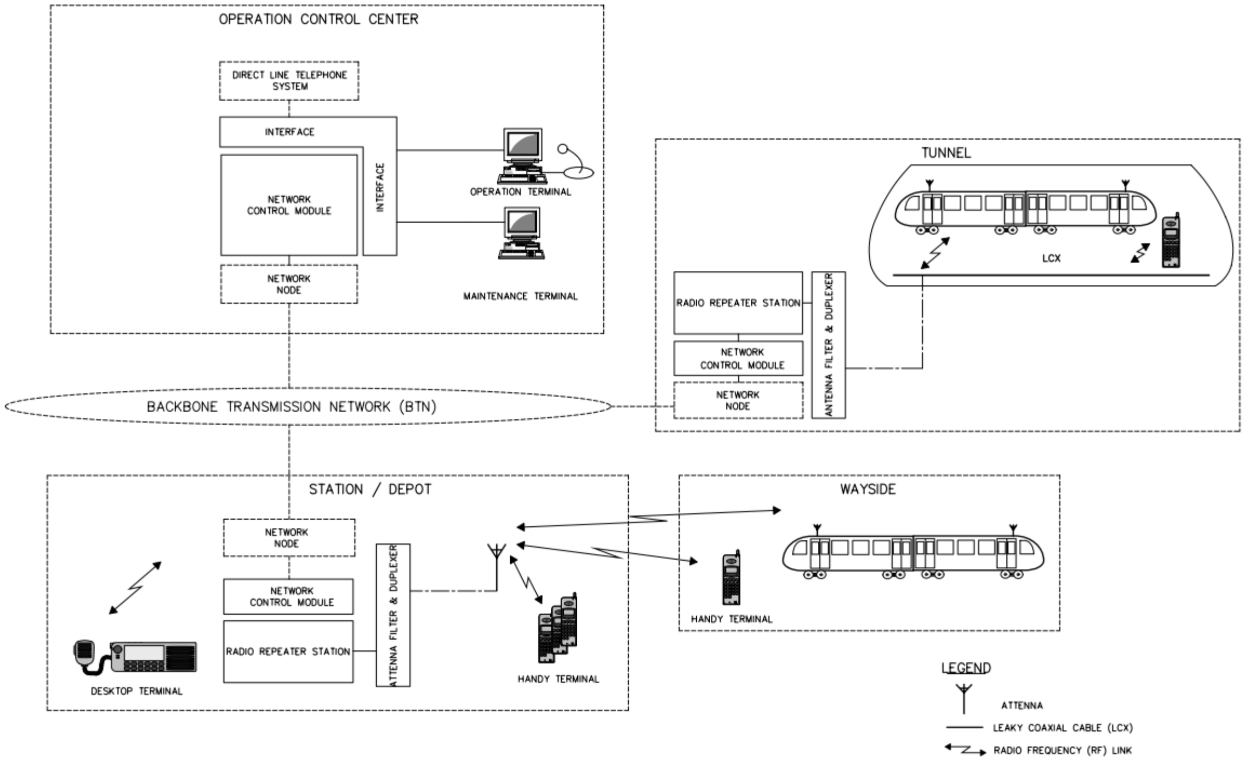


Figure 5.11.2-2 Radio Communication System

For a radio communication system designed in this project, it contains two parts: Digital Radio Repeater Station and Digital Radio Base Station

Digital radio repeater station is designed to cover areas along the route, including inside the tunnel, depot and Local Area Control Centre (LACC). The distance between the repeater station to repeater station is approximately 60 kilometers away. The Center Traffic Control (CTC) should be able to make the contact with the train driver and master stations quickly and easily. Radio system is designed to connect with Backbone Network of the project.

Digital radio base station is designed for the call between stationmasters and serves as a backup system for the train operation when digital radio repeater is faulty, damaged or not-working. The digital radio base station is designed to be a hybrid system to accommodate both analog client which is currently in use by SRT and digital experiences which are being updated on SRT.

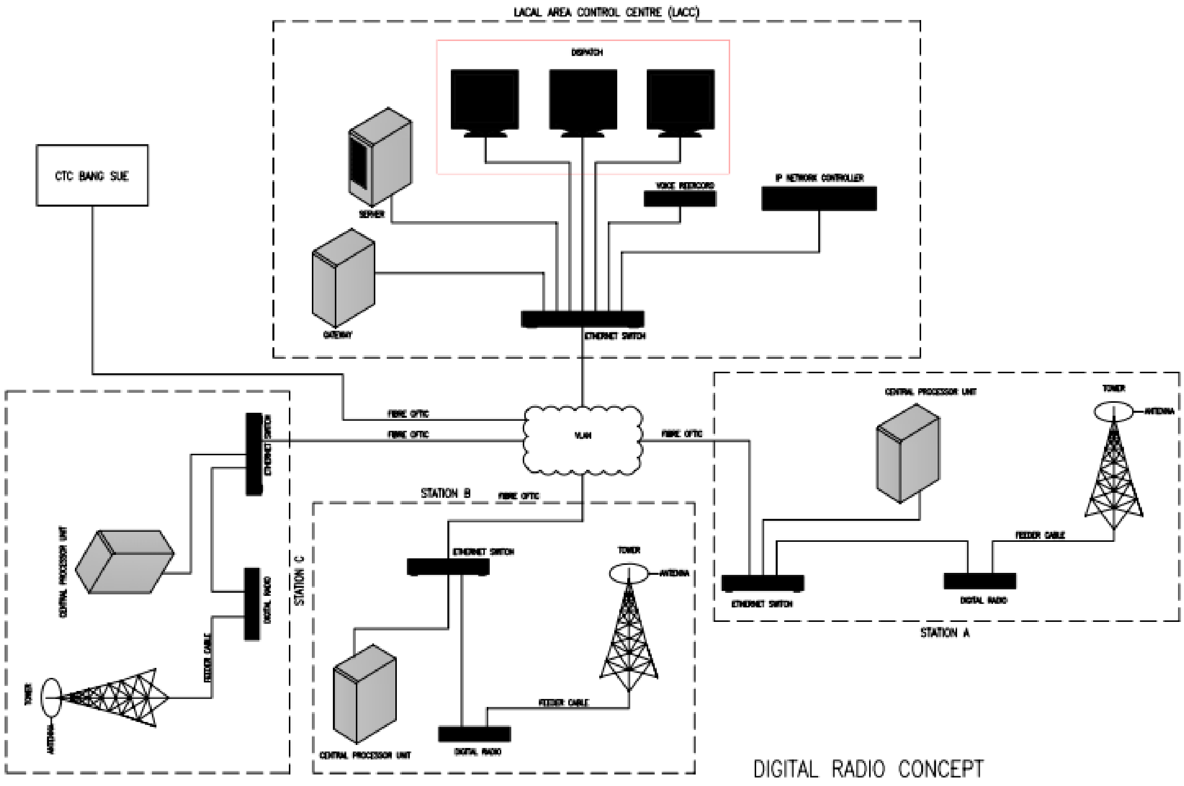


Figure 5.11.2-3 Digital Radio Concept

(4) Master Clock System : MC

Master Clock (MC) System is required to synchronize to all Clocks, Signalling and Communication system with the following requirements:

- The MC system shall obtain its reference source from a GPS linked Master Clock located at LACC
- The clock signal shall be distributed to the remote site over the BTN system.
- Slave Clocks shall be provided at the following locations in sufficient number to fulfil the minimum viewing requirement:
  - Station area such as Station Control Room, Concourse, Staff Mess and Rest rooms, platform, etc.
  - Depot such as Administration Offices, Working Areas (Indoor), Work shop areas
  - Central train control such as Operation Room
- Types of slave clock:
  - Embedded Digital
  - Wall mounted Digital
  - Analogue Single Sided
  - Analogue Double Sided

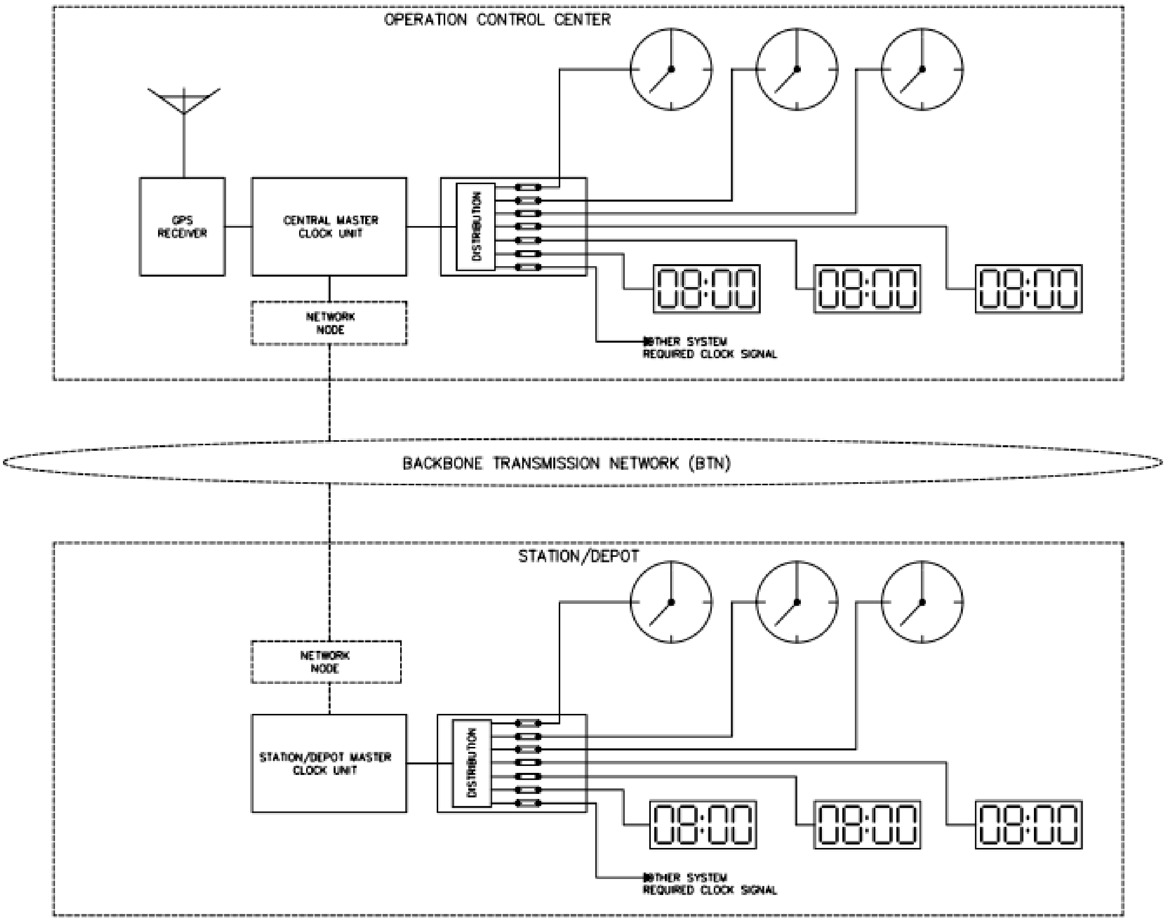


Figure 5.11.2-4 Master Clock System : MC

5.11.3 Local Area Control Centre : LACC

During the beginning stages of the operation, the system shall be controlled locally using computer base interlocking with control panel installed at station master room. However, the design shall be arranged to capable of being controlled remotely HatYai Local Area Control Centre Traffic (LACC) and local Satellite CTC located Thoung Song

In designing the building, the LACC It is considered easier to control the flow of traffic control is important. Function will be running everything as the CTC.

5.11.4 SIGNALLING DESIGN

a) Fixed signal design

Train operation control for fix signal design are generally separated into 2 sections which are (1) Signalling control in station area. (2) Signalling control in Block Section area.

- Signalling control in station area – Accommodate train running through or parking train at the station platforms for shunting or serving passengers with a convenient, safe and fast service. The Design consideration is based on Fail Safe System which means that in the case of failure the system is required to be safe. The fixed signal design is following the station layout principles with the minimum distance between the fixed signal posts not less than 1 kilometer.

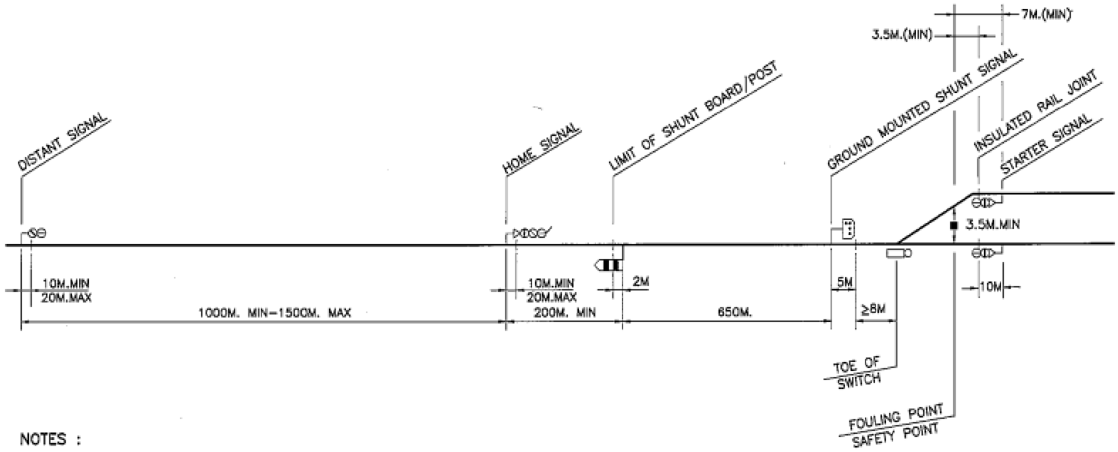


Figure 5.11.2-5 Signalling Spacing

The layout of the fixed signal details below.

- Train entering the station: Warner Signal, Outer Home signal, Inner Home Signal
- Train left the station: Starter Signal, Advance Signal

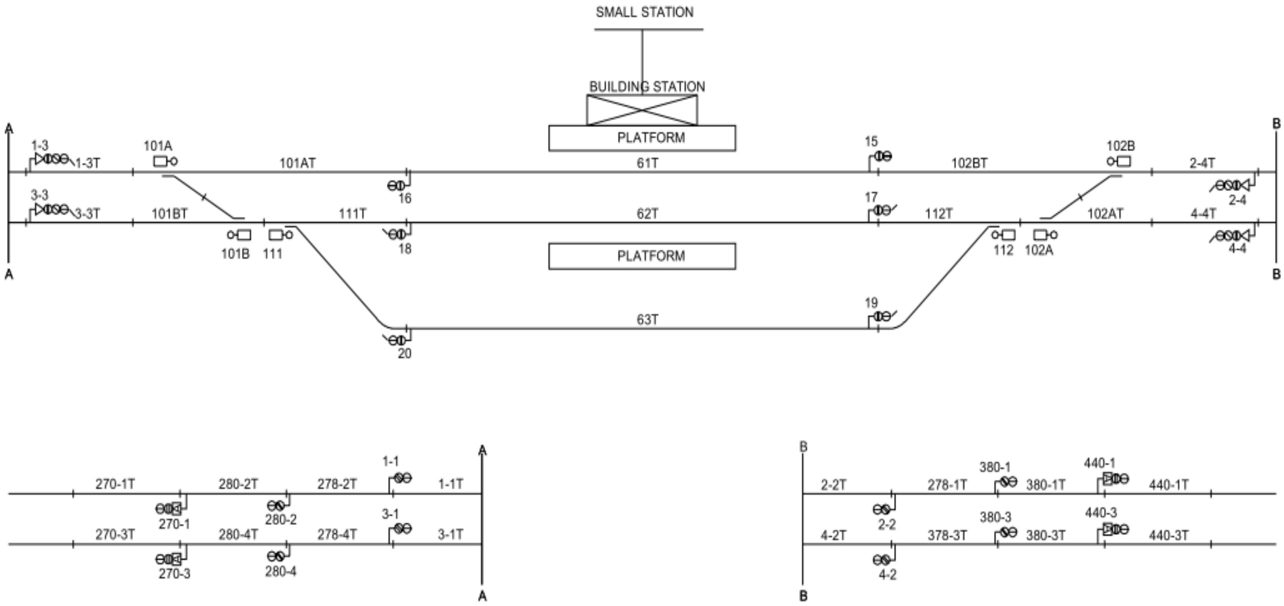


Figure 5.11.2-6 Signalling Layout for Small Station

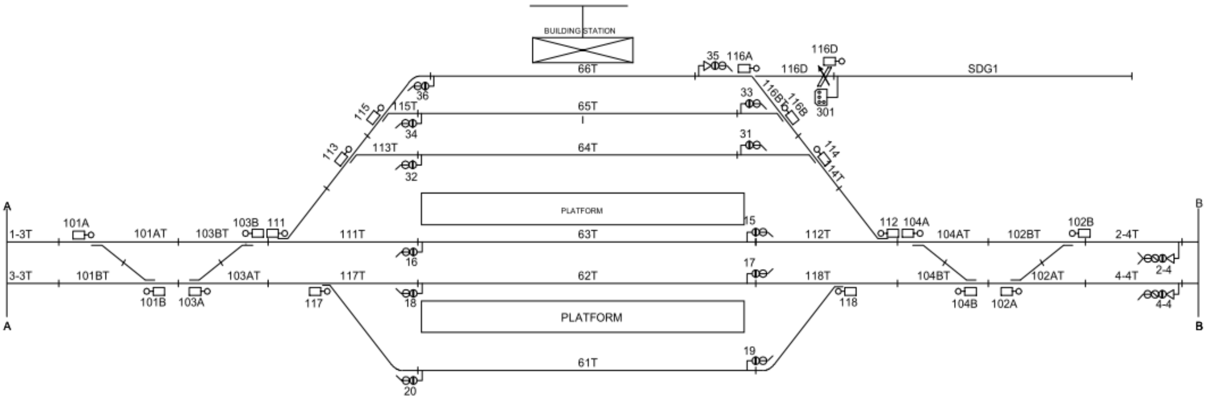


Figure 5.11.2-7 Signalling Layout for Large Station

- Block Section - are designed to be an absolute block section. And if the distance between the stations are more than 12 km, the intermediate block section will be added with the intermediate fixed signal at the halfway between stations The system are designed to accommodate the speed of 160 km/hr, hence, the train capability of running at 160 km/hr is allowed to run with such speed inside the block section by designing the intermediate signal with the control distance between fix signal and intermediate signal not less than the braking distance.

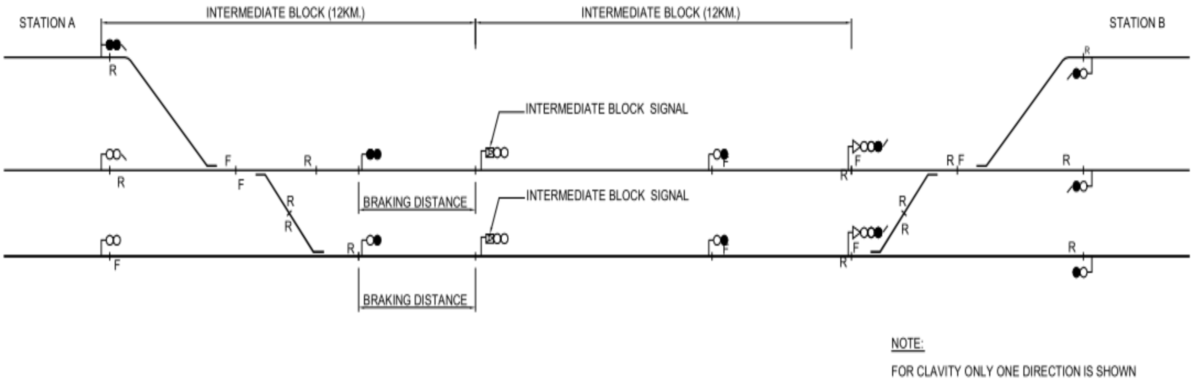


Figure 5.11.2-8 Signalling Layout for Block section

b) Bidirectional Operation

Signalling system is designed to serve the bidirectional operation to support the closure of the main line in the event of accident, maintenance, or emergency which required special train to operate.

Conclusion of Signalling Design

- Design the signaling system for the control of maximum train speed of 120 kph at station and 160 kph between stations.
- Signalling design will be based on 3-aspect Colour Light System and Upgraded to signalling control system under European Rail Traffic Management System (ERTMS) standards.
- Interlocking System is based on Computer Based Interlocking (CBI).
- Use LED signal instead of incandescent signals in this projects.

- Train Control for Southern Line is located at LACC Thoung Song.
- Designed signal post for Bi-directional system.

5.12 Detailed Work Plan

For the construction project of double track railway on Surat Thani – Hat Yai Junction – Songkhla, the Consultants have preliminarily scheduled for 6 years of the implementation period from 2559 B.E, for design phase to .2564 B.E. for project service and operation, as shown in **Table 5.12-1**.

Table 5.12-1 Project Implementation Plan

Item		Year of project implementation / B.E. year					
#NO	Description	Yr 1 2559	Yr 2 2560	Yr 3 2561	Yr 4 2562	Yr 5 2563	Yr 6 2564
1	Feasibility Study and Detailed Design						
2	Propose the project to relevant government agencies until the approval of land and expropriation decree.						
3	Auction for Construction Contractor						
4	Construction and Commissioning						
5	Service / Operation						

For the construction phase, the Consultants have specified main work tasks, and preliminarily scheduled for 4 years from the 3-rd to 6-th year of project implementation (2561-2564 B.E), as shown in **Table 5.12-2**.

Table 5.12-2 Tentative Detailed Work Plan

Item		B.E. 2561				B.E. 2562				B.E. 2563				B.E. 2564			
#No.	Description	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Site preparation, demolition existing utilities and others																
2	Earthwork																
3	Station yard and station access																
4	Railway bridge																
5	Station building and related building																
6	Culvert and drainage																
7	Utilities																
8	Trackwork																
9	Signaling and telecommunication																
10	Tunneling work																
11	Overpass, underpass and Railway Crossing																
12	Commissioning																

Chapter 6

Cost Estimation and Tender Document

Chapter 6

Cost Estimation and Tender Document

6.1 General Requirement for Median Cost Estimation

The construction cost is an important investment cost. Therefore, the Consultants have prepared the construction cost estimation based on the detailed drawings by carrying out the quantity take-off (survey) of construction items and materials, together with considering the construction technique and methodology. The quantities of works, which has been prepared in a form of Bill of Quantities and in calculating the unit rate of each item, are based on the guidelines of calculating Construction Price Median issued by the Ministry of Commerce in accordance with the Cabinet resolution on 13 March B.E. 2555. For items not particularly specified in the aforementioned document, the Consultant has adopted the price of materials from price list of manufacturer or supplier or price data from printed materials of manufacturer.

The construction cost estimation consists of 3 main sections, as follows:

(1) **Direct Cost** which comprises of material cost, equipment cost and labour cost, as follows:

(a) Material Cost

Material cost was generally obtained from the local areas where the Project passes, or some from price economic indices from Bureau of Trade and Economic Indices, Ministry of Commerce on the month and year when the price has been calculated. Some prices were from the quotation of manufacturers or suppliers of construction materials. The transportation costs is calculated based of the distance from the material source to construction site by using the rate from Department of Land Transport, Ministry of Transport based on the fuel price at that time.

(b) Equipment Cost

In large transport project, the price of equipment is an important component. As a result, there is a need for an expert with full knowledge of the work and deficiency of applications. The prices of such equipment/devices shall be closely evaluated, and including the cost of lost opportunities in the local and international market which may affect the Project Cost.

(c) Labour Cost

Labour cost was adopted from wages and machinery/plant rental record of Office of Budget Standard, Bureau of Budget, Ministry of Commerce. The machinery/plant was be calculated based on rental which already included the wage of machine/plant operator, fuel, maintenance and miscellaneous costs.

(2) **Indirect Cost** which is composed of cost of preliminaries, interest, profit and tax which has been calculated in the form of table, Table of Factor F.

Factor F is adopted from the guidelines in calculating the Construction Cost Median (Budget) provided by government agency in accordance with the Cabinet resolution on 13 March B.E. 2555 that has value of Factor F separated into the type of construction works, such as Building Works, Roadways Construction, Bridges and Viaducts Construction. These Factor F is part of costs of preliminaries, interest, profit and value added tax depending on the value of the construction works, construction period, advance payment, retention money and loan interest.

(3) **Special Expenses based on Terms and Conditions of Contract, and Other Necessary Expenses** which are the expenses to be incurred from undertaking in accordance with the terms and conditions of Construction Contract, cost of construction general support, cost relating to particular method or special equipment for construction works, and including other expenses necessary, such as site office, accommodations for the Employer or Engineer, dust protection, ground erosion protection, etc.

The data from material cost, labour cost and equipment cost are processed to be a unit rate in order to be multiplied by the quantity of work for each bill item and summed to be the direct cost of construction. Subsequently, direct cost is multiplied by Factor F, which results in Project Construction Cost.

The Consultants have adopted the construction price data of other projects similar to this project which is currently under construction in order to compare the unit prices. Therefore, from various aforementioned data when processed in calculating, the construction cost shall result to correct cost based on the guidelines (criteria) set-up by the government.

In estimating the construction cost, the Consultants have inquired the prices from both private and government sectors with similar nature of works for both currently under construction and already completed projects. In estimating the construction cost for each bill item, each type of work has back-up sheet showing clearly the quantities and unit prices and the summary completely together with the digital file of data which can be edited and adjust the construction cost from time to time. The construction cost estimate is prepared based on the criteria for calculation construction cost in accordance with the Cabinet resolution dated 13 March B.E. 2555 or the most update version in order to propose for approval of construction budget and to be the cost reference in considering the tenders as appropriate.

6.2 Summary of Estimated Construction Cost

The estimated construction cost for the project is 55,713,217,600 Baht (Fifty Five Billion Seven Hundred Thirteen Million Two Hundred Seventeen Thousand Six Hundred Baht Only) as summarized in **Table 6.2-1**.

Table 6.2-1 Estimated Construction Cost for Surat Thani – Hat Yai Junction – Songkhla

Unit : Baht

Item	Description	Cost	Factor F	Budget	Remark	
1	GENERAL REQUIREMENTS	4,247,359,958.000	1.0000	4,247,359,958.000	Factor F Condition	
2	EARTHWORKS	5,901,333,672.720	1.1581	6,834,339,672.740	- Advance	10%
3	ROADS AND STATIONS ACCESS	230,496,223.500	1.1581	266,938,252.170	- Retention	10%
4	RAILWAY STRUCTURES	7,368,252,231.000	1.1463	8,446,226,893.580	- Interest	6%
5	BUILDINGS WORKS	7,261,493,456.960	1.1765	8,543,145,766.010	- VAT	7%
6	CULVERTS AND DRAINAGES	876,287,020.000	1.1581	1,014,828,504.740		
7	UTILITIES	987,562,440.000	1.1581	1,143,696,061.760		
8	TRACK WORKS					
8.1	TRACKWORKS (Material and Installation)	7,339,103,925.200	1.1581	8,499,414,504.170		
8.2	Track Works -Machines	1,251,078,225.000	1.0700	1,338,653,700.750		
9	SIGNALLING AND TELECOMMUNICATIONS	4,627,963,745.780	1.1581	5,359,640,898.150		
10	TUNNELING WORKS	116,057,828.220	1.1463	133,037,199.040		
11	UNDERPASS AND OVERPASS STRUCTURES	8,624,214,514.000	1.1463	9,885,936,220.770		
	Sum	**48,831,203,240.380**		**55,713,217,631.880**		
	Total Budget			55,713,217,600.000		
	(Fifty Five Billion Seven Hundred Thirteen Million Two Hundred Seventeen Thousand Six Hundred Baht Only)					

6.3 Tender Document

The Consultants have prepared tender document and contract for the construction of Double Track Railway on Surat Thani – Hat Yai Junction – Songkhla Route by updating tender document of SRT's previous projects which are similar to this project. This shall result in the document with more details but based on the same standard.

The tender documents, prepared by the Consultants for this project, is made by incorporating terms and conditions of Electronic Government Procurement in the Office of Prime Minister Procurement Regulation B.E. 2549 and the regulation of SRT in B.E. 2544.

The tender document for this project consists of 5 main volumes, as follows:

Vol I: Tender Procedure Documents

IA: Instruction to Tenderers

- Letter of Invitation
- Terms of Reference (TOR)
- Electronic Procurement Document
- Prescribed Forms

IB: Condition of Contract

- Appendix A Contract Condition
- General Conditions of Contract
- Particular Conditions of Contract
- Special Conditions for Signalling and Telecommunication

Vol II: Technical and Pricing Data

IIA: Technical Data

- Schedule of Compliance with Specifications
- Specific Technical Responses
- Appendices C – OI Technical Details

IIB: Pricing Data

- Appendix B Estimate of Monthly Cash Flow of the Project
- Preamble to Bill of Quantity
- Bill of Quantity

Bill 1 General Requirements
Bill 2 Earthwork
Bill 3 Road and Station Access
Bill 4 Railway Structures
Bill 5 Building Works
Bill 6 Culvert and Drainage
Bill 7 Utilities
Bill 8 Trackwork
Bill 9 Signalling and Telecommunication
Bill 10 Tunnelling Works
Bill 11 Underpass and Overpass Structures

Vol III: Technical Specification

Section 1 General Requirements
Section 2 Earthwork
Section 3 Road and Station Access
Section 4 Railway Structures
Section 5 Building Works
Section 6 Culvert and Drainage
Section 7 Utilities
Section 8 Trackwork
Section 9 Signalling and Telecommunication
Section 10 Tunnelling Works
Section 11 Underpass and Overpass Structures

Vol IV: Drawings

Book 1: Horizontal Alignment
Book 2: Geotechnical, Drainage System and General Civil Works
Book 3: Trackwork, Telecommunication, Signalling
Book 4: Structure for Railway
Book 5: Stations and Other Facilities
Book 6: Railway Crossing
Book 7: Service Road, Station Access and Utilities

Vol V: Bill of Quantities with Estimated Median Cost