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TSTS

PREFACE

Dear Readers,

Welcome to the June-September issue of Volume 7 of our online peer-reviewed International Journal of the Society of Transportation and Traffic Studies (JSTS). This issue presents 5 papers covering a wide range of interesting topics. The first paper describes the Mechano-lattice analysis tool which has been successfully applied by the authors to predict pavement rutting and cracking. The second deals with the current hot issue of High Speed Rail in Thailand, in terms of making optimal decision as to when to invest in HSR. The third addresses the transport challenge in reducing poverty and the widening income inequality gap in Thailand. The fourth paper gives examples of road safety action including roundabouts, raised concrete median in Songkhla and describes the problems encountered in their implementation. In this issue, we present a practical paper on improving connectivity in ASEAN in order to help achieve the AEC's goals.

As always, we thank all authors who contribute to this double issue of our journal and we express our gratitude to members of the International Editorial Board and reviewers for their valuable comments and continued supports. A big thank must go to the Editorial staff under the guidance of Assoc. Prof. Dr Jittichai Rudjanakanoknad and Assoc. Prof. Dr Pawinee Iamtrakul and her hard working staff, especially Mr Gassana, and Mr Narabodee who worked tirelessly to get this issue out in good time. We trust our readers will enjoy and benefit from the articles in our online publication.

With Best wishes from all of us,

Professor Pichai Taneerananon
Chair of Editorial Board

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General Issue

THE EFFECT OF TRACTION ON GRANULAR PAVEMENT RUTTING

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Abstract: Pavement deterioration in the form of rutting and cracking has been studied by both empirical and theoretical methods. The Mechano-Lattice (ML) elasto-plastic stress-strain analysis has been shown to give close results to real pavement behavior on the road than many elastic stress-strain models. The ML analysis is capable of simulating a standard axle repeatedly traversing a pavement and is able to closely predict rutting and cracking life. This paper describes the simulation of braking on rutting using the ML analysis. The results of numerical analysis show that as traction or braking increase rutting greatly increases. In the case of B-Doubles truck, this is extreme.

Key Words: Mechano-Lattice Analysis, Pavement rutting, Cracking, Modulus

1. INTRODUCTION

The Mechano-Lattice Analysis assumes there is a linear relationship between plasticity and stress. If that restriction is adhered to it means braking or acceleration traction on the pavement surface has no effect on rutting.

Accordingly my reports to the then RTA through Unisearch Ltd in 2006 and 2007 ,under the direction of Peter Tamsett, included the effect of the increase of major principal stress and the laboratory determined non-linearity of the permanent strain to show that tractive forces applied to the surface of a pavement will increase the rate of rutting.

The present work is based on laboratory work done by ARRB under direction from AUSTROADS in which it was shown that mean stress was directly proportioned and octahedral stress was inversely proportional to the effective modulus in granular bases.

2. THE WORK ON GRANULAR BASES BY ARRB FOR AUSTROADS

In the first author’s report to the then RTA through Unisearch in 2009, the following was stated by him:-

In some forms of AUSTROADS pavement design procedure for granular based pavement moduli of some layers are adjusted as a function of the moduli of adjoining layers. Empirical methods are used. For instance, if the adjoining layers have lower moduli the

Modulus of the subject layer is reduced. That is because granular materials depend for their rigidity on the confining ability of their surroundings. This modulus adjustment increased the precision of the design and improves pavement life prediction precision also.

Mark Howard informed the first author that staff at the Australian Road Research board have devised an empirical relationship between an existing modulus and its transformation into a new usually lower modulus as a function of the pavement stress and the octahedral shear stress existing in that particular part of the pavement. See appendix A, (supplied by Mark Howard). The empirical constants in the expression were derived from experiments on road materials in triaxial tests. That heralds another significant advance in pavement design precision if it is incorporated in a design method.

Mark thought that the mechano lattice multi-layer analysis would be ideal for the inclusion of stress dependent moduli in pavement design.

The Pavements Section of the Road and Traffic Authority of NSW have sought further improvement by asking the first author to incorporate the AUSTROADS relationship into each of the 9000 ML elements in the mechano-lattice elasto-plastic stress-strain analysis, since this analysis simulates a standard axle repeatedly traversing a pavement and is able to predict rutting and cracking life. The author was also asked to carry out sensitivity analyses on the AUSTROADS formula and components, viz mean stress and octahedral shear stress. This was done by the first author (Yandell, 2009).

2.1 The Computational Program

It was decided to apply simulated standard single axles on pavements.

AUSTROADS Expression

The stress altered modulii for NSW Rhyolite according to the AUSTROADS expression is given by

$$E_{new} = C \text{ x } E_{old}[\underline{\text{mean stress/01}}]^{2.013} \text{ x [Oct shear stress/0.1]}^{-0.5} \quad \ldots\ldots\ldots\ldots (1)$$

So increases in mean stress tend to increase modulus while increases in octahedral shear stress tend to decrease modulus.

3. THE EFFECT OF MAXIMUM SHEAR STRESS AND MEAN STRESS UNDER THE WHEEL PATH ON RUTTING.

In this mechano-lattice study, instead of using the reciprocal of Octahedral Shear Stress, the Maximum Shear Stress under the wheel path was used in the expression used for modifying the modulus of the base courses.

I did use the inverse of Octahedral Shear stress in my report to the RTA dated 11 June 2009 but found longitudinal Maximum Shear Stress under a wheel path to be more relevant (Yandell, 2009a).

Figure 1 is a vertical longitudinal Maximum Shear Stress under one wheel path. The wheel rolls from right to left. It can be seen that the stress pattern is symmetric about the contact patch. The maximum shear stress is 225kPa. A grid with 20mm ML elements was used in this Standard Axle simulation to improve precision.

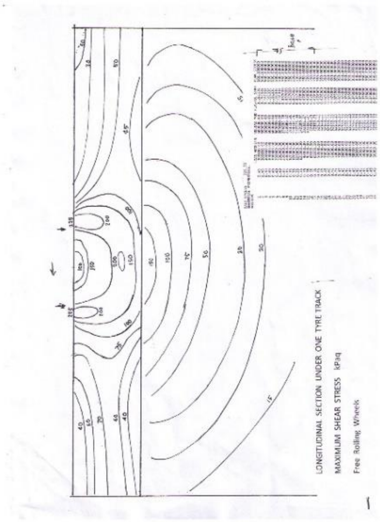


Figure 1 Vertical Longitudinal Maximum Shear Stress under one wheel path

Figure 2 is a longitudinal vertical stress pattern in which the standard rolling wheel was braked equivalent to a coefficient of friction of 1.00. It can be seen that the maximum longitudinal shear stresses near the contact patch have greatly increased from a maximum of 225 to a maximum of 700kPa.

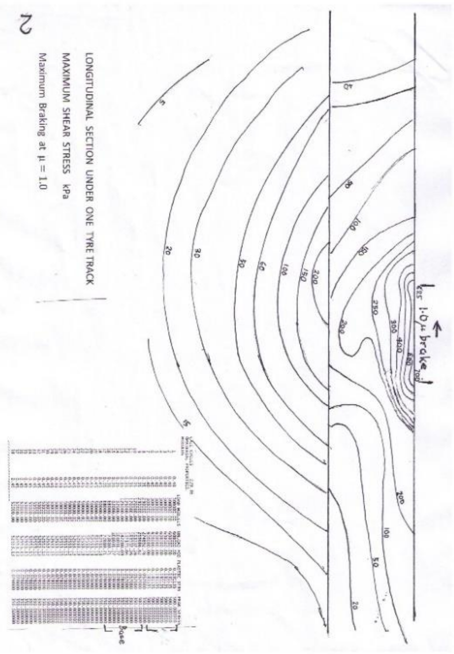


Figure 2 Longitudinal vertical stress pattern in which the standard rolling wheel

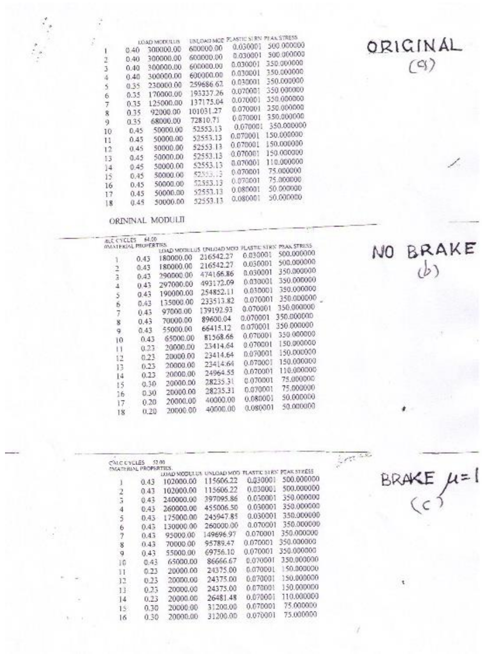
3.1 Modification of E modules using Maximum Longitudinal Shear Stress and Mean Stress

Figure 3 shows the original elastic and plastic properties of the granular pavement to be assessed. The top surface has a modulus of 300MPa. These values are used in the first rolling pass only to calculate the modified E values for the case:-

(a)	Free rolling	4(b)
(b)	0.1 μ brake	4(c)

The algorithm is assumed to be:-

$$E_{new} = E_{original} \text{ x } ([\text{Increase in mean stress})^{½} \text{ x } [[\text{Increase in max shear stress}]^{½}]^{-½}) \quad …… (2)$$



		LOAD MODULUS	UNLOAD MOD	PLASTIC STRN	PEAK STRESS
1	0.40	300000.00	600000.00	0.030001	500.000000
2	0.40	300000.00	600000.00	0.030001	500.000000
3	0.40	300000.00	600000.00	0.030001	350.000000
4	0.40	300000.00	600000.00	0.030001	350.000000
5	0.35	230000.00	259686.62	0.030001	350.000000
6	0.35	170000.00	193337.26	0.070001	350.000000
7	0.35	125000.00	137175.04	0.070001	350.000000
8	0.35	92000.00	101031.27	0.070001	350.000000
9	0.35	68000.00	72810.71	0.070001	350.000000
10	0.45	50000.00	52553.13	0.070001	350.000000
11	0.45	50000.00	52553.13	0.070001	150.000000
12	0.45	50000.00	52553.13	0.070001	150.000000
13	0.45	50000.00	52553.13	0.070001	150.000000
14	0.45	50000.00	52553.13	0.070001	110.000000
15	0.45	50000.00	52553.13	0.070001	75.000000
16	0.45	50000.00	52553.13	0.070001	75.000000
17	0.45	50000.00	52553.13	0.080001	50.000000
18	0.45	50000.00	52553.13	0.080001	50.000000

ORININAL MODULII

CALC CYCLES 64.00
MATERIAL PROPERTIES

		LOAD MODULUS	UNLOAD MOD	PLASTIC STRN	PEAK STRESS
1	0.43	180000.00	216542.27	0.030001	500.000000
2	0.43	180000.00	216542.27	0.030001	500.000000
3	0.43	290000.00	474166.86	0.030001	350.000000
4	0.43	297000.00	493172.09	0.030001	350.000000
5	0.43	190000.00	254852.11	0.030001	350.000000
6	0.43	135000.00	233513.82	0.070001	350.000000
7	0.43	97000.00	139192.93	0.070001	350.000000
8	0.43	70000.00	89600.04	0.070001	350.000000
9	0.43	55000.00	66415.12	0.070001	350.000000
10	0.43	65000.00	81568.66	0.070001	350.000000
11	0.23	20000.00	23414.64	0.070001	150.000000
12	0.23	20000.00	23414.64	0.070001	150.000000
13	0.23	20000.00	23414.64	0.070001	150.000000
14	0.23	20000.00	24964.55	0.070001	110.000000
15	0.30	20000.00	28235.31	0.070001	75.000000
16	0.30	20000.00	28235.31	0.070001	75.000000
17	0.20	20000.00	40000.00	0.080001	50.000000
18	0.20	20000.00	40000.00	0.080001	50.000000

CALC CYCLES 52.00
MATERIAL PROPERTIES

		LOAD MODULUS	UNLOAD MOD	PLASTIC STRN	PEAK STRESS
1	0.43	102000.00	115606.22	0.030001	500.000000
2	0.43	102000.00	115606.22	0.030001	500.000000
3	0.43	240000.00	397095.86	0.030001	350.000000
4	0.43	260000.00	455006.50	0.030001	350.000000
5	0.43	175000.00	245947.85	0.030001	350.000000
6	0.43	130000.00	260000.00	0.070001	350.000000
7	0.43	95000.00	149696.97	0.070001	350.000000
8	0.43	70000.00	95789.47	0.070001	350.000000
9	0.43	55000.00	69756.10	0.070001	350.000000
10	0.43	65000.00	86666.67	0.070001	350.000000
11	0.23	20000.00	24375.00	0.070001	150.000000
12	0.23	20000.00	24375.00	0.070001	150.000000
13	0.23	20000.00	24375.00	0.070001	150.000000
14	0.23	20000.00	26481.48	0.070001	110.000000
15	0.30	20000.00	31200.00	0.070001	75.000000
16	0.30	20000.00	31200.00	0.070001	75.000000

Figure 3 Original elastic and plastic properties of the granular pavement

The indices of the independent variables would have to be correlated empirically in the field.

In figure 4 it can be seen that wheel path rutting for 106 axle passes is:-

(i) 70mm using unaltered original modulii
(ii) 80mm for the rolling wheels
(iii) 500mm for the μ = 1.0 braked wheels

That means if engine braking only is used, two driving axles stopping 6 axles would only contribute in effect 0.33 equivalent coefficient of friction if each wheel is braked. This may contribute insufficient retardation in some circumstances.

If the actual coefficient of friction was only 0.5 skidding and loss of control could occur.

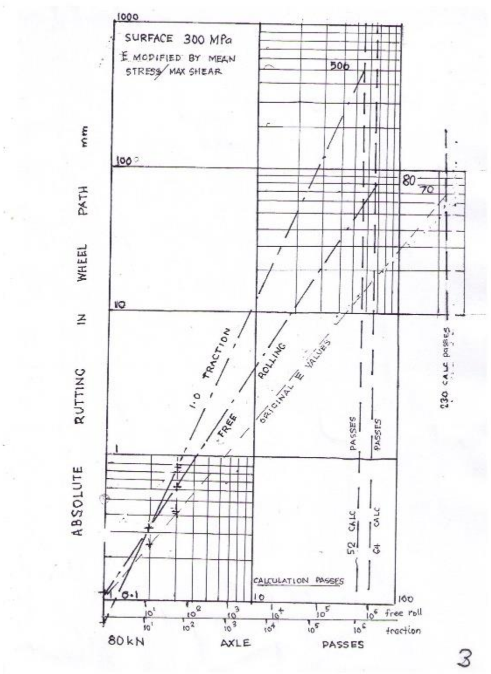


Figure 4 Wheel path rutting for 106 axle passes

For pulling on a pavement with a coefficient of friction of 0.5 the maximum uphill gradient would be 16% (one in 6).

Apart from this, rutting after 106 passes would be 6 times as great as with free rolling passes.

3.2 Modification of E Modulus using Maximum Longitudinal shear stress only.

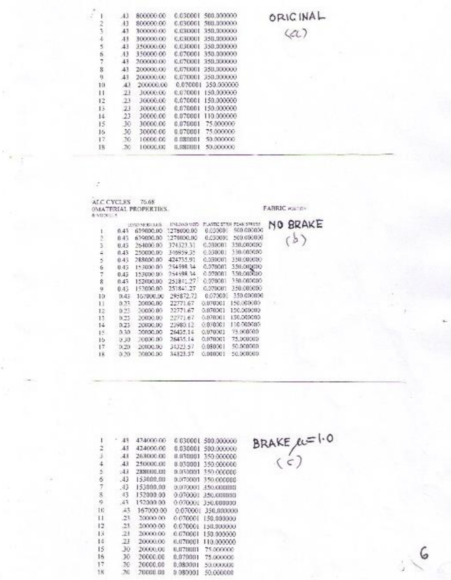
The algorythm is assumed to be

$$E_{new} = E_{original} \times ([\text{increase in Max shear Stress}]^{-1/2}) \times 2.5 \quad \ldots\ldots(3)$$

Figure 5 shows the original elastic and plastic properties of the granular pavement with a top surface modulus of 800MPa. These values are used in the first rolling pass only in order to compute the modified E values for:-

(a) Free rolling 6(b)

(b) 0.1 µ Brake 6(c)



ORIGINAL (a)

1	.43	800000.00	0.030001	500.000000
2	.43	800000.00	0.030001	500.000000
3	.43	300000.00	0.030001	350.000000
4	.43	300000.00	0.030001	350.000000
5	.43	350000.00	0.030001	350.000000
6	.43	350000.00	0.070001	350.000000
7	.43	200000.00	0.070001	350.000000
8	.43	200000.00	0.070001	350.000000
9	.43	200000.00	0.070001	350.000000
10	.43	200000.00	0.070001	350.000000
11	.23	30000.00	0.070001	150.000000
12	.23	30000.00	0.070001	150.000000
13	.23	30000.00	0.070001	150.000000
14	.23	30000.00	0.070001	110.000000
15	.30	30000.00	0.070001	75.000000
16	.30	30000.00	0.070001	75.000000
17	.20	10000.00	0.080001	50.000000
18	.20	10000.00	0.080001	50.000000

ALC CYCLES 76.68
0MATERIAL PROPERTIES.
FABRIC
NO BRAKE (b)

		LOAD MODULUS	UNLOAD MOD	PLASTIC STRN	PEAK STRESS
1	0.43	639000.00	1278000.00	0.030001	500.000000
2	0.43	639000.00	1278000.00	0.030001	500.000000
3	0.43	264000.00	374323.31	0.030001	350.000000
4	0.43	250000.00	348959.35	0.030001	350.000000
5	0.43	288000.00	424735.91	0.030001	350.000000
6	0.43	153000.00	254598.34	0.070001	350.000000
7	0.43	153000.00	254598.34	0.070001	350.000000
8	0.43	152000.00	251841.27	0.070001	350.000000
9	0.43	153000.00	251841.27	0.070001	350.000000
10	0.43	167000.00	295872.73	0.070001	350.000000
11	0.23	20000.00	22771.67	0.070001	150.000000
12	0.23	20000.00	22771.67	0.070001	150.000000
13	0.23	20000.00	22771.67	0.070001	150.000000
14	0.23	20000.00	23980.12	0.070001	110.000000
15	0.30	20000.00	26435.14	0.070001	75.000000
16	0.30	20000.00	26435.14	0.070001	75.000000
17	0.20	20000.00	34323.57	0.080001	50.000000
18	0.20	20000.00	34323.57	0.080001	50.000000

BRAKE µ=1.0 (c)

1	.43	424000.00	0.030001	500.000000
2	.43	424000.00	0.030001	500.000000
3	.43	263000.00	0.030001	350.000000
4	.43	250000.00	0.030001	350.000000
5	.43	288000.00	0.030001	350.000000
6	.43	153000.00	0.070001	350.000000
7	.43	153000.00	0.070001	350.000000
8	.43	152000.00	0.070001	350.000000
9	.43	152000.00	0.070001	350.000000
10	.43	167000.00	0.070001	350.000000
11	.23	20000.00	0.070001	150.000000
12	.23	20000.00	0.070001	150.000000
13	.23	20000.00	0.070001	150.000000
14	.23	20000.00	0.070001	110.000000
15	.30	20000.00	0.070001	75.000000
16	.30	20000.00	0.070001	75.000000
17	.20	20000.00	0.080001	50.000000
18	.20	20000.00	0.080001	50.000000

6

Figure 5 Original elastic and plastic properties of the granular pavement with a top surface modulus of 800MPa

In figure 6 it can be seen that wheel path rutting for 106 standard axle passes is:-

(i) 50mm using unaltered elastic modulii

(ii) 80mm for free rolling wheels

(iii) 150mm for the µ = 1.0 braked wheels

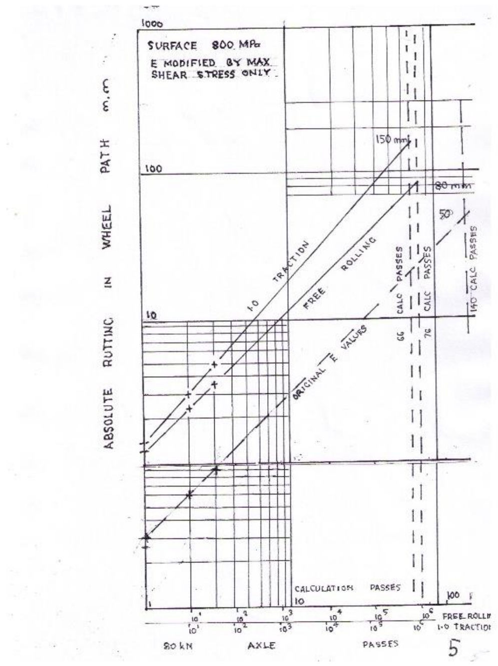


Figure 6 Wheel path rutting for 106 standard axle passes

4. CONCLUSIONS

The algorithm used in equation 2 is in line with the ARRB relationship shown in equation 1, so has some empirical credibility.

Further work would require correlation with field work to determine coefficients and indices.

This numerical analysis has shown that as traction or braking increase rutting greatly increases. In the case of B-Doubles this is extreme.

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HIGH SPEED RAIL: IT'S TIME FOR ACTION IN THAILAND

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Abstract: This paper describes economic indicators for deciding when would be the right time to invest in High-Speed-Rail in Thailand. Selected case studies from four countries, Japan, China, Korea and Taiwan were used to guide Thailand's massive HSR investment. Overview of the HSR system was described in terms of indicators for investment decision comprising indicator on percentage of project cost/GDP in the year of investment decision, and indicator on average fare/GDP per capita in the year of service opening. The paper discusses issues concerning HSR project between Bangkok and Nakhon Ratchasima in terms of funding and affordability based on the cases from the four selected countries. The results show that HSR projects in Thailand should select investment model based on the case of Japan and fare based on the case of Korea and Taiwan, and investment should start as soon as possible in order to benefit from increased competitiveness in ASEAN and the world.

Key Words: Economic Indicators, High-Speed-Rail Investment

1. INTRODUCTION

High-Speed Rail (HSR) projects of Thailand had been subjected to feasibility study for investment plans under the former Prime Minister Ms. Yingluck Shinawatra's government and the parliament approved a bill to borrow US$ 68 billion to upgrade transport infrastructure projects. Four HSR corridors were proposed in the investment plans over the 18-year project duration from 2015 to 2032. Results of feasibility study in 2012 showed that the initial line of HSR from Bangkok to Ban-Pachi in Ayutthaya province should start bidding for construction in 2014. Construction budget of HSR with running at top speed 250 km/h on standard track was estimated at US$ 843 million for a total length of 54 km. or US$ 15.6 million/km (Bangkok Post, 2013).

Unfortunately, under the ongoing political conflict condition, HSR projects were frozen by the judgement of the Constitutional Court which canceled the draft borrowing act US$ 68 billion on March 2014. However, HSR projects were considered again in Prime Minister Gen. Prayuth Chan-ocha's government after 1 year from the seizure of power from the previous government. On March 2016, the government decided to select HSR line project from Bangkok to Nakhon Ratchasima for initial construction. This project was estimated at US$ 5 billion for 250 km. length or US$ 20 million/km. and fare was about US$ 15.6 per trip. Bangkok-Klang Dong in Nakhon Ratchasima was selected to be the first construction section with a distance of 3.5 km. and was estimated at US$ 59 million or US$ 17 million/km. The joint committee on the Thai-Chinese train cooperation agreed to the construction and funding by Thailand and train technology to be supplied by China (Bangkok Post, 2016).

Currently, Thailand is facing an economic slowdown. Growth rate of GDP and GDP/capita between 2014 and 2015 were decreased to 2.3% and 2.5%, respectively (www.Knoema.com, 2016). Nevertheless, the government decides to invest in HSR projects although the rate of projects cost/km. is 28% higher than the rate calculated during the previous government. The constraints on government budget for investment in mega-projects which are concern is that HSR will create a huge public debt that would exceed the debt ceiling at 60% of GDP.

2. OBJECTIVES

The objectives of this paper are to review the economic situation and appropriate time to invest in HSR project in Thailand based on the experience of Japan, Korea, Taiwan and China.

3. GLOBAL EXPRERIENCE OF HSR INVESTMENT

Currently, HSR has been operated in many countries such as France, Spain, and Germany in Europe, Japan, Korea, Taiwan and China in Asia. Moreover, some countries have investment plan to upgrade existing rails to HSR such as India, Russia, Brazil and Canada or plan for construction the new HSR lines such as China, USA and Thailand (Qin Y., 2014). HSR projects require the huge budgets for investment. Therefore, before making such huge investments, the value of economic impact and sustainable benefits should be first evaluated over the time frame of the project.

Japan, Korea, Taiwan and China were selected for learning experience of HSR investment. GDP and GDP/capita are the indicators of economic criteria for investment decision by comparing the ratio of project cost/GDP in the year of decision, the ratio of project cost/GDP/1,000km. And the ratio of average fare/GDP per capita in the year of service opening of countries (Morichi S, 2011). (See details in Table 1)

Table1. Indicators for HSR investment decision

Description	Selected Country			
	Japan	**South Korea**	**Taiwan**	**China**
HSR route	Tokyo-Osaka	Seoul-Busan	Taipei-Zuoying	Wuhan-Guangzhou
Route length, km.	500	412	345	989
Project cost[1]	380 billion Yen (1959)	10.74 trillion Won (1993)	445 billion NT$ (1999)	116.6 billion CNY (2005)
One-way fare[2]	3,000 Yen (1964)	44,800 Won (2004)	1,490 NT$ (2007)	490 CNY (2009)
GDP	13,190 billion Yen	290.70 trillion Won	9,649 billion NT$	18,589.58 billion CNY
GDP/capita	303,979 Yen	17,212,945 Won	562,344 NT$	25,963 CNY
Project cost/GDP, %	2.9%	3.7%	4.6%	0.63%
Project cost/GDP/1,000 km, %	5.8%	9.0%	13.3%	0.6%
Avg.fare/GDP per capita[3], %	0.99%	0.32%	0.38%	0.95%

Remark: [1]in the year of investment decision, [2]in the year of service opening, [3]Average fare for distance 500 km.

Source: Morichi S., 2011

Table 1 shows that the ratio of project cost in the year of investment decision/GDP of the selected countries were increased following the year of investment decision. HSR in China showed the lowest ratio of 0.63% of project cost/GDP in 2005 due to low labour costs and domestic capacity to manufacture construction equipment (Shukla, P.R., Pathak, M., Mittal, S. and Dhar, S., 2015). On the other hand, the ratio of project/GDP of Taiwan showed the highest rate at 4.6% because the Taiwanese government selected to the Build-Operate-Transfer (BOT) funding model by sharing the proportion of investment by both private investors at 79.4% and government at 20.6% of the total project cost (www.hsr.gov.tw). However, most HSR systems in the world were constructed and operated by financial subsidy from governments. In addition, the average fare/GDP per capita showed two groups of indicators; group 1 Japan (0.99%) and China (0.95%) and group 2 South Korea (0.32%) and Taiwan (0.38%) that were measured by economic growth of countries. In the case of Japan and China, HSR systems have begun operation at early stages of economic development. In contrast, South Korea and Taiwan have started operation of HSR when GDP/capita has already indicated an adequate economic development stage (Takeshita H., 2012). (See in Figure 1)

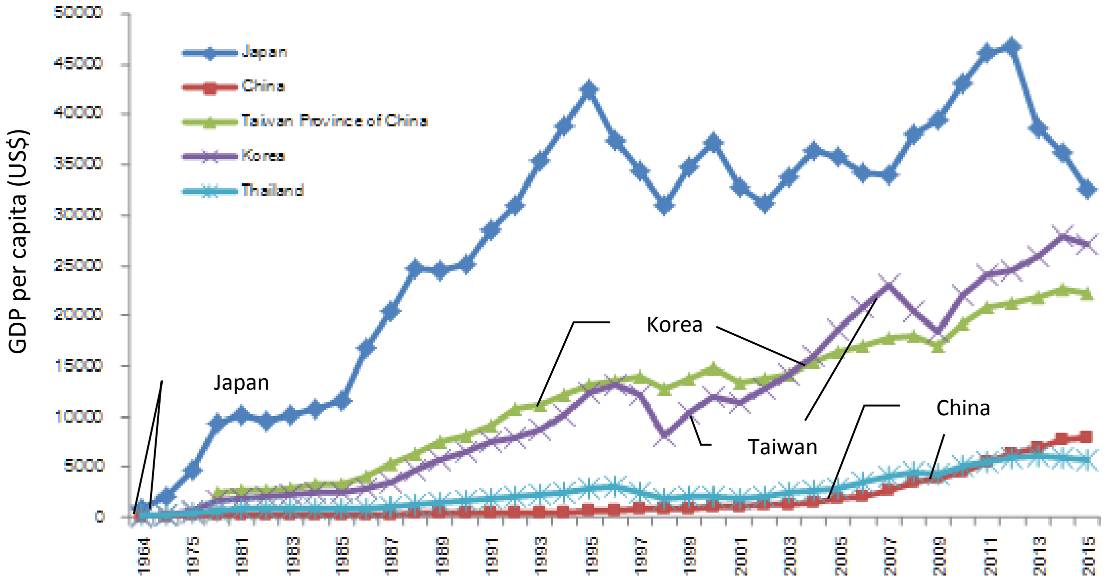

Figure1. GDP per capita during 1964-2015 and GDP per capita in the year of investment decision and service opening of four countries
Source: www.knoema.com, 2016

4. ECONOMIC INDICATORS FOR DECIDING WHEN TO INVEST IN HSR IN THAILAND

As mentioned above, HSR in Thailand will start the bidding process in August 2016 and construction for the 3.5 km. of Bangkok-Klang Dong section in September 2016 and expand to 250 km. to Nakhon Ratchasima in the future. Project investment was estimated at US$ 17-20 million/km. Funding and affordability of HSR projects in Thailand will be analyzed by using the indicators based on the experience of the four selected countries. Details of the analysis are shown in Tables 2, 3 and 4 and Figures 2, 3 and 4.

Table 2 shows possible investments in Thailand based on the cases of Japan, China, South Korea and Taiwan. Indicators of project, cost/GDP in the year of investment decision of selected countries are used to forecast the possible investment cost in Thailand during

2016-2020. GDP and GDP per capita of Thailand were as forecasted by the IMF World Economic Outlook (WEO) under normal political situation. The result of analysis showed that possible investment for Thai HSR project based on China experience is the lowest cost at US$ 2.58 billion in 2016 and will increase depending on growth rate of GDP per year. For the case based on Taiwan model, the analysis showed highest investment cost at US$ 18.85 billion in 2016 and will increase to US$ 22.29 billion if the government decide to start HSR project in 2020.

However, based on Japan model, the possible cost of HSR investment for Thailand during 2016-2017 appears to be close the estimated cost made by Thai government. The HSR investment (Bangkok-Nakhon Ratchasima) was estimated at US$ 5 billion for a route length of 250 km. or US$ 10 billion for 500 km. length, the reason for the 599 km length is that the indicator for project: cost/GDP was calculated based on 500 km. route length.

The investment cost of HSR was estimated at US$ 20 million/km. Although the possible HSR investment based on Japan model is reasonable in 2016 but it is clear that the cost is higher than the cost estimated by Thai government by about 19% in the same year. (See in Table 3 and Figure 2)

Table 4 and Figures 2and 4 showed potential HSR fare and HSR fare/km. which the potential average fare based on the case of Korea is lowest at US$ 19.01 followed by the case of Taiwan at US$ 22.57 in 2016. Furthermore, the HSR fare based on the cases of Korea and Taiwan are cheaper by about 2.5 – 3 times of the fare based on the cases of Japan and China. However, the fare of HSR project between Bangkok to Nakhon Ratchasima was estimated at US$ 0.06 per km. which is in the same range of potential average fare as in the case of Korea and Taiwan. Table 4 showed that potential HSR fare based on the experience of the four countries are almost constant throughout the four forecasted years. The estimated HSR fare was confirmed by a study of the willingness to pay HSR fares which was conducted for the HSR route between Bangkok to Surat Thani and Bangkok to Hat-Yai in 2012; the result showed that respondents were willing to pay a fare of US$ 0.06 per km (Chantruthai P., Taneerananon S., and Taneerananon P., 2012).

Table2. Potential HSR investment in Thailand based on experience of selected countries during 2016-2020

Year	GDP*	Growth rate of GDP	Potential HSR investment (billion US$)			
			Indicator: Percentage of project cost/GDP			
			Japan	China	Korea	Taiwan
	billion US$	%	2.9	0.63	3.7	4.6
2016	409.7	-	11.88	2.58	15.16	18.85
2017	428.8	4.7	12.44	2.70	15.87	19.72
2018	442.8	3.3	12.84	2.79	16.38	20.37
2019	462.8	4.5	13.42	2.92	17.12	21.29
2020	484.6	4.7	14.05	3.05	17.93	22.29

Remark: *Forecast by IMF World Economic Outlook (WEO), April 2016
Source: IMF World Economic Outlook (WEO), 2016

Table3. Potential HSR investment/km. in Thailand based on experience of selected countries during 2016-2020

Year	GDP*	Growth rate of GDP	Potential HSR investment/km. (million US$/km.) Indicator: Percentage of project cost/GDP/1,000 km.			
			Japan	China	Korea	Taiwan
	billion US$	%	5.8	0.6	9.0	13.3
2016	409.7	-	23.76	2.62	36.87	54.49
2017	428.8	4.7	24.87	2.74	38.59	57.03
2018	442.8	3.3	25.68	2.83	39.85	58.89
2019	462.8	4.5	26.84	2.96	41.65	61.55
2020	484.6	4.7	28.11	3.10	43.61	64.45

Remark: *Forecast by IMF World Economic Outlook (WEO), April 2016
Source: IMF World Economic Outlook (WEO), 2016

Table4. Potential HSR fare and fare/km. in Thailand based on experience of selected countries during 2016-2020

Year	GDP/capita*	Growth rate of GDP/capita	Average fare for distance 500 km. & average fare/km. (US$) Indicator: Percentage of average fare/GDP per capita							
			Japan (0.99)		China (0.95)		Korea (0.32)		Taiwan (0.38)	
	US$	%	US$	US$/km	US$	US$/km	US$	US$/km	US$	US$/km
2016	5939.6	-	58.80	0.12	56.43	0.11	19.01	0.04	22.57	0.05
2017	6205.3	4.5	61.43	0.12	58.95	0.12	19.86	0.04	23.58	0.05
2018	6400.8	3.2	63.37	0.13	60.81	0.12	20.48	0.04	24.32	0.05
2019	6682.3	4.4	66.15	0.13	63.48	0.13	21.38	0.04	25.39	0.05
2020	6992.5	4.6	69.23	0.14	66.43	0.13	22.38	0.04	26.57	0.05

Remark: *Forecast by IMF World Economic Outlook (WEO), April 2016
Source: IMF World Economic Outlook (WEO), 2016

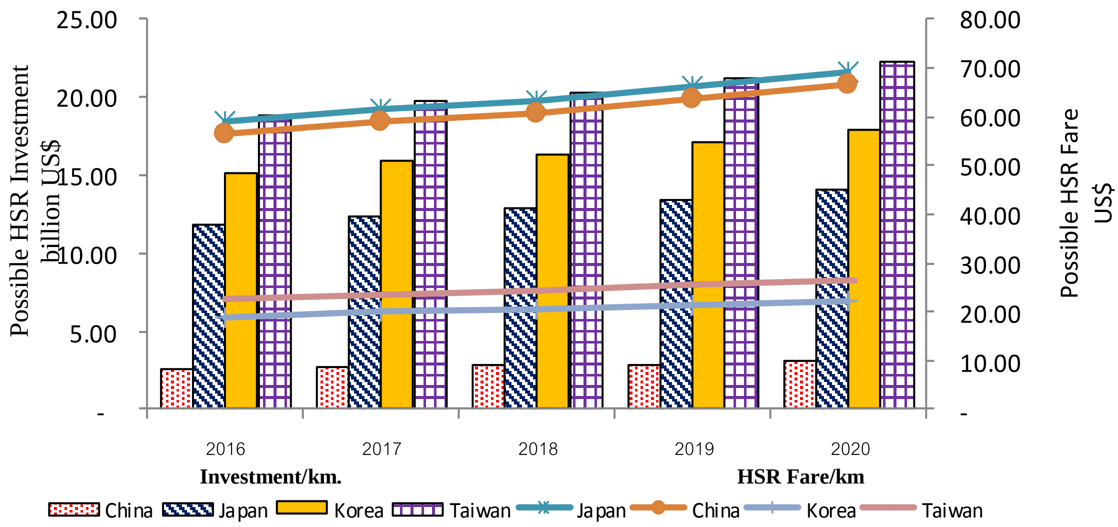

Figure2. Potential HSR investment and fare in Thailand based on the experience of selected countries during 2016-2020

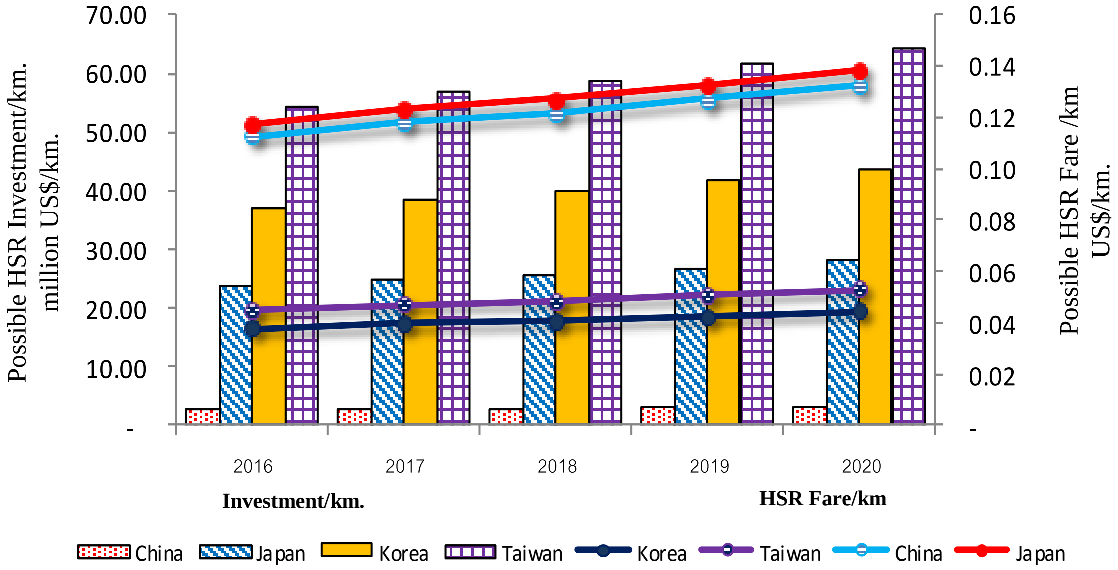

Figure3. Potential HSR investment cost/km. and fare/km. in Thailand based on experience of selected countries during 2016-2020
Source: IMF World Economic Outlook (WEO), 2016

It is well known that infrastructure development is a key step that needs to be taken to increase GDP per capita of countries. HSR project is thus important to national development as it can enhance the capacity of the national competitiveness. Figure 4 showed relationship between quality of infrastructure and GDP/capita of five countries: Japan, China, Korea, Taiwan and Thailand in 2006, 2012 and 2015. Four of the five countries except Thailand have operated HSR. It is seen that the growth in GDP/capita increases with the quality of infrastructure significantly. Although China has GDP/capita level similar to Thailand but score of the quality of infrastructure in China was increased steadily from 3.4 in 2006 and up to 4.73 in 2015.

On the other hand, the growth of GDP/capita in Thailand between 2012 and 2015 showed the rate of decline at 1.8% and score of the quality of infrastructure decreased from 4.9 in 2012 to 4.62 in 2015. As mentioned above, for HSR projects in Thailand, investment should start as soon as possible to enhance the country's competitiveness.

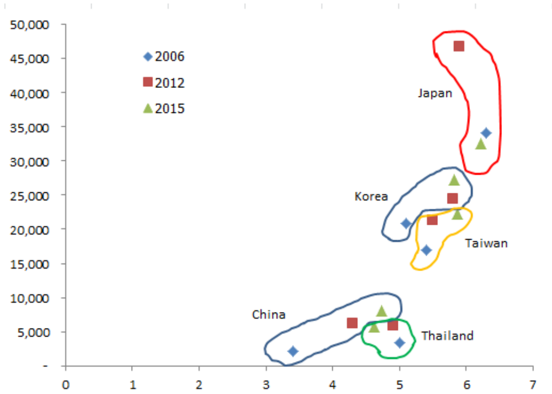

Figure4. Relationship between quality of infrastructure and GDP/capita for 2006, 2012 and 2015
Source: World Economic Forum
Remark: Score 1= extremely underdeveloped; 7= extensive and efficient by international standards

5. CONCLUSIONS

The level of economic development of a country is an important indicator for deciding when would be the right time to make investment in HSR projects. Lesson learnt from the countries with experience in operating HSR has been used as basis for making decision to invest in HSR project in Thailand. The analysis shows that now is the right time to invest. Delay in starting HSR projects will result in increase of cost to a point that the projects may not be feasible and not worthy of investment.

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REDUCING THAILAND'S POVERTY AND INEQUALITY GAP: A TRANSPORT CHALLENGE

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Abstract: Despite major progress in poverty reduction by successive governments, Thailand's poverty has persisted at a significant 10.9% or some 7.3 million people in 2013. This is a large percentage when compared to Malaysia, where the number of poor people was only 0.6% of the total population. The problems faced by the poor are multidimensional, although income poverty is crucial, it is all other dimensions as mentioned in the Multidimensional Poverty Index that have great impacts on their lives. For Thailand, a long and healthy life, and a decent standard of living are in great need of improvement. The inequality in the country has widened as measured by the ratio of the income of the riches 10% to the income of the poorest 10% while the GINI coefficient has remained relative the same over the past few years. As provision of transport plays a major role in poverty eradication, and inequality mitigation, this paper addresses the transport challenge that would have a significant impact in reducing Thailand's poverty and inequality of the people in both rural and urban settings. Two policy suggestions were put forward to help improve the living standard of the poor as well as to reduce the inequality between Bangkok and the regions of Thailand. They are the provision of basic bus service from village to town to address the plight of the 4.9 million rural poor, and the provision of urban bus service in regional cities to enhance the quality of life of the urban poor.

Key Words: Poverty, Inequality, Accessibility, Transport

1. INTRODUCTION

Global Agenda for Sustainable Development

The UN has recently launched the 2030 Agenda for Sustainable Development. The document, adopted by 193 countries on 25th of September 2015 came into effect on 1 January2016. It sets out new 17 Goals and 169 targets which will guide all actions and decisions of countries and the UN over the next15 years. At the top of the Agenda is the eradication of poverty in all forms and dimensions, as everyone agreed that poverty is the greatest global challenge and an indispensable requirement for sustainable development (UN Agenda 2030, (2016)). It is well accepted that poverty has many dimensions, other than just income poverty. The concept was first introduced by UNDP in 1997 (UNDP, 1997) and later supplanted in 2010 (UNDP, 2015) which proposed the Multidimensional Poverty Index as "A composite index measuring deprivations in the three basic dimensions captured in the human development index — a long and healthy life, knowledge and a decent standard of living". Therefore, it is useful to list all the Sustainable Development goals as a reminder when dealing with the important issue of poverty eradication as follows:

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and adequate nutrition for all, and promote sustainable agriculture
3. Attain healthy life for all at all ages

4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable, and modern energy services for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

As mentioned above, the multidimensional nature of poverty addresses the deprivation of a long and healthy life, knowledge and a decent standard of living, To attain an acceptable level of the above three elements, it is clear that affordable and safe transport must be made available for the poor, as the inadequate provision or unavailability of transport will act as a barrier to their participation in health, education and economic activities which will empower them to get out of the poverty they are in. One of the major problems is their accessibility to transport, particularly the public transport. In provincial areas the so called public transport is grossly inadequate while the provision of road infrastructure has made significant impacts on poverty reduction the short fall or in some areas lack of public transport has led people to fend for themselves. Many buy motorcycles but the poor and the elderly could not afford and could not ride the machine. In a previous paper, the impact of transport on improving poverty situation of villages in Thailand through the provision of better infrastructure was investigated (Taneerananon, 2015). In this paper, the need and means of transport of the poor and the aged in both rural and urban areas are examined.

2. THAILAND'S POVERTY AND INEQUALITY SITUATION

2.1 Poverty

The Asian Development Bank stated recently that "Despite the extraordinary gains made in living standards in Asia and the Pacific, hundreds of millions are still excluded from the benefits of rapid economic growth. Without access to basic social services, they are vulnerable to illness, unemployment …." (ADB, 2016). Of those hundreds of millions, many millions in Asia could be classified as poor in terms of health, knowledge and a decent standard of living, for Thailand alone, the number of people classified as poor are over 7 million in 2013. According to the World Bank Thailand's poverty situation has improved over the past three decades, declining from 67% in 1986 to 11% in 2014 as incomes have risen. This was brought about by sustained growth in the economy which grew at an average annual rate of 7.5 percent in the late 1980s and early 1990s, creating millions of jobs that helped pull millions of people out of poverty. The continued economic growth has turned Thailand into an upper-middle income country in 2011, with a per capita Gross National Income of 4,210 US$ (World Bank, 2016). However, despite impressive growth, poverty and inequality continue to pose significant challenges for the government; particular over the past few years as a result of very slow economic growth, and falling agricultural prices. A 2015 report by the Office of Thailand National Economic and Social Development Board shows that for 2013, the poverty challenge remained significant at 10.9% of the Thailand population, or 7.3 million people, despite an improvement from 12.6% in 2012. The 7.3 million are people living under the national poverty line of 2,572 Baht (~ 73.5 US$ at 1$=35 Baht). If 10.1% of the 'Nearly poor' were taken into account, these are the people who live within 20% above the poverty line, and who are vulnerable to suddenly become poor as a result of accidents, natural disasters, health problem which render them incapable of working, the total would be 21% or 14 million people (NESDB, 2014, 2015). As deaths from road accidents are not uncommon in Thailand, the death of a bread winner can send a family into sudden poverty (Taneerananon and Laksanakit, 2015). Table 1 gives details of the poor and the nearly poor people in Thailand over the past 26 years.

Table 1: Percentages and Number of the Poor and Nearly Poor for 1988-2013

Year	Percent. of Poor	Percent. of Nearly Poor	No. Poor x1000	No. Nearly Poor x1000
1988	65.3	9.7	34,198	5,100
1990	58.1	11.1	31,683	6,038
1992	50.1	12.0	27,826	6,647
1994	42.7	12.4	24,134	6,997
1996	35.3	13.0	20,321	7,501
1998	38.7	12.9	22,719	7,574
2000	42.6	13.1	25,516	7,842
2002	32.5	13.4	19,621	8,101
2004	26.9	13.2	16,424	8,094
2006	22.0	11.7	13,720	7,288
2007	20.1	12.1	12,677	7,627
2008	20.5	11.7	13,081	7,451
2009	17.9	11.3	11,634	7,343
2010	16.4	11.4	10,812	7,531
2011	13.2	11.5	8,757	7,637
2012	12.6	10.8	8,388	7,183
2013	10.9	10.1	7,305	6,727

Source: Modified from NESDB Report on poverty and inequality 2015

2.2 Inequality

A recent study by IMF indicates that globally, inequality has increased and become a widespread concern in both developed and developing countries and has gained considerable attention of world leaders; President Obama called widening income inequality the "defining challenge of our time"(IMF, 2015).The study explained why inequality matters in terms of both moral and economic values. As equality, like justice, is an important value in most countries, regardless of ideology, culture or religion, the lack of it can mean a persistent disadvantage for the poor and the middle income group of a society. In terms of economic prosperity of a country, the study found that widening inequality has significant implications for growth and macroeconomic stability. The study found that because the poor and the middle class are most important for growth via a number of interrelated economic, social, and political channels, it suggested that focussing policies on the poor and the middle class could mitigate inequality. Among the recommendations are better access to education and health care and well-targeted social policies which the study found could help raise the income share for the poor and the middle class.

Thailand is not immune to the inequality challenge, past and present governments have continued to address the challenge, particularly the income inequality. The Office of National Economic and Social Development Board has in 2015 published the latest report on inequality situation in Thailand for the year 2013 which is before the current military government took control of the country in 2014. The report shows that the situation of income distribution has improved slightly as measured by the value of GINI coefficient which decreases from 0.484 in 2011 to 0.465 in 2013. However, if one looks over the past 26 years, the GINI coefficient has not shown much improvement, with a value of 0.487 in 1988, vs 0.465 in 2013. The gap of income inequality has widened over the 2011-2013 period with the richest 10 % earned 36.8% of the total incomes while the poorest 10% earned a meagre 1.1% of the total. In other word, the riches 10% earned about 34.9 times of that earned by the poorest 10%. Compared with the 25.2 times difference in earning between the two groups in 2011, it is clear that the income inequality gap has widened significantly (NESDB, 2015). The report made a number policy recommendations to address the inequality concerns including the inequality in opportunity to access basic government services such as education and health, access to welfare for the age and people with disabilities, and access to employment. It should be emphasized here that to access the above mentioned services, the poor, the elderly and the disadvantaged need to first have access to affordable and safe public transport. The transport challenges are further described.

3. TRANSPORT CHALLENGES TO REDUCE POVERTY AND INEQUALITY

3.1 A Real Life Case

The following is a real life story to depict situation where transport was a barrier for the poor and the elderly to access the available government health service and how it was overcome. The story was taken from a World Bank article **(**World Bank, 2016a).

"The elderly poor, especially those over 80 years old and those who live in rural areas, find it most difficult to access healthcare as public transport is very limited - particularly at night. Paying for private transportation is too expensive. Local administrative organizations in Kalasin are promoting access to health services for the elderly through an emergency van service. Nij Simmho, 71, has diabetes and needs to travel for regular check up at the hospital. He used to pay 500 baht to get to the hospital, which took up almost his entire monthly social pension.

"Now I ask a Village Health Volunteer to call the emergency van for me," he shares. "The van just picks me up every time and I don't have to pay any service fee. I can therefore use my monthly stipend to buy food without worrying about how to get to the hospital." The transportation service by emergency vans is available in all of Kalasin's municipalities. Some municipalities like Najarn Tambon, also allow the elderly poor to use the service even for normal visits to hospitals, not just emergencies. Kalasin province's example is something Thailand can promote and scale up to ensure that basic health care services for the elderly are available to all"

From the above, it is seen that solution to transport challenges can be found if resources are distributed equitably. However, the poor, the elderly and the disadvantaged do not only go to hospital, they need to be part of the society, hence they need transport to go about their daily life, they need to be included when policies are made about provision for the basic needs which should include transport for the poor.

3.2 What have been done?

The Thai government total investment plan for transportation infrastructure amounts to 2.2 trillion baht. Most of the budget comprises 1.9 trillion baht investment in railroad systems. The rest is investment in air and water transport of 0.3 trillion baht (SCBEIC, 2016). In addition, the current investment in Bangkok Mass Rapid Transit amounts to more than 200 billion baht. With that said, it is clear that Thailand has the capacity to invest in mega projects. To help reduce the living costs of the poor, the current government has continued to provide free bus service for Bangkok and the surrounding provinces with 800 daily buses covering 73 routes, plus 164 third class rail services, and free third class long distance rail service for the provincial folks and all are paid for by the people's tax (NESDB, 2015). From the services provided with good intention, it is seen that the rural poor who make up 66.6% of the country's number of poor population of 7.3 million in 2013 benefit little if any from the free services. This is also true for the 33.4 % or 2.4 million urban poor who live in regional cities.

3.3 What is to be done?

As poverty and inequality are key issue as of concern to the government, it is suggested here that provision of basic transport to meet the multidimensional needs of the poor would help address the current shortfall and inequitable provision of free services between Bangkok and the provinces as it will improve accessibility to government services and economic activities. Thus, the following suggestions are proposed:

1. Basic bus services from village to town or city centre be provided. As a minimum, 2 services, one in the morning and one, afternoon should be provided, it should be free for the poor and the elderly who should have priority, school children can also share the ride. Interviews with Department of Land Transport provincial officers reveal that many villages may have category 4 bus service or paratransit serving their areas, but there are still probably thousands that do not have this basic service,
2. For urban areas in regional cities, free bus or at least paratransit services should be made available for the poor and the elderly who have to pay more than they can afford for paratransit service, or motorcycle taxis at night when the transit stops operating. This would be a fair policy for people in regional cities as Bangkok already has the service funded by tax papers' money. Similarly, the poor and the elderly should be given the priority.

The two suggestions would go a long way in improving the living standard of the poor whose number has probably increased due to the substantial economic slowdown over the past three years. The provided services would also help reduce inequality between Bangkok and the regions, as the IMF study has shown that policies that focus on the poor and the middle class can mitigate inequality.

4. CONCLUSIONS

The paper described the latest situation on poverty and inequality in Thailand. It shows that despite a sustained economic growth over the 80s and 90s and first decade of the twenty first century, which propelled Thailand into an upper middle income country; the level of poverty and inequality gap still persist with 7.3 million or 10.9% of the total population living under the poverty line of 2572 Baht per month (73.5US$) in 2013, and an increase in the ratio of income of the riches 10% to that of the poorest 10% from 25.2 in 2011 to 34.9 in 2013, while the GINI coefficient has remained relative constant at 0.465. The inadequacy or lack of transport provision has acted as barrier to access many government services which are in many instances, adequately provided as shown by a World Bank example. Two policy suggestions were made to help improve the living standard of the poor as well as to reduce the inequality between Bangkok and the regions of Thailand. They are the provision of basic bus service from village to town to address the plight of the 4.9 million rural poor, and the provision of urban bus service in regional cities to enhance the quality of life of the 2.4 million urban poor. As US President Andrew Jackson once said "We should measure the health of our society not at its apex, but at its base." The two suggestions should go a long way in improving the health of Thailand.

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MAKING THAILAND'S ROADS SAFER: A CASE STUDY OF PRIVATE SECTOR SAFETY INITIATIVES FOR SONGKHLA

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Abstract: The Safer Road Foundation (SRF) and the Making Songkhla Roads Safer Unit recently joined hands to initiate a road improvement project comprising the rectification of eight blackspots on Songkhla city's road network. The project was conceived along the guidelines of the U.N. Decade of Action for Road Safety which aims to reduce road accidents through making roads safer, control of vehicle speeds as well as encouraging better road disciplines among road users in general. This paper describes the undertaking of the project, perceptions and reactions of the residents, and the outcome of the improvements thus installed.

Key Words: Decade of Action for Road Safety, Road Safety in city area, SRF

1. INTRODUCTION

According to the WHO Global Status Report on Road Safety for 2015, the worldwide road traffic fatality reached 1.25 million deaths per year. In recent years, improved road safety measures have led to corresponding drops in fatality rates among the developed countries. For the low and middle income countries, however, their accident fatality rates have yet to show any appreciable slowing down. For Thailand, road accidents have been a chronic problem over the decades with ever rising rates of casualty. The country's recent fatality figure was estimated at 24,237, which translated to a very high rate at 36.2 deaths per 100,000 population, or ranking No. 2 on the global scale (WHO., 2015).

Table 1 summarizes road fatality statistics for Thailand. The table shows a large discrepancy between the number reported by Thai authorities and the WHO-estimated figure. The main reason for the difference appears to be the time period when a death is recorded: the police are likely to record death at the crash scene or a day or two after the crash while the WHO practice is to record death within 30 days of the occurrence. Table 1 also shows the estimated GDP loss of 3% according to a 2009 study by Taneerananon. Based on that percentage and with Thailand's 2014 GDP at US$404.6 billion (5 World Bank), the economic loss to the nation would amount to US$12.1 billion or about 440 billion Baht.

The United Nations has declared the interval 2011-2022 as the Decade of Action for Road Safety. According to the scheme's five pillars of action, safer roads and mobility is a pillar that should be implemented where funding is available. With the financial support from the Safer Roads Foundation, the Songkhla city was able to implement a number of initiatives designed to render its roads safer.

Table 1 Road Traffic Fatalities and Estimated GDP loss (WHO., 2015)

DATA	
Reported road traffic fatalities (2012)	14 059[c] (79% M, 21% F)
WHO estimated road traffic fatalities	24 237
WHO estimated rate per 100 000 population	36.2
Estimated GDP lost due to road traffic crashes	3.0%[d]

[c] Bureau of Policy and Strategy, Office of Permanent Secretary, Ministry of Public Health. Defined as unlimited time period following crash.
[d] 2009, Dr. Pichai Thaneerananon, PhD. "Traffic Accident Costing in Thailand 2004".

Source: *WHO., 2015 and P.Taneerananon, 2009*

A master plan traffic and transport development was prepared for Songkhla city in 2009 (OTP, (2009)). From the time of the plan's inception and approval by the central government's Office of Transport and Traffic Policy and Planning (OTP) to the present, a number of road improvement projects have been carried out for the city according to the recommended actions in the Plan. While the implemented changes have been welcomed by the residents, their awareness and compliance in the area of road safety have been less than satisfactory. A number of safety issues thus remain to be rectified, for example: motorcycle riding without helmets, riding at high speeds, illegal parking, encroachment of public road surface by street vendors. This project has identified eight spots on the city's road network where traffic safety features are either inadequate or completely lacking. These include four uncontrolled intersections, poorly controlled junctions on the frontage of two universities, mixing of vendor surface and roadway, and three potentially hazardous curves on the city's main highway (Route 414).

The Safer Roads Foundation (SRF), a not-for-profit organization, is active on a number of developing countries meting out initiatives with the aim of reducing road casualties through simple, practicable measures, such as: rectification or reduction of traffic black spots, development of safer design standards, and promoting a greater awareness of road safety through education and publicity.

The Making Songkhla Roads Safer Unit is an independent entity that seeks to improve the standard of road safety for Songkhla. From 2015, the Unit has been working closely with SRF on a number improvement projects for Songkhla City under sponsorship from the foundation. For this project, the Unit has attempted to rectify the eight black spots mentioned above using the following methods: installing speed calming at four vulnerable intersections using a compact roundabout; removing conflict due to vendors encroaching road areas at one location; installing speed reduction devices along three curves on Hwy 414; and improving the controls at the university-front junctions; one on the frontage of the Raja hat University and the other at the Thaksin University.

This paper documents the process of implementing six out of the eight programs cited above, and the concomitant issues faced by the city administration.

2. OBJECTIVES

- To install controls for safer road traffic.
- To reduce vehicle speed at vulnerable locations through proper engineering design.

3. PROJECT DETAILS

- **Locations (Figure 1)**
- **The problems at each location**

Locations 1, 2, 3 and 4 are uncontrolled junctions crisscrossed by conflicting lines of traffic, resulting in disorder at all times, and where excessive vehicle speeds on the main directions can lead to severe crashes (figure 2). Location 5 is a curved alignment along which sits a busy hawkers market. A minor road merges onto it, creating a T-junction at the curve (figure 3).

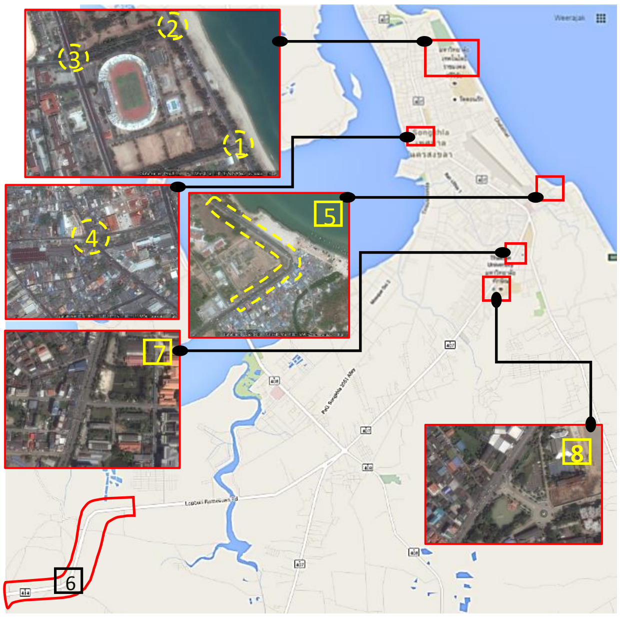


Figure 1 Locations of the eight programs
Source: *https://www.google.co.th/maps/*

Location 6 is on Hway 414 consisting of three curves separated by long stretches of straight carriageway - a potential hazard should motorists enter the curves at high speeds without being sufficiently forewarned (figure 4). Locations 7 and 8 are junctions in front of two universities; one of which was previously funded by SRF, but needs minor improvement to make it safer for motorists and the other a completely uncontrolled junction (figure 5).

Figure 2 Traffic stream conflicts at junctions
Source: *OTP, (2009)*

Figure 3 Hawker stalls spilling onto traffic surface on a curve.

Figure 4 Hazardous curves on Highway 414
Source: *https://www.google.co.th/maps/*

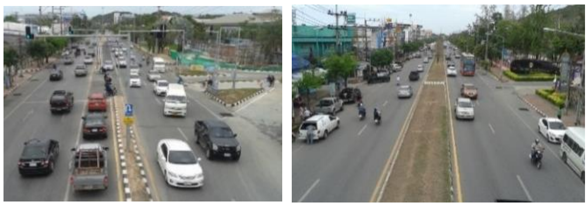


Figure 5 Black spots in front of two universities — with signalized control, and without.

■ Reactions from the residents

At the outset of the project, the working team convened a series of discussion meetings with the city’s ranking officials, representatives of the target communities and traffic police. A consensus was reached in these meetings that, at this stage, the programs be carried out on an experimental basis. The city administration, led by the Mayor, accordingly approved the plans to implement the safety measures proposed by the working team on the said basis. Opinion surveys conducted on the residents of the target areas revealed that a large percentage of the respondents were against the proposed changes. Such a sentiment stemmed, in part, from their distrust in official dealings which they thought might involve irregularities in the disbursement of their tax money. More than 70% of the people surveyed reckoned that the planned roundabouts would aggravate, instead of relieving, traffic jams given their size and their taking up space in the center of a junction. Most of the self-employed people - Tuk-tuk drivers, motorcyclists and street vendors - also echoed similar sentiments. Some locals also rejected the idea of a roundabout as an unnecessary addition to the already livable town.

Efforts were made by the project team to explain the advantages and disadvantages of the proposed roundabouts, including the sources of project funding.

Discussions with officials of state agencies also revealed that many of them did not yet possess a good understanding of traffic control measures. The traffic police reckoned that the local motorists would ignore the revised traffic rules at an improved junction. A better level of understanding was achieved after the team elaborated on the pros and cons of the project. Still, many officials did not agree with the idea of installing roundabouts, especially the one at Location 3. However, the general consensus obtained from all the meetings was for the project to proceed, on an experimental basis, with the construction of the proposed roundabouts.

In order to gain insights into the residents' lack of enthusiasm for the proposed traffic improvements, the project team conducted a general survey of the traffic situation in the city. The team found that the traffic problems faced by the city have been persistent for more than ten years, and so far little or no effort has been made to rectify the situation. Figure 6 shows examples of the daily traffic disorderliness on the city's road network. Most road users have become so inured to such urban chaos that they were unable to see any room for improvement.

Inadequate publicity about the project may have contributed to the residents' resistance. More than 70% of the locals had not been informed about the source of project funding: they thought the funds had come from the municipality's budget. Non-transparent projects in the past have bred suspicion and cynicism in the residents to the extent that they invariably question the validity of a project by the local administration. And this kind of mistrust may explain in part why the residents had been less than enthusiastic about the project.

Figure 6 Examples of traffic disorderliness in Songkhla city

4. DURING CONSTRUCTION PHASE

As the project was allowed on an experimental basis, the new safety devices to be installed must be non-permanent — for the Mayor may elect to order their removals any time he deems fit, or when the residents voice their disfavor of the installed structures. Accordingly, the roundabouts were makeshift structures consisting of an earth-filled core bounded by interlocking bricks.

- **Safety concerns during construction**

For safe traffic arrangement in the vicinity of the construction, the contractor must install a sufficient number of hazard warning and direction signs using standardized text or symbols in order to alert motorists driving through a works area. The contractor for this project, however, exhibited a lack of experience in such matters, despite the presence of an engineer controller. They ended up using either non-standardized materials or poorly drawn signage.

- **Progress meeting**

While the construction activities were underway, the City Administration invited community leaders and impacted residents for another round of discussion. Many of the attendees queried the rationale for having the additional structures: Why use such a large roundabout as the structure narrows the roadway; makes for a small turning radius, impedes through traffic? and so on. The local traffic authorities wanted to know why the central island of a roundabout was designed for such a size and located off center at a junction, and why a curb extension (marked by plastic posts and white stripes) was needed. Some community leaders expressed their preference that the Charlatan Road (Hway 414) should serve as the city's "freeway" where high speeds are allowed.

In response to such queries, the project's design team provided detailed explanations on the design features, for example: The roundabout intersections are designed for a maximum vehicle length of 8.2 m; the width of the circulatory carriageway is a minimum of 5.5 m; the curb extension, central Island and truck apron are designed to reduce vehicle speeds, to prevent vehicles on the through direction from scudding past the junction (Vesper, A., (2011)), and so on.

Even with the technical aspects thus made clear, the participants still expressed their doubts about the added structures, in particular the roundabout at Location 3 (intersection near the Provincial Government Center and the Maha Vajiravudh School). The meeting ended with an agreement that the proposed structures are to be temporary subject to subsequent evaluation and a decision by the residents whether to keep or remove them.

Two days after the progress meeting, the Mayor ordered the removal (figure 7) of the roundabout at Location-3 following complaints by a small group of residents that the roundabout being built was causing traffic congestion in the area.

Despite the issue cited above, the rest of the project has proceeded to completion, i.e. the temporary structures were installed, and the decision whether to subsequently proceed to the permanent fixtures will rest upon the city administration.

Figure 7 Removal of one of the roundabouts (at location 3) after complaints from residents.

- **Advising residents on use of roundabouts**

It was found that many motorists are unfamiliar with the proper method to negotiate a roundabout. Many drivers chose to make a U-turn at the tip of the splitter island. Some made a right turn by going counter-clockwise along the shorter arc of the central island, traveling contra-flow and cutting across the line of traffic on the circulatory way - a hazardous move. Such disregard for road discipline may be the reason why the residents reject the presence of a roundabout control - they would forgo personal safety for convenience.

In light of the above, the project team then produced a brochure that publicized the project as well as providing instructions on how to traverse a roundabout in the correct way. About 5,000 copies of the brochure was printed and distributed to residents (see figure 8).

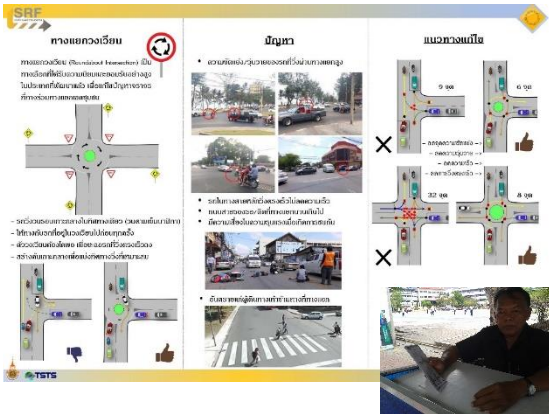


Figure 8 Brochure explaining proper use of roundabout intersection
Source: *adapted from Satiennam, W., (2015)*

5. AFTER CONSTRUCTION

■ Outcome of the project

Despite their early rejection of the safety fixtures, the residents of Songkhla, after a brief period following the complete installation of the fixtures, expressed their agreement with the concept. Many of them saw that the roundabout intersection was able to make vehicles move smoothly in all directions at a junction; and the Median Island near the hawkers market helped to create more orderly traffic flows.

A small incident occurred at the roundabout of Location 1 when the rear end of a semi-trailer side swiped the central island during a right turn, causing a slight damage to the structure. The accident was due to the excessive length (15.5 m) of the vehicle which far exceeded the design length of 8.2 m (see figure 9). The event raised some concern that the central island might all but disintegrate upon more crash impacts.

■ Reduction of stream conflicts

The presence of the roundabouts has so far been proven effective for helping to change driving behavior of the Songkhla motorists. They have managed to learn correct roundabout driving rules including proper merging, traversing clockwise, giving way to vehicles on the circulatory perimeter to move out first, etc.

Traffic at the target junctions after installing the roundabouts is seen to have improved over previously: there are now less conflict and shorter delays. The project team is in the process of studying the effectiveness of these devices in mitigating crashes at all of the experimental locations.

Figure 9 The central island after being smashed by right turning semi-trailer

■ The problems with Location 3

Residents at the vicinity of Roundabout #3 had voiced their disfavor of the structure which caused it to be removed by the city administration. Their complaints stated that the central island was too large thereby causing narrowing of the circulatory lane, which in turn led to more traffic delays than the situation without the structure. The residents also questioned the validity of the engineering study that had recommended the use of roundabouts.

Investigations of the problematic site were carried out by the project team. It was found that the narrowing of the circulatory lanes was in fact caused by the disorderly parking of private vehicles along the curbs in the area including long stretches of double parking as shown in figure 10. The vehicles are parked by parents who arrive to pick up their children at the Maha Vajiravudh School close to the intersection.

Figure 10 Parking behavior at the junction

Thus, the presence of parked vehicles along the 8 m-wide circulatory lanes are actually clogging up space, resulting in traffic jams and delays. The size of the central island and the width of the connecting roadways are not the culprits as claimed by the residents. With the roundabout removed after the residents' complaints, the intersection in question reverted to the 'No-Control' scenario, and traffic conflicts continue to rule the area (figure 11).

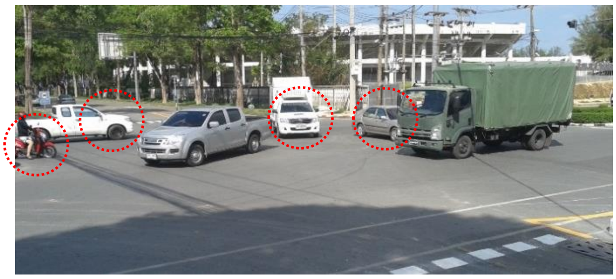


Figure 11 Traffic at this location reverts to chaos

6. CONCLUSIONS

Conclusions are drawn for the changes at Locations 1 to 6 where construction has been completed. Works at the remaining two sites have been continuing.

- People typically resist change. Changing their driving behavior will require well-thought-out strategies and perseverance in implementation. Many government agencies in charge of traffic improvement may be hampered in their decision making due to the lack of insight on an issue, and at the same time, their being subject to pressures from a discontented or mis-informed public.
- Three roundabout installations herein have successfully demonstrated their benefits during the experimental phase. More orderly traffic flows have been acknowledged by the residents and more than 70% of the people interviewed said they agree with the roundabout installations. A small number of crashes at the junctions have been noted.
- The Median Island at Location 5 (where the vendor stalls spilled over the road surface) has helped to properly segregate the opposing flows, thus resulting in safer traffic flow.
- The optical speed bar at Location 6 is showing its effectiveness in helping to reduce vehicle speeds by up to 15% according to a before and after study.

7. RECOMMENDATIONS

- Proactive publicity of the project is crucial to garnering good cooperation from the people. For the project herein, the residents had not been informed beforehand that funding for the works came from SRF sponsorship, not from their taxes. This misunderstand may have predisposed them to suspicious views due to their mistrust of government dealings, hence their reluctance to support the project. Dissemination of project details may be accomplished through low-cost channels such as brochures, pamphlets, or the social media.

- Project contractor should be instructed to install proper safety precautions during the works. Proper traffic warnings and direction signage should be posted at all strategic locations to alert drivers of any potential hazards. Signage should be made to correct standards including clear text and graphics. No sub-standard signage should be used.

8. ACKNOWLEDGMENT

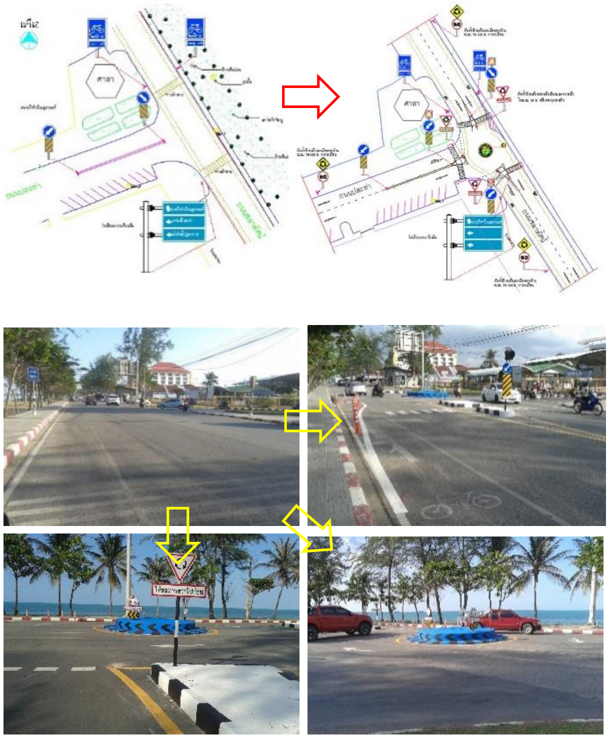
The authors wish to express their deep appreciation to the SRF for their generous support without which this project would not have been possible.

The Safer Roads Foundation is working to cut down traffic accidents.

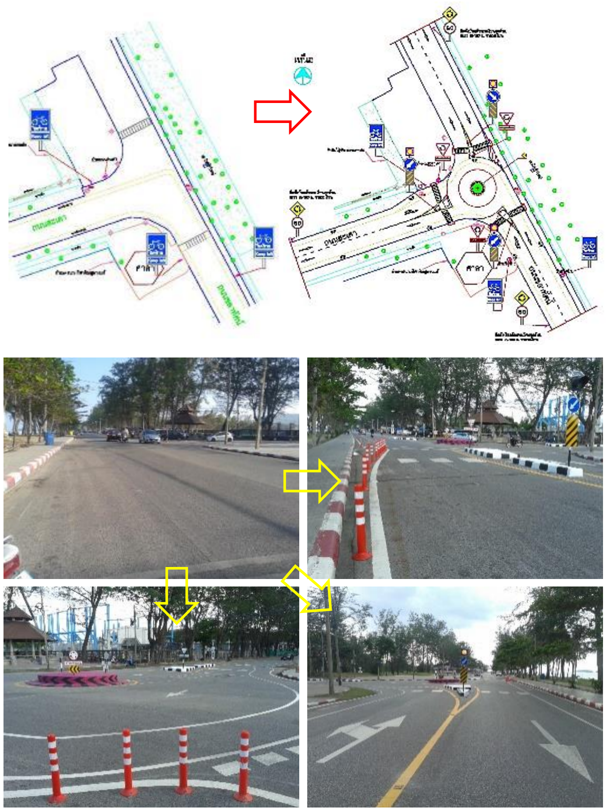
http://www.saferroadsfoundation.org/

Comparison of before and after situations as shown in figure below;

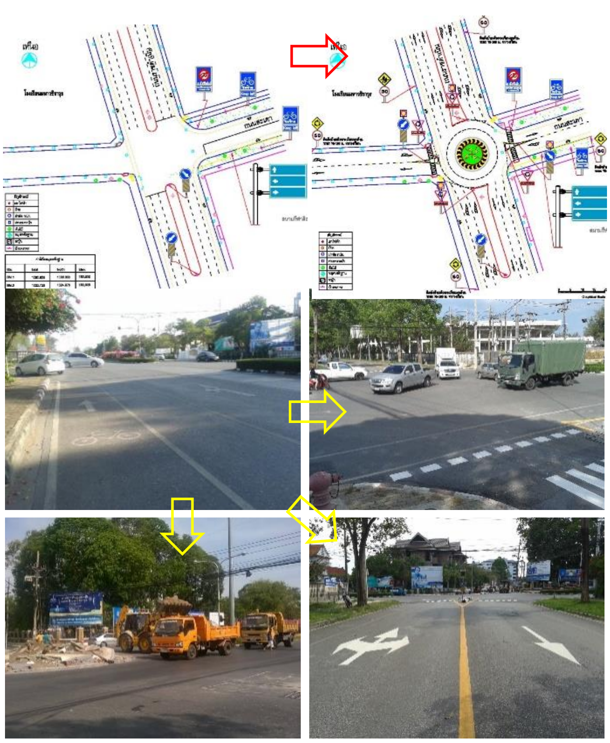
Source: *regarding detail design principle of Roundabout Intersection, adapted from Vesper, A., (2011), https://www.mainroads.wa.gov.au, http://trafficcalming.org/measures/roundabouts/*



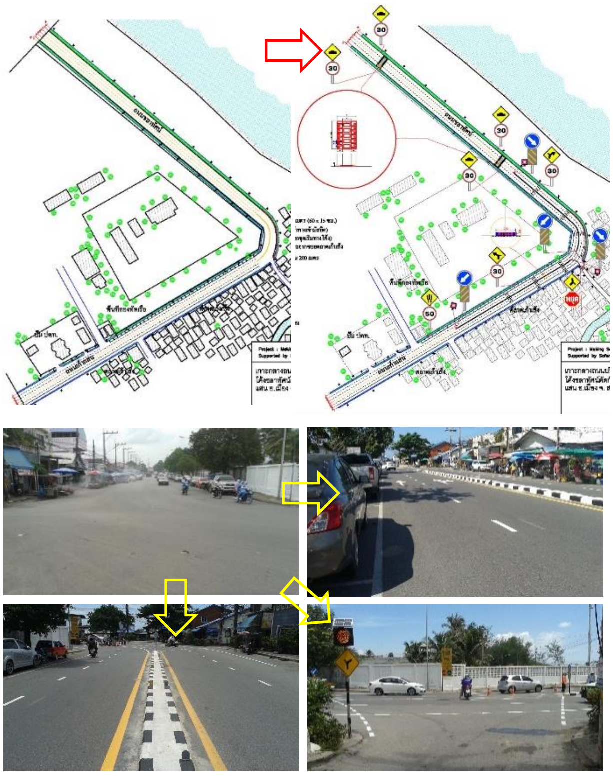
Location No.1



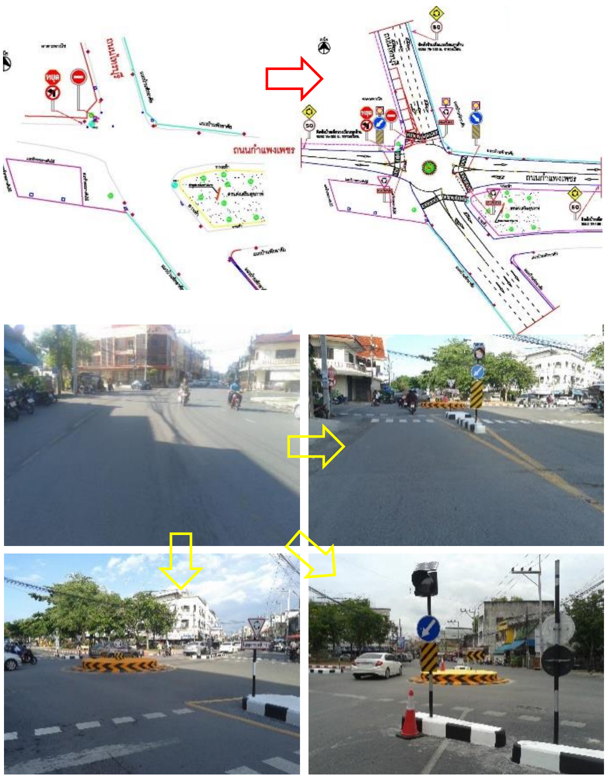
Location No.2



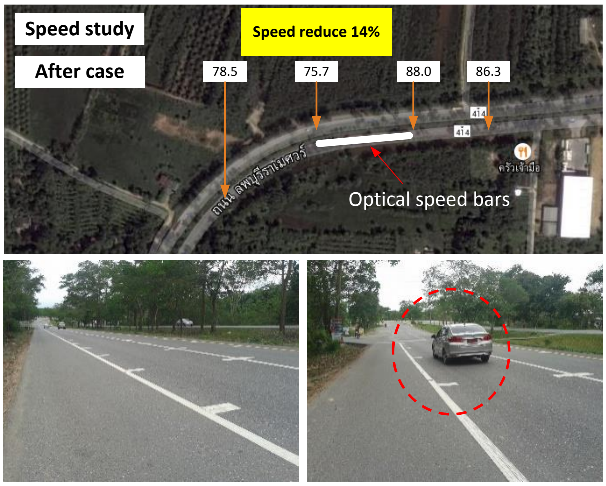
Location No.3 (Roundabout demolished)



Location No.5



Location No.4



Location No. 6

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https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/RoadandTrafficEngineering/GuidetoRoadDesign/Pages/MRWA_Supplement_to_Austroads_Guide_to_Road_Design___Part_4B.aspx (*Steps to design roundabout intersection: MRWA Supplement to Austroads Guide to Road Design - Part 4B, accessed on 4 July 2016*). Mainroads Western Australia, Date amended: 28 June 2016.

http://trafficcalming.org/measures/roundabouts/ (*Advantages and disadvantages of Roundabout for traffic calming*, accessed on 4 July 2016).

CONNECTING ASEAN IN 2016: LINKING MALAYSIA'S PERLIS AND THAILAND'S SATUN

Special Issue

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Abstract: The ASEAN Economic Community comes into being in early 2016. As the Community covers a huge market of US$2.6 trillion and over 622 million people; its impact cannot be overstated. In order to help achieve the goals of the Community, an improved connectivity should be in place. Prior to the establishment of the AEC Blueprint 2025, a highway project linking Satun, the border province in the south west of Thailand with Perlis, the Malaysian border state in the north of Malaysia, has been under consideration in the Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) project since 1994. This highway project is expected to support the economic and social development, industry development, border trade and tourism between the two countries. This paper describes the result of a recently completed feasibility study which recommends the 22 km. route including a tunnel length of 6.5 km through San Kara Khiri Mountain range and 8.2 km. elevated section to avoid potentially high environmental impacts to the sensitive mangrove forest. The economic benefit cost analysis indicates that if only direct benefits to traffic were considered, EIRR was 9.4 % which was below the investment criteria of 12 %. However, if indirect benefits including increased trade, employment and tourism were considered, the EIRR would be 16.2.

Key Words: ASEAN connectivity, Satun, Peris, Economic feasibility

1. INTRODUCTION

The ASEAN Economic Community comes into being in early 2016. As the Community covers a huge market of US$2.6 trillion and over 622 million people (ASEAN, 2016); its impact cannot be overstated. To achieve the goals of the Community, improved connectivity among member countries should be in place. Prior to the establishment of AEC Blueprin 2025, a highway project linking Satun, the border province with a 2014 population of 312,673 (Satun, 2016), located .in the south west of, and an important gateway to Thailand with Perlis, the Malaysian border state with a 2015 population of 246,000 (Perlis, 2016), located in the north of Malaysia was conceived under the Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) project in 1994. In 1995, Thai Department of Highways (DOH) conducted a feasibility study on economic, engineering and environmental impact for the construction project of Satun-Perlis. It was found that the value of economic return (EIRR) was at 13.82%. The route was designed for a distance of 3 5 kilometers in Thailand and three kilometers in Malaysia, the estimated construction cost was 3,909 million baht (value in 1996). But, the project was rejected by the Office of National Environment Board on environmental ground, the Board however, suggested DOH to find alternative routes that would not impact the mangrove environment. In 2011, DOH had budgeted a sum for the feasibility study on economic, engineering, and environmental impact of the Satun - Perlis Tunnel Highway Project, which is further described in this paper.

1.1 Project Rationale

A project on Satun-Perlis highway linkage was considered as a national priority because it is a cooperation in infrastructure and transportation network linkage between the north of Malaysia and the deep south of Thailand. This project has been under Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) since 1994. This project is expected to support the economic and social development, industry development, border trade and tourism. With high environmental impact to the area since the route has to pass through mangrove forest, drilling a tunnel through San Kara Khiri Mountains to connect Satun and Perlis was considered as it would significantly alleviate the impact to the environment.

1.2 Project Overview

Route Alignment

Project route alignment from starting point to ending point is shown in **Figure 1.** The starting point is on Highway 406 at Km 72+174. The route heads to the east, cuts through agricultural areas then intersects with Highway 2030 and down to the south along the existing paved road. From Km 0+000 to 4+150, the route was designed as at grade road, and the section from Km 4+150 to 5+150 was the area for construction of the immigration checkpoint and toll booth. After passing the toll booth to the entrance of the tunnel, elevated viaduct was designed for access control starting at Km 5+150; from Km 6+500 to 14+775, the route passed over mangrove areas. With the section designed as elevated bridges, the highway could be used regardless of the rise and fall of sea level, and the impact on mangrove ecosystem is minimized. The tunnel section starts at Km 14+775 by passing through San Kara Khiri Mountains to Malaysia side at Km 17+750 between the boundary post No.5 and No.6 . The alternative No.3 which is the optimum route heads southward to converge Highway R119 of Perlis with the total distance of approximately 21.675 kilometers. The tunnel length for alternative No.3 on Thailand side is 2.97 km long and 3.565 km long in Malaysia. Total tunnel length is approximately 6.535 kilometers.

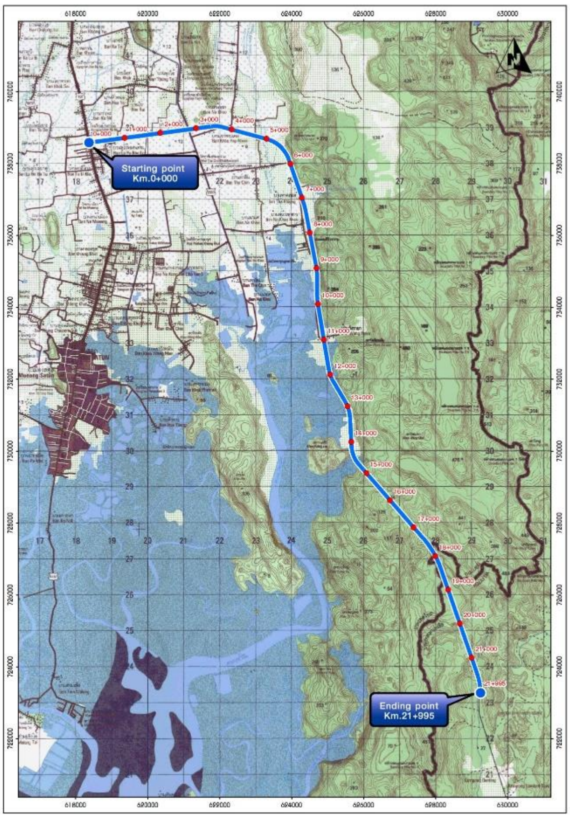

Figure 1 Project route alignment

1.3 Project Components

Satun - Perlis Tunnel Highway Project was designed by following the topography. Hence, it was designed as a combination of at grade highway, bridge over a river, elevated bridges over mangrove areas and a long tunnel through the San Kara Khiri Mountain range both in Thailand and Malaysia sides with approximately 6.5 kilometers in length to minimize the environmental impact on forests and wildlife. The configuration of project route can be summarized as follows.

From Km 0+000 to Km 5+150 the section was designed as a two-lane 3.50 meter lane width highway and 2.50 meters width of each outside shoulder and 40.00 meters of right of way. Later, when traffic volumes increase, it may be increased to four-lane highway with a raised Median, as shown in Figures 2 and 3. (Final Report, 2016).

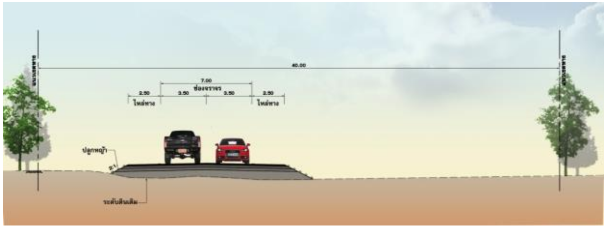

Figure 2 Two-lane highway

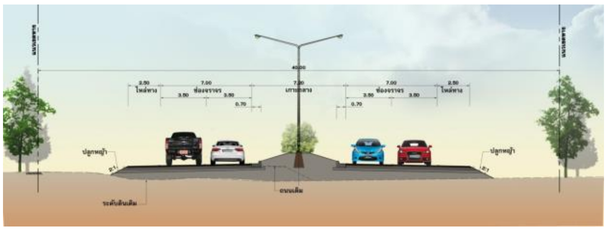

Figure 3 Four-lane highway

For the Km 5+150 to Km 14+775 section where the route passes through mangrove areas; it was designed as viaduct with a two-lane section of 3.5 m lane width and 2.50 m shoulder, 1.00 meter width of median and 30.00 meters of right of way. In the first phase of construction, only one side of the bridge would be constructed for two-lane highway traffic with provision for space for the construction of the additional two-lane viaduct in the future, as shown in Figure 4.

From Km 14+775 to Km 21+310, the route passes through high mountains that border Thailand and Malaysia. It was designed as a two-land tunnel with a width of 3.50 meters each, 0.75 meters width of each outside road shoulder and 1.00 meter with of each side of pavement as shown in Figure 5.

2. TRAFFIC AND TRANSPORT VOLUME IN THE FUTURE

The study of traffic and transport volumes was based on the hypothesis of target in each year as follows:

1) A.D.2025 assumed year of opening
2) A.D.2029 5th year of project
3) A.D.2034 10th year of project
4) A.D.2039 15th year of project
5) A.D.2044 20th year of project
6) A.D.2049 25th year of project
7) A.D.2054 30th year of project

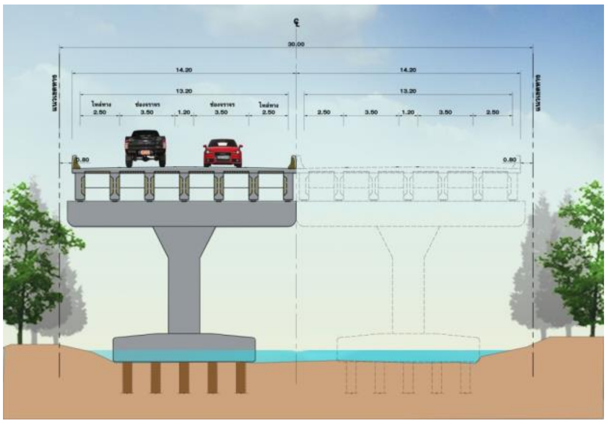

Figure 4 Viaduct over mangrove areas

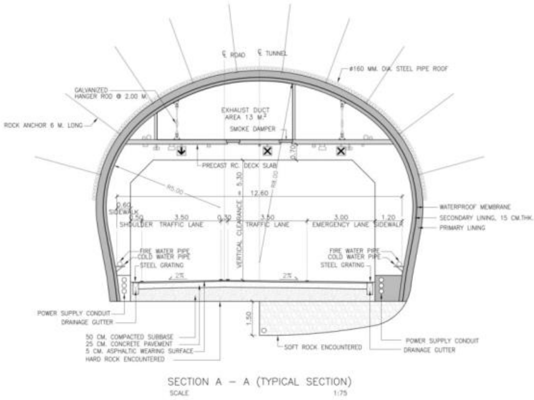

Figure 5 Tunnel section

The traffic volume forecast on the project highway (tunnel) shows that in 2025 the traffic volume would be approximately 846 vehicles per hour (6,033 vehicles per day), of which 619 vehicles per hour (4,415 vehicles per day) would be regular traffic, 125 vehicles per hour (891 vehicles per day) tourist traffic and 102 vehicles per hour (728 vehicles per day) of border trade. Traffic volumes would increase to 4,835 vehicles per hour (34,472 vehicles per day) in 2054 with a growth rate of about 10 percent per year as the detailed in Table 1.

Table 1 Forecast traffic volumes in tunnel for various year

Year	Traffic volume on the project highway							
	Regular traffic		Tourism		Border trade		Total	
	(per day)	(per hour)	(per day)	(per hour)	(per day)	(per hour)	(per day)	(per hour)
2025	4,415	619	891	125	728	102	6,033	846
2029	6,237	875	1,550	217	1,064	149	8,851	1,241
2034	9,335	1,309	3,107	436	1,712	240	14,154	1,985
2039	12,722	1,784	5,109	717	2,328	327	20,160	2,828
2044	15,546	2,180	6,778	951	2,607	366	24,931	3,497
2049	18,369	2,576	8,446	1,185	2,885	405	29,701	4,166
2054	21,193	2,972	10,115	1,419	3,164	444	34,472	4,835

Source: Forecast made by Consultant

In addition, the analysis of the level of service of the project highway shows that the two-lane highway can adequately support the traffic until 2054 (Level of service at E). If the four-lane road is constructed, the level of service will be at A from 2025 to 2034 and down to B level in 2039. After that, the level will be at C until 2054 as shown in **Table 2**. Based on this data, the four-lane highway may not be currently necessary to construct because of high budget required. From the analysis result, the Consultant recommended the two-lane highway because it is enough to support the traffic volume until 2054.

Table 2 Estimated Level of Service on project highway

Year	2-lane		4-lane	
	Traffic volume (PCU/hr/lane)	Level of service	Traffic volume (PCU/hr/lane)	Level of service
2025	423	A	211	A
2029	621	B	310	A
2034	993	C	497	A
2039	1414	D	707	B
2044	1748	E	875	B
2049	2,083	E	1,042	C
2054	2,417	E	1,210	C

3. ECONOMIC FINANCE AND INVESTMENT ANALYSIS

Analysis of direct Economic Internal Rate of Return of the project for a 30-year period, and investment value of 11,139.73 million baht shows that the project did not pass the required economic criteria.

The Economic Internal Rate of Return (EIRR) was calculated as 9.42 percent, Net Present Value (NPV) was negative at -1,874.12 million baht (discount rate of 12 percent), Benefit/Cost Ratio (B/C) was 0.70, and First Year Rate of Return (FYRR) was 5.38 percent.

Additional analyses were carried out by including indirect benefits which include a return assessment of the construction budget of 11,139.73 million baht which would cause an economic stimulus value at 14,859.44 million baht, and would increase the EIRR to 16.17 percent. The Net Present Value (NPV) was also increased tot 2,452 million baht (at discount of12 percent), Benefit/Cost Ratio was 1.39, and First Year Rate of Return (FYRR) was 27. Per cent.

Furthermore, additional analyses by considering an investment only in Thailand and postponing the project in order to have better traffic volume show that:

- In case of an investment only in Thailand, EIRR of the project would pass the minimum economic criteria for investment of 12 % with the EIRR at 12.95 percent.
- In case of five-year postponement, EIRR would be improved, but still did not pass the economic criteria. The EIRR was at 11.52 percent.
- In case of eight-year postponement, EIRR would be improved and pass the economic criteria. The EIRR was at 12.64 percent.

From financial and investment analysis, the result of the financial indicators can be presented as follows:

- If only government sector (DOH) invests in the project, with a budget of 16,930.22 million baht, the project would fail the financial criteria. The NPV was in deficit at -7653.76 million baht, FIRR 0.26, B/C Ratio 0.26 and would take more than 30 years of payback period.
- If government and private sectors jointly invest in the construction at 90:10 proportion, with the government sector contributing in land expropriation, building compensation, and construction control with total budget of 14,144.46 million baht, while the private sector contributes the construction, implementation control, management, maintenance and 10 percent of remaining construction costs of 2,548.40 million baht. The government sector gets 30 percent of net income from the private sector.
- Government sector would fail the financial indicators since NPV would be in deficit at -8514.96 million baht, FIRR -4.05, B/C Ratio 0.12, and a payback period more than 30 years.
- Private sector would pass the financial indicators with NPV of 112.67 million baht, FIRR 8.64, B/C Ratio 1.05, and a payback period of 21 years.

The analysis of economic, engineering and environmental impacts feasibility study of Satun - Perlis Tunnel Highway Project in terms of financial indicators and others found that government sector (DOH) would be suitable to either entirely invest in this project or get into joint venture with private sector as follows:

- When considering only direct benefit of feasibility study of Satun - Perlis Highway Tunnel Project, the computed EIRR of 9.42 percent would not pass the economic criteria, However, if considering the investment only in Thailand, EIRR would pass the economic indicators. The EIRR was 12.95 percent.
  In case the project was for postponed five or eight years to wait for increased traffic, EIRR would be improved at 11.5 and 12.6 percent respectively.
  Moreover, after considering the indirect benefit from the construction cost, product, trade, transportation and employment and

tourism, the rate of return would be enhanced to 16.2 percent.

- If the government sector (DOH) decides to invest in this project, the implementation would be rapidly completed. Additionally, the management on toll rate and project phrasing could be more flexible according to the benefit and necessity.

4. CONCLUSIONS

This paper describes the need to improved connectivity among ASEAN countries in order to achieve the goals of AEC set in the AEC Blue print. A recently completed study of the Satun - Perlis Tunnel Highway Project was given as a real life example of physical connectivity which would promote trade, transport, employment and tourism. This paper describes the result of a recently completed feasibility study which recommends the 22 km. route including a tunnel length of 6.5 km through San Kara Khiri Mountain range and 8.2 km. elevated section to avoid potentially high environmental impacts to the sensitive mangrove forest. The economic benefit cost analysis indicates that if only direct benefits to traffic were considered, EIRR was 9.4 % which was below the investment criteria of 12 %. However, if indirect benefits including increased trade, employment and tourism were considered, the EIRR would be 16.2.

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