JSTS

JOURNAL OF SOCIETY FOR TRANSPORTATION AND TRAFFIC STUDIES

ISSN 1906 - 8360

VOL.7 No.4

DECEMBER 2016

The Future of Human Mobility

TSTS

PREFACE

Greetings to our Readers and we wish you all a great year in 2017!

Welcome to the December issue of volume 7 of our online-peer-reviewed International Journal of the Society of Transportation and Traffic Studies. Four issues of the journal are published annually.

We apologize for the delay in getting this issue out to you, due to some unexpected technical problem.

This issue contains 6 papers covering both soft and hard aspects of transport: the first discusses the Development of Thai International Ports in the context of ASEAN Economic Community, the second describes the challenge in combating the notorious Bangkok traffic congestion thru the provision of subsidized school bus. With Mass Rapid Transit becoming the hot transport issue in Bangkok, thanks to the drastically low ridership when the Purple line was opened in August, it is timely that the paper : Influence of Land Use Types on Transit Ridership is presented in this issue. Even though Thailand has achieved the income level of a high middle income country, it still faces huge challenge in dealing with some 8 million poor; the paper: Getting Out of the Rut of Poverty in Thailand offers a glimpse of how transport accessibility can help empowering the poor and hence get them out of poverty. The last two papers deal with how recycle concrete could be used to improve the soil property, and how adding para-rubber to binder and used in pavement construction can have an impact on traffic noise.

As always, we thank all of you who have kindly contributed to this issue of our journal and we express our gratitude to members of International Editorial Board and reviewers for your valuable advice and continued supports.

We trust you continue to enjoy and benefit from this issue.

Pichai Taneerananon
Professor
Chair of Editorial Board

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DEVELOPMENT OF THAI INTERNATIONAL PORTS IN ACCORDANCE WITH ASEAN ECONOMIC COMMUNITY

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Abstract: This research investigates the existing trade facilitation at Thailand's international ports to understand obstacles and seek a practical development plan to improve and prepare them according to the ASEAN Economic Community. The study consists of field data collection at 9 international ports in Thailand. 39 stakeholders including port operators, customs officers, freight forwarders, shipping agents, ship liner, other government officials as well as importers/exporters were interviewed to understand existing situation, obstacles, and ways to improve the goods movement process. In addition, Singapore port, as a good practice example, was surveyed for gap analysis between it and Thailand's ports and is used as a guideline to improve efficiency at Thailand's ports. Lastly, port stakeholders were invited in a focus group to gather their comments. The findings from this research lead to realistic suggestions of how to improve Thailand ports to prepare Thailand for ASEAN Economic Community.

Key Words: Port, Maritime Transportation, ASEAN Economic Community.

1. INTRODUCTION

The ASEAN Economic Community or AEC, one of the three pillars of the ASEAN Community that will be established in 2015. The establishment is based on a convergence of interests among ASEAN member countries to deepen and broaden economic integration. According to Roadmap for an ASEAN Community 2009–2015, the AEC aims to establish ASEAN as a single market and production. Free flow of goods is one of the principal means by which the aims of single market and product base can be achieved. The implementation plans that might affect sea transportation are elimination of tariffs and non–tariffs barriers, rules of origin, trade facilitation, customs integration, ASEAN Single Window, and the implementation according to International Maritime Organization (IMO) and the Roadmap towards an Integrated and Competitive Maritime Transport in ASEAN (The Association of Southeast Asian Nations, 2009).

The Master Plan on ASEAN Connectivity has been set up. The key elements of ASEAN Connectivity include physical connectivity, institutional connectivity and people–to– people connectivity. The physical connectivity encompasses transport (land, maritime and air), information and communication technology and energy infrastructure. To develop maritime transport infrastructure, 47 main ports in the trans–ASEAN region are designated in providing a more efficient shipping network services (The Association of Southeast Asian Nations, 2010). Figure 1 shows the interaction between ASEAN Connectivity and ASEAN Community.

Thailand, as a main member of the AEC agreement, has depended on international trade for a long time and maritime transportation always plays an important role to its trade. Figure 2 shows that during the past 10 years, Thai seaborne trade has increased steadily and over 80% of the trade volumes are shipped by sea. The country has to adapt for incoming changes and must prepare port infrastructure and management to operate more efficiently.

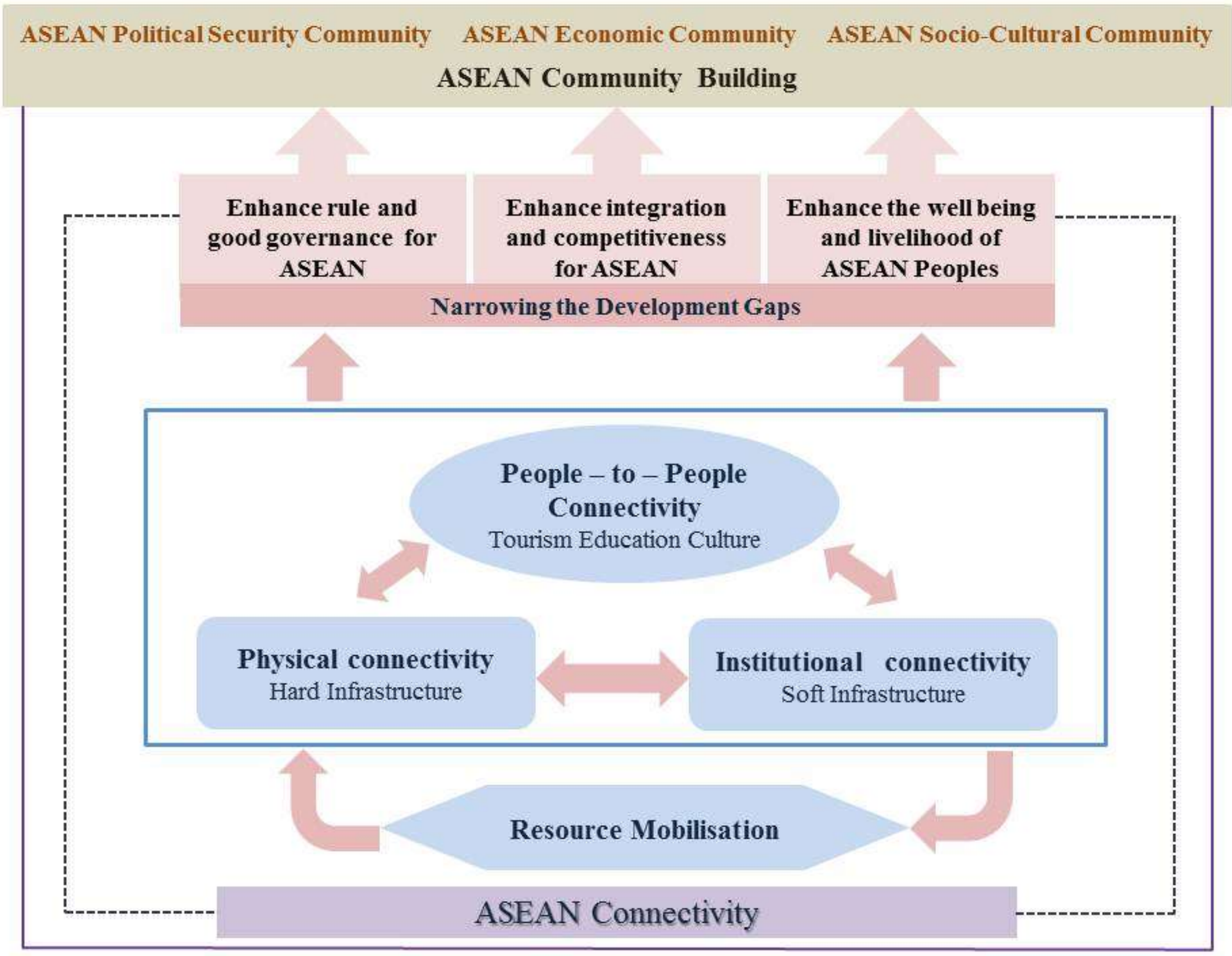

Figure 1: Interaction between ASEAN Connectivity and ASEAN Community
(Master Plan on ASEAN Connectivity, 2010)

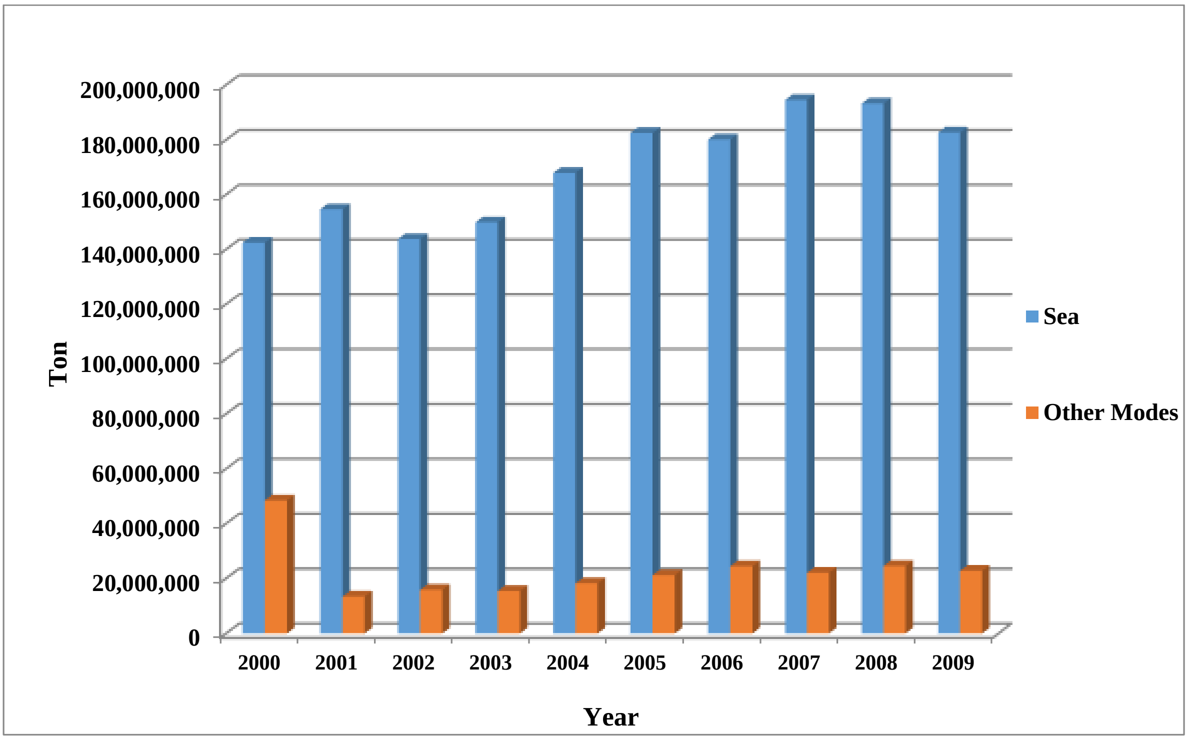

Figure 2: Volume of Thai Import-Export Goods by Mode of Transport
(Information and Communication Technology Bureau, Customs Department Thailand)

This research investigates the existing trade facilitation at Thailand's international ports. We look at existing obstacles and seek a practical development plan to improve and prepare them for the AEC. The study consists of field data collection at major ports, interview of key stakeholders regarding maritime transport to summarize the existing situations and obstacles with the objectives to recommend how to improve the goods movement process from the good-practice port, i.e., the Port of Singapore.

The remainder of the manuscript is organized as follows. Section 2 relates the study methodology. The existing situations of international ports in Thailand are described in Section 3. Section 4 presents the summary of opinions from Thailand ports' stakeholders. Section 5 shows lessons learnt from a good practice port. Then, the focus group was organized with the results shown in Section 6. The concluding remarks are discussed in the seventh and the final section.

2. STUDY METHODOLOGY

This study depends on qualitative research methodology. It comprises field data collection at international ports in Thailand as well as in–depth interviews of port stakeholders. The objective of these two steps is to understand existing situation, obstacles, and ways to improve the goods movement process. Next step is field survey at Singapore port as a good practice example. The objective is to do gap analysis between it and Thailand's ports such that management and operations between two ports are compared given that Singapore Port is one of the world's best-practice ports. Then, the differences are used as guidelines to improve efficiency at Thailand's ports. The data collected from the three steps are synthesized as the topics for the last step, focus group with port stakeholders, in order to set up suggestions of development of Thai ports according to AEC. The study methodology is shown in Figure 3.

Figure 3: Study Methodology

3. EXISTING SITUATION OF THE INTERNATIONAL PORTS IN THAILAND

To understand the present situation of Thailand's ports in details, not only secondary data from literature and research documents were collected, but the field surveys of various types of international ports such as general cargo, container, bulk, were conducted. The selection of international ports for the field data collection is based on location, administration and throughput. Nine international ports were selected based on their trade volumes and importance. They situate on all part of the country, four of them locate on the Chao Phraya River which is the most important river in the middle part of Thailand, three of them are on the eastern coast, and one is on the southern coast of Thailand. The location of the selected ports is shown in Figure 4. In administration aspect, four of the selected ports are state–owned ports and five are private–owned.

These nine international ports selected are the major ports of the countries. Their throughput shares over 90% of the Thai seaborne trade. Based on types of goods, Bangkok Port, Leamchabang Port and Songkhla Port are major ports for break bulk especially containerized cargoes, and Map Ta Put Port is the major port for liquid bulk and dry bulk. The selected private–owned ports are the prominent common user port in the central and eastern part of the country. Table 1 is the lists of the selected ports.

The field survey at the ports includes observation of cargo handling procedure, time used in each step, customs formality procedure, and interview of port users.

Management and Administration: The ports in Thailand are owned either by government or private company. The owner of the stated–owned ports are various, namely the Port Authority of Thailand (PAT) which owns Bangkok Port and Leamchabang Port, Industrial Estate Authority of Thailand (IEAT) which owns Maptaput Port, and the Treasury Department which owns Songkhla Port. Most of the state–owned ports are common user ports. However, Maptaput Port, which is an industrial port, most of the terminals are private. They were built under the concession which granted by IEAT to the manufacturers in the industrial estate to serve the imports and exports of their business. In the port, there are two terminals for common users; one is for liquid bulk and the other for general cargoes. Furthermore, most of the state–owned ports are landlord ports of which services are provided by private operators, except Bangkok Port operated by PAT. The owner of the private–owned ports are also various such as importer/exporter, manufacturer, shipping lines, logistics provider. Most of them originally aim to serve their business and then extend the service to common users and are considered to be much smaller ports than Bangkok, Laemchabang, and Maptaput ports.

Cargo Handling Operations: In containerized cargo handling, there is slightly difference between the two major ports, i.e., Bangkok and Leamchabang, and the others. The first two ports consist of several container terminals, after a container truck passing the main gate of the port, if it is a "green", or low risk, shipment which means no special inspection is required, it will directly enter the sub–gate of each terminal to the container yard. In case of a high risk or "red" shipment, the special inspection will be taken either by an X–ray machine or opening it. The other ports are small port or a large port but with only one terminal for container, so the main gate and the sub–gate are combined. In case of a "green" shipment, after the main gate the container will be taken to the container terminal and in case of high risk shipment, the inspection will be taken only by opening it because at no X–ray machines are installed at the other ports except the first two. Moreover, these ports are multipurpose terminals which handle bulk, break bulk and container, hence mobile tower cranes are usually used both for loading and discharging container and break bulk cargoes.

Customs System: The customs procedure at all ports are mostly claimed that the declaration and clearance of import and export goods are currently under the e–Customs system which means that there is no need for relevant parties to submit paper document as all data are transmitted electronically from an import and export company computer system to the e–Customs system. Presently, Thai customs formality is processed under the risk management system. If the goods are in "green" line, they can be released within 15 minutes. However, the paperless customs procedure cannot be completely operated without papers since the computer systems of the customs and the port are not linked. Therefore, paper document is still necessary for all shipments.

Table 1: Details of Studied Ports

Port Name	Type of Cargo	Ownership	Operator	Location
1. Bangkok Port	Container, Break Bulk	State–owned	Port Authority	Chao Phraya River
2. BMT Pacific	Container, Break Bulk	Private–owned	Private Company	Chao Phraya River
3. Thai Prosperity Terminal (TPT)	Container	Private–owned	Private Company	Chao Phraya River
4. Unithai Port	Container	Private–owned	Private Company	Chao Phraya River
5. Sriracha Harbor	Container, Bulk, Break Bulk	Private–owned	Private Company	Eastern Coast
6.Kerry Siam Port	Container, Bulk	Private–owned	Private Company	Eastern Coast
7. Leamchabang Port	Container, Break Bulk, Bulk	State–owned	Private Company	Eastern Coast
8. Maptaput Port	Container, Liquid Bulk, Break Bulk	State–owned	Private Company	Eastern Coast
9. Songkhla Port	Container, Break Bulk	State–owned	Private Company	Southern Coast

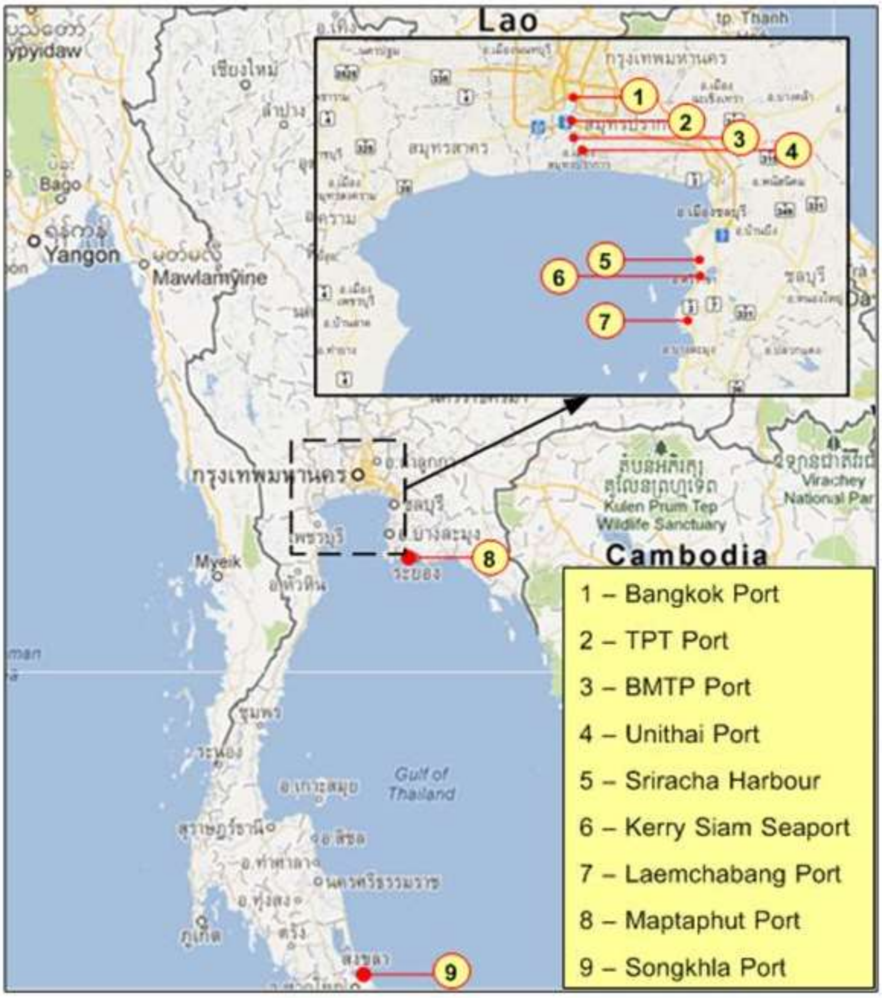

Figure 4: Locations of the Studied Ports

4. OPINIONS FROM STAKEHOLDERS

The in–depth interviews of 39 key port stakeholders including importer and exporter, service providers and related authority as shown in Figure 5. The objective of this step is to identify problems and obstacles of the ports.

Port and Terminal Operators: in-depth interviews of 9 port operators conclude that problems of the state–owned and private–owned ports are different. State–owned ports' most critical problem is congestion between a port and its hinterland. The congestion at the port itself is not much critical. The cause of the problem is due to the increase in cargo volumes is far exceeding the development of the inland transport. For the private–owned ports, they have been facing two major problems, land area for port expansion and financial investment for port business has become increasingly capital intensive. In addition, they lack government support for infrastructure and utility development.

For customs aspects, since there are plenty of customs laws and regulations concerning cargoes and ships, it needs more collaboration between the ports and the customs to eliminate problems that may occur. The computer systems of the customs should be linked up with the ports' so the fully paperless customs procedure can be operated.

Importers/Exporters: The major problems for importers and exporters are due to too many regulations issued by different government agencies in the importation and exportation. These brought unnecessary costs and delays, which result in losing the country's competitiveness. Several regulations should be revised especially those regarding transportation of domestic coastal cargoes and dangerous goods.

Freight forwarders: The clear government policy is the most important factor in the establishment of trade facilities in accordance with the AEC, not only the national single window system, but also the port infrastructure and transport network. Elimination of old-fashioned law and regulations is crucial.

Shipping lines and agents: From the viewpoints of shipping lines and agents, shipping business gets little affect from the AEC because shipping business is already in the international and competitive environment, and conforms to international maritime laws and regulations. The customs procedure which directly relates to the shipping business is the declaration of crew and their personal effects. This procedure is still in manual hence the paperless–customs should be applied to shipping. In order to save the costs and ship's turnaround time, laws and regulations concerning customs and immigration should be modified.

Customs Officers: In order to create the customs integration with the other ASEAN country members, the Customs Department is designated to be the focal point in developing the National Single Window (NSW). The major problem in the development of national single window is the difficulty in collaborations among 36 government agencies involving in the permit of import and export of some goods and each of them has their own format and system. Figure 6 illustrates the structure of NSW in Thailand.

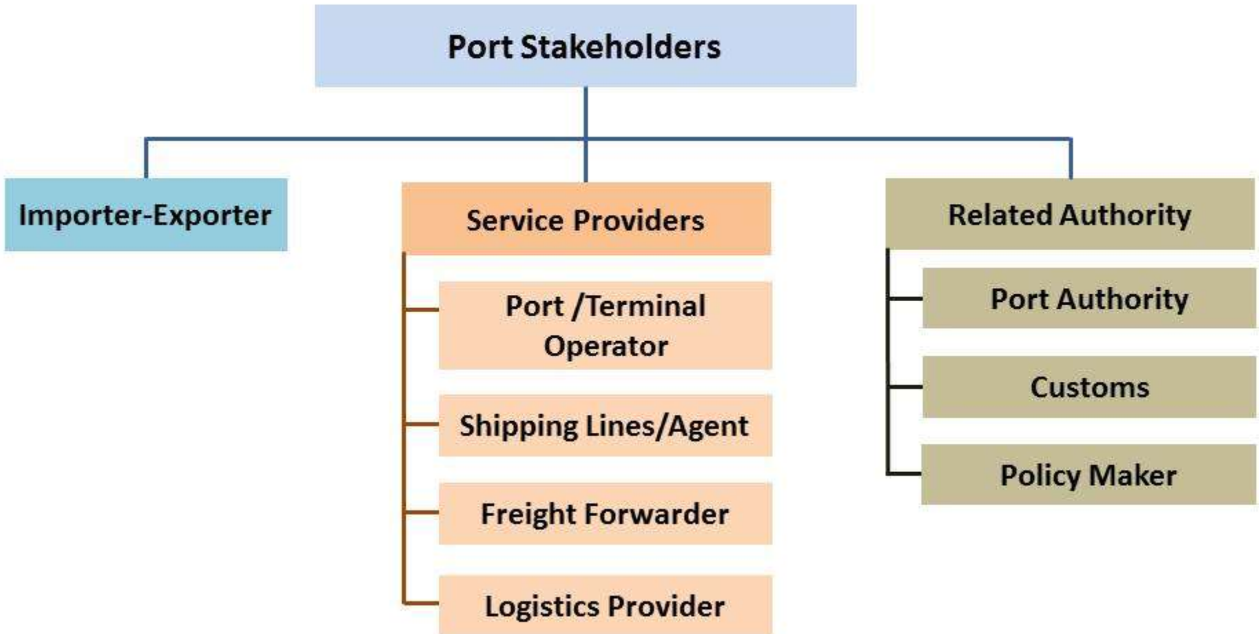

Figure 5: Port Stakeholders

Figure 6: National Single Window in Thailand
(The Customs Department, Thailand, 2016: online)

6. RECOMMEDATIONS FROM THE FOCUS GROUP OF THE STAKEHOLDERS

In order to get a practical recommendation, 37 key port stakeholders who gave an in–depth interview as well as related trade and transport associations such as Thai Shipper Council, Thai Ship Owners' Association; policy maker such as Ministry of Transport were invited again in a focus group to gather their comments. The data collected from the previous steps are synthesized to topics for discussion which include suggestion for overall port development, development of port infrastructure, and development of customs system. The recommendations from the focus group of the stakeholders are as follows:

Suggestion for overall port development: A new organization should be established to responsible for port activities, both state–owned and private–owned ports. This organization should be supported by a board of commissioners of which members are from port stakeholders in both public and private sectors. The most important task of the organization and the board is to draw a master plan for national port development. Presently, port development plan is only a small part of the National Logistics Strategic Plan. The port master plan should integrate the capacity and utilization of both private–owned ports.

Development of port infrastructure: To develop Thai ports to be a gateway of the region, the capacity of transport network that link ports and their hinterland should be improved especially the Leamchabang Port, the most important port of the country. However, the transport network that link the private port should also be taken into consideration. A multimodal transport system should be established especially rail and coastal shipping.

Development of Customs System: Thai e–Customs should be well–connected with the all parties involved in the importation and exportation and transport and service providers especially the port which is the most important node of the maritime transport. The establishment of Thai National Single Window is in a very early stage of development which is quite behind the schedule of the AEC when comparing to other

ASEAN countries. Since there are several government agencies involved, clear government policy is the most important driven force in creating the collaboration among all involved parties. The collaboration would lead to the success in establishment of national single window. Apart from the computer system, well-trained computer and language skills of staffs in both customs and port sides should be taken into consideration. Unnecessary laws and regulations related to importation and exportation should be revised or eliminated. To facilitate Thai port to be a region gateway, modern regulations regarding the goods-in-transit and transshipment cargos should be set up.

7. CONCLUDING REMARKS

In summary, this research is carried out by qualitative methodology to investigate the existing facilitation at Thailand's international ports to understand obstacles and seek a practical development plan to improve and prepare them according to the ASEAN Economic Community. The study consists of three steps, field data collection at 9 international ports in Thailand, in–depth interview of port stakeholders and port of Singapore's related personal, and the focus group for recommendations. It is revealed that the existing port facilities as well as transport network at Thailand ports should be upgraded now to accommodate the increasing trade volumes before 2015, the year that AEC established. The development of national single window would be accelerated also. In addition, computer and language trainings of related personal are compulsory. Lastly, laws and regulations related in importation and exportation should be revised. From the field survey at the Port of Singapore, we found that the success of the Port of Singapore to become the busiest container port and the world's largest transshipment hub is due to its efficient and effective port management as well as the innovation of computer software in maritime transport. The suggestion for Thai ports to become the major port of the region is to have a clear vision and work steadily until the goal is achieved. From the focus group, it is recommended that a new organization formed by port stakeholders from both public and private sectors would be established to create a master plan for national port development.

ACKNOWLEDGEMENTS

This research is jointly funded by the National Research Council of Thailand and Thailand Research Fund (Div 5), Contract No. RDG5550042. The views expressed herein are those of the authors and are not necessarily approved by the funders.

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THE CASE OF SUBSIDIZING SCHOOL BUS OPERATIONS

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Abstract:
The school bus, although a convenient transport mode for parents to send off their children to school, often involves high operating costs. As a result, the bus fee tends to be on the high side. In order to increase patronage, many bus operators resort to unsafe methods to cut costs while paying little regard to service quality and operational safety. This study seeks to assess the benefit of a high-quality school bus system which was designed and put on trial for 49 days by the study team for a school in Bangkok. The perception of the parents toward the school bus and subsequent changes in their attitude were also investigated. After the trial, satisfaction with the service was expressed by the parents who had allowed their children to ride on the trial bus, and who would love to see the continuation of the trial into the next school term. Economic analysis of the trial bus pointed to the need for a subsidy of 45,200 baht per month the availability of which would enable the setting up of a new, complete bus system for the school in question with a fare structure acceptable to the parents. The time and cost saving benefits of such a system, estimated in monetary terms, amounted to 149,400 baht per month for the parents who would settle for the school bus. At the same time, the parents who would prefer to deliver their children using the private car would enjoy the benefit of improved traffic in front of the school.

Key Words: school bus, subsidy, commuting

1. INTRODUCTION

Although many parents preferred to deliver their child to school using a private vehicle (Srisurapanon, V., *et al*, 2014, Pungprajoeb, P. and Rotkaeo, A., 2013, Srisurapanon, V. and Jaisue, S., 2016), either the automobile or motorcycle, this commuting mode has its downside: the convergence of too many cars in front of the school invariably causes traffic congestion while motorcycle deliveries may put the child rider at a greater risk of accidents and injuries.

The school bus has so far proven to be the preferred alternative mode that has been increasingly adopted especially for schools in the provinces. It has been found that, at some of these places, the school bus accounts for deliveries of more than half the number of pupils in attendance at each school. It should be noted that a large percentage of bus passengers are children from outlying districts whose parents have enrolled them at a school in the city supposedly for better education (KMUTT, 2016).

A research paper of the Bangkok Health Research Center (2013), a subsidiary of the Bangkok Hospital Group mentions a set of prerequisites for stakeholders in the provision of high-quality school bus services, namely: 1) The school-bus operator shall adhere to relevant safety regulations, including the maintenance of delivery vehicles to all prescribed standards, and the provision of emergency and first-aid equipment on-board; 2) An on-board carer shall be required who is 18 years of age or older, having passed relevant training and whose presence is mandatory throughout a delivery trip, and 3) The bus/van driver must have a proper permit for the purpose.

Operating a school bus of good quality generally involves high costs which inevitably translate into higher fees to the parents. In order to cut costs, some operators have resorted to unsafe practices such as using modified vehicles with doubtful safety standards, or doing without an on-board carer, or attempting to squeeze in too many passengers for each trip, or increasing the frequency of delivery trips. Such practices are attempts to reduce the service fee — in order to attract more patronage — while safety considerations are often overlooked.

Source: Road Safety Group Thailand
Figure 1. Overloading on a Public Passenger Truck

Figure 2. Crowding Inside a School Van

Figure 3. Squeezing in Extra Seating and Absence of On-Board Carer

Fees for the school bus service vary widely, ranging from under a thousand baht to 8,000 baht per month depending on the service quality and volume of patronage. The parameters of a bus operation can be illustrated in the following example. A school bus of service age two years with seating capacity for 15 passengers is employed to transport 42 school pupils (25 pupils use a round-trip option, 10 pupils use the school-bound option and 7 pupils use the home-bound option) each day operating two trips in the morning and two trips in the afternoon, making a combined trip distance of 100km per day (Pungprajoeb, P. and Rotkaeo, A., 2013). The monthly operating cost of the vehicle is 39,753 baht while revenue from passengers amounts to 47,000 baht, or a fee of just over 1,000 baht per passenger. The profit from this operation is thus 7,247 baht. It can be seen that the bus in question will have to squeeze in many more passengers than the 15 seats specified for the vehicle — a practice which is considered unsafe. For many families, the 1,000 baht fee is deemed too expensive, and the parents may elect to obviate this cost by themselves driving their children to school.

2. SUBSIDY TO SCHOOL BUS OPERATIONS IN OTHER COUNTRIES

In some developed countries, such as Japan, government measures are in place which provide various forms of subsidy for school bus services. Research findings of Hitotsubashi University (2003) indicate that for schools in remote areas not served by regular bus services, the Japanese government would allocate a special budget to implement school bus services for local children's daily commute free of charge. Such a budget may be arranged through funds from the central ministry of education, or from government lottery proceeds or some other local sources. This form of subsidy is based on the notion that the daily commute from home to school is an integral part of the infrastructure to be provided within the mandatory primary education package for all growing children.

In addition to their positive endorsement of such free school bus schemes, the Hitotsubashi research team recommends the sharing of the buses in question with other social activities, such as for medical transport or welfare services, in order to help distribute the costs involved, thereby helping to reduce the fare scale which would be very high if the bus use is restricted to school deliveries.

For schools in areas already served by regular bus services, a school may request a partial subsidy to arranging its own school delivery service. Arrangement of such a service may be through granting a concession for a private party to organize the deliveries wherein fares may be collected from the individual riders, or collected lump-sum by the school for payment to the bus operator. This type of arrangement invariably involves high costs, but it offers flexibility to the school in terms of bus scheduling convenience.

Alternatively, a school may opt to rent the buses only for the morning and afternoon deliveries. This option, although it involves less cost, would mean less flexibility for the school in adjusting the bus schedules since the buses are usually employed for other commercial uses during the mid-day hours.

3. OBJECTIVE OF THIS RESEARCH

This study aims to analyze the outcome of an experimental school-bus arrangement which was designed for greater time efficiency and service quality, and at the same time, looking into the changes in the attitude of the parents who participated in the trial as well as their level of satisfaction in the trial service.

For this study, only the morning school-bound trip was focused upon.

4. METHOD OF THE STUDY

- Review of the commuting modes currently in use by the pupils and related transport issues at the school selected for the experiment.
- Review of existing school bus services.
- Re-design the bus system for the school.
- Conduct the trial using the new system.
- Observe changes in behavior/attitude and satisfaction level of the parents whose children have used the new (trial) system.
- Evaluate the results of the new (trial) system.

5. EXISTING COMMUTING MODES AND RELATED ISSUES

A school in Bang Khuntien district was chosen as target for this trial. The number of pupils in attendance at the school is around 1,200. As high as 90% of the pupils are driven to school by their parents, and this mode of delivery gives rise to moderate to severe traffic congestion around the school during the morning hours from 07:20 to 07:50.

Figure 4. Traffic Congestion in Front of the School

6. EXISTING SCHOOL BUS SERVICES

Beginning in 2015, the school arranged four delivery buses (on four separate routes) to transport a total of 51 pupils. The buses were to pick up the pupils at their homes. So passengers would need to be picked up at some 5 to 6 locations before a bus could proceed to the school, thus taking it from 50 to 100 minutes to make the trip. A fee ranging from 2,800 to 3,500 per month each was charged on passengers who used a round-trip option, while a minimum of 2,500 baht on those who used either the school-bound or home-bound option. The fee level varied with the distance of delivery and the number of passengers sharing the bus on a particular route. A discount system was offered by the school to parents who have more than one child using the system. Investigation by the study team revealed that in a portion of the trips, some buses operated without an on-board carer; bus occupancy was too high on some; and the pupils ignored use of the safety belt.

Income of the bus drivers ranged from 23,000 to 33,000 baht per month depending on the number of passengers on a route.

7. FEATURES OF THE TRIAL BUS SYSTEM

7.1 Pick-Up Points Strategically Located

Designated pick-up points were employed replacing the existing system which required a bus to pick up the pupils one-by-one from their homes — hence, savings in cost and trip time.

7.2 Larger Vans Employed

Larger vans were employed for larger carrying capacities — more passengers per trip, therefore reduction in trip frequency.

7.3 Maximizing Vehicle Use

A van belonging to the King Mongkut's University of Technology Thonburi (KMUTT) was employed in the experiment. Using the van during the early morning and late afternoon helped to fill in the otherwise idle hours of the vehicle which was active only during mid-day. This represents a possibility for cost sharing.

7.4 On-Board Carer

An on-board carer is provided for the trial bus. The carer – a post-graduate student, trained specifically for the project – is to accompany the children from the first pick-up point right to the final destination, i.e. the school.

7.5 Delivery Status Reporting

An advance seat reservation must be made on the eve of the intended day of trip with the parents of the traveling pupil communicating the booking to the on-board carer via the Line application. On each trip, the carer is to report the status of the delivery to the parents via Line application including the bus's arrival times at a pick-up point and the school.

8. OUTCOME OF THE TRIAL

A trial bus system was planned featuring a route for the morning commute to the school. The trial was conducted from 19 January to 31 March 2015, or a period of 49 days. Parents could participate in the trial free of charge by allowing their child to board the bus at either of the two pickup points designated for the trial: one at front of the Holland Beer Bistro on Rama-2 Road (Point A) and the other at the market opposite Wat Yai Rom (Point B).

A 25-seat van belonging to the KMUTT was hired for the trial. The operating crew consisted of a regular employee of KMUTT as driver, and two post-graduate students as carers. The cost of the van hire (including fuel cost) plus the carers' wages amounted to 1,000 baht a day.

A carer was responsible for contacting the participating parents in order to confirm their bookings (on behalf of their children) for the next day's trip.

Each morning the carers were to station themselves at the pick-up points at 06.30 hours to help organize the pupils for boarding. The bus would depart Point A at 07.00 hrs, then travel to Point B at 07.15 hrs. It would then leave Point B at 07.20 and proceed to reach the school at about 07.30 hrs. The time performance of the trial bus was found to be very satisfactory, it being able to arrive on time for all except on two (out of the 49) days where slight delays were encountered due to bad traffic.

Upon arrival at the school the on-board carer would take video recordings of the pupils alighting the van, mark the time of arrival, and post the clips to the project's Line group thereby confirming to the parents the safe completion of each day's commute.

Interest in the service was low in the first 32 days of the trial; only 8 pupils from 5 families used the service. But after additional publicity had been attempted, whereby some of the participating parents related the positive experiences they had had with the project to other parent groups, the bus patronage quickly rose to 17. Daily occupancy of the trial bus was found to vary from 5 to 13 passengers throughout the 49-day period.

9. BEHAVIORAL CHANGE AND SATISFACTION WITH THE TRIAL

Appraisal of the trial was made with a questionnaire survey and a workshop seminar with the latter being conducted on 17 March 2015. Results of these assessments indicated that the participating parents came to recognize the advantages of the new service arrangement and would prefer the trial be continued into the next school term. They expressed their willingness to support the cost at 500 baht a month (or about 23 baht per trip, for one child passenger), and 800 baht a month (or about 36 baht per trip, for two children).

10. APPRAISAL OF THE OUTCOME OF TRIAL

10.1 Cost of the New System

The per-trip cost of the trial consisted of 500 baht bus hire (including fuel cost), and wages for the two carers at 250 baht each. The daily cost was thus 1,000 baht. The amount may be cut down to 750 baht if only one carer is employed.

10.2 Projected Revenue of the New System

825 questionnaires were sent out, from which 450 responses were received (Thongthip, P., *et al*, 2012). Information collected from the survey indicated that the percentages of parents who drove their children to school in relation to the number of children carried, i.e. 1, 2, or 3, were at 49.1%, 35.0% and 5.1% respectively.

From the percentages, it could be deduced that, for a fully occupied bus (25 seats, less one seat for the carer, leaving 24 seats for the pupils), the passenger composition could be coming from 9, 6 and 1 family(s) with 1, 2 and 3 pupils respectively (9 + 12 + 3 = 24). Accordingly, an incentive scheme should be arranged in order to promote such full-occupancy operations. Such incentive could be in the form of a discount based on the fee level that the parents had hitherto expressed their willingness for. In such a scenario, the monthly revenue to be expected of the operation should amount to 10,300 baht as shown in Table 1 below.

Table 1. Bus Revenue from a Full-Occupancy Operation

Children per family	Children using bus	Number of families	Bus fare per month (baht)	Ave. fare per trip (baht)	Total fare revenue per mo. (baht)
1	9	9	500*	23	4,500
2	12	6	800*	36	4,800
3	3	1	1000**	45	1,000
Total	24	16	-	-	10,300

Notes: Based on 22 operating days per month

*As expressed by the parents during project seminar
**Assumption of the study team

10.3 Benefits to the Parents Joining the Program

The most obvious benefit to the parents who allow their children to commute by this mode is savings in time and cost of the drive to school. Time savings of 40 minutes to one hour may be realized, while the distance the parents have to make for each delivery may be cut down by 4km. or longer.

The monetary value of such savings may be calculated as follows: Time savings — rated at 2 baht per minute based on the fare charges of taxi cabs in slow moving traffic — would mean a money saving of 80 baht or more. Savings on fuel and vehicle wear and tear over a 4km distance are rated at 5 baht per kilometer, or a total of 20 baht. Accordingly, the total saving the parents could realize for sending their children on the new bus service in lieu of themselves driving to the school, should amount to 100 baht or more per trip.

10.4 Benefits to the Rest of the Parents

The catchment area of the target school covers the districts of Bang Khuntien, Thoong Khru, and Jom Thong. The school has the capacity to arrange school buses to serve the area. The number of families having a child or more attending this school is 825. Surveys of the pupils' commuting modes indicated that 90% of these, or 742 families, choose to drive their children to school. Some 20.2% of the families, or 176 households (Thongthip, P., *et al*, 2012) expressed their interest in using the trial bus service. Simulations of the traffic situation were made with the number of parent-driven cars derived from the estimates above, i.e. 742 − 176, or 566 cars. Outcome of the simulations indicated a traffic pattern with improved flow, i.e. the average queuing time of each vehicle in front of the school was reduced by 6 minutes. The time period simulated was for the interval from 07.41 to 08.00 hrs which is the peak of congestion in front of the school.

10.5 Economic Analysis

Assuming about half of the interested families would actually switch to the trial mode, the number of patrons would be 0.5 × 176, or 88 families. To accommodate this demand, the school would need to arrange 6 buses (on 6 different routes). The cost of van hire and crew wages would be 99,000 a month (750 baht × 6 vans × 22 days). An operating manager should be required which would incur an additional cost item of 8,000 baht in wage. Operating revenue would vary with the number of users. In the scenario where 96 families choose the service, the 6 buses would be operating at full occupancy (16 families per bus for 6 buses), the revenue from bus operation would amount to 10,300 × 6, or 61,800 baht per month. And the total monetized benefit to the user families would be 211,200 baht (100 baht × 22 days × 96 families).

In addition, the average queuing time for the vehicles still making school deliveries has been estimated to shorten by 4 minutes. Assuming a monetized value of 2 baht per minute, the parents driving those 742 – 96, or 646 vehicles would thus realize a saving of 8 baht per car. This would amount to a total time saving of 113,696 baht per month (8 baht × 22 days × 646 cars).

Table 2 below shows the costs and benefits of a fully-implemented bus scheme for the school based on our trial run. As shown in the table, such a scheme will require a monthly subsidy of 45,200 baht. This subsidy, if spread over the entire number of families whose children are in attendance at the school, will come to 2.49 baht per family per day (45,200 baht ÷ 825 families ÷ 22 days). The net benefit to accrue to all families (both users and non-users of the school buses) will be 149,400 and 113,696 baht respectively, or a total of 217,896 baht.

Table 2. Cost-Benefit Picture of the New School-Bus System with 6 Routes

Cost/Revenue	Bus operator	Parents whose child using bus	Parents who drive child	Total
Vehicle hire & Carer	−99,000			−99,000
System management	−8,000			−8,000
Revenue from fare	61,800	−61,800		0
Savings in time and vehicle cost		211,200		211,200
Saving in time			113,696	113,696
Total	−45,200	149,400	113,696	217,896

11. SENSITIVITY ANALYSIS

Sensitivity of the system to changes in patronage was investigated. It was found that if more and more families join the system, the level of subsidy required would drop while the net benefits would rise. By contrast, if the patronage declines, the net benefit would drop and the extent of subsidy would increase, as shown in Table 3.

Table 3. Project Sensitivity to Changes in Patronage

Families using bus system	Ave. time saved by vehicles in queue* (Min)	Subsidy per month (baht)	Benefits to accrue per month (baht)
96	4	45,200	217,896
80	3	55,500	156,384
60	2	68,375	85,016
40	1	81,250	11,888

* *Estimates by the study team*

12. CONCLUSION

For the school under study, as high as 90% of the parents choose to drive their children to school themselves. This preference gives rise to traffic congestion at the school especially during the half hour before classes start. The proportion of pupils commuting via school buses amounts to a mere 4% of the total.

There is possibilities for sharing passenger vans among various organizations; which should help to reduce vehicle hiring costs. For the study, the passenger van employed was obtained from the fleet belonging to the KMUTT. It was used for the trial during the early morning hours and would revert to its regular functions during the midday hours.

The funds to subsidize the operation of a practical school bus service may be apportioned from the school tuition fees, or collected as a special fee for pupil's transport facilities.

The ranges of benefits herein are limited to the savings in time that would accrue to a parent's driving time if he or she delivers his child to school using a private car. Other benefits, such as reduction in delays, reduction in air pollution around the school, are not included in the estimates. If all of the mentioned advantages are incorporated in the calculations, the combined benefits of the bus system under study should prove even more appealing.

The presence of many under-regulated school bus operations should be looked into by the authorities, and the government should see to it that short-term remedial measures be immediately implemented in order to ensure the safe and efficient commute of school children. Subsidizing well-organized school bus operation is among the worthwhile measures to consider, and it should be designed as an integral part of Thailand's compulsory education package.

ACKNOWLEDGEMENTS

The study team wishes to thank the Asian Transportation Research Society (ATRANS) for their generous sponsorship of this undertaking; and the class of KMUTT transportation engineering students for their help in managing the trial bus operation.

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INFLUENCE OF LAND USE TYPES ON TRANSIT RIDERSHIP: THE CASE STUDY OF BANGKOK MRT

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Abstract: This manuscript presents the evaluation of land use type impact on transit ridership by using the data from Bangkok MRT. From the literature, it is unclear how to quantify land use types along with their distance to transit stations for transit ridership forecast. With the most comprehensive data on the number of MRT riders per hour for all 18 existing stations and high-resolution land use activity data on the area within the TOD walking radius or approximately 550 meters around each station exit from Bangkok Metropolitan Administration in 2015. The land use data are analyzed in terms of land use types, building heights and distance to nearest transit stations. Each land use type is categorized based on ridership travel patterns for mixed-use evaluation and the number of transit riders are rearranged in each period of the day. The regression analysis shows that high-density residential buildings located near the station is the most attract for transit ridership while the desolated lands including car parks, business buildings, and commercial buildings should be located farther away from the stations, respectively. In addition to peak-time ridership analysis, the findings show each land use type has a different level of impact on ridership. The findings from this research verify the TOD concept and bring the more accurate model to forecast transit ridership based on land use activity near transit stations. Apparently, trip purpose would be the most important consideration in ridership forecast process for choosing the appropriate multiple regression model and being guideline for city planning in the future.

Key Words: Transit Oriented Development (TOD), Transit Demand Modelling, Land Use Planning.

1. INTRODUCTION

Transit Oriented Development (TOD) is defined as a guideline to link the communities with transportation by developing the areas around transit station within the walking radius to high density, mixed use, environmentally-friendly area for promoting public transport use and reducing automobile use. Many cities have integrated this TOD concept with land use planning and policy to draw up TOD guidelines for land use development implementation. The land use characteristic within walkable distance around transit station is one of the key factors affecting the number of transit riders.

For Thailand, the TOD concept has gained attention from policymakers and general public while the urban growth has been accompanied by the development of businesses and services. However, the evidence of how land use developments in different types, degrees, as well as the distance to the station influence transit ridership has not been analyzed quantitatively. This research herein thus presents the quantitative analysis through the use of linear regression models with the unprecedented transit ridership data in daily and peak-hour periods from Bangkok Mass Rapid Transit Line (Bangkok MRT). This analysis will yield important information for policymakers and provide evidence for academicians to understand the impact of land use characteristics on transit ridership.

The reminder of this paper is organized as follows. Section 2 summarizes related background research. The data used for this study and analysis methodology are described in Section 3, Section 4 presents results as well as their interpretations. Then, the fifth and final section contains key concluding remarks and policy implication based on this study.

2. LITERATURE REVIEW

2.1 TOD Concept and Evaluation

Past studies showed that the TOD concept generally focuses on the 3-D planning principles as follows: density development, diversity which is mixing land use, and design with pedestrian-friendly (Cervero and Kockelman (1997)). However, TOD strategies for each station area might differ concerning types of urban structural hierarchy since the determinants and coefficients of the land use characteristics, transit accessibility, income, and density vary across urban, suburban and rural areas (Lee et al. (2013) and Chakraborty and Mishra (2013)). Some studies had tried to quantitatively analyze the effect of land uses around transit stations but did not relate them with the ridership. For example, Lin and Gau (2006) developed a multi-objective programming model for TOD planning including maximizing subway station ridership in Taipei with the selection of the ratios of floor space to site space (RFS) as a decision variable for different land uses to find the suitable bounds of RFS by sensitivity analysis. Their result showed that once the upper bound of RFS is greater than 70%, it did not generate the increase of transit ridership significantly. Recent study by Galelo et al. (2014) found that the variables that affect TOD within 400-m and 800-m radius from transit station exits are population density, building density, dwellings density, and transportation availability, respectively. Also, Singh et al. (2014) measured the levels of TOD in Netherlands with the size of grid cell 300x 300 sq.m. to determine land use indicators that affect TOD. This study found that density, land use diversity (through the use of entropy index), land use mixed-ness and the number of business establishments are the key for TOD success. The study also creates the Spatial Multiple Criteria Assessment (SMCA) that weighted each indicator according to its importance to TOD principles and proposed potential TOD indices for the city as a whole.

2.2 Land Use and Transit Ridership Association

There have been attempts to link the land use data with transit ridership. Lee et al. (2013) developed a multiple regression model for analyzing the linkage between the ridership of the Seoul Metropolitan Subway and the land use patterns of the station areas and applied to three cases: all stations case, three clusters and four clusters. The study found that the subway ridership at Seoul’s CBD and fringe areas is influenced by density, however, the sub-central area is affected by diversity. Chakraborty and Mishra (2013) also established the connections between transit ridership and land use and socioeconomic variables in Maryland for state-level planning agencies implications. It shows that land use characteristics, transit accessibility, income, and density are statistically significant in the statewide and urban areas. Sung and Oh (2011) identified effects of TOD planning factors on the transit ridership which are distinguished as weekday and weekend transit volumes at the 214 rail station areas in Seoul by developing multiple linear regression models including the determination of land development characteristics which attract more transit riders. It presents that the mixed-ness of land use type near a transit center in low-to-medium density cities has a more significant role than the development in other cities because of the maximum influence of development tactics. Jun et al. (2015) analyzed determinants of transit ridership in Seoul by using the multinomial logit model for analyzing the land use characteristics of the pedestrian catchment areas and stepwise regression models and mixed geographically weighted regression models to inspect the relationship between the land use characteristics of the pedestrian catchment areas and subway ridership. It recommended that within the distance thresholds of 600 meters from station for TOD principles, the population and employment densities decline outward from stations. Furthermore, population and employment densities, land use mix diversity, and intermodal connectivity indicated by the number of bus stops are well associated with subway ridership. Sung et al. (2014) used the spatial regression to analyze the influence of land use, rail service boundary, and accessibility to station on rail transit relationships of Seoul metropolitan region with several boundary model (250-m, 500-m, 750-m, 1-km and 1.5-km radius). It summarized that density (residential, small-scale neighborhood living, large-scale commercial, large-scale public service, and office) and station accessibility (number of entrances/exits, number of bus routes by station, distance of the closet station, etc.) are positively related to rail transit ridership and the 500-m radius provided the best fit model. Zhuang and Zhao (2014) employed the multiple regression analysis to investigate the impacts of land use and building usage on passengers in Fukuoka, Japan by a radius of 0 – 400 meters from railway stations and 400 – 800 meters for subway stations, where the number of passengers near station are much more than the suburb and low-density stations. It found that the commerce, green land, and educational facilities areas had a high correlation to the number of passengers. Deng and Xu (2015) implemented the cluster analysis method to classify 236 subway stations in Beijing into 9 categories based on boarding and alighting ridership time distribution and investigated the main land use characteristic of each categories, it concluded that the differences of land use surrounding categories would lead to the significant difference of boarding and alighting ridership characteristics.

2.3 City Planning Guideline

The Metropolitan Atlanta Rapid Transit Authority (MRTA, 2010) issues the guideline from the foundational principles of TOD. It classifies transit stations into several categories with dissimilar land use characteristics: density, transit availability, location. The guideline provided the specific standards of density development in terms of Floor Area Ratio (FAR), residential units per acre, and number of floors for each station category as shown in Table 1. For mixed-use development, the guideline recommended the land use of retail, offices, multi-family housing with different income levels, civil facilities, and entertainment to be encouraged.

Table 1: Recommended densities ranges by station category (MRTA, 2010)

Station Type	Floor Area Ratio (FAR)	Residential Units (per Acre)	Height (in Floor)
Urban Core	8 - 30	75+	8 - 40
Commuter Town Center	3 - 10	25 - 75	4 - 15
Neighborhood	1.5 - 5	15 - 50	2 - 8
Arterial Corridor	1 - 6	15 - 50	2 - 10

For Thailand, the Department of City Planning, Bangkok Metropolitan Administration (BMA) classified Bangkok in color zones based on the usage and activity. Each color zone has its own development standards (for new developments only).

The general indices for controlling volume and height of buildings are Floor Area Ratio (FAR) and Open Space Ratio (OSR) as shown in Eq. (1) and Eq. (2) respectively.

$$FAR = \frac{total\ floor\ area\ of\ the\ buildings}{land\ area} \quad (1)$$

$$OSR(\%) = \frac{total\ open\ space\ without\ any\ coverage}{total\ floor\ area\ of\ the\ buildings} \times 100 \quad (2)$$

3. METHODOLOGY

This research evaluates the impact of land use type on transit ridership by employing multiple regression analysis as follows.

3.1 Data Set

This research focuses on the area boundaries within an approximately 550 meters-radius of all 18 existing stations of MRT Blue line which cover the total of roughly 36,000 buildings (plots). The 2015 land use data are obtained in shapefile format (.shp) from the BMA. Randomly check for correctness of these data are also done by walking and Google Map. The selected the land use units within the boundary are exported by using TRANSCAD 4.5 as shown in Figure 1.

Land use characteristic data are collected and regrouped into several categories based on distinct travel patterns from each land use type, i.e., buildings are classified into four groups: 1) residential (res): home, condominium, residence; 2) commercial (com): hotel, department store, entertainment venue including mixed-use building; 3) business (bus): office building, school and university; and 4) desolated land (des): car park, waste land, desolated building. Each land use category is determined the parameters of land use characteristics for model development, i.e., land area (in 103 sq.m.), distance from building to the nearest transit station exit (m.), FAR and each station is determined the open space and park area by proxy variables: transfer mode availability, public space area, and OSR. For the purpose of this analysis, the land area variables represent horizontal land development while FAR variables represent the vertical land development. For ridership data, we use the most comprehensive data of MRT riders in 2015 to analyze and quantify the differences in the number of transit riders in each period of the day and with two ridership kinds which can be separated into six groups: 1) AM Peak boarding volume, 2) AM Peak alighting volume, 3) PM Peak boarding volume, 4) PM Peak alighting volume, 5) average daily boarding volume, and 6) average daily alighting volume. The AM and PM peak ridership numbers refer to the numbers from 7-9 AM and 5-8 PM, respectively, on working days only.

3.2 Multiple Regression Models Development

Six multiple regression models for transit ridership estimation are employed in different periods to investigate how each land use type affects MRT ridership by considering land use characteristic explanatory variables by time of the day. The possibility of multicollinearity between explanatory variables are determined, the results of correlation analysis are shown in Table 2. In this study, we select the variables with the Pearson correlation coefficients over 0.8 to be excluded due to the multicollinearity problem. Table 2 shows that the correlation of the distance of residence and business buildings from the station exit has a correlation coefficient of 0.808, while the one of public area and transit mode availability has a correlation coefficient of -0.882, the closer coefficient value to 1.0 indicated the stronger inter-correlation which leads to the multicollinearity problem, those two pair of variables are correlated with the same direction and conversely, respectively. To test the multicollinearity, we examine the variance inflation factor (VIF) which is defined as the reciprocal of tolerance; the indicator of multicollinearity calculation. The VIF of both pair of variables are not exceed 10 which mean that they are highly correlated but it can be acceptable to neglect the multicollinearity problem.

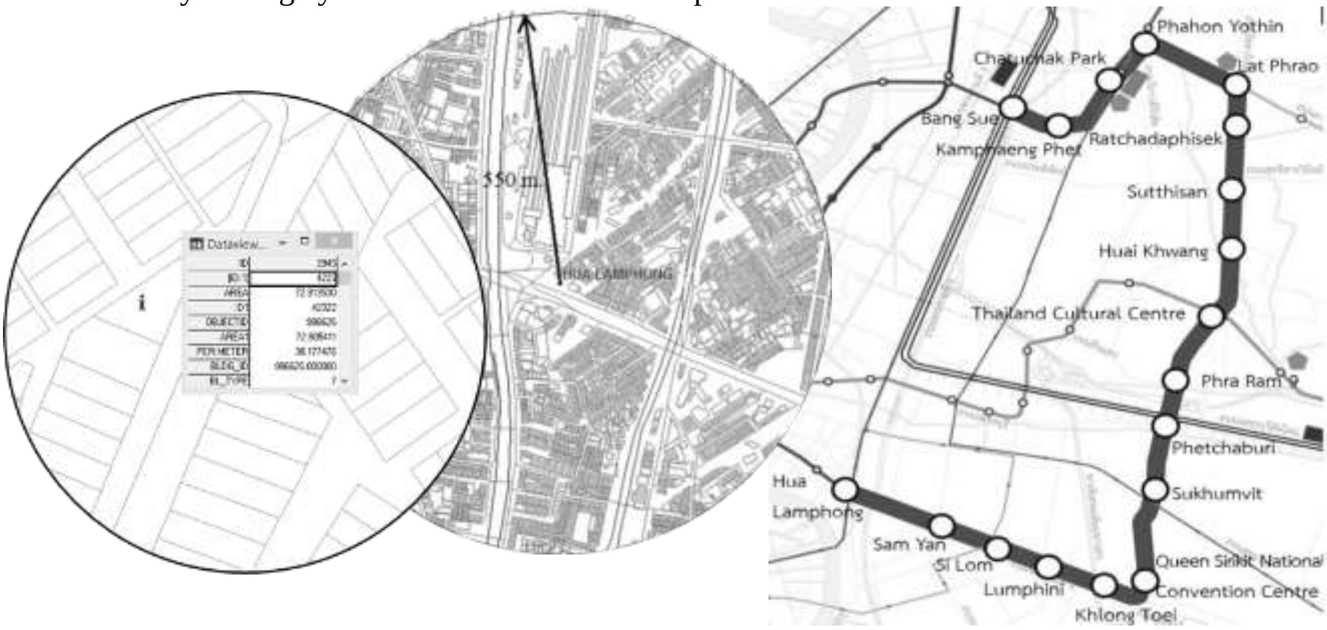

Figure 1: Land use data within a radius of 550 meters from MRT station

Table 2: Correlation analysis of land use characteristic explanatory variables

	area_res	dist_res	FAR_res	area_co	dist_co	FAR_com	area_bu	dist_bus
area_res	1							
dist_res	-0.236	1						
FAR_res	0.079	-0.129	1					
area_com	-0.177	-0.212	0.294	1				
dist_com	-0.444	0.454	-0.424	-0.375	1			
FAR_co	-0.104	-0.403	0.035	-0.111	-0.185	1		
area_bus	-0.401	-0.128	0.388	-0.018	-0.097	0.305	1	
dist_bus	-0.232	0.808	-0.192	-0.413	0.303	-0.268	-0.004	1
FAR_bus	0.109	-0.017	0.009	-0.042	0.024	0.107	-0.013	0.195
area_des	0.003	0.184	-0.619	0.109	0.161	-0.389	-0.493	0.130
dist_des	0.276	0.065	0.120	0.362	-0.373	-0.405	-0.008	-0.043
FAR_des	-0.099	-0.136	0.482	-0.128	-0.228	-0.011	0.731	0.054
transfer	-0.744	0.548	-0.074	-0.052	0.540	0.009	0.043	0.397
public	0.650	-0.438	0.041	0.011	-0.450	0.134	-0.023	-0.352
OSR	0.455	-0.215	-0.601	-0.178	-0.146	-0.126	-0.579	-0.020

	FAR_bus	area_des	dist_des	FAR_des	transfer	public	OSR
area_des	-0.033	1					
dist_des	0.203	0.159	1				
FAR_des	-0.110	-0.441	0.203	1			
transfer	-0.234	0.061	-0.303	-0.114	1		
public	0.365	-0.059	0.226	-0.120	-0.882	1	
OSR	0.020	0.479	-0.015	-0.442	-0.459	0.405	1

4. RESULTS & INTERPRETATIONS

The multiple regression models are employed to compare the effect of each explanatory variable as shown in Tables 3 and 4 with the selection of variables at significance level of 0.05.This section consists of results and interpretations in 3 cases, i.e., weekday, weekend and summary of the influence of explanatory variables on ridership.

4.1 Analysis of Weekday Ridership

Analysis of weekday ridership is divided into 4 cases to clarify the travel behavior of home-based trips as shown in Table 3. The explanatory variables which have the same effect on ridership for all cases are FAR of residential type and area of business building. Both have no consistent relationship to weekday ridership in all cases. Noticeably as expected, two pairs of weekday ridership analysis cases are affected by almost exactly the same explanatory variables: AM Peak boarding & PM Peak alighting ridership and AM Peak alighting & PM Peak boarding ridership.

AM Peak Boarding & PM Peak alighting ridership

First, for the aspect of land use area in terms of building type, the results show that residential land use type has the largest positive influence on the ridership, followed by commercial building while business building failed to has a statistically significant effect and the area of desolated area has the negative influence on the ridership because it does not attract passengers for any activity. In addition, the empty land around the station is against both high density and mixed-use from TOD guidelines. Second, for the distance factor, the results show that the lower distance from residence to the nearest station can build up ridership but it is observed that the greater distance can build up ridership for the rest of others land use type. It can be denoted that riders prefer to stay near the stations since they prefer to get convenience for work trip in rush hour. On the contrary, the distance from buildings of desolated land, business building, and commercial building to the stations can encourage less ridership so it should be located farther away respectively. Note that the desolated land in this study might include parking area that transit riders might park their cars in that area and change to transit mode; therefore, the desolated land which located far away beside the residential area can support MRT ridership. Lastly, for FAR analysis, the desolated land and commercial building has positive impact on ridership increasing while the higher FAR of business building is against that. Actually, the high FAR can be intimated the more living area, high density which follow TOD concept but the results of business buildings which have negative coefficient of FAR can be explained by the reason that business office in Bangkok usually provide parking lots for their employees in the building and encourage driving to work. Also, although desolated land might not support TOD principle from the model but if it is located farther away, it could encourage passenger to use transit mode.

AM Peak alighting and PM Peak boarding ridership

This analysis case can well represent the destination land use of AM Peak travel. With regard to the total building area, the results show that commercial type has the largest positive impact on the ridership, followed by residential but business building area fail to have a statistically significant effect on the ridership while desolated area has the negative influence on the ridership. Among the distance factor, the distance to the nearest station has no significant relationship on ridership for all land use type. It can be implied that distance is not the point for these cases because the research boundary is in the walkable distance (each MRT station are only about 1-km apart from each other) and in the current situation; it always has a motorbike taxi as a transit mode to facilitate the passengers in the AM peak hour. For FAR factor, the significant variables are only the FAR of desolated areas, so the reasoning is the same as mentioned above.

Table 3: Multiple regression model for weekday ridership analysis.

Explanatory variables		Weekday							
		AM Peak				PM Peak			
		Boarding		Alighting		Boarding		Alighting	
		Beta	t-value	Beta	t-value	Beta	t-value	Beta	t-value
constant			-10.242		-4.199		-3.916		-14.198
residential	area_res	1.316	9.173	0.542	2.719	0.536	2.829	1.056	10.686
	dist_res	-1.098	-5.716					-1.125	-7.573
	FAR_res								
commercial	area_co	0.894	6.982	0.688	5.430	0.670	5.504	0.724	8.354
	dist_com	1.154	9.471					1.224	12.579
	FAR_co	0.487	6.022	0.279	2.126			0.603	8.785
business	area_bus								
	dist_ bus	1.108	5.907					1.099	7.554
	FAR_	-0.713	-7.963					-0.900	-12.732
desolated	area_des	-0.327	-4.471	-0.320	-2.255	-0.478	-3.789	-0.449	-8.841
	dist_ des	0.360	4.117					0.856	12.684
	FAR_	0.614	4.398	0.516	3.125	0.407	2.567		
non-building	transfer	2.628	10.391	1.678	4.674	1.707	4.903	1.590	10.044
	public	2.238	12.373	1.293	4.356	1.439	5.075	1.634	13.173
	OSR	0.778	6.257						
Adjusted-			0.956		0.789		0.801		0.967

Table 4: Multiple regression model for average daily ridership analysis

Explanatory variables		Average Daily			
		Boarding		Alighting	
		Beta	t-value	Beta	t-value
constant			-8.283		-10.335
residential	area_res	0.840	6.826	0.788	7.536
	dist_res	-0.840	-4.419	-0.766	-4.743
	FAR_res	0.298	3.012	0.389	4.629
commercial	area_com	0.670	6.208	0.623	6.794
	dist_com	0.710	5.102	0.762	6.441
	FAR_com	0.527	5.502	0.577	7.098
business	area_bus				
	dist_ bus	0.905	4.777	0.816	5.067
	FAR_ bus	-0.528	-5.665	-0.574	-7.243
desolated	area_des	-0.371	-4.088	-0.319	-4.133
	dist_ des	0.681	7.796	0.745	10.038
	FAR_ des				
non-building	transfer	1.610	8.138	1.451	8.633
	public	1.540	9.938	1.412	10.725
	OSR				
Adjusted-R^2		0.949		0.964	

4.2 Analysis of Average Daily Ridership

Table 4. shows that area of business building, FAR of desolated land, and OSR index do not significantly influence average daily ridership. For the rest of significant explanatory variables, transit mode availability and public space with higher values tend to make a higher MRT ridership. In addition to the area of building, residential type has the most positive impact on ridership, followed by commercial type while area of desolated unit has the negative impact. With regard to distance, the greater distance of residential type has negative influence on ridership but the rest of buildings have positive influence with different coefficients. Lastly, commercial and residential building with higher FAR tends to promote ridership significantly.

4.3 Summary of the Influence of Explanatory Variables on Transit Ridership

Based on the six presented cases, some variables are only statistically significant either weekday or average daily analysis. Thus, we can summarize the impact of explanatory variables on ridership as follows: With regards to the land use area variables, the residential area and commercial area have the positive influence on the ridership increasing while desolated area has the negative impact which corresponds with the TOD concept. The results of distance variables suggest that shorter distance of residential type tend to increase ridership, this is consistent with existing land use condition around MRT stations which many condominiums are located along the MRT alignment, while the rest of variables bring less ridership increasing, so it can be implied that these type should be farther away located from the stations. Lastly, the FAR variables, the higher FAR of residential and commercial type are positively related to ridership but higher FAR of business building is against ridership increasing because these high-rise buildings generally have sufficient parking spaces that support automobile travel. For non-building characteristic of each station, transfer mode availability and public area are highly related to MRT ridership and the greater value of these factors have a positive effect on MRT ridership. Overall, MRT ridership mostly affected by transfer mode availability, indicating that transit network connectivity tremendously support the MRT mode. Also, the public space area supports MRT ridership and it can be concluded that the greater public space will provide better accessibility to station. Based on the analysis results, the R^2 of boarding and alighting average daily ridership model (0.949 and 0.964, respectively.) are higher than those of the weekday ridership analysis, so it can be implied that average daily multiple regression analysis have more explanatory power in forecasting MRT ridership.

5. CONCLUSION

This research identifies the relationship between MRT ridership and land use characteristics around the station in terms of area, distance to station, FAR, OSR, interchange availability, public area availability based on walkable distance of 550 meters from 18 existing Bangkok MRT station. The land uses are classified into 4 types: residential, commercial, business, and desolated area with non-building characteristic of each station. The multiple regression models are applied to six cases according to time of day and boarding/alighting ridership. The finding of this research can be concluded as follows: First, the best fit model to explain the relationship is the average daily model with approximately R2 of 0.95., therefore, the average ridership model must be better alternative for determining ridership. Second, for the building factor consideration we found that the greater residential proportion around station has the most positively influence with regard to ridership and the lower distance from residential areas to the nearest station increases the MRT ridership while the desolated land, business building, and commercial building should be farther away located, respectively. Third, transfer mode availability and the higher public space showed statistical significance and consistently positive association with MRT ridership, meaning that completed transit network with good connectivity are key factors of MRT ridership attraction as passengers can walk to a station easily with good accessibility. Finally, it is obvious that trip purpose is one of the most important attentions in ridership forecast, so we should consider the objective of ridership forecast before determining the appropriate multiple regression model. However, one of the important limitation of land use development in Thailand compare with other countries is the lack of land use planning, so we can't classify the station by location, function, or design land use characteristics around. Developing land use without planning would have a disastrous effect on transportation system. The finding of land use impact on MRT ridership can be a guideline for city planning in the future.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support provided by the National Science and Technology Development Agency and the National Research Council of Thailand (Contract No: P15-50071). The views expressed herein are those of the authors and are not necessarily approved by the funding agencies. We also would like to thank Assistant Professor Dr. Apiwat Ratanawaraha who provides valuable suggestions for this study.

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GETTING OUT OF THE RUT OF POVERTY IN THAILAND: THROUGH TRANSPORT ACCESSIBILITY

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Abstract: The December 2016 government cash handouts of 19 billion Baht to some 7 million Thais was a testament to the poverty challenge for the government. This paper describes the global and Thailand poverty situation which shows that the number of poor people have declined over the past decades to about 10.7% and 10.9 % of global and Thailand population respectively and theongoing challenge facing the government. The importance of transport accessibility as a crucial means to enable the poor to access opportunities which include health, education, social services and employments has been highlighted. The lack of safe and affordable public transport in provincial Thailand has led to the proliferation of unsafe and relatively expensive motorcycle taxi and paratransit services. This has happened not because Thailand cannot afford to provide reasonable public transport for the poor; as the recent government' s plan to invest 896 billion Baht in transport infrastructure projects in 2017 can attest to. The lack of institutions to identify the transport needs of the poor and oversee the implementation of transport measures to address their needs appears to be the barrier. These inclusive institutions are imperative in the process of empowering the poor to get out of the rut of poverty.

Key Words: Poverty, Transport accessibility, Public transport, Inclusive institutions

1. INTRODUCTION

1.1 Poverty: The Number one Global Challenge

The 2030 Agenda for Sustainable Development which 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. After decades of policies and interventions aimed at eradicating poverty, poverty has persisted and remained the number one global challenge. The latest 2013 comprehensive data on global poverty show that 767 million people were estimated to live below the international poverty line of US$1.90 per person per day, or 11 out of 100 of the current world population are poor (World bank, 2016). So it is no surprise that in its Agenda for Sustainable Development, the UN has set the most ambitious goal on poverty to date: **End poverty in all its forms everywhere.** To achieve sustainable development, it is imperative to address the issue of poverty eradication with unwavering resolve as it is an indispensable requirement for sustainable development (UN Agenda 2030, 2016). That the issue of poverty is complex and is multidimensional in nature is well accepted and has been previously described (Taneerananon, 2016). To recap, the multidimensional nature of poverty addresses the deprivation of a long and healthy life, knowledge and a decent standard of living. To empower the poor to get out of the rut of poverty, it is imperative that safe and affordable transport be provided, as the unavailability of transport will be a barrier to their participation in health, education and economic activities which are crucial and fundamental steps to prosperity. The provision of better road infrastructure has been shown to have some impacts on poverty reduction (Taneerananon, 2015). However, to benefit from the infrastructure provided, it was assumed that the poor have access to means of transport, which is not always the case as many rural areas still lack public transport. This paper examines why, despite Thailand's financial capability in investment in mega transport infrastructure projects, it still has not addressed the transport needs of the poor in rural areas and provincial cities of Thailand.

2. THE POVERTY SITUATION

2.1 Global Trend in Poverty

According to the 2016 World Bank report on poverty and shared prosperity, significant progress has been made in reducing the number of global poor over the last two decades which saw the total number of the extreme poor declined continuously since 1990. Almost 1.1 billion people were lifted out of poverty in 2013 compared to the number in 1990. Figure 1 shows the trend in reduction in the number of global poor and the poverty headcount ratio (World Bank, 2016). It can be seen that the number of poor has declined from 1850 million in 1990 to 767 million in 2013, while the poverty headcount ration has gone down from 35% to 10.7 % over the same period.

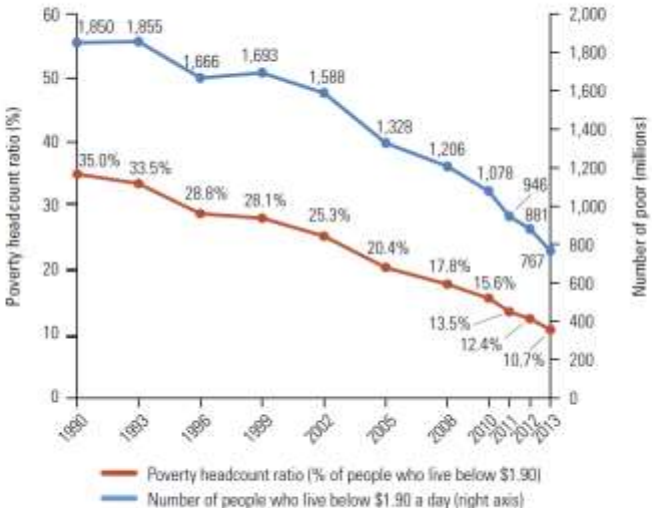

Figure1: Trends in the Global Poverty Headcount Ratio and the Number of the Global Poor, 1990–2013
(Source: World Bank, 2016, page 25)

2.2 Thailand's Poverty Situation

The Asian Development Bank recent report concludes 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, tens of 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. However, 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 Thais 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, 2016a). 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 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). For Thailand, deaths and disability from road accidents are an ongoing cause for national concern, particularly those involving motorcycle users who are mostly in the low-income group. The death or disability of a bread winner can send a family into sudden and prolong poverty (Taneerananon and Laksanakit, 2015). Table 1 gives details of the poor and the nearly poor people in Thailand over the past 26 years.

Thus, poverty situation in Thailand remains a formidable challenge for the government as the country is embarking on a new phase of economic development under the name of Thailand 4. Policy.

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

Year (B.E.)	Perctge of Poor (%)			Perctge of Near-Poor (%)	No. of Poor (%)			No. of Near-Poor (*1000)	Perctge of Very and Slightly Poor (%)	
	Poor	Very Poor	Slightly Poor		Poor	Very Poor	Slightly Poor		Very Poor	Slightly Poor
2531	65.26	50.95	14.31	9.73	34,198	26,698	7,500	5,100	78.1	21.9
2533	58.08	42.03	16.05	11.07	31,683	22,926	8,757	6,038	72.4	27.6
2535	50.09	34.83	15.26	11.97	27,826	19,349	8,477	6,647	69.5	30.5
2537	42.65	25.63	17.03	12.37	24,134	14,500	9,635	6,997	60.1	39.9
2539	35.31	19.58	15.72	13.03	20,321	11,271	9,050	7,501	55.5	44.5
2541	38.72	22.32	16.41	12.91	22,719	13,093	9,626	7,574	57.6	42.4
2543	42.63	26.53	16.10	13.10	25,516	15,880	9,637	7,842	62.2	37.8
2545	32.52	17.98	14.55	13.43	19,621	10,845	8,776	8,101	55.3	44.7
2547	26.86	13.89	12.98	13.24	16,424	8,491	7,934	8,094	51.7	48.3
2549	22.01	10.68	11.33	11.69	13,720	6,658	7,063	7,288	48.5	51.5
2550	20.09	9.20	10.89	12.09	12,677	5,803	6,873	7,627	45.8	54.2
2551	20.46	8.91	11.55	11.65	13,081	5,696	7,385	7,451	43.5	56.5
2552	17.93	7.69	10.24	11.32	11,634	4,991	6,643	7,343	42.9	57.1
2553	16.39	6.95	9.44	11.41	10,812	4,583	6,229	7,531	42.4	57.6
2554	13.23	5.16	8.06	11.53	8,757	3,417	5,340	7,637	39.0	61.0
2555	12.61	5.03	7.58	10.80	8,388	3,346	5,042	7,183	39.9	60.1
2556	10.94	4.05	6.89	10.08	7,305	2,703	4,602	6,727	37.0	63.0

Source: NESB Report on poverty and inequality 2015

3. PLANNING FOR SUSTAINABLE DEVELOPMENT

The current government, in a bid to move the country into the next phase of economic development which counts among its stated goals: getting the country out of the middle income trap, while not leaving anyone behind, has proposed a new paradigm the so called Thailand 4. Policy as a tool to achieve the goals. It is an ambitious policy and together with the 20-year National Strategic Plan, according to the Prime Minister would set Thailand on the path to prosperity and sustainable development (PRD, 2016). Even though one of the six areas being focused in the 20- year plan, is social equality; it is crucial that the plight of the near-poor and the poor which make up 21% of /Thailand population be addressed now so that the stated principle in of government's sustainable development that will leave no one behind becomes ultimately true. There is no doubt that a key enabler for their path out of the rut of poverty is access to safe and affordable if not free transport. The importance of which will be discussed in the next section.

3.1 The Importance of Transport Accessibility

Accessibility has been defined as the ease of reaching goods, services, activities and destinations, collectively they were called opportunities. Other definitions of accessibility include physical access to goods, services and destinations, which is the common meaning of transportation, in social planning, accessibility refers to people's ability to use services and opportunities (Litman, 2016). Hence, accessibility is considered the ultimate goal of most transportation activity. In this paper transport accessibility refers to the availability of affordable and safe public transport so that the poor can use the transport to access government services including health and education, works, goods and other opportunities. Figure 2 shows the type of transport many of the low income people in regional cities in south Thailand have to make do with. It is clear that for lack of access to public transport, people have to fend for themselves and inevitably expose themselves to the ubiquitous danger of road traffic injury.

Figure 2: Lack of accessibility to public transport exposes children to risk of fatality

To further illustrate the importance of transport accessibility, a case study of Thailand is presented below:

It is a real life story illustrating a 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, 2016b).

"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 ups 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"

It is seen from the above case study that accessibility to a van has enabled the poor to regularly access proper health service at a hospital and subsequently helped improve their health. However, the poor, the elderly and the disadvantaged do not only go to hospital, they need to be included in the society, hence they need transport access to go about their daily life and be part of the community and maintain their human dignity and quality of life.

4. RECENT GOVERNMENT'S POVERTY REDUCTION EFFORTS

Despite the continuous decline in the level of poverty in Thailand, poverty still persists and affects millions of people. In the latest development in November 2016 Thai government announced a 19 billion Baht (538 million USD) in cash handouts for poor people in the country. People who earn up to 30,000 THB (845 USD) a year was to receive a 3,000 THB one-time handout while those earning between 30-100,000 THB would get 1,500 THB. Prime Minister Genera Prayut Chan-o-cha described the move as a measure to help low-income earners and a stimulus to the economy. The money was to distributed in December to the 8.3 million poor people who registered with the national E-payment database , however, slight delay was encountered as the Finance Ministry needed to confirm that those registered were poor and eligible for the handouts (Thaipbs.or.th, 2016).

The poor need the occasional handouts to make life a bit brighter especially when the economy has been in the doldrums over the past years. But it cannot replace the provision of transport accessibility to this group of the population as it does not empower them in the long term and cannot be sustained. Only affordable and safe transport can empower and thus help the poor improve their quality of life. 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). Even though the services are provided with good intention, it is clear 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. There is no doubt that Thailand has the capability to invest in large transport infrastructure projects, total investment plan for transportation infrastructure amounts to 2.2 trillion baht(SCBEIC, 2016). In December 2016, the Transport Ministry's action plan was approved by the cabinet, 36 infrastructure projects worth 896 billion baht were scheduled for investment in 2017 (Bangkokpost, 2016). This planned massive investments confirm the country's capability in developing its transport infrastructure, however, what appears to be lacking is the insight into the transport needs of the low income people who have had a hard time going about their daily activities.

5. GETTING OUT OF THE RUT OF POVERTY TO PROSPERITY

In their land mark study of why nations fail, Acemoglu and Robinson showed the link between inclusive economic and political institutions and prosperity (Acemoglu and Robinson, 2012). The authors showed that inclusive economic institutions that create a level playing field, encourage investments in new technologies and skills are more conducive to economic growth than extractive economic institutions that are structured to extract resources from the many by the few and that fail to provide incentives for economic activities. On the other hand, extractive economic institutions are synergistically linked to extractive political institutions, which concentrate power in the hand of a few, who will then have incentives to maintain and develop extractive economic institutions for their benefit and use the resources they obtain to cement their political power. They argued that the synergy between extractive economic and political institutions create a vicious circle, where extractive institutions, once in place, tend to persist. Similarly, there is a virtuous circle associated with inclusive economic and political institutions. For nations to prosper, two conditions have to hold: power has to be centralised and the institutions of power have to be inclusive. In essence, their theory is about how nations can take steps towards prosperity, by transforming their institutions from extractive to inclusive.

5.1 The Need for Inclusive Transport Institutions

Although the authors' work explain poverty in terms of nations' failure to put in place institutions that include extensive participation of the people; by the same token, it can be argued that the public transport accessibility in regional Thailand has not progressed as well as it should especially when compared to Bangkok. This could well be a result of centralised planning with little or no input from the locals. What little progress that has been made over the decades are mostly from the local initiatives.. As an example, failure to provide adequate public transport in provincial cities has given rise to motorcycle taxi and other unsafe paratransit modes. When discussing national transport investment, the emphasis has mostly been on road infrastructure until recently when large investment in rail is on the card, but nothing significant that people in rural areas or provincial cities can benefit, especially the poor. There is clearly a need to create institutions to address the transport needs of the local low-income people who as the government has repeatedly said will not be left behind in Thailand new economic model to future prosperity. Government can do this by setting up institutions to identify the needs for and oversee the implementation of public transport in regional areas of Thailand, this should include urban public transport in provincial cities, and transport from village to town centres. Empowering the low-income population by providing them with means of transport will help them to help themselves and would enable them to get out of the rut of poverty in a sustainable way.

6. CONCLUSIONS

This paper describes the global and Thailand poverty situation. It shows that the number of poor people have declined over the past decades to about 11% and 8 % of global and Thailand population respectively. The importance of transport accessibility as a crucial means to enable the poor to access opportunities which include health, education, social services and employments has been highlighted. The lack of safe and affordable public transport in regional areas of Thailand has led to proliferation of unsafe and relatively expensive motorcycle taxi and paratransit services in regional Thailand with no end in sight. This has happened not because Thailand cannot afford to provide reasonable public transport for the poor as the recent government' s plan to invest 896 billion Baht in mega transport infrastructure projects in 2017 can attest to. It is the lack of institutions to identify the transport needs of the poor and oversee the implementation of transport measures to address their needs with transport accessibility being paramount. These inclusive institutions are imperative in the process of empowering the poor to get out of the rut of poverty.

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THE SOIL IMPROVEMENT WITH RECYCLE CONCRETE FOR ENVIRONMENTAL SUSTAINABILITY

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Abstract

Recycle Concrete is a by-product from building demolition. This study presents an alternative material for road construction incorporating Recycle Concrete as a key component. The paper describes the experimental result of the alternative material made up of lateritic soil and recycle concrete for environmental sustainability at various percentages of 5, 10, 15, 20, 25, 30, 35 and 40 by weight. The parameters associated with California Bearing Ratio (CBR) testing were obtained. Results of the study showed that recycle concrete mixed with laterlitic soil showed that the ratio of 15 percent, the percentage of CBR up to 31.95 percent and 45 percent by weight to the percentages of CBR at 9.03%. In term of Portland cement, the CBR trends to increase with the cement. The findings will enhance the increased use of recycle concrete in road construction which will help manage the burden of industrial scale concrete waste generation in Thailand while promoting Environmental Sustainability.

Keywords: Sustainable, Recycle Concrete, Road Construction, Lateritic Soil, California Bearing Ratio

1. Introduction

The expansion of the construction caused a lot of problems with waste management of the construction. In the United States, It has found that 40% of the waste came from the entire building process, the demolition of old buildings and the construction of new buildings. Concrete wastes can have environmental impact due to the increasing amount of waste and the transportation of waste. So the waste can be utilized to reduce the construction costs of bury garbage or waste incineration. The building demolition waste from collapsed buildings should be utilized as much as possible to help preserve the global environment by reducing drilling materials from the earth. Therefore, this paper will propose the use of concrete waste to improve soil quality for use in road construction.

2. Theory

Thailand continues to grow both in large public and infrastructure projects. As a result, the construction and improvement of infrastructure such as the construction and improvement of roads which is found throughout the country. Therefore, the demand for the use of materials such as stone, sand for use as building materials such as base and subbase of the road resulting in a shortage of materials or the quality of the soil is not suitable for road construction. Therefore, it must be taken to improve the quality of local materials such as soil improvement with concrete waste to be qualified for use as building materials. This is an alternative that can solve the shortage of road construction materials and also re-use of waste materials through recycling.

A significant current in public interest has an interest in environmental conservation by introducing industrial waste to good use. The concept of a research work to bring waste materials to the construction industry by providing concrete waste from the building to improve soil for road construction materials. Therefore, this paper studies the properties of soil mixing with concrete waste compared with Portland cement concrete. The use of concrete waste can make the construction of roads more economical and increase the value of concrete waste. Lateritic soils were most found in Southern Thailand and not suitable for used in the road construction. Therefore, the soil was necessary to improve the quality of the soil before used in road construction [1].

Thailand record for the year 2008, Director of the Environment Agency found that many areas around Bangkok have illegally dumped waste materials derived from large construction projects such as stone, brick, concrete, wood and steel average of 300 tons or 0.5 percent of total waste [2].

Similarly, China has had a remarkable period of rapid growth and many projects of construction buildings. Ministry of Housing and Urban Development - Rural China has revealed that 2 billion square meters of building area every year. This rapid growth in construction activities increases construction waste problems around the world.

The construction in China found that the use of cement and steel, up to 40 percent of the world and the construction industry alone generates waste in the country to 100,000 tonnes per day or 40 million tons per year. The problem is that although the construction company will be responsible for the disposal of these correctly. Only 5 percent of construction waste is disposed legally and less than 1 percent of the waste can be recycled [3].

The California Bearing Ratio (CBR) was developed by the California State Highways Department to evaluate the strength of road subgrades. It is widely used in the design of flexible pavement in highway constructions. The higher the CBR value, the better the material [4]. From the CBR value of each soil type can also determine soil properties and their application for pavement construction as shown in Table 1.

Table 1 Requirements of materials used for base, subbase and subgrade [1]

% CBR	Engineering Properties	Applications
0 – 3	very poor	subgrade
3 – 7	poor to fair	subgrade
7 – 20	fair	subbase
20 – 50	good	subbase, base
50 – 80	very	good base
> 80	excellent	base

3. Test methods

Experimental procedure is as follows:

1. Test for the engineering properties of soil are the grain size distribution (Sieve analysis) the Liquid Limit (LL) and the Plastic Limit (PL).

2. Test for standard compaction and California Bearing Ratio (CBR).

3. Use of construction waste in road construction to solve the problem of waste management. The ratio for soil mixing with recycle concrete and soil mixing with cement are given in Table 2 and Table 3 respectively. The tests were performed varying the cement percentages from 0 to 9%.

Table 2 The ratio for soil mixing with recycle concrete

Series#	Soil: recycle concrete
1	100:0
2	95:5
3	90:10
4	85:15
5	80:20
6	75:25
7	70:30
8	65:35
9	60:40

Table 3 The ratio for soil mixing with Cement

Series#	Soil:C
1	100:0
2	97:3
3	95:5
4	93:7
5	91:9

Each of lateritic soil mixing samples were subjected to preliminary tests which are the water contents determination, specific gravity test and the Atterberg's limits tests. They were carried out to ASTM specifications. The following strength tests were performed: compaction test to obtain the maximum dry density (MDD) and the optimum moisture content (OMC) of the soil, compaction, CBR test to determine the maximum penetration load.

4. Experimental results

The results of the preliminary tests (water content, Atterberg's limits test and specific gravity) as well as the engineering tests (compaction and CBR) are discussed.

4.1 Properties of the Lateritic soil

The water content of lateritic soil sample is 19.46% and the specific gravities are 2.74. it is shown that the LL, PL and PI of the soil are 47.03%, 23.96% and 23.07% respectively. The summary of preliminary test results is shown on Table 4.

Table 4 Properties of the Lateritic soil

Soil Properties	Value
Water content	19.46 %
Liquid Limit	47.03 %
Plastic Limit	23.96 %
P.I.	23.07 %
S.G.	2.74

The lateritic soil was classified as SW according to Unified Soil Classification System (USCS) and therefore has an American Association of State Highway and Transportation Official (AASHTO) classification code of A-2-7.

4.2 Compaction test results

Purpose of the test object compaction of soil samples to determine the relationship between the OMC and MDD as a percentage of recycle concrete and Portland cement, respectively. The results for OMC and MDD of soil samples mixed with recycle concrete has shown in Table 5.

Table 5 The OMC and MDD of soil samples mixed with recycle concrete

%RECYCLE CONCRETE	OMC (%)	MDD (gm/cc)
0	16.10	1.82
5	14.10	1.82
10	13.91	1.82
15	14.06	1.82
20	14.04	1.82
25	14.01	1.82
30	14.07	1.83
35	14.10	1.83
40	13.49	1.83
45	13.45	1.85

Table 5 shown that the OMC is proportional to the ratio of recycle concrete. The OMC ranged between 13.45% and 16.10% with MDD of between 1.82 and 1.85 gm/cc. The amount of 5% recycle concrete found that the OMC reduced by about 12.42% compared to 0% recycle concrete.

Table 6 The OMC and MDD of soil samples mixed with Portland cement

%C	OMC (%)	MDD (gm/cc)
0	16.10	1.82
3	16.00	1.81
5	16.00	1.81
7	16.28	1.82
9	16.51	1.81

A summary of the compaction test results for soil samples mixed with Portland cement is shown on Table 6. The OMC of the soil samples at 7% cement and 9% cement increased with increase in cement content. However, the maximum dry density resulted from the tests remaining constant after the increasing cement content.

Table 7 CBR value of soil sample mixed with recycle concrete

% recycle concrete	CBR (%)
0	15.98
5	25.70
10	29.18
15	31.95
20	25.82
25	18.52
30	14.12
35	14.82
40	9.49
45	9.03

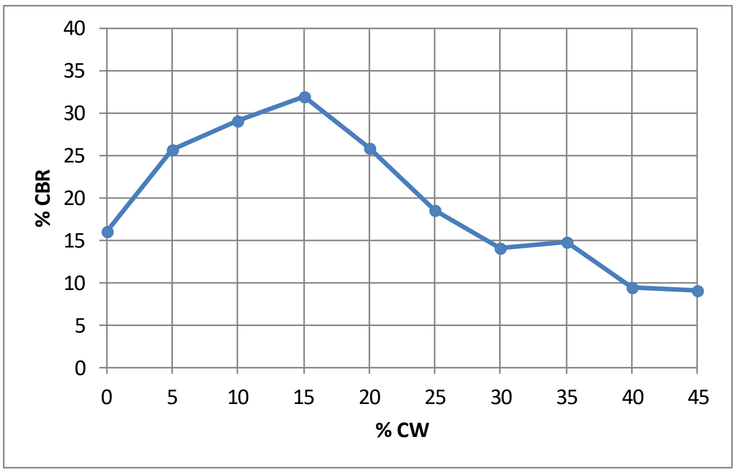

Figure 1 CBR value of soil sample mixed with recycle concrete

Table 7 and Figure 1 show a summary of the results obtained from CBR tests. The CBR of the soil increased with increase in recycle concrete contents to a maximum at the optimum content of 15% recycle concrete. The CBR value of soil sample mixed with RECYCLE CONCRETE increased from 15.98% at 0% to 31.95% at 15% recycle concrete.

Table 8 CBR value of soil sample mixed with cement

%C	CBR (%)
0	15.98
3	16.58
5	17.25
7	18.41
9	23.79

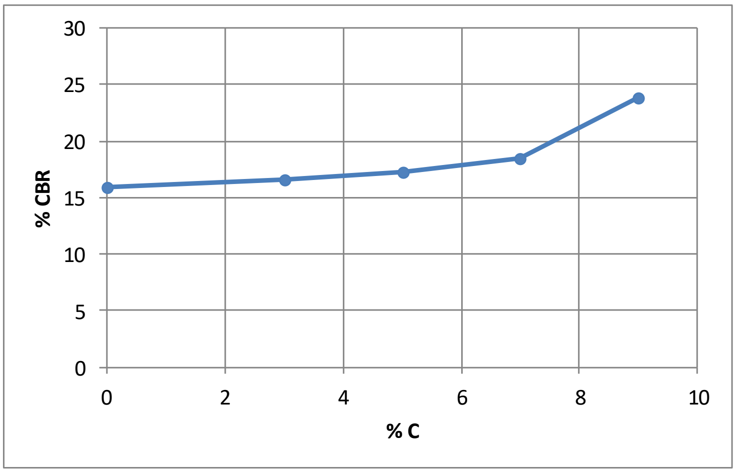

Figure 2 CBR value of soil sample mixed with cement

From the Table 8 and Figure 2, the CBR increased with increase in cement contents. The CBR value of soil sample mixed with cement increased from 15.98% at 0% to 23.79% at 9% cement content.

5. Conclusions and recommendations

1. The relationship between the CBR and the ratio of concrete waste of 15% is the highest CBR value. It is found in the range of 20-50%, it will be suitable as base or sub-base materials in pavement construction. While for the concrete waste mixture ratio of 45% by weight will perform as sub-base materials.

2. The relationship between CBR and Portland cement have higher CBR. It need improvement for the material to be considered for use as base materials.

3. Results of the preliminary tests classified the lateritic soil samples as fair pavement construction materials. With optimum stabilization, lateritic soil will be suitable as base materials in pavement construction.

4. This method of using lateritic soil mixed with recycle concrete as road construction building materials is friendly to the environment, but itself has some limitations. Its universality of application is needed to be considered.

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PREDICTING NOISE FROM TRAFFIC ON PARA - ASPHALTIC CONCREATE AND PARA SLURRY SEAL PAVEMENTS

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ABSTRACT

Noise from road traffic is a source of disturbance and annoyance to people living or working along a major road. Traffic noise is generated from sources such as running engines, vehicle exhaust pipes and the scuffing of wheels against road pavement.

This research aims to predict the level of noise emanating from two types of road pavement, namely para-asphaltic concrete and para slurry seal, the use of which is being promoted by the Thai government in attempts to stimulate greater demand for natural rubber which is currently in oversupply. The Wang-a-pisit noise pollution equation is employed for noise prediction in this study. Actual noise levels were recorded at a number of test sites, together with the collection of related field data for model input which comprised: road geometry, vehicle speed, and traffic volume. Various relationships between loudness levels and noise generating factors are presented herein.

The Pair t-Test method was employed to test the fit of predicted values against the actual measurements. It was found that the predicted values were lower than the actual levels obtained from the field tests. This indicates certain shortcomings of the Wang-a-pisit prediction model when it is employed for cases involving para-asphaltic concrete and para slurry seal. It is therefore recommended that testing parameters and noise factors for the model be adjusted accordingly so as to obtain more accurate predictions in future studies.

Keywords: Traffic Noise Level, Noise Prediction, Para-Asphaltic Concrete, Para-Slurry Seal, FHWA TNM
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1. Introduction

Noise from road traffic has become a pervasive environmental issue causing discomfort to people living or working along a major road. The U.S. Environmental Protection Agency has established a noise threshold at 70 dBA for prolonged exposure — loudness beyond the threshold may lead to hearing damage. As traffic volumes on major roads are trending higher given the fast increases in car population, the resulting noise level is expected to rise accordingly thereby becoming a threat to the well-being of roadside communities. The study of noise and the impact of noise should therefore be incorporated in the planning of new traffic projects including construction, extension, widening or any other improvement of existing road networks. Noise levels can be forecasted using a number of existing prediction models.

In its attempt to help shore up the prices of rubber produce, the Thai government is currently promoting the use of rubber latex as an ingredient in the material mix for road pavement. Two types of such paving materials now in wide use are the para-asphaltic concrete and para slurry seal. This study aims to investigate the correlation of the actual noise generated on the two types of pavement to the theoretical values predicted by a noise model.

2. Purpose of the study

This study is an attempt to test the validity of the Wang-a-pisit 2010 Model when it is employed for forecasting noise generated on para-asphaltic concrete and para slurry seal pavements.

3. Related research works

[U.S. Department of Transportation, 1978] introduced a prediction model called FHWA which was employed to estimate the average noise level, or L_{eq}, emanating from free-flowing road traffic in the US. The value of L_{eq} was found to be dependent upon a number of factors including the energy released by a vehicle, traffic volume, average vehicle speed, the distance from road centre to sound receptor, road length, and existing obstacles to sound wave propagation.

[Kittisak Na Nong Khai, 2004] in his study of the noise levels from traffic in the city of Chiang Mai proposed that prediction models be split into two categories, one for traffic with continuous flow and the other for non-continuous flow. His findings indicated that an FHWA-based model was suitable for forecasting the noise levels from continuous flow traffic, while one constructed along the concept of the Jrailw was good for non-continuous flow traffic.

[O. Wang-a-pisit, 2010] investigated the performance of prediction models in forecasting noise levels from traffic on three types of pavement in Thailand, namely: concrete, asphaltic concrete and porous asphaltic concrete. Attempts were made to re-calibrate the FWHA model to match the conditions of the pavement types, and it was found that output of the re-calibrated model was very comparable to actual measurements obtained for the pavement types.

Review of related literature indicated only a very small extent of research on this topic has been attempted so far. This has prompted the authors to look into the validity of the Wang-a-pisit Model if it is applied to predicting traffic noise on para-asphaltic concrete and para slurry seal pavements.

4. Scope of the Study

The extent of this study was limited to the investigation of noises generated by traffic on roads paved with para-asphaltic concrete and para slurry seal. On a test road, only a single measuring station was employed to record traffic noise as well as traffic density. The location of the station was determined for its having a smooth and dry pavement free from strewn rocks or gravel, and being without noises from other sources which would interfere with the reading of noise from the traffic. A suitable stretch of road for testing must be on a wide open area, without any presence of large structures in a radius of 30m that might reflect sound waves towards the measuring station. Moreover, the site must be on a straight and level stretch of road without a noticeable bend or gradient, which would allow all vehicles to traverse it at a constant speed. Readings were made of vehicles while they are traversing single-file without passing traffic in the contra-direction.

Tests were conducted on three major arteries of the road network in Songkhla province, as follows:

1. Alignment from Ban Koh Mee, at Tambon Khor Hong, to Ban Koh Mee Nai, at Tambon Khlong Hae, in Hat Yai district, Songkhla province. Paved with para-asphaltic concrete, 3.40m wide, having 2 traffic lanes, 1.30m shoulders, total route length 2.445km.
2. Road branching off Hwy 4287 at Km 20+600 to Toun Nga Chang Waterfall. Paved with para-asphaltic concrete, 3.50m wide, 2 traffic lanes, 1.00m shoulders, route length 11.50km.
3. Road connecting Hat Yai Airport to Hat Yai city. Paved with para slurry seal. 3.70m wide, 4 traffic lanes, 2.20m shoulders, Route length 7.00km. This major road connects Hat Yai city with neighboring provinces.

Fig. 1: Locations of the three test stations for this study

5. Method employed for the study

Actual noise levels at the test sites were measured using noise metering devices. Parameters relating to traffic at a site were also collected. Information thus obtained was inputted into the prediction model whose output was then compared against the actual noise profiles obtained at a site. Data fit between the actual set of measurements and the model output was determined, and the results tabulated. The flowchart of the steps is shown in Fig. 2.

5.1 Data collection

Data to serve as input for the prediction model consist of two categories:

5.1.1 Traffic-related Data

These are factors that will have a bearing on the loudness of the noise generated. Such factors include: traffic density, average speed, and road geometry.

Traffic Volume was measured by recording the number of vehicles using a counting tape as well as manual counting, as shown in Fig 3. Counting was done per direction of travel, and for separate types of vehicles, as follows: motorcycle, sedan, 6-wheeled bus, trucks at three sizes — 6-wheeled, 10-wheeled, and larger.

Vehicle Speed was measured for separate types of vehicles as cited above. Speed was calculated based on the amount of time a vehicle takes to traverse a given distance. The traversing time was determined using a stopwatch.

Schematic of data collection

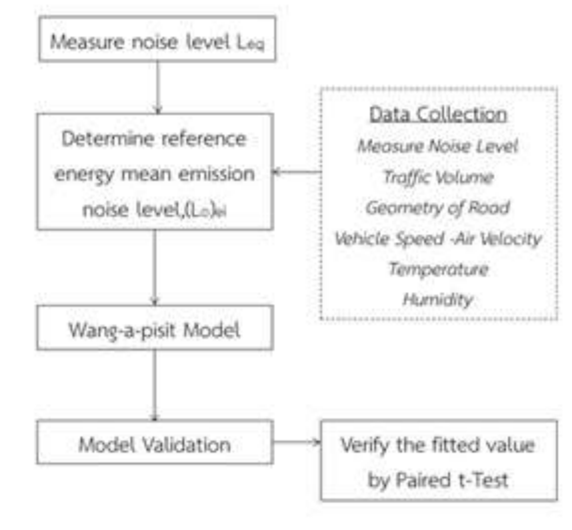


Fig. 2: Steps in the method employed for the study

5.1.2 Noise level data

Noise level was measured using a digital meter as shown in Fig. 4 while wind speed determined by a device shown in Fig 5. Readings of the meters were made at intervals of 15 minutes. The microphone of the noise meter was positioned at 1.5m height from road surface (see Fig. 6).

A measuring station was established on each of the following road sections:

- Toun Nga Chang Road – at Km 6+200 to 6+300
- Ban Koh Mee Road – at Km 6+200 to 6+300
- Hat Yai Airport Road – at Km 0+850 to 0+950

Fig. 3: Field measurement of traffic volumes and noise levels

Fig. 4: Traffic noise meter

Fig. 5: Wind speed meter

Fig. 6: Position and height of installed noise meter

5.2 Details of field measurements

Table 1: Fundamental data obtained from test sites

Variable	Location of Data Station			
	Toun Nga Chang	Koh Mee	Hat Yai Airport (inside lane)	Hat Yai Airport (outside lane)
Traffic Volume (Veh/hr)	220	325	335	345
PC (Veh)	185	270	289	320
MV (Veh)	30	35	18	10
HV (Veh)	5	20	28	15
Avg.Temp.	31.20	35.40	34.40	34.40
Avg.Hum.	66%	68%	70%	70%
Avg.Wind (m/s)	0.92	1.54	1.36	1.36

* Shown in the table above are traffic compositions and ambient conditions over a 4 hour period. At the respective sites, PC (passenger car) counts were: 185, 270, 289 and 320; MV (medium-sized vehicle) 30, 35, 18, and 10; HV (heavy vehicle) 5, 20, 28 and 15; Ave. Temperature 31.20, 35.40, 34.40 and 34.40; Relative Humidity 66%, 68%, 70% and 70%; Ave. Wind Speed (m/s) 0.92, 1.54, 1.36 and 1.36.

5.3 Traffic Noise Prediction Model

The data obtained from the test sites were used as input into a simulation model. Output of the model under study was then analyzed in order to gauge the validity of the model. In this study, the Wang-a-pisit Model was employed.

$$(L_{eq})_i = (L_o)_{EAU} + [10\log_{10}(N_i \pi d_o / S_i T)] + [10(1+\alpha)\log_{10}(d_o/d)]_i + [6.6 - 5.31\log_{10}S_i + G) + (\Delta_{shielding})_i + \Delta_{atm} + \Delta_{wind} + 7.72]$$

$$(L_o)_{EAU} = 38.10 \cdot \log S - 2.4$$

Where

$(L_{eq})_i$ = Mean noise level (d BA)

$(L_0)_{EAU}$= Reference noise level from 4-wheeled passenger vehicles

$[10\log_{10}(N_i \pi d_o/S_i T)]$ = Correction factor for traffic count and speed measurement

N_i = Number of vehicles of each type

D_0 = Reference distance, 15m

S_i = Average vehicle speed (Km per hour)

T = Duration of test (4 hours)

$[10(1+\alpha)\log_{10}(d_o /d)]_i$ = Correction factor for the distance from noise source to microphone (dB)

d_o = Reference distance, 15m

d = perpendicular distance from road centerline to microphone

α = Site parameter associated with noise absorption

$[6.6 - 5.31\log 10 S_i + G]$ = Correction factor for road gradient (dB)

Si = Ave. Speed (km per hour)

G = % value of road gradient

$(\Delta_{shielding})_i$ = Correction factor where there is presence of noise shield to microphone (dB)

Δ_{atm} = Correction factor for ambient weather, temperature and moisture.

Δ_{atm} = $(5.4x10^{-4}xD)$ dB

D = Distance from road centerline to microphone (ft.)

Δ_{wind} = Correction factor for wind speed

Δ_{wind} = $-[0.88\log(l/15)U\cos\theta]$

U = Wind speed (metre per second)

θ = Angle, in radians, of wind direction to road alignment

5.4 Appraisal of the model

The noise levels predicted by the model were checked against those from actual field measurements in order to determine the validity of the model. The Paired t-Test method was employed to determine the fit of the two sets of results.

The Paired t-Test is a statistical inference for testing the differences of two groups of samples. In this study, the two sample groups — actual site data versus results of model prediction — are dependent samples. A Null Hypothesis (H_0) was established where the sample groups showed no significant differences. But an Alternative Hypothesis (H_a) was not practicable due to uncertainties in the resulting t's which may fall either on the high or low sides. Instead, a Two-Tail test was conducted with significance level at 0.05, or a confidence at 95%. Furthermore, the t-stat, t-critical and p-value were considered in order to check whether the output of the model was valid for the purpose hereof. Parameters involved in the Paired t-Test method are shown below:

$$t = \frac{\bar{d} - \mu}{SE/\sqrt{n}}$$

Where:

d = Difference between the means obtained from actual measurements and from model-predicted values;

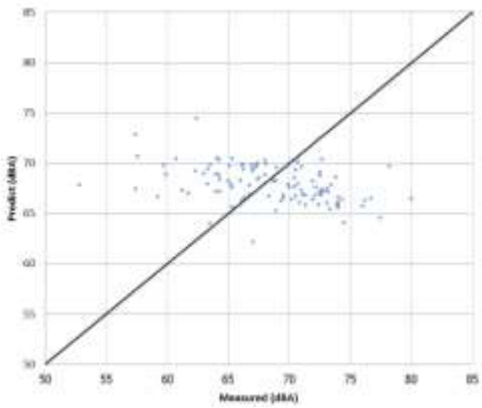
SE = Standard deviation

n = Number of vehicles observed

6. Outcome of the study

The noise levels from actual readings at the test sites and the values given out by the Wang-a-pisit Model were plotted on X-Y coordinates in order to analyze the resulting fits and deviations. The plotted curves are shown in Figures 7 and 8. It can be seen in Fig 7(a) that the actual measured dBA levels on the para-asphaltic concrete pavement of the Toun Nga Chang Road were comparable to the values given by the Model.

Fig. 7(b) displays the results of testing on para-AC pavement on the road from Ban Koh Mee to Ban Koh Mee Nai. Fig.8 shows results of tests on para slurry seal surfaces. For these tests, the values predicted by the Wang-a-pisit Model were found to be lower than the actual measurements on the sites. This was due to the high volume of traffic and the presence of noise from vehicles traversing in contra-direction, which led to accentuated levels of noise. The results indicated that the Wang-a-pisit Model does not account for the factor of noise from contra-directional traffic.



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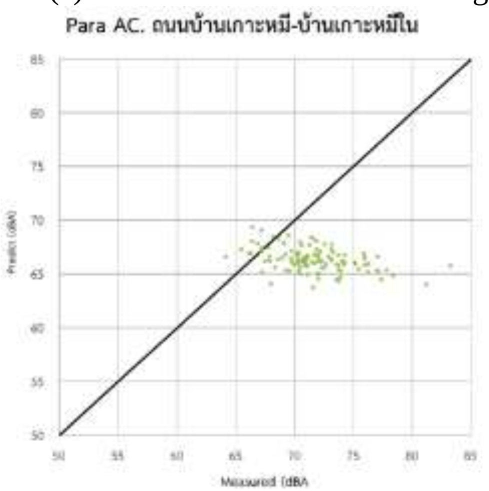
(a) Results from tests on Toun Ng Chang Road (para-asphaltic concrete)



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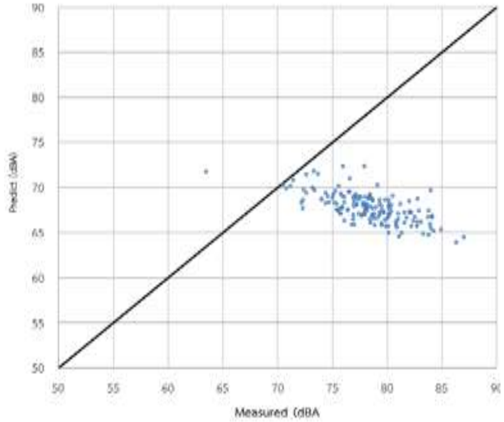
(b) Results from tests on Ban Koh Mee Road (para-asphaltic concrete)

Fig. 7: Correlation between values of traffic noise from actual measurements and model predictions. Tests on roads with para-asphaltic concrete pavement.



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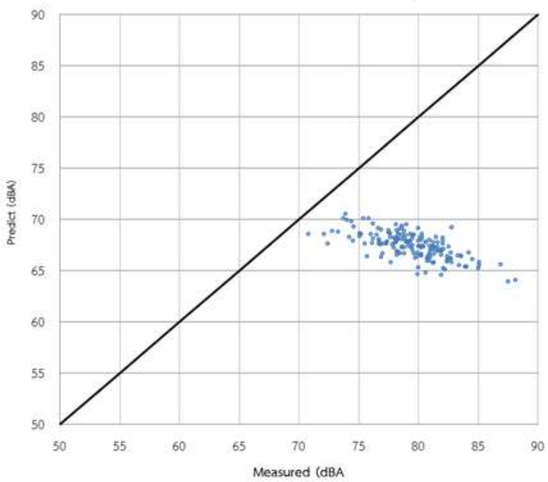
(c) Results from tests on Hat Yai Airport Road (inside lane – para slurry seal)



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(d) Results from tests on Hat Yai Airport Road (outside lane – para slurry seal)

Fig. 8: Correlation between measured values of traffic noise and model predictions. Tests on roads with para slurry seal pavement

Table 2: Results of Paired t-Test on the measured noise values on Toun Ng Chang Road (para-asphaltic surface) versus values predicted by the model

Item	**Actual measureme nt**		**Predicte d value**
Mean	68.47		67.94

Variance	24.65		3.59
RMSE		10.16%	
Observations	107		107
Hypothesized Mean Difference		0	
df		136	
t Stat		1.038	
P(T<=t) one-tail		0.150	
t Critical one-tail		1.65	
P(T<=t) two-tail		0.30	
t Critical two-tail		1.97	

Table 2 shows value of t-Stat (1.038) being less than the Critical two-tail (1.97) which conforms to the null hypothesis. With P(T<=t) two-tail (0.30) being higher than 0.05, it indicates a good fit between the actual measurements and the predicted values. Mean Difference of the L_{eq} is 0.53 dBA.

Table 3: Results of Paired t-Test on values obtained on Ban Koh Mee Road (para-asphaltic surface)

Item	**Actual measurement**		**Predicted value**
Mean	71.65		66.33
Variance	10.46		1.16
Observations	115		115
RMSE		13.59%	
Hypothesized Mean Difference		0	
df		16.74	
t Stat		16.74	
P(T<=t) one-tail		1.97	
t Critical one-tail		1.66	
P(T<=t) two-tail		3.93	
t Critical two-tail		1.97	

Table 3 shows the t-Stat (16.74) being lager than t-Critical two-tail (1.97). This invalidates the null hypothesis. With P(T<=t) two-tail (3.93) higher than 0.05 it means the predicted values are lower than the actual values measured on the test site. Mean difference of the L_{eq} is 5.32 dBA.

Table 4: Results of Paired t-Test on values obtained on Hat Yai Airport Road (Inside lane, para-slurry seal surface)

Item	**Actual measurement**		**Predicted value**
Mean	78.34		67.75
Variance	11.73		2.51
Observations	163		163
RMSE		17.87%	
Hypothesized Mean Difference		0	
df		228	
t Stat		35.81	
P(T<=t) one-tail		7.04E-96	
t Critical one-tail		1.97	
P(T<=t) two-tail		1.40E-95	
t Critical two-tail		1.97	

Table 4 has the value of t-Stat (35.81) larger than that of the t-Critical two-tail (1.97). This invalidates the null hypothesis at 0.05 significance. Accordingly, the predicted noise values are lower than the actual values measured on site. Mean difference of L_{eq} was 10.59 dBA.

Table 5: Results of Paired t-Test on values obtained on Hat Yai Airport Road (Outside lane, para-slurry seal surface)

Item	**Actual measurement**		**Predicted value**
Mean	79.43		67.41
Variance	8.83		1.60
Observations	164		164
RMSE		19.11%	

Hypothesized Mean Difference		0	
df		220	
t Stat		47.70	
P(T<=t) one-tail		2.68E-118	
t Critical one-tail		1.66	
P(T<=t) two-tail		5.36E-118	
t Critical two-tail		1.97	

Table 5 (for tests on the outside lane of the Hat Yai Airport Rd) has the value of t-Stat (47.7) which was larger than that of the t-Critical two-tail (1.97). This invalidates the null hypothesis at 0.05 significance. Accordingly, the predicted noise values are lower than the actual values measured on site. Mean difference of L_{eq} was 12.02 dBA.

Table 6: Summary of all Paired t-Tests at 0.05 significance on values obtained on pavements of para-asphaltic concrete and para slurry seal surfaces.

Road	**Pavement type**	**Mean Difference**	**t-Stat**	**t-Value**
1. Toun Nga Chang	Para-AC	0.53	1.038	1.97
2. Ban Koh Mee	Para-AC	5.32	16.74	1.97
3. Airport Road (inside lane)	Para slurry seal	10.59	35.81	1.97
4. Airport Road (outside lane)	Para slurry seal	12.02	47.70	1.97

7. Conclusion and recommendations

The average loudness of the traffic noise on para-asphaltic concrete and para slurry seal pavements as obtained from the Wang-a-pisit Model was found to have a lower value than that from actual measurement on the test sites. The higher noise readings at a test site could have been caused by a number of factors present during the test that have not been fully accounted for in the model, such as the roughness of road pavement, interferences to the traffic flow, excessive winds, climatic variables including temperatures, rains, and humidity.

It is therefore recommended that the Wang-a-pisit Model be adjusted to cater for a wider range of traffic surfaces. To this end, the authors shall undertake further studies in due course in order to enhance the validity of the model for future use in predicting noise levels on these two types of pavement.

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