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Traffic Simulation Analysis for Depot Construction Period of Bangkok–Nakhon Ratchasima High-Speed Train

Juraluk Thinphowong [1], Boonsap Witchayangkoon [1*], Winai Raksuntorn [1], Sayan Sirimontree [1], Sanya Namee [2], Ahmad Sanusi Hassan [3], Yasser Arab [3]

[1] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, THAILAND.*

[2] *Department of Disaster Prevention and Mitigation, Ministry Of Interior, Royal Thai Government, THAILAND.*

[3] *School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, MALAYSIA.*

**Corresponding Author (Email: Drboonsap @ gmail.com).*

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Abstract

Thailand plans to build the Bangkok–Nong Khai (Northeastern) High-Speed Railway as part of the Kunming-Singapore railway central section, using dual standard-gauge tracks and operating speed 250 km/h. The first part is the Bangkok-Nakhon Ratchasima High-Speed Railway. This study conducts the traffic simulation analysis for traffic management inside the depot construction site of Bangkok-Nakhon Ratchasima High-Speed Railway Depot Project. Using Aimsun software with microscopic traffic simulation modeling, this study models a total of five options and compares the results under a traffic management plan to alleviate the difficulty of traffic control task of 700 vehicles per day carrying materials to deliver inside the construction project site. Delivery materials include spun piles, landfill materials, ready-mix concrete, and machinery and service vehicles. This study reveals that the construction site traffic depends on volume to road capacity ratio, volume to unloading time ratio, vehicle-time schedule, and limited stopping area. From the analysis, the best solution is to divide the traffic volume into two periods a day to distribute the volume of traffic inside the depot construction project, as the total travel times and delays are decreased and cause no effect on the public traffic system. The operating cost is also the lowest.

Disciplinary: Civil and Traffic Engineering, Construction Management.

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1. Introduction

Thai Government initiates to build the Bangkok–Nong Khai (Northeastern) high-speed railway (608 km) as part of the Kunming–Singapore railway central section, using dual standard-gauge tracks and operating speed 250 km/h. The construction for the first portion is the Bangkok–Nakhon Ratchasima high-speed rail line (253 km, worth 176,600 million Baht (5900 million USD), estimated 14700 passengers per day, EIRR 14.9%).

Figure 1: Kunming–Singapore railway central section (original image courtesy of Nikkei Asian Review).

1.1 High-speed Train Depot

High-speed train depot (Figure 2) provides train standard services and supports for the service and maintenance works of the trains in the depot. The Bangkok-Nakhon Ratchasima high-speed railway depot is a megaproject in Thailand worth 7764 million Baht (260 million USD). The depot construction comprises landfill up to the level of rail, 41 maintenance, training, and office buildings, road, drainage, and other infrastructure systems.

The main works of this depot construction project consist of earthwork, civil and structural work, architectural work, and building service work. Since this project must be finished within 36 months as per contract agreement, the traffic volume of material transportation, at the peak time of construction period, as per construction plan is 700 vehicles per day. Therefore, the traffic volume at the peak period is very high, so the traffic management plan is required for this project.

Figure 2: High-speed train depot model.

2. Literature Review

Most traffic studies involve normal urban road traffic management (e.g. Kantonon et al. (2018), Pananun et al. (2018)).

Khanta (2008) evaluated the capabilities of traffic simulation model software packages and gave recommendations in selecting the appropriate simulation package for a particular work project.

Zou et al. (2012) analyzed traffic impacts of urban construction projects using traffic simulation based on surveys and analysis of the traffic information. The study suggested distribution reasonably the traffic volume to the balance of the project. In addition, they applied an integrated assessment impact index calculation method and evaluation, to reinforce the traffic management for the construction projects.

Yang et al. (2012) reported the traffic impact simulation study for road construction projects in China, using Vissim software. The traffic impact assessment was beneficial for traffic policy and management especially in terms of traffic flow guide, signal adjustment, spot management, signs replacement, and facilities resetting.

Hammad (2020) studied construction site layout planning problems based on location and traffic assignment models, optimized for multi-objective purposes. The consideration for location and traffic decisions ensures effective operations for the construction stages and enhances on-site traffic management.

This work models traffic flow within the construction site, to analyze and manage traffic during construction of large depot Bangkok–Nakhon Ratchasima High-Speed Train.

3. Train Depot Site Details

Bangkok-Nakhon Ratchasima High-Speed Railway Depot, contract 4-4, is part of a mega project of the State Railway of Thailand (SRT). The north side of this project is connected with Motorway No. 9. This depot construction project area is 500,000 square meters located at Chiang Rak-Noi (geolocation 14.150571356878872, 100.58012701535907), see Figure 3.

4. Method

4.1 Delivery of Construction Materials

To construct the depot, it is required to plan the traffic management of the construction site, under constraints that all the construction must be finished within 36 months. For the depot site landfill, it is planned that 625 dump trucks daily deliver dirt to fill the site, and after compaction has the level of the rail. The depot will have 41 buildings and needs totaling 110,000 piles. It is estimated that 35 trailer trucks per day come to the site for concrete pile delivery. It is expected that 30 ready-mix concrete trucks a day enter the site for fresh concrete delivery. It is estimated that the site will have 10 machinery and service vehicles per day. Table 1 gives detail of the delivered materials to be and the daily number of vehicles entering the construction site.

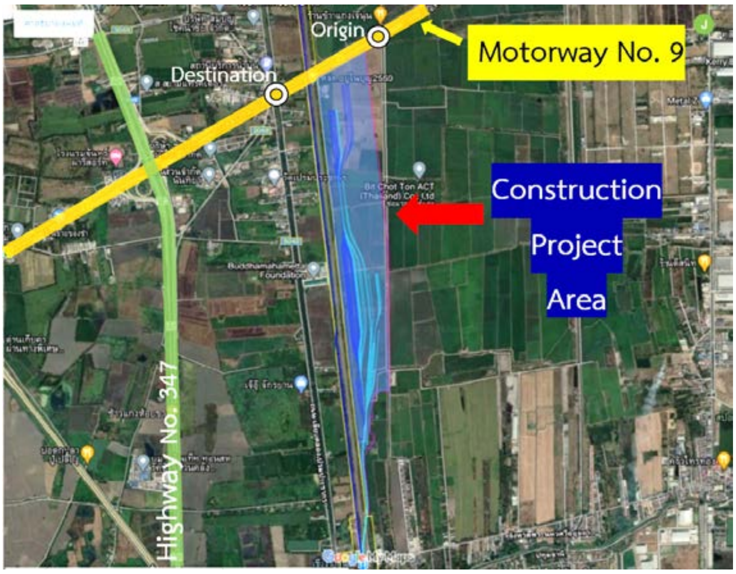

Figure 3: Bangkok-Nakhon Ratchasima high-speed railway depot position and dimensions. (Courtesy of Google map)

Table 1: Materials to be delivered to the construction site and the daily number of vehicles.

Materials	Specification	Total Amount	Number of vehicles sending materials/services into the construction site (vehicles/day)
Spun Piles	40cm diameter, 9mm thickness, 18m long	110000 piles	35
Landfill materials	Following the engineering specification	2.5million m^3	625
Ready-mix Concrete		70000 m^3	30
Machinery and service vehicles	Per requests	Per requests	10
		Total	700

4.2 Characteristic and Conditions of Vehicles

For each type of delivered material, the characteristics and conditions of vehicles are important for modeling. Table 2 shows speed constrain, estimated time for unloading material, and deviation unloading time for each type of vehicle.

Table 2: Vehicle constrain.

Materials	Type of Vehicle	Speed limit (km/hr)	Material unloaded time (seconds)	Deviation in unloading time (seconds)
Spun Piles	Open trailer truck (25m long)	20	3600	900
Landfill materials	Dump truck	20	300	60
Ready-mix Concrete	Ready-mix concrete truck	20	900	300
Machinery and service vehicles	Service truck	20	-	-

4.3 Traffic Simulation Options

This study investigates traffic conditions according to traffic management plans based on five options (Table 3) that have been established by the authors of possible traffic flow in the construction site. This study uses Aimsun, a traffic simulation software, is utilized to model each option and analyze and determine the suitable traffic management plan use for this project before the work started. Besides, traffic management costs can be estimated accurately. The temporary service road in the site is one-way 15km long, comprising a 6km main road, and 9km sub-roads.

Table 3: Simulation option of daily traffic management inside the construction site.

Option	Number of traffic lanes inside the site (one-way)	Allowed number of vehicles per working area	Distance from the origin point to the destination	Number of working periods per day	Simulated working hours (hr/day)
1	1	1	Nearest distance	1	10
2	1	3	Nearest distance	1	10
3	1+ 1 additional lane for the distances 3km	3	Nearest distance	1	10
4	1+ 1 additional lane for the distances 3km	3	Re-route for a longer distance for dump trucks	1	10
5	1	3	Nearest distance	2	10+10

Table 2, the nearest distance is the shortest distance from origin passing the unloading point and go out to the destination. Inside the project, the temporary service road will be established to support construction work such as material transportation work, equipment mobilization, and other services. The route line of the temporary service road is depended on traffic management plan options. For all options, the vehicles will start from the origin point and go to the destination point on the public road out of the project area as shown in Figure 3.

4.4 Aimsun Modeling and Simulation of Traffic Condition

Aimsun microscopic traffic simulation models can represent the traffic condition under the assumption of efficiency. In this study, five options of the traffic management plan have been set up for the analysis. In the Aimsun microscopic traffic simulation modeling environment, the input data include the number of lanes, speed limit, vehicle-time schedule, material unloading area, stopping time at unloading area, and vehicle travel route. The origin point and destination point are on the public road outside the construction project area. The detectors have been placed on the road at the joint between project road and public road for the count the number of vehicles entering and exiting the project.

5. Simulated Results and Discussion

Table 3 gives the analysis detail of each option including start work and finish work. The total travel time is the sum of time of each vehicle counted from the origin point to the destination point, including the traffic time and materials' unloading time.

For each option, the Aimsun models give serious traffic impact on the construction site. In Figure 4, The red dots and the red lines indicate problematic traffic conditions. The bigger the dot, the more traffic problem occurs. The dark lines represent an additional lane is added to the roads. From the simulated results Table 3 and Figure 4, it can be seen that option 1 the work cannot get all finish. option 5 gives the lowest total travel time and the least traffic problem. Also, the workers' overtime cost is the lowest for option 5. This also can save the operating cost of the vehicles.

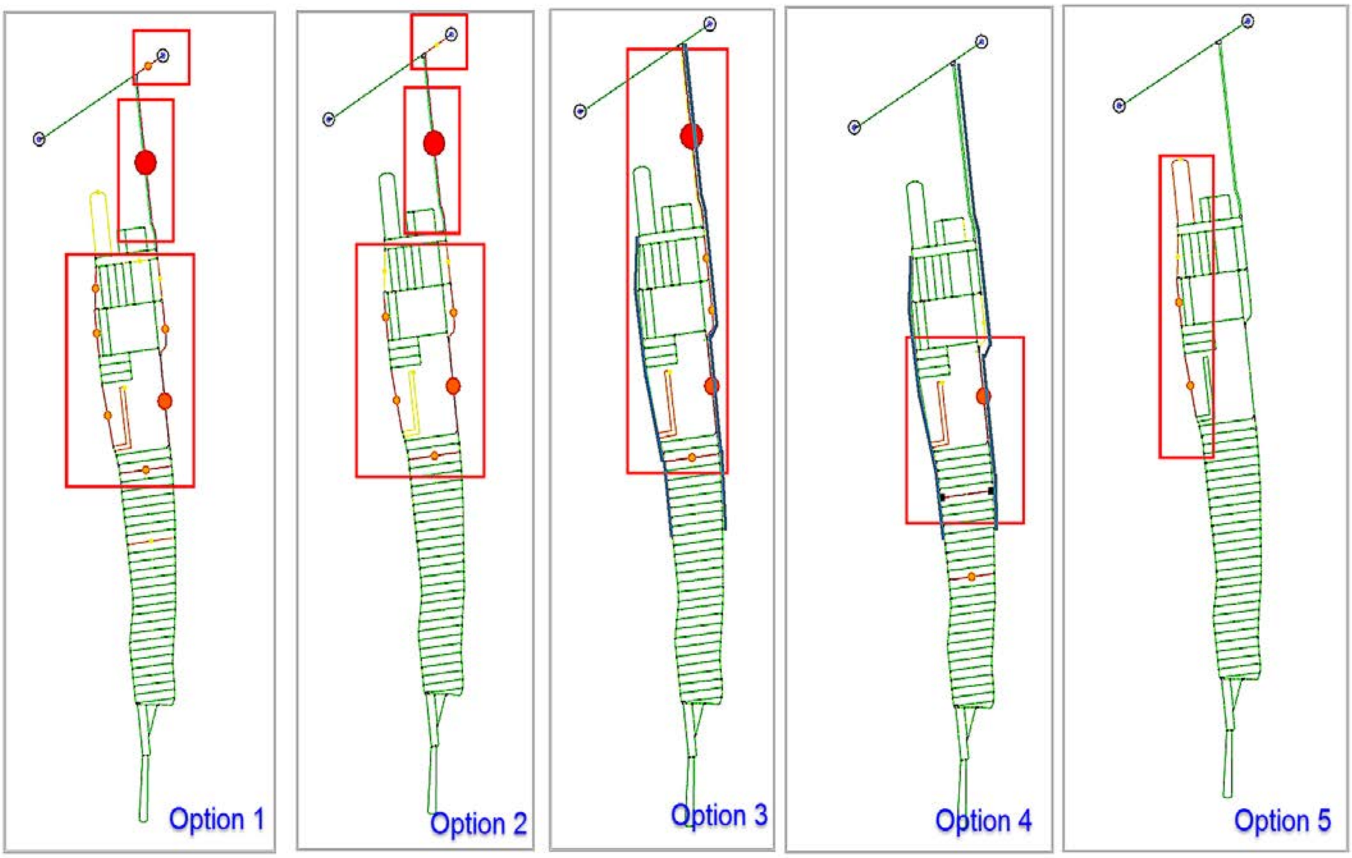

Figure 4: Result from the Aimsun analysis.

Table 3: Detail and result of the analysis.

Option		Start work	Finish work	Total travel time (hr)	Staff working overtime (count after 10hr working time) (hr/staff)	Traffic impact on the public road
1		7 AM	Not Finish	2103.2	14	YES
2		7 AM	11 PM	1458.9	6	YES
3		7 AM	10 PM	1427.5	5	NO
4		7 AM	10 PM	1365.2	5	NO
5	Period 1	7 AM	6 PM	1155.6	1	NO
	Period 2	6 PM	5 AM		1	NO

6. Conclusion

This research simulates and analyzes the traffic of vehicles delivering construction materials to the construction site to build the depot of the Bangkok-Nakhon Ratchasima High-Speed Train project in Thailand. It is estimated that construction materials are delivered daily by 700 vehicles including open trailer trucks, dump trucks, ready-mix concrete trucks, and service trucks. A total of five options has been simulated under different construction and traffic constraints. Using the Aimsun modeling software with microscopic traffic simulation modeling, the simulation results show that the option 5 model consisting of two periods gives the best solution with the least operating cost and produces no effect to the public traffic system. This study shows that the construction site traffic depends on volume-to-road capacity ratio, volume-to-unloading time ratio, vehicle-time schedule, and limited stopping area.

7. Availability of Data, and Material

Data can be made available by contacting the corresponding author.

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Juraluk Thinphowong is a Master's degree student at the Department of Civil Engineering, Thammasat School of Engineering, Thailand. She received a Bachelor of Engineering in Civil Engineering and Management from Thammasat University. Her interests involve Construction Project Management and Traffic Control and Management.

Dr. Boonsap Witchayangkoon is an Associate Professor in the Department of Civil Engineering at Thammasat University. He received his B.Eng. from the King Mongkut's University of Technology Thonburi with Honors. He continued his PhD study at the University of Maine, USA, where he obtained his PhD in Spatial Information Science & Engineering. Dr. Witchayangkoon interests involve Applications of Multidisciplinary and Emerging Technologies to Engineering.

Dr. Winai Raksuntorn received his PhD (Civil Engineering) from the University of Colorado, USA. He is currently an Assistant Professor in the Department of Civil Engineering, Faculty of Engineering, Thammasat University. His research interests include Transportation Safety Analysis, Traffic Operations, and Management, Traffic Impact Studies, Traffic Flow Modeling, Highway Capacity Analysis, Advanced Traffic Management for Intelligent Transportation Systems.

Dr. Sayan Sirimontree earned his bachelor's degree from Khonkaen University Thailand, master's degree in Structural Engineering from Chulalongkorn University Thailand, and Ph.D. in Structural Engineering from Khonkaen University Thailand. He is an Associate Professor at Thammasat University Thailand. He is interested in the Durability of Concrete, Repair, and Strengthening of Reinforced and Prestressed Concrete Structures.

Dr. Sanya Namee works at the Department of Disaster Prevention and Mitigation, Ministry of Interior, Thailand. He holds a Bachelor of Engineering from King Mongkut's Institute of Technology Ladkrabang, a Master of Engineering degree from Prince of Songkhla University and a Ph.D. degree in Civil Engineering from Thammasat University, Thailand. His research interests encompass Hazardous Material Transport.

Professor Dr.Ahmad Sanusi Hassan teaches at Architecture Programme, the School of Housing, Building and Planning, Universiti Sains Malaysia (USM), Penang, Malaysia. He obtained a Bachelor and Master of Architecture degrees from the University of Houston, Texas, the USA, and a Doctor of Philosophy (PhD) degree from the University of Nottingham, UK. His research focuses on Sustainable Architecture and Urban Design Development for Southeast Asia, history and theory of Architecture, Computer-Aided Design (CAD), and Computer Animation.

Dr.Yasser Arab is a Senior Lecturer at Universiti Sains Malaysia. He obtained his Bachelor of Architecture from Ittihad Private University, Aleppo, Syria. He obtained a PhD in Sustainable Architecture from Universiti Sains Malaysia (USM), Penang, Malaysia. His research focused on the Environment Performance of Residential High-Rise Buildings' Façade in Malaysia.