The Criteria Establishment for the Dumping site Selection of Urban Metro Construction by the Application of the Analytical Hierarchy Process

Titiwat Triwong, and Warapoj Meetom

***Abstract*—** The dumping of excavated soil from metro work in the urban area of Bangkok Metropolitan, Thailand, which is made in limited area with limited time for transport, makes it difficult to locate the dumping site. This research focused on identifies and weight the criteria used in the selection of soil dumping site. Firstly, investigation by interviewing related to experts and the previous researches that were obtained 62 preliminary criteria. Secondary, the preliminary criteria screening by using the Item Objective Congruence Index were obtained 19 criteria. Next, classified the chosen criteria by KJ method consist of 4 criteria groups. Finally, each criterion was weighted by Analytical Hierarchy Process. It was concluded that the criteria and the relative weight were as follows – 1) criteria of the local people's resistance, 69.7%. 2) criteria of the site access, 15.3%. 3) criteria of the infrastructure in area, 7.7%, and 4) criteria of the area terrain, 7.3%.

***Keywords*—** Criteria, Dumping Site of Urban Area, IOC, KJ method, Analytical Hierarchy Process (AHP)

I. Introduction

The Transport Office of Thailand is the organization which studies, analyses and conduct the main plan and the master plan for the national investment in the transport and traffic, by constructing electric trains in Thailand since 2004 for two routes with 44 kilometers distance – the Bangkok Mass Transit System (BTS) and the Mass Rapid Transit Authority of Thailand (MRT) until the 2013, altogether 7 routes 291 kilometers – Light Red Line, Dark Red Line, Orange Line, Violet, Blue, Light Green and Dark Green Line. However, from the study of the Office of Transport and Traffic Policy and Planning [1] it was found that these routes do not cover the usable area, accordingly this Office studied the electric train routes, possible both subway and on land, to consider the routes in accordance with the land use, focusing to cover the crowded use of land in the Ratchadaphisek Ring and determining the routes connected to the main communities inside the external circle in the 20 kilometers radius. There was then the agreement to extend the original network and newly construct 508 kilometers more, with the subway 65 kilometers. It was expected to have the excavated soil more than 6,000,000 m^3 or equal to the area of 2,000 Rais.

The previous research used the Analytical Hierarchy Process for Location Analysis, such as Petroleum Pipe Laying Site [2], Location for Government Offices [3], Location for Municipal Solid Waste [4]-[6], Industrial Site Selection [7], [8], Warehouse Site Selection [9]-[11], Shopping Mall Selection [12]-[14], Location for Agricultural [15], [16], Solar Plant Selection [17]-[19]. However, it was found that the researches related to the site selection for soil dumping from the urban metro construction were in small numbers, resulting in the less criteria for soil-dumping site selection accordingly.

At present the Mass Rapid Transit Authority of Thailand [1] reserves less soil dumping site for channel digging of the electric train in the sections Hua Lampong, Wat Mangkorn and Wang Burapa Stations. Moreover the temporary soil depositing areas around the digging site are limited and narrow, since they are in the urban communities. The traffic problem with the law limited the time for the heavy truck transport in urban area. The government organization and the contractor sections must prepare to face with problem of no proper dumping site, to more large amount of excavated soil continuously from the construction site. This is expected to occur in the future, since there will be more adding electric train construction. These problems will give more effect, making more difficult management and the construction might not finish in time, with the higher cost respectively.

Consequently, in order to prepare for facing these problems, this research has presented the method of determining the decision criteria in the dumping site selection of urban metro construction.

II. Research Methodology

This research methodology was presented as Fig. 1, firstly by the collection of the criteria obtained from the related literature and one part from the characteristic factor according to the decision criteria given by the experts, for use in the dumping site selection of the urban metro only. Secondly was the criteria selection by considering from the content accuracy. Thirdly was the classification of these criteria with KJ method. Lastly was the weighting of all criteria by the related experts for the importance in each criterion by Analytical Hierarchy Process. These decision

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criteria would be used in the proper dumping site selection in 30 kilometers radius as specified by Mass Rapid Transit Authority of Thailand.

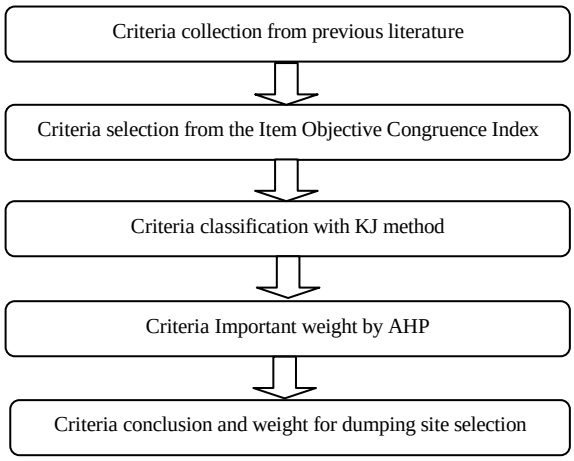

Fig. 1 Research methodology

A. Decision Criteria Investigation

In this study, the researcher sought and revised the related literature in the dumping site selection of the urban metro construction. Six experts were interviewed – 2 Project Managers, 2 Project Engineers and two Excavated Soil Transporters who involve in transporting excavated soil at present.

B. Criteria Selection from IOC

In this step, the researcher let the experts investigate the accordance of the contents, to screen the related factors, by bringing the preliminary investigation result to calculate for finding the Item Objective Congruence Index (IOC). In this study, these were the criteria in making consideration as follow:

- Give +1 for certainty that the questions accord with the objectives
- Give 0 for uncertainty whether the questions accord with the objectives or not
- Give -1 for certainty that the questions did not accord with the objectives

After that, the experts' marks were calculated to find the accordance index with the formula of Ravinelli and Hambleton [20] by the IOC is consistency index between question items and objective.

C. Criteria Classification with KJ method

This step continued from the criteria selection to classify them to be congruent with the objective in the dumping site selection of the urban metro construction. KJ method or Affinity Diagram is a brain-storming technique developed by Japanese expert Kawakita Jiro, for the objective in collecting various data and ideas of the members in the organization, which gives opportunity for the members to be able to express ideas widely and promotes the idea participation in the interesting topic by noting the members' ideas on small notepad which is convenient for the data classification in the easily-understood and convenient communications. The members of groups/organizations participated in data making and expressed ideas freely [21].

D. Analytical Hierarchy Process

The Analytical Hierarchy Process is the process used in "measuring or priority level" of decision making in various matters efficiently, with optimal correct decision result true to the decision objectives the most [22]. Since it uses the pairwise comparison in decision making, it gives the numerical sum, easy to order the importance and eliminate the decision with bias, such as the study as in [23], which studied the criteria weighting in the evaluation for Thailand Quality Award (TQA). It used the Analytical Hierarchy Process as the method in finding relative weights from the interviews of experts in 7 sections of Thai industry. This AHP has three main parts as follow:

1. Problem Decomposition
2. Comparative Judgment
3. Synthesizing

The steps of this process were made to give the criteria weights and after that they would be collected to find these criteria weights further.

III. Results

A. Result from Collection of Decision Criteria from Previous Literature

From the revision of the previous literature related to the site selection work as follows [2]-[19], [24]-[28] and the interviews of 6 experts, consisting of 2 Project Managers, 2 Project Engineers and 2 Excavated Soil Transporters in the metro construction. It could conclude the decision criteria used in the dumping site selection of urban metro construction for 62 items.

B. Criteria Selection Results

From the interview results, the researcher chose the questions with IOC more than 0.5 from the 6 experts as the questions. After examining the questionnaire, it was found that each question made by the researcher had the content accuracy, covering each side and the research objectives. Accordingly, the analytical result with IOC, left only 19 criteria from the total 62, as in Table I.

TABLE I
THE ACCORDANCE WITH THE CONTENT

Content Topic	IOC
1. Transportation costs	1
2. Volume of excavated soil	0.6
3. Terrain elevation	1
4. Volume of site	1
5. Distance from roads	1
6. Distance from residential areas	1
7. Distance from archaeological sites	0.6
8. Infrastructure facilities	0.6
9. Traffic infrastructure	1
10. Soil types	0.8
11. Land use	0.6
12. Distance from surface water	0.6
13. Flood Plain	0.6
14. Odor	0.6
15. Dust	0.6
16. Noise	0.6
17. Public reaction	1
18. Local development	0.8
19. Government attitude	0.6

C. Criteria Classification Results

The analytical result by considering the criteria selection found that the decision criteria obtained were in a large number and repetitive. KJ method was then used as the tool in the criteria classification by storming ideas and knowledge from 6 experts, who involves in the soil-dumping site selection, to consider 19 topics for classification. The researcher explained and specified the problem issues of the criteria used for the selection of the dumping site from the urban metro to the experts, so that they understood the problems or the accorded contents of the group. They were allowed to write their ideas on a piece of paper and attached it on the board, for all of them to see all ideas. After that the researcher asked the ideas from the experts to classify and conclude further.

The classification results of the 19 related criteria left only 4 groups, which all experts agreed to use in the selection of the dumping site. They were

- The criteria of Area Terrain
- The criteria of Site Access
- The criteria of Infrastructure in Area
- The criteria of Local People's Resistance

D. Results of Criteria Importance Weighting for the Dumping Site Selection from Urban Metro Construction

After the classification of 4 criteria, the researcher returned to interviews the 6 experts – 2 Project Managers (PM), 2 Project Engineers (PE) and 2 Excavated soil Transporters (EST) again. This time the researcher interviewed the experts individually, to give the importance and weights to the 4 criteria by using AHP in Expert Choice Program, by comparing each pair of the 4 criteria alternatively. It would stop when the Consistency Ratio (CR) was equal to 0.1 or less, as in Fig. 2 and 3, which was the example of giving relative weight from the Project Manager 1, with Expert Choice Program.

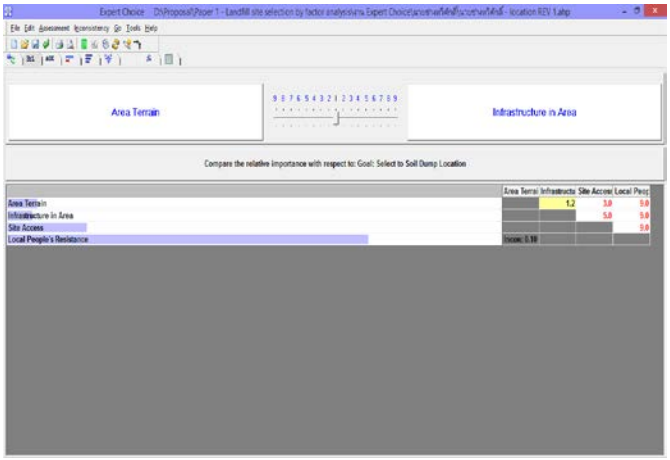

Fig. 2 Metric table of importance 4 criteria of project manager 1

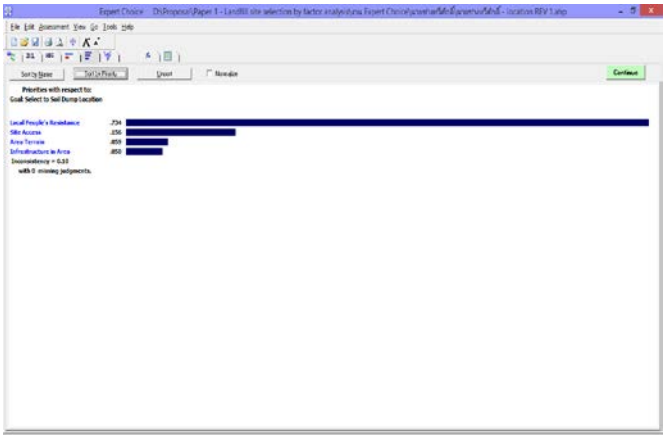

Fig. 3 The 4 criteria relative weight of project manager 1

From the Table II and Fig. 4, it could conclude and compare the relative weight of 4 criteria for the dumping site selection of urban metro construction.

TABLE II
CRITERIA WEIGHTS FROM THE EXPERTS

Criteria	Relative Weights (%)					
	PM1	PM2	PE1	PE2	EST1	EST2
1. Area Terrain	5.9	18.3	4.8	5.3	6.2	7.4
2. Site Access	15.6	17.5	11.8	11.7	18.8	15.4
3. Infrastructure in Area	5.0	3.7	19.4	9.3	6.8	8.0
4. Local People's Resistance	73.4	60.5	64.0	73.7	68.2	69.2

Fig. 4 Relative weight from experts

When the weight of each criterion was obtained from AHP, the result of the percentage of each criterion weight was calculated for Geometric Mean. It was found that the sum of the 4 criteria from Geometric Mean had the value not equal to 1, which could not be compared with each other. It must be made in the same base by dividing the Geometric Mean of each criterion by the total sum of the Geometric Mean. It is called Normalization to make each criterion in the same base as in Table III.

TABLE III
NORMALIZATION VALUE OF CRITERIA

Criteria	Normalization Value (%)
Local people's resistance	69.7
Site Access	15.3
Infrastructure in Area	7.7
Area Terrain	7.3

IV. Discussion

From Table II and Fig. 4, each expert gave the importance and weight in each criterion differently. Project Manager 2 gave the weight to the importance of the area terrain the most (about 18.3%), compared with the Project Engineer 1 who gave the weight of this importance the least (about 4.8%). However, in average all 6 experts gave the importance of the area terrain criteria about 8.0%. For the criteria of the area access, the excavated soil transporter 2 gave it the most weight (about 18.8%) whereas the Project Engineer 2 gave the least importance (about 11.7%) and of all 6 experts in average 15.1%. The Project Manager 2 and the Project Engineer 1 had a clearly different idea in giving importance weight to infrastructure in area serving the use around the area, the Manager gave the least weight (about 3.7%) and in the opposite the Engineer gave the most weight (about 19.4%), resulting to 8.7% in total average. All agreed that the Local people's resistance criteria had the most importance, in the total average 68.2%, the Project Engineer 2 gave the most weight (about 73.7%) and the Project Manager 2 gave the least importance (about 60.5%).

After adjusting the mean of each criterion, in Table III was the relative weight percentage of each criterion adjusted in the same base to be able to compare the importance weight of each criterion more properly and correctly. From the results arranged in order to descending, it was found that the local people's resistance criteria had the most importance 69.7%, followed by the area access 15.3%, then the infrastructure in area 7.7% and finally the area terrain 7.3%.

Consequently, from the results of relative weight order from the 6-expert interviews, it could say that the management with people was difficult but must be first considered. It was the same as the area access which must affect the surrounding communities as the shadow with the area difference, as the phrases in dealing with rubbish that "not in my back yard" and "not in anyone back yard" are the saying with the result in the site selection of municipal solid waste elimination and dumping, with the reason not to let the waste or non-utilization things come dwelling [29]. It was the same as excavated soil dumping, no community or people would like to have soil dumped near their houses or community.

On the contrary, for the criteria of infrastructure in area and area terrain criteria, almost all experts saw that they could be managed, without much affecting people or community, but they might affect the community indirectly in the long term without good planning or decision making.

V. Conclusion

In this study it was found that the criteria obtained from the interview of the experts who involved with the excavated soil transport of urban metro which was presented in the form of giving importance weight of each criterion, could lead to the guideline in planning and decision making of any organization to choose the site for soil dumping, especially excavated soil from the metro construction which was in the large amount. It should be considered the criteria or issues related to the site selection, especially the criteria of local people's resistance must be considered first and followed by the issue of the site accessibility the organization should survey or make public reaction with the community expected to choose first. And the issues of the electric and water supply in area and the area condition should not be left out since they might affect indirectly to the communities in the future and increase the capital cost in management. From the work with close characteristic as the above mentioned as in [5] and [29], said that the criteria used to select any area or location must accord with the work or the place, by considering from many sides to equip with the further proper decision making process. Therefore it is necessary to study the location, facilities and the community ideas, to lead to the dumping site selection correctly and properly.

For this study in the future, it must study the route part increasingly, to make the decision making system to choose the selection of excavated soil transporting and route in urban metro more completely.

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