Evaluating Urban Metro Construction Excavated Soil Disposal Sites based on fuzzy AHP

Warapoj Meethom[1], Titiwat Triwong[2]

[1]*Research Centre for Productivity Improvement in Industrial, Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Thailand*
[2]*Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Thailand*

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Abstract - *The evaluation of urban metro construction excavated soil disposal sites is regarded as considerable important for solving the problems of decision-making to select the urban metro construction excavated soil transportation under the Truck Ban Ordinance that affects the contractor companies on both the transportation cost and the risk of disposal site. Then each excavated soil transportation alternative and disposal site is of importance for the contractors who use it for evaluating the appropriate ones. In decision-making, there are many decision criteria of both quantitative and qualitative criteria: transportation cost, site access, area infrastructure, area terrain, stress of driver and liquidity of traffic that result in imprecise and uncertain evaluation results. Thus the Fuzzy Analytical Hierarchy Process (FAHP) is proposed in this research to properly solve the problem with the experiences of the decision-maker that are the excavated soil transportation contractor company. This technique is illustrated in a study measuring the most important criteria in three disposal site.*

***Key Words*: Fuzzy AHP, decision-making, excavated soil transportation, urban metro construction, Truck Ban Ordinance**

1. INTRODUCTION

To develop the decision planning for selection the urban metro construction excavated soil disposal sites. The contractor companies expect that the excavated soil disposal sites can enable the excavated soil transportation planning to cover both quantitative and qualitative aspects. In other words, the good decision planning for the excavated soil transportation selection will reduce the transportation cost and risk that may occur during the excavated soil transportation to the disposal site. So, the excavated soil transportation contractor companies regard it as the Construction and Demolition Waste (C&D Waste) that the sites should be sought sufficiently for the disposal of construction waste by using the lowest cost [1]. It is difficult to find the disposal sites in Thailand, especially for the excavated soil disposal sites.

In the past, there was not any excavated soil transportation contractor company or governmental agency developing the decision criteria for the selection of urban metro construction excavated soil disposal sites. Triwong and Meethom [2], [3] mentioned that the decision criteria for the selection of excavated soil disposal sites needs to have the criteria that would be applied to formulate the excavated soil disposal sites, and the criteria must cover both quantitative and qualitative characteristics, including the transportation cost criteria, site access criteria, area infrastructure criteria, area terrain criteria, stress of driver criteria, and liquidity of traffic criteria. The objective of criteria development to formulate the urban metro construction excavated soil disposal sites is to enable the alternatives formulated by the planners to respond to the real situation when the construction is under operation. There are the limitations on excavated soil disposal sites, construction site area, truck schedule, congested traffic, areas under the Truck Ban Ordinance, and risk of working in the city where the mistake must be prevented.

In this research, the researchers realize the evaluation process. In other words, the researchers intend to formulate the decision process for the excavated soil disposal sites selection that suitably corresponds to the objective of decision criteria weighting under user need. Because the importance weighting of the selection criteria involves many criteria and the decision-makers or experts often give precedence to their opinion for the selection rather than to the expressing judgements, the fuzzy set theory is a very useful tool in case of imprecise and uncertain data while AHP proposed by Saaty [4] is a general decision method, but the extension part of AHP called Fuzzy AHP is used to solve the hierarchical fuzzy decision-making problems. Mikhalov and Tsvetinov [5] took FAHP for use in the evaluation of service system with the customers' uncertainty and vagueness. FAHP could find the suitable point from varied and endless demand. Ishizaka and Nguyen[6] used Fuzzy-AHP to help formulate the indicator alternatives in the bank account system that was finally used for selecting the appropriate bank account system. It can be seen that the decision-making under the fuzzy environment and different expert experiences will result in vague opinions. Therefore, the objective of this research is to apply FAHP in solving the decision-making problems with regard to the selection of urban metro construction excavated soil disposal site under the Truck Ban Ordinance based on user-need.

2. FUZZY ANALYTIC HIERARCHY PROCESS

2.1 The Extent Analysis Fuzzy AHP Method

FAHP makes allowances for the vagueness and imprecision of human preference. It has been developed to take into account this uncertainty and imprecision, that uses the hierarchical structure to show the alternative structure and hierarchical evaluation criteria [6]. The top level of the structure is called the objective or sometimes called the goal. The subsequent level is the evaluation criteria used to consider the appropriate alternative to achieve the best result according to the objective. Each criterion may consist of sub-criterion in the subsequent levels. In each evaluation criterion, it is not necessary to have equal sub-criteria. The criteria classified into the same level should have equal importance, and less important criteria are classified into the subsequent levels. The lowest level is the attribute of each criterion.

Regarding the prioritization of factor criteria such as the quality, the relative weight can be carried out by the criteria pairwise comparison in each level of the structure. The FAHP can be done by setting the importance level of each criterion as the fuzzy number. The scale is generally divided into 9 levels [4] that the value may be from $\tilde{1}$ to $\tilde{9}$. The factor pairwise comparison applies the quantitative ratio to make the comparison more explicit. This study proposes the subjective pairwise comparison and the fuzzy scale [7] involving the importance is measured in the form of relationship weight as shown in Table 1 below.

Table -1: Triangular Fuzzy Conversion Scale

Linguistic scale	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Just equal	(1,1,1)	(1,1,1)
Equally important	(1/2,1,3/2)	(2/3,1,2)
Weakly important	(1,3/2,2)	(1/2,2/3,1)
Strongly more important	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strongly more important	(2,5/2,3)	(1/3,2/5,1/2)
Absolutely more important	(5/2,3,7/2)	(2/7,1/3,2/5)

Fuzzy AHP is the combination of the Fuzzy Set and AHP to correct some errors of AHP with regard to the human opinion. Regarding the calculation to easily get Fuzzy, Chang (1996) [8] proposed the following method.

Step 1: Setting as Fuzzy Number

If $x_0 \in R$ making $\mu_m(X_0) = 1$ and $\forall\lambda \in (0,1)$, $M_\lambda = [X, \mu(X) > \lambda]$

In searching μ_m as Membership Function of M: R $\rightarrow$ [0,1] as follows:

$$\mu_m(X_0) = \begin{cases} (x-l)/(m-l), & x \in [l, m] \\ (x-u)/(m-u), & x \in [m, u] \\ 0, & otherwise \end{cases} \quad (1)$$

I and u are upper and lower values of members respectively, and m is a mean value of M Triangular Fuzzy Number shown as (l, m, u).

Step 2: Synthesis value of Fuzzy can be calculated as follows:

$$S_i = \sum_{j=1}^{m} \tilde{M}_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j} \right]^{-1} \quad (2)$$

By

$$\sum_{j=1}^{m} \tilde{M}_{gi}^{j} = \left(\sum_{i=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right) \quad (3)$$

And

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j} = \left(\sum_{i=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right) \quad (4)$$

So

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j} \right]^{-1} = \left(\left[\frac{1}{\sum_{i=1}^{n} \mu_j} , \frac{1}{\sum_{i=1}^{n} m_j} , \frac{1}{\sum_{i=1}^{n} l_j} \right] \right) \quad (5)$$

To get

$$S_i = \sum_{j=1}^{m} \tilde{M}_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{gi}^{j} \right]^{-1} \quad (6)$$

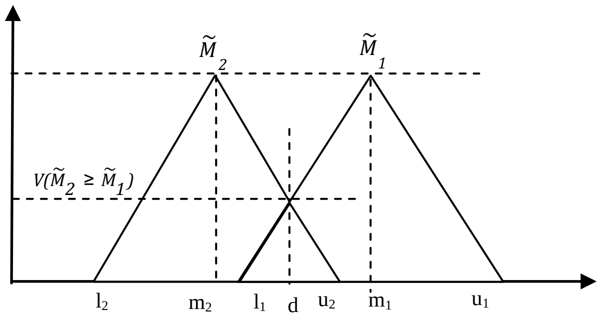

Fig-1 Degree of possibility $\tilde{M}_2 \geq \tilde{M}_1$

Step 3: Degree of Possibility can be calculated as follows:

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup_{y \geq x} \left[\min\left(\tilde{M}_1(x), \tilde{M}_2(y)\right)\right] \quad (7)$$

Making that

$$V(\tilde{M}_2 \geq \tilde{M}_1) = hgt(\tilde{M}_1 \cap \tilde{M}_2) = \tilde{M}_2(d)$$

$$= \begin{cases} 1 & , if\ m_2 \geq m_1 \\ 0 & , if\ l_2 \geq l_1 \\ \dfrac{l_2 + l_1}{(m_2 - u_2) - (m_1 - l_1)} & , otherwise \end{cases} \quad (8)$$

Degree of Possibility for Convex Fuzzy Number of k can be calculated as follows:

$$V(\tilde{M} \geq \tilde{M}_1, \tilde{M}_2, ...M_K) = \min V(\tilde{M} \geq \tilde{M}_i), i = 1,2,3,...,k \quad (9)$$

Supposed that

$$d'(A_i) = \min V(S_i > S_k) \quad (10)$$

for k=1,2,3,…,n; k ≠ i to get the following weight

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^t \quad (11)$$

that A_i = *(i=1, 2, 3,…,n)* is n factor

And the Normalization of weight value can be done as the following equation.

$$W = (d(A_1), d(A_2), ..., d(A_n))^t \quad (12)$$

After the weight is obtained, it is multiplied by the decision criteria to get the final scores which will be ranked. The alternative with the highest scores will be selected.

2.2 Establishing Comparison Matrices

When the problem of level 1 is considered by the criterion n, the relative importance of the criteria from i to j will be proposed by the triangular fuzzy numbers $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$. Again, the decision-makers can consider the criteria i by the very strongly more important scale in comparison with the criterion j. So, the decision-makers may set $\tilde{a}_{ij}$ = (2, 5/2, 3). If the decision-makers think that the criterion j is very strongly more important than the criterion i, the pairwise comparison between i and j can be proposed in the form of $\tilde{a}_{ij}$ = (1/3, 2/5, 1/2), which is the traditional AHP with the comparison matrices $\tilde{A}_{ij} = \{\tilde{a}_{ij}\}$ as shown in the equation below.

$$\tilde{A}_{ij} = \begin{bmatrix} 1 & \tilde{a}_{ij} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{ij} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/\tilde{a}_{n1} & 1/\tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad (13)$$

2.3 Calculation The Consistency Index and Consistency Ratio of Comparative Matrix

To ensure the decision quality level, the consistency evaluation should be analysed. Saaty [4] proposed the consistency index which can be used to indicate the pairwise comparison matrices. From the discovery of consistency value, the fuzzy comparison matrices have to be converted to crisp matrices. This process is called the defuzzification method. It is found that there are many methods [8], [9] by which the crisp number is derived from the triangular fuzzy number. In this research, the method of Chang et al. [10] is used to defuzzify the fuzzy number. This method is rather apparent about the fuzzy perception by showing the preference (α), and the risk tolerance (λ) of the decision-makers. The decision-makers are able to understand the uncertainty that they have to encounter the different environment. A triangular fuzzy number is written in the form of $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ that can be defuzzified to the crisp number as follows:

$$(a_{ij}^{\alpha})^{\lambda} = \left\lfloor \lambda \cdot 1_{ij}^{\alpha} + \left(1 - \lambda \cdot \mu_{ij}^{\alpha}\right) \right\rfloor, 0 \leq \lambda \leq 1, 0 \leq \alpha \leq 1 \quad (14)$$

When $l_{ij}^{\alpha} = (m_{ij} - l_{ij}) \times \alpha + l_{ij}$, it means the extreme left side value of α -cut for a_{ij}, $u_{ij}^{\alpha} = u_{ij} - (u_{ij} - m_{ij}) \times \alpha$ and it means the extreme right side value of α-cut for a_{ij}. Noticeably, α can be considered under the uncertain and fluctuating environment with the value from 0 to 1. In the same manner, λ can be considered as the optimism degree of decision-makers. The value between 0 and 1 means that if $\lambda = 0$, the decision-makers are very optimistic. In contrast, if $\lambda = 1$, the decision-makers are more pessimistic.

After that, all members in the comparison matrices are converted from the triangular fuzzy number to the crisp number as follows.

$$\left[(A^{\alpha})^{\lambda}\right] = \left[(a_{ij})^{\lambda}\right] = \begin{bmatrix} 1 & (a_{ij}^{\alpha})^{\lambda} & \cdots & (a_{1n}^{\alpha})^{\lambda} \\ (a_{21}^{\alpha})^{\lambda} & 1 & \cdots & (a_{2n}^{\alpha})^{\lambda} \\ \cdots & \cdots & \cdots & \cdots \\ (a_{n1}^{\alpha})^{\lambda} & (a_{n2}^{\alpha})^{\lambda} & \cdots & 1 \end{bmatrix} \quad (15)$$

The consistency index (C.I.) for the comparison matrices can be calculated as shown in the equation below.

$$C.I. = \frac{\lambda_{max} - n}{n - 1} \quad (16)$$

λ_{max} is the maximum eigenvalue of the comparison matrices, and n is the dimension of matrix.

The consistency ratio (C.R.) is defined from the ratio between the consistency of matrix derived from the evaluation and the consistency of random matrices [11].

$$C.R. = \frac{C.I.}{R.I.(n)} \quad (17)$$

R.I. (n) is the random index [12] which depends on the dimension of matrix n as shown in Table 2.

Table – 2 Random Index (R.I.) of Random Matrices [11]

N	3	4	5	6	7	8	9
R.I.(n)	0.58	0.9	1.12	1.24	1.32	1.41	1.45

If C.R. of the comparison matrices is equal to or less than 0.1, this decision-making approach is accepted. But if C.R. is not acceptable, it means that the decision-maker have to weight or make the decision again. In this step, Microsoft Office Excel 2016 can help the decision-maker in the evaluation process.

3. ESTABLISHING THE URBAN METRO CONSRUCTION EXCAVATED SOIL DISPOSAL SITES

When the urban metro construction excavated soil disposal sites has to be selected, it is extremely necessary to take into consideration the quantitative criteria for the transportation cost criteria and regarding the qualitative aspect must be taken into consideration as well, more or less depending on expert preferences. These criteria are called the "decision criteria". It is not so easy to use the criteria for evaluating the disposal sites with different importance. To enable the evaluation to conform to the construction planners' objective, the source of decision criteria should be from the expert particularly specializing in the excavated soil transportation. In other words, the ideas or conclusions crystallized from the working experiences of the excavated soil transportation expert must be gained from the source of decision criteria. Therefore, this research gained the selection criteria structure of the urban metro construction excavated soil disposal sites from Triwong and Meethom [2], [3]. The major and minor criteria were discussed and improved by the managers and engineers of the Urban Metro Construction Project of Thailand, and also the excavated soil transportation contractors in the Urban Metro Construction Project of Thailand as shown in Table 3.

Table-3: The Urban Metro Construction Excavated Soil Disposal Sites Criteria

Criteria
Transportation cost (C_1)
Site access (C_2)
Area infrastructure (C_3)
Area terrain (C_4)
Stress of driver (C_5)
Liquidity of traffic (C_6)

Regarding the urban metro construction excavated soil disposal sites, the researchers specified the study scope in 3 disposal sites because of limited study time and data access. The disposal site of Rama II Road, Soi 82, has the entire area of 120,000 m^2 with the depth of approximately 2.5 meters and the distance of 27 kilometres as shown in Figure 2. The disposal site of Yothathikan Road, Nonthaburi 2023, has the entire area of 128,000 m^2 with the depth of approximately 1.5 meters and the distance of 24 kilometres as shown in Figure 3. The disposal site of 90/1 Soi Pracha Uthit 72 has the entire area of 96,000 m^2 with the depth of approximately 3 meters and the distance of 20 kilometres as shown in Figure 4. The hierarchical structure of the urban metro construction excavated soil disposal sites is shown in Figure 5.

Since the study objective is to select the urban metro construction excavated soil disposal sites, the hierarchical structure of the problem will be formulated from all 6 criteria by making pairwise comparisons of the decision criteria. It is difficult for the decision-maker to compare 6 criteria simultaneously and explicit. The urban metro construction excavated soil disposal sites has the limitations and conditions on the excavated soil transportation in the urban area. Accordingly, the experts' experience is just good answers for the decision. The data utilized for the Fuzzy AHP implementation are obtained interviewing expert of the urban metro construction excavated soil transportation: each respondent compares disposal sites and criteria in pairwise comparisons.

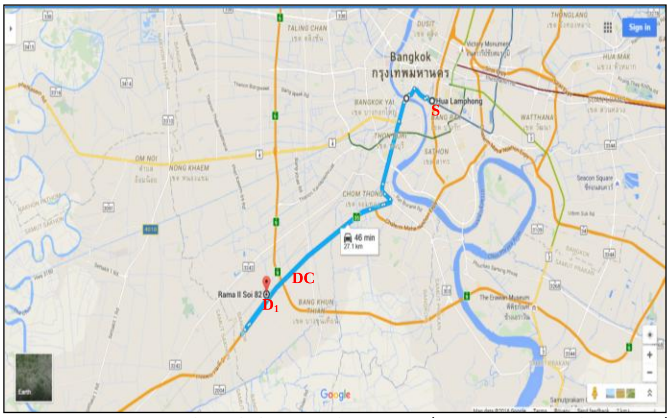

Fig-2: Excavated soil disposal site D_1 (Rama II Road, Soi 28)

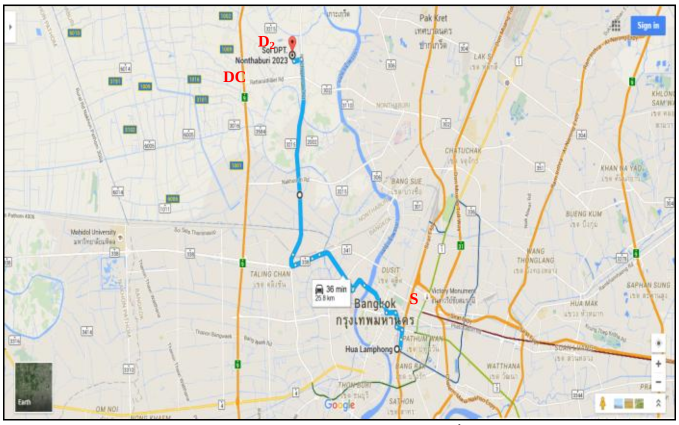

Fig-3: Excavated soil disposal site D_2 (Yothathikan Road, Nonthaburi 2023)

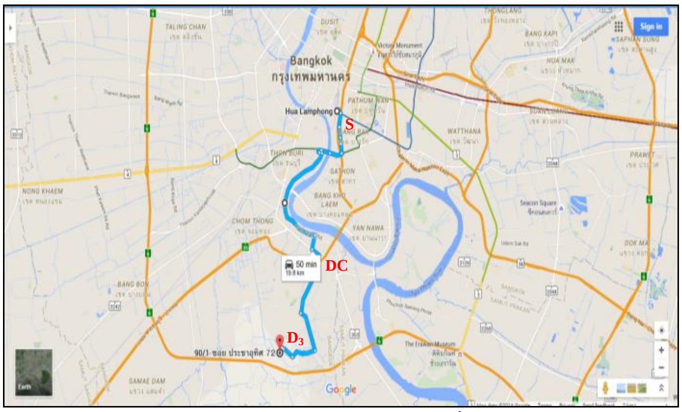

Fig-4: Excavated soil disposal site D_3 (Yothathikan Road, Nonthaburi 2023)

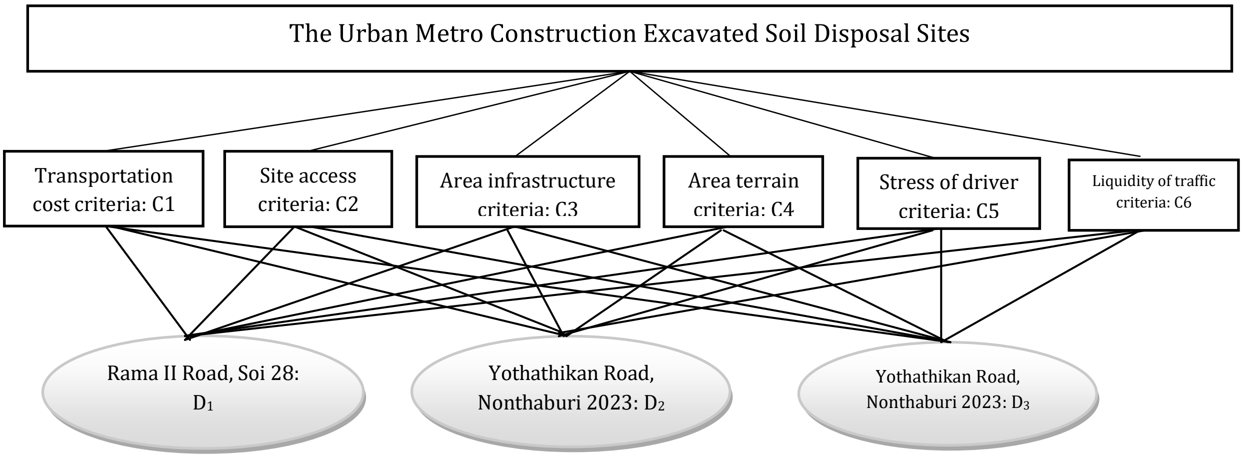

Fig-5: Hierarchy structure of urban metro construction excavated soil disposal sites

Table – 4 Pairwise Comparisons Matrix of The Criteria

Criteria	C1	C2	C3	C4	C5	C6	Weight
C1	(1,1,1)	(1.5,2,2.5)	(1,1.5,2)	(1,1.5,2)	(2,2.5,3)	(2,2.5,3)	0.325
C2	(0.4,0.5,0.667)	(1,1,1)	(1,1,1)	(0.5,1,1.5)	(2,2.5,3)	(2,2.5,3)	0.232
C3	(0.5,0.667,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1.5,2,2.5)	(1.5,2,2.5)	0.192
C4	(0.5,0.667,1)	(0.667,1,2)	(1,1,1)	(1,1,1)	(0.5,1,1.5)	(0.5,1,1.5)	0.130
C5	(0.333,0.4,0.5)	(0.333,0.4,0.5)	(0.4,0.5,0.667)	(0.667,1,2)	(1,1,1)	(0.5,1,1.5)	0.005
C6	(0.333,0.4,0.5)	(0.333,0.4,0.5)	(0.4,0.5,0.667)	(0.667,1,2)	(0.667,1,2)	(1,1,1)	0.071

C.R.=0.021

Table – 5 Pairwise Comparisons Matrix of Disposal Sites Within "Transportation Cost": (C1)

C1	D1	D2	D3	Weight
D1	(1,1,1)	(0.667,1,2)	(1,1.5,2)	0.375
D2	(0.5,1,1.5)	(1,1,1)	(0.667,1,2)	0.335
D3	(0.5,0.667,1)	(0.5,1,1.5)	(1,1,1)	0.290

CR=0.016

Table – 6 Pairwise Comparisons Matrix of Disposal Sites Within "Site Access": (C2)

C2	D1	D2	D3	Weight
D1	(1,1,1)	(0.667,1,2)	(1,1.5,2)	0.404
D2	(0.5,1,1.5)	(1,1,1)	(2,2.5,3)	0.517
D3	(0.5,0.667,1)	(0.333,0.4,0.5)	(1,1,1)	0.079

CR=0.026

Table – 7 Pairwise Comparisons Matrix of Disposal Sites Within "Area Infrastructure": (C3)

C3	D1	D2	D3	Weight
D1	(1,1,1)	(0.5,1,1.5)	(1.5,2,2.5)	0.441
D2	(0.667,1,2)	(1,1,1)	(1,1.5,2)	0.393
D3	(0.4,0.5,0.667)	(0.5,0.667,1)	(1,1,1)	0.167

CR=0.009

Table – 8 Pairwise Comparisons Matrix of Disposal Sites Within "Area Terrain": (C4)

C4	D1	D2	D3	Weight
D1	(1,1,1)	(0.667,1,2)	(1,1.5,2)	0.404
D2	(0.5,1,1.5)	(1,1,1)	(2,2.5,3)	0.517
D3	(0.5,0.667,1)	(0.333,0.4,0.5)	(1,1,1)	0.079

CR=0.026

Table – 9 Pairwise Comparisons Matrix of Disposal Sites Within "Stress of Driver": (C5)

C5	D1	D2	D3	Weight
D1	(1,1,1)	(1,1.5,2)	(1,1.5,2)	0.448
D2	(0.5,1,1.5)	(1,1,1)	(1.5,2,2.5)	0.405
D3	(0.5,0.667,1)	(0.4,0.5,0.667)	(1,1,1)	0.147

CR=0.047

Table – 10 Pairwise Comparisons Matrix of Disposal Sites Within "Liquidity of Traffic": (C6)

C6	D1	D2	D3	Weight
D1	(1,1,1)	(0.667,1,2)	(1,1.5,2)	0.373
D2	(0.5,1,1.5)	(1,1,1)	(0.5,1,1.5)	0.326
D3	(0.5,0.667,1)	(0.667,1,2)	(1,1,1)	0.301

CR=0.019

By expressing relative importance with linguistic terms (just equal, equally important, weakly important, strongly more important, very strongly more important, absolutely more important). Then the judgments are converted in fuzzy numbers using Table-1. As exemplification of the Fuzzy AHP procedure, comparing criteria under alternative target by means of pairwise linguistic judgments, we obtain the following fuzzy comparison matrix (Table-4).

Therefrom, we analyse the consistency of the matrix as equation (16) and (17). Next, we determine the row sum in equation (3) and the normalized row sum in equation (6), for each indicator (criterion) associated with a row of Table-2. Then crisp weights are calculated using (11) and, via normalization, the relative weights for each criterion under the target in equation (12). The same methodology is, then, applied for each item (disposal site) of the structured hierarchy.

When the comparison results of all 6 criteria with the goal is the urban metro construction excavated soil disposal sites as shown in Table 4 and the comparison results of each criterion among all 6 criteria with all 3 disposal sites as shown in Table 5-10, it is found from all tests that C.R. is less than 10% that is acceptable. This result reflects the nature of the analysed contractor company, in the excavated soil transportation, Transportation cost are strategically more relevant than other criteria. It is found that the expert gives the maximum relative weight to the "transportation cost criteria" with the scores of 32.5% as the analysis goal.

The overall relative weight results for each site are obtained by multiplying their triangular fuzzy number with the corresponding weights along the hierarchy. Table-11 shows calculated relative weights in Fuzzy AHP for urban metro construction excavated soil disposal sites. It summaries the importance of the relative weight for selecting a disposal site 1 (Rama II Road, Soi 28: D_1) The most important relative weight supports the essential of urban metro construction excavated soil disposal sites selection, in particular the qualitative criteria since it give too much importance to its relationship with the locals. The second most important relative weight is disposal site 2, which has the long distance site. The disposal site 3 has the lowest score. This may be explained by the low qualitative criteria.

Table – 11 The overall relative weight of Disposal site

Disposal site	Triangular Fuzzy Number			Weight
Disposal site 1: D1	0.139	0.383	1.104	0.354
Disposal site 2: D2	0.132	0.374	1.040	0.371
Disposal site 3: D3	0.091	0.242	0.682	0.245

4. CONCLUSIONS

Urban metro construction excavated soil disposal sites evaluation is an effective instrument to maintain both quantitative and qualitative decision criteria to encourage the contractor companies or involved governmental agencies to recognize the importance of them that may affect the surrounding society and environment where the excavated soil transportation occurs. This research proposes the method for evaluating the urban metro construction excavated soil disposal sites based on fuzzy AHP. The application of fuzzy AHP evaluation to conduct the urban metro construction excavated disposal sites evaluations can not only reflect the human preference due to the vagueness and imprecision of opinions but also the decision-making to successfully achieve the goal or objective that involves the evaluation of each criterion. Therefore, it can be said that this method contribution is the proposal of the urban metro construction excavated soil disposal sites evaluation that the decision-makers can take part in the evaluation by applying fuzzy AHP where they can capture the vagueness of human judgements and derive weights in the evaluation system more than that specified in the objective and reasonable. Moreover, this research can reduce the subjectivity evaluation process. Additionally, the systematic structure of fuzzy AHP approach proposed in this study that can be selected with a high degree of consensus. Hence, it can also be said that a reference for management practitioners when solving decision-making problems based on users-need. The findings of the study serve as a starting point for urban metro construction excavated soil transportation managers to understand the importance of the selection criteria, however, further studies on a larger scale are needed to these observations.

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BIOGRAPHIES

He is a lecturer at King Mongkut’s University of Technology North Bangkok, where he obtained his PhD. from the same university. His research areas include Decision Support System, Logistics and Multimodal Transportation.

He is a lecturer at King Mongkut’s University of Technology North Bangkok, graduated as Civil engineer in 2000, M. Eng. Industry in 2002 and M. Eng. Civil in 2010. In 2016, he is studying Industry engineering PhD.