Neutrosophic Hybrid MCDM Framework to Evaluate the Risks of Excavation System

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Abstract: The building of excavations is an extremely dangerous job that incorporates a variety of different variables. It is possible to significantly lower the likelihood of an accident occurring by first accurately identifying high-risk variables and then taking appropriate preventative steps. Single-valued neutrosophic verbal sets (SVNVS) can effectively represent qualitative and vague information when used in the identification process for high-risk variables of excavation systems. In addition, the identification of high-risk elements associated with an excavation system is a multi-criteria decision-making (MCDM) issue. This issue may be resolved by using the multi-attribute border approximation area comparison (MABAC) technique. The MABAC method operates on the presumption that criteria are compensating. However, the identification process for high-risk variables of excavation systems may include characteristics that are not compensatory. Under conditions of single-valued neutrosophic sets, a MABAC approach is developed. The weights of the criterion are calculated using this approach, which uses the mean-squared deviation weight method. In addition to that, an illustrated example is carried out to demonstrate the process that is involved in the MABAC approach.

Keywords*:* Neutrosophic Sets; MCDM; MABAC; Mean Squared Deviation weight; SVNSs; Excavation System.

1. Introduction

Accidents are more likely to occur during the construction of the excavation if possible high-risk elements are not recognized and mitigated on time. One way to think of the excavation is as a sophisticated construction network for subterranean engineering[1], [2]. Due to the highly disguised nature of the construction process, the processing of construction information connected to excavation construction presents the managers of the project with a particularly difficult problem when compared to the processing of construction information linked to other civil engineering projects[3], [4]. In addition, in geotechnical engineering, the experiences of specialists and engineers are essential, and they may give helpful references for engineering projects at various phases. This is because excavation construction is fraught with a great deal of uncertainty and fuzziness[5], [6].

To acquire correct risk levels, it is necessary to conduct an excavation risk assessment. The multivariable and nonlinear connection that exists among the variables and risk levels is the source of the majority of the challenges that are associated with this procedure[7], [8]. In the most recent decades, a large number of scholars have developed a variety of approaches to anticipate or evaluate the dangers associated with deep excavation. These methods include the fuzzy set theory as well as machine learning techniques like artificial neural networks (ANNs).

Smarandache offered the neutrosophic set for the first time from a philosophical standpoint at the beginning[9]. A neutrosophic set may be summed up using three degrees: the degree of truth membership, the degree of indeterminacy membership, and the degree of falsity membership. It generalizes the idea of classic sets, fuzzy sets, interval-valued fuzzy sets, vague sets, intuitionistic fuzzy sets, interval-valued intuitionistic fuzzy sets, tautological sets, and vague intuitionistic fuzzy sets[10]–[12]. From a scientific standpoint, it is necessary to specify the neutrosophic set as well as the set-theoretic procedures. If this is not the case, then it will be difficult to use in actual scenarios[13], [14]. In light of this, Wang et al. came up with the idea of a single-valued neutrosophic set (SVNS), and they also presented the set-theoretic operators and several features associated with SVNSs[15], [16].

A novel approach has been developed, and it's called the MABAC technique. It demonstrates the basis of decision-making by using a clear calculation approach, a systematic process, and good logic in its operation. Peng and Yang utilized the MABAC to the R&D project choice technique to rate the projects and achieve the one they sought. This was accomplished by integrating the benefits of Pythagorean fuzzy sets with the MABAC[17], [18]. MABAC is a technique that was suggested by Xue et al. for the selection of materials to be used in interval-valued intuitionistic fuzzy environments. However, to the best of our knowledge, the investigation of the MADM issue using the MABAC approach has not been published in the current body of scholarly literature[19]–[21]. As a result, using the MABAC approach in MADM to rank the alternatives and come up with the best one while working in a single-valued neutrosophic system is an exciting study area[22]–[24].

The main contribution in this paper is organized as follows:

I. The identification of the risks in the excavation systems is evaluated under the single-valued neutrosophic sets.
II. This kind of this problem has not been applied under a neutrosophic environment in previous research.
III. The excavation criteria are computed by the mean squared deviation.
IV. The MABAC method is extended by the single-valued neutrosophic sets to rank the risks in the excavation system.
V. A real case study is conducted in this paper in Egypt.
VI. This research uses the cost and profit criteria and the single-valued neutrosophic operations in the normalization process.

The organization of the structure of this work is described below. In Section 2, the MABAC approach is constructed such that it may solve the issue of identifying dangers in excavation systems. In Section 3, we look at an example that illustrates how the excavation system in Egypt worked. The last section of the paper is called Section 4.

2. The MABAC Method

In this section, a MABAC approach for evaluating excavation systems is presented. The MABAC approach is broken down into two distinct stages. Obtaining the weight vector of variables is the primary objective of the initial phase[15]. During the second step, the discrepancies between the excavation system and the appropriate border approximation region are determined and the options are ranked. Fig. 1 is a diagram that illustrates the framework of the MABAC approach. The remainder of this section will go into further depth about its specifics[25], [26].

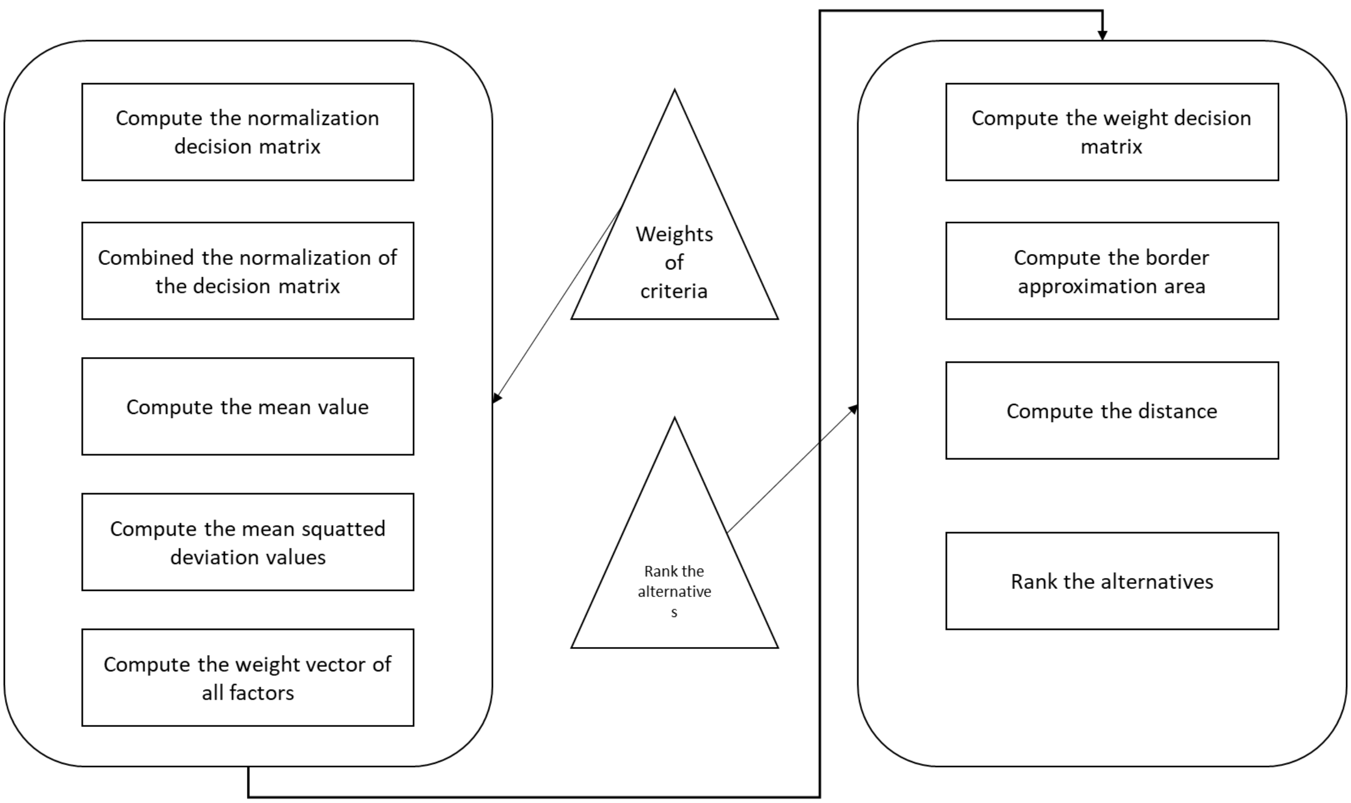

Fig 1. The framework of the MABAC method.

Table 1. The MABAC variables.

Symbols	Description
M	Number of alternatives
n	Number of criteria

EXCSA ($\mathrm{EXCSA_1, EXCSA_2, EXCSA_3 \dots . EXCSA_m}$)	Alternatives
EXCSC ($\mathrm{EXCSC_1, EXCSC_2, EXCSC_3 \dots . EXCSC_n}$)	Criteria
DM_1, DM_2, DM_3	Decision Makers
$w = (w_1, w_2. w_3, \dots w_e)^T$	Weight Vector
e	Experts
$DM_g(g = 1,2,3, \dots \dots e)$	Decision Makers
$r = 1,2,3 \dots . . m$	Alternatives
$j = 1,2,3, \dots . n$	Criteria

Obtained the decision matrix as:

$$H^g = \begin{pmatrix} H_{11}^g & H_{12}^g & \cdots & H_{1n}^g \\ H_{21}^g & H_{22}^g & & H_{2n}^g \\ \vdots & & \ddots & \vdots \\ H_{m1}^g & H_{m2}^g & \cdots & H_{mn}^g \end{pmatrix},$$

Where $H_{rj}^g = (S_{rj}^g, T_{rj}^g, I_{rj}^g, F_{rj}^g)$ is a single-valued neutrosophic verbal number (SVNVN) of $EXCSA_r$ against $\mathrm{EXCSC_j}$ donated by experts $DM_g(g = 1,2,3, \dots \dots e)$

Phase 1: Compute the weight vector of factors.

At this point in the process, the weight vector of the factors is acquired. A mean-squared deviation weight approach is used to estimate the relative importance of each criterion. The following is an explanation of the particulars of this phase.

Step 1: Compute the normalization decision matrix.

In this step, if the criterion is cost then the criterion should be normalized. The profit criteria are not normalized.

$$Nor_{rj}^g = \begin{cases} neg(H_{rj}^g) & cost\ criteria \\ H_{rj}^g & otherwise \end{cases} \tag{1}$$

Step 2: Combined the normalization of the decision matrix.

There are many decision-makers and experts, so the normalized decision matrices should be combined into one matrix. The combined normalized decision matrix obtained by $Com = (Com_{rj})_{m \times n}$

Step 3: Compute the mean value.

In the future phases, a mean-squared deviation weight approach will be established. The mean value of all the different alternatives is used in this technique to evaluate every criterion. At this stage, the mean value of all the alternatives concerning the criteria is determined.

The mean value donated as $M(Com_j)$

Step 4: Compute the mean squatted deviation values (ϑ)

The mean squared deviation can be computed as:

$$\vartheta(Com_j) = \sqrt{\sum_{r=1}^{m}\left(d(Com_{rj} - M(Com_j))\right)^2} \quad (2)$$

Step 5: Compute the weight vector of all factors.

The weights of factors can be computed as:

$$w_j = \frac{\vartheta_j}{\sum_{j=1}^{n}\vartheta_j} \quad (3)$$

Phase 2: Rank the alternatives by the MABAC method.

Step 6: Compute the weight decision matrix.

The weight decision matrix can be computed by multiplying the weight vector of each criterion by the aggregated normalized decision matrix as:

$$WD\ (wd_{rj}) = w_j * Com_{rj} \quad (4)$$

Step 7: Compute the border approximation area.

The border approximation area can be computed by the MABAC method and donated as $B = \left(b_j\right)_{n\times 1}$

$$b_j = \left(\prod_{r=1}^{m} wd_{rj}\right)^{\frac{1}{m}} \quad (5)$$

Step 8: Compute the distance between the weighted normalized decision matrix and the border approximation area.

The distance between b_j and wd_{rj} can be computed as:

$$T = \left(t_{rj}\right)_{m\times n} = \begin{cases} t\left(Com_{rj}, b_j\right)\ if\ Com_{rj} > b\_j \\ -t\left(Com_{rj}, b_j\right)\ otherwise \end{cases} \quad (6)$$

Step 9: Rank the alternatives.

The alternatives are ranked according to:

$$F_r = \sum_{j=1}^{n} t_{rj} \quad (7)$$

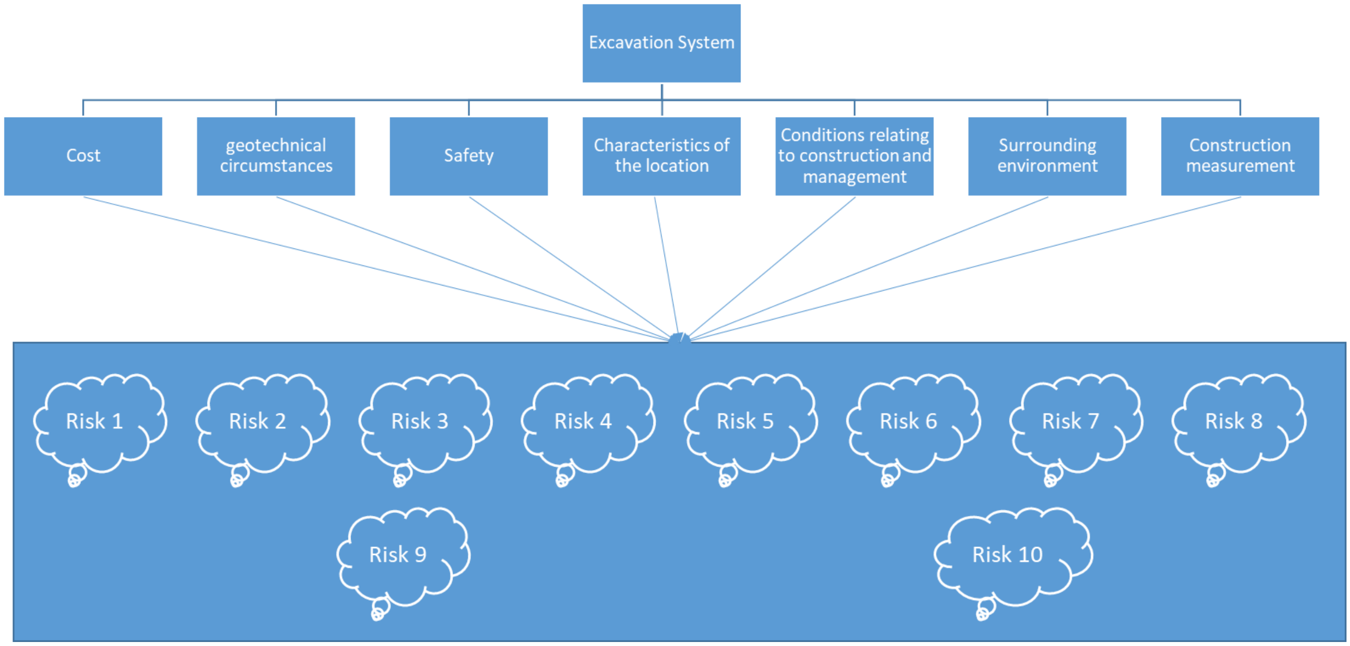

Fig 2. The hierarchy tree of criteria and alternatives.

3. Results

In this part, the MABAC approach is used to evaluate the excavation system. This section's primary objective is to explain how the MABAC should be used.

The building activity of excavation has a greater danger. Because the building of the excavation involves a variety of different aspects. An investigation into the building of an excavation in Zhuhai, China, is used as the case study. Excavation construction carried out in a risk-free way is an extremely important aspect of the construction unit.

Archaeology one hundred years ago was quite different from what it is now. Petrie used enormous teams of Egyptian excavators; nevertheless, their efforts were not acknowledged for the work that they did throughout the excavations that took place on a grander scale and at a quicker speed.

Archaeologists utilize a wide variety of techniques that allow for more exact documentation than ever before, which has resulted in digs that are more specific and concentrated than ever before. Archaeologists in Egypt oversee their digs, and there has been an increase in the number of efforts made to engage local populations in Egypt via various outreach programs. The project will make in Saqqara, Egypt. The Saqqara site is part of a sprawling necropolis at Egypt's ancient capital of Memphis that includes the famed Giza Pyramids as well as smaller pyramids at Abu Sir, Dahshur, and Abu Ruwaysh. The ruins of Memphis were designated a UNESCO World Heritage site in the 1970s.

It is necessary to establish both criteria and risk variables. For this research, five highly knowledgeable specialists in expert systems have been asked to carry out an excavation risk assessment. Fig 2. Shows the hierarchy tree between criteria and alternatives (risks). There are three experts to evaluate the criteria and alternatives. The weights vector of experts is (1/3,1/3,1/3).

In this portion, it was mentioned that SVNVN may be used to characterize assessments. Every specialist evaluates every risk concerning every factor. The verbal aspects are taken into consideration. For instance, the first decision-makers compared $\text{EXCSA}_1$to EXCSC_1 based on its verbal value. In addition, we have asked every supervisor to give the following data: (1) The extent to which the individual thinks that the evaluation is accurate. (2) The extent to which the individual believes that the evaluation is inaccurate. (3) The extent to which he does not have complete confidence in the evaluation. An SVNN can show all three of these different types of information. Let experts evaluate the criteria and alternatives to build the decision matrix. Table 2 shows the decision matrix by the e1.

Table 2. The decision matrix of e1 by the SVNVNs.

	EXCSC_1	EXCSC_2	EXCSC_3	EXCSC_4	EXCSC_5	EXCSC_6	EXCSC_7
EXCSA_1	0.9,0.1,0.1	0.3,0.8,0.2	0.1,0.8,0.6	0.1,0.8,0.6	0.4,0.6,0.2	0.9,0.1,0.1	0.9,0.1,0.1
EXCSA_2	0.7,0.5,0.1	0.6,0.5,0.1	0.9,0.1,0.1	0.7,0.5,0.1	0.4,0.6,0.2	0.8,0.1,0.1	0.4,0.6,0.2
EXCSA_3	0.1,0.8,0.6	0.2,0.8,0.4	0.4,0.6,0.2	0.8,0.1,0.1	0.9,0.1,0.1	0.7,0.5,0.1	0.1,0.8,0.6
EXCSA_4	0.6,0.5,0.1	0.9,0.1,0.1	0.3,0.8,0.2	0.7,0.5,0.1	0.2,0.8,0.4	0.4,0.6,0.2	0.6,0.5,0.1
EXCSA_5	0.4,0.6,0.2	0.8,0.1,0.1	0.3,0.8,0.2	0.4,0.6,0.2	0.1,0.8,0.6	0.2,0.8,0.4	0.8,0.1,0.1
EXCSA_6	0.1,0.8,0.6	0.2,0.8,0.4	0.9,0.1,0.1	0.8,0.1,0.1	0.3,0.8,0.2	0.4,0.6,0.2	0.9,0.1,0.1
EXCSA_7	0.7,0.5,0.1	0.6,0.5,0.1	0.4,0.6,0.2	0.7,0.5,0.1	0.9,0.1,0.1	0.7,0.5,0.1	0.3,0.8,0.2
EXCSA_8	0.4,0.6,0.2	0.9,0.1,0.1	0.3,0.8,0.2	0.8,0.1,0.1	0.3,0.8,0.2	0.8,0.1,0.1	0.1,0.8,0.6
EXCSA_9	0.1,0.8,0.6	0.8,0.1,0.1	0.7,0.5,0.1	0.9,0.1,0.1	0.3,0.8,0.2	0.4,0.6,0.2	0.6,0.5,0.1
EXCSA_{10}	0.9,0.1,0.1	0.6,0.5,0.1	0.4,0.6,0.2	0.1,0.8,0.6	0.7,0.5,0.1	0.6,0.5,0.1	0.9,0.1,0.1

Phase 1: Compute the weights vector of each criterion.

Step 1: Compute the normalization decision matrix.

In this step, we specify the cost and profit criteria to make a normalization matrix on the cost criteria only. Cost criterion is a cost criterion and others are profit criteria. The normalization decision matrix is shown in Table 3.

Table 3. The normalized decision matrix of e2 (Nor^2).

	EXCSC_1	EXCSC_2	EXCSC_3	EXCSC_4	EXCSC_5	EXCSC_6	EXCSC_7
EXCSA_1	0.1,0.5,0.6	0.3,0.8,0.2	0.1,0.8,0.6	0.1,0.8,0.6	0.4,0.6,0.2	0.9,0.1,0.1	0.2,0.8,0.4
EXCSA_2	0.4,0.2,0.2	0.6,0.5,0.1	0.9,0.1,0.1	0.7,0.5,0.1	0.2,0.8,0.4	0.8,0.1,0.1	0.4,0.6,0.2
EXCSA_3	0.6,0.2,0.1	0.2,0.8,0.4	0.4,0.6,0.2	0.2,0.8,0.4	0.9,0.1,0.1	0.6,0.5,0.1	0.1,0.8,0.6
EXCSA_4	0.1,0.5,0.6	0.6,0.5,0.1	0.3,0.8,0.2	0.7,0.5,0.1	0.2,0.8,0.4	0.4,0.6,0.2	0.6,0.5,0.1

$EXCSA_5$	0.1,0.5,0.6	0.8,0.1,0.1	0.3,0.8,0.2	0.6,0.5,0.1	0.1,0.8,0.6	0.2,0.8,0.4	0.8,0.1,0.1
$EXCSA_6$	0.4,0.2,0.2	0.2,0.8,0.4	0.2,0.8,0.4	0.8,0.1,0.1	0.3,0.8,0.2	0.6,0.5,0.1	0.2,0.8,0.4
$EXCSA_7$	0.1,0.5,0.7	0.6,0.5,0.1	0.6,0.5,0.1	0.7,0.5,0.1	0.9,0.1,0.1	0.6,0.5,0.1	0.3,0.8,0.2
$EXCSA_8$	0.1,0.5,0.6	0.2,0.8,0.4	0.3,0.8,0.2	0.8,0.1,0.1	0.2,0.8,0.4	0.8,0.1,0.1	0.6,0.5,0.1
$EXCSA_9$	0.6,0.2,0.1	0.8,0.1,0.1	0.6,0.5,0.1	0.9,0.1,0.1	0.3,0.8,0.2	0.4,0.6,0.2	0.2,0.8,0.4
$EXCSA_{10}$	0.1,0.5,0.6	0.6,0.5,0.1	0.6,0.5,0.1	0.1,0.8,0.6	0.7,0.5,0.1	0.6,0.5,0.1	0.6,0.5,0.1

Step 2: Combined the normalization of the decision matrix.

This step shows the combined decision matrix table 4 shows the integrated decision matrix.

Table 4. The integration decision matrix.

	$EXCSC_1$	$EXCSC_2$	$EXCSC_3$	$EXCSC_4$	$EXCSC_5$	$EXCSC_6$	$EXCSC_7$
$EXCSA_1$	0.1,0.5,0.6	0.3,0.8,0.2	0.1,0.8,0.6	0.1,0.8,0.6	0.4,0.6,0.2	0.9,0.1,0.1	0.2,0.8,0.4
$EXCSA_2$	0.4,0.2,0.2	0.6,0.5,0.1	0.9,0.1,0.1	0.7,0.5,0.1	0.2,0.8,0.4	0.8,0.1,0.1	0.4,0.6,0.2
$EXCSA_3$	0.6,0.2,0.1	0.2,0.8,0.4	0.4,0.6,0.2	0.2,0.8,0.4	0.9,0.1,0.1	0.6,0.5,0.1	0.1,0.8,0.6
$EXCSA_4$	0.1,0.5,0.6	0.6,0.5,0.1	0.3,0.8,0.2	0.7,0.5,0.1	0.2,0.8,0.4	0.4,0.6,0.2	0.6,0.5,0.1
$EXCSA_5$	0.1,0.5,0.6	0.8,0.1,0.1	0.3,0.8,0.2	0.6,0.5,0.1	0.1,0.8,0.6	0.2,0.8,0.4	0.8,0.1,0.1
$EXCSA_6$	0.4,0.2,0.2	0.2,0.8,0.4	0.2,0.8,0.4	0.8,0.1,0.1	0.3,0.8,0.2	0.6,0.5,0.1	0.2,0.8,0.4
$EXCSA_7$	0.1,0.5,0.7	0.6,0.5,0.1	0.6,0.5,0.1	0.7,0.5,0.1	0.9,0.1,0.1	0.6,0.5,0.1	0.3,0.8,0.2
$EXCSA_8$	0.1,0.5,0.6	0.2,0.8,0.4	0.3,0.8,0.2	0.8,0.1,0.1	0.2,0.8,0.4	0.8,0.1,0.1	0.6,0.5,0.1
$EXCSA_9$	0.6,0.2,0.1	0.8,0.1,0.1	0.6,0.5,0.1	0.9,0.1,0.1	0.3,0.8,0.2	0.4,0.6,0.2	0.2,0.8,0.4
$EXCSA_{10}$	0.1,0.5,0.6	0.6,0.5,0.1	0.6,0.5,0.1	0.1,0.8,0.6	0.7,0.5,0.1	0.6,0.5,0.1	0.6,0.5,0.1

Step 3: Compute the mean value.

The values of the mean can be computed in this step.

Step 4: Compute the mean squatted deviation values (ϑ)

The mean squared error of each alternative against criteria computed by using Eq. (2). The results are shown in Table 5.

Table 5. The mean values mean squared deviation values to each criterion and the weight of the criteria.

	Mean values	Mean squared deviation	$Weight$
$EXCSC_1$	0.464444	4.436222	0.139157
$EXCSC_2$	0.608889	4.436222	0.144117
$EXCSC_3$	0.565556	4.436222	0.146621
$EXCSC_4$	0.635556	4.436222	0.14046
$EXCSC_5$	0.515556	4.436222	0.143866
$EXCSC_6$	0.665556	4.436222	0.143415
$EXCSC_7$	0.553333	4.436222	0.142363
Sum	4.008889	4.436222	1

Step 5: Compute the weight vector of all factors.

The weights of the criteria can be computed using Eq. (2). The last column in Table 5 shows the weights of the criteria. The sum of all criteria is 1 as shown in the last row in Table 5.

Phase 2: Rank the alternatives by the MABAC method.

Step 6: Compute the weight decision matrix.

The weighted decision matrix can be computed by using Eq. (4). Table 6 shows the values of multiplying the weights of criteria by the normalization matrix.

Table 6. The weighted decision matrix.

	$EXCSC_1$	$EXCSC_2$	$EXCSC_3$	$EXCSC_4$	$EXCSC_5$	$EXCSC_6$	$EXCSC_7$
$EXCSA_1$	0.018554325502179,0.0834944647598056,0.0881330461353504	0.0432349847217352,0.115293292591294,0.0288233231478235	0.0293242498622452,0.107522249494899,0.068423249678572	0.0140459850723839,0.112367880579071,0.0842759104343034	0.0575464609527626,0.0863196914291439,0.0287732304763813	0.129073786505034,0.0143415318338927,0.0143415318338927	0.0711816861193207,0.0711816861193207,0.0332181201890163
$EXCSA_2$	0.0324700696288133,0.0510243951309923,0.0603015578820819	0.0864699694434704,0.0720583078695587,0.0144116615739117	0.131959124380103,0.0146621249311226,0.0146621249311226	0.0983218955066874,0.0702299253619195,0.0140459850723839	0.0479553841273022,0.0959107682546043,0.0383643073018417	0.114732254671142,0.0143415318338927,0.0143415318338927	0.0569453488954566,0.0854180233431849,0.0284726744477283
$EXCSA_3$	0.0649401392576266,0.0	0.0288233231478235,0.1	0.0586484997244903,0.0	0.0655479303377916,0.0	0.105501845080065,0.03	0.0956102122259513,0.0	0.0142363372238641,0.1

	371086510043581,0.0278314882532685	15293292591294,0.0576466462956469	879727495867355,0.0293242498622452	702299253619195,0.0327739651688958	83643073018417,0.0191821536509209	717076591694635,0.0143415318338927	13890697790913,0.0854180233431849
$EXCSA_4$	0.0139157441266343,0.0695787206331714,0.0834944647598056	0.0912738566347743,0.0576466462956469,0.0192155487652156	0.0488737497704086,0.107522249494899,0.0293242498622452	0.0983218955066874,0.0702299253619195,0.0140459850723839	0.0383643073018417,0.105501845080065,0.0479553841273022	0.0573661273355708,0.0860491910033562,0.0286830636677854	0.0759271318606088,0.0759271318606088,0.0189817829651522
$EXCSA_5$	0.0231929068777238,0.0603015578820819,0.0649401392576266	0.0960777438260782,0.0384310975304313,0.0192155487652156	0.0439863747933677,0.117296999448981,0.0293242498622452	0.0655479303377916,0.0795939154101755,0.0234099751206399	0.0143866152381907,0.115092921905525,0.0863196914291439	0.0286830636677854,0.114732254671142,0.0573661273355708	0.113890697790913,0.0142363372238641,0.0142363372238641
$EXCSA_6$	0.0742173020087161,0.0278314882532685,0.018554325502179	0.0384310975304313,0.105685518208686,0.0480388719130391	0.0977474995408172,0.0488737497704086,0.0293242498622452	0.112367880579071,0.0140459850723839,0.0140459850723839	0.043159845714572,0.115092921905525,0.0287732304763813	0.0669271485581659,0.0812686803920586,0.0239025530564878	0.0711816861193207,0.0711816861193207,0.0332181201890163
$EXCSA_7$	0.018554325502179,0.0649401392576266,0.0834944647598056	0.0864699694434704,0.0720583078695587,0.0144116615739117	0.068423249678572,0.0830853746096946,0.0244368748852043	0.0983218955066874,0.0702299253619195,0.0140459850723839	0.105501845080065,0.0383643073018417,0.0191821536509209	0.0956102122259513,0.0717076591694635,0.0143415318338927	0.0474544574128805,0.104399806308337,0.0284726744477283
$EXCSA_8$	0.0231929068777238,0.0603015578820819,0.0649401392576266	0.0960777438260782,0.0480388719130391,0.0288233231478235	0.0439863747933677,0.117296999448981,0.0293242498622452	0.112367880579071,0.0140459850723839,0.0140459850723839	0.0383643073018417,0.115092921905525,0.0383643073018417	0.114732254671142,0.0143415318338927,0.0143415318338927	0.0379635659303044,0.099654360567049,0.0616907946367446
$EXCSA_9$	0.0649401392576266,0.0371086510043581,0.0278314882532685	0.0960777438260782,0.0384310975304313,0.0192155487652156	0.0977474995408172,0.0733106246556129,0.0146621249311226	0.126413865651455,0.0140459850723839,0.0140459850723839	0.043159845714572,0.115092921905525,0.0287732304763813	0.0573661273355708,0.0860491910033562,0.0286830636677854	0.0664362403780327,0.0854180233431849,0.0284726744477283
$EXCSA_{10}$	0.0510243951309923,0.106687371637529,0.111325953013074	0.0864699694434704,0.0720583078695587,0.0144116615739117	0.068423249678572,0.0830853746096946,0.0244368748852043	0.0140459850723839,0.112367880579071,0.0842759104343034	0.100706306667335,0.0719330761909533,0.0143866152381907	0.0860491910033562,0.0717076591694635,0.0143415318338927	0.0901634690844729,0.0569453488954566,0.0189817829651522

Step 7: Compute the border approximation area.

The border approximation area can be computed by using Eq. (5).

Step 8: Compute the distance between the weighted normalized decision matrix and the border approximation area.

The distance between the weighted decision matrix and border approximation area can be determined by using Eq. (6). The results are shown in Table 7.

Table 7. The distance between the weighted decision matrix and border approximation area.

	$EXCSC_1$	$EXCSC_2$	$EXCSC_3$	$EXCSC_4$	$EXCSC_5$	$EXCSC_6$	$EXCSC_7$
$EXCSA_1$	0.047025	0.026686	0.041417	0.074759	0.007341	0.011038	0.018116
$EXCSA_2$	0.000639	0.012274	-0.00257	0.046667	0.016932	-0.0033	0.01337
$EXCSA_3$	-0.01328	0.041097	0.012093	0.032621	-0.00225	0.034941	0.056079
$EXCSA_4$	0.023832	0.00747	0.021868	0.046667	0.026523	0.02538	0.01337
$EXCSA_5$	0.005278	-0.00694	0.026755	0.032621	0.050501	0.054063	-0.0151
$EXCSA_6$	-0.02255	0.03149	0.012093	0.004529	0.021728	0.02538	0.018116
$EXCSA_7$	0.023832	0.012274	0.012093	0.046667	-0.00225	0.034941	0.022861
$EXCSA_8$	0.005278	0.012274	0.026755	0.004529	0.026523	-0.0033	0.041843
$EXCSA_9$	-0.01328	-0.00694	0.021868	0.018575	0.021728	0.02538	0.022861
$EXCSA_{10}$	0.125881	0.012274	0.012093	0.074759	0.021728	0.02538	0.008625

Step 9: Rank the alternatives.

The sum of each row can be computed using Eq. (7). Then rank the alternatives according to the lowest value of the sum. Table 8 shows the rank of alternatives.

Table 8. The rank of alternatives.

	Sum of distance	Rank
$EXCSA_1$	0.226382	9
$EXCSA_2$	0.08401	1
$EXCSA_3$	0.161305	7

EXCSA_4	0.16511	8
EXCSA_5	0.147174	5
EXCSA_6	0.090781	3
EXCSA_7	0.150418	6
EXCSA_8	0.113899	4
EXCSA_9	0.090193	2
EXCSA_{10}	0.280739	10

4. Conclusion

In engineering practice, a built decision structure for risk analysis of an excavation system provides a useful guide for project supervisors to recognize high-risk aspects. This helps project supervisors to take appropriate measures in time to minimize the occurrence likelihood of risk accidents in the initial building phase of excavation. The method that has been proposed may be used in any other engineering project that calls for the judgments of DMs and the information tracked of variables. Additionally, the proposed framework is adaptable for use in the MCDM process. The last point is that the approach associated with MCDM modeling may be transformed into computer software, which can minimize the amount of time and effort required to gather and analyze the views from a variety of specialists.

A technique for a neutrosophic excavating system has been devised mainly for this work. SVNVNs are used inside the excavation system approach to display qualitative and ambiguous information. MABAC has been upgraded so that it can manage SVNVNs. In addition to this, the excavation system approach presents the central concept of MABAC and considers the non-compensation of requirements. In addition, to acquire criterion weights, the mean-squared deviation weight technique using SVNVNs has been devised. From the MABAC method and neutrosophic sets, alternative 2 is the best, and alternative 10 is the worst.

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