Analytical hierarchy process for selection of roadheaders

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Synopsis

Selection of the most suitable roadheaders (boom type tunnelling machines) for the galleries/tunnels to be excavated in certain rock and under known project conditions is important for avoiding problems during application. This research utilized a multiple attribute decision-making method and studied how this will be applied for the selection of boom-type excavation machines. The Cayirhan Coal Basin was used for selecting roadheaders using the analytical hierarchy process, which is one of the multiple attribute decision-making methods. To conclude, this study reveals that decision-making methods can be used in the process of selecting roadheaders for the excavation of galleries.

Keywords: roadheaders, multiple attribute decision-making, analytical hierarchy process.

Introduction

In order to make correct decisions, effective methods are required in many operation processes in industry. The decisions vary from choosing machines to the production method. Today, as a result of effective communication, the increase of information has led to the exposure of decision-makers to complex system elements having many variables. In such cases the decision-makers have to make decisions by using appropriate algorithms and methods. Since there are more ambiguities and risk in disciplines such as mining and geology, decision-making methods, which evaluate the uncertain information and opinion of experts, are needed.

Decision-making means the process of 'making an appropriate choice from options in order to realize one or more aims'[1]. There have been many studies about decision-making algorithms and methods in recent years. The general tendency of the studies is towards multiple attributes (criteria) decision-making (MADM) and multiple objective decision-making (MODM) methods. While MADM is based on determining the most appropriate alternative from the options considering multiple and conflicting criteria for realizing only one aim, MODM tries to determine the most appropriate option for realizing a set of conflicting aims[2,3]. In recent years fuzzy multiple attributes decision-making (FMADM), in which the fuzzy logic method is used, has also been used[4,5].

Driving of the galleries/tunnels is an important operation in mining and construction sectors and directly affects the efficiency of production. Mechanization is becoming widespread in excavation operations today. Mechanical excavation methods are faster and more reliable than the conventional methods. After a certain length of tunnel, the costs of the mechanical excavation decrease sharply[6,7]. However, these advantages can be acquired only if the right machine is selected. If the expected performance is not acquired from the machines, the costs will be much more than that of the drilling and blasting method. Using some decision-making methods to choose a machine can prevent many of the problems faced in the future. In this study, the opportunity to use multi-criteria decision-making in the selection of excavation machines such as roadheaders has been researched.

Excavation machines are generally classified as full face and partial face machines according to the contact between the surface to be excavated and the cutting part of the machine. The roadheader, which is one of the partial face excavation machines, is being used widely in underground mining and tunnelling projects. A roadheader can be used for all types of gallery sizes and shapes. In addition, it is cheaper, its maintenance is easier than

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that of the full-face tunnelling machines and the need for the professional staff can be met easily. However, it cannot be used in the excavation of very hard rocks and unstable rock conditions[6].

In order to determine the mechanized excavation systems to be used in driving the galleries, first of all, studies about the cuttability (excavability) of the rocks should be done. The cuttability of the rocks is dependent on their physical, mechanical and mass properties. For determining the cuttability of the rocks, small and full size cutting sets are used for measuring the cutting forces during the cutting process. The gallery and project parameters (size, shape, gradient, etc.) should be considered when choosing the excavation system to be used. During this investigation, performance predictions (specific energy, cutting rate, etc.) of the machines can be estimated by using various methods[8,9].

In excavation operations, sometimes the effectiveness of the machine can be very low and sometimes the machine may not be used because of problems relating to the cutting, loading, stability of the machine, condition of the face and ground and design of the galleries, etc.

It is generally possible to determine whether a roadheader can be used for the excavation of a particular gallery. However, during the excavation, the above-mentioned problems are common. In order not to face such problems, after deciding to use a roadheader in a particular gallery, the right machine should be chosen, which will be compatible with the specific properties of the galleries. However, in the selection stage many conflicting machine parameters are faced. For example, when the weight of the machine increases, its stability also increases; but the pressure it applies on the ground also increases. When the pallets are broadened in order to prevent this, the width of the machine increases and this makes the working conditions difficult. Considering all such parameters and bearing in mind the specific conditions of the gallery, the priority of the needs should be determined and the optimal selection should be made. So in the roadheader selection process, the multiple criteria decision-making methods, defined as 'selecting the appropriate alternative for an aim related to various criteria', can be used.

The use of analytical hierarchy process for selecting roadheaders

When using a multiple criteria decision-making method, the criteria that will affect the selection should be determined beforehand. Roadheaders have integrity in terms of weight, power and size and some parts of them cannot be modified or changed easily. For this reason the parameters that cannot be modified afterwards should be considered as 'selection criteria'. The criteria, which can be modified later, don't need to be considered. For example, since the users can change the cutting heads or the cutters on the heads easily, the cutting head design parameters may not be taken as a criterion.

As the MADM are used, the criteria to be determined for the selection may be qualitative as well as quantitative. Explaining the criteria in quantitative terms may reduce the need for an expert view. For example, the stability criteria need not been stated in numbers until that they have been explained in quantitative terms by developing a stability analysis method[10–12]. The criteria, which are not quantitative but qualitative such as 'judgement, experience of experts i.e. linguistic information' can also be taken as selection criteria. For example, boom type, material loading and transport type, easiness of maintenance and usage, etc. However, in these cases, many expert views are needed in order to apply decision-making methods.

The criteria should be determined by considering the properties of the region and requirements of the galleries by an expert group. The technical criteria to be generally considered are given below. Besides technical properties, cost of the machine, easiness of maintenance and usage, etc. can be taken as selection criteria.

➤ *Applicable maximum torque*—It is possible to run into hard and abrasive rocks that the roadheaders may have difficulty in cutting along the galleries. Because of this, the machine able to cut harder rocks than the other machines having similar properties should be preferred. In such case, generally the cutting head power (*P*) is considered. But the *P* value is not an indicator alone, as seen in Equation [1], it is proportional to torque (*T*) and the number of cycles (f_d). The *T* value is proportional to the cutting force (F_C) and the radius of the head (*R*), as seen in Equation [2]. If f_d is lowered according to the equations, the applicable maximum *T* will increase. So, when the heads are of similar sizes, the F_C that the machine with a higher *T* value will be higher. As the F_C increases, efficient excavations will be made in larger cutter depths. When the depth increases, the debris sizes also increase, and consequently the amount of the dust will decrease. In addition, as a result of the efficient cutting, the wear of the cutter will also decrease.

$$P = 2\pi f_d T \quad [1]$$

$$T = F_c R \quad [2]$$

➤ *Applicable maximum boom forces*—The boom forces of roadheaders are vertical, horizontal and axial. These provide the necessary forces for the cutters. The higher these forces in the integrity of the machine, the more efficient the cutting operation will be. When the boom forces are considered as selection criteria, if the machines are longitudinal cutting head-type roadheaders, it will be necessary to look at the maximum axial and horizontal boom forces, which they can apply. In such machines, as the vertical force is approximately the same as the horizontal force, it need not be considered. In transverse cutting head type roadheaders, their horizontal, vertical and axial forces can be used as selection criteria.

➤ *Cutting capacity* (cutting rate)—This is one of the most used performance parameters, and generally gives information about the effectiveness of the machine. Cutting rate is described as 'the volume of the rock that is cut in unit time'. Since the higher the cutting rate, the lower the excavation costs, those machines having a high cutting speed will be preferred. The cutting rate of a roadheader can be calculated by using one of the performance prediction methods[8,9].

- *Stability states*—The stability of a roadheader is important in terms of continuity of the excavation, and consequently the efficiency of the excavation. The stability states of the machines are considered generally as horizontal and vertical stability. In order to increase the stability of the roadheaders, horizontal and vertical hydraulic cylinders are attached. However, these sometimes cannot be used in wide tunnels and on wet and soft grounds. For this reason, selecting stable machines is important in the choosing stage. The stability of roadheaders can be analysed in detail by using methods and computer programs that can yield quantifiable results[10,11]. By these methods, the stability of the machines can be calculated as turning around the vertical axis, turning inside and back directions, and sliding. Consequently, these can be used as selection criteria. The calculation of these criteria should be found assuming that different machines will cut in similar conditions.
- *Maximum cutting width and height*—The size of the tunnel section to be cut should not be smaller than the minimum cutting range of the machines. After this has been provided, the machine can excavate the section of the gallery in one position without moving, after the boom of the machine is placed in front of the gallery axis. In this way, spending extra time on manoeuvring will be prevented, and the cutting rate will increase. The machine having a cutting width and height more than other similar machines will be preferred according to these criteria. Maximum cutting depth under the ground level can be also considered as a selection criterion like maximum cutting width and cutting height.
- *Travelling* (tracking) speed—As the travelling speed of the machine increases, the time spent for the right, left, forward and backward movements will decrease. So the machine whose walking speed is higher will be preferred.
- *The pressure applying on the ground*—If the ground is wet and soft, the machine may sink. In such a case it is preferred that the pressure, which the machine applies on the ground, will be low. The pressure applied by the machine on the ground is related to the width of the pallets and weight of the machine.
- *Maximum working gradient*—The selected machine should be able to work in the inclined parts of the galleries. Additionally, machines that have the ability to work in grounds having a high gradient are preferred, considering changes in the situation and also other applications in the future.
- *Other criteria*—The above criteria have been determined as general criteria that can be used in selecting among various roadheaders for efficiency of the excavation. Some other parameters may be defined as selection criteria according to requirements of the project.

After determining the selection criteria, rules of the MADM can be applied. Since the analytical hierarchy process (AHP), which is one of the MADM was used in this study, this method will be explained first.

Analytical hierarchy process

AHP, developed by Saaty, is a method that enables reaching a decision by using quantitative and qualitative data[13,14]. As the problem is stated in the hierarchical tree structure in this method, the problem becomes easy to understand. A hierarchical tree comprises a minimum of three stages: 'target, criteria and alternatives'. Use of this method is widespread in mining and geology[15–18].

AHP is based on determining the relative priorities (weighting) of the criteria by pairwise comparison. In pairwise comparison, the question is asked that 'how many times is a criterion more important than another one?' and it is answered according to the scale in Table I. With this scoring technique, priority ranking can be obtained objectively, in spite of criteria being contradictory. Pairwise comparison is also applied for obtaining the relative priorities of the alternatives according to each criterion. For each pairwise comparison, a matrix is obtained and it is of n x n size, where n is the number of elements. The eigenvector is found corresponding to the maximum eigenvalue of the matrix. Normalizing this vector gives us the priority degrees (weights) relatively[14].

In pairwise comparison, the scorings should not conflict with each other. If the maximum eigenvalue of the comparison matrix is closer to the criteria number, the scoring will be more consistent. For controlling the consistency of comparison, the consistency ratio is determined[13]. Firstly, the consistency index (T_i) of the matrix is determined by Equation [3].

$$T_i = \left(\lambda_{\max} - n\right)/\left(n - 1\right) \qquad [3]$$

where λ_{max} is the maximum eigenvalue and n is the size of matrix. The random consistency index (R_i) is obtained by Equation [4].

$$R_i = 1.98\left(n - 2\right)/\left(n\right) \qquad [4]$$

The consistency ratio is determined by the T_i/R_i ratio. If the ratio is below 0.1 this shows the comparison is consistent[13].

Lastly in AHP, the normalized eigenvectors created by the scoring of the alternatives considered for each criterion are turned into a matrix, and this matrix is multiplied with the normalized eigenvector, including the weights of the criteria. The result gives the preference values of the alternatives.

Analysis of Cayirhan Coal Basin in terms of roadheader selection

Lignite basin lies in the Cayirhan Coal Basin, about 100 km northwest of Ankara in Turkey, as seen in Figure 1. The

Table I

Scale for pairwise comparison

Definition	Degree of importance
Equal	1
Moderate	3
Strong	5
Very strong	7
Extreme	9

(2,4,6 and 8 can also be used)

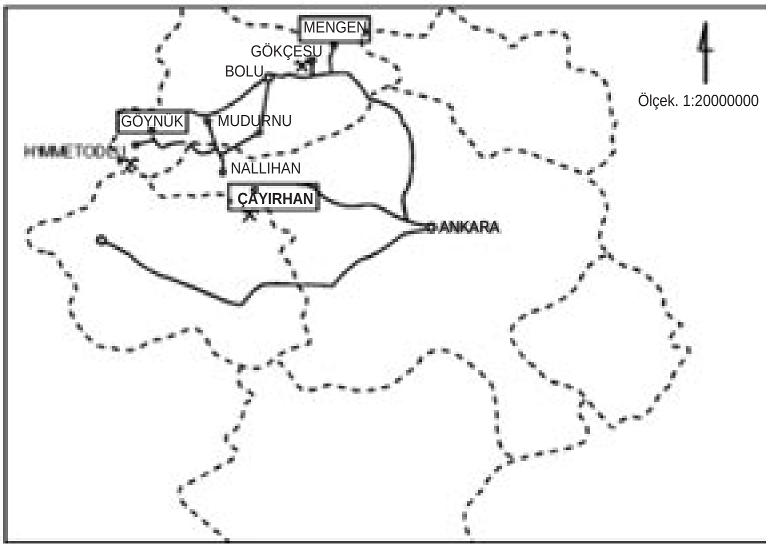

Figure 1—Location of the Cayirhan Coal Basin

overburden thickness is between 150 and 200 m from the basin. Across the basin, there are two lignite seams called the upper and lower seam and they are separated by an interburden. While the average upper seam thickness is 1.52 m and the lower seam thickness is 1.72 m, the thickness of the interburden between the two seams is 1.3–2 m in the western part of the field and 0.5–0.7 m on the eastern side. Mineable resources of these seams are 236 Mt. Since the production method is the longwall retreat mining method, long gateroad galleries are driven for development purposes. Gateroad galleries were planned to follow the lignite seams. For this reason, excavation of the gateroads is realized within the two coal-seams' boundaries, wich are separated by a sterile layer (interburden). The panels that are planned to be exploited in the future are being designed in the same way[19].

For determining the type of machine and its cutting capacity, which will be used in Cayirhan Coal Basin, specimens were taken from the coal-seams and the interburden which separates the seams. Using these specimens, full-scale cutting tests were carried out at the University Laboratories[10]. These specimens were taken from the B0610 gateroad gallery. Minimum specific energy (SE) values were obtained at 10 mm cutting depth as distance between cutters/depth of cutting (s/d) is 2 for both specimens. In these optimum cutting conditions (d=10 mm, s/d =2), SE values that were found for the coal and interburden specimens is 2.15 kWh/m^3 and 6.87 kWh/m^3 respectively.

If a roadheader is considered for the excavation, the cutting head power (P) of roadheader to be used can be estimated by Equation [5], using the SE value in optimum cutting conditions and the cutting rate (V). It is assumed that the specimens taken from the mine almost represent the real seam structure and that the face is composed equally of coal and interburden. It is calculated that for a cutting rate of 20 m^3/h to be achieved, some 113 kW power is needed in the roadheader cutting head according to Equation [5]. However, when it is assumed that nearly one quarter of the gallery sections is composed of interburden, a cutting head power will be 84 kW. According to these results, selection of a roadheader from the medium weight group of roadheaders has been found appropriate, since machines having this range of cutting head powers belong to this group.

$$P = \frac{V.SE}{\eta} \qquad [5]$$

where η is the productivity coefficient of the system (0.8).

While the Cayirhan Coal Basin was analysed for roadheader selection, the galleries and project parameters were considered as well as the cuttability of the rocks. The width and height of the biggest roadway that has been excavated at present (and is also planned for the future) is 6 m width and 5.20 m in height[20]. Although machines that can cut a smaller size than this can also be selected, it is preferable that the selected machine can cut as big as possible a section. Also, it can be considered that the machine can excavate under the ground level as deep as possible. In the mine geological conditions impose that often it may be necessary also to drive inclined roadways. Because of this, the machines that can work in as high as possible a gradient are needed. Because of the water, the ground is generally wet and soft. Since this has negative effects on driving speed, a machine that has a comparatively low ground pressure is preferred[19–21].

When using MADM, the objective was determined as choosing the right roadheader for an efficient and trouble-free application in the Cayirhan Coal Basin. The criteria to be used for selecting a roadheader were determined together with 5 engineers working in Cayirhan who are familiar both with the mine conditions and project requirements. Determined criteria and their numbers are given in Table II. The roadheaders in the middle-weight group of roadheaders from 3 different companies are taken as alternatives (A1, A2, A3) in selecting. These three machines have a weight of 44 tons and their cutting head axes are parallel to the boom axis. The parameter values necessary for the calculation of criteria are given in the Table III for every option. The height

Table II

Criteria and numbers of the criteria

Criterion number	Criteria
C1	Maximum available torque (kNm)
C2	Maximum horizontal boom force (kN)
C3	Maximum axial boom force (kN)
C4	Balancing force in sliding state (kN)
C5	Moment of the turning around vertical axis (kNm)
C6	Cutting rate (m^3/h)
C7	Maximum cutting height (m)
C8	Maximum cutting width (m)
C9	Maximum cutting height under ground level (m)
C10	Maximum working gradient (degree)
C11	Travelling (tracking) speed (m/sec)
C12	Pressure applying on the ground (N/cm^2)
C13	Moment of the turning to side directions (kNm)
C14	Moment of the turning to back direction (kNm)

Table III

Parameters of the three alternative roadheaders

Machine parameters	A1	A2	A3
Machine weight (kN)	440	440	440
Cutting head power (kW)	140	132	82
RPM of the cutting head (1/sec)	41.3	55	32 and 58
Axial boom force (kN)	180	150	259
Horizontal boom force (kN)	65	62	76.5
Vertical boom force (upwards) (kN)	65	68	59.2
Vertical boom force (downwards) (kN)	65	60	54.9
Machine width (m)	2.4	2.2	2.4
Pallet width (m)	0.5	0.6	0.457
Boom length (m)	4.5	5	4
Distance between the horizontal and vertical turning points of the boom (m)	0.3	0.35	0.64
Distance between the boom and the ground when the boom is parallel to the ground (m)	1.5	1.65	1.69
Distance between the back leg (stabilizer) of the machine and the centre of the gravity (m)	3	4.82	4
Maximum horizontal position angle of the boom (degree)	32	40	45
Maximum upward vertical position angle of the boom (degree)	38	43	50
Maximum downward vertical position angle of the boom (degree)	19	27	30
Maximum cutting width (m)	5.5	6.9	6.9
Maximum cutting height (m)	4.4	5.1	5.2
Maximum cutting height under ground level (m)	0.24	0.6	0.2
Maximum working gradient (degree)	18	18	14
Pressure applying on the ground (N/cm^2)	14.5	13.4	11.95
Travelling (tracking) speed (m/sec)	9.3	10	14

of the machines is below 3 m and their width is below 3.5 m and in all of them, the debris is transferred from loading apron to the chain conveyor.

The values of each criterion for three alternative machines are given in Table IV. Some of them were taken directly from the machine data and the others were calculated by using the related values in Table III. The criterion of the maximum available torque of the machines was calculated by Equation [1]. The criterion of the cutting rate of the machines was calculated using the average of the specific energy values of coal and interburden for the optimum cutting conditions. It is (6.87 + 2.15) / 2 = 4.51 kWh/m^3. For example, for the second option A2, whose cutting head power is 132 kW, if specific energy of 4.51 kWh/m^3 is spent, the net cutting rate will be 23.41 m^3/h according to Equation [5]. In the same way, the calculated values of this criterion for the other machines are given in Table IV.

The stability of alternative machines were analysed by using the machine design parameters (weight of the machine, width of the machine, pallet width, boom length, the distance between the horizontal and vertical turning points of the boom, the distance between the boom and the ground when the boom is parallel to the ground, the distance between the end point of the boom and its centre of the gravity, the distance between the back leg of the machine and the centre of the gravity), which are given in Table III. As the machines were compared with each other, the gallery gradient was taken as 0° and the friction coefficient between the ground and the machines was taken as 0.9. Apart from this, in order to compare the machines, it was assumed that the same cutting head was used in all three machines Thus, moments of the turning around the vertical axis and turning in side and back directions and sliding stability states were calculated using the stability analysis programme[10,11] and the results are presented in Table IV. The interesting point here is that the balance force in the sliding state of all the machines is the same. The reason for this is that the weight of the machines is the same for the three selected machines.

Selection of roadheader for Cayirhan Coal Basin by application of analytical hierarchy process

While the AHP is used in the selection of roadheader for the Cayirhan Coal Basin, the criteria shown in Table II have been considered. As mentioned above, the aim of the selection was to select the most appropriate machine to excavate effectively with minimum application risks. The scale given in Table I has been used in the comparison (scoring) of both the criteria and the alternatives for each criterion. The scorings were done with 5 authorized engineers from Cayirhan Park Teknik Coal Enterprises by considering the numerical information shown in Table IV. The matrix, which was obtained from the pairwise comparison of the criteria, is shown in Table V.

Table IV

The criteria values of the alternatives

Criterion number	A1	A2	A3
C1	32.39	22.93	24.48
C2	65	62	76.5
C3	180	150	259
C4	246	246	246
C5	47.18	65.07	28.81
C6	24.83	23.41	14.55
C7	4.4	5.1	5.2
C8	5.5	6.9	6.9
C9	0.24	0.6	0.2
C10	18	18	14
C11	9.3	10	14
C12	14.5	13.4	11.95
C13	373.48	295.68	341.03
C14	1048.50	1774.45	1458.55

Table V

Pairwise comparison matrix of the criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	1	1	2	3	3	3	3	3	5	5	5	6	7	8
C2	1.00	1	2	3	3	3	3	3	5	5	5	6	7	8
C3	0.50	0.50	1	2	2	2	2	2	4	4	5	5	7	8
C4	0.33	0.33	0.50	1	1	1	1	2	4	4	5	6	7	8
C5	0.33	0.33	0.50	1.00	1	1	1	2	4	4	5	6	7	8
C6	0.33	0.33	0.50	1.00	1.00	1	1	2	3	3	5	5	6	7
C7	0.33	0.33	0.50	1.00	1.00	1.00	1	2	3	3	5	5	6	7
C8	0.33	0.33	0.50	0.50	0.50	0.50	0.50	1	2	3	5	5	6	7
C9	0.20	0.20	0.25	0.25	0.25	0.33	0.33	0.50	1	2	2	2	5	6
C10	0.20	0.20	0.25	0.25	0.25	0.33	0.33	0.33	0.50	1	1	2	4	5
C11	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.50	1.00	1	2	4	5
C12	0.17	0.17	0.20	0.17	0.17	0.20	0.20	0.20	0.50	0.50	0.50	1	4	5
C13	0.14	0.14	0.14	0.14	0.14	0.17	0.17	0.17	0.20	0.25	0.25	0.25	1	3
C14	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.17	0.20	0.20	0.20	0.33	1

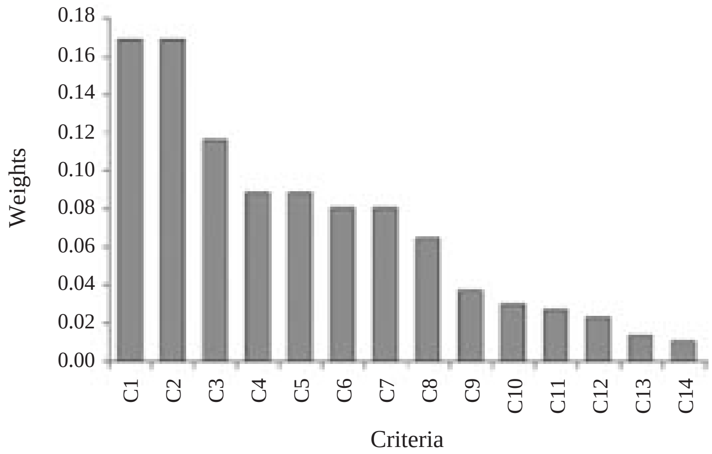

Figure 2—Weights of the criteria

The normalized eigenvector corresponding to the maximum eigenvalue (λ_{max}=15.03) of the matrix that shows relative importance (weight) of the criteria was estimated and is shown in Figure 2.

The pairwise comparison of alternatives according to each criterion was also done with Saaty's scale and the normalized eigenvectors of obtained matrices were calculated. For example, the matrix obtained as a result of the comparison of alternatives according to the C2 criterion and its normalized eigenvector is shown in Table VI. The scorings of the alternatives for the other criteria were done and normalized eigenvectors, which are shown in Table VII, were calculated in the same way. As a result of the consistency analysis of all the comparison matrixes, the consistency ratios have been found to be below 0.1.

Lastly, according to the AHP, the normalized eigenvectors obtained by scoring the alternatives according to each criterion were turned into one matrix and this matrix was multiplied by the normalized eigenvector, including weights of the criteria. As a result of this operation, the values for each option are A1=0.29, A2=0.34, A3=0.38.

Table VI

Pairwise comparison matrix of alternatives for the C2 criterion and its normalized eigenvector

C2	A1	A2	A3	Eigenvector
A1	1	1.00	0.33	0.20
A2	1.00	1	0.33	0.20
A3	3.00	3.00	1	0.60

Table VII

Normalized eigenvector obtained from pairwise comparison matrices of the alternatives for the each criterion

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
A1	0.67	0.20	0.12	0.33	0.23	0.45	0.05	0.05	0.14	0.47	0.10	0.12	0.54	0.13
A2	0.17	0.20	0.12	0.33	0.69	0.45	0.47	0.47	0.78	0.47	0.17	0.32	0.16	0.59
A3	0.17	0.60	0.76	0.33	0.08	0.09	0.47	0.47	0.08	0.07	0.72	0.56	0.30	0.28

The alternatives were arranged as A3 > A2 > A1 according to the AHP. This result states that the optimum machine found by the analytical hierarchy process method is the machine in option A3.

Conclusion

Roadheaders have been used extensively in mining operations. Their selection should be made correctly in known rock and project properties. Some serious problems may occur as a result of wrong selections and the production will be affected negatively. In this study, in the selection of excavation machines, the opportunity to use the multiple criteria decision-making methods that have been used extensively in various fields has been researched. We tried to find out the most appropriate roadheader for the Cayirhan Coal Basin by using the analytical hierarchy process, which is one of the multiple criteria decision-making methods.

The multiple criteria decision-making methods can be used in various fields of mining where there are ambiguities in the selection of excavation machines. By using these methods, some conflicting criteria can be evaluated together and scoring can be done by considering the properties of the region and the requisites. Therefore, they are useful in decision-making problems and they also increase effectiveness.

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KEY DATES

Submission of abstracts:
15 September 2006

Acceptance of abstracts:
22 September2006

Submission of final papers:
13 October 2006

TOPICS

Papers are invited on the following topics and any other relevant aspect associated with the handling and remediation of mine waste products and the related impacts on the achievement of mine closure acceptable to the authorities and all other stakeholders.

- Strategic planning
- Scoping, pre-feasibility, feasibility, etc.
- Financial aspects
- Mine design issues
- Processing issues
- Environmental issues
- Remediation and rehabilitation
- Financing and investor related issues
- Regulatory issues
- Safety, health and risk management issues
- Stakeholder challenges

WHO SHOULD ATTEND

The conference will be of value to:

- All stakeholders involved in the environmental sustainability debate
- Mine executives and management
- Metallurgical and processing executives and management
- Environmentalists
- Technology suppliers
- Financiers and investors
- Health, safety and risk management personnel and officials
- Governmental Minerals and Energy personnel
- Research and academic personnel

First Announcement and Call for Papers

The Southern African Institute of Mining and Metallurgy
Founded in 1894

COLLOQUIUM

MINE WASTE DISPOSAL AND ACHIEVEMENT OF MINE CLOSURE—WHAT DOES IT TAKE?

2 NOVEMBER 2006

The South African National Museum of Military History, Saxonwold

BACKGROUND

The disposal of mine waste is one of the most significant impacts of a mine both during and after the active phase of the mine's life. It is becoming increasingly important to design and run mine waste disposal facilities with closure in mind. This is imperative, not only to reduce environmental and social impacts, but also to avoid sterilization of potentially recoverable material in the dump at some future date.

These objectives are difficult to balance and more debate around this subject is urgently required.

OBJECTIVES

Inform and educate mining and other stakeholders of the unavoidable issues in mining and processing in southern Africa related to mine waste disposal and achievement of closure, and:

- to highlight current advances in waste facility design and operation from a closure perspective
- to show case good practice cases from southern Africa
- to emphasize the importance of mine wastes for closure
- to review the achievement of closure and related benchmarks where they exist.

EXHIBITION/SPONSORSHIP

There are several sponsorship opportunities available. Companies wishing to sponsor or exhibit should contact the Conference Co-ordinator.

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