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The Characterization and Classification Studies of Bentonite Mines in IRAN for Application in Drilling and Foundry by AHP Technique

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Abstract

Bentonite is a clay groups which is a very important in todays industry, according to its chemical and physical properties. The most of the consumption of Bentonite in IRAN are in the fields of drilling and foundry. According to the drilling and foundry standards of IRAN, about 25 Bentonite mines have been identified and classified and lastly decided by AHP (Analytical Hierarchy Process) technique. More than 300 tests about the parameters like wetness, swelling, compressive strength, dry strength, pH, methylen blue, gelling index, yield, viscosity, plastic viscosity, filter loss and sieve analysis have been investigated.The Tashtabkhor mine with highest score (19.85) and the Chahkeshmir mine with lowest score (4.523) in drilling and the Boteh gaz mine with highest score (19.37) and the Gol khandan mine with lowest score (5.094)in foundry , were the mines selected amount 25 mines.

INTRODUCTION

The word Bentonite has been used by a scientist called Knight for the first time in 1898. Origin of the word is referred to local name for benthone shale's in state Waioming of America, and generally bentonites are classified as hydrothermal and sedimentary groups. [5]. Other applications for bentonite include forage and mineral flocculation, syrup filtration and purification, fillers, hydrophilic and fat absorbers. United states of America possesses the greatest bentonite resources and active soil deposits and it is the greatest producer and consumer for these minerals and its annual production is more than 2.5 million tons [2]. Greece is the other main bentonite producer in the word but china looks to be the pioneer of bentonite producer in global market and has consumed the targets quantity of bentonite for drilling mud by 37% of total global production, while U.S has the highest consume rate of bentonite in foundry industries by 26% of total bentonite [3]. The occurrence of huge reserves of bentonite deposite has been reported from number places in Iran specially Khorasan which is suituated in eastern of Iran.

Bentonite deposits have been known in six regions which most of them are related to Cenozoic volcanic activities. Making distinction among them. Could be useful in bentonite prospecting. These regions are as followed:

1) Semnan- Torud bentonite zone
2) Alborze – Azerbaijan bentonite zone
3) Eastern Iran bentonite zone
4) Central Iran bentonite zone
5) Tafresh – Takab bentonite zone

In addition to above mentioned zones, there have been recognized in Zagros mountain rang.

In Iran bentonite is mostly used for well drilling and foundry industries and has been known since time immemorial and classified in several varieties and used as detergent and some times as drugs (medicine).

Petroleum exploration in southern parts of Iran generated new utilizations for bentonite in well drilling. Now a day, more than 50% bentonite produced in Iran is used in petroleum industry [2]. About 70 ore deposits and mineral traces of bentonite have been distinguished and specified, of which a few are in use and operation.

CHARACTERISTICS OF BENTONITE IN IRAN

Mineralogy

The main mineral of all bentonits of Iran is Montemorillonite minor mineral such as Crystobalite, zeolite, quartz and calcite are found in most of these bentonites. In a few bentonite deposits of Iran, albite and feldespare are seen.

Geological Age

Crystalline lattice of Montemorillonite is the feature so that argon produced by potassium alteration remains in bentonite rocks. This feature makes it suitable for radiometry dating of that formation which includes bentonite. Since (Ar-k) dating method is not accessible in Iran, necessarily we have to use of volcanic actives for this purpose. Almost all bentonite of the world have been originated from Jurassic to Pleistocene bentonite. With cretaceous age are abundant in USA, Asia and Europe. Any way most bentonite of the word belongs to tertiary period. In Iran, it is not know any bentonite deposit with cretaceous age or earlier and possibly it dose not exist. All bentonite of Iran are younger than cretaceous, as it is seen, bentonite production have depends on volcanic condition of sedimentary basin and lack of metamorphism effluences in the region.

EXPENTMETAL WORK

Importance of distinguishing bentonite features and properties used for drilling has always been considered. With a glance to available data sources, it is clear that there is not any remarkable studying in this field. On the other hand, it would be so useful, if characteristics of bentonite used for drilling and foundry were determined.

Tests carried out in other to determine wetness, swelling,compressive strength,dry strength , pH , methylenblue , gellingindex, yield, viscosity, plastic viscosity,filter loss and sieve analysis. Sieving test is ignorable since sampling has been carried out in form of lumps and sample were pulverized and all tests have been carried out according to available Standard for drilling in Iran National standards INS (revised on 2004 April – no 5857, 5856). There is not a unique standard for this purpose in Iran and all tests have been performed on Iran Khodro Standards Company, the greatest car manufacture in Middle East. It must be noted that most of obtained data. Have been classified by AHP technique for industrial used. The tests have been carried out with the same standard.The results are shown in tables 1 to 19.

HIERARCHICAL ANALYSIS TECHNIQUE

Optimal selection and proper decision making widely influence result of decision-making. One of the most competent decision-making is AHP technique. AHP process changes complicated and difficult problems by analyzing them in from of simplified and solve them. This procedure has much utilizaed in economical and social issues.

This technique was introduced by L-saaty in 1980. It is based on couple comparison and provides investigating various scenarios for decision maker. In appropriate choice my cause irretrievable losses. Hence, it is necessary to apply appropriate technique for correct and optimal decision making. AHP

technique has been applied in order to select the best mine from the drilling and foundry point of view with regard to favorite criteria and current condition [1, 5].

In AHP, elements of each surface are compared dually with relevant element in higher level and their weight will be calculated. These weights are called, relative weight. Then by combination relative weights, final weight of each choice will be determined.

In dual (couple) comparison, personal judgment of decision maker will be used, so if the element "(i) is compared with (j) one says priority of (i) against (j) would be one of following option:

1. Completely more important or favorite
2. Strongly favorite or preferred
3. Severely favorite or preferred
4. More favorite or preferred
5. Same important or preferred

Each option has been considered as digits between (1 - 9). By making tables relevant to dual comparison of each criterion, each weight would be calculated. To achieve this goal through dual comparison matrix, arithmetic average method is used. This method includes following steps:

1) Sum of quantities in each column separately
2) Each element in dual comparison matrix would be divided to total amount of relevant column and normalized dual matrix will be resulted.
3) Average of elements in each row of normalized matrix would be calculated [5]. (Tables3-19)

MINE DATA

Table 1: Information About Bentonite Mines (Foundry)

No	Mine name	Wetness (max 12%)	Compressive strength (min 5 Ib/in^2)	Dry strength (min 22 Ib/in^2)
1	A	7.4	3.27	22.55
2	B	8.69	5.36	13.4
3	C	9.71	6.54	23.17
4	D	7.25	1.99	13.93
5	E	12.88	2.41	14.55
6	F	13.15	2.27	23.65
7	G	7.71	1.13	10.47
8	H	9.2	2.7	26.4
9	I	5.95	2.13	14.47
10	J	9.79	3.83	22.6
11	K	7.49	2.27	27.63
12	L	7.68	2.27	14.22
13	M	9.61	4.55	31.85
14	N	4.44	3.36	38.7
15	O	8.38	4.5	56.8
16	P	9.36	4.98	26.73
17	Q	6.4	4.55	39.91
18	R	3.1	1.56	20.9
19	S	9.88	5.97	46.64
20	T	7.16	6.01	64.98
21	U	6.16	5.02	47.02

Contd...

No	Mine name	Wetness (max 12%)	Compressive strength (min 5 Ib/in^2)	Dry strength (min 22 Ib/in^2)
22	V	7.28	4.2	32.92
23	W	7.81	5.04	33.04
24	X	6.93	4.97	35.33
25	Y	7.26	4.66	29.98

Table 2: Information About Bentonite Mines(Foundry)

pH (8-10)	Swelling (min22)	Methylen blue (min60)
8.9	26	66
8.51	19	60
8.49	22	72
9.63	13	48
9.64	18	60
8.12	10	60
9.98	3	32
8.24	4	14
9.28	14	48
6.9	22	60
9	9	40
9.44	24	68
9.89	25	96
9.79	22	54
9.25	36	84
8.7	17	96
9.77	24	72
8.51	2	14
9.02	23	88
9.21	28	64
8.8	25	52
9	27	66
8.81	26	66
8.79	22	60
8.19	23	72

Table 3: Information About Bentonite Mines (Drilling)

Wetness (max 15%)	Gelling index (max 2millit)	Yield (min16m^3 / ton)	Viscosity (min15cp)	Plastic Viscosity (max15 cp)	Filter loss (max 15millit)	Sieve analysis (max2)
7.4	1	50	32	7	4	0.71
8.69	7	12	14	8	27	5
9.71	1	8	9	5	14	0.71
7.25	23	24	16	4	51	1.42

Contd...

Wetness (max 15%)	Gelling index (max 2millit)	Yield (min16m^3 / ton)	Viscosity (min15cp)	Plastic Viscosity (max15 cp)	Filter loss (max 15millit)	Sieve analysis (max2)
12.88	56	11	10.5	4	17	1.14
13.15	58	2	4	3	44	1.78
7.71	81	1	2	1.5	69	1.78
9.2	90	26	19	6	13	2
5.95	0.5	21	14.5	4	15	1.92
9.79	0.5	2	4	3	14	2
7.49	59	18	15	6	50	2
7.68	0.5	13	11.5	5	13	1.78
9.61	0.5	33	25.5	9	8	1.14
4.44	31	6	6	3	35	1.14
8.38	0.5	GELUP	GELUP	GELUP	1	0.71
9.36	0.5	26	19	6	31	3
6.4	1.5	22	15	4	30	4.64
3.1	89	2	3	2	70	2
9.88	1.5	24	20	8	14.5	2.21
7.16	1.5	37	28.5	10	10	2.35
6.16	19	6	5	2	71	1.14
7.28	1	20	15	5	17	1.78
7.81	1	21	16.5	6	14	2.85
6.93	0.5	21	15.5	5	7	2.07
7.26	1.5	22	21	5	9	1.4

Table 4: Couple Comparative Matrix of Standards for Bentonite (Foundry)

	Compressive strength	Dry strength	Swelling	pH	Methylen blue	Wetness
Compressive strength	1	8	7	5	5	2
Dry strength	.125	1	2	4	4	7
Swelling	.142	.875	1	3	3	6
pH	.2	.625	.714	1	1	3
Methylen blue	.2	.625	.714	1	1	3
Wetness	.5	.25	.285	.4	.4	1
Sum of columns	2.167	11.375	11.713	14.4	14.4	22

Table 5: Calculation of Standards Weight for Bentonite (Foundry)

	Compressive strength	Dry strength	Swelling	pH	Methylen blue	Wetness	Average of Rows
Compressive strength	.461	.703	.597	.35	.35	.091	.425
Dry strength	.057	.088	.171	.277	.277	.318	.198
Swelling	.065	.077	.085	.208	.208	.272	.152
pH	.093	.055	.061	.069	.069	.137	.081
Methylen blue	.093	.055	.061	.069	.069	.137	.081
Wetness	.23	.022	.025	.027	.027	.045	.063
Sum of columns	1	1	1	1	1	1	1

Table 6: Table for Insertion of the Grades Concerning Compressive Strength

Compressive strength	1-2.2	2.2-3.4	3.4-4.6	4.6-5.8	5.8-7
Score	1	5	10	15	20

Table 7: Table for Insertion of the Grades Concerning Dry Strength

Dry strength	10-15	15-20	20-25	25-35	35<
Score	1	5	10	15	20

Table 8: Table for Insertion of the Grades Concerning Ph

pH	6.5-7	7-7.5	7.5-8	8-9	9-10
Score	1	5	10	15	20

Table 9: Table for Insertion of the Grades Concerning Swelling

Swelling	<10	10-15	15-22	>25	22-25
Score	1	5	10	15	20

Table 10: Table for Insertion of the Grades Concerning Methylen Blue

Methylen blue	10-30	30-40	40-50	50-60	>60
Score	1	5	10	15	20

Table 11: Table for Insertion of the Grades Concerning Wetness Rate

Wetness Rate	>12	10-12	8-10	6-8	<6
Score	1	5	10	15	20

Table 12: Couple Comparative Matrix of Standards for Bentonite (Drilling)

	Yield	Viscosity	Plastic Viscosity	Filter loss	Sieve analysis	Gelling index	Wetness
Yield	1	8	8	6	5	5	2
Viscosity	.125	1	1	3	4	4	6
Plastic Viscosity	.125	1	1	3	4	4	6
Filter loss	.166	.75	.75	1	2	2	5
Sieve analysis	.2	.625	.625	.833	1	1	3
Gelling index	.2	.625	.625	.833	1	1	3
Wetness	.5	.25	.25	.333	.4	.4	1
Sum of columns	2.316	12.25	12.25	14.999	17.4	17.4	26

Table 13: Calculation of Standards Weight for Bentonite (Drilling)

	Yield	Viscosity	Plastic Viscosity	Filter loss	Sieve analysis	Gelling index	Wetness	Average of Rows
Yield	.431	.653	.653	.4	.287	.287	.076	.398
Viscosity	.054	.081	.081	.2	.23	.23	.231	.158
Plastic Viscosity	.054	.081	.081	.2	.23	.23	.231	.158
Filter loss	.071	.062	.062	.066	.115	.115	.192	.097
Sieve analysis	.087	.051	.051	.055	.058	.058	.116	.069
Gelling index	.087	.051	.051	.055	.058	.058	.116	.069
Wetness	.0216	.021	.021	.022	.022	.022	.038	.051
Sum of columns	1	1	1	1	1	1	1	1

Table 14: Table for Insertion of the Grades Concerning Yield

Yield	1-10	10-15	15-25	25-35	>35
Score	1	5	10	15	20

Table 15: Table for Insertion of the Grades Concerning Viscosity

Viscosity	1-5	5-15	15-20	20-25	>25
Score	1	5	10	15	20

Table 16: Table for Insertion of the Grades Concerning Plastic Viscosity

Plastic Viscosity	9-10	8-9	6-8	3-6	<3
Score	1	5	10	15	20

Table 17: Table for Insertion of the Grades Concerning Filter Loss

Filter loss	>40	30-40	20-30	10-20	1-10
Score	1	5	10	15	20

Table 18: Table for Insertion of the Grades Concerning Sieve Analysis

Sieve analysis	>5	4-5	3-4	2-3	<2
Score	1	5	10	15	20

Table 19: Table for Insertion of the Grades Concerning Gelling Index

Gelling index	>48	24-48	12-24	2-12	<2
Score	1	5	10	15	20

Table 20: Table for Insertion of the Grades Concerning Wetness Rate

Wetness Rate	>12	10-12	8-10	6-8	<6
Score	1	5	10	15	20

CALCULATION OF FINAL SCORE

Table 21: Final Score (Mine A)

Mine A	Compressive strength Ib/in^2	Dry strength Ib/in^2	pH	Swelling millit	Methylen blue millit	Wetness %	Yield m^3/ton	Viscosity cp	Plastic Viscosity cp	Filter loss millit	Sieve analysis	Gelling index millit
Results	3.27	22.55	8.9	26	66	7.4	50	22	7	4	.71	1
Score	5	10	15	15	20	15	20	20	10	20	20	20

Final score for foundry = 5* 0.425+10*0.198+15*0.152+15*0.081+20*0.081+15*0.063=10.165

Final score for drilling=20*0.398+20*0.158+10*0.158+20*0.097+20*0.069+20*0.069+15*0.051=18.165

Table 22: Final Score

Mine name	Final score (foundry)	Final score (drilling)
A	10.165	18.165
B	11.508	7.22
C	15.82	8.283
D	5.823	10.862
E	7.451	8.105
F	8.068	4.523

Contd....

Mine name	Final score (foundry)	Final score (drilling)
G	5.094	6.027
H	7.177	12.989
I	6.138	12.375
J	9.037	7.306
K	8.806	9.106
L	9.548	10.13
M	14.13	15.13
N	13.22	6.788
O	14.715	19.85
P	14.685	12.22
Q	15.435	10.6
R	6.107	5.937
S	19.37	11.52
T	19.28	16.398
U	16.395	6.648
V	13.28	12.48
W	15.405	12.565
X	16.295	12.705
Y	15.81	16.175

RESULTS

Bentonite has various types and fortunately most of them exist in Iran and identified Bentonite deposits are relatively abundant but most of them are not active and applicable. bentonite mines of Iran have a good potential and must be exploited. In this research, by determining properties of bentonite used for drilling and foundry industries, we would be able to provide required bentonite in this field.

By classification and tests carried out in Tashtabkhor and Chahkeshmir mines in the field of drilling they received 19.85 and 4.523 score as highest and lowest, respectively and in the field of foundry industry, Bute gaz and Golkhandan mines received 19.37 and 5.094 score as highest and lowest, respectively. Some of the mines are able to select optimum choice easily and or by mixing several type of bentonite.

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APPENDIX

	MINE NAME
A	SANGAB MARKHOR
B	HOZE HAFEZ
C	KOH SEFID
D	PARCHEEN
E	SHIR GESHT
F	CHAH KESHMIR
G	GOL KHANDAN
H	GAVIJ
I	ASHKAFTOOK
J	GEERIMONEG
K	ALAKCHI
L	KHOR
M	MEHRGAN
N	ZARIN
O	TASHTAB KHOR
P	SHARGH TOROOD
Q	NAGHAREH KHANEH
R	BOROON FERDOS
S	BOTEHGAZ
T	GOLESTAN
U	KABOTAR KOH
V	CHAHKAM1
W	CHAHKAM2
X	GELKAN
Y	RASHM SAR KAVIR