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Engineering Geological Characteristics of Carbonate building stones in southwest of Yazd

T. Mirjalili [1], M. Khamehchiyan* [2], M.R. Nikudel [3]

Abstract

Understanding the engineering properties of decorative building stones is of particular importance. In this regard, engineering geological features and scoring of carbonate rocks of mines southwest of yazd were performed in this research. after identifying the mines related to carbonate rocks in the southwest of Yazd, sampling was performed at the mine site and after packing, it was transferred to the laboratory. From three places to Quaternary age (travertine and onyx), from three places to Oligomocene age (Abarkooh marble) and from three places to Cretaceous age (Sangchini, crystal marble and black limestone) from each point 3 blocks A stone with approximate dimensions of 20 × 30 × 20 cm was prepared. Figure 2 shows the sampling sites. In order to evaluate the lithological, physical, strength and durability properties of the studied rocks, various laboratory experiments were performed. Then, according to the results of the experiments, the stones were scored based on the engineering properties of the stone. In terms of the highest score, Sangchini(90%), Black limestone(85%), Abarkooh marble(78%), Onix(69%), Hojjatabad travertine(53%), Turan Posht travertine(53%) and finally crystal marble(52%) had the lowest score, respectively.

Keywords: *Carbonate building Stones, Engineering Geology Characteristics, Southwest of Yazd .*

1. Master graduate, Department of Engineering Gology, Tarbiat Modares University.
2. Professor, Department of Engineering Gology, Tarbiat Modares University, khamechm@modares.ac.ir
3. Associate Professor, Department of Engineering Geology, Tarbiat Modares University.

*** Corresponding Author**

Extended Abstract:

1. Material and methods

Building stones are used as stone materials due to their very useful properties in the architecture and facade of buildings in urban areas. Carbonate building stone refers to a rock that more than 50% of it is composed of carbonate minerals. In this research, after selecting 5 mines related to carbonate rocks in the southwest of Yazd, sampling was performed at the mines sites and transferred to the laboratory. The geographical location of the sampling site is shown in Fig. 1, also the characteristics of samples and mines are presented in Table1.

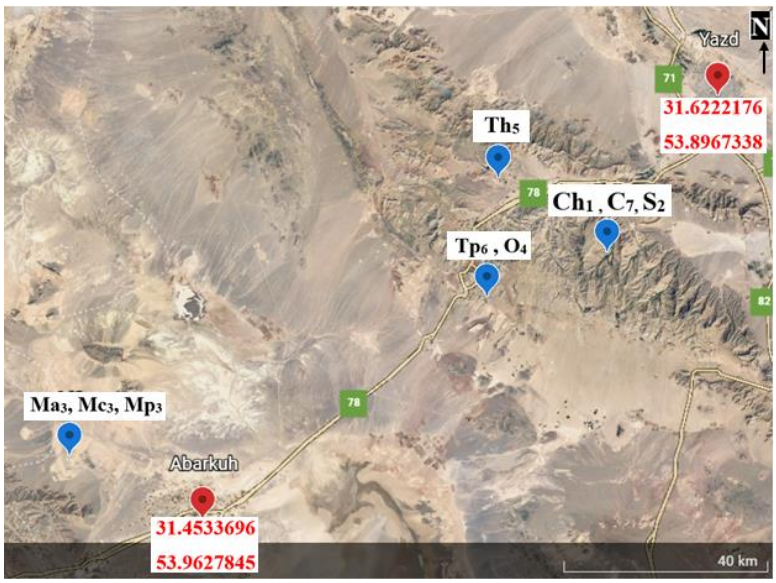

Figure 1: Location of the studied mines in the southwest of Yazd.

Table1: Mines and sample characteristics of the studied rocks in the southwest of yazd.

Name of mine	Name of brand	Age, Stone category and Mineralogical composition
Dehbala mine	Sangchini (Ch_1)	Cretaceous age -Metamorphosis Calcium carbonate
	crystal marble (C_7)	Cretaceous age -Metamorphosis Calcium carbonate
Ashnaei mine	black limestone (S_2) has two types of deigns included: simple and fossilized	Cretaceous age -Sediment Calcium carbonate
Abarkooh marble mine	Marble has 3 types of colors included :marble Parkahoei (Mp_3) - marble kerm (Mc_3) – Canary marble(Ma_3)	Oligomocene age - Sediment Calcium carbonate
Hojjatabad mine	Hojjatabad travertine (Th_5)	Quaternary age- Sediment - Calcium carbonate
Turan Posht mine	Turan Posht travertine (Tp_6)	Quaternary age- Sediment - Calcium carbonate
	Turan Posht Enix (O_4)	Quaternary age- Sediment - Calcium carbonate

In order to evaluate the lithological, physical, strength and durability properties of the studied rocks, various laboratory tests were performed and the results were compared. Experiments performed include: lithological properties, physical properties tests (including dry density, saturation density, water content, porosity), wave velocity test, point load index, Brazilian strength, Uniaxial compressive strength, impact value, compressive value, slake durability index in sulfuric acid solution and carbonic acid solution in 15 cycles with the same pH, rock soundness test with sodium sulfate in 15 cycles and freezing- thaw test in 90 cycles. Number of tests, samples and standard related to each test are presented in Table2.

Table 2: Number of tests, number of samples and standard related to each test.

Test	Sample shape	Number of samples tested	Test standard
Physical properties	Irregular	Each sample - 5 pieces	ASTM D5446 – 08
compressional Wave test	Cylindrical	Each sample - 3 tests	ASTM D2845-00
point load index	Cylindrical	Each sample -4 tests	ASTM D5731-ISRM
Uniaxial compressive strength	Cylindrical	Each sample - 3 tests	ASTM D2938 – ISRM
Brazilian strength	Disc	Each sample - 3 tests	ASTM D3967
the Slake durability index of the solution in sulfuric acid in 15 cycles with pH=5.25	Irregular shape	Each sample - 10 pieces	ASTM D4644 – 08 – ISRM
the Slake durability index of the solution in carbonic acid in 15 cycles with pH=5.25	Irregular shape	Each sample - 10 pieces	ASTM D4644 – 08 – ISRM
Impact value	Irregular shape	Each sample - 1 test	IS 2386
Crushing strength	Irregular shape	Each sample - 1 test	ISRM – ASTM D2938
Micropetrographic description	Thin sections	Each sample – 1section	-

rock soundness test with sodium sulfate in 15 cycles	Irregular shape	Each sample - 10 pieces	ASTM C88
freezing- thaw test in 90 cycles	Irregular shape	Each sample - 4 pieces	-

2. Results and Discussion

Scoring *of carbonate rocks southwest of Yazd*

In this research, many experiments in the field of physical properties, strength, mechanical and durability have been performed and the results have been examined. The percentage of water absorption is used for the physical characteristics of the stone. In this research, the percentage of water absorption has a direct relationship with the percentage of porosity, which in turn affects other tests such as physical characteristics, wave speed, and durability. As the porosity increases, the wave velocity decreases, which is the trend in all samples. Except for marble and onyx (due to the microscopic structure of the stone), it has been observed. The low wave velocity can be in Onyx due to the presence of needle-shaped aragonite crystals that are layered and repeated in the stone, and in crystal marble due to loose coarse crystals having 3 directions cleavage. For the strength and mechanical tests of stone, due to the lack of repetition and consistency of the results of the resistance tests (uniaxial test and tensile strength) with the test of impact value and compressive value, these two tests have not been used for scoring.

To test the durability of the rock, the slake durability test in acidic solution, the rock soundnes test and the freezing-thaw test were used. Considering that calcium carbonate is the main mineral that makes up the studied carbonate samples and carbonate rocks in contrast to chemical agents, they have a high susceptibility to corrosion and solubility. The slake durability test, which shows the largest decrease in the durability index, has been used to score the durability of carbonate rocks.

The scoring basis is based on the stone selection regulations for breakwaters and hydraulic structures, but Table 1 suggests that the effect of unit volume weight shows itself in durability. For building stones, the importance of durability and strength is greater than the density. As the percentage of water absorption increases, the durability decreases at the same time, so rocks with less water absorption are more important. In this research, the engineering characteristics of stone were scored based on the degree of importance in Tables 3 and 4, and then the scoring results of each stone were determined in Table 5.

Table 3: Scoring of stones based on engineering characteristics (Mirjalili, 2014).

Engineering Characteristics	**Description**	**Excellent**	**Good**	**Medium**	**Weak**
Water content (%)	Range	0-2	2-3	3-5	More than 5
	Score	25	20	15	10
Unit weight volume (kN/m3)	Range	More than 24	22-24	18-22	Less than 18
	Score	15	10	5	3
Compressive strenght (MPa)	Range	More than 50	40-50	30-40	Less than 30
	Score	20	15	10	4
Tensile strength (MPa)	Range	More than 20	15-20	10-15	Less than 10
	Score	20	15	10	4
Durability (%)	Range	Less than 1%	%1-%2	%2-%3	More than 3%
	Score	20	15	10	4

Table 4: Classification of stones based on the sum of scores from Table 4.

Total score	75-100	50-75	25-50	0-25
Description	Excellent	Good	Medium	Weak

Table 5: Scoring results of carbonate rocks southwest of Yazd.

Stone number and symbol	The name of the stone	Water content (%)	Unit weight volume (kN/m3)	Compressive strenght (MPa)	Tensile strength (MPa)	Durability (%)	Total score	Description
Ch_1	Sangchini Dehbala	25	15	20	15	15	90	Excellent
S_2	Ashenaei Black limestone	25	15	20	10	15	85	Excellent
Ma_3	Abarkooh marble (Abanary)	25	15	10	10	15	75	Good
Mc_3	Abarkooh marble (kerm)	25	15	15	10	15	80	Excellent
Mp_3	Abarkooh marble (Parkahoei)	25	15	20	10	10	80	Excellent
O_4	Turan Posht Enix	25	15	15	4	10	69	Good
Th_5	Hojjatabad travertine	20	15	10	4	4	53	Good
Tp_6	Turan Posht travertine	20	15	10	4	4	53	Good
C_7	Dehbala crystal marble	25	15	4	4	4	52	Good

3. Conclusions

Based on lithological studies of carbonate rocks in the mines southwest of Yazd, Dehbala (Cretaceous age) Sangchini with fine calcite crystals and Dehbala (Cretaceous age) marble with large crystals of about 2 to 5 mm, both of which the texture of the lime is crystalline and metamorphic. Dehbala black limestone (Cretaceous age) and Abarkooh marble (oligomycene age) are composed of chemical and biochemical texture in marine conditions and have stylolite joints. Also, three types of sedimentary limestone (Quaternary age) have chemical texture including Hojjatabad travertine and Turan Posht travertine have calcite crystals and high porosity, but Turan Posht travertine has aragonite needle crystals and has no porosity.

In fracture durability test, the results showed that Sangchini, black lime and Abarkooh marbles are the most suitable stones for use in areas with polluted atmosphere compared to crystal marble and travertines. The results obtained from resistance tests show that in terms of strength, the carbonate stones of this study are porcelain, black lime and then marble with the highest strength and other stones such as onyx, Hojjatabad travertine and Turan back travertine and finally crystal marble show the lowest strength. It can be said that the presence of physical properties (cavities, pores and structure) control the strength properties of rocks.

With considering the results of the tests for engineering propreties, the rocks were scored based on the degree of importance. In terms of highest scores, respectively, Sangchini (Ch1=90%), black limestone (S2=85%), Abarkooh marble (M3=78%), Enix (O4=69%), Hojjatabad travertine (Th5=53%), Turan Posht travertine (Tp6=53%) and finally crystal marble (C7=52%) recived the lowest score.