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Investigation of the effect of mineralogy and physicomechanical properties of source rock on compressive strength of concrete

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Abstract

Mineralogy and physical and mechanical properties of rocks used in the production of aggregates are one of the most important parameters for deciding on the method of their use for various engineering purposes. Concrete is one of the products produced in the construction industry that has the highest consumption of stone in the form of sand gravel materials in its building. In this paper, the effect of mineralogy as well as physicomechanical properties of aggregate on compressive strength of concrete with C25 strength class has been investigated. The source rocks of the studied aggregates are intrusive masses with andesite and basalt composition and crystallized limestone and dolomite that are exposed in the east of Ardabil (Iran). In order to conduct research, 20 samples of active sand mines and workshops in the area were harvested and physical and mechanical tests, lithography and mineralogy were performed. Then, the ratio of concrete components according to ACI-211-1.91 regulations was determined so that in all designs, the ratio of water to cement is kept constant and no additives are used. To analyze the results, the rock masses of the region were divided into four categories based on the material and mineralogical composition and the effect of their physicomechanical properties on the strength of concrete in each category was investigated separately. The results show that the strength of concrete made with andesitic rock mass (class II) has the highest value and class IV (dolomitic rock mass) has the lowest value. Also, Concrete made of limestone (grade III) offers a wide range of strength depending on different mineralogical and physico-mechanical properties.

Keywords: *Rock, Concrete, physicomechanical, Mineralogy*

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Extend Abstract

1. Introduction

Concrete of three parts; Water, cement and aggregates are formed and are the most widely used man-made material and its main part is aggregate, which accounts for about 70 to 75% of the concrete structure (Li et al., 2018, Bismark et al., 2018) and in fact how fine and coarse aggregates are mixed will have a significant impact on the economy and quality of concrete (Amritkar et al., 2015). Physico-mechanical properties of aggregates to lithological properties such as; The mineralogical composition, texture, size, shape and geological characteristics of engineering (density, water absorption, durability, strength) of the source rock depend. The choice of the type of aggregates for concrete is the main factor affecting the quality of concrete. So that in case of preparing concrete mixtures with one type of cement and with the same water to cement ratio (W / C), the use of different aggregates that are separated in terms of mineralogical composition and physico-mechanical properties leads to To different compressive strengths in concrete (Petrounias et al., 2018, Yilmaz and Turul, 2012). In this study, in order to investigate the effect of mineralogy and engineering characteristics of source rock on compressive strength of concrete, four mines in Namin-Ardabil region were selected and sampled from source rock and their aggregates and mineralogical tests (including XRF, XRD and Microscopic sectioning and interpretation (including core strength, density, porosity, water absorption, Los Angeles abrasion, and materials smaller than 75 microns) were performed on them. Then concrete samples were prepared in 15 × 15 × 15 cm cubic molds in the laboratory so that the W / C ratio was kept constant in all designs. Then, the test for determining the compressive strength of concrete was performed and the results of the tests were analyzed through correlation relations. In Ardabil province, especially Ardabil city, despite the many problems that rock resources have compared to mountain and river resources, the lack of river and mountain sand resources has caused producers to turn to stone mines. The purpose of this study is to investigate the engineering geological properties of aggregates produced from igneous and sedimentary rocks that are widely used in the region to prepare concrete. The results of this study show the effect of mineralogical composition and physico-mechanical properties of aggregates on the compressive strength of concrete.

2. Materials and methods

20 samples of crushed aggregates that were prepared from 4 mines with different lithology were used to make concrete samples (Table 1). Ardabil Cement Factory was used to prepare Portland cement and Ardabil city water was used to mix the materials. The pH of water is 7.12 and the specific gravity of cement is 3.15. The American Concrete Association Bylaws (ACI-211.1-91, 2002) were used to prepare the concrete mixing plan. For this purpose, 20 samples of ordinary concrete cubes with dimensions of 15 × 15 × 15 cm were made from 20 different types of granulated materials. In all designs, the water to cement ratio is equal to 0.61 and the target slump is equal to 75 mm and the characteristic 28-day strength of the cylindrical sample is equal to 25 MPa. And the ratio of concrete components in terms of mass of cement, aggregate and water is equal to 1.0:5.92:0.61.

3. Results

The results of physicomechanical tests of aggregates and source rock masses show that there is a wide variety in terms of engineering characteristics in the collected samples so that four groups of aggregate source rocks have been identified(Table 1).

Table 1. Results of physicomechanical tests of rock and aggregate samples

Passing #200(%)	Losangelos (%)	Compressive Strength MPa	Porosity (%)	Water Absorption 24h(%)	Natural Density gr/cm^3	Macroscopic description	Sample No.	Rock Group
1.2	9	98.3	0.23	0.35	2.64		A1	
1.6	11	97.5	0.25	0.40	2.64		A2	
1.4	10	88.2	0.32	0.51	2.63	Basalt	A3	I
0.7	14	91.3	0.26	0.4	2.60		A4	
1.5	13	85.4	0.37	0.54	2.65		A5	
0.8	11.5	119.4	0.44	0.58	2.69		H1	
1.9	10.5	117.5	0.45	0.60	2.67		H2	
1.1	11	123.6	0.40	0.50	2.66	Andesite	H3	II
0.6	10.5	131.7	0.39	0.50	2.68		H4	
1.3	11	121.8	0.41	0.50	2.67		H5	
4.7	16	76.5	0.59	0.74	2.65		G1	
5.2	16	73.9	0.55	0.66	2.69		G2	
6.3	15	64.8	0.54	0.65	2.68	Limestone	G3	III
4.5	14	87.4	0.57	0.68	2.67		G4	
5.0	15	83.2	0.54	0.63	2.66		G5	
6.2	15	46.8	0.70	1.02	2.61		K1	
5.8	24	48.7	0.75	1.91	2.60		K2	
5.8	21	48.6	0.73	1.06	2.62	Dolomite	K3	IV
6.4	17	45.7	0.84	1.09	2.65		K4	
5.5	16	46.4	0.74	1.07	2.64		K5	

The results of XRD analysis for rock samples in the region show that according to these results, there are large amounts of carbonate (CaCO3) in sedimentary rock samples and large amounts of silica (SiO2) in igneous rock samples(Table 2).

Table 2. Petrographic characteristics of the studied aggregates

Rock Group	Sample No.	Lithology	Main Mineral	Sub-Mineral
I	A1,A2,A3,A4,A5	Basalt	Cpx,Plg,Ol	Aug,Opq,dis
II	H1,H2,H3,H4,H5	Andesite	Cpx,hbl,Plg	Bio,ser,dis
III	G1,G2,G3,G4,G5	Limestone	Ca	Qz,opq
IV	K1,K2,K3,K4,K5	Dolomite	Dol,Ca	Qz,opq

Cpx=Clinopyroxene, plg=Plagioclase, Ol-Olivine, hbl=Hornblende, bio=biotite, Aug=Augite, opq=Opaque, dis=diopside, cal=Calsite, dol=Dolomite, qz=Quartz, ser=Sericite

The results of compressive strength of concrete made from groups I to IV, showed that their initial classification in groups was done correctly. The lowest values of compressive strength of concrete samples were obtained from the samples made with group IV aggregates. The average compressive strength of concrete samples in this group is about 15.9 MPa and the highest value of resistance is related to group II samples with an average strength of 27.6 Mpa(Table 3).

Table 3. The results of compressive strength test of concrete (MPa) made of the source rock studied

IV	III	II	I
Dolomite	**Limestone**	**Andesitic**	**Basalt**
17.4	22.6	27.8	26.6
14.8	21.1	26.4	25.9
15.2	17.8	27.2	26.0
15.8	19.4	28.6	25.5
16.3	20.7	28.1	25.1
15.9	**20.3**	**27.6**	**25.8**

4. Conclusion

Studies show that concrete made with Group II stones has a high compressive strength compared to other groups and this is due to the good adhesion of cement paste and aggregate which is affected by the presence of resistant minerals such as amphibole, biotite and plagioclase. Because these minerals are crystallized in the Bowen reaction series at low temperatures, they have a high resistance to weathering and erosion. Also, the amount of material smaller than 75 microns in the aggregates of this group is relatively low and the rock core resistance is high. Concrete made with Group IV stones also shows less resistance than other groups due to the presence of calcite mineral and excess fine grain percentage as well as low density and high porosity of the rock. In general, it can be said that the aggregates produced from limestone and dolomite mines due to the presence of carbonate-type fine materials in the rock field and since the percentage of materials smaller than 75 microns is more than other groups and also due to high water absorption, It causes real aggregation of aggregate during drying, which results in a reduction in the compressive strength of hardened concrete.

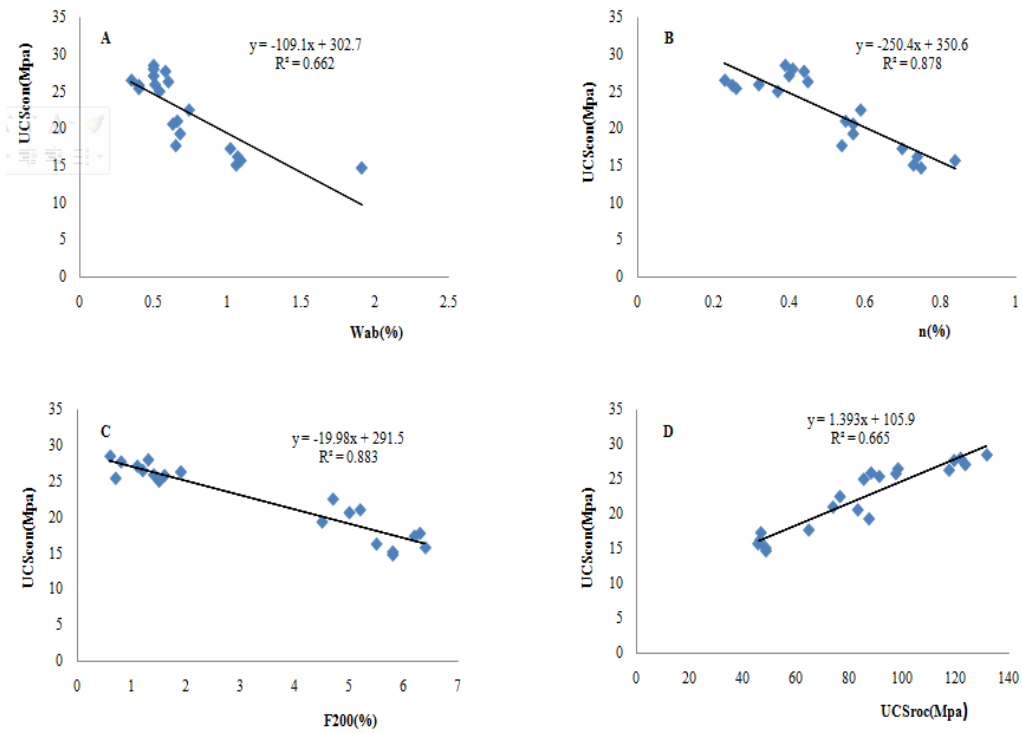

Figure 1. (**A**) Percentage of water mass absorption of rock mass(W_{ab}) against compressive strength of concrete(UCScon), (**B**) Porosity of rock mass(n) against compressive strength of concrete, (**C**) Percentage of materials smaller than 75 microns of aggregates(F_{200}) against the compressive strength of concrete, (**D**) Uniaxial compressive strength of rock mass against compressive strength of concrete

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