



# Effect of basalt aggregates and plasticizer on the compressive strength of concrete

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## Abstract

The purpose of this research is to investigate the feasibility of using basalt aggregates and plasticizers in concrete mixes. An elaborate experimental program that included a variation of plasticizer and basalt in concrete mixes. The laboratory investigation included measurements of sieve analysis, compressive strength, and slump test. The compressive test was evaluated at 7, 14, 28 days of curing time. The results show significant improvement in concrete strength up to 2% of additive plasticizer after that concrete strength was reduced.

**Keywords:** Basalt Mix; Concrete; Compressive Strength; Jordan.

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## 1. Introduction

Concrete is basic elements that used in different types of construction. Also concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle. These disadvantages make concrete limited to use in certain conditions. The most common problems appear on concrete are manifested by bleeding, cracking, and corrosion. There are several chemical and natural additives could be added to concrete mixes to improve its properties [1, 2, 3].

Basalt stone is emerging as an efficient additive to concrete to enhance the properties of concrete, which is demonstrated in reduction in cracking, increase in the hardness of the concrete. The goal of this research is to assess the impact of addition of basalt on compressive and tensile strength and early and late cracking. To achieve our goals a laboratory experiment plan is designed and implemented at the concrete laboratory at Zarqa University over last five months. The research plan included preparation and testing of 60 concrete test samples. Several basalt addition ratios are considered. The basalt combinations are (0.5%, 1%, 2%, 3% and 4%). A commercial super plasticizer composed of basalt (SP6RR) is used here.

## 2. Materials

### 2.1. Aggregates

Properties of aggregates used in cement mix affect the performance of the mix strongly. Aggregates compose up to 75% of the mixed concrete.

Aggregate physical, thermal, chemical properties would improve volume stability and durability of concrete as compared to those of cement. In good quality concrete two separate lots are used: coarse and fine aggregate [4]. Coarse Aggregate is that portion of an aggregate retained on the 4.75mm (No.4) sieve. That portion of an aggregate passing the 4.75mm (No.4) sieve and retained on the 75µm (No.200) sieve is called fine aggregate [5]. Figure (1.4) shows aggregate that we used:

## 2.2. Basalt

Jordan is fortunate to have an excellent supply of raw basalt rock and has factories that dry, crush and screen the basalt rock into various grades for a number of industrial uses in Jordan. Basalt can be used in manufacturing and made into fine, superfine and ultra-fine fibers. [5].

Basalt is a hard, dense, dark volcanic rock composed chiefly of plagioclase, pyroxene, and olivine, and often having a glassy appearance. Basalt has various attractive properties like High thermal conductivity, inert with no environmental risks, High E modulus resulting in excellent specific tenacity three times that of steel fiber, High-tensile strength, Resistant to acids and aggressive chemicals, Electro-magnetic resistant, and Good fatigue resistance.

Basalt is a magnesium-rich primitive rock containing also Silicon, Iron & Calcium & Trace minerals. It is a natural product, environmentally friendly with no elutriation/leaching into ground water. It is also non-toxic & safe to aquatic animals and plant-life.



**Fig. 1:** Basalt Types Used in the Study.

**Table 1:** Basalt Powder Chemical Analysis Using Method SOP.NO. 131M02-007 [3].

Method of Test	Chemical Components	Percentage by Mass
SOP.No.131M02-007	SiO <sub>2</sub>	48.84 %
	Al <sub>2</sub> O <sub>3</sub>	15.52 %
	Fe <sub>2</sub> O <sub>3</sub>	10.38 %
	TiO <sub>2</sub>	1.66 %
	P <sub>2</sub> O <sub>5</sub>	0.37 %
	CaO	9.52 %
	MgO	6.60 %
	Na <sub>2</sub> O	3.95 %
	K <sub>2</sub> O	1.01 %
BS EN 196-2:2005	L.O.I	1.15 %

## 3. Methods and experimental measurements

There are several tests performed on coarse and fine aggregates.

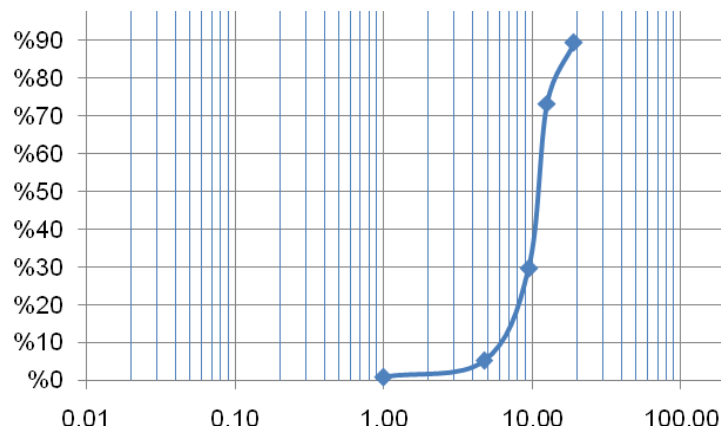
### 3.1. Tests on coarse aggregate

#### Sieve analysis

Grain size distribution according to ASTM C 136-01a standard test method for Sieve analysis of fine and coarse aggregates [6]. Table 2.1 shows grading of coarse aggregate.

**Table 2:** Grading of Coarse Aggregate

Opining size(mm)	Ret. (gm)	Cumulative ret.(gm)	Percent of cum. ret. %	Percent of cum. Pass %
19	213	213	10.65	89.35%
12.5	322	535	26.75	73.25%
9.5	873	1408	70.40	29.60%
4.75	488	1896	94.80	5.2%
Pan weight	104	2000	2000	0%



**Fig. 2:** Grain Size Distribution for Coarse Grains.

#### Physical Properties

According to ASTM C127-88, Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate [7]. Tables 3 show our result of weights and specific gravities of coarse aggregate.

**Table 3:** Physical Properties of Coarse Aggregate (Specific Gravity and Water Absorption).

Physical Property	Result
Apparent specific Gravity	2.77
Bulk specific gravity	2.66
Water absorption	1.62%

#### Determination of Aggregate Impact Value (AIV)

Aggregate impact values is evaluated as shown in figure 3.



**Fig. 3:** Test Procedure for Aggregate Impact Value.

The impact value for two was estimated in the laboratory and found to be 13.64%.

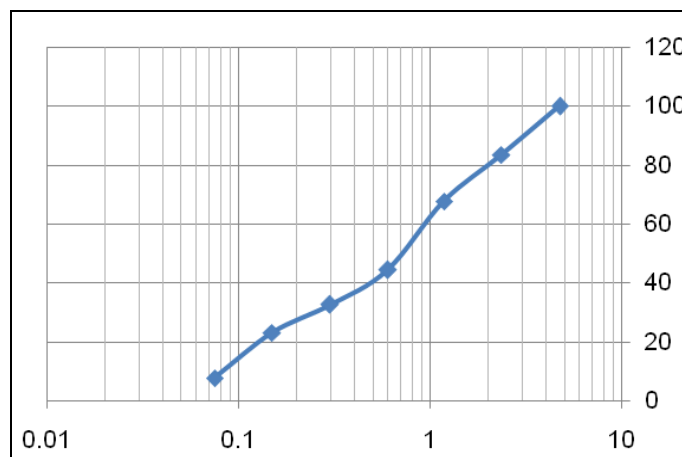
Tests on fine Aggregate

Sieve analysis

According to ASTM C 136-01a, standard test method for Sieve analysis of fine and coarse aggregates. Table 4 shows grading of fine aggregate. Note that the sieve analysis was made for one source of sand (Silica sand).

**Table 4:** Grading of Fine Aggregate.

Sieve No.	Opining size (mm)	Ret. (gm)	Cumulative ret. (gm)	Percent of cum. ret. %	Percent of cum. Pass %
4	4.75	-	0	0	100
8	2.36	331	331	16.55	83.45
16	1.18	314	645	32.25	67.75
30	0.600	467	1112	55.60	44.40
50	0.300	236	1348	67.40	32.60
100	0.150	191	1539	76.95	23.05
200	0.075	307	1846	92.30	7.7
Pan		154	2000	100	0



**Fig. 4:** Grain Size Distribution for Fine Grains.

#### 4. Production of concrete

Concrete was poured into cubes and cylinders in three layers with compact each layer by 25 times for testing the hardened concrete properties. After casting, the concrete specimens were kept in the laboratory at room temperature for 24 hours. After that, they were placed in the water bath until the time of testing. Curing was performed in accordance with the ASTM C511 standard [8].



**Fig. 5:** Concrete Cubes Stored in Water.

Mixtures without and with super plasticizer

Class A mix

In this class, the concrete mixes proportions are (1 cement: 1.5 sand: 3 basalt).

**Table 5:** Component Weights for 1m<sup>3</sup> of Class A Concrete.

Types of materials	calculations	Weight ( $kg/m^3$ )
Coarse sand	$2 kg / 0.001 m^3$	2000
Cement	$1 kg / 0.001 m^3$	1000
Water	Water content (lit/m <sup>3</sup> ) 0.50 lit / 0.001 m <sup>3</sup>	500
W/C	500 / 1000	0.50

#### Class B mix

In this class, the concrete mix proportions are 1 cement: 1.5 sand: 3 basalt. And super plasticizer (SP6RR) was added to Mix B at the following weight percentages 0.5, 1.00, 2.00, 3.00 and 4, 00 %.

The aggregates were divided into coarse and sand (2 kg for coarse, 1 for sand). Table 6 show components weights for one cubic meter of concrete.

**Table 6:** Component Weights for 1m<sup>3</sup> of Class B Concrete

Types of materials	Calculations	Weight ( $kg/m^3$ )
Coarse sand	$2 kg / 0.001 m^3$	2000
Cement	$1 kg / 0.001 m^3$	1000
Water content (lit/m <sup>3</sup> )		
Water	0.45- 0.3 lit / 0.001 m <sup>3</sup>	450 - 300
W/C	(450-300) / 1000	0.45 – 0.30

#### Slump test

Slump test was conducted to assess the workability of the mix. This test has been presented and the result shown in table 7 for each class (According to ASTM [9] Designation: C 496 – 96 Test for slump of Portland cement concrete).

**Table 7:** Slump Test Results

Mix class	Slump (cm)
A	6.5
B	6.2

## 5. Results and discussion

The properties of hardened concrete can be significantly improved by basalt and (SP6RR). The compressive strength of concrete is the major way to describe the properties of hardened concrete as compressive and tensile strength. Strength usually gives an overall picture of the quality of concrete because it is related to the structure of cement paste [6]. In our study we measure the strength of concrete by compressive strength tests.

#### Compressive Strength test on cubes

According to Bs1881: part 116:1983[10] Method of determination of compressive strength of concrete cubes. List of tables and figures represents compressive strength results of the concretes in class A and B mixes.

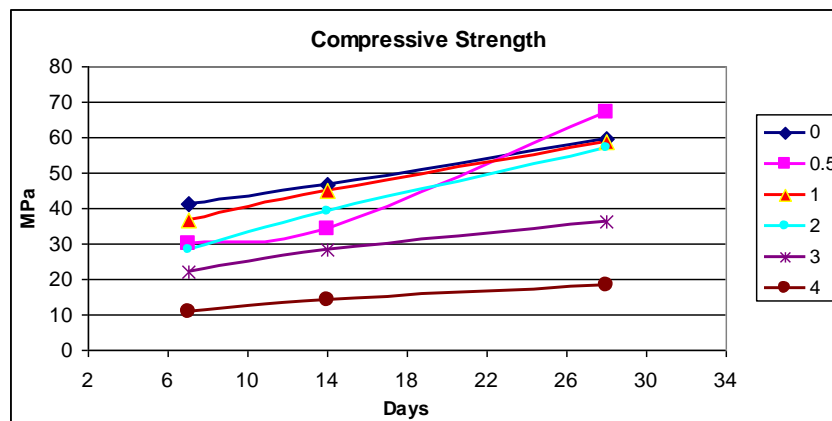
**Fig. 6:** Compressive Strength Test Equipment.

The results in table 8 seem to indicate that there may be an effective volume threshold for adversely affecting the compressive strength of concrete that is exceeded at 0.5 %.

**Table 8:** Compressive Strength for All Sample.

Curing Time (days)	Cube strength at SP6RR percent of (Mpa)					
	0 %	0.5%	1 %	2 %	3 %	4 %
7	41.15	29.9	36.65	28.53	22.25	11
14	46.75	34.25	45.0	39.25	28.5	14
28	59.75	67.00	58.67	57.00	36.25	18.25

The addition of super plasticizer (SP6RR) at low values i.e. 0.5% actually increases the 28 days compressive strength by about (12.25%). when the volumes get higher like 3.00% to 4.00% then the compressive strength decreases. At percentages between 1.00% to 2.00% then the compressive strength about same value.



**Fig. 7:** Compressive Strength for All Samples at Several Percentages of SP6RR.

## 6. Conclusion and recommendations

From the laboratory tests we observe the following advantages:

- 1) Absorption ratio and specific gravity are excellent.
- 2) Adding basalt to concrete mix makes the concrete have high density leading to an increase in resistance.
- 3) When we use the basalt in the concrete it does not need a large percentage of water because it is basalt is characterized by low absorption.
- 4) We found improved strength at mix ratio between (0.5 % - 2 %) of the additive, where the additive reduces the water / cement ratio and improve self-compaction.
- 5) When the additive ratio exceeded 2% strength is reduced which is negative effect.

## 7. Acknowledgment

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