INVESTIGATING THE EFFECT OF DIFFERENT FORMS OF GRAVEL AS AN AGGREGATE ON COMPRESSIVE STRENGTH OF CONCRETE

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Abstract - Concrete has high importance as building materials in the modern especially with different material reinforced to become an armed material. It consists of raw materials, cement, sand with the addition of types of gravel, and water which are available and easy to work. A good mix was prepared to achieve the best concrete properties as they gradually harden with time. In this project concrete was used different size(coarse – 3/4 inch, fine – 1/2 inch and crushed), and different forms (rounded, longitudinal and irregular) of gravel and study their effect on the compressive strength. Almost aggregate accupate 60-70% of concrete volume, that affect the physical and mechanical characteristic of concrete to a great extent . The samples were prepared for each size and shape of the gravel, after the process finishing, kept the samples in the maturation basin for a period of (7,14, 28) days. Then the compression test was carried out. The difference in size and shape of the aggregates has been shown to have some influence on the strength of concrete. It was found that the samples of the different sizes were resistance to compression higher than the compression of the samples with different shapes. The gain of using both crushed and irregular gravel is about 30-36% depending on grained size and shape with different curing time.

Key words - Portland cement, gravel, compressive strength.

I. INTRODUCTION

Concrete is the most widely construction materials used in the world due to its more property like durability sustainability. Therefore 4 ton/person of concrete are produce in the world while about 1.7 ton/person in the USA [1]. Concrete is a mixture of fine aggregate (sand) and coarse aggregate (gravel or crushedston) with cementation pate [2]. Which in term is made up of Portland cement with water and may be some additives like fly ash slug cement or chemical admixture[3].This publication covers the materials used in concrete and the essentials required to design and control concrete mixtures for a wide variety of structures[1]. The high cost of conventional concrete materials is a major factor affecting housing delivery in developing countries [4]. Concrete is stone-like material used for the construction of bridges, pavements, highways, houses and dams. It is produced by mixing fine aggregate (sand), coarse aggregates (gravel) or crushed rocks, cement and water and allowed to cure over a period of time. Several factors are known to influence the strength of concrete[5].They include their batch ratios, mixing mechanism, transporting and curing processes, aggregate texture, shape and nature of other constituent materials. Additionally, the sizes of the aggregates have been shown to have some influence on the strength of concrete[6, 7]. However aggregate generally accupate 60-70% of the total volume of concrete. This percentage affect the whole characteristic of concrete [8]. Important properties of aggregate like size, shape, surface texture, strength, stiffness, soundness, affect the characteristic of concrete [9,10].

Its known that aggregates were inert chemically and soldifiy together by cement. But nowadays the technology regarded that the aggregates exhibits chemicalsbondattheinterfaceofaggregateand paste [11]. The water to cement ratio, degree of compaction ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate, were an important certified factores, The crack growth is mainly occure in an interfacial zone around the cement paste or at the aggregate/cement paste. So the the integrity of the cement paste and the nature of the coarse aggregate are an important dependent in the strength of concrete at the interfacial zone[12, 13]. The concrete failures in buildings under construction or after construction because of the lack in more factores such as the effect of the mixing methods employed in the mixing of coarse aggregate, cement and water together on the properties of the concrete produced[14] .

Therefore concrete is considered the main significant construction material in the recent year and the concrete technology focus on economical improvement in strength which depend upon the use of locally available material [15].

II. EXPERIMENTAL PART

The materials were used explained below, also the preparation of sample of the used materials is discussed.

2.1. Used materials

1-Portland cement resistant to salts .

2-Gravel.
3 -Sand.
4 –water.
5 –oil for mold lubrication.

2.1.1. Cement

Iraqi Ordinary Portland cement resistant to salts was used in all mixtures, that manufactured by Tasluja Cement Factory , and the compounds essential for cement are as follows in a table .

Tables (1) and (2) show the chemical and physical properties of the cement used in this research, respectively. The chemical and physical properties test by Lafarge Iraq (UCC Tasluja Cement Factory). So the used cement conforms to the Iraqi Specification No.5/1984 [16].

Table (1): Chemical composition of the cement [16].

Abbreviation of Oxide	Limits of Iraqi Specification No.5/1984	Test Rustle (%)
Lime saturation factor	0.66-1.02	1
MgO	≤5.0	1.8
SiO_2	-	17.75
CaO		63.37
Sulfate Content SO_3	2.5 if C3A < 5 2.8 if C3A > 5	2.4
Loss on ignition	≤ 4.0	2.5
Non soluble substances	≤1.5	1.15
Fe_2O_3	-	4.28
Al_2O_3	-	5.29

Table (2): Physical Properties of the cement [16].

Physical property	Limits of Iraqi Specification No.5/1984	Test Results
Fineness (Blaine method), m^2/kg	> 230	341
Setting time (Vicat's method) Initial setting time: minutes Final setting time: hours	 ≥45 ≤10	 140 3:10
Soundness (expansion) %	≤0.8	0.3
Compressive Strength is not less than (MN/m^2) 3days 7days	 ≥15 ≥23	 35.2 44.2

2.1.2. Aggregate.

Aggregate is a very important constituent in concrete. Its occupy 70 -80 per cent of the volume of concrete so it quality has great effect on concrete properties .Aggregate generally consists of rock particles grading in size as fine particle sand and coarse gravel.

So we used two types of gravel accordingly to the size and shape of aggregate as follows:

- Aggregate according to the size obtained by sieves.

a- coarse aggregate: Gravel aggregate was used after sifting by sieve 18 .75mm according to the IQS.

b -fine aggregate: Fine aggregate was used after sifting by sieve 4mm according to the IQS.

c–Crushed rock or crushed gravel.

- Aggregate according to the shape, the shapes were obtained by sorting :

a– Round aggregate .
b– longitudinal aggregate .
c –Irregular aggregate.

a) Round aggregate.

(b) Longitudinal aggregate.

(C) Crushed gravel.

Fig(1): show the different form of aggregate

2.1.3. Sand

AL-Ekaidir in Karbala province sand is used as fine aggregate. It is tested to determine the grading and other physical properties. The sand grading is observed according to the requirement of the Iraqi Specification No.45/1984 [17], as shown in table (3). The physical properties of natural sand are carried out by National Center for Construction Laboratories that are illustrated in table (4).

Table (3): Grading of fine aggregate and requirements [17].

Sieve Size (mm)	Accumulative Passing (%)	Accumulative Passing (%) According to Limits of I.O.S No.45/1984
4.75	100	90-100
2.36	92.22	85-100
1.18	85.37	75-100
0.60	68.25	60-79
0.30	27.53	12-40
0.15	9.11	0-10

Table (4): Physical properties of sand [17]

Properties	Specification	Result	Iraqi Specifications No.45/1984
Specific gravity	ASTM C128-88	2.64	-
Absorption (%)	ASTM C128-88	0.77	-
Dry loose- unit weight (kg/m^3)	ASTM C29-89	1591	-
Sulfate content as SO_3 (%)	IQ.S No.45/1984	0.09	≤ 0.5
Material finer than 75μm sieve (%)	IQ.S No.45/1984	3.9	≤ 5

2.1.4. Water

Water that proper to drink is used,almost any natural water that has no taste or odor can be mixed with cement for casting and maturation of concrete In this study. The water used in this experiment was with PH=7.5, and the water was added using a water to cement ratio of 0.5.

2.2. Equipment

1 – Mixer.
2 - steel molds(15*15*15) cm show in figure (2).
3 – sensitive balance.
4 – water measuring cylinder.
5 – steel reinforcement rods.
6 - A device for measuring the compression strength.
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Fig (2): lubrication of mold

2.3. Working method

In this research, the materials used for concrete work are prepared and the equipments are also prepared in the laboratory as well as in a suitable location and condition for the work .The materials are prepared as follows, which include cement ,gravel, sand and water for the step followed in the mixing process.

2 .3.1. Concrete Mix.

Six types of concrete mixtures were used, its ratio and weight were fixed for all mixtures, where the most used percentage was selected in the construction work
C25 by used different size and shape of aggregate as remembered before, [coarse aggregate, fine aggregate, andcrush aggregate], [round aggregate, longitudinal aggregate, and irregular aggregate].
The weight of the materials used the sand, cement and gravel were calculated according to the ratio of the application balance in a dry way. First, the tools used for the mixing process were prepared, so the materials were added and the water was added according to the mixture. The ingredients were mixed together to obtain homogenization by mixing manually for each six mixture. The models were then poured into steel molds whose internal walls are lubricated with oil for easy exit.The models are placed in the mold for 24h, the symbols are then stamped. The models are then removed from the mold and placed in the maturation basin for (7 ,14, 28) day according to the required standard .

Fig (3): show the concrete samples after the process of curing

The samples are expose to air for about short time in order to be dried and then ready for the compression test.

2.4. Compression Test

The material is highly resistant to the power of a central compressed. upon reaching the limits of compressive resistance, the material is crushed .when concrete manufacturing is possible to have high strength, so it is one of the tests important for concrete because it expresses the existence and validity of the use of the concrete and where most of the properties of the other depend on it ,such as tensile, bending , shear and consistency checking ,so it became necessary to hold examination of compression of concrete to determine the quality was conduct laboratory testing and examination using the device after a period of maturation of the cube for 7day ,14 day and 28day per cubic in terms of shape and size used same mold . Three samples were tested for concrete with the different form of gravel in each time of curing.

Compressive strength is a key value for design of structures. The compression test was using the compression strength machine (Model: WP-310, Gunt, Germany), shown in Fig. (4), at the Babylon University/ Collage of material engineering – department of ceramic laps . It done by applying a load at (0.8 kN/min) rate until failure.(ASTM c39/c39M -03)[18], The following equation used for determining the compressive strength :

$$f = \frac{P}{A} \qquad (1)$$

f:compressive strength of the specimen (KN/mm2)
P:maximum load (KN)
A:cross section area of the specimen in (mm2).

Figure (4) Compression strength machine.

Fig (5): shows the concrete cubes after the compression test with no access to the failure condition

III. RESULTS AND DISCUSSIONS

3.1. Compression test results.

The results of the compression test of coarse, fine,crushed, rounded, longitudinal and irregular gravel after 7,14, 28 days as curing time have been discussed Below .

Table 5 : Compression strength of concrete for (7,14, 28) day as curing time for coarse, fine and crushed gravel.

Type of gravel	Compression Strength (Mpa)		
	For 7 Days	For 14 Day	For 28 Day
Coarse (3/4) inch	22.1	24.8	28.4
Fine (1/2 inch)	21.1	22.4	25
Crushed	23.6	25.5	32.8

Table(6): Compression strength of concrete for (7, 14, 28) day as curing time for rounded, longitudinal and irregular gravel.

Type of gravel	Compression Strength (Mpa)		
	For 7 Days	For 14 Day	For 28 Day
Rounded	19.7	20.9	25.2
Longitudinal	14.5	15.1	17.3
Irregular	22.1	24.9	27.1

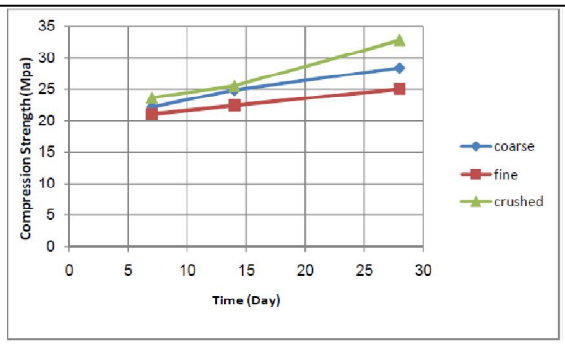
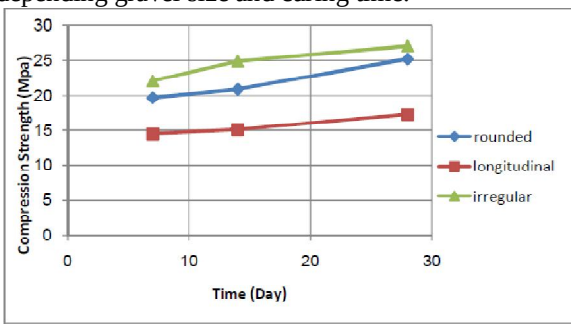


Fig (6): The effect of gravel size on the compressive strength of concrete

From Figure(6) We found an increase in compression strength of concrete containing coarse gravel because of good cohesion between cement paste and aggregates , and there is no segregation which cause weakness of concrete. And clear that the compression strength increase with curing time, but not a good increasement compared to the strength of fine gravel that show lower strength than coarse gravel because the surface area of fine gravel is high which allow of the crack to grow through applied tothe load. While that the compression strength of crushed gravel increase with curing time ,because of good homogeneous between aggregate and cement paste ,and less void in the concrete .So the strength is better than the coarse and fine aggregate for good contact between them.

The percentage of increment between 3-24% depending gravel size and curing time.



Fig(7):The effect of gravel shape on the compression strength of concrete.

From figure (7) we found that the strength of concrete increase with curing time , and less void volume with less internal friction and there is no internal stress or residual stresses which result good compression strength because of its nature shape, so it is higher than longitudinal gravel but lower than irregular shape. and the compression strength of concrete with longtidinal gravel that the compression strength increase with curing time , and workability of this type is rather good to get some of well strength, so its strength less than the rounded and irregular shape.

While the same figure observe an increment in compression strength with increasing curing time , and good cohesion of mixture and less void volume

and this result in good compression strength. It was shown that the irregular shape is the best one compared.

The increment rate are between 11 to 36% depending on gravel shape and curing time.

CONCLUSION

From the results of the study, the following conclusions are hereby made:

1. This paper presents the experimental investigation on the influence of size and shape of gravel on the compressive strength of concrete as curing time for (7,14, 28)day .
2. The aggregate shape and size gradation affect workability and compressive strength of hardened concrete.
3. Compressive strength of concrete made from different size aggregates increases with increase the curing time .
4. Highest compressive strength was achieved from all grades of concrete containing crushed gravel for 28 day.
5. Lowest compressive strength was achieved from all grades of concrete containing longitudinal gravel for 28 day.

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