EXPERIMENTAL STUDY ON THE COMPRESSIVE STRENGTH OF CONCRETE CUBES WITH RESPECT TO THE TYPE OF MATERIAL USED

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ABSTRACT*: Strengthening of concrete specimen in compression by changing the type of the concrete ingredients has been investigated in this research study. Seven cubes of size 6"x 6"x 6" were prepared and cured properly in curing tank and tested for compressive strength after 14 days.For this purpose 3 types of cement, coarse aggregate and sand were used. The cement used were ordinary Portland cement, white cement and sulphate resisting cement, the coarse aggregate were pull 111 crush, Margala crush and SaklhiSarwar crush and the sand used were local Chenab sand, Ravi sand and lawrencepur sand. These cubes were designed by ACI mix design method using assumed minimum strength of 15 MPa. Six combinations were made and compared in compressive strength after 14 days with the seventh combination containing locally available materials. The mix designed ratio is established on the basis of the properties of respective materials. These combinations were tested in compressive testing machine by applying loading rate of 250 Kpa/s. Comparative study between concrete cubes was carried out in terms of compressive strength. The findings of this experimental study show that to use proper material for construction in order to gain maximum strength using economical materials. Future research studies are recommended to be carried out to investigate the durability of these concrete cubes.*

Keywords: Constituents of concrete; Concrete cubes; Seven combinations; Compressive strength

1. INTRODUCTION

In the developing countries like Pakistan, most of the residential, low rise commercial and educational buildings (up to three floors) are constructed using concrete because it is the essential for building construction. In many situations like overloading, change in functionality of the building and alteration in the architectural plans, a concrete structure is needed to overcome the forces generated due to above stated effects.

There are many ways to strengthen concrete structure these days like adding different admixtures, providing reinforcement, fiber polymer but in this project we tried to find the most suitable combination of concrete constituents to empower the concrete in compression. The concrete is majorly made up of three kinds of constituents except water first one is binder or cement, second one is major part of the concrete that is Coarse aggregate and the third and probably the last one is filler like sand. Sometimes admixture is also added like accelerator, retarder, water reducer and strength improver.

In Pakistan, there are a lot of brands of material available that can be used in concrete construction. The available brand of cements are Ordinary Portland cement, white cement, SRC cement, and low heat cement modified cement and many more. The available famous quarries of coarse aggregate are pull 111 crush, Margala crush, Sargodha crush and SakhiSarwar crush. The famous sand that are majorly used are Lawrencepur sand, Chenab sand and Ravi sand. These are the materials we usually used in our local area of Punjab. By using these mention materials we have to find the suitable combination securing both economical and strength benefits. By this we will be able to gain our desired result with simple ingredients without using any economically expensive admixture. In further dealing with mega projects locally the results enables us to choose the best material that will be strong and durable as well. Concrete cubes are casted and tested in the compressive testing machine to check the property of the specific material.

2. EXPERIMENTAL PROGRAM

2.1. Preparation of Test Specimens

Concrete mix prepared from the material chosen with respect to combination by the ratio derived from the ACI mix design and cast in the laboratory as shown in Fig.1. First of all concrete mix of local materials like Ordinary Portland cement, pull 11 crush and Chenab sand were mixed with the ratio designed 1:3:4 and water added according to the mix design (W/C = 0.8494).The designed strength of the concrete cube is to achieve a minimum of 15 MPa. Oiled the mould of size 6"x6"x6" and poured the materials in 3 layers compacting each by 25 strokes of tempering rod as shown in Fig 2.(Due to unavailability of compacting machine).

Fig.1: Preparation of concrete mix

Six other cubes were also casted by repeating the same procedure as described above. The ingredients of all these combinations are shown in the Table 1.

Fig.2: Prepared compacted sample

Table. 1 : Combinations

Sr.	TEST FOR	CEMENT	AGGREGATE	SAND
1	CEMENT	Ordinary Portland	Karyana Crush	Chenab
2	CEMENT	White	Karyana Crush	Chenab
3	CEMENT	SRC	Karyana Crush	Chenab
4	AGGREGATE	Ordinary Portland	Margala	Chenab
5	AGGREGATE	Ordinary Portland	SakhiSarwar	Chenab
6	SAND	Ordinary Portland	Karyana Crush	Ravi
7	SAND	Ordinary Portland	Karyana Crush	Lawrnancepur

2.2. Test Performed

After 24 hours of casting the cubes were demolded and properly cured for 14 days in curing tank. On the 14th day of curing the cubes were dragged out of the curing tank and allowed to dry for 24 hours to make them ready for testing. After that, the cubes were tested in the compressive testing machine of 3000 kN Capacity. The machine was manually set to apply the load at the rate of 250 Kpa/s while the area of the cube was 23225 mm^2 as shown in the Fig 5. The compressive strength of the cubes was found to be less than the designed because the cubes were tested after 14 days instead of 28 days due to short of time. (Concrete can achieve 60% of its strength after 14 days & 90% after 28 days).

Fig.3: Setting loading rate and area of sample

Analytical procedure to calculate compressive strength

3.1 Design of concrete cubes

Fig.4: Compression Testing Machine

3. RESULTS AND DISCUSSION

3.1 Experimental observations

Recorded data in terms of loads was used to plot bar chart to represent the values of compressive strength which is shown in Fig.5, where it is obvious that the maximum load in compression carried by the concrete cube was 213 kN. Moreover, the behavior of concrete cube up to failure was noticed to be almost linear. As well as the failure mode of concrete cubes is concerned, it was due to de-bonding of the cement mortar and aggregate as shown in Fig.6(b) which resulted in the brittle failure of the concrete cube.

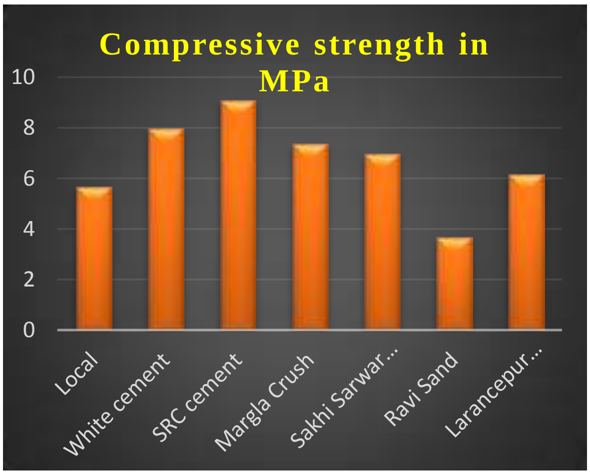

Fig.5: Bar chart between strength of concrete cubes

Fig.6: (a) cubes (b) failure pattern of cube

The concrete cubes are designed using ACI mix design method. In which first of all we performed tests to find the properties of the cement, aggregate and sand.

3.2 Finding properties

Properties and characteristics of materials determined using different cement sand and aggregate tests.

1. finess of cements
2. the consistency of cement
3. initial and final setting time of cement
4. Compressive test of hydraulic cement mortar
5. sieve analysis of coarse aggregate
6. Aggregate impact value
7. Bulk density
8. Relative density

After calculating these properties carefully used them in ACI mix design to find the ratio of specific strength of 15MPa

3.3 Establishing Ratio

Using ACI mix design the ratio of materials and w/c ratio is calculated this involves following steps

1. Required material information

The properties like sieve analyses of both fine and coarse aggregates, unit weight, specific gravities, and absorption capacities of aggregates were determined.

2. Choice of slump

The value of slump is assumed for the purpose of designing concrete mix. In our case, the value of slump is 1-2 in (25-50mm).

3. Maximum aggregate size

The maximum aggregate size that confirms the limitations given in the ACI

- 1/5 the minimum dimension of structural members,
- 1/3 the thickness of a slab, or
- 3/4 the clearance between reinforcing rods and forms. These restrictions limit maximum aggregate size to 1.5 inches, except in mass applications.

In our case that is 0.5 inch that fulfils the conditions as well.

4. Estimation of mixing water and air content

A table is given in ACI mix design to calculate the water content in air entrained and non-air entrained concrete for the slump value assumed and maximum aggregate size. For mild exposer that is 2.50%

5. Water to cement ratio

It is calculated keeping in view the strength we are going to design. For 15 MPa (2175 PSI) that is 0.795

6. Calculation of Cement content

When the water content and the w/c ratio is determined, the amount of cement per unit volume of the concrete is found by dividing the estimated water content by the w/c ratio.

7. Estimation of coarse aggregate content

The percentage of coarse aggregate to concrete for a given maximum size and fineness modulus of aggregate is given in the Table in ACI mix design. In this case finess of 2.5 and maximum aggregate size 0.5 the corresponding value is 0.582

8. Estimation of Fine aggregate content

The volume of fine aggregates is found by subtracting the volume of cement, coarse aggregate, water and air from the total concrete volume.

9. Adjustment for moisture in the aggregate

To adjust water amount just decrease the amount of water by surface moisture and increase the amount of aggregate equal to the surface moisture by weight.

3.4 Comparison with Experimental Results

The maximum strength of the concrete cube obtained experimentally is 9.1Mpa and the designed value was 15 Mpa are closed because 15Mpa is the strength designed to be obtained after 28 days and the experimentally obtained value 9.1 is the actually gained by concrete cube after 14 days. It can be noticed that the experimental compressive strength of concrete cube is close to analytically obtained value. Based on this observation, it may be concluded that the casting and testing are done well.

3.5 Comparison of the strength each cube

As early described that we casted 7 cubes so our aim is to compare their strength in order to find the behavior of every individual material in the concrete cube sample so now start one by one.

1. Cube 1 (Local)

In the first cube, the combination of a material selected was Ordinary Portland cement, Chenab sand (locally available) and pull 11 crush (local). This is our so-called ideal cube because it's easily availability and cost-effective. Other six combinations are compared with this one. The compressive strength gained after 14 days was found to be 5.7 Mpa (134.4kN).

2. Cube 2 (White cement)

In this cube, only the Ordinary Portland cement was replaced by white cement white cement is also locally available but our purpose was to check whether the compressive strength increases or decreases while working with white cement. So our experimental results show that the compressive strength increases because it gained more strength in 14 days than that of Ordinary Portland cement but usually its strength is less than the ordinary Portland cement due to less percentage of iron oxide and C_4AF in the manufacturing of White Cement. The compressive strength gained after 14 days was found to be 8 Mpa (186.6kN).

3. Cube 3 (SRC cement)

In this combination, the cement is replaced by sulphate resistant cement which is also easily available but used in the areas where structure is exposed to water or having excessive humidity for example foundations or under water concreting. So our goal is to compare its compressive strength with Ordinary Portland cement concrete cube's strength. The compressive strength gained after 14 days was found to be 9.1 Mpa (213kN). Early Strength is gained in this case due to sulphate resisting behavior, a Lower percentage of C_3A and C_4AF and a Higher percentage of silicates in comparison with ordinary Portland cement.

4. Cube 4 (Margla crush)

In this combination, the Coarse Aggregate pull 11 crush is replaced by Margla crush the strength of concrete cube majorly depend on the properties of aggregate in lower strength concrete as in our case the bond broke between the cement-aggregate instead of breaking aggregate particle so the strength of aggregate is not influencing factor. Possibly the factor is the ability to make a bond with cement so it depends on many properties like F.M (Finess modulus), bulk density, relative density and water absorption of the material. The compressive strength gained after 14 days was found to be 7.4 Mpa (173kN). Which is more than the local Sargodha crush due to above stated properties.

5. Cube 5 (SakhiSarwar crush)

In this combination, the Coarse Aggregate Pull 11 crush is replaced by SakhiSarwar crush. The origin of SakhiSarwar crush is very far from Sargodha and near to its corresponding sites but our concern is to check the compressive strength of the concrete made up Sakhi Sarwar aggregate. The compressive strength gained after 14 days was found to be 7 Mpa (163.4kN). It is higher than pull 11 crush concrete cube but lower than Margla Crush concrete cube. This is not high strength concrete the bond broke between the cement-aggregate instead of breaking aggregate particle so the strength of aggregate is not influencing factor. The possible reason is the difference in F.M (Finess modulus) which is higher than pull 11 crush but lower than the SakhiSarwar crush, bulk density, relative density and water absorption of the aggregate.

6. Cube 6 (Ravi Sand)

In this combination, the Chenab Sand is replaced by the Ravi sand. The strength of the concrete is very much influenced by the type of sand. The experimental results showed that the Ravi sand has fine particles as compared to Chenab sand and contains more impurities than any other sand so it showed low compressive strength. The compressive strength gained after 14 days was found to be 3.7 Mpa (86.6kN).

7. Cube 7 (Lawrencepur)

In this combination, the Chenab Sand is replaced by the Lawrencepur sand. The strength of the concrete is very much influenced by the type of sand. The experimental results showed that the Lawrencepur sand has Coarser particles as compared to Chenab sand and Ravi Sand and contains fewer impurities than Chenab and Ravi sand so it showed High compressive strength than Chenab and Ravi sands. The compressive strength gained after 14 days was found to be 6.2 Mpa (116.9kN). Sieve analysis shows that the Lawrencepur sand has ideal grading for concrete due to the presence of coarser particles. So it gains more strength than other two sands.

3.6 Cost Comparison

After designing of Concrete cubes, the cost comparison between the materials used for same application was carried out. While comparing the cost, not only cost of the materials was taken into consideration but also the carriage cost the material to the construction site is also considered. The comparison in Pakistani rupees is given in Table 2.

In the cements, only the actual cost is taken into account due to locally availability and other materials the cost of per 100cft is taken which includes material and carriage cost both.

Table 2: Cost comparison of RC and masonry beams

Material	Cost/unit	Availability
Ordinary Portland cement	500/50kg bag	Easily available in all major cities at actual cost. Very less carriage cost.
White cement	1000/50kg bag	
SRC cement	580/50kg bag	
Pull 11 crush	3300/100cft	The materials which are not locally available the carriage cost is also included w.r.t Sargodha city
Margla crush	6000/100cft	
Sakhisarwar	9000/100cft	
Chenab Sand	900/100cft	
Ravi sand	2000/100cft	
Lawrencepur	2700/100cft	

4. CONCLUSIONS AND RECOMMENDATION FOR FUTURE WORK

Based on the findings of the experimental study reported in the paper, following conclusions are drawn:

- Since there is very low compressive strength difference between the Ordinary Portland cement concrete, white cement concrete and Sulphate Resistance cement concrete cube. It allows us to choose as per requirement of the site situation to use white cement to obtain different colored concrete and the in water exposed sites use Sulphate resisting cement. Keeping the cost of the cement in view.
- The coarse aggregate gives compressive strength in this order first Margala crush second SakhiSarwar crush and then the local pull 11 crush. So in order to obtain maximum strength use Margala crush. After Margala crush the sakhiSarwar crush gives good strength the last option in case of strength is local pull 11 crush. The in case of cost the local is cheapest due to very less carriage cost. So we have to choose the crush which cost least and give maximum strength keeping in view the site location.
- The quality of sand is very important for the strength of concrete. The Lawrencepur sand give maximum strength as compared to Chenab and Ravi sand because it has coarser and well-graded particles. While the Ravi sand contains the majority of a finer particle along with impurities gives the least strength and Chenab sand having least impurities and have coarser particles than Ravi sand gives slightly lower Strength as compared to the Lawrencepur sand.
- Site to site the cost of the material varies due to carriage cost so our choice is limited because of the budget of the project.
- Lab conditions were not ideal because of the weather of the Sargodha the temperature was 30^{o}C at the time of casting and testing of concrete cubes.
- For future work it is recommended to select some different materials to check their compressive strength may be they give more strength and least cost than these materials.

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