

## Use of slate in making lightweight concrete.

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**Abstract.** This research was implemented to develop and to determine that how much self-weight of concrete decreases with the increase of Lightweight Aggregate and what its effect on the strength. Laboratory tests have been carried out to investigate the properties of fresh normal concrete as well as lightweight concrete and the strength development of hardened concrete. Five compositions of the concrete mix design were prepared and tested 0% of the Light Weight Aggregate, 10%, 20%, 30% and 40%. The workability was determined for each and every batch separately. The compressive strength test was carried out at the ages of 3, 7, and 28 days to examine the strength development of hardened concrete (normal + lightweight) mixes. Three Standard concrete cylinders were cast comprising of mixed, cured and tested, for analyzing the compressive strength and weight. The results show that water-cement ratio increases with increase of Light Weight Aggregate in concrete mix and their strength gradually decreases after the 10% use of LWA. It has been observed with different tests that up to 10% mix of Light Weight Aggregate in normal concrete, the strength increases 12.8% compared to normal concrete. It is practically concluded that addition of Light Weight Aggregate in concrete mix, the dead load reduces about 2.5% with the increase of every 10% batch. The trend of lightweight concrete uses is increases due to their lower dead load, strong thermal, acoustic, environmental, fire-retardant qualities and also reduced the building time.

**Keywords.** Slate, concrete, aggregate, fire-retardant

### 1. Introduction

Lightweight concrete is a type of concrete which contain an expanding agent that it increases the volume of the concrete mixture while giving additional qualities such as decreasing the dead weight. Light weight aggregate is that type of coarse aggregate which is used in the preparation of light weight concrete and such concrete then used in concrete blocks, structural concrete and pavements. Light weight aggregate is produced from shale, clay, or slate. Slate is a sedimentary rock grey in color, which is composed of clay or volcanic ash.

Fahad et al reported that using recycle plastic aggregate showed about 13% reduction in chloride penetration where compressive strength tends to decrease [1]. Emon et al reported that using brick chips as light weight aggregate along with low cost steel wire fibers enhance the mechanical performance of concrete such as compressive and split tensile strength [2]. Tang et al concluded that sedimentary light weight aggregate density is lower than normal aggregate and provide 29-35% lighter concrete when compared to normal density concrete [3]. Reddy et al performed experiments on preparation of fly ash pellet and finally he concluded that round shape of fly ash pellet gives better workability compared to the angular natural gravel [4]. Mo et al reported that using light weight aggregate in addition to fibers improve the bond properties of light weight concrete [5].

Alengaram et al reported that using oil palm kernel shell as light weight aggregate increase water absorption, low abrasion, increase compressive and split tensile strength, increase creep value and thermal conductivities was lower than normal weight concrete [6]. Hassanpour et al concluded that using fibers into light weight concrete reduces the workability, increase the density, increases the compressive strength and significantly higher splitting tensile strength compare to normal weight concrete [7]. Al-Khaiat and Haque reported that Lytag coarse and fine aggregate light weight concrete compressive



strength is less sensitive to initial curing but water penetration and durability is more sensitive to initial curing [8]. Kakade and Dhawale reported that coconut shell aggregate has good absorbance to shock, compressive strength is according to requirement of structure light weight concrete [9]. Akcaozoglu et al investigated the use of waste poly-ethylene Terephthalate (PET) bottle in concrete as light weight aggregate [10].

## 2. Experimental work

### 2.1 Data collection about LWA:

Tracing of lightweight aggregate was carried out throughout Pakistan. The 1<sup>st</sup> lightweight aggregate pumice aggregate was found, which is available mostly in Baluchistan desert area. Pumice aggregate is the residue of Lava and access to this material is quite difficult. Finally, the slate aggregate was found, and all the data and chemical composition of slate aggregate (lightweight) was collected from Engr. Muhammad Gul (ex-employee of the PCSIR). Lightweight aggregate in raw form was collected from PCSIR lab (Peshawar).

### 2.2 Collection of Materials:

Different materials have been collected from different sources. The lightweight aggregate is collected from the PCSIR laboratory (Peshawar) and from Manki Sharif source Nowshehra. The normal aggregate and sand are collected from the petty source of Model town (Main Source Margla) and (Main Source Nizampur). The Askari cement was used having compressive strength of 10000 Psi.

### 2.3 Tests on Materials:

2.3.1. *Tests on Cement:* The following tests were performed on cement.

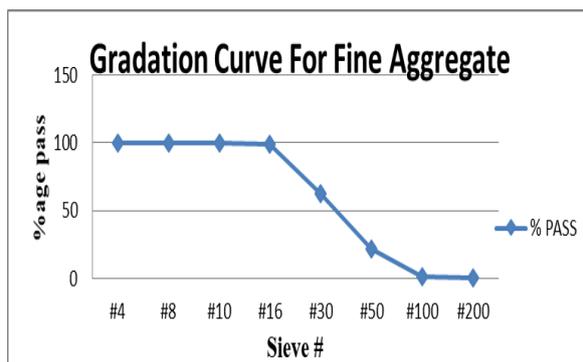
Consistency test, initial & final setting time of cement, fineness of cement, and Soundness test on cement.

2.3.2. *Tests on Sand:* Sieve Analysis of Sand and Bulk Specific Gravity and Water absorption.

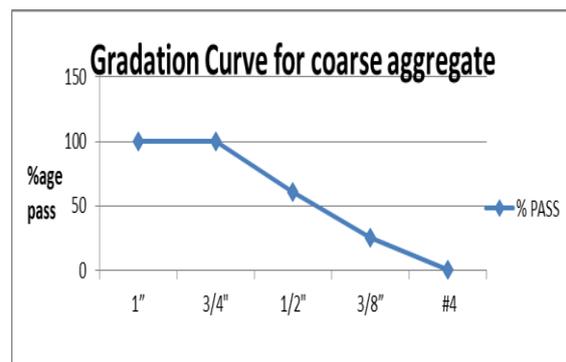
Fineness Modulus =  $\Sigma$  Cumulative retained / 100 = 2.64

Bulk Specific gravity =  $A / (B + D - C) = 2.64$

Absorption % =  $(D - A) / A \times 100 = 2\%$



**Figure 1:** Gradation curve of Fine aggregate



**Figure 2:** Gradation curve of coarse aggregate

The gradation curve in figure 1 shows that for fine aggregate the material passed 100% from Sieve#4 to Sieve#16 but did not passed from Sieve#100 and onward.

The gradation curve in figure 2 shows that for coarse aggregate the material passed 100% from 1inch Sieve to 3/4inch Sieve but did not passed from Sieve#4 and onward.

### 2.3.3. Tests on Light Weight Aggregate:

#### 2.3.3.1. Specific Gravity and Water Absorption Test on Lightweight aggregate:

This test was performed according to ASTM-C 127

Specific gravity of aggregate =  $W_3/(W_2-W_1) = 1721/(1755.2-720) = 1.63$

Absorption of aggregate =  $W_2-W_3/W_3 = 1755.2-1721/1720 = 2.1$

#### 2.3.3.2. Sieve Analysis of Lightweight Aggregate:

This test was performed according to ASTM-C136 [12]

#### 2.3.3.3 Tests on Normal Aggregate:

#### 2.3.3.4. Specific Gravity and Water Absorption Test:

This test was performed according to ASTM-C 127 [11]

Specific gravity of aggregate =  $W_3/(W_2-W_1) = 1930.9/(1944.9-1195) = 2.577$

Absorption of aggregate =  $W_2-W_3/W_3 = 1944.9-1930.9/1930.9 = 0.72$

#### 2.3.3.5. Sieve Analysis of Normal Aggregate:

This test was performed according to ASTM-C136

### 2.4 Selection of samples:

Different sample were selected to continue research work i.e. 0%, 10%, 20%, 30% and 40% mix of Light Weight Aggregate with Normal Weight Aggregate.

### 2.5 Slump test for Concrete:

This test was performed according to ASTM-C143 [13]

**Table 1.** W/C and slump value

<b>%age of LWA in Concrete</b>	<b>W/C ratio</b>	<b>Increase by % in W/C ratio</b>	<b>Slump value(inch)</b>
0%	0.55	0	1.5
10%	0.55	0	2
20%	0.57	3.64	2
30%	0.59	7.27	1
40%	0.62	12.73	1.5

The detail of water cement ratio and slump value for different samples i.e. 0% 10% 20% 30% 40% mix is shown table 1. As the LWA addition was increased the w/c ratio was gradually increased but there is variation in slump value i.e. increase and decrease.

### 2.6 Compression test:

Concrete's compressive-strength mostly depends on the mix design. But it is affected by several other factors. Such as mixing of concrete, placing of concrete and curing of concrete as well as quality of concrete ingredients. For knowing compressive-strength of concrete, generally, concrete-cylinder is tested at laboratory.

#### **Procedures of Making Concrete Cylinder:**

Making concrete-cylinder specimen is simple and it is done in three simple steps.

1. Cleaning & fixing mould.
2. Mixing, Placing, Compacting & Finishing concrete.
3. Curing.



**Figure 3.** Compression test of concrete cylinder under observation

### **3. Results and discussions**

The properties of the LWC mix samples determined by the following test: fineness test, workability test and Water cement ratio, and Compressive strength.

#### *3.1 Fineness test*

The fineness tests were performed on fine aggregate and course aggregate, and the result are listed in graph form shown in figure 1 and figure 2. The gradation curve in figure 1 shows that for fine aggregate the material passed 100% from Sieve#4 to Sieve#16 but did not passed from Sieve#100 and onward. The gradation curve in graph of figure 2 shows that for coarse aggregate the material passed 100% from 1inch Sieve to 3/4inch Sieve but did not passed from Sieve#4 and onward.

#### *3.2 Workability and Water cement ratio*

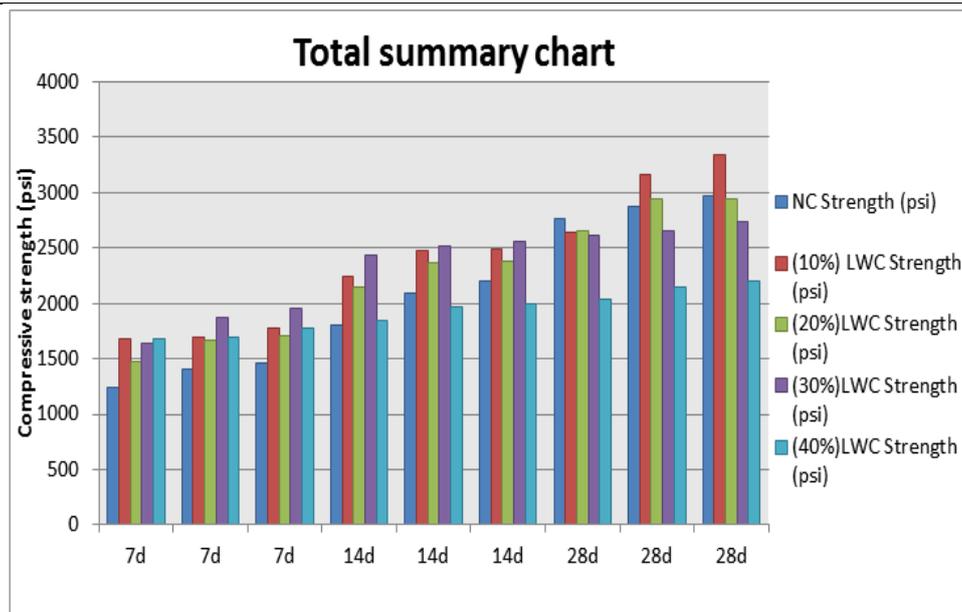
As the LWA addition was increased the w/c ratio was gradually increased and the test results are indicated in table 1. The concrete mixes workability was measured by using the slump cone test. The results listed in table 1 shows that most of the LWC mixes has a slump values ranging from 1inch to 2inch immediately after mixing. To be within the scope of this investigation, the workability of all the LWC mixes cast, was kept almost the same by changing the w/c ratio whenever needed.

### 3.3 Compression test:

The test results are shown in Table 2 with figure 4. These results show the comparison of normal weight aggregate with different type of LWA mixes using locally available natural lightweight aggregates, LWA. The concrete mixture tested for 7days, 14 days and 28days compressive strength, figure 3.

**Table 2:** Total summary table of compressive strength of different samples

Days	NC Weight (kg)	10%LWC Weight (kg)	20%LWC Weight (kg)	30%LWC Weight (kg)	40%LWC Weight (kg)
7d	13.29	12.86	12.58	12.34	11.84
7d	13.17	12.96	12.8	12.21	11.74
7d	13.23	12.91	12.69	12.28	11.79
14d	13.16	13.01	12.81	12.71	11.45
14d	13.48	13.05	12.86	12.72	11.92
14d	13.32	13.03	12.84	12.72	11.69
28d	13.31	13.14	13.01	12.6	11.94
28d	13.5	12.98	12.91	12.02	11.81
28d	13.41	13.06	12.96	12.31	11.88



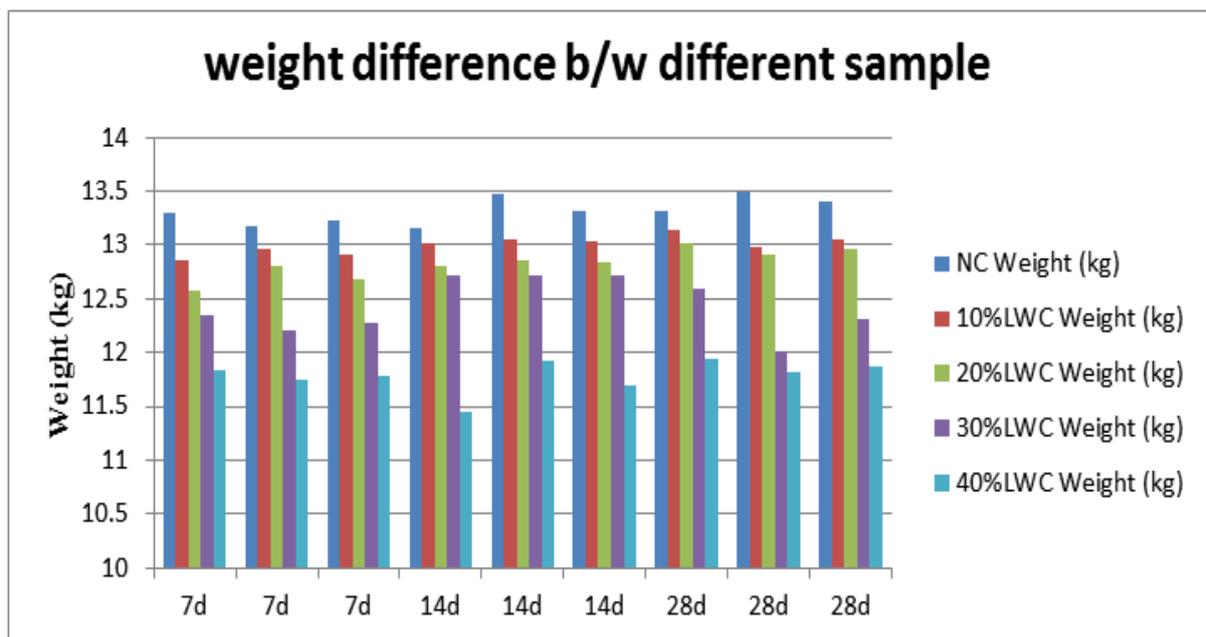
**Figure 4:** Total summary chart of compressive strength.

The graph of figure 4 shows the increase in strength of different samples with increase of LWA which were tested for 7days, 14days and 28days respectively. After 28days strength the 10% mix of LWA shows a tremendous increase in its compressive strength.

3.4 Difference between Weights of NWC & LWC is shown in table 3:

**Table 3:** Total summary table of weight difference of different samples

Days	Control Strength (psi)	(10%) LWC Strength (psi)	(20%)LWC Strength (psi)	(30%)LWC Strength (psi)	(40%)LWC Strength (psi)
7d	1239	1681	1480	1642	1685
7d	1411	1695	1660	1877	1691
7d	1460	1772	1701	1948	1773
14d	1798	2245	2151	2441	1841
14d	2089	2479	2370	2521	1964
14d	2201	2488	2379	2558	2001
28d	2766	2647	2655	2607	2037
28d	2875	3163	2936	2649	2144
28d	2964	3344	2942	2736	2198



**Figure 5.** Graph showing the detail about the weight difference

The weight difference of sample 10%, 20%, 30% and 40% mix are shown in the graph of figure 5. The variation in weight of various samples is on regular basis i.e. there is no sudden increase or sudden decrease.

#### 4. Conclusions

- Incorporating 10% slate as light weight aggregate in concrete shows maximum strength at all ages.
- The strength of light weight aggregate concrete increases by 12.8% at 28 days when 10% light weight aggregate is added.

- c. Incorporating 40% light weight aggregate shows decline in strength by 25%.
- d. The addition of Light Weight Aggregate in concrete mix, the dead load reduces about 2.5% with the increase of every 10% batch which makes the total reduction of dead load by 10% when 40% light weight aggregate is added.
- e. The workability of light weight aggregate concrete tends to increase, the maximum value for slump was noted at 40% replacement which was 12.73% compared to control mix.

## 5. Recommendations

- a. The Super plasticizer should be used to reduce the water cement ratio of the lightweight concrete and increase also their compressive strength.
- b. The strength of LWAC should be increases with the use steel fiber with the specific ratio.
- c. The strength of the Light Weight Aggregate Concrete should be enhancing with the use of bagasse ash with different trials.

## References

- [1] Alqahtani Fahad, Ghataora Gurmeh, Khan Iqbal, Dirar, Samir Kioul, Azzedine Al-Otaibi, Mansour, Lightweight concrete containing recycled plastic aggregates. 2018;
- [2] Bashar A, Manzur T, Yazdani N. Improving performance of light weight concrete with brick chips using low cost steel wire fiber. *Constr Build Mater* 2016;106:575–83.
- [3] Tang C, Chen H, Wang S, Spaulding J. Cement & Concrete Composites Production of synthetic lightweight aggregate using reservoir sediments for concrete and masonry. *Cem Concr Compos* 2011;33(2):292–300.
- [4] Reddy MVS, Nataraja MC, Sindhu K. Performance of Light Weight Concrete using Fly Ash Pellets as Coarse Aggregate Replacement. 2016;9(2):95–104.
- [5] Mo KH, Alengaram UJ, Jumaat MZ. Bond properties of lightweight concrete – A review. *Constr Build Mater* 2016;112:478–96.
- [6] Alengaram UJ, Abdullah B, Muhit A, Zamin M. Utilization of oil palm kernel shell as lightweight aggregate in concrete – A review. *Constr Build Mater* 2013;38:161–72.
- [7] Hassanpour M, Shafiq P, Bin H. Lightweight aggregate concrete fiber reinforcement – A review. *Constr Build Mater* 2012;37:452–61.
- [8] H. Al-Khaiat and M.N. Haque, effect of initial curing on early strength and physical. 1998;28(6):859–66.
- [9] Kakade SA, Dhawale AW. light weight aggregate concrete by using coconut shell. 2015;3(3):127–9.
- [10] Atis CD. An investigation on the use of shredded waste PET bottles as aggregate in lightweight concrete. 2010;30:285–90.
- [11] ASTM C 127, Specific Gravity, and Absorption test of coarse aggregate.
- [12] ASTM C 136, Standard test for sieve analysis of fine aggregates.
- [13] ASTM C 143, Standard test for slump of hydraulic cement concrete.