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# Experimental Study on Mechanical Properties of Bloated Light Weight Aggregate Concrete Blocks Masonry

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#### Keywords

Blocks masonry, light weight concrete, Mechanical properties, slate lightweight aggregate

## ABSTRACT

Self-weight of the structure is an important issue. The self-weight of the structure represents the large portion of the total load. By reducing the self-weight of the members helps us not only in the material cost but also in the construction cost. By doing this considerable savings could be attained. The aim of the project is to carry out the mechanical characterization of solid blocks masonry made from light weight aggregate concrete blocks, through experimental investigation. The basic material properties of masonry including compressive strength, diagonal tensile strength, shear strength, young's and shear moduli are obtained through laboratory testing on masonry prisms, triplets and wallets. The samples are made up of light weight aggregate concrete blocks. The light weight aggregate used is expanded slate light weight aggregate. The size of the blocks is 12"x8"x6" (LxWxH). Various physical and mechanical tests are carried out including absorption, density, compressive strength, tensile strength and modulus of elasticity. The blocks are solid. Concrete mix is designed for the concrete block in order to achieve minimum concrete block strength required by building code of Pakistan. The concrete mix designed for the blocks shows lower density and having the compressive strength that comply with the minimum requirement of building code of Pakistan. After detail cost analysis of both normal weight concrete blocks are used.

#### INTRODUCTION

Lightweight concrete is defined as the concrete that is made lighter than the conventional concrete by changing material composition or production method.

The use of lightweight concrete is gaining wide acceptance in building construction, due to the considerable reduction in mass. Reduction in weight by the use of lightweight aggregate is preferred especially for structures built in seismic zones. Reduced dead load by using lightweight aggregate results in reduction of earthquake damages to structures. (Venkatadinesh & Kumar, 2018). The ancient development of lightweight aggregate used by romans were Grecian and Italian pumice, which were locally available lightweight aggregate. Since that time there has been advancement in the production of lightweight concrete using either the natural lightweight aggregates such as pumice or the artificial lightweight aggregates.

Masonry has been used to construct significant structures since the beginning of civilization for its durability and aesthetic reasons. In addition, fire and heat resistance and versatility make masonry an appealing building material these days. There is an intense need for using the light weight concrete blocks to use as a masonry. So an extensive study of the lightweight concrete blocks masonry is required. As from the name, the lightweight concrete blocks are lightweight in nature, having less self-weight than the normal concrete blocks.

# SIGNIFICANCE OF RESEARCH

Strictly speaking the term "lightweight" is relative, and the reason for the use of lightweight concrete is usually for the economy in steel and foundations that can be realized by weight reduction. Beside the weight savings, lightweight concrete has substantially better fire resistant qualities than normal weight concrete, and significantly lower heat transmission. The use of lightweight aggregate in masonry blocks permits increased labor productivity because the decreased weight makes for greater speed and ease of handling. Similar considerations apply in the case of precast elements and tilt up construction using structural light weight concrete. In these as well as in cast in place applications, contractors find that the same sound control used with other materials and the processes will produce a highly serviceable end product.

For architects and engineers structural lightweight concrete has opened up a broad range of applications, tall building frames, long span roof and bridges structure thin shell construction, including hyperbolic paraboloid roof structure, sculpture and special design effects in form and texture.

## **EXPERIMENTAL PROGRAM**

Experimental process consists of different methods/levelsapplied for fulfilling the required objective of research work, as given in below;

- Batching of materials like cement, slate light weight aggregate and water
- Mixing of slate light weight coarse aggregate, fine aggregate, cement and water was mixed by mixermachine and mixed thoroughly.
- Casting of concrete blocks in vibratory machine.
- Curing of concrete sample for required time period

After curing concrete sample was tested after 28 days, different tests conducted such as compressive strength test, flexural test, diagonal compression, triplet tests and masonry compressive strengthto analyze the effect of using slate lightweight aggregate in concrete.

#### MATERIAL AND METHODS

Some different kinds of materials were used in this research work i.e. slate lightweight aggregate, locally available OPC cement. Which are discussed below.

## A. Slate light weight aggregate

Slate is a metamorphic rock that is formed when shale and clays are put under great pressure and heated inside the earth for millions of years. Like shale, it splits apart into sheets, which means that it has good cleavage.

Bloated slate aggregates were prepared of slate material. Slate is a metamorphic laminated clay rock which is available in huge quantities in Pakistan. The average chemical composition of raw slate is as follow: SiO2 = 62.92%, Fe2O3 = 07.04%, Al2O3 + TiO2 = 18.79%, Alkalies (CaO, MgO, Na2O, K2O) = 6.22%, loss on ignition = 4.88% (PCSIR, 2011). For the preparation of concrete aggregates, the raw slate was broken into pieces with a diameter 5mm to 15mm. A rotary kiln method was employed for expansion of slate, involving application of 1100 Co temperature under control conditions. The broken slate pieces were fed into 9.15m long and 1.22m diameter rotary kiln at its higher end, while fire took place at the lower end. During progress of the material through rotary kiln, temperature of the particles gradually rose until bloating occurred. During heating some of the slate aggregates got fused together causing agglomeration. The material was then discharged from kiln into a tank. On cooling the processed material was screened to fractions of the desired sizes. The finished product was round in shape and having smooth surfaces. The bigger/agglomerated particles were reduced in size by crushing. The coarse aggregate thus obtained was having shapened and angular shape with opened pored texture.

# B. Ordinary Portland cement

Locally available OPC used, is the mixture of different ingredients like calcareous, siliceous, aluminous materials and grinding the clinkers to a powder form. The cement used 1 in the experimental work was of Kohat Factory Cement (OPC). The specific gravity of this binding material is 3.15. Initial setting time for ordinary Portland cement may vary from 45-60 minutes and the final setting time for such cement is about 10 h ours. The oxide contents are as follows: 62-69% CaO, 16-24% SiO2, 4-9% Al2O3, 0.4-0.6% Fe2O3 and 0.1-0.4% MgO confirming to ASTM C 15 0.

#### C. Mix Proportion

Mix design for concrete is by trial method. In trial method concrete is made up of different mix proportions and different water/cement ratios. For some mix proportions, the fine aggregate used as locally available sand and in some cases the powdered slate is used as fine aggregate. For some ratios, no fine aggregate is used in the concrete, and the aggregates used in these cases are in SSD condition. The size of the aggregate used for the mix proportion of the concrete is 1/2'' down. For lightweight concrete the density is the important factor, so after different trials the ratio to be used further for casting of blocks is based on strength and density i.e. having low density. Details of different trials is as follows in the table.

S.NO	ТҮРЕ	RATIO	W/C RATIO	DENSITY lb/ ft <sup>3</sup>	STRENGTH (psi)
1	Concrete having fine aggregate is powder slate	1:2:4	0.54	95.00	1388
2	Concrete having fine aggregate is powder slate	1:3:6	0.78	99.00	438
3	Concrete having crushed aggregate mixed with powder slate i.e. in original form after crushing		0.60	97.00	1347
4	Concrete having fine aggregate is sand	1:2:4	0.50	100	565
5	Concrete having no fine aggregate	1:3	0.32	75	530
6	Concrete having no fine aggregate and aggregate is in SSD condition	1:2	0.33	81.80	1398
RESULTS AND DISCUSSIONS					
A. Com	pressive strength				

#### Table 1. Mix Proportion for concrete

The compression test was performed according to the specification given in section 7 of the ASTM C 39 [2]. The concrete blocks were tested under the uni-axial compression loading in universal testing machine (UTM). A steel plate of thickness ¾" was placed on the top of the specimens according to the ASTM standards to distribute the load evenly to the concrete block surface as shown in the figure 1. The compressive load was applied on concrete block until failure. The concrete block size was 6"x8"x12". The ultimate load was recorded and the compressive strength of the specimen was found by the following formula.

Compressive strength (psi) = Ultimate load (lb) / Area (in2) Compressive strength of concrete blocks is as shown in table below.

Table 2 compressive strength of concrete blocks.					
S.No	Load (lb)	Compressive strength (psi)			
1	148549	1547			
2	120338	1254			
3	133782	1393			



Figure A. Compressive Strength of Concrete Blocks

# B. Flexural strength

The flexure strength of the concrete is determined according to the ASTM C 78[3] standard. Results are calculated and reported as the modulus of rupture. The strength determined will vary where there are differences in specimen size, preparation, moisture condition, curing, or where the beam has been molded or sawed to size.

If the fracture initiates in the tension surface with in the middle third of the span length, calculate the modulus of rupture as follows:

Where

R = modulus of rupture, psi or MPa

P = maximum applied load indicated by the testing machine, lbf, or N,

L = span length, in, or mm,

b = average width of specimen, in, at the fracture and

d = average depth of specimen, in, or mm, at the fracture

If the fracture occurs in the tension surface outside of the middle third of the span length by not more than 5 percent of the span length, calculate the modulus of rupture as follows

R = 3Pa/bd2

#### Where

a = average distance between line of fracture and the nearest support measured on the tension surface of the beam, in, (or mm).

In this case the fracture initiates in the tension surface with in the middle third of the span length.

S.No	P, load	L, Span length	b, width	d, depth	R, modulus of rupture
	Tons	(in)	(in)	(in)	(psi)
1	1.5	24	6	6	367
2	1.46	24	6	6	357

## Table 3 flexural strength of concrete beam



#### Figure B.Flexural Strength of Concrete Beam

# C. Modulus of Rupture Test

In order to evaluate the bending (flexure, tensile) capacity of the concrete blocks, point load test was performed on concrete blocks according to the specification mentioned in section 21 of the ASTM C-496 [1]. The concrete blocks were tested in flexure using simply supported end conditions with a span length of 10 inches. A vertical concentrated (point) load was applied at the middle of the specimen until failure. Calculate the modulus of rupture of the specimens as follow: Fbt = Mmid/Sb

#### Where

ere

Mmid is the mid span bending moment of the block and,

Sbt is the section modulus of block section = bt2/6 and,

b & t is the width and thickness of the block respectively

The compressive load on the concrete block was applied until failure in the direction perpendicular to the 6"x 8" side with the help of the UTM as shown in figure c.



Figure C. Modulus of Rupture test of Concrete Blocks

The modulus of rupture of concrete blocks is as shown in table below.

S.NO	W, load	l, span length	b, Width	t, thickness	S, Rupture Modulus,
	Tons	(in)	(in)	(in)	(psi)
1	4.38	10	8.00	6.00	502
2	5.10	10	8.00	6.00	585
3	3.53	10	8.00	6.00	405

#### Table 4 modulus of rupture of concrete blocks

## Conclusions

Based on experimental work the following conclusions and recommendations are made.

- Lower unit weight of concrete blocks indicates, that aggregates are highly porous.
- Lower water absorption of concrete is due to aggregates pores are filled with water, as the aggregates used in the concrete are in SSD condition.
- The mean compressive strength of masonry unit complies with the minimum requirements of Pakistan building code 2007.
- > Higher modulus of rupture for concrete masonry indicates the compact microstructure of concrete.
- > The expanded aggregate is hard, highly cellular and has tough skin and uniform structural strength.
- > The failure of light weight concrete is abrupt as compared to the normal weight concrete.
- > The strength of bloated slate aggregate varies with the cement content.

# Recommendations

After concluding the conclusion with the help of test results, the researchers drawn some recommendations for future researches, which are given below;

- More refined testing is required to study the behavior of concrete in which the normal weight aggregate is replaced by the bloated slate aggregate.
- Experimental determination of quasi static loading test.
- > Experimental determination of monotonic static test.
- Structure instead of bricks masonry.

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