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Evaluation of Mechanical Properties of Concrete Hollow Block Masonry Units

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Abstract — *Concrete hollow block masonry are nowadays a common practice to be provided as infill walls in Reinforced Concrete structures due to their improved sound and fire proofing properties. Moreover, its low cost and easy and robust construction has also boosted their use in construction industry. This research focusses on finding the mechanical properties of concrete hollow block masonry. Water absorption test on CMU, compressive strength test on CMU, compressive strength test on mortar cubes and compressive strength test on grout has been conducted and shown promising result.*

Keywords- *Concrete block masonry units, water absorption, compressive strength, mortar cubes*

I. INTRODUCTION

Construction of houses with masonry is the oldest and most common technique used throughout the world particularly in Pakistan. Masonry has very broad spectrum, which include different material and construction methods. Unreinforced masonry can withstand gravity loads very well because it has good compressive strength but its tensile strength is very low and can be considered negligible for design purpose. The tensile strength of a typical masonry mortar joint can be in the range of 1/30th of its compressive strength, that is why its performance is very poor against lateral loading produced by earthquakes **[1].**

RCC frame structures with infill walls, confined brick masonry, hollow burnt clay and hollow concrete block masonry are techniques, used in seismically active areas of the world. In hollow concrete block masonry, hollow spaces (cells) can be reinforced and grouted to improve its tensile and shear strengths. Increased tensile strength makes the structure ductile, structurally integrated and provide better energy dissipation under seismic loading **[2].**
Hollow concrete block masonry has got significance due to its unique properties and has become ultimate choice to designers and engineers and its use in masonry construction is constantly increasing due to the various advantages listed below;

a) It is thermally insulated. Its buildings remain cool in summer and warm in winter
b) Its Sound insulated, there is least disturbance inside the buildings due to external noise
c) It gives adequate strength and its buildings are structurally stable
d) It is highly durable
e) It provides good resistance against fire and
f) It is economical

In Pakistan, use of concrete masonry units in masonry is comparatively new therefore there is a lack of awareness regarding its use. This research work focusses on finding the mechanical properties of concrete hollow blocks. These tests and their results are briefly discussed in this paper.

II. WATER ABSORBTION TEST

For carrying absorption test, density, net volume and average net area of the CMU, three full-size specimen of concrete masonry units (CMU), having age more than 28 days were collected from stack and its weight as received weight Wr lbs. was found. The specimens were kept immersed in water at room temperature for 24 hours and its fully saturated weight Ws lbs. and immersed weight Wi lbs. were determined. The specimen was then kept for 24 hours at ventilated oven at 100°C to 115°C as per ASTM C-140 and dry weight Wd lbs. of the specimen was worked out. The net weight of the CMU was then determined using the below formula was found to be 4.5%.

$$\text{Absorption (\%)} = (Ws-Wd)/Wd\times100$$

III. DENSITY OF CONCRETE MASONRY UNIT (CMU)

From the previously calculated weights described in Section II, the density of oven dried specimen was found using the below formula and was found to be 132.45 pounds per cubic feet.

$$\text{Density } D = Wd/(Ws-Wi)\times62.4 \quad \text{lbs/(ft\^3)}$$

IV. AVERAGE NET AREA AND NET VOLUME OF CONCRETE MASONRY UNIT

Similarly, from different weights of CMU determined vide section III above the average net area and net volume of hollow Concrete Masonry Units (CMU) was calculated as follows:

Net Volume, Vn, ft^3 = Wd/D=(Ws-Wi)/62.4

Average Net Area, An, in^2= (Vn x 1728)/H

The ratio of gross to net area was calculated as 117.5/69.3 in^2 while %age net area to gross area was found to be 58.98%.

V. COMPRESSIVE STRENGTH(Fm□) OF CONCRETE MASONRY UNITS (CMU)

For determining the compressive strength of hollow concrete hollow block masonry fm□, five numbers prisms were constructed of matured concrete masonry units according to UBC 97 Section 21-1702 and accordingly tested as per UBC 97 **[3]** Section 21-1702 through Section 21-1708. The size of the prisms was kept 16"x8"x16", two masonry units in stack bond, laid in a full mortar bed, having h/tp ratio equal to 2, which has correction factor of 1 as per UBC 97 table 21-17-A. For the loads to be distributed uniformly over the specimen, Gypsum capping was provided all over the prisms before applying the loads. All the prisms were cured for 28 days before testing after which they are subjected to uniaxial loading via Universal Testing Machine till their failure as shown in **Figure 1**. The compressive strength of prism was worked out as:

Net Area Compressive strength (fm□)

fm net□ = Pmax / An

Gross Area Compressive strength (fm□)

fm gross□ = Pmax / Ag

Where,

fm□ = Compressive strength of masonry at 28 days.
fmnet□ = Net Compressive strength of masonry at 28 days.
fm gross□ = Gross Compressive strength of masonry at 28 days.
Pmax = Maximum Compressive Load
An = Average Net Area of Specimen (Prism)
Ag = Gross Area of Specimen (Prism)

Figure 1: Testing of concrete block masonry units under compression using universal testing machine

After performing the test an average result of compressive strength of masonry net/gross was found to be 1628/960 psi.

VI. MORTAR COMPRESSIVE STRENGTH

The mortar used in the model building was in the ratio of 1:4 (Cement: Sand) as in common practice of hollow concrete masonry in Pakistan. 50 samples (cubes) were cast from the mortar used during construction of the model building. The size of the cubes was kept 2″x2″x2″. After 28 days the cubes were tested in universal Testing Machine (UTM) for compressive test as per ASTM C-109 [4] as shown in Figure 2. and calculated compressive strength as follows,

$$fm = P / A$$

Whereas, fm = Compressive strength of mortar at 28 days.
P = Compressive Load
A = Area of Loaded surface

The average compressive strength of mortar cubes was found to be 1100 psi.

Figure 2: Mortar cubes under compression test

VII. COMPRESSIVE STRENTH OF GROUT

Course grout was used in designated cells as shown in the drawings through low lift grouting method. The Ratio of material for preparation of grout was kept 1:1.5:3 (Cement: Sand: Coarse aggregate) with slum 8″ to 10″. The specimens were prepared and tested as per ASTM C- 1019 and UBC 97 21-18.

$$fg = P / A$$

Whereas, fg = Compressive strength of grout at 28 days.
P= Compressive Load
A= Area of Loaded surface

Average compressive strength of grout was found to be 2875 psi.

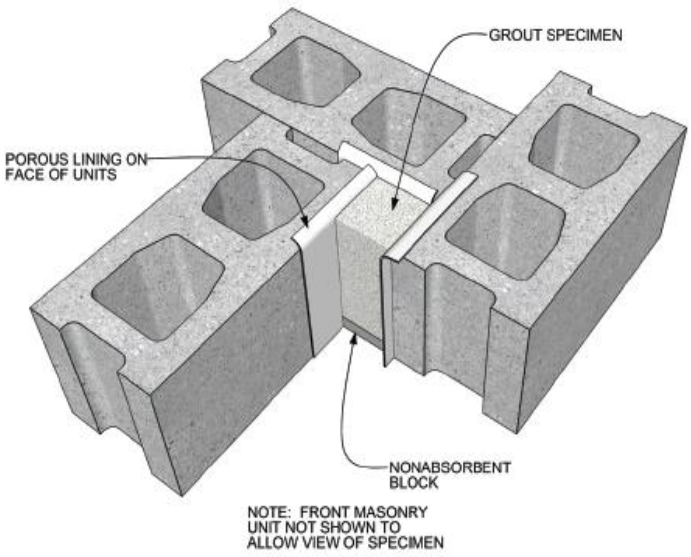

Figure 3: Preparation of grout for testing

VIII. CONCLUSIONS AND RECOMMENDATIONS

Pakistan is situated in seismically active region of the world. It has been hit by moderate earth quakes every year, however, the Hamalaya region has the potential of generating earthquakes of magnitude 8 and greater once in every 100 years which triggers severe losses to public and private properties and precious human lives. Pakistan is a poor country, especially the Northern areas which are prone to high seismic activities are living below the poverty base-line. The inhabitants of the region use economical but non-engineered means of building construction, mostly of unconfined stone, brick and concrete masonry, which though efficiently resist gravity loads but are very weak against earthquake loadings. According to **[5]**, 73% of the building stock of Abottabad city is comprised of unreinforced masonry whereas the situation is much worsed in rural areas. Concrete block masonry units are nowadays common to be provided in RC structures which are having good sound and fire proof properties.

The mechanical properties tests conducted on concrete hollow block masonry have shown promising results and hence further tests needs to be conducted on masonry prisms, masonry wallets and piers to get information about their stress strain behavior, diagonal shear strength and lateral load resisting capabilities.

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