Properties of Aerated (Foamed) Concrete Blocks

***Prakash T M ** Naresh kumar B G *** Karisiddappa ****Raghunath S**

Abstract: Aerated concrete block is a type of masonry unit manufactured by precast technique. Aerated concrete is produced by the mixing of Portland cement, sand, water and air voids are entrapped in the mortar of mix by means of suitable aerating agent. In this experimental study the feasibility of using aerated concrete block as an alternative to the conventional masonry units has been investigated. The preliminary studies focused on estimating physical and elastic properties of Aerated concrete block units. These included Initial rate of absorption, density test, water absorption test etc. The compressive strength, stess-strain characteristics and the flexural strength of the units were obtained. There is scanty information on the physical and elastic properties of Aerated concrete blocks. The present investigation has endeavored to study all such properties. Having obtained the results, it would now be interesting and useful to compare the results with that of conventional masonry units.

Index Terms: Aerated concrete block, Initial Rate of Absoprtion, Dry density, Compressive strength, Flexural strength, Stress-strain chracteristics.

1 Introduction

The quest for finding a light weight material as a replacement for conventional masonry units has been there since nearly three decades. In India, over the past two decades a significant time has been utilized for making attempts to promote Aerated Concrete Blocks (ACB) as an alternative to the conventional masonry units. Alongside with this growth of development of manufacture of Aerated concrete blocks, concrete industry has seen a small but significant growth in usage of Aerated (foamed) concrete blocks. Simultaneously, there has been a very significant change in the replacement of burnt clay bricks by concrete masonry units. It appears that the usage of Aerated concrete block masonry may become more common in the coming years.

Many structures, not only in urban and semi-urban regions, but also in rural regions of India have started using concrete masonry units in place of the traditional bricks. The use of Aerated concrete blocks as a load-bearing masonry unit, at present, is very much limited, in the Indian context. Only recently in a very few reinforced concrete framed buildings, Aerated concrete block masonry is used in place of conventional masonry in-fill. There is hardly any example of Aerated concrete block units being adopted in load bearing structures. It is in this context that the present research work finds its back ground. Also, there has been scanty literature on the performance of Aerated concrete block masonry as a structural member, in India, whether as a load bearing member or as a masonry in-fill reinforced concrete frames.

**Prakash T M is currently pursuing Ph.D., working as Associate Professor, Civil engineering Department, P E S College of Engineering, Mandya, Karnataka, India. tmprakash.1964@gmail.com*

*** Naresh Kumar B G is working as Principal in Maharaja Institute of Technology Mysore, Belawadi, S R Patna Taluk, Mandya District, Karnataka, India. nareshgowda58@gmail.com*

****Karisiddappa is working as Principal in Government Engineering College,Hassan, Karnataka, India. karasiddappamce@yahoo.com*

*****Raghunath S is working as Professor in civil Engineering Department,BMSCE, Bangalore, India. raghunath.smrc@gmail.com*

Aerated concrete is produced by the mixing of Portland cement, sand, water and air voids are entrapped in the mortar mix by means of suitable aerating agent. Broadly speaking, aerated concrete falls in to the group of cellular concrete (microporite bening the other). The prominent advantage of aerated concrete is its lightweight which economizes the design of supporting structures. It provides a high degree of thermal insulation and considerable savings in material due to porous sturucture. By appropriate method of production, aerated concrete with a wide range of densities (300 – 1800 kg/m^3) [1] can be obtained thereby offering flexibility in manufacturing products for specific applications.

Autoclaved aerated concrete is quite different from dense concrete (i.e. normal concrete) in both, the way it is produced and in the composition of the final product. In contrast, autoclaved aerated concrete is of much lower density than dense concrete.

1.1 Relative advantages of aerated concrete block units over conventional masonry units

- Aerated concrete block combines insulation and structural capability as one material for walls, floors, and roofs. Its light weight properties make it easy to cut, shape and size. Aslo accept nails and screws readily, and allow it to be routed to create chases for electrical conduits and small-diameter plumbing runs.
- Aerated concrete blocks are precisely shaped and conform to tight tolerances. Due of the high dimensional accuracy, the blocks can be laid with very thin mortar joints. 10 mm mortar joint is standard compared to nearly 25-35 mm for normal concrete blocks.
- Because of high dimensional accuracy, the blocks being of almost perfect size and shape, plastering can be reduced from the normal 25-40 mm thickness to less than

ISSN 2229-5518

10mm.

- Fire resistance is excellent, because it is noncombustible and it will not burn or give off toxic fumes.
- In addition to light weight it also gives a high sound reduction for privacy, both from outside noises and from other rooms when used as interior partition walls.
- Since aerated concrete blocks weigh lesser, the dead load is lesser on the structure and hence the structure is subjected to lower load leading to economical designe.
- The weight of one hollow Aerated concrete block is only 9.6 kg compared to about 36 kg for an equivalent solid concrete block. Hence construction will be fast resulting in labour and consequent cost saving.

2 Tests on Aerated Concrete Blocks

In this paper an attempt has been made to compile the information on the absorption characteristics, wet compressive strength, density of aerated concrete blocks and stress-strain characteristics.

2.1 Initial Rate of Absorption

Initial rate of absorption (IRA) test was conducted, in accordance with ASTM C 67 [2]. The specimen was kept in a tray containing distilled water up to a depth of 25 mm from the bottom of the tray for 60 Seconds. Later, the specimen was removed from the tray and weighed, thus the initial rate of absorption is obtained and the results are presented in Table 1. It can be noted that the range of IRA values is quite similar to that of any common type of masonry unit.

TABLE1

Initial Rate of Absorption of ACB

Specimen No.	I.R.A ($kg/m^2/min$)	Average I.R.A ($kg/m^2/min$)	C O V
1	1.93	1.85	0.06
2	1.90		
3	1.70		
4	1.70		
5	1.93		
6	1.93		

2.2 Dry Density

This test was carried out on blocks samples collected randomly in and around Bangalore City. IS: 2185-(Part I) 1979 [3] specifications were followed to conduct this test. The results are presented in Table 2. The extremely low density is an interesting result to be noticed.

TABLE 2

Dry Density of ACB

Specimen No.	Volume (mm^3)	Dry Density (kg/m^3)	Average Dry Density (M Pa)	COV
1	200x200x200	601.50	597.42	0.011
2	200x200x200	589.25		
3	200x200x200	607.50		
4	200x200x200	591.25		
5	200x200x200	596.45		
6	200x200x200	598.60		

2.3 Water Absorption

The blocks were tested in accordance with the procedure laid down in IS: 2185 (Part I)-1979[3]. The code specifies two methods to be adopted, by 5 hour boiling water test or the 24 hour cold water immersion test. The latter method was adopted. Water absorption for blocks should not be greater than 20% by weight up to class 12.5 as per IS: 1077-1992 [4] specifications. The result of the water absorption test is presented in Table 3.The test clearly indicates the very high water absorption. This is beyond the permissible units of 15 to 20%.

TABLE 3

Water absorption of ACB

Specimen No.	Water Absorption (%)	Average Water Absorption (%)	C O V
1	36.97	36.08	0.03
2	35.68		
3	37.26		
4	34.93		
5	35.37		
6	36.32		

2.4 Wet Compressive Strength

The compressive strength of the block is the main contributing factor for the strength of masonry. IS: 2185 (Part-I)-1979 [3] specifies the minimum compressive strength. The minimum compressive strength for a non-load bearing unit is 1.2MPa while that for a load bearing unit, it varies from 1.6MPa to 5.6 MPa. This test was conducted as per the specification laid in the IS: 3495-1992 [4]. For the Aerated concrete blocks the wet compressive strength has been presented in Table 4. The compressive strength is indicative of the minimum acceptable value.

ISSN 2229-5518

TABLE 4

WET COMPRESSIVE STRENGTH OF AERATED CONCRETE BLOCKS

Specimen No.	Wet Compressive Strength (N/mm^2)	Average wet Compressive Strength Average (MPa)	C O V
1	3.28	3.2	0.10
2	3.31		
3	3.06		
4	2.85		
5	3.75		
6	2.94		

2.5 Flexural Strength Test

This test was conducted as per the guidelines, given in the reference by Dayaratnam [5]. The test specimen was placed centrally on two roller supports and load was applied through another roller, taking care not to cause local failure. The transverse load was applied at a uniform rate not exceeding 300 N/min through the central roller. The individual breaking load was recorded and flexural strength was calculated using pure bending equation. The flexural strength test results are presented in Table 5. As compared to other masonry units, the flexural strength is relatively high especially for blocks having compressive strength in the range of 3.5 MPa.

TABLE 5

FLEXURAL STRENGTH OF AERATED CONCRETE BLOCKS

Specimen No.	Span Length (mm)	Breadth (mm)	Depth (mm)	Flexure Strength (N/mm^2)	Average Flexure Strength MPa	C O V
1	150	100	100	0.56		0.35
2	150	100	100	0.62	0.44	
3	150	100	100	0.50		
4	150	100	100	0.23		
5	150	100	100	0.43		
6	150	100	100	0.29		

2.6 Stress-Strain Characteristics

Strain measurements were carried out on the block specimens with a uni-axial compressive load applied parallel to its length in a 600kN UTM. Steel plates were placed on the specimens to facilitate uniform compression. The strains were measured using a demountable mechanical strain gauge of 100mm gauge length. The relative deformation of the studs mounted on the specimen was measured using a digital dial gauge of least count 0.001mm.

The stress strain values were computed and a best fit graph was plotted to obtain the modulus of elasticity of the block specimens. Plate 1 shows a specimen being monitored for strain measurement under compressive loading. Figure 1 show the best fit curve obtained from the test conducted on several specimens.

Plate 1: Stress-strain measurement under compressive load

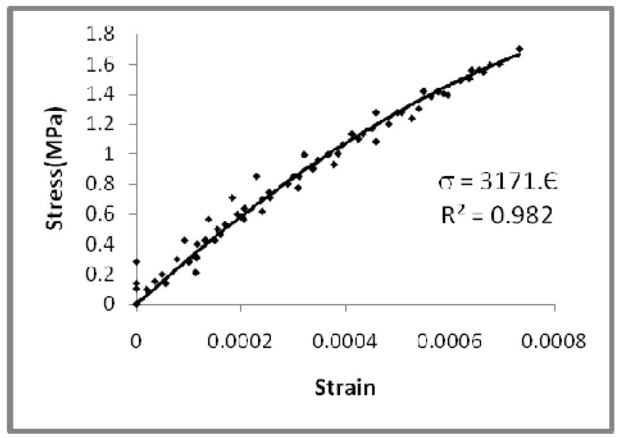

Fig 1: Stress-Strain plot for ACB blocks

3 COMPARISON OF RESULTS

As mentioned earlier, there has been rather scanty information on the physical, strength and elastic properties of Aerated concrete blocks. The present investigation has endeavored to study all such properties. Having obtained the results, it would now be interesting and useful to compare the results with that of conventional masonry. Very recently Mangala Keshava [6] has carried out an extensive study on the strength and elastic properties of a variety of masonry available in and around Bangalore (South India). The results obtained by her have been used to compare with the investigations [6] carried out in the present study.

Legend

ACB: Aerated Concrete Block
TMB: Table molded brick
WCB: Wire cut brick
SCB: Solid concrete block (150mm and 200mm thick)
HCB: Hollow concrete block (150mm thick)
SMB: Stabilized mud blocks, 8% cement (143mm thick)

i. Initial Rate of Absorption (IRA)

Figure 2 gives a similar comparison of IRA values of a variety of blocks.

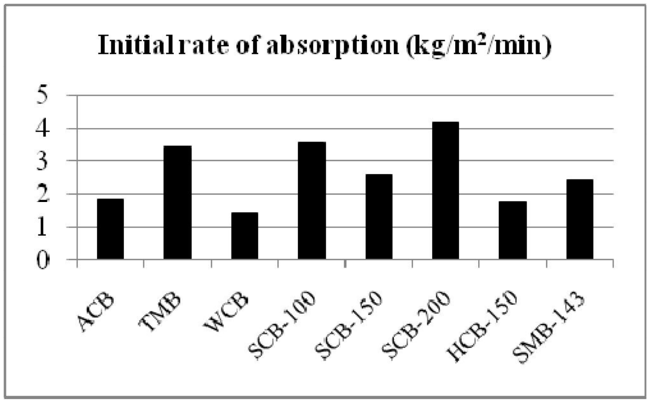

Fig 2: Comparison of IRA values of different types of units

It can be noted that the IRA values of ACB masonry unit is much lower than that of conventional solid concrete block masonry unit. This is because the concrete block units have larger porosity and capillary action, while the pores in ACB units are discontinuous, through well dispersed.

ii. Block density:

Figure 3 gives a comparison of the block density of a variety of masonry units. One of the major merit of ACB block is its extremely low density, which is less than even that of ACB units, by nearly 50%.

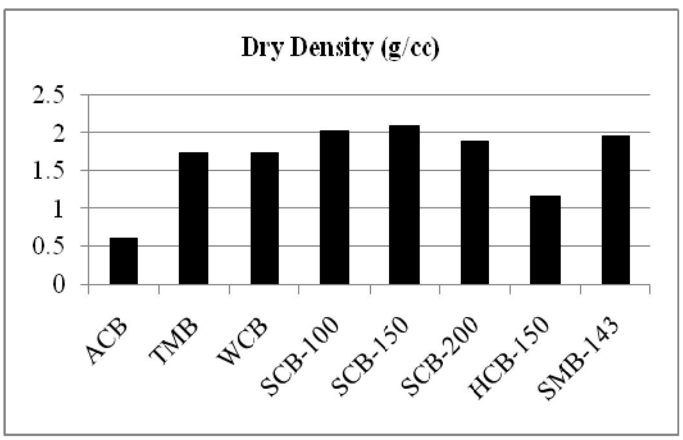

Fig 3: Comparison of IRA values of different types of units

iii. Water absorption

Figure 4 gives a comparison of water absorption of a variety of units. As compared to all other types of blocks, the water absorption of ACB is rather higher. This is a relative demerit of ACB. There is a need for manufacturer to find ways of reducing water absorption.

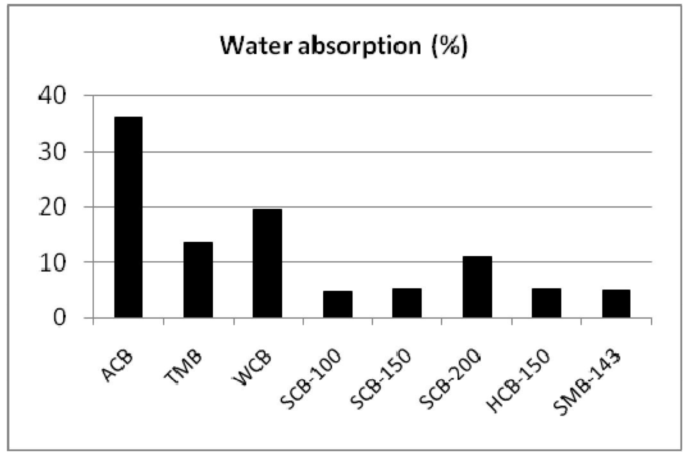

Fig 4: Comparison of water absorption of different types of units

iv. Wet compressive strength

Figure 5 gives a comparison of compressive strength of a variety of units. The compressive strength of ACB, as compared to other units, is relatively on the lower side. However, it satisfies the minimum requirement.

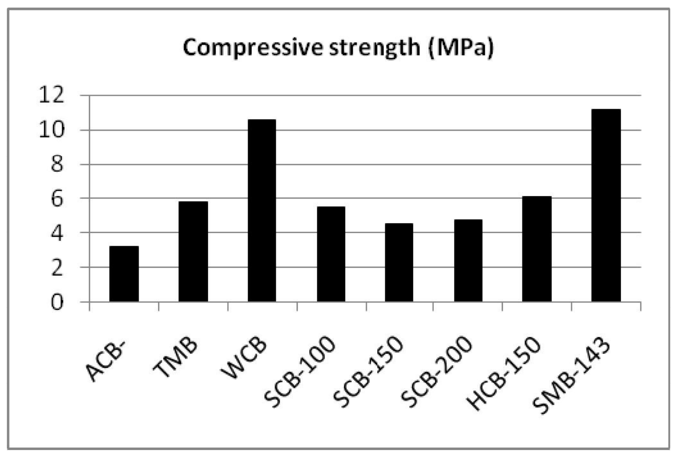

Fig 5: Comparison of wet compressive strength of different types of units

v. Modulus of Elasticity

Figure 6 gives a comparison of modulus of elasticity of a variety of units. It is intersting to note that, although the density is low and compressive strength is relatively low, the modulus of elasticity of ACB is relatively high.

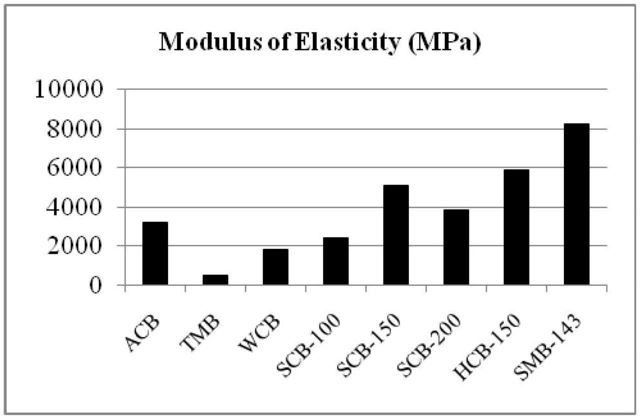

Fig 6: Comparison of modulus of elasticity of different types of units

vi. Flexural strength

Figure 7 gives a comparison of flexural strength of a variety of units. The flexural strength of ACB is comparable with that of table moulded bricks, but relatively less than that of concrete block units.

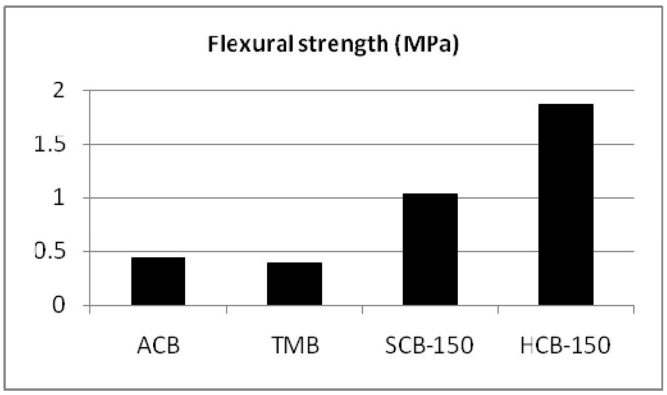

Fig 7: Comparison of flexural strength of different types of units

4 Conclusions

1) Solid concrete blocks possess more Initial rate of absorption since they are generally manufactured using bigger sized fine aggregates and thus tend to have more pores. These pores may enhance the capillary action and thus leading to higher Initial rate of absorption. On the other hand Aerated concrete blocks possesses fine discontinuous pores and blocks the movement of water through the body and therefore it is seen to possess low Initial rate of absorption values.
2) Aerated concrete block has the least density when compared to any other type of masonry unit. Indeed the extremely low density is extremely favorable to structures due to the great reduction in self weight and thus may resulting in lower structural costs.
3) The water absorption is extremely high, indeed more than what the IS code specify. This aspect is detremental to the performance in terms of durability. Perhaps there is a need to look into this aspect in great detail; otherwise the low density benefit will be offset by the unwanted need to protect it by water ingression.
4) Aerated concrete block units has the least compressive strength when compared to any other type of masonry unit. It, however, meets the minimum requirement.
5) It is extremely interesting to note that, although the compressive strength is low, the modulus of elasticity is very high compared to the common table moulded bricks and Solid concrete blocks. This may find special benefit in the limiting deflection due to lateral loads.
6) The flexural strength of Aerated concrete block units is favourable for structural purposes. Flexural strength is suggestive of the benefit of Aerated concrete block as compared to table moulded bricks. However, it is here that hollow and solid concrete blocks perform much better.

References

[1] Narayanan N, Ramamurthy K " Structure and Properties of aerated concrete: A review", *Cement and Concrete composites*, 2000, 22, pp 321-329.

[2] ASTM C-67, *"Standard Test Methods of Sampling and Testing Brick and Structural Clay tile"*, ASTM Standards, 1995.

[3] IS: 2185-1979, *"Specification for concrete masonry units Part I Hollow and solid concrete blocks"*, Bureau of Indian Standards, New Delhi, India, Reaffirmed 1998.

[4] IS: 3495-1992, *"Methods of Test for Burnt Clay Building Bricks"*, Bureau of Indian Standards, New Delhi, India.

[5] Dayaratnam P, "Brick and Reiforced Brick Structures", Oxford IBH Publishing Co.Pvt.Ltd.,New Delhi, India,1987.

[6] Mangala keshav "Behaviour of Masonry Under Axial Eccentric and Lateral Loading" Ph.D Thesis, Visvesvaraya technological University, Belgaum, India, 2012.