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# Investigation on behaviour of AAC Wall Panel with different Types of Welded Wire Fabric Reinforcement

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**Abstract—***In this paper a typical AAC wall panel is design to resist the load that come on the panel such as wind load, self-weight and handling stresses during erection, placement, and any accidental load. Wall panel currently manufactured have high reinforcement which is responsible for high cost. To address the problem in present study slabs with varying percentage of reinforcement are used in manufacturing of slab. In addition the autoclaving process induces high thermal stress which can lead to cracking of wall panel due to thermal expansion of embedded steel reinforcement and larger spacing between the reinforcement. An attempt has been made to reduce the cost of the reinforcement by using closely spaced and small diameter wielded wire mesh reinforcement and they are also used to overcome the problem of thermal cracking. Four wall panels with different percentage of reinforcement are prepared and tested under uniformly distributed load as conform to IS 6072.1971. The test results showed that the panel with reduced diameter and reduced reinforcement spacing free from thermal crack. However except for one type of wall panel all other panel showed higher deflection than the permissible deflection as per IS 6072.1971 under the permissible load of 1kN/m$^2$. Therefore it can be reduced by using higher-grade steel to overcome the above problem.*

**Keywords***: AAC(Autoclave aerated concrete),wire mesh, Aluminum powder.*

## 1. INTRODUCTION

Autoclaved Aerated Concrete (AAC) are ultra-light-weight concrete with a unique cellular structure that provides superior energy efficiency, fire resistance and acoustical properties. AAC has become highly popular in India especially with the growth in multi-storey apartments or commercial complex. It has wide application of roof panel and wall panel for internal using structure and partition walls and non-load bearing walls and light load floor slabs. AAC is composed of cementitious mortar surrounding disconnected air voids and microscopic air bubbles. The air bubbles are the results of gas formed within the mortar. High temperature and pressure steam help to create this autoclave cured concrete, which is rapidly formed and has dense microstructures. Reinforced autoclaved aerated concrete (RAAC) components are designed and manufactured in a manner different from normal dense concrete components because of the different characteristics and material properties of AAC. AAC can provide as much as a 70% weight reduction in the wall panel. However, insufficient information available on AAC wall panel's in-plane structural behaviour limits the use of such AAC panels for its conventional applications in seismic regions. AAC production technologies are energy-efficient and consume low quantities of raw materials as compared to the production of other construction materials, which can be attributed to low density and a special waste free and environmental friendly production formula of AAC. Typical AAC density is between 450 and 1,000 kg/m3.

### 1.1 Advantage of and application of AAC

The cellular concrete is considered more durable compared to traditional insulating materials, especially when considering potential chemical fire exposure such as in process facilities. Lightweight concrete has its obvious advantages of higher strength to weight ratio, better tensile strain capacity, lower coefficient of thermal expansion, and enhanced heat and sound insulation characteristics due to air voids in the concrete. The reduction in the dead weight of the construction materials using lightweight concrete could result in a decrease in cross-section of concrete structural elements (columns, beams, plates and foundation). In addition, the reduction in dead load may reduce the transmitted load to the foundations and bearing capacity of the soil. Subsequently, steel reinforcement can be minimized due to the lightweight. AAC blocks can be appropriate in different parts of building; it can be used in both non-load bearing and load bearing walls. Autoclaved aerated concrete blocks can be applicable in construction engineering (compensation for the foundation, pipeline backfilling, roof insulation, etc.), but also get some application results in infrastructure facilities (such as bridge and culvert backfill, road widening, resolving bumping at bridgehead of soft base embankment.

## 2. MANUFACTURING PROCESS OF AAC WALL PANEL IS DIVIDED IN TO FOUR STAGES

1. Sand slurry preparation
2. Reinforcement
3. Batching
4. Casting
5. Cutting
6. Autoclave steam curing
7. Separating

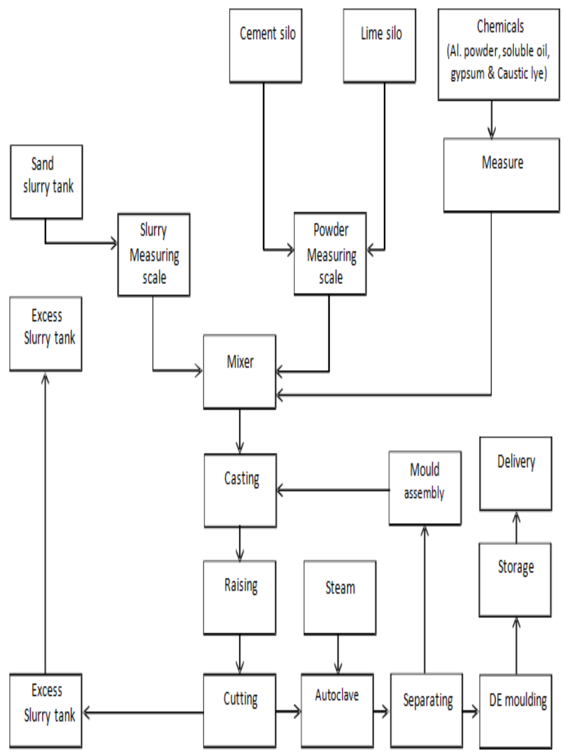


**Fig. 2.1: AAC production process flow chat**

**Table 2.1: Process timing**

| Sl. No | Process | Standard cycle time | Remarks |
|---|---|---|---|
| 1 | Batching | 15 | No lagging time |
| 2 | Hardening time | 180 | Every 15 min one mould is coming for cutting |
| 3 | Cutting time | 15 | Taking moulds for cutting-6 min |
| | | | Cutting time-7 min |
| | | | Tilting and placing on the steam trolley-7 min |
| 4 | Waiting period | 180 | Waiting period-180 min |
| 5 | Autoclaving | 780 | Loading time-10 min |
| | | | Door closing and vacuuming-30 min |
| | | | Rising time-150 min |
| | | | Content period-420 min |
| | | | Releasing time-150 min |
| | | | Unloading time-20 min |
| 6 | DE moulding | 15 | No lagging time |

## 3. THE MATERIAL USED AND THERE IMPORTANCE IN THE MANUFACTURING OF SLAB

a. Silica Sand b. Cement

c. Lime d. Caustic lye

e. Gypsum f. Magnasite

g. Casein h. Acetylalcohol

i. Sodium gluconate j. Thinner

k. Aluminium powder l. Reinforcement

m. Silicon oil n. Inertol

**o. Latex**

**a.** Silica sand mainly contains normally more than 95% $SiO_2$ that is used for this exemplary work. They are produced from both loosely consolidated sand deposits and by crushing weak cemented sandstone. The use of aggregates provides volume stability to the hardened concrete. The shrinkage potential of a cement paste is quite high when compared to the aggregates. Controlling shrinkage of the concrete material is important since shrinkage and cracking potential increase together.

**b.** Cement is a material that has cohesive and adhesive properties in the presence of water. Such cement are called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. Ordinary Portland cement of 53 grades (IS:12269-1987) is used as binding material.

**c.** The process by which lime (calcium carbonate) is converted to quicklime by heating, then to slaked lime by hydration, and naturally reverts to calcium carbonate by carbonation is known as the Lime Cycle. The conditions and compounds present during each step of the lime cycle have a strong influence of the end product, thus the complex and varied physical nature of lime products. The powdered lime stored in silo is used in the manufacturing of AAC wall panel.

**d.** Caustic lye is used to dissolve the casein

**e.** Gypsum forms as an evaporate mineral and as a hydration product of anhydrite.

**f.** Casein is used as gluing agent.

**h.** Acetyl alcohol is used to control the formation of air bubbles and dissolve the air bubbles.

**i.** Mineral turpinten oil used as thinner material to maintain the viscosity of inertol during application to the reinforcement.

**j.** Aluminium is used as a foaming agent in AAC production and it is widely proven as the best solution for its purpose. When aluminium is added to the mixing ingredients, it reacts with hydroxide of calcium or alkali, which liberates hydrogen gas and forms bubbles. The speed at which the air bubbles form is critical to the success of the final aerated concrete product.

**k.** Silicon oil used as water repellent in manufacturing of AAC products.

### 3.1 Material Properties of AAC Wall Panel

1. Slab dimension = 2500*600*75 mm
2. Density = 6.4 kN/m3
3. Modulus of elasticity = 2.1X 106 kN/m2
4. Characteristic compressive strength = 3.5 – 4 N/mm2
5. Reinforcement cover = 15 mm
6. Load = 1.128 kN.$m^2$
7. Wire mesh of 2.9, 3.4, 4 mm diameter and 100 mm spacing

**Table 3.1 Characteristics of series of slab**

| Sl no | Panel specimens | Dimension (mm) | Main reinforcement(mm) | Transverse reinforcement(mm) | Number layers |
|---|---|---|---|---|---|
| 1 | P1 | 600*2500*75 | 8 | 5.5 | 2 |
| 2 | P2 | 600*2500*75 | 2.9 | 2.9 | 2 |
| 3 | P3 | 600*2500*75 | 3.4 | 3.4 | 2 |
| 4 | P4 | 600*2500*75 | 4 | 4 | 2 |

## 4. CUBE COMPRESSIVE STRENGTH

**Table 4.1: Compression strength result**

| TESTS ON BASIC MATERIAL PROPERTIES (as per IS:6441(part-V)(1973) | | | | | | |
|---|---|---|---|---|---|---|
| Sl No | Specimen type | Specimen size , mm | Type of Test | Failure Load, kN | Strength, MPa | Average strength, MPa |
| 1 | Cube | 150x150x150 | Compression | 100 | 4.44 | 3.80 |
| | | | | 68 | 3.02 | |
| | | | | 89 | 3.95 | |

## 5. DENSITY AND MOISTURE ABSORPTION

**Table 5.1 Density and moisture absorption results**

| TESTS ON BASIC MATERIAL PROPERTIES as per IS:6441(part-I)(1972) | | | | | | |
|---|---|---|---|---|---|---|
| Sl No | Specimen type | Specimen size , mm | Type of Test | volume | Density ($kg/m^3$) | Moisture (%) |
| 1 | Cube | 75X75X75 | Density and moisture absorption: | $4.128X10^{-6}$ | 550.37 | 1.61 |
| | | | | | 544.54 | 2.51 |
| | | | | | 589.67 | 1.65 |
| | | | | Avg | 561.53 | 1.93 |

## 6. DRYING SHRINKAGE

**Table 6.1 Drying shrinkage results**

| Sl no | Specimen dimension | Avg.drying shrinkage | Requirement as per IS 6072 (part II) 1971 |
|---|---|---|---|
| 1 | 40X40X160 | 0.0166 % | 0.09 % max |

## 7. RESULTS AND DISCUSSIONS

### 7.1 Testing of Wall Panels

Seven wall panel having different reinforcement pattern had tested in this investigation to explore the possibility to reducing the reinforcement percentage. The details of wall tested are given in as per IS: 6072-1971

1. The slab is placed on two supports so that the (ace surrounded by the length and breadth of the slab is horizontal and the centre-to-centre distance between the supports (called effective span) is equal to the length of the slab.
2. The slab is loaded for half an hour with half the design load; this load being applied vertically and uniformly distributed all over the slab.
3. After half an hour without removing, the load applied in step 2, the balance half of the full design load is applied in the same manner as in step 2
4. The total design load is kept in position for half an hour after which the sample shall be examined for any cracking and maximum deflection at mid-span of the slab for the full load (design imposed load + self-weight of slab) shall be measured.
5. If the sample has cracked or if the maximum measured deflection is more than l/300 of the effective span, the sample shall be considered to have failed the test

### 7.2 ULTIMATE LOAD

Unless cracks have occurred under the design load, the sample as loaded in step 4 shall be loaded further in suitable increments of load until the slab fails. The total load at failure shall be considered as the ultimate load.

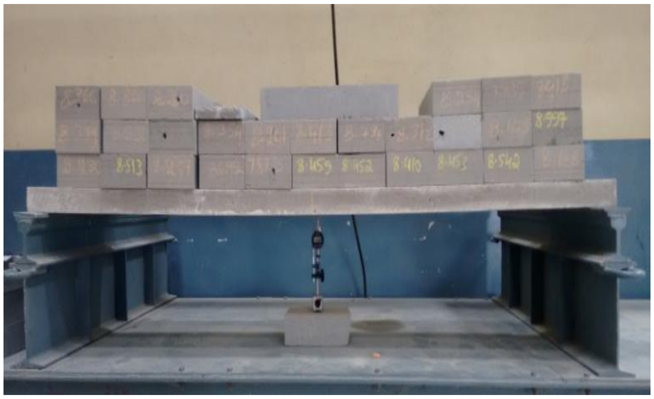

**Fig. 7.1: Ultimate load arrangement on wall panel**

### 7.3 Test Results

Seven wall panels were tested under UDl load with static incremental loading. In all panels have been loaded and the results are noted. The load at which the first visible crack developed is recorded as cracking load. Then the load is applied until the specimen fails or terminal deflection level of 12 mm (i.e 1.5 times the allowable deflection as per IS: 6072.1971) is reached. The test results are tabulated in table 7.1 to 7.4

**Table 7.1: Load deflection for panel P1**

| Sl. No | LOAD (kN) | DEFLECTION (mm) | REMARKS |
|---|---|---|---|
| 1 | 0.68 | 2.85 | |
| 2 | 1.02 | 5.35 | |
| 3 | 1.2 | 7.4 | |
| 4 | 1.77 | 10.34 | First crack |
| 5 | 2.66 | 12.89 | Ultimate load |

**Table 7.2 Load deflection for panel P2**

| Sl. No | LOAD (kN) | DEFLECTION (mm) | | REMARKS |
|---|---|---|---|---|
| | | P 2-1 | P 2-2 | |
| 1 | 0.25 | 0.92 | 0.89 | First crack |
| 2 | 0.50 | 2.13 | 2.16 | |
| 3 | 0.75 | 3.62 | 3.68 | Ultimate load |

**Table 7.3 Load deflection for panel P3**

| Sl. no | LOAD (kN) | DEFLECTION (mm) | | REMARKS |
|---|---|---|---|---|
| | | P 3-1 | P 3-2 | |
| 1 | 0.25 | 1.19 | 1.25 | |
| 2 | 0.50 | 3.03 | 3.05 | |
| 3 | 0.75 | 5.58 | 5.61 | First crack |
| 4 | 1.0 | 11.67 | 11.82 | Ultimate load |

**Table 7.4: Load deflection for panel P4**

| Sl. no | LOAD (kN) | DEFLECTION (mm) | | REMARKS |
|---|---|---|---|---|
| | | P 4-1 | P 4-2 | |
| 1 | 0.25 | 0.88 | 0.91 | |
| 2 | 0.50 | 2.27 | 2.15 | |
| 3 | 0.75 | 4.8 | 4.69 | |
| 4 | 1.0 | 8.14 | 7.98 | First crack |
| 5 | 1.25 | 9.64 | 9.83 | Ultimate load |

### 7.4 Load Deflection Characteristics

i. The control panel P1 shows some non-linear load deflection characteristic from the beginning but after reaching the deflection of 2mm, it shows nearly linear deflection characteristic. The panel develops the first crack after reaching the deflection of 9.2 mm, as shown in Fig 8.1 which is well above the prescribed deflection of 8 mm at first rack. The panel continues to take additional load after visible crack and test was terminated when deflection reaches about 11 mm.

ii. As per IS:6072.1997 the maximum deflection at first crack should not exceed 8 mm. in the present study panel P2 develop first crack and collapse at deflection of 4 mm and the load of 0.75 kN, as shown in Fig 8.2a,8.2b. This is due to high degree of under reinforcement of panel which is just equal to the minimum reinforcement specified in codal ($A_{st}/bd = 0.85/f_y$). The load deflection characteristic is nearly linear up to failure.

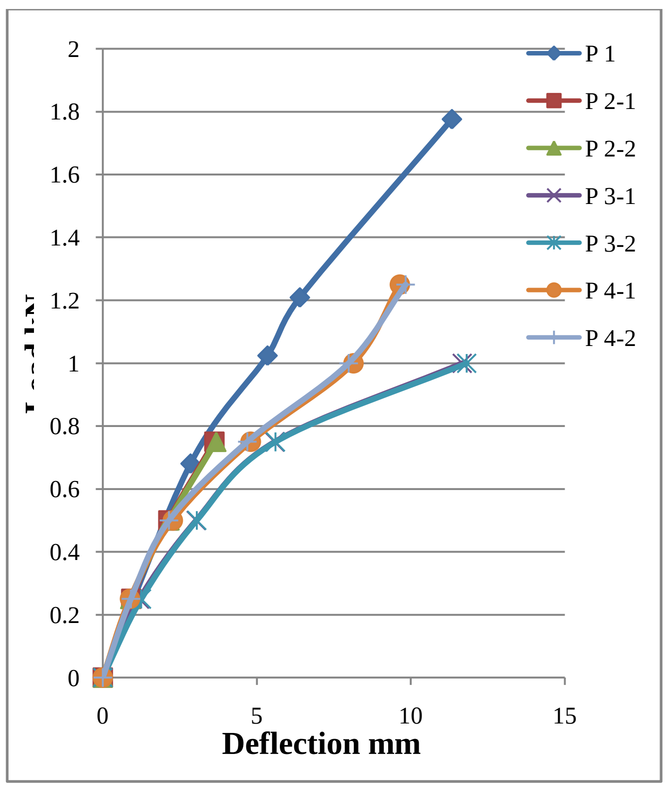


**Fig. 7.2: Load v/s mid span deflection for all panels**

iii. Panel P3 shows small linear portion of load deflection characteristic and there after nonlinear deflection characteristic up to the maximum load of 1 kN. It is seen from Fig 8.3a, 8.3b reinforcement yielding and panel show linear ascending load deflection characteristic after development of first crack at 0.75 kN. The test was terminated after deflection level reach 12 mm i.e (1.5 times prescribed maximum deflection limit).

iv. Panel P4 shows nearly linear characteristic up to deflection of 8.14 mm up to developing first visible crack and it is likely continued to take additional load till test was terminate when the deflection reached

## 8. CONCLUSION

i. The panel P2, P3, P4 doesn't satisfied the codal requirement IS: 6072.1971 on deflection

ii. The wall panel carried 1.5 times higher load than the design load of 1kN.

iii. The crack patterns of P3 and P4 show that they are likely to fail by flexure for load exceed at terminal deflection.

iv. Crack produced in the autoclave process was not observed in P2, P3 and P4 whereas control panel P1 shown visible crack after autoclave process this is attributed to the better provision of reinforcement consisting smaller diameter bar and closely spaced reinforcement compared to control panel P1.

v. The deflection at first crack can be reduced by using higher-grade steel i.e Fe 500 and by arranging closely spaced reinforcement.

## REFERENCE


[1] Anthony Gates and Guy Marriage "Autoclave Aerated Concrete as a suitable alternative to conventional concrete in a seismically active location" 44th Annual Conference of the Architectural Science Association, ANZAScA 2010, unitec Institute of Technology.

[2] Boshra Aboul-Anen, Ahmed El-Shafey, and Mostafa El-Shami "Experimental and Analytical Model of Ferro cement Slabs" International Journal of Recent Trends in Engineering, Vol. 1, No. 6, May 2009.

[3] Georgijus SEZEMANAS, Marijonas SINICA, Petro ZACHARČENKO, "Influence of Zeolite Additive on the Properties of Plaster Used for External Walls from Autoclaved Aerated Concrete" ISSN 1392–1320 MATERIALS SCIENCE Vol. 19, No. 2. 2013.

[4] Ali J. Hamad "Materials, Production, Properties and Application of Aerated Lightweight Concrete" International Journal of Materials Science and Engineering Vol. 2, No. 2 December 2014.

[5] N.Narayanan, K. Ramamurthy "Structure and properties of aerated concrete" Cement & Concrete Composites 22 (2000) 321-329.

[6] IS:6072-1971 Specification for Autoclaved Reinforced Cellular Concrete Wall Slabs.

[7] IS: 6441(Part I - IX) –1972 Methods Of Test For Autoclaved Cellular Concrete Products

[8] L.S.Negi & R.S.Jangid, "Structural Analysis", Tata McGraw-Hill Publications, New Delhi, 2003

[9] N. Krishnaraju, *Advanced Reinforced Concrete Design*, 3rd Edition, CBS Publishers, New Delhi

[10] Rudolph Szilard, Dr.-Ing., P.E **"**Theories and Applications of Plate Analysis" Published by John Wiley & Sons, Inc., Hoboken, New Jersey. Published simultaneously in Canada