ACOUSTIC PROPERTIES OF AERATED CONCRETE

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Abstract - *This paper discusses acoustic properties of aerated concrete aerated by colloidal gas aphrons.. The dependence of acoustic resistance on density of light weight material has been discussed. Two different sound levels at source have been used to study the change in sound resistance with density, and surface density. Sound absorption coefficients have been also studied with respect to density of the material.*

Keywords: Density, Surface area Density, Sound absorption Coefficient, Colloidal gas aphrons.

1. INTRODUCTION

Aerated concrete is produced by incorporating air or an inert gas in cement or cement-mortar matrix. It does not have coarse aggregates. The physical properties of aerated concrete are density dependent and those in turn depend upon the total number of voids and their size and spatial distribution in it. One of the most desired properties of aerated concrete is acoustic resistance. The acoustic resistance is dependent on density and surface area density of the material. The sound absorption coefficient is characteristic property of the material.

Acoustic resistance: Aerated concrete has better insulation properties to sound transmitted by air than of other solid building materials like dense concrete, clay bricks etc. under comparable conditions. The sound insulation of solid, one leaf homogeneous wall is primarily dependent on the weight per unit area, i.e. its surface related mass. The generally accepted relationship for solid walls' sound insulation is given by Berger's law (RILEM, 1993) as follows:

$$Rs = 14.5 \log(m) + 10 \text{ dB} \quad \ldots(1)$$

Where,

Rs =sound reduction index (dB),

m = mass of the element (kg/m2), also known as surface density.

Sound absorption is a property different from sound insulation. Sound absorbing material reduces the sound reflection from a surface, while sound insulating material reduces the sound passing through. The sound absorption coefficient indicates how much of the sound is absorbed in the actual material. The absorption coefficient can be expressed as (Halliday et al., 1997) follows:

$$\alpha = Ia / Ii \quad \ldots(2)$$

Where,

α = absorption coefficient,

Ia = sound intensity absorbed (W), and

Ii = incident sound intensity (W).

Most aerated concretes show moderately good sound absorption. One of the advantages of absorbent light-weight concretes over denser materials when used in cavity construction is the "built-in" absorption which is provided in the cavity, thus giving the effect of a sound-absorption quilt, a sound attenuating expedient which is sometimes used in cavity walls.

2.0 MATERIALS USED

Aerated concrete has been prepared by aerating cement paste, cement fly ash paste, and cement GBFS mix. The aerating agent used is Colloidal gas aphrons (CGAs). Aerated concrete of different densities in a particular sort of mix has been produced by using different volumes of CGAs.

3.0 EXPERIMENTAL METHODS

3.1 Preparation of CGAs

CGAs were produced by stirring a mixture of water and surfactant (sodium lauryl sulphate) at a high stirring rate of around 6000 rpm in CGAs generator (Sebba, 1971). The measured air hold-up was 0.70 and unit weight of CGAs produced was 326.14 kg/m3.

3.2 Preparation of aerated concrete mixes

Aerated concrete mixes were prepared in a planetary mixer (IS: 10890-1984). In each mix, cement to fine aggregate (any one out of Ennore sand lowest fraction, fly ash, or GBFS) ratio was maintained at 0.3, whereas water to total solids ratio was maintained at 0.5. In each mix, addition of CGAs was varied from zero ml upto 800 ml in an increment of 200 ml. In this way, a total of fifteen mixes were prepared (table 2). CGAs had air-holdup of 0.70 and hence, contained 30% of water. This water content of CGAs was accounted for in calculating the total water volume to be added for maintaining water to solid ratio at 0.5. Pastes were poured in 20cm x 12 cm x 5 cm mould, cured in air for 24 hrs followed by 28-days water curing. Mortar cubes were dried at 105±2C to a constant weight. A wood piece of same dimension was also taken.

3.3 Acoustic studies

To study the acoustic resistance of the given bricks, a wooden box was designed with a sliding opening. The box was fully lined with acoustic resistant material (polystyrene) to avoid disturbance from external noise persistence. Two side holes were provided in the box for placing noise-level meter inside the box, so that the noise could be measured both at the source and at the receiver end. The noise meter used was SVAN 945 A. The noise level was measured at each side for 1 minute continuously and the time-average value was given by the instrument. The acoustic testing set-up is shown in figure-1.

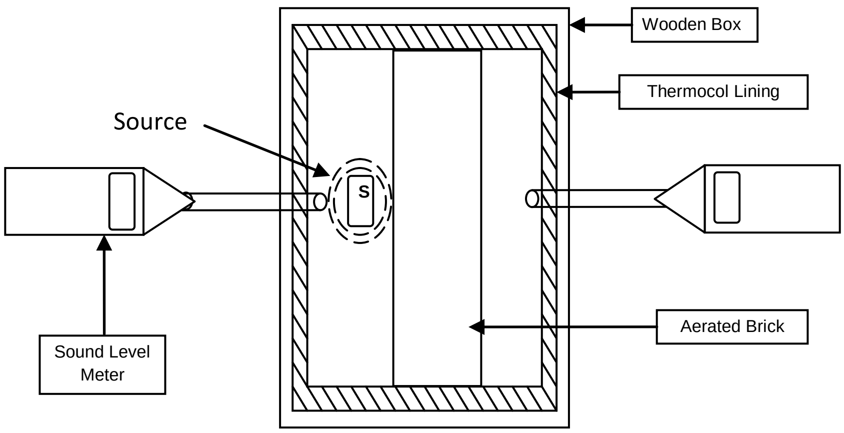

Figure-1: Schematic diagram of set-up for acoustic testing of aerated concrete

Acoustic resistance testing was carried out by placing one brick at a time inside the box-at the center of the box. The sound source of 500 Hz was placed at one side of the brick and the noise level was measured at the other side. A noise-level meter each was placed at the sound source and at the other side of the brick to record the sound levels both at the source and at the receiver ends. The sound-levels were measured in dB at the source and receiver sides. Two tests were carried out by varying the sound level at the source. One of the tests was carried out by keeping the source-sound level constant at 71 dB, and the other test was carried out at a level of 108 dB. The sound pressure in dB was converted into sound intensity (W/m2). The reduction of the sound intensity from source to receiver end was also calculated. Sound-absorption coefficient was also determined for each sample, (and the wooden plank taken for comparison) measuring the sound levels at the other side of the sample using the apparatus shown in Figure-1.

4.0 RESULTS AND DISCUSSION

Acoustic characterization of aerated concrete was done in terms of relative sound reduction, sound reduction per unit surface area, and sound absorption coefficient. Two tests were carried out varying the sound level at source. First test was carried out keeping the source sound level constant at 71 dB, and the other test was carried out at a constant sound level of 108 dB. Relative sound reduction index and sound absorption coefficient were determined for each sample measuring the sound levels at the source and the receiver side. At each side, the sound level was corrected by subtracting the reference sound level. Reference sound level is the sound level when no source sound was placed at source side. Reference sound level indicated the sound level of the environment of the experimental set up.

The reference sound level was measured each time the sample was placed in the designated position and the sound source of the experiment was not placed. In every measurement, the reference sound level determined was 2 dB. Sound insulation was determined from the difference of sound levels at source and receiver sides, and was reported in dB. Surface density was calculated for each sample and the sound-level reduction was also reported per unit surface density as in Table-1.
The "Mass Law" states that the sound insulation has a linear relationship with the surface density (i.e. mass per unit area) of the partition, and increases with the frequency of the sound.

Table-1: Relative sound-level reduction in aerated concrete (thickness 0.05 ⊡ 0.002 m)

Sample	Density, (kg/m^3) water/solid=0.4	Area density, (kg/m^2)	Sound-level reduction at source sound level 71 dB ±0.5		Sound-level reduction at source sound level 108 dB ±0.5	
			dB	dB /area density	dB	dB /area density
Cement+fly ash+water	1402	74	11.0	0.149	32.2	0.435
Cement+fly ash+ water+CGAs 200 ml	1197	69	10.0	0.145	29.3	0.425
Cement+fly ash+ water+CGAs 400 ml	1186	62	9.0	0.145	32.5	0.524
Cement+fly ash+ water+CGAs 600 ml	1034	56	7.0	0.125	30.8	0.550
Cement+fly ash+ water+CGAs 800 ml	919	45	4.0	0.089	25.3	0.562
Cement+GBFS+water	1209	58	7.0	0.121	28.6	0.493
Cement+GBFS+water+CGAs 200 ml	1081	53	11.0	0.207	28.4	0.536
Cement+GBFS+water+CGAs 400 ml	1029	50	11.0	0.220	29.1	0.582
Cement+GBFS+water+CGAs 600 ml	1016	49	10.0	0.204	28.7	0.586
Cement+GBFS+water+CGAs 800 ml	997	38	9.0	0.236	28.4	0.747

In the present study, insulation had more than doubled when surface density had been less than halved. Sound-level reduction (dB) was consistently getting reduced with decreasing surface density in both the mixes at 71 as well 108 dB sound level of source (Figure-2). The dB per unit surface density had shown a decreasing trend with increasing dry density of the aerated concrete at 108 dB (figure-3). The trend was more regular in case of cement-GBFS mix at 108 dB.

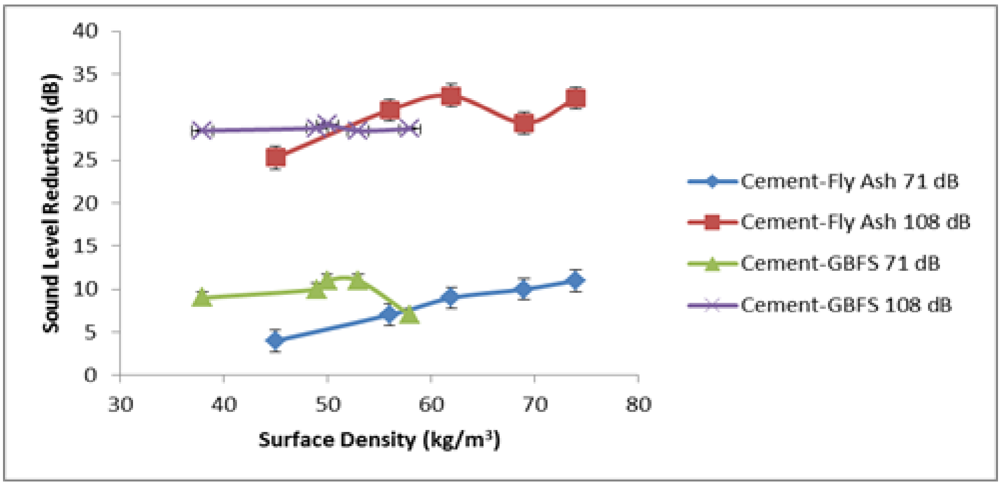

Figure-2: Relative sound level reduction vs. surface density

Sound-reduction values were found to be higher for all systems at the higher sound-pressure level. Thus, it showed interestingly that each systems' capacity to insulate increase when the pressure level of sound was increased.

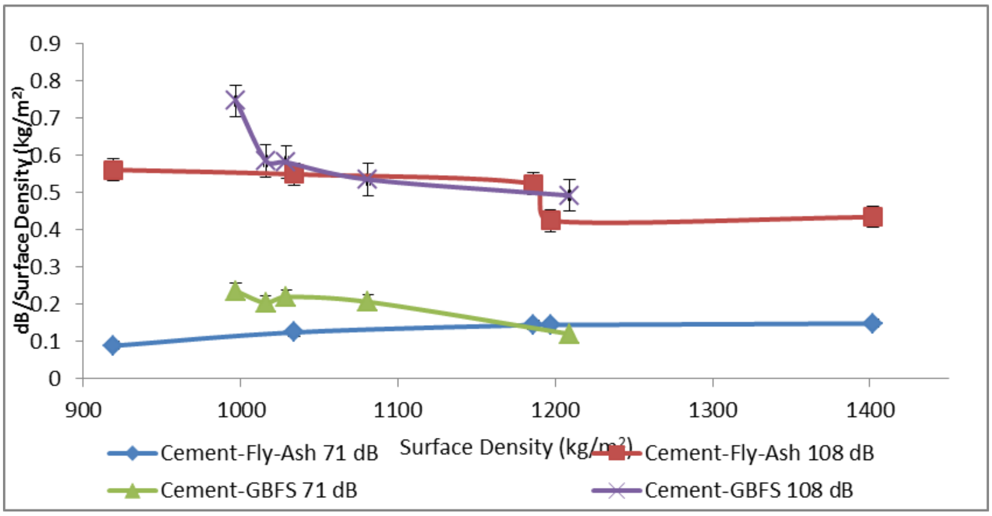

Figure-3: dB/Surface density vs. surface density.

Table-2: Relative sound-absorption coefficient of aerated concrete

Sample	Density, (kg/m³)	Sound absorption coefficient, (71 dB)	Sound absorption coefficient, (108 dB)
Cement+fly ash+water	1402	0.333	0.508
Cement+fly ash+ water +CGAs 200 ml	1197	0.262	0.485
Cement+fly ash+ water +CGAs 400 ml	1186	0.188	0.489
Cement+fly ash+water +CGAs 600 ml	1034	0.333	0.712
Cement+fly ash+water +CGAs 800 ml	919	0.110	0.469
Cement+GBFS+water +CGAs 0 ml	1209	0.188	0.460
Cement+GBFS+water +CGAs 200 ml	1081	0.286	0.457
Cement+GBFS+water +CGAs 400 ml	1029	0.286	0.466
Cement+GBFS+water +CGAs 600 ml	1016	0.262	0.461
Cement+GBFS+water +CGAs 800 ml	997	0.238	0.481

Sound-absorption coefficient of cement-fly ash system decreased after addition of CGAs (Table-2). However, the trend observed was different in cement-GBFS system where there was a marginal increase. The absorption coefficient value for each system increased at the higher sound level (Figure-4). The sound absorption coefficient for the wood plank was also calculated, and was found to 0.11, which is very near to reported values in literature.

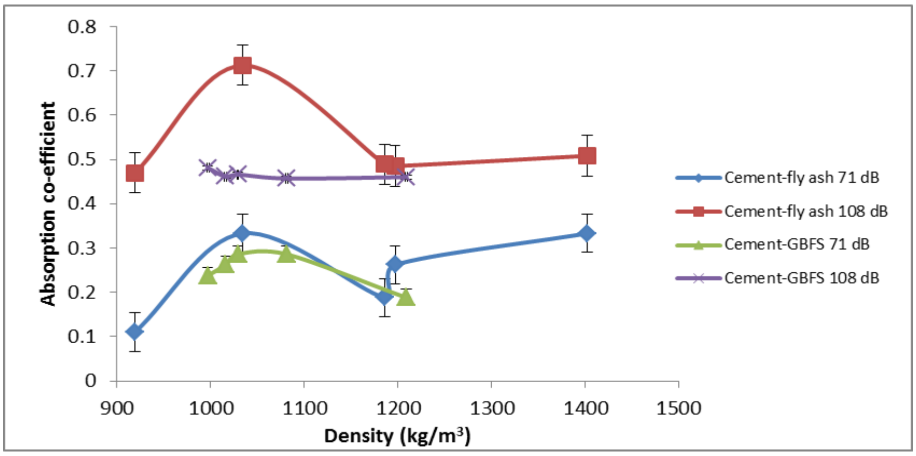

Figure-4: Absorption coefficient vs. density

5.0 Conclusions

The values of sound-reduction index and sound-absorption coefficient in present work indicated that acoustic properties were dependent on the density and matrix of the material as well as on the sound pressure of the source. Air content was not the only governing factor for the acoustic properties but other mechanical properties like elasticity of the concrete might play a role in determining the acoustic properties of the aerated concrete.

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BIOGRAPHIES

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