IOP Conf. Series: Materials Science and Engineering **271** (2017) 012014 doi:10.1088/1757-899X/271/1/012014

Vibration behaviour of foamed concrete floor with polypropylene and rise husk ash fibre

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Abstract. In the history of the construction industry, lightweight concrete or foamed concrete is a special concrete which can very useful in the construction sector because it is very lightweight and it can compact by itself at each angle of foamwork. Foamed concrete is one of lightweight concrete which widely used for floor construction due to its light weight and economic. The significant challenges in the floor design process are considering the vibration that needs improvements for the poor dynamic behaviour insulation. An alternative material to replace sand with certain amount of rice husk ash (RHA) and polypropylene was introduced. Research was determine the dynamic behavior of foam-polypropylene and foam-RHA concrete by using impact hammer test. The natural frequency for normal foamed concrete, 0.5 % of Polypropylene and 15% of RHA is 29.8 Hz, 29.3 Hz and 29.5 Hz respectively.

1. Introduction

Lightweight concrete has becoming a demand in a construction development due to its numerous benefits especially with the attempts at achieving weight reduction along with the standard of comfort that was established by the light weight floor system. Nowadays, many construction industries have been using foamed concrete floor system in construction. This is because the foamed concrete floor has many advantages such as low density, low construction cost and low material disposal [1, 2].

The practical range of concrete density for lightweight concrete is between 300 kg/m^3 and 1850 kg/m^3. Compared with normal weight concrete which has the density in the range of 2250 to 2400kg/m^3, lightweight concrete structure has the density of 1400 to 1840kg/m^3 which generally 20% to 40% lighter than normal weight concrete. For application to structural, partition, insulation and filling grades, a wide ranges of densities (400-1600 kg/m^3) of foamed concrete can be obtained by proper controlled in dosage of foam [3].

Research had been done by Zegers on the lightweight floor system, with the focus on the low frequency comfort, he stated that in designing light weight floor systems specific problems are encountered. Particularly comfort demands of such a lightweight floor system are harder to meet, as has been reviewed on the existing floor systems; especially vibrations related demands in combination with lightweight floor systems are not yet successfully combined [4].

Modern technologies preferred lighter weight and long floor system which may bring trouble to vibration. A floor system is one of the most complex and important parts of a building structure. The demands for the improvement of floor vibrations have been brought up since years. Since excessive floor vibration may lead to discomfort and is inconvenience to the people especially to the building occupants as heavy-weight impact noise causes by any rhythmic activities such as foot walk,

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rearranging furniture and rattling of boards and windows in which becomes a main source of indoor noises [5].

In order in improvise the vibration behaviour of light-weight concrete, this research was continued with the vibration behaviour of foamed concrete floor with RHA and Polypropylene. Impact hammer test was used to determine the frequency estimation, damping ratio and mode shape of the floor structure. According to Murray, limits for vibration frequencies between 4Hz to 8Hz. Outside this frequency range, people accept higher vibration acceleration [6].

Many researchers has investigated to use other composite material to incorporated with the concrete to enhance the floor performance such as by replacing certain amount of cement or sand with organic or synthetic waste material such as rice husk ash and polypropylene.

Rice Husk Ash (RHA) which is an agricultural by-product has been reported to be a good pozzolan by numerous researchers. Investigation that have done by Mehta and Pirth on used of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete[7]. Mehta again reported that ground RHA with finer particle size than OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength[8]. There were many research on using varying percentages of RHA for concrete strength and its workability however lack of research on dynamic behaviour or RHA in foamed concrete. Therefore, a certain percentage of RHA was used in foamed concrete to study its dynamic behaviour on floor performances.

In order to increase strength and reduce brittleness of foam concrete Polypropylene fibre is introduced. Polypropylene (PP) fibre is introduced to increase the flexural strength and impact resistance of the foam concrete as well as can help in shrinkage failure problem of the foam concrete [9]. The usage of these fibres has increased tremendously in construction of structures because addition of fibres in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete [12].

2. Experimental of RHA and Polypropylene Concrete

The slab design is 1.6m long and 0.75m width with the thickness of 0.125m as shown in figure 1. Additional material is 0.5% and 15% for poplypropylene and RHA repectively added into the mix of foam concrete.Table 1 illustrated the material characteristic of the floor system.

Figure 1. Actual size of slab.

Table 1. Characteristic of floor system.

Material characteristic	Foamed concrete with RHA	Foamed concrete with Polypropylene
Density (kg/m^3)	1600	1600
RHA	0.15 to sand replacement	-
Polypropylene	-	0.05 to sand replacement
Cement-sand ratio (C/S)	1:3	1:3
Water-cement ratio (W/C)	0.55	0.55
Foam Agent-Water ratio (FA/W)	1:20	1:20

3. Vibration due to Impact Hammer

Impact hammer test were used to determine the vibration behaviour of the slabs. Data were obtained through vibration impact from the hammer strike and accelerometer were recorded the data. Before the testing conducted, all slabs have a gridline to make testing process easier. Hammer was strike on location A as shown in figure 2. The impact hammer with weighted about 5 kg was been strike using super-soft tip. The hammer have been imparted in about 90° angle in relation to the object surface and applied constant force. For each tests of impact hammer, it were been take ten times of data collection. Two accelerometer were been placed on the grid point and it was been roving during the test until the test done. Accelerometer is used to measuring acceleration and it is very sensitive and must be placed on plane surface to avoid from noise.

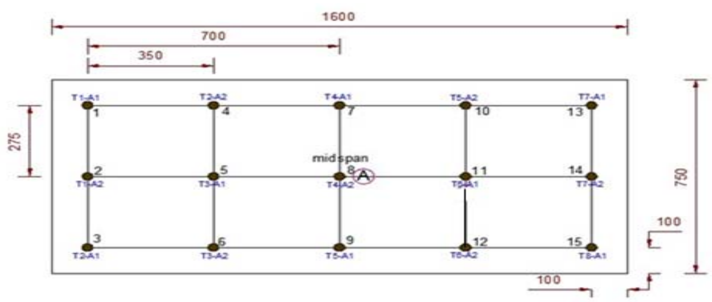


Figure 2. Gridline of slab for testing.

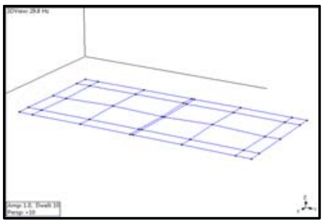
3.1. Result and Discussion

From the analysis of dynamic behaviour, natural frequency are identified by peaks in the Fast Fourier Transform (FFT) graph. FFT resolves a time waveform into its sinusoidal components. The FFT takes a block of time-domain data and return the frequency spectrum of the data. Natural frequency and of normal foamed-concrete, 0.5% Polypropylene and 15% RHA is 29.8 Hz, 29.3 Hz and 29.5 Hz, respectively. Damping ratio is defined using ratio of two peaks and calculated using Equation (1)[10].

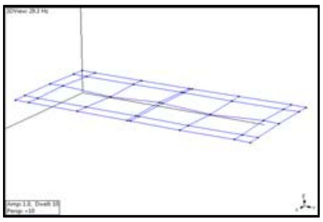
$$\delta = \frac{1}{m} ln \frac{y_n}{y_{n+m}} \quad (1)$$

where, m is cycle apart, y_n is the amplitude on n^{th} and $y_{n+m}$is the amplitude of the $n+m^{th}$ cycle. Damping ratio for normal foamed-concrete, 0.5% Polypropylene and 15% RHA is 3.37%, 4.79% and 3.98%, respectively.

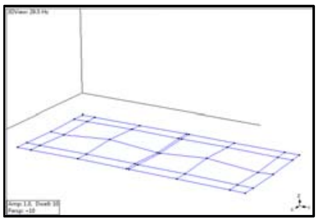
Figure 3 and figure 4 illustrated the mode shapes for each type of slab. The measured mode shapes and frequencies presented were calculated from the data obtained. The analysis showed that, the first mode shape and second mode shape for each slab were approaching the similarity feature shape between all slabs.



a. Normal foamed-concrete



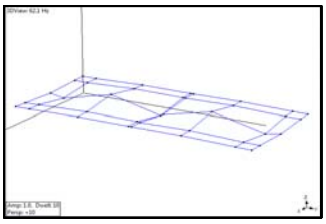
b. 0.5% of Polypropylene



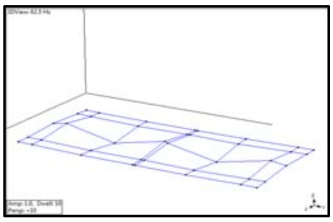
c. 15 % of RHA

Figure 3. First mode shape.

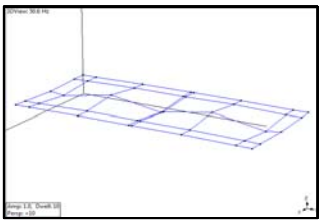
The first mode shape is shown in figure 3 for all types of slab. For normal foamed concrete, its frequency is 29.8Hz, 0.5% of Polypropylene is 29.3 Hz and 15% of RHA is 29.5 Hz. The mode shape is quite similar to the deflected mode caused by uniform gravity loading. The highest displacement is located at the center of mode shape.



a. Normal foamed-concrete



b. 0.5% of Polypropylene



c. 15 % of RHA

Figure 4. Second mode shape.

The second mode shape is shown in figure 4 for all types of slab. For normal foamed concrete, its frequency is 62.1 Hz, 0.5% of Polypropylene is 62.5 Hz and 15% of RHA is 50.6 Hz. The mode shape is quite similar to the deflected mode caused by uniform gravity loading.

Natural frequency is the frequency at which a structure will vibrate when displaced and then quickly released. Overall, the experimental modal analysis gives the value of natural frequencies in range 29.3Hz to 29.8 Hz for all type of slabs. These frequencies are acceptable because its above limit for vibration frequencies between 4 Hz to 8Hz based on Design Guide. Damping usually expressed as the percent of critical damping or as the ratio of actual damping to critical damping. For damping that determined from the experimental data, it gives high value of 3.37%, 4.79% and 3.98%. Although it high but still recommended based on previous reference by Aalami [11] which is from 2% -3% for bare concrete floor and 5% -8% with full height partitions.

Elastic modulus plays an important part in the vibration of wave. Since the disturbance from surrounding cannot perfectly eliminate, it was important to obtain the vibration reactions characteristics. Wave propagation was occurred by excitation and by bouncing. Figure 5 demonstrated the wave propagation from the analysis. It shown by using wave propagation, vibration interference can be easily recognized.

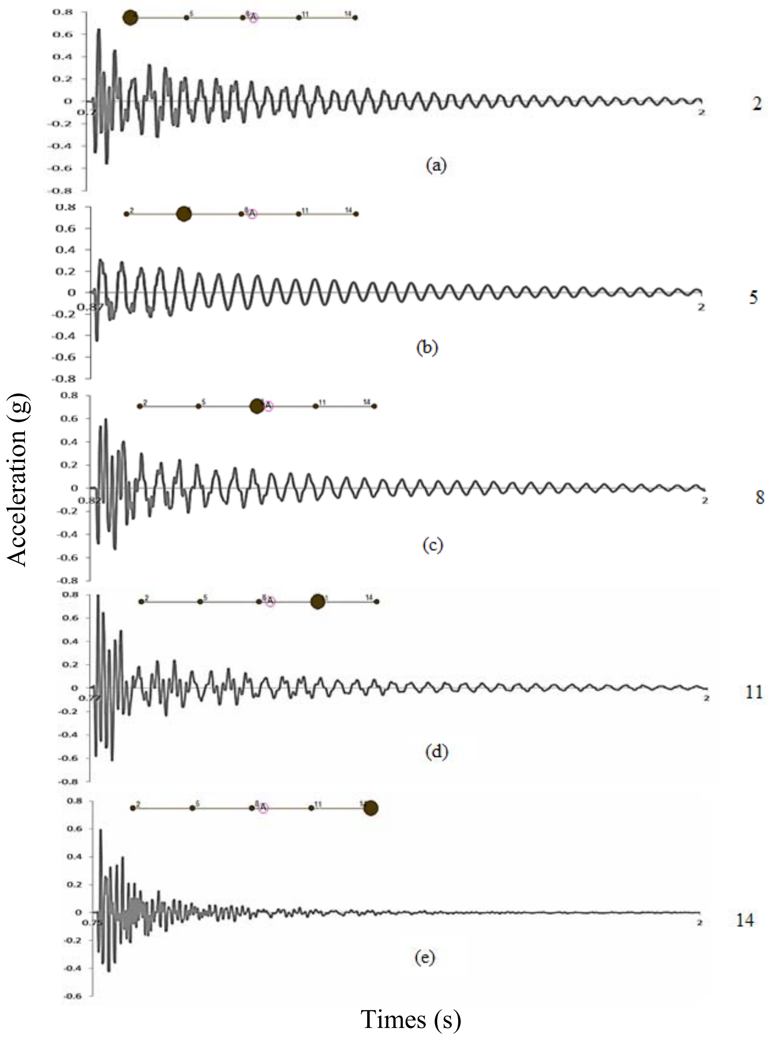


Figure 5. Wave propagation.

4. Conclusion

The main conclusion that can be made from the case study are, the experimental natural frequency for normal foamed, 0.5% of Polypropylene and 15% of RHA is 29.8 Hz, 29.3 Hz and 29.5 Hz, respectively. Therefore, it is accepted based on previous research [6], which is stated the limit frequency between 4-8 Hz.

For damping, the experimental damping ratio for first mode foamed-concrete slab is 3.37%, 0.5 % of Polypropylene is 4.79% and for 15% of RHA is 3.98%. Recommended damping ratio for bare concrete floor based on previous research, Aalami [11] is 2.0-3.0%. Therefore, the damping ratio are accepted based on recommended from previous study.

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Acknowledgement

This work was supported by Universiti Tun Hussein Onn Malaysia. The author also wishes to acknowledge Centre of Graduate Studies, UTHM.