Study on Concrete with Partial Replacement of Sand By Floral Foam

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Abstract
The concrete industry is the largest user of natural resources in the world. Concrete is a globally accepted construction material in all types of civil engineering structures. Sand is a vital ingredient of concrete as a fine aggregate. Natural sand is a prime material used for the preparation of concrete and also plays an important role in mix design. The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production is one of the environmental issues to the scarcity of river sand. Research is being carried out on the utilization of waste products in concrete as a replacement for natural sand. Floral foam can produce alternative sand for structural concrete as a partial or total replacement. It has contributed a lot to our country's economy in the florist industry. If it is not treated properly, it may become toxic waste in landfills. However, floral foam is high in porosity and low in density. In this paper, an attempt is made to utilize floral foam as a sand replacement for designing the floral foamed concrete with Grade M30. The ingredients of these floral foamed concrete are floral foam, sand, aggregates, cement, and water. In this study, 48 types of cube samples with different percentages of ingredients were prepared. Crushed floral foam was used as a partial replacement for sand at 20%, 40%, and 60% of concrete mixes. The fresh and hardened properties of new concrete are studied and compared with concrete made using conventional materials. Compressive strength tests and water absorption tests were carried out by using a compressive machine and some calculations regarding water absorption. The data and results were tabulated in the table and analyzed by using graphs. As a result, 40% replacement of crushed floral foam has given a better effect on the concrete bond between cement and floral foam particles. However the samples content 60 % of crushed floral foam has better performance in term of water absorption.

Keywords: floral foam, microplastics

1.0 Introduction

Concrete is a very strong and versatile mouldable construction material. It consists of cement, sand, and aggregate mixed with water. The amount of sand and gravel in a bag of concrete determines the mixture's strength and texture. Sand is a vital ingredient of concrete as a fine aggregate. Sand offers a requisite surface area for the film of binding material to adhere to and spread. Besides that, it will increase the volume of mortar & consequently make mortar more economical. River sand has been the most popular choice for the fine aggregate component of concrete in the past. However, excessive consumption of materials has created environmental concerns, reduced river sand deposits, and rising prices of such materials. The rapid extraction of sand from the river bed causes problems like deepening of the river beds, loss of vegetation on the bank of rivers, disturbance to the aquatic life as well as agriculture due to lowering the water table in the well, etc (Anzar & Mir, 2015). Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for river sand. From the past two decades, research has been done by partial or full replacement of river sand by the other compatible materials like crushed rock dust, quarry dust, glass powder, recycled concrete dust, and others to maintain ecological balance (Ilangovana, 2008). The reuse of this waste will help to save costs, conserve limited resources, and ultimately protect the environment.

Green concrete is defined as concrete which uses waste material as at least one of its components, the production process does not lead to environmental destruction, high performance, and life cycle sustainability. By substituting recycled materials for natural materials, it should be possible to substantially improve the resource productivity of the concrete industry immediately (Kumar Mehta, 2010). In recent years, the recyclable potential of construction and demolition (C&D) waste has made it a target of interest and the main focus of waste management policies on encouraging minimization, reuse, recycling, and valorization of the waste as opposed to its final disposal in landfills (Deshpande, 2012). The floral foam has been the base medium of choice for florists all over the world since its invention in the US by manufacturer Smithers-Oasis in the 1950s. The RMIT study showed the floral foam microplastics also leach chemicals into the surrounding water and these were more toxic to aquatic invertebrates than leachates from other plastic families (Charlene Trestrail, 2019). In the florist industry, it has contributed a lot to our country's economy. However, it also produces plenty of toxic waste in the disposal department. It breaks down into dust that is labelled harmful to the skin, and if inhaled, harmful to the respiratory system. If these floral foams are treated improperly, it will become solid wastes in landfills or even disposed of through incineration and will pollute the environment. Recycle these floral foams and use as sand in concrete can solve the problem of wasting and disposing of these toxic by products. Indirectly reduce pollution to the environment and preferably reduce the cost of construction material. Therefore, the study of the application of floral foam into the manufacturing of concrete should be carried out to produce an environmentally friendly and low cost floral foamed concrete.

The present paper focuses on the replacement of sand partially with floral foam. The objective of this study is to produce concrete containing floral foam as a partial replacement for sand. The floral foamed concrete will be tested using compressive strength and water absorption. The floral foamed concrete will be produced in a mixed condition of cement, sand and aggregate. It will be produced in a ratio which is 1:2:4 for each material replacing the sand with floral foam. This concrete is suitable for wall panels. The cube sample of size 150x150x150mm were prepared at 0% (control mix), 20%, 40% and 60% of floral foam. For each percentage, six samples will be produced for each testing. The total of samples that need to be tested on the 7th and 28th days are 48 samples altogether. Compressive strength test and water absorption test to be carried out on concrete that has been a substitute with floral foam. Most of these studies have been performed to find the effectiveness of floral foam as thesand by concentrating on the amount of floral foam present in the mix and on the enhanced characteristics resulting from its use.

2.0 Introduction of floral foam

Floral foam is a rigid, deformable, spongelike plastic used in floral arrangements to secure the stems of flowers. It has effectively replaced the conventional way of arranging flowers which entailed utilizing wet newspapers, twigs, chicken wire, and pin holders. The recurring problem in the past with these traditional methods of flower arrangement is the shorter lifespan of the floral designs that may take hours to create. Besides that, it can make the flowers last longer and helps in keeping the artistic designs in place. Floral foam is pH balanced. It will help the flowers to last longer by maintaining the acidity of the environment where can optimize the acidity of the environment. Floral foam is made of phenol material used for real flower arranging. According to Niir Project Consultancy Services (2015), it also holds water of about forty times its weight, making flowers survive approximately seven to ten days after being steamed or cut from the plant. The life of flowers placed in the floral foam is dependent upon the properties of the foam and properties of water, or flower food solution, used to saturate the foam (Anil Ranwala, 2010). Floral foam can be divided into three types of conditions which is dry floral foam, wet floral foam, and coloured floral foam. The standard colours for all types of floral foam are green but it also available in many other colors, such as purple, red, yellow, and brown. It usually is supplied in a brick shaped but can be bought in spherical shapes. Dry Floral Foam bricks (also known as floral styrofoam), are easy to cut and work within the same way as wet floral foam except do not need to soak them in water. They are mainly used for artificial flower arrangements. The dense and compact nature of dry floral foam can also accommodate artificial flowers that have a stem that has been fitted with a sharp metal spike or florist wire. The added weight of dry floral foam also ensures that the floral foam arrangement will hold its shape. Floral Styrofoam's robust design makes it the best fit for silk, dried and fake flower arrangements as the foam are denser and more unlikely to crumble. Floral foam is a dense, lightweight and porous material that can be cut into virtually any shape. The density of the floral foam means that it holds large quantities of water, which in turn, increases the life of flowers.

Figure 1: Dry Floral Foam

2.1 Properties of floral foam

Most floral foam is made from phenolic foam. Phenolic foams (PF) have a combination of properties that make them attractive for a number of engineering applications such as insulation, lightening, energy absorption and fire protection (Mougel, 2019). The phenolic foam has been recognized the best insulation material for the excellent fire resistance performance, low smoke emission, high temperature resistance, stability, superior thermal performance, extremely sound insulating property & structural strength performance. Phenol-formaldehyde plastics are used globally as floral foam and generate microplastics that can enter the environment. Microplastics (MPs) are synthetic solid particles or polymeric matrices, with regular or irregular shape and with size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water (Charlene Trestrail, 2020). This synthetic substance is made from a variety of materials, including carbon black and formaldehyde. Some of the basic properties of phenolic foam of floral foam are presented in the Figure 2.

Primary microplastics are plastic particles that were originally manufactured at those sizes in which they are encountered in the environment. A key concern of microplastics pollution is whether they represent a risk to ecosystems and human health. Data on the exposure and effect levels of microplastics are therefore required to evaluate the risk of microplastics to environments and human health. The adverse effects on organisms that are exposed to microplastics can be separated into two categories that are physical effects and chemical effects. The former is related to the particle size, shape, and concentration of microplastics, and the latter is related to hazardous chemicals that are associated with microplastics. Though data on microplastic exposure levels in environments and organisms have rapidly increased in recent decades, limited information is available on the chemicals that are associated with microplastics. (Claudia Campanale, 2020).

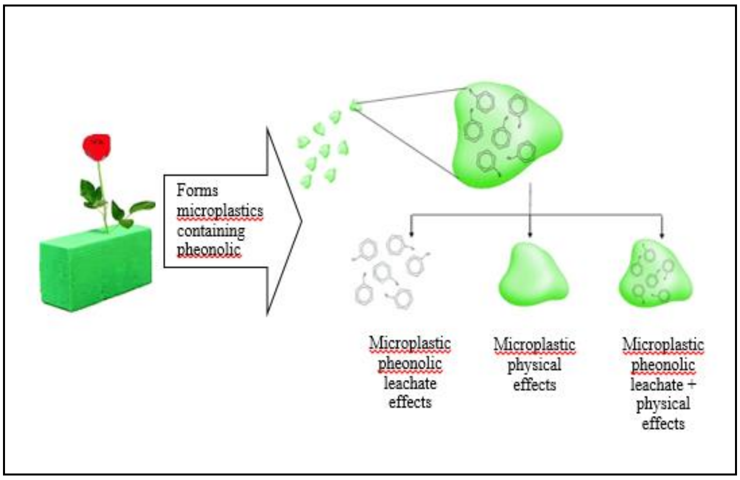

Figure 2: Phenolic foam of floral foam

2.2 Concrete

Concrete is a building material made from a mixture of broken stone or gravel, sand, cement, and water, which can be spread or poured into moulds and forms a mass resembling stone on hardening. Portland cement is the most energy-intensive materials of construction (Mehta, 2001). Coarse aggregate usually is stone aggregate or natural fibers, while fine aggregate usually is sand. Sand is a major component of the mortar and is also the second most important component in the manufacture of concrete. Sand offers a requisite surface area for the film of binding material to adhere and spread. Besides that, it will increases the volume of mortar & consequently make mortar more economical. Well-graded sand adds to the density of mortars and concrete to prevents excessive shrinkage of mortar. The sand is used with cement for the construction of walls, pillars, tops of walls, floors, beams, stairs and even terraces. Furthermore, many materials are recycled and used as the ingredients of concrete such as natural fibers from the farm and fly ash from coal power plants.

Concrete is versatile, it has many functions and widely used in farms and other agriculture enterprises. This is because concrete is strong, fire resistance, insect and rodent proof, decay resistant, highly storm resistant, wear resistant and waterproof. Besides, maintenance cost for concrete construction is low (Herren, 2010). The strength and durability of concrete depend on many factors, such as the composition and proportions of the materials, the water-cement ratio of fresh concrete, the strength and proportion of aggregates by size, the type of cement used, the uniformity of the mixture, and the method or process of the preparation of concrete. The precision in mixing all the ingredients of concrete is important because the proportions of ingredients will influence the properties of the concrete. For an accurate mixture, each particle of aggregates is covered with cement paste and bound to each other when cement paste dries and hardens. The aggregates must be clean and free from clay and silt. This is because the tiny sizes of clay and silt will influence the function of aggregate in the concrete mix. Therefore, the sand used to make concrete is usually the washed sand that has been flushed with water and free of clay and silt (Herren, 2010).

Grade of concrete denotes its strength required for construction. Regular grades of concrete are M15, M20, M25, M30. Based on various lab tests, the grade of concrete is presented in mixed proportions. The strength is measured with concrete cube or cylinders by civil engineers at the construction site. Cube or cylinders are made during casting of structural members and after hardening it is cured for 28 days. Then a compressive strength test is conducted to find the strength. Another contributing factor affecting concrete strength is the water content used which in some cases are increased to improve workability (Cemex, 2013). When the fines content in the sand are excessive, there is the need to add more water to the concrete mix in other to improve the workability. The presence of sand fines in concrete is likely to affect the workability, strength and long-term performance of concrete (Gambhir, 2002). The percentage limit of sand fines (clay/silt) is recommended by various building standards in other to check their effects on the strength of concrete.

3.0 Methodology

The methodology flowchart of this study is available in the Figure 3. The proper planning and structure study of research methodology is crucial were as it serves as a guide to achieving the objectives of the study.

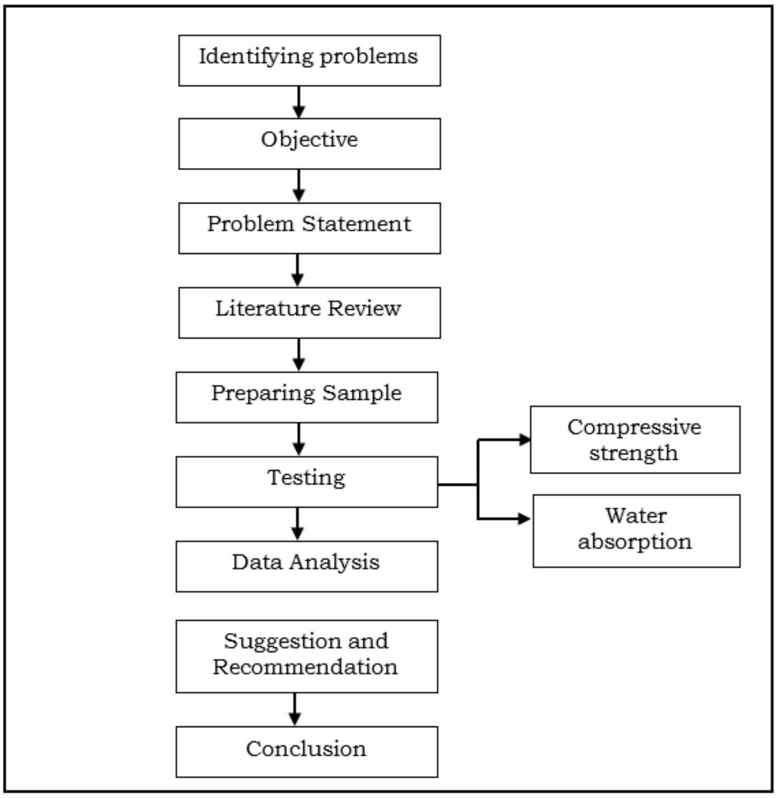

Figure 3 : Methodology flow chart

3.1 Materials

The materials used were aggregate, cement, sand, crushed floral foam, ordinary portland cement and water. Crushed floral foam as shows in Figure 4 was used in concrete mixture as partial replacement of sand. The maximum particle size of aggregates is 20 mm.

Figure 4: Crushed floral foam

3.2 Testing method and procedures

The preparation of these method includes crushed floral foam, concrete mixing and others are carried out in the laboratory. The procedure for selection of suitable ingredients of concrete and determination of their relative amounts with the purpose of producing a floral foamed concrete.

3.2.1 Sample size

In this study, a total of 48 cube samples of 150x150x150mm were cast for strength and water absorption testing. Crushed floral foam was used for 0%, 20%, 40% and 60% replacement of sand. The percentage value of floral foam replacing sand is taken based on the findings of previous studies. For each percentage, six cube samples were prepared to investigate compressive strength and water absorption respectively.

3.2.2 concrete mixtures

A concrete mix design is a procedure for the selection of suitable ingredients of their relative amounts with purposes of producing concrete. A mix ratio of 1:2:4 for water-cement ratio 0.5 was taken in this study. Table 1 represents a mixed proportion of floral foam concrete for varying floral foam replacement by the weight of sand. All different batches of concrete were made by use of crushed floral foam at 20%, 40% and 60% by volume of mixture with the constant water/cement ratio. Floral foam concrete was produced in laboratory by using a hand mixing with adding of crushed floral foam into a concrete mix as shows in Figure 5(a) and Figure 5(b).

Table 1: Mix proportions of floral foam concrete

Replacement percentage of floral foam	0%	20%	40%	60%
Cement (kg)	1.12	1.12	1.12	1.12
Sand (kg)	2.33	1.87	1.40	0.93

Aggregate (kg)	4.82	4.82	4.82	4.82
Water (kg)	0.56	0.56	0.56	0.56
Floral Foam (g)	0	9.77	19.67	29.33

5(a) **5(b)**

Figure 5(a) and 5(b): Mixing of concrete

3.3 Testing of samples

The different concrete mixes with varying crushed floral foam content percentage were produced, replacing 0% (control mix), 20%, 40%, and 60% sand in terms of weight. All batches of floral foamed concrete having 48 cubes of 150x150x150mm size are tested using compressive strength test and water absorption test.

3.3.1 Compressive strength test

The compressive strength was measured by three 150x150x150 mm cubes at 7 and 28 days for each mix of floral foamed concrete, in accordance with BS EN 12390-3. Before testing, the samples were initially cured in the air for 24 hours. The moulds were removed and immersed into the water in a curing tank for 7and 28 days for testing. Figure 6 shows the curing process of the samples.

Figure 6: Curing process

This test is important conducted on hardness of concrete. The cube samples were inserted into a universal testing machine of which the surface of the cubes ware aligned perpendicularly to the platens. An automatic loading rate was applied to the specimen until a failure occurred (Figure 7).

Figure 7: Compressive strength test

3.3.2 Water absorption test

Water absorption is usually measured by drying the specimen to constant mass, immersing it in water and measuring the increase in mass as a percentage of dry mass. All testing was measured on 3 cube samples with size of 150 mm for each mix of floral foamed concrete after moist curing. An average of the three values at each age was calculated.

4.0 Results and discussion

The data and result from the test conducted can be observed and analysed as compared with the standard of compressive strength of different grades of concrete at 7 and 28 days as shows in Table 2. All 48 cube samples of size 150x150x150mm, floral foamed concrete was successfully produced with each percentage has been tested respectively. The objective to produce concrete containing floral foam as a replacement to sand and to test the strength and water absorption of floral foamed concrete has been achieved. All the data and result can be analysed from the table and graph plotted.

Table 2: Compressive strength of different grades of concrete

Grade of Concrete	Minimum compressive strength N/mm^2 at 7 days	Specified characteristic compressive strength (N/mm^2) at 28 days
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40

4.1 Compressive strength test

Test was conducted on concrete using floral foam as replacement of sand partially on their 7th and 28th days. The main purpose of this test is to find out the strength of the concrete when compressed under load. From Table 3 and Figure 8, data indicates the compressive strength values of that the 7 days strength increases from 18.9 N/mm² to 20.7 N/mm² with incorporation of 20% floral foam. However, there was a reduction in compressive strength of concrete after a curing period of 28 days. The strength decreased to 19.0 N/mm². For concrete with the 40% of floral foam on day 7, the strength was increased compared to 20% which is 20.7 N/mm² to 24 N/mm². When the curing time increased, the cube sample with 40% of floral foam decreased to 22.1 N/mm² on day 28. As the comparison, 40% floral foam replacement show larger compressive strength compared to 20% on 28 days. On day 7 for 60% floral foam, it performed better with compressive strength values of 24.3 N/mm². While the compressive strength values of 21.6 N/mm² were found for 60% floral foam replacement respectively on 28 days. As discussed above, the 40% floral foam shows that the percentage replacement has given a better effect the concrete bond between cement and floral foam particles especially for 28 days curing. The compressive strength of concrete is its principal and the most important mechanical property which is generally obtained by destructive testing of the cube sample in the laboratory only after a standard curing of 28 days and used for design purposes (T. S. Thandavamoorthy, 2011). There is a significant improvement in the strength of concrete because of the void filling ability. This is probably because the voids were reduced for the maximum 40% floral foam. The rough texture of floral foam also tends to bond the concrete mixed tightly.

Table 3: Compressive strength values of floral foamed concrete

Type	Replacement percentage of floral foam	Age (day)	Weight (kg)	Density (kg/m³)	Load (kN)	Strength (N/mm²)	Average Strength (N/mm²)
FF0	0%	7	7.99	2367	495	22.0	18.9
			7.95	2356	415	18.4	
			7.85	2324	368	16.4	
		28	8.01	2373	469	20.8	22.6
			7.95	2356	425	18.9	
			8.11	2401	630	28.0	
FF20	20%	7	8.03	2378	486	21.6	20.7
			8.05	2385	463	20.6	
			7.93	2348	449	19.9	
		28	7.79	2305	425	18.9	19.0
			7.79	2305	438	19.4	
			7.90	2341	425	18.8	
FF40	40%	7	7.88	2333	534	23.7	24.0
			7.89	2336	550	24.4	
			7.99	2366	536	23.8	
		28	7.77	2301	469	20.8	22.1
			7.90	2339	488	21.7	

			7.87	2332	536	23.8	
FF60	60%	7	7.82	2317	543	24.1	24.3
			7.91	2344	534	23.8	
			7.95	2354	563	25.0	
		28	7.67	2271	481	21.4	21.6
			7.63	2261	503	22.3	
			7.66	2268	476	21.2	

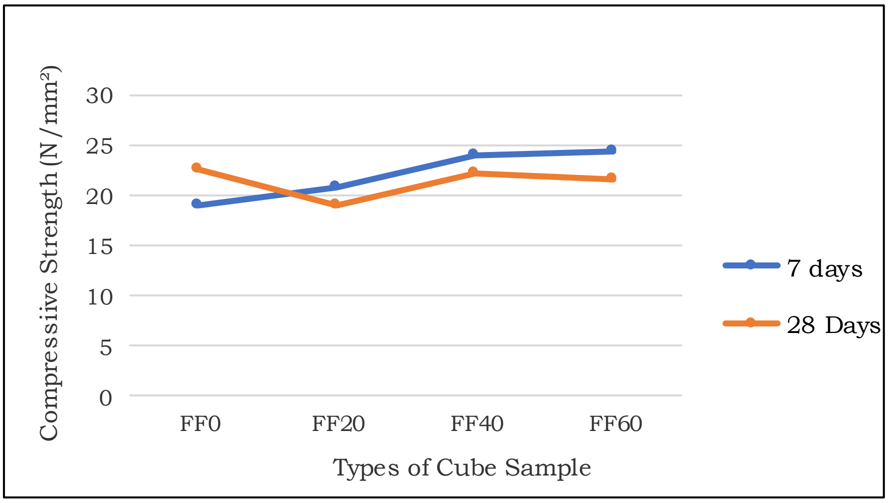

Figure 8: Compressive strength values of floral foamed concrete

All the cube sample of % replacement of floral foam cannot achieve the specified characteristic compressive strength at 28 days but they achieved the minimum compressive strength at 7 days. It is because the minimum compressive strength standard is 20 N/mm^2. The value of compressive strength did not achieve may be due to improper proportions of cement water ratio, properties of aggregates, and poor mixing process.

4.2 Water absorption test

Water absorption test is one of the tests used to measure the weight of water absorbed by the 0% control, 20% of floral foamed concrete, 40% of floral foamed concrete and 60% of floral foamed concrete. Water absorption is an important factor due to the porous structure of the concrete. The purpose of this test is to identify the capability of the concrete to absorb water. There are three samples for each test and the average result will be taken. It can be seen that water absorption decreased when the percentage of foam is increased. Table 4 reports the size of cube samples, their weight after curing, the weight increments during the phase of immersion in water and the water absorption percentages.

Table 4: Percentage water absorption values of floral foamed Concrete

Type	Replacement percentage of floral foam	Age (day)	Weight before curing (kg)	Weight after curing (kg)	Percentage water absorption (%)	Average percentage (%)
FF0	0%	7	7.13	7.99	12.06	12.27
			7.07	7.95	12.45	
			6.99	7.85	12.30	
		28	7.10	8.01	12.82	12.76
			7.21	7.95	10.26	
			7.04	8.11	15.20	
FF20	20%	7	7.06	8.03	13.74	12.21
			7.16	8.05	12.43	
			7.18	7.93	10.45	
		28	7.02	7.79	10.97	11.71
			7.01	7.79	11.13	
			6.99	7.90	13.02	
FF40	40%	7	7.12	7.88	10.67	12.19
			7.03	7.89	12.23	
			7.03	7.99	13.66	
		28	7.09	7.77	9.59	11.36
			7.02	7.90	12.54	
			7.03	7.87	11.95	
FF60	60%	7	7.12	7.82	9.83	11.98
			7.06	7.91	12.04	
			6.97	7.95	14.06	
		28	7.00	7.67	9.57	9.65
			6.96	7.63	9.63	
			6.98	7.66	9.74	

Figure 9 shows the result of water absorption for different percentages of floral foam. Water absorption slightly decreases from 0% to 20%. For 20% replacement of floral foam, the water absorption decreases from 12.27% to 12.21% for 7 days. It slightly decreased to 11.71% on 28 days. This is because the porosity of the concrete is getting smaller as the volume of floral foam used increased. An optimum percentage of water absorption on standard concrete is around 7% to 10%. This means that 20 % replacement of floral foam has not achieved the optimum percentage of water absorption required in concrete on its 28 days. A pattern was observed on a cube samples with 40% of floral foam where the water absorption decreased from 7 days to 28 days which is from 12.19% to 11.36%. This may because the floral foam concrete is less porous when the volume of the floral foam increasing. However, the concrete inclusion 40% of floral foam decreased in 7 days and 28 days but were not achieved for the great absorption water. For 60% replacement of floral foam, the absorption decreases from 11.98% to 9.65%. From the results, the concrete inclusion 60% of floral foam in 28 days have good absorption water which is 9.65%. The higher the volume of floral foam used, the greater the water absorption of the concrete. This is because the porosity of the concrete is getting smaller as the volume of floral foam used increased. This means that 60% replacement of floral foam has achieved the optimum percentage of water absorption required in concrete on its 28 days compared to other cube sample.

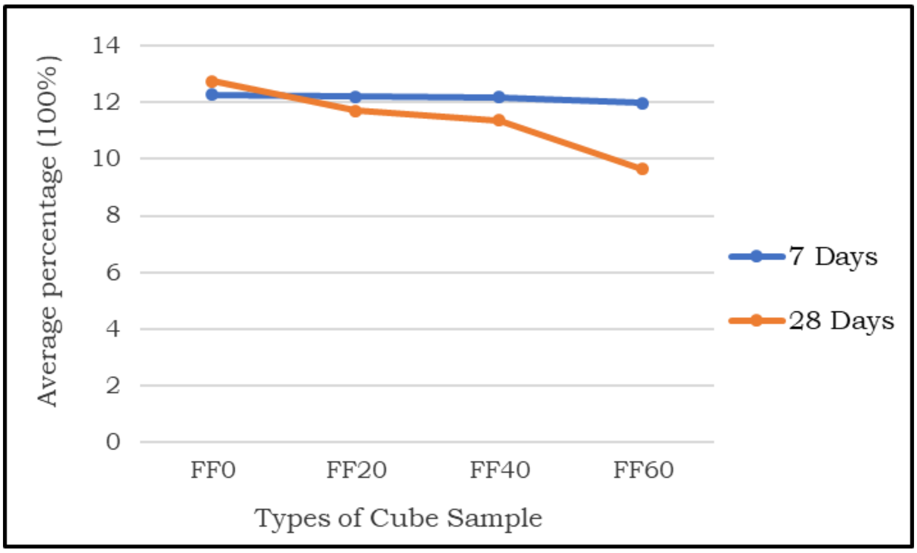

Figure 9: Percentage water absorption curve for floral foamed concrete

5.0 Conclusions

Based on the results and the discussion of compressive strength, the partial substitution of sand with floral foam in the production of concrete led to a reduction in the compressive strength of the concrete especially on 28 days curing. However, the strength for all percentage can be considered in construction except 20% of floral foam because the strength is below the required strength of concrete to be used in structural design. The 40% floral foam shows that the percentage replacement has given a better effect the concrete bond between cement and floral foam particles. For water absorption of floral foamed concrete, when percentage of floral foam increase, the water absorption capacity of the concrete is decrease. It shows the floral foam is low in porosity when the volume of floral foam increased. The conclusion is 60% of floral foam on 28 days has an optimum percentage of water absorption. Curing conditions can greatly affect the water absorption of concrete.

More research needs to be done to make effective use of material like floral foam to improve the workability, compressive strength and water absorption. This will lead to a cheaper material will be used with good durability and strength properties. Some other recommendations for future research are as follows:

a. Additional test can be conducted on floral foamed concrete such as flexural test, fire resistance test and other durability test such as acid resistance test.

b. A different water cement ratio and a different grade of floral foamed concrete can be designed for future research.
c. The percentage of floral foam can be increased to see the effects on the concrete properties. The curing duration can be increased to 30 days to see if there will be future strength increase.

References

Ahsanul Kabir, M. H. (2012). Predicting 28 days compressive strength of concrete. *In International. Conference. on Advances in Design and Construction of Structures 2012,* (pp.18-22).Kuala Lumpur Malaysia

Bahoria B.V., P. D. (2012). Replacement of natural sand in concrete by waste products: a state of art. *Journal of Environmental Research and Development,* 1651-1656.

C.Mougel, T. p.-Z. (2019). Phenolic foams: a review of mechanical properties, fire resistance and new trends in phenol substitution. *Elsevier,* 86-117.

Cemex. (2013). The effects of water additions to concrete: cemex USA - *Technical Bulletin*, 1-5.

Charlene Trestrail, M. W. (2019). *Foaming at the mouth: ingestion of floral foam microplastics by aquatic animals. science of the total environment.*

Charlene Trestrail, M. W. (2020). Foaming at the mouth: ingestion of floral foam microplastics by aquatic animals. *Science of The Total Environment, 705.*

Claudia Campanale, C. M. (2020). A detailed review study on potential effects *International Journal of Environmental Research and Public Health.*

Dr. Arno Gardziella, D. L. (2000). *Phenolic resins: chemistry, applications, standardization, safety and ecology.* New York: Springer.

Mehta, P. K. (2001). Reducing the environmental impact of concrete. *Concrete International*, 61-66.

MI, G. (2002). *Concrete manual: a laboratory manual for quality control of concrete*. New Delhi: Dhanpat Rai & Co. Ltd.

Mir, A. H. (2015). Replacement of natural sand with efficient alternatives: recent. *International Journal of Engineering Research and Applications,* 51-58.

N.K.Deshpande, D. a. (2012). Strength characteristics of concrete with recycled aggregates. *International Journal of Engineering,* 38-42.

R Ilangovana, K. N. (2008, January). Strength and durability properties of concrete containing quarry rock dust as fine aggregate. *Research Gate.*

Ranwala, A. (2010). Benefits of saturating floral foam with floralife®. *Floralife, 12* (12).

Ranwala, A. (2010). Benefits of saturating floral foam with floralife®. floralife, *The Care and Handling Experts*, 12(12).

Rhodes, C. J. (2018). Plastic pollution and potential solutions. *Science Progress*, 207-260.

Suhendro, B. (2014). Toward green concrete for better sustainable environment. *Procedia Engineering, 95*, 305-320.

Thandavamoorthy, T. S. (2015). Determination of concrete compressive strength: a novel approach. *Pelagia Research Library*, 88-96.

Zong, S. P. (2014). evaluation of relationship between water absorption and Advances. *Materials Science and Engineering, 8.*