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Structural Characteristics of Profile Sheet-Polystyrene Fibre Reinforced Composite Slab

Ezeh John. Chukwuma., Ibearugbulem Owus. Mathias., Nwaiwu Chinedu. Christian., Uzoukwu Chukwudum Sunny.

Civil Engineering Department, Federal University of Technology Owerri, Imo State, Nigeria
email: cskambassadors@gmail.com

ABSTRACT

This work presents the determination of structural characteristics of profile sheet-polystyrene fibre reinforced composite slab. It investigates the compressive strength, flexural strength and deflection of slab of profile sheet with concrete mixture of polystyrene beads, cement and sand with agro fibre reinforcement. The materials used include: ordinary limestone cement, fine aggregate, coarse aggregate, polystyrene beads, profile sheet, agro fibre, 10mm reinforcement bars, binding wire and water. Manual mixing operation was adopted, and all polystyrene concrete ingredients were batched by weight. A total of seventy-two (72) cubes of size 150mm x 150mm x 150mm were produced from six (6) mix ratios of water-cement ratio: cement: sand: polystyrene beads, 0.45:1:6:0, 0.45:1:5:1, 0.45:1:4:2, 0.45:1:3:3, 0.45:1:2:4, and 0.45:1:0:6, for compressive strength test. Also, a total of sixteen (16) slabs of size 1200mm x 558mm x 125mm were cast for flexural strength of slab. Out of the sixteen(16) slabs cast; Twelve (12) were produced from profile sheet- polystyrene fibre reinforced composite with mix ratio 0.45:1:3:3 and six (6) different fibre content in the mixture, two (2) were produced from conventional composite having normal concrete ingredients (coarse aggregates, fine aggregates, cement and water) with 10mm rebar, profile sheet and mix ratio of 0.45:1:2:4. The remaining two (2) slabs were made from plain polystyrene fibre reinforced slab with mix ratio of 0.45:1:3:3 and 0.31% Agro fibre content in the mixture, without profile sheet. The 28th day average compressive strength for the six (6) mix ratios used were 4.81MPa, 5.3MPa, 6.2MPa, 6.4MPa 4.33MPa, and3.08MPa respectively. The average static modulus of elasticity for the six (6) mix ratios were 7.42GPa, 7.49GPa, 7.71GPa, 7.71GPa, 6.03GPa, and 3.66GPa respectively. The average flexural strength of profile sheet-polystyrene fibre reinforced composite slab for the six (6) different fibre content in the mixture were 2.1MPa, 2.45MPa, 3.3MPa, 3.9MPa, 3.4MPa, and 2.85MPa respectively. The maximum deflection for the slabs were observed to occur at slab with 0.21% Agro fibre content in the mixture while the minimum deflection occurred at the slab with 0.31% Agro fibre content in the mixture. The compressive strength of polystyrene concrete was below normal structural concrete value. Polystyrene concrete is a light-weight concrete in terms of density. The flexural strength of profile sheet-polystyrene fibre reinforced composite slab was within limit for light structural slab.

Keywords: Polystyrene fibre concrete, slab, profile sheet, polystyrene beads, agro fibre, composite, compressive strength, flexural strength, static modulus of elasticity and deflection

1.0 Introduction

A structure is an assembly of elements that transfer stresses (loads) from one element to another without much or excessive differential deformation of any of its elements. In building, structural elements include slabs, beams, columns and foundations. A slab is a planar structural element that is flat and has two dimensions. Its thickness is very minimal in relation to its other two dimensions. (Ibearugbulam, Ezeh, and Ettu, 2014). It acts basically as a flexural member; its primary function is to carry lateral loads, fixed and transient loads to beams and columns (Mosley, Bungey, and Hulse, 1999). Slab can be produced using different construction materials like wood (timber), steel, and composite members like concrete, steel-composite etc. The EN 1994-1-1:2004 defines “composite slab as a slab in which profile steel sheets are used as permanent shuttering initially and subsequently combined structurally with the hardened concrete to act as tensile reinforcement in the finished floor. In this flooring/slab system, steel decking that are usually cold formed with different types of embossments are commonly used. This steel deck performs as a formwork during concrete casting in the service stage. For continuous composite slab, reinforcement steel is required at the support to resist the negative bending moment (Marimuthu, Seetharaman, Jayachandran, Chellappan, and Dutta, 2007). The design of concrete slab can be seen in BS 8110 parts 1, 2 and 3. The actual problem associated with concrete slab is self-weight. To solve the problem of self-weight for concrete slab, a lot of lightweight materials have been used as replacement to components of concrete. Industrial and agricultural wastes are among the lightweight materials that have been shown to be appropriate. which includes sawdust, palm kernel shell, fly ash, coconut shells, and pre-expanded polystyrene beads, among others which are produced from milling stations, industries and so on (Ganiron, 2014).

1.1 Statement of Problem:

Over the years, composite slabs, commonly used in the building industry, has posed challenges of excessive self-weight. This study investigates the potentials of profile sheet-polystyrene fibre reinforced composite slabs for construction in order to get reduced weight in composite slabs whilst still maintaining a good strength and meeting deflection and shrinkage criteria as well as obtaining a cost-effective composite slab.

1.2 Objectives of Study:

The main objective of this study is to determine the structural characteristics of profile sheet-polystyrene fibre reinforced composite slab. The specific objectives are firstly to determine the workability and the setting time of polystyrene concrete, secondly to determine the compressive strength of polystyrene concrete furthermore to determine the flexural strength of profile sheet-polystyrene fibre reinforced composite slabs, conventional composite slabs and plain polystyrene concrete fibre slab and finally to determine the deflection of profile sheet-polystyrene fibre reinforced composite slabs

1.3 Justification of Study :

The notable significance of this project is that it will provide the structural characteristics of profile sheet-polystyrene fibre reinforced composite slab. Profile sheet-polystyrene fibre reinforced composite slab as a lightweight slab will help to reduce the load on structures as the slab will reduce the load transferred to both beams and columns. Another very notable significance of this project is that it will also encourage waste recycling of polystyrene and agro fibre, which is a very interesting area as far as global waste recycling is concerned. Research have been carried out on the use of many lightweight components like sawdust, palm kernel shell but the use of polystyrene and agro fibre needs to be investigated. Hence, this is the basis for the present research work.

1.4 Scope of Study:

The scope of this study is limited to determination of structural characteristics of profile sheet-polystyrene fibre reinforced composite slab. Compressive strength, static modulus of elasticity, flexural strength, and deflection are among the structural properties that were determined. The time of final setting of polystyrene concrete was determined**.**

2.0 MATERIALS

The materials used for this work were Portland limestone cement, Polystyrene beads, Profile sheet, fine aggregate (natural sand), coarse aggregate(crushed granite), Agro fibre, Water, 10mm reinforcement bars, binding wire.

i. Firstly the cement Dangote 3X Portland Limestone cement which conforms to NIS 44-1, part1 was obtained from a dealer in Owerri and used for all the work.

ii**.** To carry out this work, polystyrene bead was obtained from the Jik saw PLC at Industrial Cluster, Owerri North, Imo State, Nigeria. The diameter ranged from 3.1mm to 1.12mm.

iii. The aggregates used in this research work were coarse aggregate and fine aggregate. The coarse and fine aggregates used for this work were purchased from tipper stand at Owerri, Imo State Nigeria, it was sun-dried for seven days inside the laboratory before usage. The aggregates used were free from deleterious matters. The maximum diameter of natural sand used as fine aggregate was 5mm while that of coarse aggregate used was crushed granite of 19mm. The compacted bulk density of the coarse aggregate is 1615kg/m^3 and the non-compacted bulk density is 1400kg/m^3.

iv. Water from a well on the Federal University of Technology campus in Owerri, Imo State, was used for this study. The water meets BS EN 1008: (2002) standards and is potable. It is also suitable for curing and mixing concrete, as it satisfies drinking standards.

v.The profile sheet used for this research work were obtained from Owerri timber Market and the t hickness is 1mm conforming to (2005, Eurocode 3). They were cut to 1200mm x 558mm x 75mm and used to produce slab of 1200mm x 558mm x 125mm.

vi. The agro fibre used in this project is from raffia palm tree and was bought from Afor Ogbe market in Ezinihitte Mbaise. The fibres were cleaned. The fibres were further dried in natural sunlight to remove moisture content and long uniform fibres were obtained.

vii. The reinforcement bars were purchased from a dealer in Owerri Timber market. The rebars were as specified in BS 4449:1997 and 10mm size reinforcement bars was used for the control slab.

viii. The binding wires were purchased from Owerri Timber market in Imo State and the Grade are as specified in BS 4449: 1997.

3.0 Methodology

3.1 Determination of Workability, and Setting Time of Polystyrene concrete

In this research work, slump test was performed on the mixes used to produce Polystyrene concrete fibre composite slab. Slump test gives good consistent results for a plastic mix. The test was conducted in accordance with the specification of BS EN 12350-2:2000. Second to that was the Penetration Resistance Test for Polystyrene concrete While casting cubes to determine the compressive strength, flexural strengths, penetration resistance test was also conducted according to the specification of BS EN 12504-2:2012.

3.2 Determination of the Compressive Strength of Polystyrene concrete

The compressive strength of the polystyrene concrete used to create the fiber composite slab was ascertained by a compressive strength test. A manual mixing technique was employed to produce polystyrene concrete. For batching, the mix ratios were 1:6:0, 1:5:1, 1:4:2, 1:3:3, 1:2:4, and 1:0:6; these correspond to cement, sand, and polystyrene beads, in that order. The water-to-cement ratio was 0.45 for the entire mixture. The polystyrene concrete ingredients were batched by weight. Batching was done as per mix proportion see Table C1, page 122, Appendix. Cement and sand were mixed dry through, then properly mix these ingredients by adding water after that mix all by adding polystyrene beads, it makes uniform mixture. 150 x 150 x 150 mm molds were cleaned and lubricated to make it simple to remove the samples after they have set. Fresh polystyrene-concrete was poured into the molds in three layers, each of which was manually compacted after at least 25 blows. The surface was leveled once the compaction process was finished.

Six different mix ratios were utilized to create a total of 72 cubes. For each of the four curing ages—7, 14, 21, and 28—three cubes were taken from each mix. The 7th day's compressive strength was obtained using the first set of 18 cubes made from the mix ratios; the 14th day's compressive strength was obtained using the second set of 18 cubes; the 21st day's compressive strength was obtained using the third set of 18 cubes; and the 28th day's compressive strength was obtained using the fourth set of 18 cubes. After being submerged in water for a specified amount of time, the Polystyrene concrete cubes were tested using Okhard Machine Tool's WA-1000B digital display Universal Testing Machine (UTM). The machine conforms to the requirement of BS EN 12390-4 (2000) and has a testing range of 0-1000kN. The compression load at failure was recorded and used in Equation (3.1) to determine the compressive strength of the Polystyrene concrete.

$$\text{Compressive strength} = \frac{compressive\ load\ of\ cube\ at\ failure\ (N)}{cross\ sectional\ area\ of\ mould\ (\text{mm}^2)} \quad (4.1)$$

3.3 Density of Polystyrene concrete

The density of the cubes was obtained in accordance with BS 1881-114: 1983 The cubes for the compressive Strength Test were weighed in a digital weighing balance that has accuracy of 0.01g and recorded and the density of the samples were computed using Equation 3.2.

$$Density = \frac{mass\ of\ sample\ (kg)}{volume\ of\ the\ sample\ (\text{m}^2)} \quad (4.2)$$

3.4 Static Modulus of Elasticity of Polystyrene concrete

The static modulus of elasticity of the Polystyrene concrete were determined as a function of thecompressive strength and density using Equation 3.3

$$Es = (1 \cdot 7P^2 fC^{0.33})\ X\ 10^{-6} \quad (4.3)$$

Where ES =Static modulus of Elasticity

P= density

Fc= compressive strength

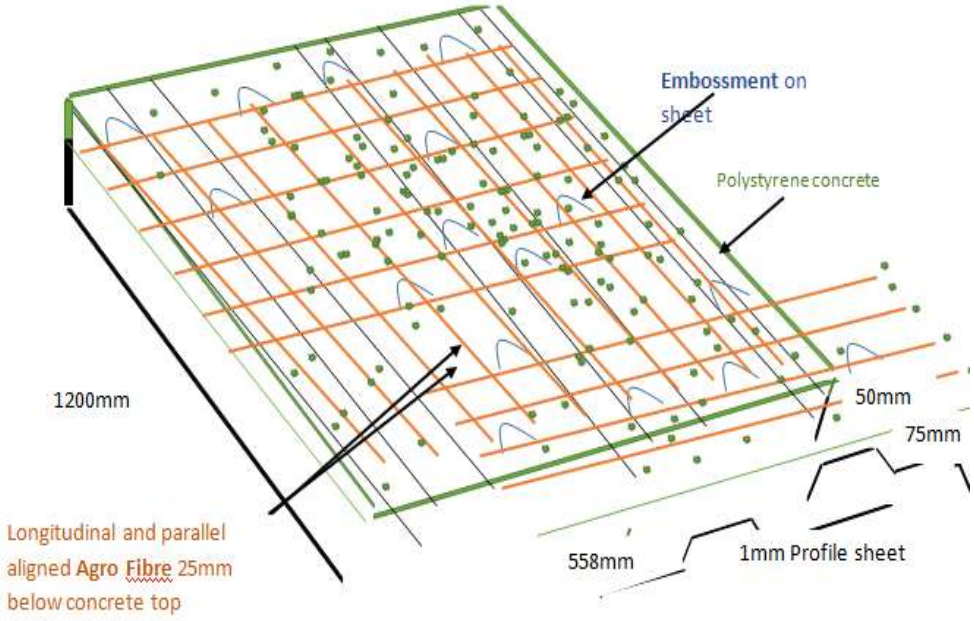
3.5 Determination of Flexural Strength of profile sheet- polystyrene concrete fibre Composite Slabs.

Flexural strength tests were carried out to determine the Flexural strength of the Profile Sheet-Polystyrene concrete fibre composite slab, the test was carried out in accordance with BS EN 12390-5:2000.

The Profile Sheet-Polystyrene concrete fibre composite slab measured 1200 x 558 x 125 mm and reinforced with agro fibre for crack control were produced using manual mixing method and proper vibration to obtain good compaction of the composite. Figure 3.1 shows the components of the composite slab. The mix ratio used was 1:3:3. The mix ratios stand for cement, sand and polystyrene beads respectively. Water cement ratio for all the mixes was 0.45. There were six different % content of Agro fibre in concrete(see Table D1, page 123, Appendix D).

The profile sheets were cold rolled and were cut into size 1200mm x 558mm x 75mm. To make sure that there was proper bond between polystyrene concrete and the profile sheet, embossments were used at intervals of 300mm to create friction between the concrete and the profile sheet. The fresh polystyrene-concrete were filled into the profile sheet and 50mm above the top with temporary wooden support by the sides. Longitudinal and parallel (see Table D1) aligned Agro Fibre were placed 25mm below concrete top to form a mesh which was used as crack control. After the compaction has

been completed, the surface was leveled. A total of twelve (12) slabs were produced. Two (2) slabs each from the six different Agro fibre content in the mixture.



4.1 Typical example of the Polystyrene concrete fibre composite slab

3.2.4 Determination of Deflection at Failure of profile sheet- polystyrene concrete fibre Composite Slabs.

The deflection of polystyrene concrete fibre composite slab was measured using instrument as can be seen in Plate 4.2. The instrument used was constructed using the principle of incompressibility of water. The load from the slab was allowed to act on the T- flange pump that was filled with water and connected to burette that contained water to a particular level. When the slab fails, the changes in height of water in the burette and pump pipe were recorded and having known the areas of the T-flange pump and the burette the deflection was computed.

Plate 4.2: Deflection measurement using principle of incompressibility of water

4.0 RESULTS

4.1 Results

The results obtained for characteristic strength of polystyrene concrete and profile sheet-polystyrene fibre reinforced composite slab are presented here. The results of the test performed were tabulated as shown in Table 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10.

4.1.1 Workability

The results of the workability test were as presented in Table 4.1; from the results the level of slump can be ascertained.

Table 5.1: Workability Test Result for Polystyrene concrete

Mix ratios	Slump Value (mm)	Type of slump
1:6:0	110	True
1:5:1	100	True
1:4:2	100	True
1:3:3	95	True
1:2:4	115	True
1:0:6	120	Collapsed

4.1.2 Penetration Resistance for Polystyrene concrete

The results obtained from the final setting time of polystyrene concrete were as shown in Table 5.2 and Figure 5.1. The final setting time at 3.5MPa was 725 minutes.

Table 5.2: Penetration Resistance Test for Polystyrene concrete

Penetration Resistance in (MPa)	Elapsed Time in (min)
0	50
0	100
0.7	200
0.8	300
1	400
1.7	500
3.1	600
3.3	700
4.1	800

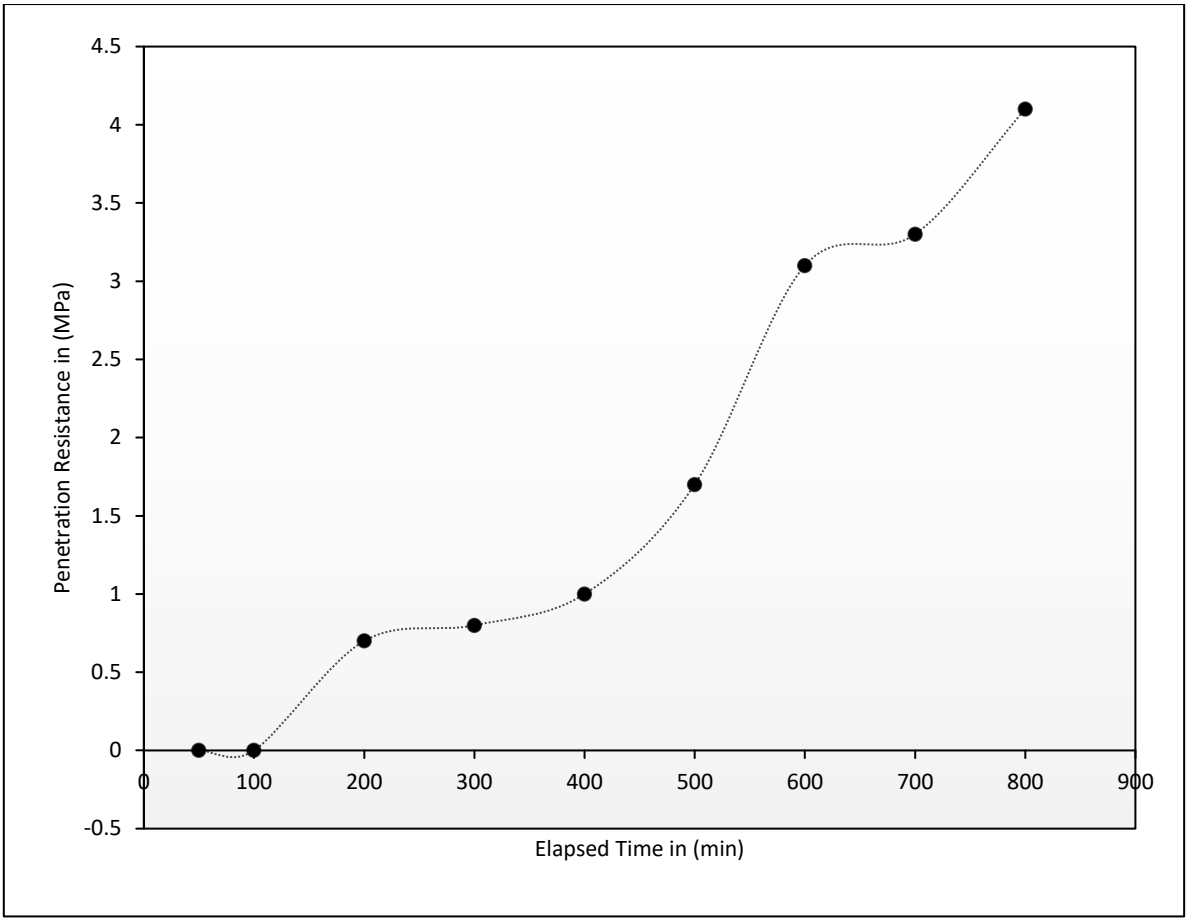


Figure 5.1 Penetration Resistance Curve for Polystyrene concrete

5.1.3 Compressive Strength Test Results for Polystyrene concrete

The results of compressive strength at 7th day were as shown in Table 5.3. The average compressive strength for each mix ratio was as well computed for comparing purposes

Table 5.3: 7th -day Compressive Strength Results for Polystyrene concrete

Mix ratio	**Sample No.**	**Area of Sample (mm^2)**	**Weight of Sample (Kg)**	**Crushing load (KN)**	**Compressive Strength ($N/mm^{2)}$**	**Average Compressive Strength ($N/mm^{2)}$**
1:6:0	A	22500	5.3	78	3.47	
1:6:0	B	22500	5.29	74.1	3.29	3.41
1:6:0	C	22500	5.45	78.1	3.47	
1:5:1	A	22500	5.43	76.57	3.40	
1:5:1	B	22500	5.35	99.56	4.43	3.74
1:5:1	C	22500	5.33	76.57	3.40	
1:4:2	A	22500	5.3	112.8	5.01	
1:4:2	B	22500	5.28	103.7	4.61	4.86
1:4:2	C	22500	5.3	111.8	4.97	

1:3:3	A	22500	5.3	117	5.2	
1:3:3	B	22500	5.41	120.38	5.35	5.0
1:3:3	C	22500	5.13	100.13	4.45	
1:2:4	A	22500	4.9	68.9	3.06	
1:2:4	B	22500	4.34	75.56	3.36	3.26
1:2:4	C	22500	4.8	75.45	3.35	
1:0:6	A	22500	4.2	52.05	2.31	
1:0:6	B	22500	3.78	51.4	2.28	2.28
1:0:6	C	22500	3.67	50.9	2.26	

Table 5.4: 14th - day Compressive Strength Results for Polystyrene concrete

Mix ratio	**Sample No.**	**Area of Sample (mm^2)**	**Weight of Sample (Kg)**	**Crushing load (KN)**	**Compressive Strength (N/mm^2)**	**Average Compressive Strength (N/mm^2)**
1:6:0	A	22500	5.46	86.32	3.84	
1:6:0	B	22500	5.35	83.98	3.73	4.04
1:6:0	C	22500	5.45	102.65	4.56	
1:5:1	A	22500	5.34	83.62	3.72	
1:5:1	B	22500	5.48	110.04	4.89	4.3
1:5:1	C	22500	5.2	96.53	4.29	
1:4:2	A	22500	5.36	123.45	5.49	
1:4:2	B	22500	5.25	132.10	5.87	5.6
1:4:2	C	22500	5.39	122.40	5.44	
1:3:3	A	22500	5.4	130.50	5.8	
1:3:3	B	22500	5.36	127.13	5.65	5.7
1:3:3	C	22500	5.13	127.13	5.65	
1:2:4	A	22500	4.87	77.09	3.43	
1:2:4	B	22500	4.25	82.62	3.67	3.60
1:2:4	C	22500	5.0	83.10	3.69	

1:0:6	A	22500	4.1	58.65	2.61	
1:0:6	B	22500	4.0	57.96	2.58	2.61
1:0:6	C	22500	3.81	59.5	2.64	

Table 5.5: 21st-day Compressive Strength Results for Polystyrene concrete

Mix ratio	**Sample No.**	**Area of Sample (mm^2)**	**Weight of Sample (Kg)**	**Crushing load in (KN)**	**Compressive Strength (N/mm^2)**	**Average Compressive Strength (N/mm^2)**
1:6:0	A	22500	5.43	91.64	4.07	
1:6:0	B	22500	5.37	92.87	4.13	4.37
1:6:0	C	22500	5.43	110.25	4.9	
1:5:1	A	22500	5.54	123.10	5.47	
1:5:1	B	22500	5.35	117.9	5.24	5.49
1:5:1	C	22500	5.21	129.6	5.76	
1:4:2	A	22500	5.41	117	5.20	
1:4:2	B	22500	5.36	120.6	5.36	5.4
1:4:2	C	22500	5.0	126.95	5.64	
1:3:3	A	22500	5.36	138.38	6.15	
1:3:3	B	22500	5.28	141.75	6.30	6.2
1:3:3	C	22500	4.98	138.38	6.15	
1:2:4	A	22500	4.89	86.15	3.83	
1:2:4	B	22500	4.36	92.67	4.12	4.02
1:2:4	C	22500	5.1	92.8	4.12	
1:0:6	A	22500	4.13	65	2.89	
1:0:6	B	22500	4.06	64	2.84	2.95
1:0:6	C	22500	3.9	70	3.11	

Table 5.6: 28th-day Compressive Strength Results for Polystyrene concrete

Mix ratio	**Sample No.**	**Area of Sample (mm^2)**	**Weight of Sample (Kg)**	**Crushing load in (KN)**	**Compressive Strength (N/mm^2)**	**Average Compressive Strength (N/mm^2)**
1:6:0	A	22500	5.48	104	4.62	
1:6:0	B	22500	5.37	98.8	4.39	4.81
1:6:0	C	22500	5.47	122.2	5.43	
1:5:1	A	22500	5.44	100.75	4.48	
1:5:1	B	22500	5.42	131.0	5.82	5.3
1:5:1	C	22500	5.29	126	5.60	
1:4:2	A	22500	5.3	148.2	6.59	
1:4:2	B	22500	5.26	136.5	6.07	6.2
1:4:2	C	22500	5.41	133.65	5.94	
1:3:3	A	22500	5.27	144`	6.4	
1:3:3	B	22500	5.4	142.88	6.35	6.4
1:3:3	C	22500	5.2	145.13	6.45	
1:2:4	A	22500	4.97	90.69	4.03	
1:2:4	B	22500	4.36	100.75	4.48	4.33
1:2:4	C	22500	5.0	100.75	4.48	
1:0:6	A	22500	4.13	69.4	3.08	
1:0:6	B	22500	4.35	68.1	3.03	3.08
1:0:6	C	22500	3.84	70.1	3.12	

4.1.4 Density Results for Polystyrene concrete

Before the samples were crushed, the 28-day weight of the compressive strength test was used to determine the density. The results are shown in Table 5.7.

Table 5.7: 28^{th}-day Density Results for Polystyrene concrete

Mix ratio	Sample No	Volume of Sample in (m^3)	Weight of Sample in (Kg)	Density of the Polystyrene concrete in (Kg/m^3)
1:6:0	A	0.003375	5.48	1622.79
1:6:0	B	0.003375	5.37	1591.68
1:6:0	C	0.003375	5.47	1621.50
1:5:1	A	0.003375	5.44	1611.34
1:5:1	B	0.003375	5.42	1605.55
1:5:1	C	0.003375	5.29	1567.88
1:4:2	A	0.003375	5.3	1569.07
1:4:2	B	0.003375	5.26	1557.19
1:4:2	C	0.003375	5.41	1601.6
1:3:3	A	0.003375	5.27	1562.22
1:3:3	B	0.003375	5.4	1600
1:3:3	C	0.003375	5.2	1539.89
1:2:4	A	0.003375	4.97	1472.98
1:2:4	B	0.003375	4.36	1486.89
1:2:4	C	0.003375	5.0	1478.86
1:0:6	A	0.003375	4.13	1222.98
1:0:6	B	0.003375	4.35	1289.76
1:0:6	C	0.003375	3.84	1138.99

Average density of Polystyrene concrete is 1507.85Kg/m^3

4.1.4 Static modulus of elasticity Results

The static modulus of elasticity results for each mix ratio were as shown in Table 5.8.

Table 5.8: Static modulus of elasticity Result for Polystyrene concrete

Mix ratio	Density of Sample in (kg/m^3)	Compressive Strength (N/mm^2)	Static modulus Of elasticity (GPa)	Average Static modulus of elasticity (GPa)
1:6:0	1622.79	4.62	7.42	
1:6:0	1591.68	4.39	7.02	7.42
1:6:0	1621.50	5.43	7.81	

1:5:1	1611.34	4.48	7.24	
1:5:1	1605.55	5.82	7.84	7.49
1:5:1	1567.88	5.60	7.38	
1:4:2	1569.07	6.59	7.80	7.71
1:4:2	1557.19	6.07	7.47	
1:4:2	1601.6	5.94	7.85	
1:3:3	1562.22	6.4	7.66	7.71
1:3:3	1600	6.35	8.01	
1:3:3	1539.89	6.45	7.46	
1:2:4	1472.98	4.03	5.84	6.03
1:2:4	1486.89	4.48	6.16	
1:2:4	1478.86	4.48	6.10	
1:0:6	1222.98	3.08	3.69	3.66
1:0:6	1289.76	3.03	4.08	
1:0:6	1138.99	3.12	3.21	

4.1.5 Flexural Strength Test Results of Profile Sheet- Polystyrene concrete Fibre Composite Slab

The flexural strength test results of profile sheet-polystyrene concrete fibre composite slab were as shown in Table 5.9.

Table 5.9: 28th-day Flexural Strength Result for Profile Sheet-Polystyrene concrete fibre composite Slab

Mix ratio	***Test***	***Agro fibre content (%)***	***Sample number***	***Crushing Load in (KN)***	***Flexural Strength of the Slab in (MPa)***	***Average Flexural Strength in (MPa)***
1:3:3	1st	0.21	A	19.4	2	2.1
1:3:3	1st	0.21	B	21.3	2.2	
1:3:3	2nd	0.24	A	24.2	2.5	2.45
1:3:3	2nd	0.24	B	23.3	2.4	
1:3:3	3rd	0.28	A	31	3.2	3.3
1:3:3	3rd	0.28	B	29.6	3.4	
1:3:3	4th	0.31	A	38.8	4	3.9
1:3:3	4th	0.31	B	36	3.8	
1:3:3	5th	0.35	A	34.9	3.6	3.4
1:3:3	5th	0.35	B	31	3.2	
1:3:3	6th	0.38	A	30	3.1	2.85
1:3:3	6th	0.38	B	25.2	2.6	

4.1.6 Deflection at Failure Results of Profile Sheet-Polystyrene Fibre Reinforced Composite Slab

Deflection at Failure results of polystyrene concrete fibre composite slab were as shown in Table 5.10.

Table 5.10: Deflection at Failure Result for Polystyrene concrete fibre composite Slab

Mix ratio	**Test**	**Agro fibre content (%)**	**Sample number**	**Crushing Load in (KN)**	**Flexural Strength of the Slab in (MPa)**	**Average Flexural Strength In (MPa)**	**Deflection in mm At failure**
1:3:3	1st	0.21	A	19.4	2	2.1	25
1:3:3	1st	0.21	B	21.3	2.2		22
1:3:3	2nd	0.24	A	24.2	2.5	2.45	23
1:3:3	2nd	0.24	B	23.3	2.4		18
1:3:3	3rd	0.28	A	31	3.2	3.3	18
1:3:3	3rd	0.28	B	29.6	3.4		20
1:3:3	4th	0.31	A	38.8	4	3.9	15
1:3:3	4th	0.31	B	36	3.8		10
1:3:3	5th	0.35	A	34.9	3.6	3.4	24
1:3:3	5th	0.35	B	31	3.2		20
1:3:3	6th	0.38	A	30	3.1	2.85	22
1:3:3	6th	0.38	B	25.2	2.6		23

5.0 DISCUSSION.

The results presented above have been discussed in this section.

5.1 Workability and setting time of polystyrene concrete

The slump results for 1:6:0, 1:5:1, 1:4:2, 1:3:3, 1:2:4 and 1:0:6 for 0.45 water cement ratio are 110mm, 100mm, 100mm, 95mm, 115mm, and 120mm respectively. The mix ratio 1:6:0, 1:5:1, 1:4:2, 1:3:3, and 1:2:4 had true slump while the mix ratio 1:0:6 had a collapse slump.

More compaction resulted in segregation and polystyrene beads floated on the concrete surface. Much compaction is not advised in polystyrene concrete.

Experimentally the workability increased with increase in polystyrene beads content, except 1:0:6 having only polystyrene.

5.2 Penetration Resistance Test

The penetration resistance of polystyrene concrete composite is 710 minutes while those of normal concrete ranges from 240 minutes to 480 minutes; this means that the presence of polystyrene beads increased the final setting time of concrete more than 38%.

5.3 Compressive Strength Test

The 7th day average compressive strength of polystyrene concrete ranged from 2.28MPa to 5.0MPa. The 14th day average compressive strength of polystyrene concrete ranged from 2.61MPa to 5.7MPa. The 21st day average polystyrene concrete compressive strength ranged from 2.95MPa to 6.2MPa. The 28th day average compressive strength of polystyrene concrete ranged from 3.08Mpa to 6.4Mpa. This shows that increase in curing age increases compressive strength of polystyrene concrete up to 8.1%.

The values obtained for 28th day average compressive strength ranged from 3.08MPa to 6.4MPa with 1:0:6 having the minimum compressive strength and 1:3:3 having the maximum compressive strength. The values obtained are less than the minimum value of light weight concrete for 28th-day strength which should not be less than 17.5MPa for structural purposes.

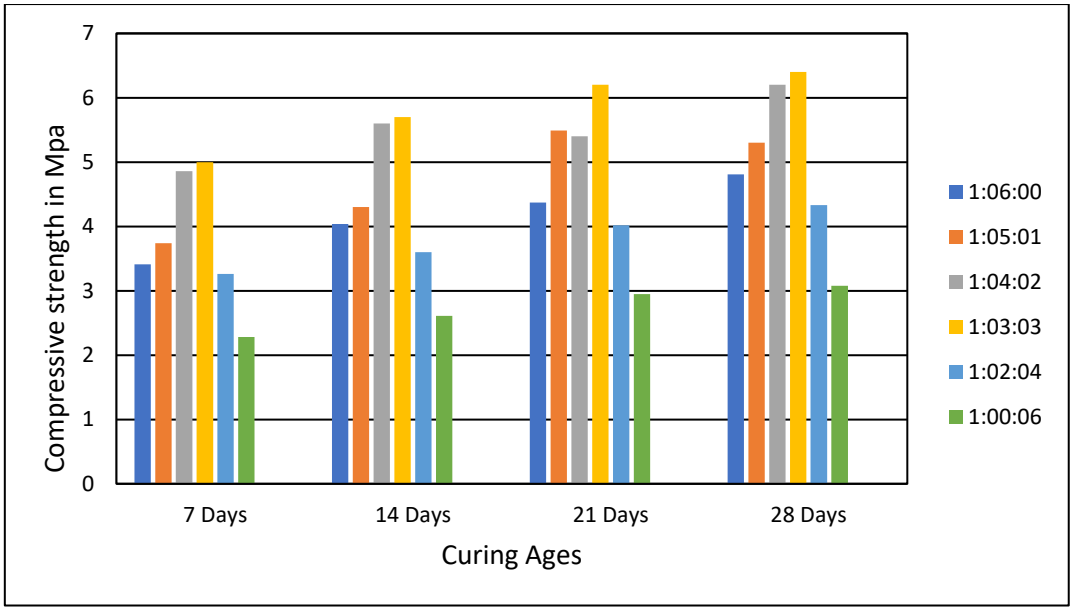


Figure 6.2: Compressive strength of Polystyrene concrete and Curing Ages.

5.4 Relationship between Polystyrene concrete compressive strength of various mix ratios and curing ages.

The relationship between compressive strength mix ratios and curing ages graphs are presented as shown in Figure 4.3 to Figure 4.8, Equation 4.1 to Equation 4.6 describes the relationship between compressive strength, mix ratios and curing ages. From this Equation 4.1 to Equation 4.6, the compressive strength increases with increase in curing age.

For mix ratio of 1:6:0, the compressive strength relates with curing ages x as shown in Equations 6.1

$$Fc = 0.0647x + 3.025 \quad (6.1)$$

For mix ratio of 1:5:1, the compressive strength relates with curing ages x as shown in Equations 6.2

$$Fc = 0.056x + 3.345 \quad (6.2)$$

For mix ratio of 1:4:2, the compressive strength relates with curing ages x as shown in Equations 6.3

$$Fc = 0.0756x + 4.31 \quad (6.3)$$

For mix ratio of 1:3:3, the compressive strength relates with curing ages x as shown in Equations 6.4

$$Fc = 0.097x + 5.77 \quad (6.4)$$

For mix ratio of 1:2:4, the compressive strength relates with curing ages x as shown in Equations 6.5

$$Fc = 0.0519x + 2.895 \quad (6.5)$$

For mix ratio of 1:0:6, the compressive strength relates with curing ages x as shown in Equations .6

$$Fc = 0.0391x + 2.045 \quad (8.6)$$

Figure 6.3: Compressive strength of Polystyrene concrete for mix ratio of 1:6:0 and curing ages

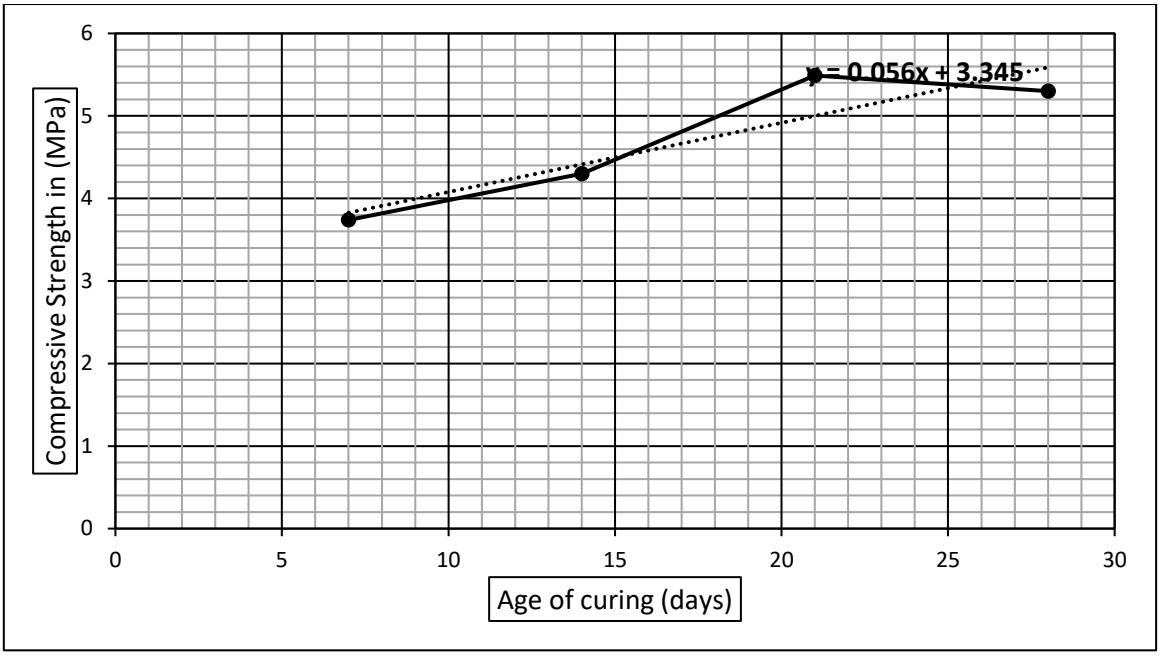


Figure 6.4: Compressive strength of Polystyrene concrete for mix ratio of 1:5:1 and curing ages

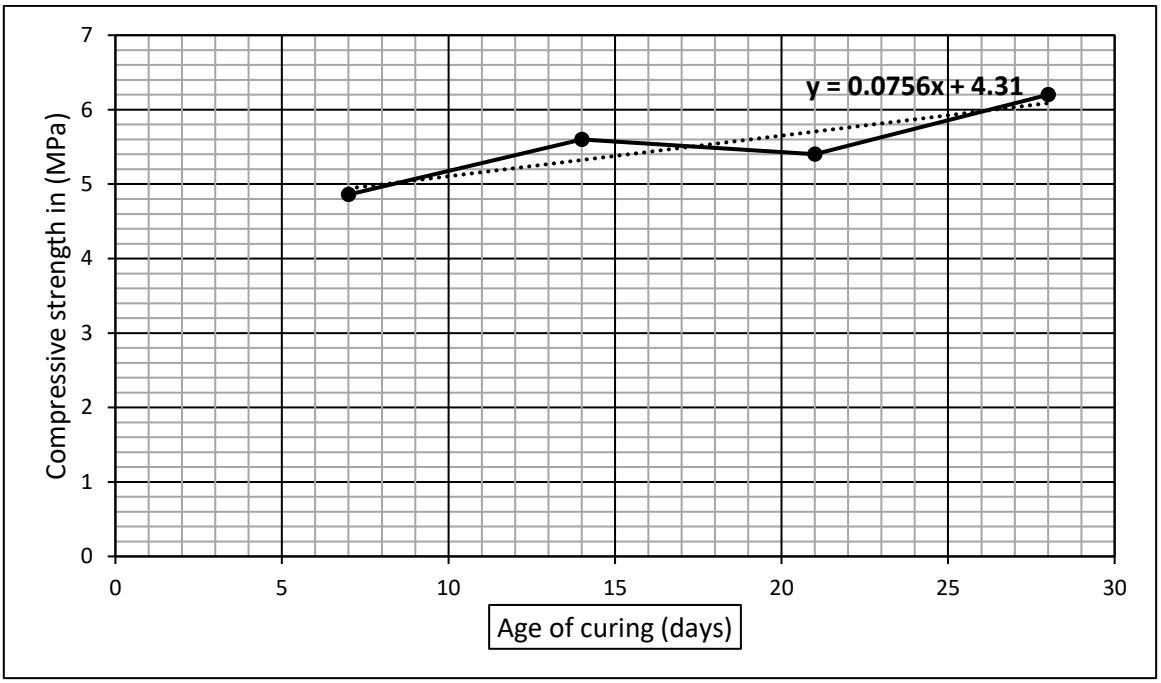


Figure 6.5: Compressive strength of Polystyrene concrete for mix ratio of 1:4:2 and curing ages

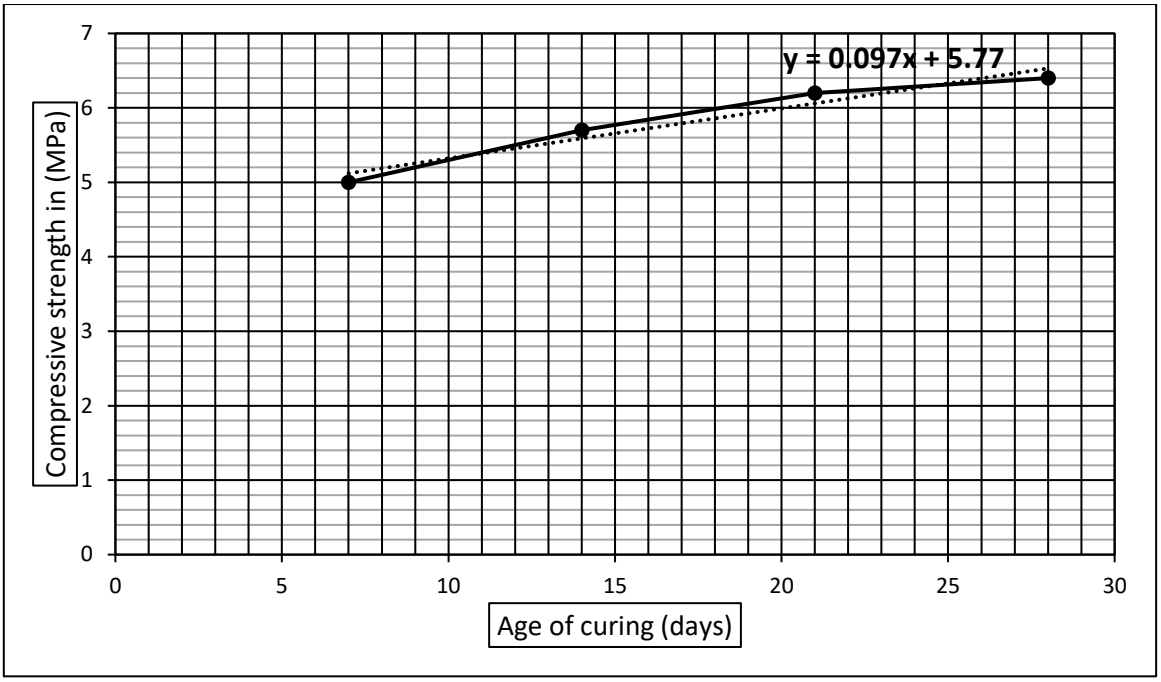


Figure 6.6: Compressive strength of Polystyrene concrete for mix ratio of 1:3:3 and curing ages

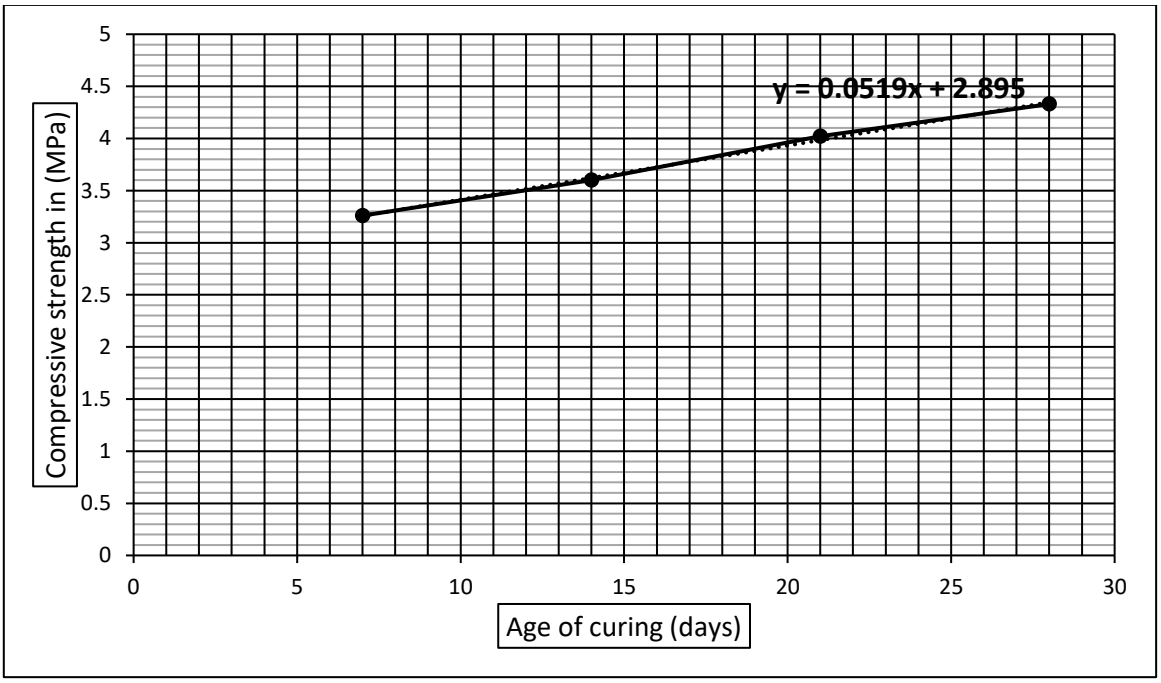


Figure 6.7: Compressive strength of Polystyrene concrete for mix ratio of 1:2:4 and curing ages

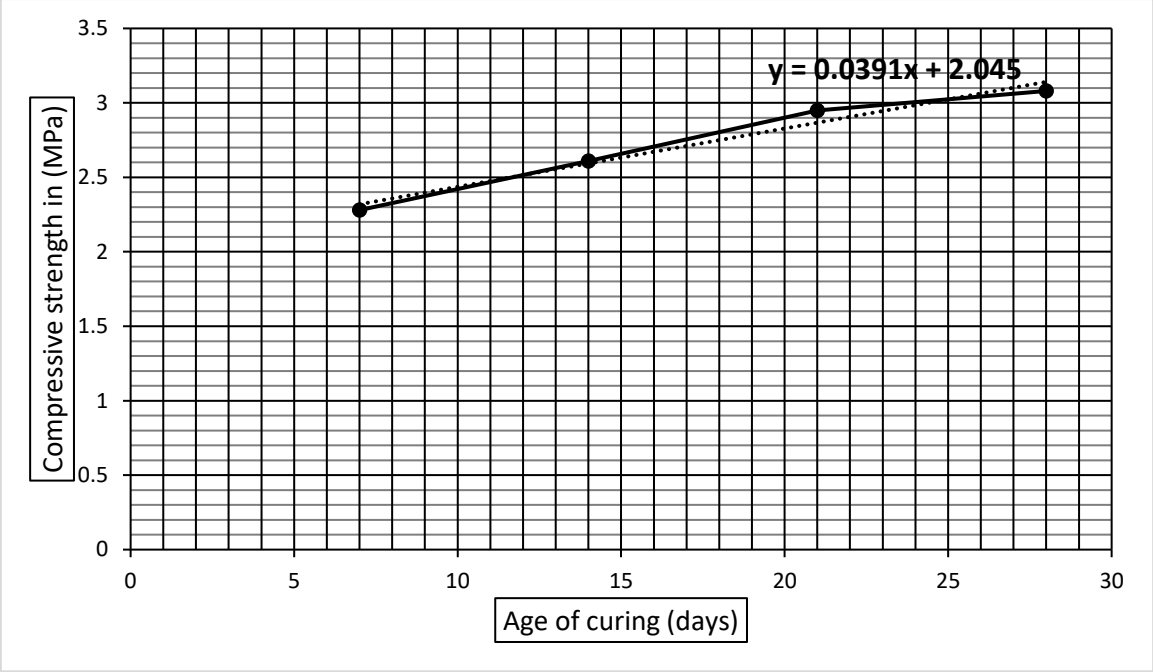


Figure 6.8: Compressive strength of Polystyrene concrete for mix ratio of 1:0:6 and curing ages

5.5 Density Test

The average density of polystyrene concrete was 1507.85Kg/m^3; from literature, the density of light-weight concrete should not exceed 1840kg/m^3. Therefore, polystyrene concrete composite is a lightweight concrete in terms of density.

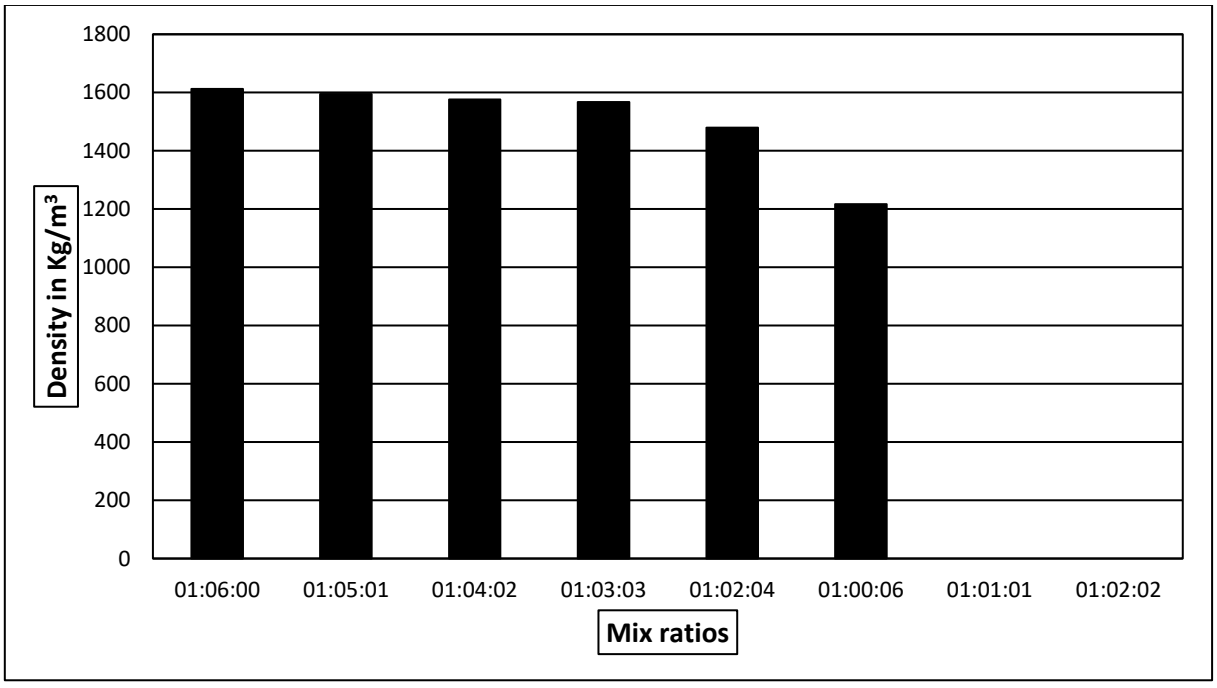


Figure 6.9: 28th Day Density of Polystyrene concrete and mix ratios.

5.6 Static Modulus of Elasticity

The static modulus of elasticity of polystyrene concrete ranged from 3.66GPa to 7.71GPa; but the static modulus of elasticity of normal concrete ranged from 21.4Gpa to 46.4Gpa. This means the values obtained from polystyrene concrete were less than those of normal weight concrete.

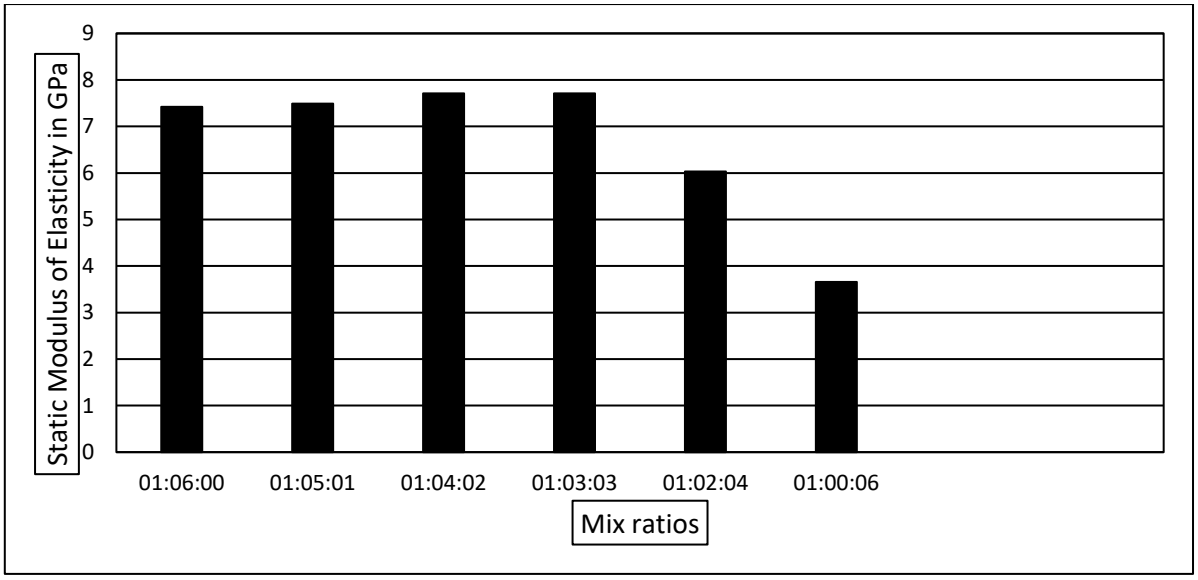


Figure 6.10: Static Modulus of Elasticity of Polystyrene concrete and Mix ratios.

5.7 Flexural strength Test

The average flexural strength of profile sheet-polystyrene fibre reinforced composite slab ranged from 2.1MPa to 3.9MPa. The average flexural strength of plain polystyrene concrete fibre slab was 1.25MPa. The flexural strength of conventional composite slab with 10mm rebar was 7MPa but the permissible stress in bending for concrete ranged from 2.5MPa to 16MPa.

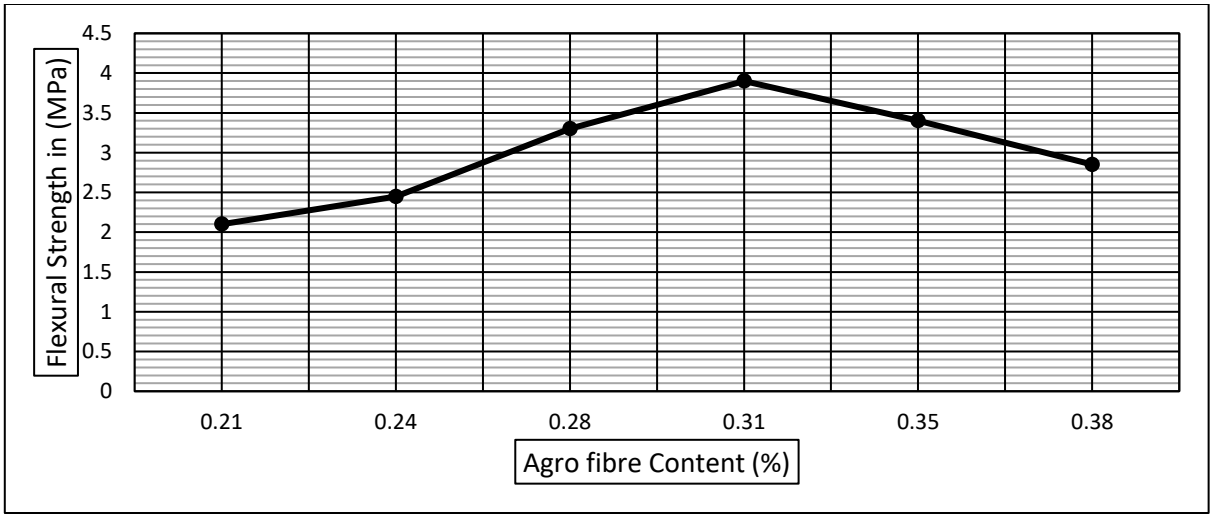


Figure 4.11: Flexural strength of Profile Sheet-Polystyrene Fibre Reinforced composite slab and Agro Fibre Content.

5.8 Deflection Test

The deflection at failure for profile sheet-polystyrene fibre reinforced composite are discussed below alongside with its flexural strength.

For 0.21%Agro fibre content, the average deflection is 23.5mm and the average flexural strength is 2.1Mpa;

For 0.24%Agro fibre content, the average deflection is 20.5mm and the average flexural strength is 2.45Mpa;

For 0.28%Agro fibre content, the average deflection is 19mm and the average flexural strength is 3.3Mpa;

For 0.31%Agro fibre content, the average deflection is 12.5mm and the average flexural strength is 3.9Mpa;

For 0.35%Agro fibre content, the average deflection is 22mm and the average flexural strength is 3.4Mpa;

For 0.38%Agro fibre content, the average deflection is 22.5mm and the average flexural strength is 2.85Mpa;

For convectional slab, the deflection at failure is: -

For 10mm rebar's, the average deflection is 11mm and the average flexural strength is 7Mpa.

For plain polystyrene concrete fibre slab, the average deflection is 21mm and the average flexural strength is 1.25Mpa.

From the results, increase in Agro fibre resulted to an increase in flexural strength with corresponding decrease in deflection values till the 0.31%Agro fibre content, further increase of Agro fibre decrease the flexural strength with corresponding increase in deflection values.

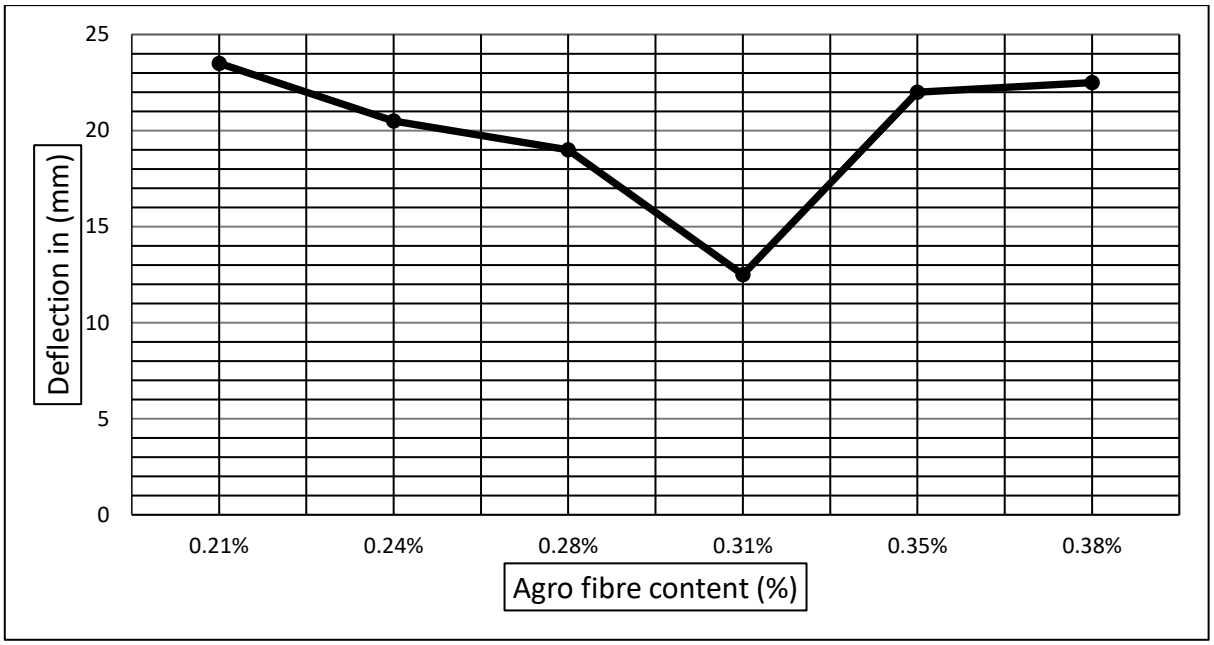


Figure 6.12: Deflection of Profile Sheet-Polystyrene fibre reinforced composite slab and Agro fibre content.

6.0 CONCLUSIONS

The objective of this work was to investigate structural characteristics of Profile Sheet-Polystyrene fibre reinforced composite slab. The following conclusions were drawn from this study.

The workability of the mix ratios utilized was noted, and Table 5.1 shows that the polystyrene concrete was workable and quickly completed and compacted. Workability rises with increasing polystyrene bead content, and this concrete was considered medium workable by Shetty (2006). The concrete's typical final setting time ranged from 240 to 480 minutes. This means that the addition of polystyrene beads extended the setting time by more than 38%. The final setting time of 710 minutes was observed during the practical to establish the structural features.

The average compressive strength of polystyrene concrete composite ranged from 3.08MPa to 6.4MPa, which is far below the recommendations in ACI 213, (1987) which states that the minimum 28 days' strength value of light weight concrete should not be less than 17MPa for structural purposes. The value was below recommended value for normal structural concrete, but the value was within ordinary concrete value, which has its maximum as 10MPa.

The average deflection of profile sheet-polystyrene fibre reinforced composite slab ranged from 12.5mm to 23.5mm as can be seen from Table 4.12, which according to ACI 318, Table 9.5(a), the minimum depth for deflection of reinforced concrete should be L/16, therefore, the deflection was within limit for structural slab.

Although the permissible stress in bending for concrete ranged from 2.5 MPa to 16 MPa for slabs, the average flexural strength of profile sheet-polystyrene fiber reinforced composite slab ranged from 2.1 MPa to 3.9 MPa, and the flexural strength of convectional composite slab with 10 mm rebar gave 7 MPa. Consequently, the flexural strength was within limit for light structural slab.

Shrinkage in profile sheet-polystyrene fibres reinforced composite slab was adequate as the slabs showed no visible crack at 28^{th}-day. Raffia palm agro fibre served as a good crack control in composite slab.

7.0 RECOMMENDATIONS

The following Recommendations were made: -

i. Further studies should be carried out on how to improve the strength of profile Sheet-Polystyrene fibre reinforced composite slab using admixtures.

ii. Further studies should be carried out on the fire resistance of profile sheet-polystyrene fibre reinforced composite slabs compared to traditional concrete.

iii. The relationship between deflection and flexural strength should be observed at different loading other than crushing load.

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