

EXPERIMENTAL STUDY ON LIGHT WEIGHT FOAM CONCRETE BRICKS

Dr.G.Balamurugan¹, K.Chockalingam², M.Chidambaram³, M.Aravindha kumar⁴,

M.Balasundaram⁵

Professor¹, U.G Student², U.G Student³, U.G Student⁴, U.G Student⁵

Department of Civil Engineering

Sethu Institute of Technology, Pulloor, Kariapatti, Virudhunagar, Tamilnadu, India.

Abstract - This paper presents an experimental study on the effect in strength of foam concrete using three different filler materials such as river sand, sea sand and quarry dust with cement. Cement and filler mixed in proportions 1:0, 1:1, 1:2 and 1:3 in weight basis. The foaming agent was added with water and mixed thoroughly. Mixed cement and filler added slowly with this and after certain minutes this gel poured in to the mould of size 19 x 9 x 9 cm to get the brick specimen. The specimens were water cured for 28 days. The compressive strength of this light weight foam concrete bricks at an age of 28 days was obtained at normal temperature. Then the specimens after 28 days curing were heated to 100°C in an oven for 24 hours and tested. Also the specimens kept at 100°C for 24 hours were suddenly immersed in water and subjected to thermoshock and tested for compressive strength. The loss of strength due to thermal and thermo shock effect were compared with conventional concrete (River sand as filler). From the results, it is found that sea sand as well as quarry dust can be used as alternate filler material for natural river sand in foam concrete.

Key Words: Foam concrete, Foaming agent, Cement, Sea sand, River sand, Quarry dust.

1. INTRODUCTION

Foam concrete is nowadays largely used in construction industry due to light weight and easy preparation. It occupies the portion to fill better than any other compound. Uniform distribution of air bubbles through the mass of concrete makes 20% of entrapped air, which makes it so light than the conventional concrete. Foam concrete has been successfully used and it has gained popularity due to lower weight. For foam concrete, generally river sand is used as filler material. Due to rapid usage, there is a shortage of conventional construction material river sand and so costly one. In order to minimise this it is necessary to think of alternate materials. It is observed from previous study that

the maximum ratio of cement with filler for foam concrete as 1:2.5, so in this study we fixed the trial mixes from 1:0 to 1:3 to confirm the maximum ratio. This is an experimental study on how the strength of foam concrete varied when sand is replaced by sea sand as well as quarry dust.

2. MATERIALS AND THEIR PROPERTIES

2.1 Cement

The cement used for this study is Ordinary Portland cement (OPC) of 53 grade conforming to IS 1226: 1978. The various properties of cement are tabulated in Table 1.

Table 1. Properties of cement

S. No	Description	Value
1.	Initial setting time	45min
2.	Final setting time	570min
3.	Standard consistency	34 %
4.	Specific gravity	3.14

2.2 River Sand

Sand used for this study was collected from river Cauvery, Tiruchirappalli. In this study sand passing through IS sieve of size 600 microns was used. The various properties of sand are tabulated in Table 2.

Table 2. Properties of river sand

S. NO	Description	Value
1.	Specific gravity	2.61
2.	Fineness modulus	52.42 %
3.	Void ratio	0.56
4.	Density	2.58

2.3 Quarry Dust

Quarry dust is a residue obtained during stone crushing process in crusher units. It is also used as an effective alternative material in normal concrete instead of fine aggregate sand. In this study Quarry dust passing through IS sieve of size 600 microns was used. Quarry Dust was collected from Reddiapatti in Virudhunagar district. The various properties of quarry dust are tabulated in Table 3.

Table 3. Properties of quarry dust

S. NO	Description	Value
1.	Specific gravity	2.84
2.	Fineness modulus	56.2 %
3.	Void ratio	0.64
4.	Density	2.67

2.4 Sea Sand

Sea sand is the material which is available in plenty all over the world along the shore. The sea sand was used in the construction field after the removal of salt content from it. An experimental setup with sea sand has been made suitable for construction purpose by reducing the salt content to equalize its properties similar to the river sand. The salt was removed from sea sand by washing with ample water. Hence, it is converted in to inert material free from nature of corrosion. Sea sand passing through IS sieve of size 600 microns was used for this study. Sea sand was collected from Sea shore near Sayalgudi in Ramanathapuram district. The various properties of sand are tabulated in Table 4.

Table 4. Properties of sea sand

S. NO	Description	Value
1.	Specific gravity	2.38
2.	Fineness modulus	31.1 %
3.	Void ratio	0.48
4.	Density	2.47

2.5 Water

Potable water with pH value 7 was used for mixing and curing throughout this experiment.

2.6 Foaming Agent

Foaming agent is a material that facilitates formation of foam such as a surfactant or a blowing agent. A surfactant when present in small amounts, reduces surface tension of a liquid (reduces the work needed to create the foam) or increases its colloidal stability by inhibiting coalescence of bubbles. A blowing agent is a gas that forms the gaseous part of the foam. There are two types of foaming agent. They are

- Synthetic-suitable for densities of 1000kg/m³ and above.
- Protein-suitable for densities from 400kg/m³ to 1600kg/m³.

For this experiment animal Protein based Foaming agent was used. Foams from protein-based have a weight of around 800 g/litre. Protein-based foaming agents produced from animal proteins other than horn, blood, bone of animals. The recommended dosage is 30 ml per litre of water.

3. MIX PROPORTIONING

In this study four different mix ratios of cement with filler were prepared. Two alternate fillers were used in place of sand. The different mix ratios are tabulated in Table 5.

Table 5. Mix ratios

S.NO	Description	Mix Ratios
1.	Cement : River sand	1:0, 1:1, 1:2, 1:3
2.	Cement : Sea sand	1:0, 1:1, 1:2, 1:3
3.	Cement : Quarry dust	1:0, 1:1, 1:2, 1:3



Fig -3: Casting of specimen



Fig -1: Foam generator



Fig -4: Foam concrete brick

4. CASTING OF SPECIMEN

The mould of size 19 x 9 x 9 cm was used to prepare the specimen. After 24 hrs of casting the moulds were removed and the specimens were cured in water for 28 days in room temperature.



Fig -2: Brick moulds

5. TESTING PROCEDURE

5.1 DENSITY TEST

The specimen were (3 no's) kept in oven at 100 C for 60 minutes and then weighed. The density of specimen was calculated and is tabulated in Table 6.

Table 6. Density of brick specimen (Kg/m³)

Ratio	cement : River sand	cement : Sea sand	cement : Quarry dust
1:0	607.54	607.53	607.53
1:1	964.91	897.98	1341.78
1:2	1120.89	1026.64	1510.72
1:3	1435.99	1341.78	1767.38

5.2 WATER ABSORPTION TEST

The specimen were (3 no's) immersed in water for 24 hours and weighed (W1) then they kept in a ventilated oven for one hour and weighed (W2). Percentage of water absorption = $W1 - W2 / W2 \times 100$. The percentage of water absorption was calculated and tabulated in Table 7.

Table 7. Percentage of water absorption

Ratio	cement : River sand	cement : Sea sand	cement : Quarry dust
1:0	13.43	13.43	13.43
1:1	11.67	11.86	10.58
1:2	9.78	10.26	9.50
1:3	9.37	9.36	8.54

5.3 COMPRESSION TEST

In a compression test a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. The compressive strength of specimen was calculated and tabulated in Table 8, Table 9 and Table 10.



Fig -5: Compressive strength test on foam concrete brick

Table 8. Compressive strength of foam concrete bricks using river sand as filler

Cement : River sand	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.82	1.69	1.70	1.73
1:1	1.99	1.91	1.96	1.95
1:2	2.82	2.80	2.92	2.84
1:3	3.70	3.77	4.02	3.83

Table 9. Compressive strength of foam concrete bricks using sea sand as filler

Cement : Sea sand	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.82	1.69	1.70	1.73
1:1	1.78	1.82	1.74	1.78
1:2	2.21	2.11	2.28	2.2
1:3	3.13	3.20	3.29	3.21

Table 10. Compressive strength of foam concrete bricks using quarry dust as filler

Cement : Quarry dust	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.82	1.69	1.70	1.73
1:1	2.90	2.94	3.09	2.98
1:2	4.65	4.77	4.69	4.70
1:3	5.27	5.51	5.67	5.49

5.4 TEMPERATURE EFFECT

The strength of brick gets affected due to the increase in temperature. To find the change in strength, the concrete cubes of age 28 days were kept at 100°C in an oven for 24 hours. Then it is immediately tested in compression. The compressive strength of specimen was calculated and tabulated in Table 11, Table 12 and Table 13.

Table 11. Thermal effect on foam concrete bricks (River sand as filler)

Cement : River sand	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.65	1.53	1.56	1.58
1:1	1.85	1.79	1.74	1.79
1:2	2.65	2.71	2.78	2.71
1:3	3.80	3.75	3.72	3.76

Table 12. Thermal effect on foam concrete bricks (Sea sand as filler)

Cement : Sea sand	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.65	1.53	1.56	1.58
1:1	1.62	1.6	1.66	1.63
1:2	1.92	2.14	2.13	2.06
1:3	3.15	3.09	3.18	3.14

Table 13. Thermal effect on foam concrete bricks (Quarry dust as filler)

Cement : Quarry dust	Compressive strength (N/mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.65	1.53	1.56	1.58
1:1	2.71	2.83	2.99	2.84
1:2	4.49	4.61	4.64	4.58
1:3	5.20	5.42	5.59	5.40

5.5 THERMOSHOCK EFFECT

The strength of brick also gets affected when the concrete is exposed to high temperature like fire and then due to sudden cooling. To find the change in strength, the concrete cubes of age 28 days were kept at 100°C in an oven for 24 hours and then immersed in water for a few minutes and then tested in Compression Testing Machine. The compressive strength of specimen was calculated and presented in Table 14, Table 15 and Table 16.

Table 14. Thermoshock effect of foam concrete bricks (River sand as filler)

Cement : River sand	Compressive strength (N / mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.58	1.47	1.49	1.51
1:1	1.78	1.73	1.66	1.72
1:2	2.58	2.64	2.71	2.64
1:3	3.73	3.69	3.74	3.72

Table 15. Thermoshock effect of foam concrete bricks (Sea sand as filler)

Cement : Sea sand	Compressive strength (N / mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.58	1.47	1.49	1.51
1:1	1.58	1.54	1.57	1.56
1:2	2.04	1.94	2.06	2.01
1:3	3.13	3.12	3.07	3.10

Table 16. Thermoshock effect on foam concrete bricks (Quarry dust as filler)

Cement : Quarry dust	Compressive strength (N / mm ²)			Mean compressive strength (N/mm ²)
	S1	S2	S3	
1:0	1.58	1.47	1.49	1.51
1:1	2.64	2.76	2.92	2.77
1:2	4.43	4.53	4.58	4.51
1:3	5.14	5.36	5.53	5.34

6. RESULTS AND DISCUSSIONS

6.1 DENSITY OF FOAM CONCRETE BRICKS

From the Table 6, it is observed that the density of foam concrete bricks increased with increase in mix ratio. Further Quarry dust as filler foam concrete density is higher than sea sand or river sand as filler. The variation in density is presented in Chart - 1.

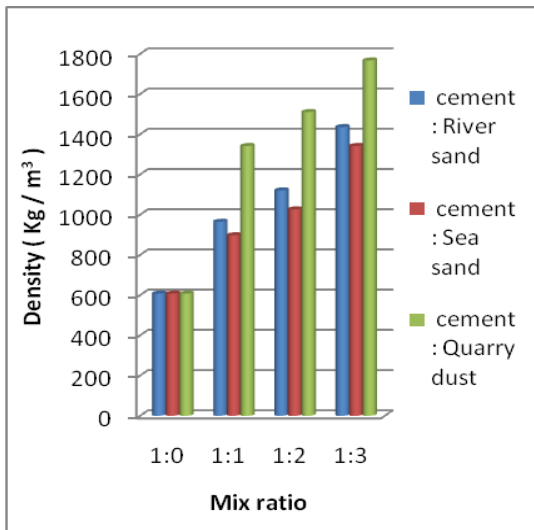


Chart -1: Density of foam bricks

6.2 EFFECT OF WATER ABSORPTION ON FOAM CONCRETE BRICK

From the Table 7, it is observed that the percentage of water absorption is in decreasing order for higher mix ratios. It is also observed that sea sand as filler foam concrete observes more water than other two. The variation in Percentage of water absorption is presented in Chart - 2.

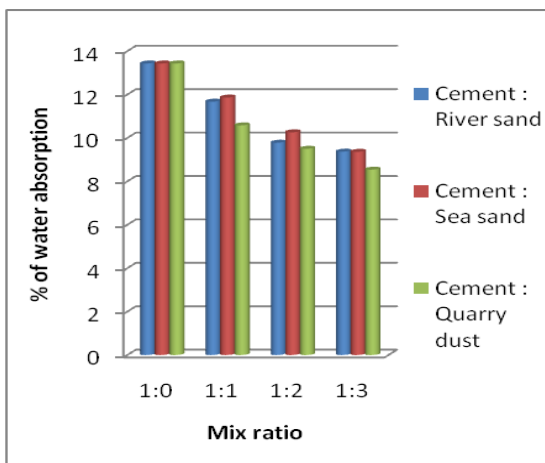


Chart -2: Water absorption of foam concrete bricks

6.3 COMPRESSIVE STRENGTH OF FOAM CONCRETE BRICKS

From Table 17, it is observed that the quarry dust as filler in foam concrete bricks obtained higher compressive strength than conventional bricks whereas sea sand as filler also gained very close values. The variation in Compressive Strength of foam concrete bricks at an age of 28 days is given in Chart - 3.

TABLE 17. Compressive strength on foam concrete brick (N/mm²)

Ratio	cement : River sand	cement : Sea sand	cement : Quarry dust
1:0	1.73	1.73	1.73
1:1	1.95	1.78	2.98
1:2	2.84	2.2	4.70
1:3	3.83	3.21	5.49

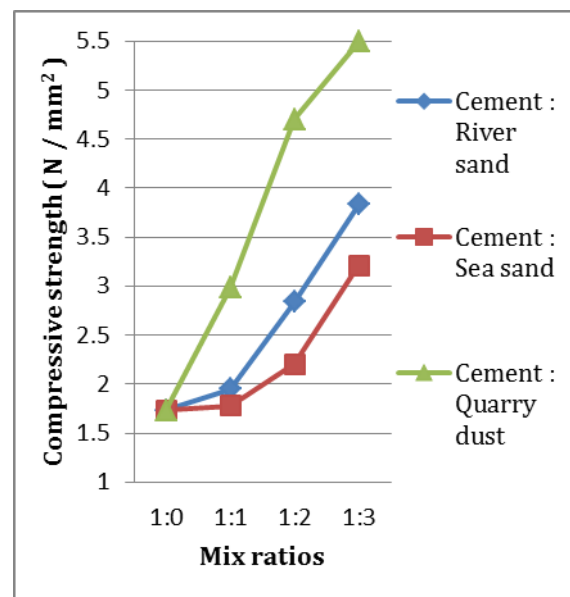


Chart -3: Compressive Strength of foam concrete bricks at an age of 28 days

6.4 EFFECT OF TEMPERATURE ON FOAM CONCRETE BRICKS

From Table 18, it is observed that the quarry dust as filler in foam concrete is less affected due to thermal effect when compared with other filler used foam concrete. The percentage of variation in strength is tabulated in Table 19, Table 20 and Table 21.

Table 18. Temperature effect of foam concrete

Ratio	Normal temperature (N/mm ²)	Thermal effect (N/mm ²)		
		River sand	Sea sand	Quarry dust
1:0	1.73	1.58	1.58	1.58
1:1	1.95	1.79	1.63	2.84
1:2	2.84	2.71	2.06	4.58
1:3	3.83	3.76	3.14	5.4

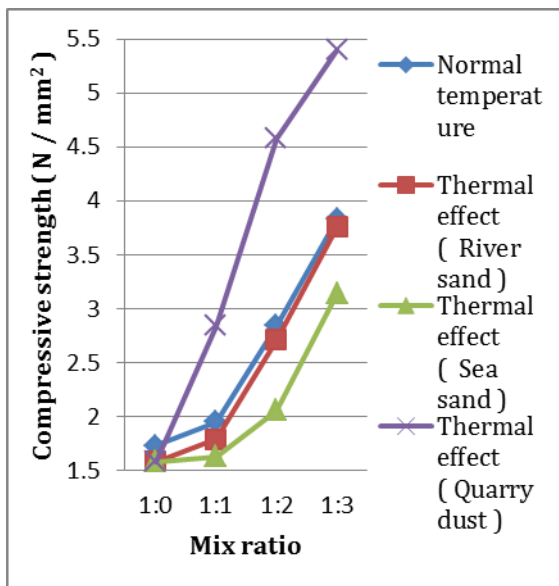


Chart -4: Thermal effect of foam concrete bricks at an age of 28 days

Table 19. Percentage of variation in compressive strength due to thermal effect in foam concrete bricks (River sand as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermal effect	
1:0	1.73	1.58	8.67
1:1	1.95	1.79	8.21
1:2	2.84	2.71	4.58
1:3	3.83	3.76	1.83

Table 20. Percentage of variation in compressive strength due to thermal effect in foam concrete bricks (Sea sand as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermal effect	
1:0	1.73	1.58	8.67
1:1	1.78	1.63	8.43
1:2	2.2	2.06	6.36
1:3	3.21	3.14	2.18

Table 21. Percentage of variation in compressive strength due to thermal effect in foam concrete bricks (Quarry dust as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermal effect	
1:0	1.73	1.58	8.67
1:1	2.98	2.84	4.70
1:2	4.7	4.58	2.55
1:3	5.49	5.4	1.64

From Table 19, Table 20 and Table 21, it is noted that the percentage of variation in compressive strength is in decreasing with increasing mix ratios. This indicates higher mix ratio withstand temperature better than lower one.

6.5 EFFECT OF THERMOSHOCK ON FOAM CONCRETE BRICK

From Table 22, it is observed that the quarry dust as filler in foam concrete is less affected due to thermoshock when compared with other filler used foam concrete. The percentage of variation in strength is tabulated in Table 23, Table 24 and Table 25.

Table 22. Thermoshock effect of foam concrete brick

Ratio	Normal temperature (N/mm ²)	Thermoshock effect (N/mm ²)		
		River sand	Sea sand	Quarry dust
1:0	1.73	1.51	1.51	1.51
1:1	1.95	1.72	1.56	2.77
1:2	2.84	2.64	2.01	4.51
1:3	3.83	3.72	3.1	5.34

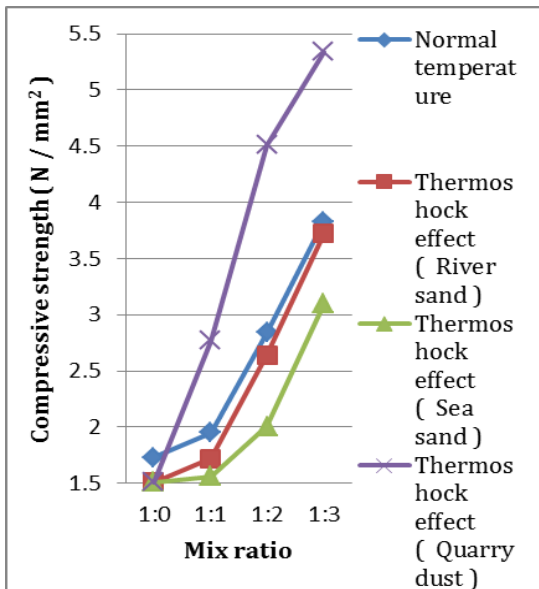


Chart -5: Thermoshock effect of foam concrete bricks at an age of 28 days.

Table 23. Percentage of variation in compressive strength due to thermoshock effect in foam concrete bricks (River sand as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermoshock effect	
1:0	1.73	1.51	12.72
1:1	1.95	1.72	11.79
1:2	2.84	2.64	7.04
1:3	3.83	3.72	2.87

Table 24. Percentage of variation in compressive strength due to thermoshock effect in foam concrete bricks (Sea sand as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermoshock effect	
1:0	1.73	1.51	12.72
1:1	1.78	1.56	12.36
1:2	2.20	2.01	8.46
1:3	3.21	3.10	3.43

Table 25. Percentage of variation in compressive strength due to thermoshock effect in foam concrete bricks (Quarry dust as filler)

Ratio	compressive strength (N/mm ²)		%reduction in compressive strength (N/mm ²)
	Normal temperature	Thermoshock effect	
1:0	1.73	1.51	12.72
1:1	2.98	2.77	7.05
1:2	4.70	4.51	4.04
1:3	5.49	5.34	2.73

From Table 23, Table 24 and Table 25, it is observed that the percentage of loss in compressive strength is in decreasing with increasing mix ratios. This indicates higher mix ratio withstand thermoshock better than lower mix ratio.

6.6 VARIATION IN COMPRESSIVE STRENGTH DUE TO TEMPERATURE EFFECT

Table 26, Table 27 and Table 28 shows the comparison of compressive strength of foam concrete subjected to temperature effect. From this it is observed that even after thermoshock also the compressive strength is higher than

the conventional concrete at normal temperature for quarry dust as filler.

Table 26. VARIATION IN COMPRESSIVE STRENGTH DUE TO TEMPERATURE EFFECT (River sand as filler)

Ratio	Compressive strength (N/mm ²)		
	Normal temperature	Thermal effect	Thermoshock effect
1:0	1.73	1.58	1.51
1:1	1.95	1.79	1.72
1:2	2.84	2.71	2.64
1:3	3.83	3.76	3.72

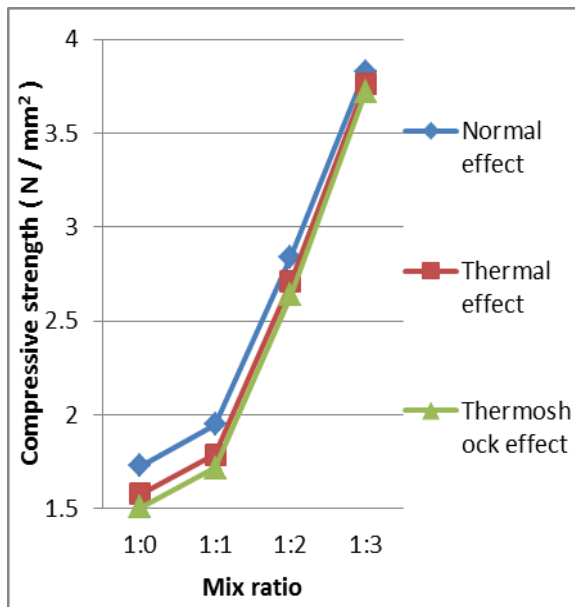


Chart -6: Temperature effect on foam concrete with river sand as filler at an age of 28 days

Table 27. VARIATION IN COMPRESSIVE STRENGTH DUE TO TEMPERATURE EFFECT (Sea sand as filler)

Ratio	Compressive strength (N/mm ²)		
	Normal temperature	Thermal effect	Thermoshock effect
1:0	1.73	1.58	1.51
1:1	1.78	1.63	1.56
1:2	2.2	2.06	2.01
1:3	3.21	3.14	3.10

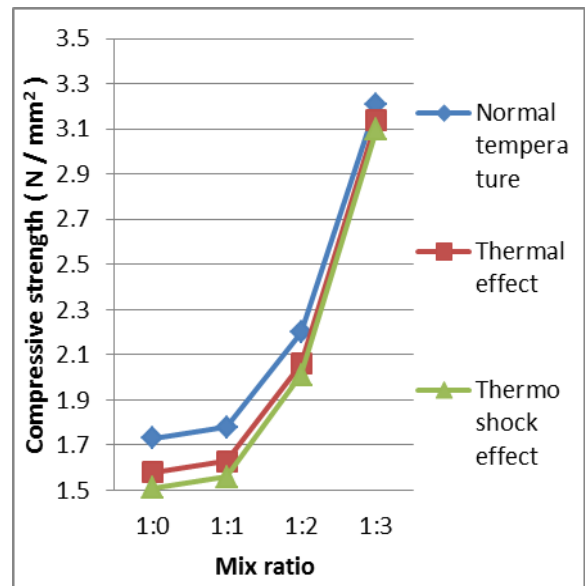


Chart -7: Temperature effect on foam concrete with sea sand as filler at an age of 28 days

Table 28. VARIATION IN COMPRESSIVE STRENGTH DUE TO TEMPERATURE EFFECT (Quarry dust as filler)

Ratio	Compressive strength (N/mm ²)		
	Normal temperature	Thermal effect	Thermoshock effect
1:0	1.73	1.58	1.51
1:1	2.98	2.84	2.77
1:2	4.70	4.58	4.51
1:3	5.49	5.40	5.34

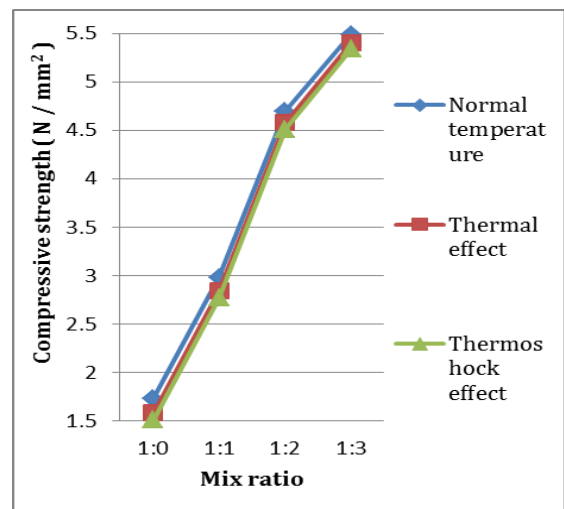


Chart -8: Temperature effect on foam concrete with quarry dust as filler at an age of 28 days

From Chart – 6, Chart -7 and Chart - 8, it is observed that the percentage of loss in compressive strength is decreasing with increasing mix ratios. For higher mix ratio the variation in compressive strength is very less for all filler materials.

7. CONCLUSIONS

From the test results the following conclusions are made

- Foam concrete specimen with quarry dust as filler gained more density and sea sand as filler gained very close density with conventional foam concrete (River sand as filler).
- Maximum water absorption of foam concrete brick specimen is well below the allowable limit of 15%.
- Compressive strength of specimen using quarry dust as filler gained more and sea sand as filler gained very close results with conventional foam concrete.
- Reduction in compressive strength due to thermal effect is in decreasing order for higher mix ratios of all filler materials.
- Reduction in compressive strength due to thermoshock also in decreasing order for higher mix ratios of all filler materials.

From the above conclusions sea sand as well as quarry dust may be used as alternate materials in foam concrete as filler.

8. REFERENCES

[1] Dr.A.S.Kanagalakshmi, K.Sasikumar and E.Britto Pravin, "An Investigation on Foam Concrete with Quarry Dust Replacement For Filler in Mix Design", International Journal of Emerging Technology in Computer Science & Electronics, ISSN: 0976-1353, Volume 13, Issue 1, March 2015, pp. 570 – 581.

[2] Mr.S.Yuvaraj, S.Karthik, M.Naveen Raj, S.S.Ridhu Pharan, P.Sargunam, S.Sethunarayanan and C.Vyshnav, "Experimental Research on Foam Concrete with Partial Replacement of Sand by M-Sand", International Journal of Advanced Technology in Engineering and Science, ISSN: 2348-7550 Vol.No.3, Special Issue No.01, August 2015, pp. 285 -290.

[3] S.Ravi Shankar and Jijo Abraham Joy, "Experiment on Foam Concrete with Quarry Dust as Partial Replacement for Filler", International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol.4 Issue 03, March-2015, pp. 487 – 493.

[4] Abbas M. Abd and Dunya S. Jarullah, "Producing Lightweight Foam Concrete Building Units Using Local Resources", Civil And Environmental Research, ISSN 2224 – 5790 (Paper), ISSN 2225-0514 (Online) Vol.8, No.10, 2016, pp. 54 – 63.

[5] Mr.Ashish S.Moon, Dr.Valsson Varghese and Mr.S.S.Waghmare, "Foam Concrete Can be used For Sustainable Construction as a Building Material", International Journal for Scientific Research & Development, Vol.3, Issue 02, 2015 ISSN (Online): 2321-0613, pp. 1428 - 1431.

[6] Maheshkumar H.Thakrele, "Experimental Study on Foam Concrete", Environmental and Infrastructure Engineering Research and Development, ISSN (E): 2249-7978, Vol.4, Issue 1 Feb 2014, pp. 145 – 157.

[7] Alonge O. Richard and Mahyuddin Ramli, "Experimental Production of Sustainable Lightweight Foamed Concrete", British Journal of Applied Science & Technology 3(4): 994-1005, 2013, pp. 994 – 1005.

[8] Chen Bing, Ph.D; Wu Zhen and Liu Ning, Ph.D; "Experimental Research on Properties of High – Strength Foamed Concrete", Journal of Materials in Civil Engineering, January 2012, 113 -118.

[9] G.Balamurugan and Dr.P.Perumal, "Use of Quarry Dust to Replace Sand in Concrete- An Experimental Study", International Journal of Scientific and Research Publications, ISSN: 2250-3153, Vol. 3 Issue 12, December 2013, pp. 50 -53.

[10] G.Balamurugan and Dr.P.Perumal, "Behaviour of Concrete on the Use of Quarry Dust to Replace Sand-An Experimental Study", Engineering Science and Technology: An International Journal, ISSN: 2250-3498, Vol. 3, No.6, December 2013, pp. 776 – 781.

[11] G.Balamurugan and P.Perumal, "Experimental Study on the Thermal and Thermoshock Effects on the Concrete Strength due to the use of Quarry Dust for Replacing Sand", European Journal of Scientific Research, ISSN: 1450-216X, Vol. 92 No.1, December 2012, pp. 113 – 119.