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A study of mechanical properties of lightweight cement mortar

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ABSTRACT

The present work contributes to the difference between mechanical properties of lightweight cement mortar by using common waste such as coconut shell powder, wood waste and sea shell powder as the partial replacement of sand. These waste materials can be found easily and I tried to make better use of them in this present work. The mechanical properties conducted were workability, compressive strength test and split tensile strength test. The results were concluded by describing the best material for replacement of sand and its optimum quantity which is to be added to produce lightweight cement mortar. Lightweight cement mortar can be used in cases of underwater construction, for better heat resistance, eco-friendly construction. In, by and large, the mortar is plastic liquid-like structure comprises of OPC cement or Ordinary Portland Cement, water and Fine aggregate. The common mortar can be used for masonry works in most of the cases. But to impart special characteristics to the common mortar we need to add some ingredients such as fly ash, rice husk ash, metakaolin etc, so, in this present work, I used different waste material as a partial replacement for the fine aggregate or sand.

Keywords— *Lightweight Cement Mortar, Waste Materials, Density, Compressive Strength, Tensile Strength.*

1. INTRODUCTION

The prime objective of my project work is to make better use of recyclable waste materials such as a seashell, coconut shell and wood waste to prepare lightweight cement mortar. Lightweight cement mortar is also good for the environment and eco-friendly. By and large, mortar comprises of Ordinary Portland Cement, water and fine aggregate or sand. In general, mortar can be used for masonry works. But in this scientific era, we can produce different kinds of mortars each of them having specular properties. In this present work, I intended to produce lightweight cement mortar with common waste materials. To impart different properties to mortar we might be willing to add some additives such as fly ash, rice husk ash, metakaolin etc. Mortar is fluid like structure which is in a plastic stage so that its constituents could not be separated from it. Lightweight cement mortar can be used for underwater construction, Lightweight cement mortar can be used in cases of underwater construction, for better heat resistance, eco-friendly construction. Sometimes the cost of pumping may vary from low to high because of mortar density, machine efficiency. Usually, the density of normal cement mortar varies from 1438 Kg/m^3 to 2038 Kg/m^3. So it is common phenomena of cement mortar to produce the heat of hydration which dries up the water in the internal core. But if the production of the heat of hydration is more it causes fractures on the surface of hardened cement mortar which is avoidable. While coming to waste production, the total waste produced in the world by 2050 will be 27 billion tonnes per year. As we come to India there will be 0.7kg of waste produced per person per day by 2025. And construction and demolition waste produced in India is 14.5 million tonnes per year. So, this state of production of waste must be changed and we have to reuse the waste produced as possible as it is. Nowadays, there are so many concretes and cement mortars which uses different waste by-products. One of them is light-weight cement mortar. In this present paper, we are using recycled waste products to produce light-weight cement mortar. Light-weight cement mortar is the mortar whose density is lesser compared to that of the traditional cement mortar. The minimum density of cement mortar can be achieved by replacing cement and fine aggregate with some recycled waste by-products. This lightweight cement mortar can be used in tall building construction and underground water construction, tunnelling, airports, soil stabilization, roads etc., This Lightweight mortar can also be used as fire resistant, soundproof and cost of production is also less since we use recycled waste by-products.

1.1 Experimentation

The system of methods followed in this present work was,
Stage-1: Mixing of materials.
Stage-2: The casting of cubes.
Stage-3: Testing.
Stage-4: Results and conclusions.

Before continuing this process, I must define the properties of materials used for the generation of lightweight cement mortar. In general, mortar is composed of cement, fine aggregate and water. In this present work, I replace fine aggregate with ground coconut shell, wooden waste and seashells.

Table 1: Material properties

S. no	Material	Density (Kg/m^3)
1	Cement	1440
2	Water	1000
3	Sand	1520
4	Wooden waste	900
5	Seashell	515
6	Coconut shell	556

Total 76 cement mortar cubes were casted for compressive strength test and 76 cement mortar moulds were casted for the tensile strength test. The mixing proportion followed in this present work was 1:3 (1 portion of cement and 3 portions of fine aggregate). In this present work, I replaced 20, 25, 30, 35, 40 and 45 percent of waste material as partial replacement of fine aggregate.

2. COMPRESSIVE STRENGTH TEST

Total 76 cubes of cement mortar were casted in cement mortar moulds. The size of mould as per IS: 10080-1982, is 70.6mm x 70.6mm x 70.6 mm. initially, normal cement mortar was prepared in proportions of one part of cement and three parts of sand. The water to cementitious material ratio considered for this proportion was 0.6. Total four normal cement mortar cubes for prepared for the purpose of testing. Later the sand was replaced with each of the waste material partially. The test results were noted for 7, 14, 28 and 58 days respectively. The entire test was conducted by the compressive testing machine. Compressive strength of cube can be calculated from the formula,

Compressive strength (MPa) = (Load resisted by cube / Area on which load is acting)

Table 2: Compressive strength values of normal cement mortar

S. no	Age of curing in days	The volume of the cube (mm^3)	Compressive strength (MPa)
1	7	351.8958	12.2565
2	14	351.8958	13.7949
3	28	351.8958	15.5641
4	58	351.8958	11.5294

The maximum value was obtained for 28 days as 15.5641 MPa. Later the sand was replaced with waste material by 20, 25, 30, 35, 40 and 45 percent respectively. The waste material was grinded to2.56mm.

Table 3: Compressive strength values obtained at different curing periods when sand was replaced with grounded wooden waste partially

S. no	Percentage of wooden waste added (%)	The volume of cube mm^3	Compressive strength (MPa)				Average tensile strength (MPa)
			7th day	14th day	28th day	58th day	
1	20	351.8958	8.9585	10.3022	11.8476	10.0704	10.2946
2	25	351.8958	9.8565	11.3349	13.0352	10.0799	11.0766
3	30	351.8958	10.5465	12.1284	13.9476	11.8555	12.1195
4	35	351.8958	11.9595	13.7534	15.8164	13.4439	13.7433
5	40	351.8958	10.6548	12.2530	14.0909	11.9772	12.1926
6	45	351.8958	8.5596	9.8435	11.32	9.622	9.8362

Table 4: Compressive strength values obtained at different curing periods when sand was replaced with grounded coconut shell partially

S. no	Percentage of ground coconut shell added	Volume of cube mm^3	Compressive strength (MPa)				Average tensile strength (MPa)
			7th day	14th day	28th day	58th day	
1	20	351.8958	7.6565	8.8049	10.1256	8.6067	8.7984
2	25	351.8958	8.5236	9.8021	11.2724	9.5815	9.7949
3	30	351.8958	9.4563	10.8747	12.4465	10.5795	10.8392
4	35	351.8958	10.5636	12.1481	13.9703	11.8747	12.1391
5	40	351.8958	9.6548	11.1030	12.7684	10.8531	11.0948
6	45	351.8958	7.5596	8.6935	9.9975	8.4979	8.6871

Table 5: Compressive strength values obtained at different curing periods when sand was replaced with grounded seashell partially

S. no	Percentage of grounded sea shell added	Volume of cube mm^3	Compressive strength (MPa)				Average tensile strength (MPa)
			7th day	14th day	28th day	58th day	
1	20	351.8958	6.6565	7.6549	8.8032	7.4827	7.6565
2	25	351.8958	7.5656	8.7004	10.0055	8.5046	8.6940
3	30	351.8958	8.4586	9.7273	11.1864	9.5085	9.7202
4	35	351.8958	9.3645	10.7691	12.3845	10.5268	10.7612
5	40	351.8958	9.5652	10.9999	12.6499	10.7524	10.9918
6	45	351.8958	10.3545	11.9076	13.6938	11.6397	10.5989

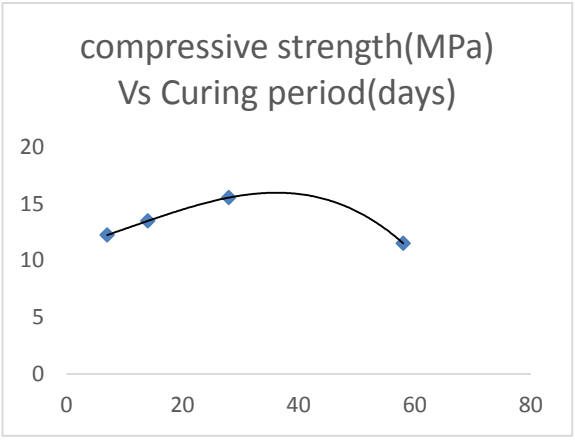

Fig. 1: Compressive strength (MPa) vs. curing period (days)

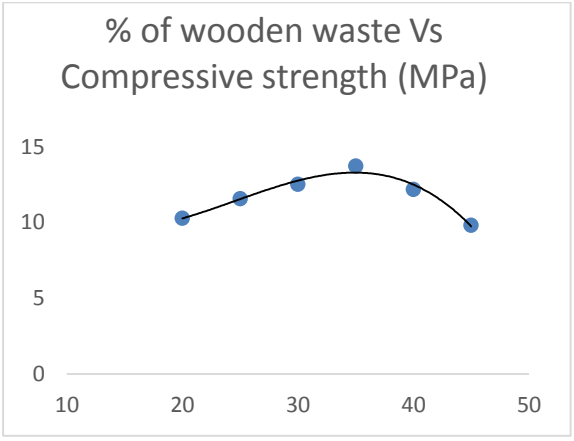

Fig. 2: Percentage of wooden waste vs. compressive strength (MPa)

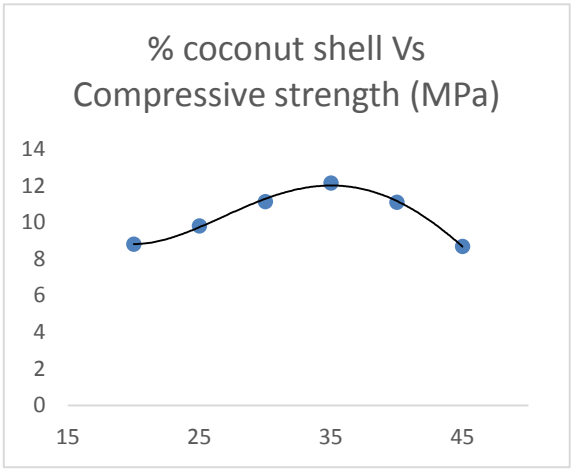

Fig. 3: Percentage of grounded coconut shell vs. compressive strength (MPa)

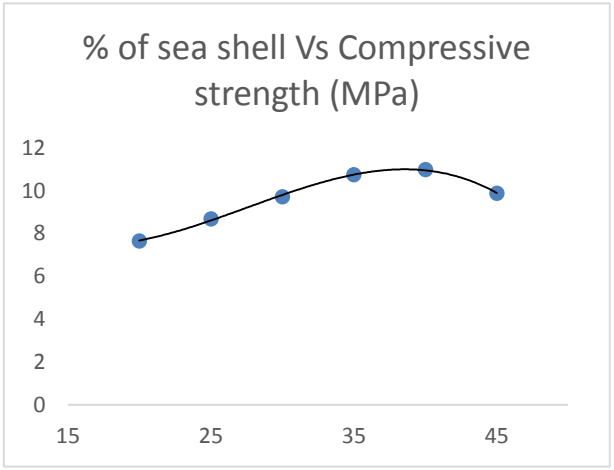

Fig. 4: Percentage of grounded sea shell vs. compressive strength (MPa)

3. TENSILE STRENGTH TEST

Tensile strength test is used to identify the rapid hardness of the cement mortar. The test is also useful in indirect measure of compressive strength. Initially, the lightweight cement mortar was prepared by replacing sand with different recyclable waste material. The plastic cement mortar was placed in briquette mould. The briquette moulds were sent to keep dry for twenty-four hours and then sent to curing for seven, fourteen, twenty-eight and fifty-eight days respectively. The least sectional area of the briquette mould is 6.45 sq.cm. So the tensile strength is calculated from,

Ultimate Tensile Strength = (Load at failure/ 6.45)

Table 6: Tensile strength values of normal cement mortar (MPa)

S. no	Age of curing (days)	Tensile strength (MPa)
1	7	2.586
2	14	2.9739
3	28	3.4199
4	58	2.907

Overall 76 moulded specimen were prepared tensile strength test by replacing sand with different recyclable waste material in different proportions.

Table 7: tensile strength values obtained at different curing periods when sand was replaced with ground wooden waste partially

S. no	Percentage of wooden waste added (%)	Tensile strength in MPa				Average tensile strength (MPa)
		7^{th} day	14^{th} day	28^{th} day	58^{th} day	
1	20	2.45	2.8175	3.2012	2.72	2.7971
2	25	2.50	2.875	3.3062	2.8103	2.8728
3	30	2.54	2.921	3.3591	2.8552	2.9188
4	35	1.962	2.2563	2.5947	2.2055	2.2546
5	40	1.935	2.2252	2.5590	2.1751	2.2235
6	45	1.9236	2.2121	2.5439	2.1623	2.2094

Table 8: Tensile strength values obtained at different curing periods when sand was replaced with ground coconut shell partially

S. no	Percentage of ground coconut shell added (%)	Tensile strength in MPa				Average tensile strength (MPa)
		7^{th} day	14^{th} day	28^{th} day	58^{th} day	
1	20	2.0145	2.3166	2.6640	2.2644	2.3148
2	25	2.0366	2.3420	2.6933	2.2893	2.3403
3	30	2.1896	2.518	2.8957	2.4615	2.5162
4	35	2.2263	2.5602	2.9442	2.5027	2.5583
5	40	1.9263	2.2152	2.5475	2.1654	2.2136
6	45	1.6396	1.8855	2.1683	1.8431	1.8848

Table 9: Tensile strength values obtained at different curing periods when sand was replaced with ground sea shell waste partially

S. no	Percentage of grounded sea shell added (%)	Tensile strength in MPa				Average tensile strength (MPa)
		7^{th} day	14^{th} day	28^{th} day	58^{th} day	
1	20	1.9666	2.2615	2.6	2.21	2.2595
2	25	1.9862	2.2841	2.6267	2.2327	2.2824
3	30	2.1325	2.4523	2.8201	2.3971	2.4505
4	35	2.1562	2.4796	2.8515	2.4238	2.4777
5	40	1.9156	2.2029	2.5333	2.1533	2.2012
6	45	1.5623	1.7966	2.0661	1.6669	1.7729

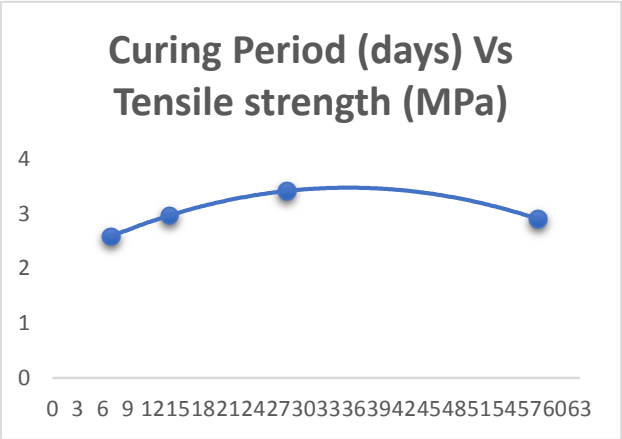

Fig. 5: Curing period (Days) vs. tensile strength (MPa)

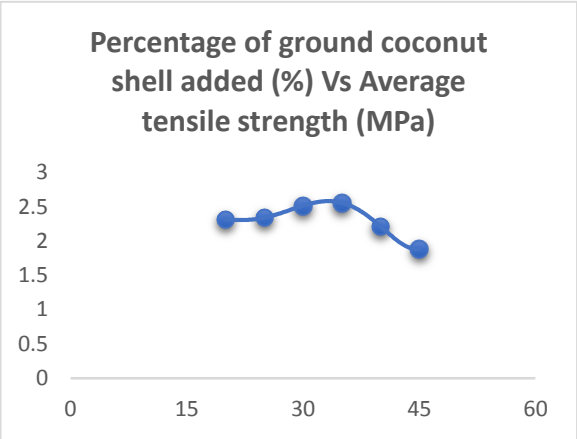

Fig. 6: Percentage of grounded coconut shell added vs. average tensile strength (MPa)

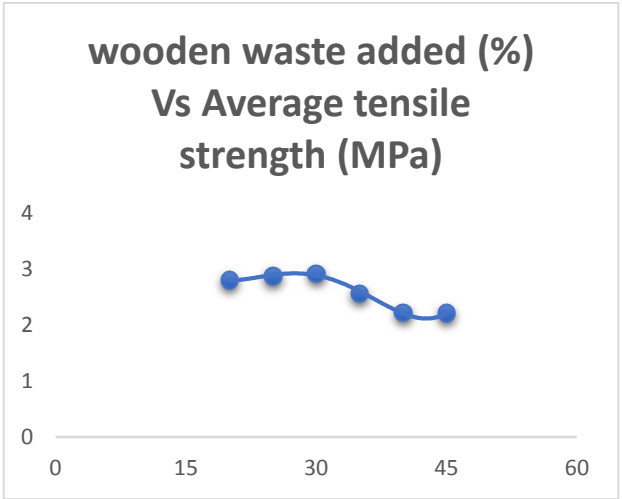

Fig. 7: Percentage wooden waste added vs. average tensile strength (MPa)

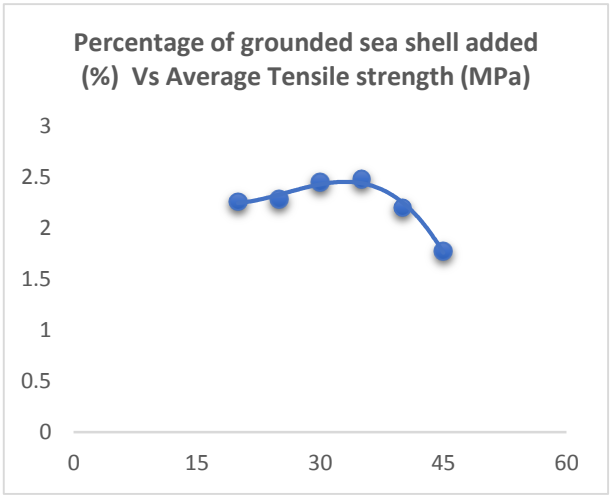

Fig. 8: Percentage of grounded sea shell added vs. average tensile strength

4. DENSITY TEST

Density test is to ensure that the mortar is light weight or not. Density test is the most important test in this present work as the lightweight cement mortar should be of less dense. In general, lesser dense mortar cannot resist compressive strength and duclity test. So, in this work, my prime aim is to increase the strength of the mortar and decreasing its density. Lesser density material can float on the water such as wood, coconut shell and sea shell. They have less density value compared to the sand. The density of the cement mortar cube can be calculated from the following,

Density = weight of the cube/volume of the cube

Table 10: Density values obtained when sand was replaced with ground wooden waste partially

S. no	Density of cement cube (Kg/m^3)	Percentage of wooden waste replaced with sand (%)	Desnity of resulting cube (Kg/m^3)
1	2052	20	1956.5625
2	2052	25	1858.7343
3	2052	30	1765.7976
4	2052	35	1577.5077
5	2052	40	1258.1307
6	2052	45	1006.5046

Table 11: Density values obtained when sand was replaced with grounded coconut shell partially

S. no	Density of cement cube (Kg/m^3)	Percentage of grounded coconut shell replaced with sand (%)	Density of resulting cube (Kg/m^3)
1	2052	20	1867.5662
2	2052	25	1774.1878
3	2052	30	1685.4784
4	2052	35	1516.9305
5	2052	40	1137.6978
6	2052	45	910.1582

Table 12: Density values obtained when sand was replaced with grounded sea shell partially

S. no	Density of cement cube (Kg/m^3)	Percentage of grounded sea shell replaced with sand (%)	Density of resulting cube (Kg/m^3)
1	2052	20	1788.9685
2	2052	25	1699.52
3	2052	30	1614.544
4	2052	35	1453.0895
5	2052	40	1089.8175
6	2052	45	871.8537

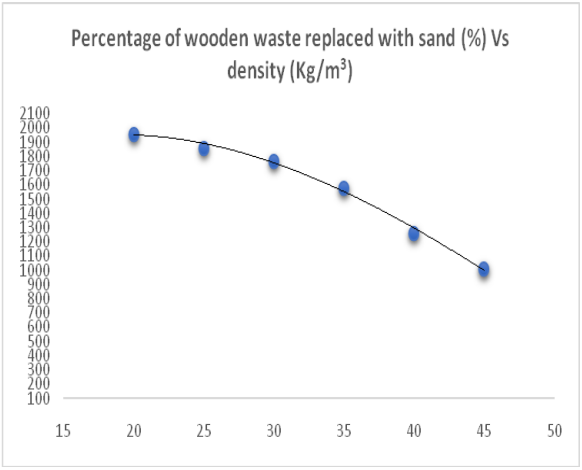

Fig. 9: Percentage of wooden waste replaced with sand vs. density (Kg/m^3)

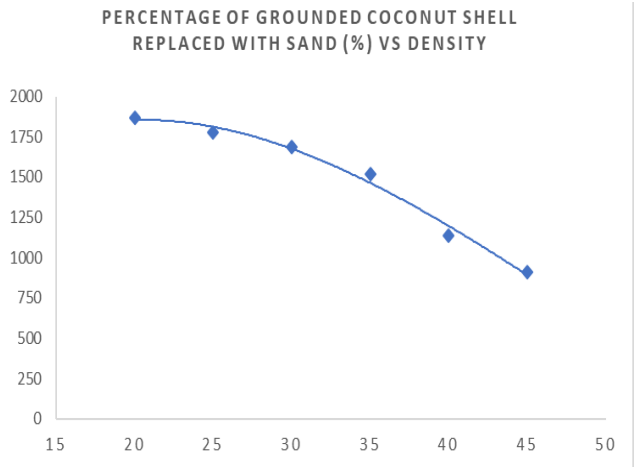

Fig. 10: Percentage of grounded coconut shell vs. density (Kg/m^3)

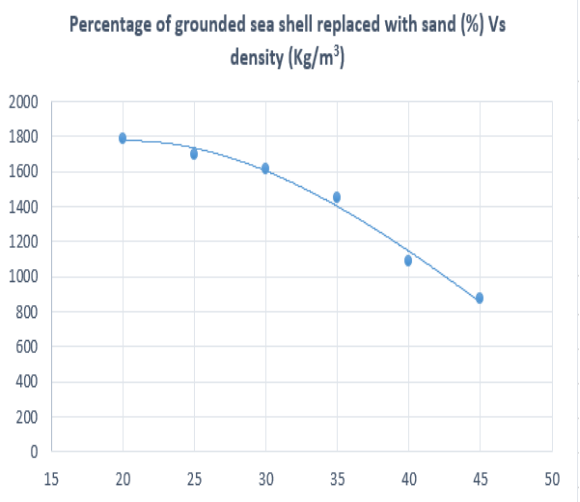

Fig. 11: Percentage of grounded sea shell vs. density (Kg/m^3)

5. RESULTS AND DISCUSSION

Total of seventy six cubes of lightweight cement mortar was casted for compressive strength test and seventy-six moulds of lightweight cement mortar were casted for tensile strength test and eighteen cubes were casted for density test. After all experimental studies the following results were made:

(a) Compressive strength test was conducted on seventy six cement mortar cubes of size 70.6 mm x 70.6 mm x 70.6 mm moulds. The compressive strength value of normal mortar was 15.561 MPa at the 28^{th} day. Then the sand was replaced partially with wooden waste, grounded sea shell and grounded coconut shell. Each of these materials was replaced at 20, 25, 30, 35, 40 and 45 percentages with sand. For wooden waste, the maximum compressive strength was observed as 13.7433 MPa with 35 percent of sand replaced with wooden waste. For grounded coconut shell, the maximum compressive strength was observed as 12.1391 MPa with 35 percent of sand replaced with a coconut shell. For grounded sea shell, the maximum compressive strength was observed as 10.9918 MPa with 40 percent of sand replaced with sea shell powder.

(b) Tensile strength test was conducted on seventy-six cement mortar moulded specimen with a least cross-sectional area of 6.45 cm^2. The tensile strength of normal mortar was 3.4199 MPa on the 28^{th} day. Then sand was replaced with wooden waste, grounded sea shell and grounded coconut shell. Each of them was used as a replacement for sand at different proportions. For wooden waste, the tensile strength was reported as 2.9188 MPa with 30 percent of wooden waste. For grounded coconut shell, the tensile strength was reported as 2.5583 MPa with 35 percent of coconut shell powder. For grounded sea shell, the tensile strength was reported as 2.4777 MPa with 35 percent of sea shell powder.

(c) Overall eighteen cubes of lightweight cement mortar were casted for density test. For grounded coconut shell, the density was reported as 1867.5662 Kg/m^3 maximum and 910.1582 Kg/m^3 as a minimum. For wooden waste, the maximum density value was reported as 1956.5625 Kg/m^3 and minimum as 1006.5046 Kg/m^3. For grounded sea shell powder, the maximum density value was reported as 1788.9685 Kg/m^3 and minimum as 871.8537 Kg/m^3.

6. CONCLUSION

After all testing and experimental studies, the following conclusions were made,

(a) The compressive strength values were decreased for grounded coconut shell and grounded sea shell compared to those of wooden waste. This was because the densities of the coconut shell and sea shell were lower than that of wooden waste. The compressive strength values for wooden waste were reported as nearly equal to those of normal mortar.

(b) The tensile strength values were decreased for all the three materials because the densities were lesser than that of normal mortar. But as we see, the tensile strength values of wooden waste were reported as highest among those of the remaining two.

(c) The sand was replaced with each of the waste materials at 20, 25, 30, 35, 40 and 45 percent. Since the waste material content was increased the density of the lightweight cement mortar was decreased. The density values were mainly depended on the waste material that was replaced with sand.

Finally, for the preparation of the lightweight cement mortar, the optimum values are either 30 percent of wooden waste or 35 percent of grounded coconut shell powder or 40 percent of grounded sea shell powder. The best material for better results is a wooden waste. Wooden waste satisfied every requirement for preparation of lightweight cement mortar.

7. REFERENCES

[1] Fred Sabins, Ultra Lightweight Cement, Eleventh Quarterly Technical Progress Report, Cementing Solutions. Inc, 2003.

[2] J. Gadea, A. Rodriguez, P.L. Campos, J.Garabito, V.Calderon, Lightweight mortar made with recycled polyurethane foam, Department of Construction Engineering and Land, Higher Polytechnic School, University of Burgos, Villa Diego s/n, E-09001, Spain.

[3] J.Hemanth, Compressive strength and micro structural properties of lightweight high strength cement mortar reinforced with eloxal, Akshaya Institute of Technology, Karnataka, India.

[4] Nurhayat Degirmenci, Arin Yilmaz, Use of pumice fine aggregate as an alternative to standard sand in the production of lightweight cement mortar, Engineering and Architectural faculty, Balikesir University, Cagis Campus 10145, Turkey.

[5] Corinaldesi Valeria, Study of lightweight mortars made of wooden waste, Dept.SIMAU, Universita Politecnica Delle Marche, Via Breece Bianche, 60131, Ancona, Italy.

[6] Tiekun Jial, Jiuanwei Li, Xiaofeng Wang and Xinai Zhang, Preparation and properties of Lightweight Cement Mortar with Granulated Blast Furnace Slag and Expanded Perlite as aggregate, Department of Materials Science and Engineering, Luoyang Institute of Science and Technology, Luoyang, 471023, P.R. china.

[7] Sang-Joon Ma, The study on the development of lightweight foamed mortar for tunnel backfill, Geotechnical Infrastructure Research Department, Korea Institute of Construction Technology, 1190, Siminde-Ro, Ilsanseo-Gu, Goyand-Si, 411-712, Republic of Korea.

[8] Taha Mehmannavaz, Salihuddin Radin Sumadi, Muhammad Aamer Rafique Bhutta, Mostafa Samadi, Seyed Mahdi Sajjadi, Effect of waste materials in lightweight concrete, Faculty of civil engineering, Universiti Teknologi Malaysia, Skudai 81300, Johor, Malaysia.

[9] Hesham Alsharie, Talal Masoud, Aziz Ibrahim Abdulla and Aseel Ghanem, Properties of lightweight cement mortar containing treated pumice and lime stone, Department of Civil engineering, Faculty of Engineering, Jerash University, Jerash, Jordan.

[10] K. Senthamarai Kannan, L. Andal and M. Shanmugasundaram, An Investigation on Strength development of cement with Cenosphere and silica fume as a pozzolanic replacement.

[11] Semenov Vyacheslava, Rozovskaya Tamaraa, Gubsckiy Aleksandra, Gareeva Rozlinaa, Effective lightweight masonry mortars with dispersed reinforcement.

[12] Abdul Harris, The influence of aluminium waste addition on density and compressive strength of mortar, Department of Civil Engineering, Institute Teknologi Adhi Tama Surabaya, Indonesia.

[13] Mercedes del Rio Merino, Javier Guijarro Rodriguez, Francisco Fernandez Martinez and Jaime Santa Ceuz Astorqui, Viability of using olive stones as lightweight aggregate in construction mortars.
[14] Ziyad Majeed Abed, The effect of using lightweight Aggregate on some properties of cement mortar.
[15] Mambou Ngueyep Luc Leroy, Keyangue Tchouata Jules Hermann, Atangana Nkene Elise Rose, Ndop Joseph, Fotseu Miyo Christian Dupont, Ndijaka Jean-Marie Bienvenu, Density and strength of mortar made with the mixture of wood ash, crushed genesis and river sand as fine aggregate.
[16] Farzad Khamchin Mogaddam, Rasiah Sri Ravindra rajah and Vute Srivivatnanon, Properties of metakaolin concrete –Review.

