EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE BY USING PARTIAL REPLACEMENT OF CEMENT WITH LIME POWDER AND COARSE AGGREGATE WITH COCKLE SHELLS

1 A. Jayasri, 2K. Durga Prasad, 3A. Hari sankar, 4MD. Riyaz ali, 5R.Chandra shekhar
1Student, Department of Civil Engineering, Godavari institution of engineering & Technology(A),Rajahmundry, AP, India
2Student, Department of Civil Engineering, Godavari institution of engineering & Technology(A), Rajahmundry, AP, India
3Student, Department of Civil Engineering, Godavari institution of engineering & Technology(A), Rajahmundry, AP, India
4Student, Department of Civil Engineering, Godavari institution of engineering & Technology(A), Rajahmundry, AP, India
5Assistant Professor, Department of Civil Engineering, Godavari institution of engineering & Technology(A), Rajahmundry, AP, India

Abstract: Due to the day to day innovations and development in construction field, the use of natural aggregates is increased tremendously. At the same time, the demand of materials also increased and the availability of the materials are also decreased. Because of these reasons the reuse of solid waste materials like cockle shells and lime powder came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregates for making concrete. The cockle shell is not only solid waste and also marine waste obtained at sea shores. This waste material should have to be reused in order to deal with the limited resource of natural aggregate. Cockle shells and lime powder are used as a replacement to the coarse aggregates and cement respectively. The cockle shell waste was partially replaced as coarse aggregates by 10%, 20%, and 30%. Lime powder was replaced as cement by 5%, 10%, and 15%. M30 grade of concrete was designed and tested. The mix design prepared by replacing the coarse aggregates and cement at different percentages of cockle shells and lime powder. Experimental tests performed are Compressive strength test, Split tensile strength test, for M30 grade concrete with different percentages of cockle shells and lime powder after 7, 14 and 28 days curing period. The obtained strength results are compared with conventional concrete.

Keywords: cockle shells , lime powder, M30, solid waste.

1. INTRODUCTION

1.1 General

Now a days the use of concrete in infra-structural activity is on the rise and materials being the most important but costly component of concrete, effort to reduce the costly partial replacement of materials with supplementary material has gained momentum and is even made as a government regulation. However, the production of concrete is not environmentally friendly. In this scenario, the use of conventional waste materials, such as fly ash, lime powder, recycled aggregate , sea shells ,granite stones rice husk ash, ground granulate blast furnace slag, silica fume, sugar cane bagasse etc. are replacement of materials in concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry. Currently, solid waste such as lime powder and cockle shells are being used as supplementary in cement and coarse aggregate replacement materials. Therefore, a great potential exists to reduce the concrete industries.

1.2 Objectives of project

- The main objective is to encourage the use of these products as construction material in building
- To evaluate the cockle shells and lime powder, compressive strength and split tensile strength at 7 days, 14days and 28 days by replacing in concrete.
- These should reduce the usage of natural products like aggregates.
- To encourage the use of waste.
- Environmental friendly disposal of cockle shells. Hence this should controls the pollution of environment.

2. LITERATURE REVIEW

Arun Raj . I, K. P. Ravi Kumar (2018): Investigation on replacement of coarse aggregate and cement by sea shells and prosopis juliflora ash. The substituent to coarse aggregate and cement by sea shell and prosopis juliflora ash at level of 10%, 20%, and 30% for M25 grade of concrete. The average maximum compressive strength and tensile strength is obtained at 20%. The strength is gradually decreased at 30% replacement.

B. Madhan kumar, P. Yuvaraj, C.Suriya Kumar (2017): Experimental study on suitability of the cockle shells and lime powder as partial replacement for concrete. Cement is partially replacement with lime powder about 10%, 20%, 30%. The coarse aggregate is partially replacement with cockle shells about 10%, 20%, 30% using M30 grade of concrete. Results shows at 10% replacement provide high strength concrete compared to conventional concrete and also produce workable concrete.

3. MATERIALS AND PROPERTIES

3.1 Materials used:

The ingredients used in this concrete mix are,

- Ordinary Portland Cement of 53 Grade cement conforming to IS: 169-1989.
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Water.
- Cockle shells as partial replacement to coarse aggregate.
- Lime powder as partial replacement of cement.

Cement: Cement is the most important material used in constructions. It has adhesive and cohesive properties so as to render it to form a good bond with other materials. As it is a binder material in concrete, when it is mixed with aggregates and water it turns the particles in to a whole compound and solidifies. Cement is most important and costliest ingredients of concrete, and it is obtained by burning a mixture of the siliceous, argillaceous and calcareous material in a definite proportions.

Oxide and compound composition of a typical portland cement[6]

Typical oxide composition percent	
Cao	63
SiO_2	20
Al_2O_3	06
Fe_2O_3	03
MgO	10.5
So_3	02
K_2O/ Na_2O	01

Calculated compound composition percent	
C_3A	10.80
C_2S	54.10
C_3S	16.60
C_4AF	9.10

Properties of cement:

S no	Tests on cement	Results
1.	Fineness of cement	25%
2.	Standard consistency of cement	34%
3.	Soundness of cement	0
4.	Initial setting time of cement	0
5.	Final setting time of cement	5mm
6.	Specific gravity of cement	3.16

Fine aggregates

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete.

Properties of fine aggregate:

S no.	Tests on fine aggregate	Results
1.	Specific gravity of fine aggregate	2.6
2.	Water absorption of fine aggregate	1.6%
3.	Sieve analysis of fine aggregate	3.78

Coarse aggregate Crushed aggregates of 20mm size produced from local crushing plants were used. The aggregate exclusively passing through 16mm sieve size and retained on 20mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, specific gravity in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading.

Properties of coarse aggregate

S no.	Tests on coarse aggregate	Results
1.	Specific gravity of coarse aggregate	2.64
2.	Water absorption of coarse aggregate	0.62%
3.	Sieve analysis of coarse aggregate	3.49
4.	Impact value of coarse aggregate	18.06%
5.	Aggregate crushing value	16.6%
6.	Flakiness of coarse aggregate	36.8%
7.	Elongation of coarse aggregate	48.9%

Water

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in concrete and it should have PH value ranges between 6 to 9.

Cockle shells

A cockle is an edible, marine bivalve mollusc. Although many small edible bivalves are loosely called cockles, true cockles are species in the family Cardiidae. There are more than 205 living species of cockles, with many more fossil forms.

Seashell is a waste obtained near the seashore area as the result of disintegration of dead animals. Seashell consists of three layers outer, intermediate and inner layer .Outer layer is made up of calcite material whereas inner layer is otherwise known as nacre which is made up of calcium carbonate. Since 95% of calcium carbonate present in seashell, it has the strength nearly equal to coarse aggregate. The sieve analysis for seashell is executed to find out its size.

Properties of cockle shells

S.no	Tests on cockle shells	Results
1.	Specific gravity of cockle shells	2.6
2.	Water absorption of cockle shells	0.82%
3.	Crushing value of cockle shells	16%

Lime powder

Since long, Lime has been used to make things like plaster and mortar. Lime is usually made by burning of limestone. Chemically lime itself is calcium oxide (Ca_O) and is made by roasting calcite ($CaCo_3$) to remove carbon dioxide (Co_2). Lime is also called calx or quicklime. Quick Lime is very caustic and can even dissolve human bodies. When lime is mixed with water, lime slowly turns into the mineral portlandite(dense) in the reaction Cao + H_2O = Ca $(OH)_2$. Lime is mixed with an excess of water so it stays fluid, this is called slaking and the lime resulting is called slaked lime. Slaked lime continues to harden over a period of weeks. Lime has to be mixed with sand and other ingredients to take form of slaked lime cement, that can be used as mortar between stones or bricks in a wall or spread over the surface of a wall There, over the next several weeks or longer, it reacts with CO2 in the air to form calcite again(artificial limestone).

Properties of lime powder

Calcium hydroxide(Lime) is relatively insoluble in water, with a solubility product Ksp of 5.5 × 10−6. It is large enough that its solutions are basic according to the following reaction

$$Ca(OH)_2 \rightarrow Ca_2^+ + 2\ OH^-$$

At ambient temperature, calcium hydroxide dissolves in pure water to produce an alkaline solution with a pH of about 12.4. Calcium hydroxide solutions can cause chemical burns. At high pH value (see common ion effect), its solubility drastically decreases. This behavior is relevant to cement pastes.

Chemical composition of lime powder[5]

S.no	Compound	Content
1	Sio_2	59.0
2	Al_2o_3	21.0
3	Fe_2o_3	3.70
4	Cao	6.90
5	Mgo	1.40
6	So_3	1.0
7	K_2o	0.9
8	Loi	4.62

4. Concrete mix design

The grade of concrete is depends up on the mix design of concrete. The mixes up to M20 are nominal mix i.e. M15, M20. whereas mix above M20 is designed mix. The mix design is based in strength criteria and durability criteria used for moderate environment. The ratios by weight of cement, fine aggregate and coarse aggregate are obtained using the specifications given in IS: 10262-2009. These proportions are maintained strictly same throughout the casting process to obtain a uniform standard and workable concrete mix. Normally cubes are tested for compressive strength and tensile strength after 7days, 14days and 28 days. In our project work the age of curing at 7, 14 and 28 days are conducted. the process of considering required amount of ingredients of concrete and also calculating their relative amounts with the objective of producing a concrete of the required strength, durability, and workability as economically as possible, is termed the concrete mix design. The properties of compressive and tensile strength of hardened concrete which is generally considered to be an index of its other properties, depending up on many factors, e.g. w/c ratio quality of cement, water, aggregate, exposure conditions, material properties, mixing, placing, compaction and curing condition.

- Grade of designation : M30
- Type of cement : 53 grade
- Maximum nominal size of aggregates : 20mm
- Minimum cement content : 320Kg/m^3 as per IS : 456 – 2000
- Maximum cement content : 450Kg/m^3 as per IS : 456 – 2000
- Exposure condition : moderate
- Type of aggregate : crushed angular aggregates

Mix proportions

Cement: fine aggregate: coarse aggregate : water

400 : 690 : 1134 : 180

1 : 1.73 : 2.83 : 0.45

5. Experimental work

The methodology of the present thesis work contains collection of raw materials, determining the physical properties of the collected materials and confirming the raw results to the standard values. Further, determining the proper mix design by using obtained physical properties. With M30 grade mix designs desired mix proportion is determined and further work was continued using those proportions by increasing the percentage of lime powder and cockle shells used as a partial replacement of cement and coarse aggregate respectively. Hardened concrete tests like compressive test and tensile test were conducted and results were determined. Each variation is labeled after a mix designation and samples are casted for determining tests Compressive strength and Tensile strength with standard specimen sizes and later compared results with increase in percentage of partial replacement of lime powder and cockle shells.

Cubes are casted of 150×150×150mm dimension to find compressive strength and cylinders are casted of 150× 300mm dimension to find tensile strength. All together 3 proportions of lime powder (5%, 10%,15%) are replaced on cement and 3 proportions of cockle shells (10%, 20%, 30%) are replaced on coarse aggregate with combination. Each proportion comprises of 9 cubes are tested for 7, 14 and 28 days of curing. The results are compared with conventional concrete.

6. Results and discussions

6.1 WORKABILTY:

6.1.1 Slump Cone Test:

The test was conducted for fresh concrete prepared before the moulding process. A total of 4 mix proportions of replaced concrete are prepared at different times. Workability Results obtained from slump cone test for M30 grade of concrete is shown in table:

Workability of concrete

S.no	Mix designation	Slump cone (mm)
1	C_0	50
2	C_{10}	65
3	C_{20}	73
4	C_{30}	79

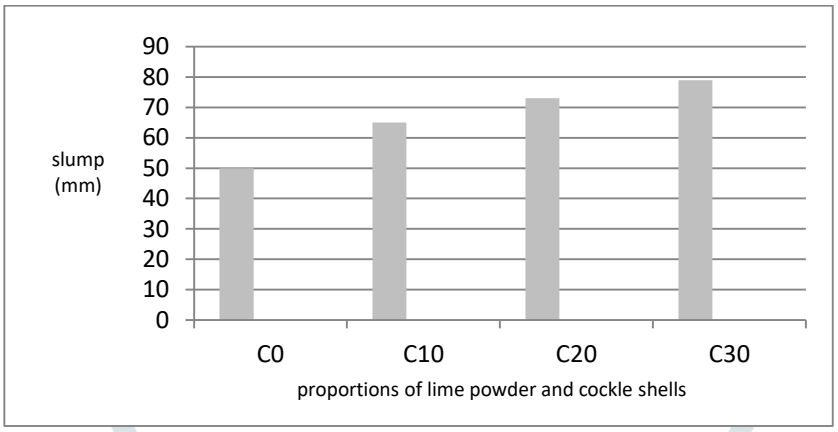
Where

C_0 = conventional concrete for M30 grade.

C_{10}= concrete with 5% replacement of lime powder in cement and 10% replacement of cockle shells in coarse aggregate

C_{20} = concrete with 10% replacement of lime powder in cement and 20% replacement of cockle shells in coarse aggregate

C_{30} = concrete with 15% replacement of lime powder in cement and 30% replacement of cockle shells in coarse aggregate



Workability of concrete.

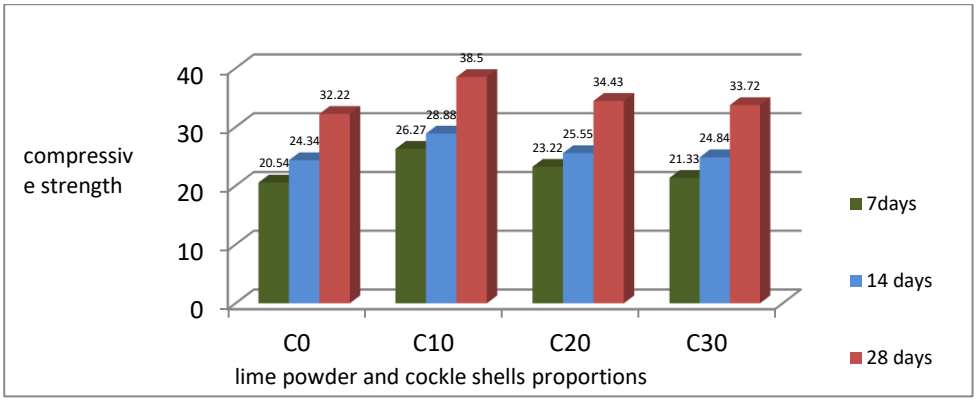
The above graph shows the workability of M30 grade of concrete by slump cone method. The result shows that decrease in workability of concrete by replacing cement with lime powder and coarse aggregate with cockle shells with different proportions. The workability of concrete decreased with increasing the proportion of lime powder and cockle shells. The workability of concrete decreases because of rough texture of cockle shells.

6.2 Compressive strength

A total of 36 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days testing each specimen after conducting the workability tests. The results are tabulated below:

Compressive strength of concrete

S.no	Mix designation	Replaced concrete %		Compressive strength N/mm^2		
		Lime powder %	Cockle shells %	7 days	14 days	28 days
1.	C_0	0	0	20.54	24.34	32.22
2.	C_{10}	5	10	26.27	28.88	38.5
3.	C_{20}	10	20	23.22	25.55	34.43
4.	C_{30}	15	30	21.33	24.84	33.72



Compressive strength for M30 grade of concrete

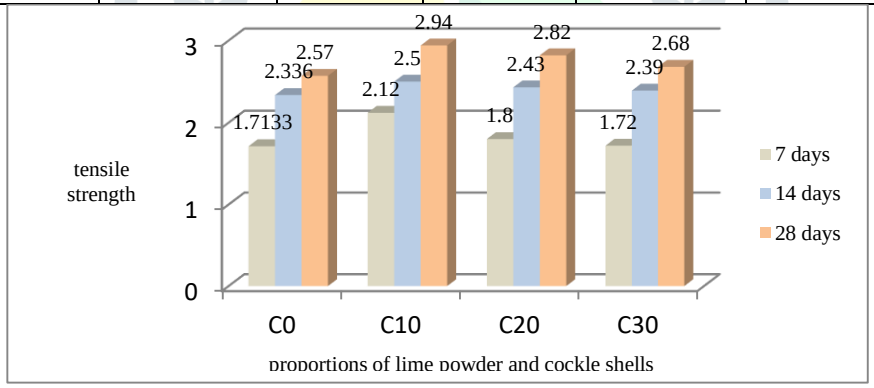
The above graph shows the compressive strength of M30 grade of concrete. The result shows that increase in strength of concrete by replacing cement with lime powder and coarse aggregate with cockle shells with different proportions. It clearly shows that strength increased by replacing the materials compared to conventional concrete. The optimum strength is obtained for 5% and 10% replacement of lime powder and cockle shells in cement and concrete.

6.3 Tensile strength

A total of 36 cylinders of size 150mm diameter and 300mm height were casted and tested for 7 days, 14 days and 28 days testing each specimen after conducting the workability tests. The results are tabulated below:

Tensile strength of concrete

S.no	Mix designation	Replaced concrete %		Tensile strength n/mm^2		
		Lime powder	Cockle shells	7 days	14 days	28 days
1.	C_0	0	0	1.7133	2.336	2.57
2.	C_{10}	5	10	2.12	2.5	2.94
3.	C_{20}	10	20	1.8	2.43	2.82
4.	C_{30}	15	30	1.72	2.39	2.68



Tensile strength of M30 grade of concrete.

The above graph shows the tensile strength of M30 grade of concrete. The result shows that increase in strength of concrete by replacing cement with lime powder and coarse aggregate with cockle shells with different proportions. It is clearly shows that strength is increased by replacing the materials compared to conventional concrete. The optimum strength is obtained for 5% and 10% replacement of lime powder and cockle shells in cement and concrete.

Conclusion:

1. Strength of concrete is more in lime powder and cockle shells blended concrete than the conventional concrete.
2. Comparative study on lime powder and cockle shells replaced concrete with various replacement percentages of lime powder(0%, 5%, 10%, 15%) and cockle shells(0%, 10%, 20%, 30%) shows that , a replacement level of 5% and 10% lime powder and cockle shells in concrete performs and shows increase in strength as 16.94% than the other replacements.
3. For M30 grade of concrete 5% and 10% replacement of lime powder and cockle shells respectively shows optimum compressive strength as 19.49% than normal concrete.
4. For M30 grade of concrete 5% and 10% replacement of lime powder and cockle shells respectively shows optimum tensile strength as 14.39% than normal concrete.

5. As the replacement of cement by lime powder by 0%, 5%, 10%, 15% and coarse aggregate by cockle shells by 0%, 10%, 20%, 30% in concrete, the workability of concrete decreases by 15mm, 23mm and 29mm respectively compared to conventional concrete. The workability of replaced concrete decreases due to rough texture of cockle shells.

6. The cockle shells replaced in coarse aggregate helps in the reduction of pollution in environment.

7. Hence the optimum replacement level of lime powder and cockle shells obtained from the studies is 5% lime powder and 10% cockle shells for M30 grade of concrete

References

1. Bharathi, R. Y., Subhashini, S., Manvitha, T., & Lessly, S. H. (2016). Experimental study on partial replacement of coarse aggregate by seashell & partial replacement of cement by flyash. *Int. J. Latest Res. Eng. Technol*, *2*(3), 69-76.e

2. Agbede, O. I., & Manasseh, J. (2009). Suitability of periwinkle shell as partial replacement for river gravel in concrete. *Leonardo Electronic Journal of Practices and Technologies*, *15*(2), 59-66.

3. Yang, E. I., Kim, M. Y., Park, H. G., & Yi, S. T. (2010). Effect of partial replacement of sand with dry oyster shell on the long-term performance of concrete. *Construction and building materials*, *24*(5), 758-765.

4. Nahushananda, C. H. G., & Mutusva, T. (2015). Investigation of properties of concrete with seashells as a coarse aggregate replacement in concrete. *International Journal of Science and Technology Special Issue*, *1*(1), 285.

5. Muthusamy, K., & Sabri, N. A. (2012). Cockle shell: a potential partial coarse aggregate replacement in concrete. *International Journal of Science, Environment and Technology*, *1*(4), 260-267.

6. Elliott Richardson, A., & Fuller, T. (2013). Sea shells used as partial aggregate replacement in concrete. *Structural Survey*, *31*(5), 347-354.

7. Mehta, P.K. (1978). "History and status of performance tests for evaluation of soundness of cements". In cement standards-*Evaluation and Trends*. ASTM international.

8. Evangelista, L., & de Brito, J. (2007). Mechanical behaviour of concrete made with fine recycled concrete aggregates. *Cement and concrete composites*, 29(5), 397-401.