Analysis Of Palm Shell and Almond Shell as A Partial Replacement to Aggregate in Concrete Design

Prathamesh Dunghav¹, Prayas Dhurke², Harshwardhan Shinde³, Prof. Sangeeta Mishra⁴ ¹⁻²⁻³Department Of Civil Engineering, JSPM's Rajarshi Shahu College of Engineering, Tathawade-411033, Pune, India ⁴Professor Department of Civil Engineering B.Tech, JSPM's RSCOE, Pune, India

Abstract—In the world, the demand for natural construction materials is decreasing due to the limited availability and also their exploitation is making the industries think for an alternative source for the production of concrete materials, this research has experimented the use of palm shells, almond shells as an alternative substitute to coarse aggregates in the concrete design for M20 grade. The experiments are carried out at the varying percentage for almond shells and palm shells at 0%, 5% and 10% as a partial replacement to coarse aggregate. The data analysis of all the three materials coarse aggregate, Palm Shell and Almond shells is also done. The cost analysis of all the three materials is also done based on the availability in the market. Results show that the partial replacement for coarse aggregate up to 10% for Palm Shell and up to 5% for Almond shells is satisfactory as needed for M20 grade concrete. Also, the partial replacements help in the reusing of waste material. This research helps in knowing the feasibility of agricultural waste materials using as a replacement to aggregate in concrete design thus reducing the way agricultural waste, and finding a economical path for concrete design

Index Terms—Partial substitute, Palm shell aggregate, Almond shell aggregate, Cost Analysis, Conventional concrete, environmentally friendly, Recycled Palm Shells, Recycled Almond Shells

1. INTRODUCTION

Palm shell (PS): -

Palm Shell is the waste product which is generated after the palm oil production. Palm Shell is the outer part of the Palm fruit, which covers and protects the endocarp of it. It is the hard outer part which remains after the fruit is extracted. Palm fruits are mainly used for the oil production and the waste product of it is thrown away at a high rate. The key characteristics of Palm Shell are that its origin is a byproduct of Palm fruit, its physical appearance as dark brown, and hard in colour and strength It is sustainable and a renewable source as it's a waste product that is generated through a natural product. It is lowest content and high calorific value. It also has a low moisture content.

Almond shells are Almond shells are the hard outer substance of the almond food, which are thrown away after the almonds are removed, it is by product and a waste product, which contributes nearly 50% of the total almond fruit with its shell. It has high strength compared to the almonds, inner FruitAnd is used for the protection of it. It has low moisture content and is used for various proposes, including as a option for animal feeding mulch and even as a fuel, it is the surrounding of the kernel

The origin of its generation is almond harvesting and the almond industry in which the almond fruit is extracted, and the shells are thrown away

The almond shell is generally composes of cellulose,hemicellulose and lignin which is the reason for its structural rigidity

Almond shells are economical waste as it is generator through a fruit, that is naturally made

It has many potential uses which also includes using almond shells as bio fuel and as it has a source of lignocellulose it can be used for plastic reinforcement. It also is used in the cosmetic industry.

Almond shells can also be used as a mulch in soil amendment

Using Almond Shell as Coarse Aggregate Replacement

There are many studies which are conducted for checking the compressive strength of almond shell, but there are few studies which have conducted to check the compressive strength of almond shell as a partial replacement to coarse aggregate in concrete design using conventional concrete.

In a study that was conducted, it was observed that elements have an average compressive strength compared to the conventional concrete. It also has an average moisture content a low performance slump. It has low density and also high air content. The studies had concluded that element shells have a good performance depending upon the percentage which is used as a substitute in lightweight concrete.



Fig.1

Using Palm Shell as Coarse Aggregate Replacement In the case of Palm Shell too there are many test which are conducted to check the compressive strength of the Palm Shells but there are few studies which check the compressive strength of such as a partial replacement to course aggregate in concrete design. The studies have concluded that using Palm Shell as a partial substitute can be a good alternative to course aggregate to Limited extend, depending on the percentage of Palm Shell is used. It is a good alternative to you for production of lightweight concrete as Palm Shell, economical and friendly studies. Also show that use of Palm Shell is decreases the concrete density and thus compromising with the compressive strength of the concrete, thus using them at a particular percentage makes it possible.



Fig.2

Materials And Methods: -

Cement: - The cement used in the study is of OPC 53 grade and it was taken from an ongoing construction site from Wakad. The amount of cement was relative to the mix design necessary for the concrete mixing. The cement refers to IS12269 :2013

Aggregates The aggregates used in this study was of maximum 20 MM size and was taken for an ongoing construction site in Wakad. The aggregates in this study refer to IS 383.

Crush Sand: - The amount of crushed sand taken was as per the mix design needed for concrete mixing. The crush sand was taken from an ongoing construction site in Wakad. The crush sand refers to IS 383:1970, IS1542:1992

Water: - The water cement ratio in this concrete was 0.5. The water was taken from an ongoing construction site in Wakad, Pune.The water is usable for constructon work.

Almond shells: - The almond shells used in the research paper were obtained from the local shops in Pune. The almond shells were broken down into small pieces of maximum 20 MM. The elements can be seen as of good quality through naked eyes as seen in figure no 1. Shelves for having double density of around three 50 KG per metre cube and water absorption of 24% and before mixing, the almonds were not washed, they were used directly by properly mixing them with each other.

Palm shells: - The Palm Shell were obtained from a local fruit seller in Pune as they were a waste material. Using Palm Shell as a partial replacement to coarse

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aggregate can be a very good solution for creating light weight concrete as it will be economical and costeffective. It also has very good environmental impact. Many studies have given results and shown that using Palm Shell is as a partial substitute to course aggregate results in reduction of the density of concrete, the compromising with the strength, but using them at a particular percentage will make them of satisfactory, use Palm Shell, which are generally light and organic inner and outer black and colour, they have micro grooves on their external convex shaped surface which gives them a rough texture. The Palm Shell's which were bought were kept for drying in the sun till the moisture in it reduces broken down a small piece of about 20 MM.

Mix Design Ratio: -

The Mix design for this study is a referred to IS456 2000 and as needed for M20 grade the mix design is made and accordingly the percentages of Palm Shell and Shell for 5%

and 10% have been substituted The details are shown in table no.1.



Fig.3



Fig.4

Test preparations: - The main test which was conducted in the study was compression test, but accordingly slum test was also performed and the result are shown further in the Results and Discussion section.the concrete was mixed and poured into a 150 x 150 x 150 MM mould.The deshuttering of concrete cubes were done after 24 hours and the concrete cubes were kept for curing for 28 days.The CTM test was conducted. The number of cubes casted are shown in the table no.2 along with the type and they are percentage of substitution

Test Conducted: - That compression test was conducted in the lab on the CTM machine on an ongoing construction site in Wakad Pune. The details of the compression test are shown in table no.5 for each of the cubes

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Mix Ratios						
Mixtune	coment	Fine	Coarse	\aareaste/ka/mi	2)	Water
with type	cement	aggiegate	Almond Dalm			water
	(kg/m3)	(kg/m3)	Coarse Aggregate	Shells	Shells	(kg/m3)
			(kg/m3)	(kg/m3)	(kg/m3)	
original for 1 m3	315	821	1110			157.6
casted for 0 %	6.3	16.42	22.2			3.152
casted for 5 %	6.3	16.42	21.09	1.11	1.11	3.152
casted for 10 %	6.3	16.42	19.98	2.22	2.22	3.152
Table no 1						



Fig.6



Fig.5



Fig.7

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Туре	Curing time	Replacement	Amount	Total
	Days	%	Nos	
Nominal	28	0	3	
Palm Shell	28	5 %	3	15
	28	10%	3	
Almond	28	5%	3	
	28	10%	3	
	Т	able no .2]	

Results and Discussions: -

Introduction: -In this section, the results of the experiments done, will be shown along with the slum test, concrete density, mechanical properties, and their compression strength, and also the cost analysis of Palm Shell and almond shells will be done.

Slum test: - the slum cone results of all the types of concrete with the partial substitute to almond and Palm Shell of five percentage and 10 percentage. it was seen that as the almond shell increases in the concrete the slum decreases. And as the almond shell decreases, the concrete slump increases while in the other case of Palm Shell as the Palm Shell increases, the concrete slum decreases and as the Palm Shell decreases, the concrete slum increases.



Fig.8

Compressive test: - The compressive strength for nominal concrete for three cubes. The average was 21.35 MPA.

The average compression strength of three cubes for 5% Palm shell as a partial substitute to coarse aggregate was 19.14 MPA and for 10% of Palm Shell as a partial substitute to coarse aggregate, was 17.01 MPA.

Average compressive strength for three cubes of almond shell has a 5% substitute to coarse was 18.0 9MPA and for 10% of partial substitute was 16.31 MPA

5.3. Concrete density: - The total density of the conventional concrete according to mix design of m20 grade is 2403.6kg/m3. But the concrete, which was mixed on site, the amount of it was 2% of the mixed designed amount. Therefore, the total density of the mixed concrete on site for nominal mix was 48.072 kg/m3.

5.4. Mechanical Properties: - The mechanical properties of PS AS and nominal concrete are shown in table no 3. The mechanical properties of nominal concrete and partial replaced AS AND PS are taken from the journals which are given in the references.

5.7) Cost ananlysis :- The cost of all the three material materials highly depends on the availability of them, In general availability in the local market of Palm Shell and almond shell is comparatively very less to coarse aggregates, but as they are recycled waste, their cost is comparatively low to coarse aggregate.Due to their low availability in market in some regions, the cost prices get high of almond shell and Palm Shell.According to the availability in Pune, the cost analysis is done.

Туре	Rate
Coarse aggregate	700/
20 mm	700/ tonne
Palm shell	5000/ <u>tonne</u>
Almond shell	9000/tonne

Table no .3

Mechanical Properties Comparison				
Property	M20 Grade	Dalm Shell	Almond Shell	
Troperty	concrete	500 - 1300 kg /	Amond shell	
Density	2400 kg / m3	m3	400-1200 kg / m3	
Compressive Strength	20 MPA	3-15 MPA	2-12 MPA	
Modulus of Elasticity	22-30 GPA	15 - 12 GPA	4-10 GPA	
Impact Value	<20%	4 - 9 %	5-10%	
Aggregate Crushing Value	25-30 %	7-12 %	8-13 %	
Los angeles Abresion Value	< 30 %	20-30%	22 - 35 %	
Water Absorption	0.5 -2.5 %	5-23 %	7-25 %	
Toughness	High	Medium	Low to Medium	
Shape And <u>Texture</u>	<u>Angular to</u> sub angular	Rough and Irregular	Irregular and flaky	

Table no .4

Compressive Strength						
Туре	Percent	Cross Sectional Area	Calculation	Compressive Strength	Average	
Nominal	0	150*150 mm	0.495/0.0225	22		
			0.481/0.0225	21.38	21.35	
			0.465/0.0225	20.67		
Palm Shell	5	150*150 mm	0.426/0.0225	18.93		
			0.446/0.0225	19.82	19.14	
			0.420/0.0225	18.67		
	10	150*150 mm	0.393/0.0225	17.48		
			0.406/0.0225	18.04	17.62	
			0.390/0.0225	17.33		
Almond	5	150*150 mm	0.414/0.0225	18.4		
			0.398/0.0225	17.7	18.09	
			0.409/0.0225	18.2		
	10	150*150 mm	0.370/0.0225	16.44		
			0.368/0.0225	16.36	16.31	
			0.363/0.0225	16.13		

Table no .5





CONCLUSION:

Through this research and the comparison of both we came to a conclusion that till 10%, Palm Shell can be used as a partial substitute of coarse aggregate until 5% of elemental shells can be used as a partial substitute to coarse aggregate.

And through the cost analysis of PS and AS and coarse aggregate the cost depends highly on the availability of them in the market in some regions where the Palm Shell is and almond shells are available the cost is very less as they are recycling materials in the region where their availability is very low. The cost is high compared to coarse aggregates.

REFERENCES:

- Amarnath, Y. R., & Ramachandrudu, C. (2014). "Compressive Strength of Concrete Using Palm Kernel Shell as Partial Replacement for Coarse Aggregate". International Journal of Civil Engineering and Technology, 5(7), 11–18.
- [2] Williams, F. N., et al. (2019). "Suitability of Palm Kernel Shell as Coarse Aggregate in Lightweight Concrete Production". Civil and Environmental Research, IISTE.
- [3] Hama, M. F. (2023). "Almond Shell as Coarse Aggregate Replacement in Concrete". ResearchGate, DOI: 10.13140/RG.2.2.36906.76936.
- [4] Odeyemi, S. O., et al. (2021). "Bond and Flexural Strength Characteristics of Partially Replaced Self-Compacting Palm Kernel Shell Concrete". Malaysian Journal of Civil Engineering.

- [5] Kolo, D. N., et al. (2020). "Models to Predict the Fresh and Hardened Properties Palm Kernel Shell Concrete". Malaysian Journal of Civil Engineering.
- [6] "Almond Shell as Coarse Aggregate Replacement in Concrete Mohammed Fadhil Hama"Tishk International University (2022)
- [7] "Structural Behavior of Concrete produced using Palm kernel shell as a partial substitute to coarse aggregate" (2023) AJISE,
- [8] IS 10262:2019 Concrete Mix Proportioning Guidelines.
- [9] IS 456:2000 Plain and Reinforced Concrete Code of Practice.
- [10] IS 516:1959 Methods of Tests for Strength of Concrete.