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EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLYASH AND KADAPA STONE POWDER

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ABSTRACT

Concrete is the most important construction material for civil engineering. Concrete is one of the most durable materials. The concrete of its Flexibility, Durability, Sustainability, and Economy have made it the world's most widely used building material. In the manufacturing of one ton of cement of lime stone, 80 Units of electric power apart from one ton of CO_2 at large into the atmosphere. Out of the total CO_2 emission (from a variety of resource) worldwide, even industries contribute about 7% of CO_2 emissions. Annual cement manufacture rate of the world is increasing very much year by year. But at present researchers are in interest of finding new materials by waste produced from industries which are harmful to environment. Fly ash is a by-product of the combustion of pulverized coal in electric power generating plants. It is the most widely used supplementary cementitious material in concrete. In Kadapa district, there are number of stone polishing industries and huge quantities of fine powder from the process of polishing the stones to convert them into polishing stone suitable for laying of flooring and other such works, is generated. The present paper deals partial replacement of cement with fly ash and kadapa stone powder. In this experiment work 20%, 30%, 40% of fly ash and 5%,10%,15% of kadapa stone powder were partially replaced with cement. The mechanical properties like compressive strength, Split Tensile Strength and Flexural Strength of concrete were investigated with reference to conventional concrete.

Keywords: *Fly ash, Kadapa stone powder, Compressive strength, Flexural strength, Split tensile strength*

I.INTRODUCTION

Concrete is the most widely used construction material in the world, and its popularity can be attributed to two aspects. First, concrete is used for many different structures, such as dams, pavements, building frames, or bridges, much more than any other construction material. Second, the amount of concrete used is much more than any other material. Its worldwide production exceeds that of steel by a factor of 10 in tonnage and by more than a factor of 30 in volume. In a concrete structure, there are two commonly used structural materials: concrete and steel. A structural material is that carries not only its self-weight, but also the load passing from other members. The properties of concrete can also be increased by using by-products and natural wastes as supplementary cementing material. Lot of energy and cost can also be saved by using these natural wastes and industrial by-products as partial replacements to OPC.

II. MATERIALS

The materials used in the present study are

2.1 Cement

OPC 53 Grade Ultra- tech cement is used in this investigation. The quantity required for this work is assessed and the entire quantity purchased and stored properly in casting yard. The following tests were conducted in accordance with IS codes.

Table no 1 – Physical properties of cement

S.NO	PARTICULARS	RESULTS
1	Specific Gravity	3.16
2	Standard Consistency	31.5%
2	Initial Setting Time	32min
3	Final Setting Time	635min
4	Fineness	225m^2/kg

2.2 AGGREGATE

Aggregates represent a skeleton of concrete. More or less three-quarters of the amount of conventional concrete is occupied by aggregate. It's inevitable that a constituent occupying one of these large percentages of the mass have to make a contribution of essential properties to both the fresh and hardened product.

2.2.1 FINE AGGREGATE

Aggregates passing through 4.75 mm sieve and predominately retained on 75 µm sieve are classified as fine aggregate. River sand is the most commonly used fine aggregate. In addition, crushed rock fines can be used as fine aggregate. However, the finish of concrete with crushed rock fines is not as good as that with river sand. In the present study we are using River sand for the good finishing and to fill the voids between the coarse aggregate. River sand is taken from Cheyyeru River near Nandalur. The properties of sand are given in below.

Table 2: Properties of Fine Aggregate

S.No.	Particulars	Results
1	Type	River Sand
2	Specific gravity	2.62
3	Size	4.75 mm
4	Grade of sand	Zone II

2.2.2 COARSE AGGREGATE

Aggregates predominately retained on 4.75 mm sieve are categorized as coarse aggregate. Usually, the size of coarse aggregate is from 5 to 150 mm. For normal concrete used for structural members including beams and columns, the maximum size of coarse aggregate is about 25 mm. For mass concrete used for dams or deep foundations, the maximum size may be as large as 150 mm. In this study the size of the aggregate is 20 mm and it is taken from the quarry Akepadu village near Rajampet. The physical properties of coarse aggregate are listed in below table.

Table no 3 – Physical Properties of coarse aggregate

S.No.	Particulars	Results
1	Type	Crushed stone
2	Specific Gravity	2.64
3	Size	20mm
4	Water absorption	0.8%

2.3 WATER

Water is used for mixing and curing of concrete. In the present investigation, tap water available in the campus was used for both mixing and curing of concrete. P_H value is 7.1.

2.4 FLY ASH

Fly ash is used as a cementitious material drawn from burning of coal in high temperature. There are two types of Fly ash such as

- ASTM class F
- ASTM class C

Fly ash used in this study was low-calcium (ASTM Class F) dry fly ash. Since the ASTM class F contains calcium of about 5% by mass, where as class C contains more than 5% of calcium which tends to change in micro structure of concrete and properties of concrete. Class C fly ash normally comes out of coal power plants with higher lime content generally more than 15 % often as high as 30 % may give class C unique self-hardening characteristics. The Calcium content in fly ash plays a significant role in strength development and final compressive strength. Higher the Calcium content results in faster strength development and higher compressive strength. However, in order to obtain the optimal binding properties of the material, fly ash as a source material should have low Calcium content and other characteristics such as unburned material lower than 5%, Fe_2O_3 content not higher than 10%. The fly ash used in this study satisfies the requirement of IS: 3812-2003. The specific gravity and Finesses modulus (passing through 45 μm) of Fly Ash was 2.3 and 7.86. The chemical composition for cementitious material is shown in Table 4

Table 4- Chemical composition (%) of Fly ash

	% By Weight in the Fly Ash of RTPP, Muddanur.	**Requirement as per IS:3812-2003**
SiO_2	58.75%	>35%
Al_2O_3	24.14%	-
Fe_2O_3	5.16%	-
TiO_2	6.13%	-
CaO	1.00%	-
MgO	0.39%	<5.0%
Na_2O	0.65%	<1.50%
K_2O	0.63%	<1.50%
P_2O_5	0.59%	-
SO_3	0.25%	<2.75%
Loss on ignition	6.24%	<12.00%

2.5 Kadapa Stone Powder

In Kadapa district, there are number of stone polishing industries and huge quantities of fine powder from the process of polishing the stones to convert them into polishing stone suitable for laying of flooring and other such works, is generated. This powder is finer than cement.

Table no: 5 Chemical composition of stone Powder

S.No	Property	Values
1	Silica (Sio_2)	22.35%
2	Calcium Oxide (CaO)	38.91%
3	Magnesium Oxide (MgO)	2.75%
4	Ferric Oxide (Fe_2O_3)	1.30%
5	Alumina (Al_2O_3)	2.80%
6	Loss of Ignition (LOI)	30.52%

III. EXPERIMENTAL STUDY

3.1 Mix Proportions

In the present investigation M30 concrete is prepared with the water cement ratio 0.5. Concrete mixes are prepared by different proportions of cement replacing with Fly Ash and Kadapa Stone Powder. The mix designations are follows:

1. A refers to the conventional OPC concrete
2. B refers to 20% Fly Ash +80% Cement
3. B1 refers to 20% Fly Ash + 5% KSP +75% Cement
4. B2 refers to 20% Fly Ash + 10% KSP +70% Cement
5. B3 refers to 20% Fly Ash + 15% KSP + 65% Cement
6. C refers to 30% Fly Ash +70 % Cement
7. C1 refers to 30% Fly Ash + 5% KSP + 65% Cement
8. C2 refers to 30% Fly Ash + 10% KSP +60% Cement
9. C3 refers to 30% Fly Ash + 15% KSP + 55% Cement
10. D refers to 40% Fly Ash + 60% Cement
11. D1 refers to 40% Fly Ash + 5% KSP + 55% Cement
12. D2 refers to 40% Fly Ash + 10% KSP + 50% Cement
13. D3 refers to 40% Fly Ash + 15% KSP + 45% Cement
14. E refers to 5% KSP + 95% Cement
15. F refers to 10% KSP + 90% Cement
16. G refers to 15% KSP + 85% Cement

3.2 CASTING OF SPECIMENS

The specimens are casted in the present study are cubes of size 150X150X150 mm, Cylinders of size 150 mm diameter and 300 mm height for 7 days, 14 days and 28 days and Beam specimens of size 150X150X700 mm for 28 days specimens of optimum content.

3.3 MIX PROPORTIONS

Mix Proportions for M_{30} concrete.

Table 6: Mix Proportions of Concrete

Material	Quantity
Cement	352 Kg/m^3
Fine Aggregate	717.9 Kg/m^3
Coarse Aggregate	1149.35 Kg/m^3
Water	176 lit/m^3

IV. EXPERIMENTAL RESULTS

4.1 Compressive Strength

The compressive strength of concrete is measured to be the most valuable and significant mechanical property of concrete since it gives the overall picture of the concrete quality**.** The compressive strength of M_{30} grade concrete mixes by replacing OPC with kadapa stone powder and fly ash in cement with various percentages. The results of compressive strength for these concrete mixtures tested at 7 days, 14 days and 28 days are presented in below table. The graphical representation is represented in below fig.

Table no: 7 Compressive strength Test Results

S.NO	Mix proportions		Compressive Strength		
			7 DAYS	14 DAYS	28 DAYS
1	N.C	A	20.83	25.46	30.18
2	20F	B	21.36	27.18	32.82
3	20F+5KSP	B1	23.13	26.43	31.25
4	20F+10KSP	B2	16.76	20.03	27.05
5	20F+15KSP	B3	13.76	17.37	25.76
6	30F	C	22.36	27.80	33.57
7	30F+5KSP	C1	25.18	30.30	33.60
8	30F+10KSP	C2	22.23	27.46	31.05
9	30F+15KSP	C3	15.30	18.76	22.76
10	40F	D	17.70	22.56	28.93
11	40F+5 KSP	D1	17.23	20.06	26.56
12	40F+10 KSP	D2	14.96	17.83	23.76
13	40F+15KSP	D3	11.98	15.31	21.24
14	5% KSP	E	21.45	28.76	31.90
15	10% KSP	F	23.75	30.65	34.96
16	15% KSP	G	17.53	24.46	27.36

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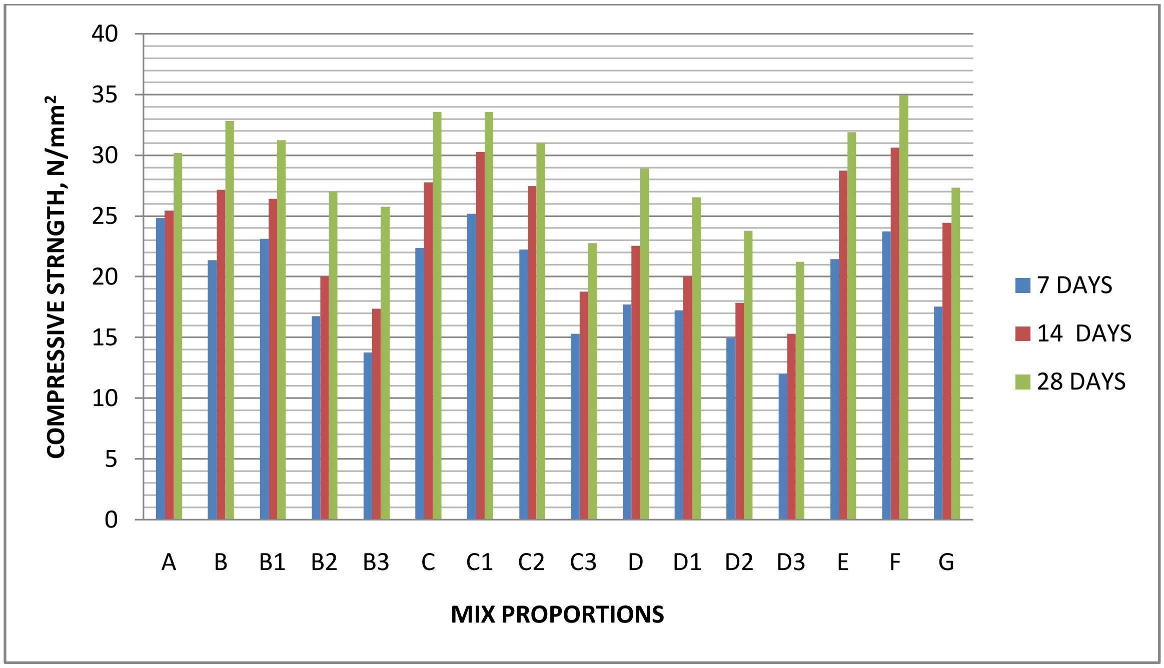

Fig 1- Compressive strength

The Compressive Strength of Concrete is increases 6.62% at B , 3.55% at B1, 11.23% at C, 11.33% at C1 and max 15.84% at F Mix Proportion than Conventional M30 grade Concrete. Optimum at F i.e. 10% KSP.

4.2 .Rebound Hammer Test:

The test results for 7, 14, 28 days of compressive strength by N.D.T with various percentage replacement of cement by kadapa stone powder and fly ash are present table.

Table no: 8 Compressive strength-NDT
(REBOUND HAMMER TEST RESULT)

S.NO	Mixing proportions	Compressive Strength		
		7 DAYS	14 DAYS	28 DAYS
A	N.C	24.00	32.3	38.0
B	20F	21.3	27.0	32.0
B1	20F+5KSP	24.0	26.4	31.7
B2	20F+10KSP	16.3	20.1	25.1
B3	20F+15KSP	13.7	17.3	24.5
C	30F	22.2	27.5	23.4
C_1	30F+5KSP	25.1	30.3	33.3
C2	30F+10KSP	22.0	26.4	30.9
C3	30F+15KSP	14.30	17.7	22.5
D	40F	16.0	21.5	28.5
D1	40F+5 KSP	17.2	20.7	26.4
D2	40F+10 KSP	13.9	16.8	23.5
D3	40F+15KSP	11.0	14.7	21.2
E	5% KSP	21.0	27.7	31.9
F	10% KSP	23.5	30.0	33.7
G	15% KSP	17.0	24.3	27.0

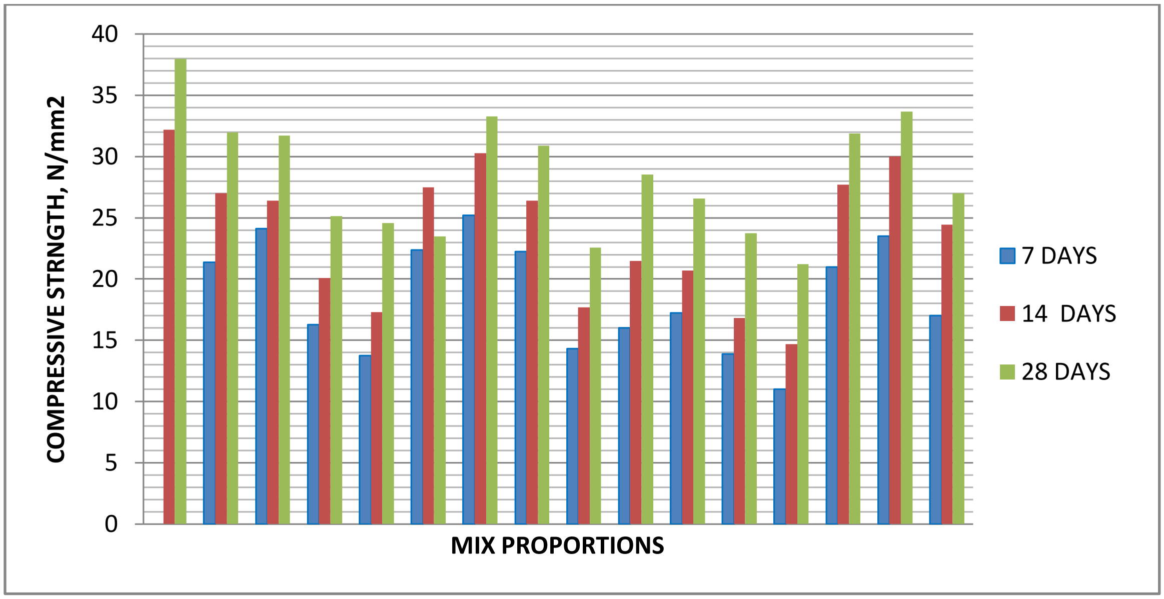

Fig 2- Compressive strength –NDT(Rebound Hammer)

4.3 Split Tensile Strength Test

The Split Tensile strength of M_{30} grade concrete mixes by replacing OPC with kadapa stone powder and fly ash in cement with various percentages. The results of compressive strength for these concrete mixtures tested at 7 days, 14 days and 28 days are presented in below table. The graphical representation is represented in below fig.

Table no: 9 Split Tensile Strength Test Results

S.NO	Mix proportions		Split tensile Strength		
			7 DAYS	14 DAYS	28 DAYS
1	N.C	A	2·51	3.12	3.29
2	20F	B	2.03	3.07	3.45
3	20F+5KSP	B1	2.53	2.90	3.31
4	20F+10KSP	B2	2.26	1.91	2.33
5	20F+15KSP	B3	1.57	2.25	2.42
6	30F	C	2.03	3.12	3.56
7	30F+5KSP	C1	2.46	3.1	3.69
8	30F+10KSP	C2	2.04	2.46	2.87
9	30F+15KSP	C3	1.34	1.95	2.23
10	40F	D	1.55	1.93	2.94
11	40F+5 KSP	D1	1.69	2.04	2.62
12	40F+10 KSP	D2	1.72	2.12	2.36
13	40F+15KSP	D3	1.79	1.99	2.23
14	5% KSP	E	2.00	2.57	3.06
15	10% KSP	F	2.40	2.95	3.52
16	15% KSP	G	1.40	2.01	2.68

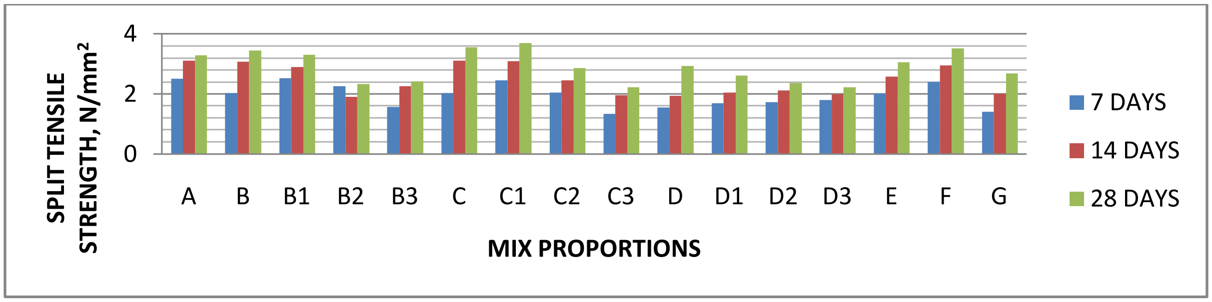

Fig 3 Split Tensile Strength

The Split Tensile Strength of Concrete increases by 4.86% for B , 0.6% for B_1, 8.21% for C, 12.16% for $_{C1and}$ 7% for F Mix Proportion than Conventional M_{30} grade Concrete.

4.4 Flexural strength Test Results

The Flexural strength of M_{30} grade concrete mixes by replacing OPC with kadapa stone powder and fly ash in cement with various percentages. The results of compressive strength for these concrete mixtures tested at 28 days are presented in below table. The graphical representation is represented in below fig.

Table no :10 Flexural Strength Test Results

S.NO	Mixing proportions		Flexural strength
			28 DAYS
1	N.C	A	6.41
2	20F	B	6.87
3	20F+5KSP	B1	6.59
4	20F+10KSP	B2	5.11
5	20F+15KSP	B3	5.10
6	30F	C	7.45
7	30F+5KSP	C1	7.60
8	30F+10KSP	C2	5.47
9	30F+15KSP	C3	5.48
10	40F	D	5.37
11	40F+5 KSP	D1	4.86
12	40F+10 KSP	D2	4.62
13	40F+15KSP	D3	4.52
14	5% KSP	E	6.02
15	10% KSP	F	6.93
16	15% KSP	G	5.52

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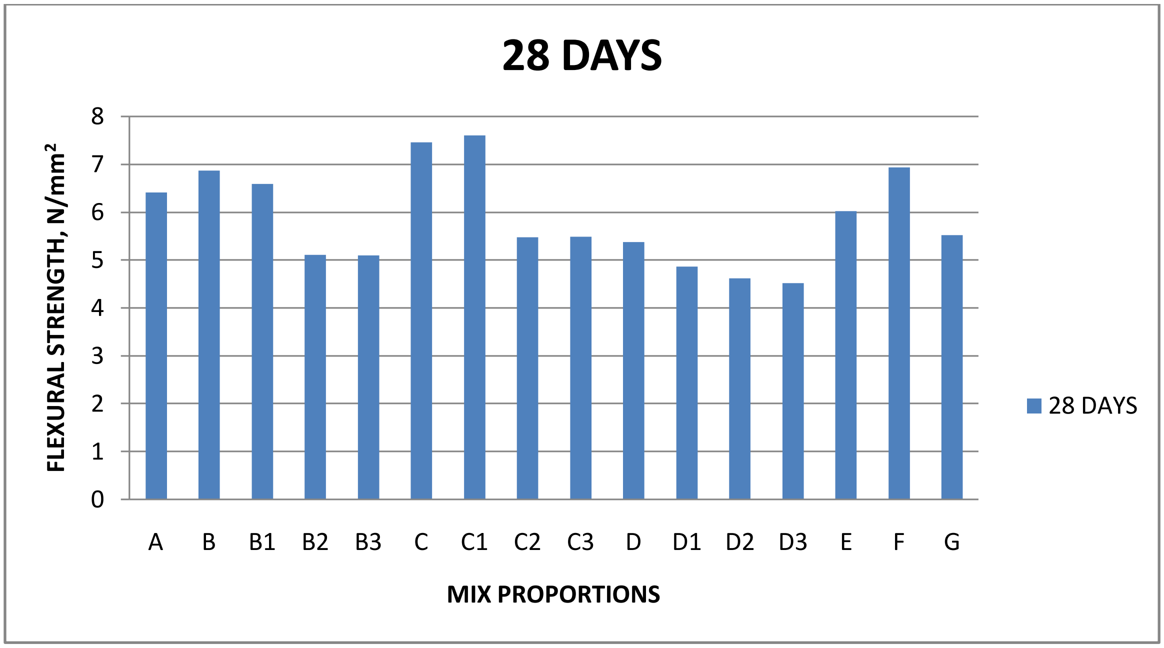

Fig 3 Flexural Strength

The Flexural Strength of Concrete is increases 7.2% at B, 2.81% at B_1, 16.22% at C, 18.66% at C_1 and 8.11% at F Mix Proportion than Conventional M30 grade Concrete.

V. CONCLUSION

5.1 Conclusions

Initially M_{30} grade concrete of 20%, 30% and 40% of Fly Ash is replaced with cement out of which 20% replacement of cement is optimum, which gives 6.62% more strength than the convential concrete. The Compressive Strength of Concrete, by replacement in cement with 20% Fly Ash- 5%, 10% and 15% Kadapa Stone Powder has shown inclination by 3.55% in strength than the conventional concrete .The Compressive Strength of Concrete of 20%, 30% and 40% of Fly Ash is replaced with cement out of 30% replacement of cement is optimum, which gives11.23% more strength than the conventional concrete. For 30% Fly Ash-5%, 10% and 15% Kadapa Stone Powder in combination for 30% Fly Ash and 5% Kadapa Stone Powder has shown inclination by 11.33%in strength than the conventional concrete. For 40% fly Ash and5%10% and 15% Kadapa Stone Powder in replacement with cement, this gives less strength than conventional concrete.

- The compressive Strength of Concrete, by the replacement in cement with 20% Fly Ash and 5% Kadapa Stone Powder has shown inclination of 3.55% is more strength than the conventional concrete.

The Split Tensile Strength of Concrete of 20%, 30% and 40% Fly ash is replaced with cement out of which 20% replaced of cement is optimum which gives 4.86% more strength tan the conventional concrete. The Split Tensile Strength of Concrete ,by replacement in cement with 20% Fly Ash -5%,10% and15% Kadapa Stone Powder in combination for 20% Fly Ash and 5% Kadapa Stone Powder has shown inclination by 0.6% in strength than the conventional concrete. .The Split Tensile Strength of Concrete of 20%,30% and 40% of Fly Ash is replaced with cement out of 30% replacement of cement is optimum, which gives8.21% more strength than the conventional concrete. For 30% Fly Ash-5%, 10% and 15% Kadapa Stone Powder in combination for 30% Fly Ash and 5% Kadapa Stone Powder has shown inclination by 12.16%%in strength than the conventional concrete. For 40% fly

Ash and 5%10% and 15% Kadapa Stone Powder in replacement with cement, this gives less strength than conventional concrete.

- The Split Tensile Strength of Concrete, by the replacement in cement with 20% Fly Ash and 5% Kadapa Stone Powder has shown inclination of 0.6% is more strength than the conventional concrete.

The Flexural Strength of Concrete of 20%, 30% and 40% Fly ash is replaced with cement out of which 20% replaced of cement is optimum which gives 7.2% more strength tan the conventional concrete. The Flexural Strength of Concrete ,by replacement in cement with 20% Fly Ash -5%,10% and15% Kadapa Stone Powder in combination for 20% Fly Ash and 5% Kadapa Stone Powder has shown inclination by 2.81% in strength than the conventional concrete. .The Flexural Strength of Concrete of 20%,30% and 40% of Fly Ash is replaced with cement out of 30% replacement of cement is optimum, which gives16.22% more strength than the conventional concrete. For 30% Fly Ash-5%, 10% and 15% Kadapa Stone Powder in combination for 30% Fly Ash and 5% Kadapa Stone Powder has shown inclination by 18.6%% in strength than the conventional concrete. For 40% fly Ash and 5%10% and 15% Kadapa Stone Powder in replacement with cement, this gives less strength than conventional concrete.

- The Flexural Strength of Concrete, by the replacement in cement with 20% Fly Ash and 5% Kadapa Stone Powder has shown inclination of .2.81% is more strength than the conventional concrete.

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