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STUDIES ON SPLIT TENSILE STRENGTH CHARACTERISTICS OF UTILIZING NAGALOOTI WASTE STONE AGGREGATE IN CONCRETE

[1]V Chandra Sekhar Reddy, [2]Prof. C. Sashidhar

[1] *Research Scholar, Department of Civil Engineering, JNTUA College of Engineering, Anantapur*
[2] *Professor, Department of Civil Engineering, JNTUA College of Engineering, Anantapur*

Abstract: The main aim behind the research is to reduce the production cost of cement concrete and also to clear land fills by utilizing available waste stones in Nagalooti, kurnool district. The objective behind the research is also to reduce river sand usage in concrete keeping in view the level of ground water table and environmental conditions. Concrete cylinder specimens were cast by replacing conventional aggregate with crushed Nagalooti waste stone, also replacing cement with flyash up to 30% in conventional cement concrete of M25 grade in 20 different mix proportions and different percentages. In this experiment natural aggregates are replaced by Nagalooti waste stone aggregates in proportions of 0,25,50,75,100% and also cement is replaced with fly ash by 0,10,20,30%.

Key words: Nagalooti Waste stone aggregates, Natural aggregate, concrete and flyash.

I. INTRODUCTION

Concrete is the most common construction material used in Construction industry. Cement is a basic component of concrete used for all civil engineering constructions. The advancement of concrete technology can reduce the consumption of natural resources and energy sources and reduce the burden of pollutants on environment. The cost of natural resources was also increased to great extent. They have forced to focus on reduce, recovery and reuse of natural resources by finding other alternatives. Presently large amounts of stone waste are generated in layered stone processing Quarries/Plants in Nagalooti, near Nandikotkur in Kurnool District. The use of the replacement materials result in reduction of production cost, energy savings, arguably superior products, and fewer hazards in the environment.

In this study natural aggregates were replaced with Nagalooti waste stone aggregates in proportion of 0,25,50,75,100% , also replacement of cement with flyash by 0,10,20,30%. During processing process of the finished product, a lot of waste stone is generated in irregular shape and these waste stones were dumped on both sides of roads and also kept in abundant stocks near quarries. It creates many landfills and eventually disposal will become problem in these areas. Since long back some of the habitants are using these waste stones as coarse aggregates (CA) in Concrete for casting of Roof slabs, keeping in view of the initial cost and easy availability in the eastern part of Kurnool district.

II.LITERATURE REVIEW

Elham Khalizadesh shirazi et al.[1] in this study reusing, reduction and recycling of natural wastes was done instead of accumulated land fills leading to health hazards, and concluded that several solutions for incorporation of these industrial by products in preparation of concrete ,mortar, Embankments, also in paper industry and agriculture industry. Dr. T Sekhar et al. [2] conducted studies on strength characteristics of concrete made with waste material like broken tiles and broken glass pieces and concluded that compressive strength, split tensile strength and flexural strength to be around 16% to 24% lesser than controlled concrete compressive strength, but concrete made from waste materials as aggregate will solve the disposal problem of these waste material. Mamery Serifou et al. [3] studied the possibility of using fresh concrete waste as recycled aggregates in concrete and concluded that compressive strength decreases gradually, with respect to increase in percentage of recycled aggregates, substitution of natural aggregates up to 25, 50 and 100% with recycled aggregates reduces the compressive strength by about 15, 25 and 32% respectively and reduces the tensile strength by 18% with replacement of 100% recycled aggregates. Hanifi Binici et al. [4] in this study mechanical properties of concrete was studied by using marble dust and lime stone dust and concluded that compressive strength characteristics of concrete increased by 12% 20% at 28 days by using marble dust, where as compressive strength is decreased by 8%, 12% at 28 days by using lime stone dust. The results indicate that the marble dust concrete would probably have lower water permeability than the lime stone dust and control concrete. Jay P. Chotalia et al. [5] studied the strength properties of waste marble concrete with plain concrete and concluded that compressive strength of marble concrete is increased by 81.32% and Split tensile strength is increased by 46.20% and flexural strength is increased by 43.42%, cost of plain concrete also reduced by 7.44%. Ms.Monica C.et al. [6]_studied the usage of industrial waste such as marble powder ,quarry dust, wood ash, paper pulp etc., in concrete and concluded that replacement of fine aggregate up to 50% marble sludge powder and up to 50% quarry dust have given an excellent result in strength aspect and quality aspect. But more than 50% replacement affects the compressive and split tensile strength. Allam M.E et al. [7] studied the durability performance of green concrete containing granite waste powder as partial replacement to cement and sand with different combinations and concluded that reduction in compressive strength of green concrete (partially containing granite powder instead of cement) were less than the normal concrete mix, and also found to have less compressive strength when the mix containing granite powder was used instead of sand to some extent compared with normal

concrete mix. Prof. Roshanlal et al. [8] studied the strength characteristics of concrete by replacing with waste marble aggregates instead of natural aggregates and concluded that mix containing 20% and 30% waste marble aggregate has enhanced the compressive strength at 28 days by 8.7% and 5.5% when compared with control mix. Similarly with the same mix split tensile strength increased by 12% and 6% compared with control mix. A. Harika et al. [9] studied the thermal strength properties of concrete produced with stone waste aggregate, compressive and split tensile strength tests on concrete were conducted at 0,100,200,400,600 & 800^{o}C temperature and concluded that compressive strength and split tensile strength decreased with increase in lime stone aggregate in concrete mix at 28 days. Further as the temperature increases the ultimate strength decreases with time variation.

III. EXPERIMENTAL PROGRAM

In this experimental programme concrete cylinders of 150mm dia and 300 mm height were cast, by replacing the natural aggregate with Nagalooti waste stone aggregates both for Coarse Aggregate (CA) and Fine Aggregate (FA) in proportion of 0,25,50,75,100% and also replacement of cement with fly ash by 0,10,20 and 30%.

IV.MATERIALS

A. Cement:

In this research work ultra tech cement of OPC 53 grade was used for all concrete mixes. The cement was of uniform colour i.e., grey with a light greenish shade and free from any hard lumps. Various tests conducted on the cement, it was found that Specific Gravity of Cement is 3.1, Initial and final setting time found that 48 minutes and 240 minutes respectively. Normal Consistency is 35% and Fineness percentage is 4%.

B. Fly Ash:

Fly ash is a by-product obtained during the combustion of coal in Thermal Power Plants. In the present study, Low calcium (Class F) fly ash obtained from Raichur Thermal Power Plant, Karnataka, INDIA. Specific Gravity of fly ash is 2.20; Surface area is 300-400 sq m/kg.

C. Natural Aggregate (HBG metal) (Coarse Aggregate) :

This crushed hard broken granite metal is used as coarse aggregate procured from Ulindakonda quarry near Kurnool town of A.P. To get a reasonable good grading of aggregate 60-65% passing through 20mm sieve and retained at 12.50 mm sieve is used. Specific Gravity of aggregate is observed as 2.97 and Fineness Modulus is 3.54 as per table 2.

D. River Sand (Fine Aggregate):

River Sand is used as Fine aggregate collected from Thungabhadra River, Specific gravity of river sand found as 2.84 and Fineness Modulus is 3.12 as per table 2.

E. Nagalooty Waste Stone Material (CA & FA):

Nagalooti, a village near Nandikotkur of Kurnool District, in which layered stone called Nagalooty waste stone, is being used for roofing, flooring and also for casting foundations and walls. The physical properties of fine and coarse aggregates are viz., Specific Gravity and Fineness Modulus of CA is 3.06 and 3.34 for FA is 2.73 and 2.97 respectively as per table 2.

F. Objective of Research:

Major objective of this research is to test the behaviour of these waste stone as CA & FA in cement concrete and to find out in which combination of these material can be utilized in production of concrete and also to propose the different applications of these crushed Nagalooty stone for using as coarse aggregate and fine Aggregate in different mix combinations in concrete.

G. Mix proportions:

The concrete mix is designed as per IS 10262 – 2009. Concrete is produced by replacing the coarse aggregate with Nagalooty waste stone, fine aggregate with Nagalooty waste stone dust and cement with fly ash to some extent for comparing with M25 Grade Concrete, with a water cement ratio of 0.48. The volume of the mix proportions are given in the table 1.

Table 1: **Mix Proportion of M25 grade concrete**

Unit of Batch	Cement (kg/m^3)	FA(Kg)	CA(Kg)	Water (kg/m^3)
		River Sand	HBG Metal	
Cubic meter content	399	724	1262	192
Ratio of ingredients	1	1.81	3.16	0.48

Table 2: Mechanical Properties of Coarse Aggregate & Fine Aggregate

S.No	Mechanical Properties	Coarse Aggregate		Fine Aggregate	
		Natural HBG Metal	Nagalooty Waste Stone Metal	River Sand	Nagalooty Waste Sand Dust
1	Impact Value	26.52%	18.08%	-	-
2	Crushing Strength	25.95%	16.47%	-	-
3	Water absorption	0.05%	0.15%	-	-
4	Bulking of FA	-	-	3%	4%
5	Water Content	-	-	27.78%	23.81%

H. Mixing, Casting and Curing:

Cylinders are cast in 20 different combinations of mixes as per design mix. For each combination, 9 cylinders are cast with 150mm dia and 300 mm height for 7, 28, & 60 days of curing. The samples were demoulded after 24 hrs from casting and kept in a water tank for curing.

I. Split Tensile strength:

Split tensile strength test was conducted by using Universal testing machine (UTM) by applying uniform load until cylinder fails and ultimate load, strength of cylinders are found.

V. ANALYSIS OF RESULTS OBTAINED

In the Laboratory Experimental programme, results obtained about split tensile strength of cylinders were represented in Tables 3, 4, 5 and 6. The values mentioned are the average split tensile strength values of cylinders of 3 specimens for each mix combination. Based on the results obtained for different mix combinations named M1 to M20, strength was analysed with Natural Aggregate concrete M1 V/S other Mix Combination Concrete from M2 to M20 Mix combinations. Split tensile Strength of cylinders are cast with normal aggregate i.e, 20mm HBG metal, River sand and Cement mixed as per design Mix for M25 grade concrete designated as M1 Mix. Similarly other different Mix Proportions are designated as M2 to M20 Mix as clearly mentioned in the tables.

Table 3: Split Tensile Strength values of Cylinders (M1-M5mix)

Mix Designations and different proportions							Average Split tensile Strength in MPa			Percentage of strength decreased with respect to natural Mix Concrete (M1 Mix)		
Mix Designation	Cement	Fly Ash	HBG metal(CA)	NWS metal(CA)	Sand (FA)	NWS Dust (FA)	7 days	28 days	60 days	7 days	28 days	60 days
M1	100	0	100	0	100	0	2.33	3.32	3.51	-	-	-
M2	100	0	75	25	75	25	2.26	3.23	3.42	3	2.71	2.56
M3	100	0	50	50	50	50	2.10	3.04	3.18	9.87	8.43	9.4
M4	100	0	25	75	25	75	2.05	2.94	3.11	12.01	11.44	11.39
M5	100	0	0	100	0	100	1.95	2.90	3.06	16.31	12.65	12.82

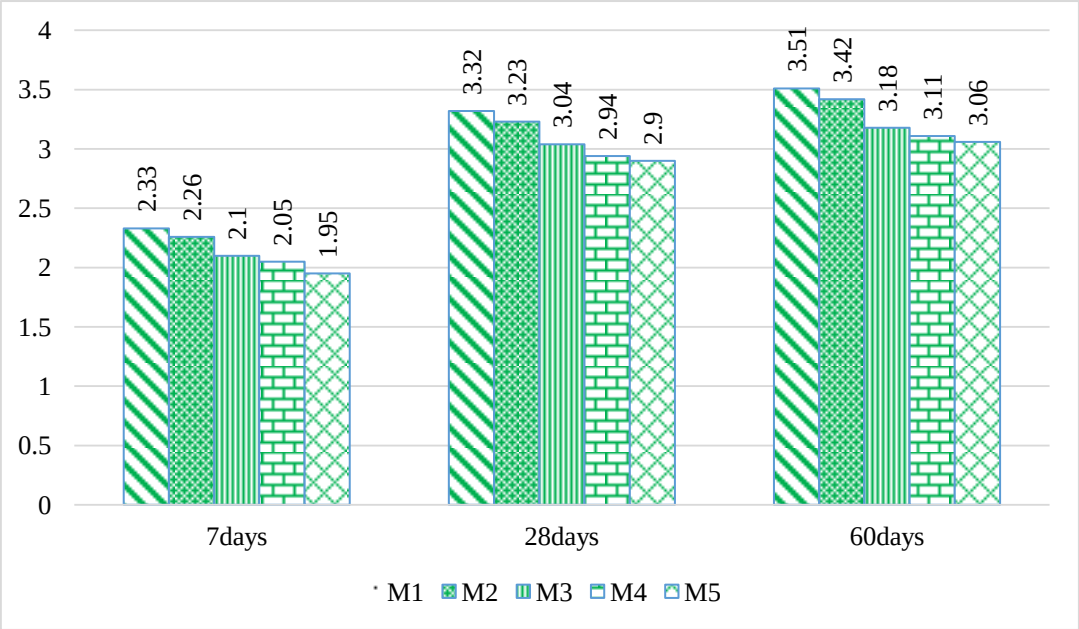

Fig 1: Tabular Analysis of results obtained for the mixes M1 to M5

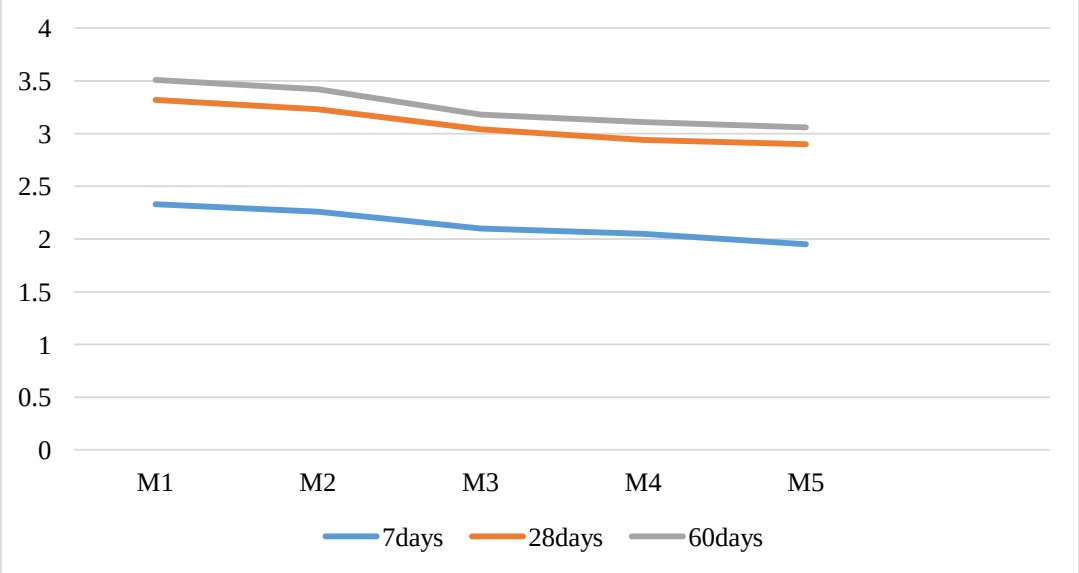

Fig 2: Graphical Analysis of results obtained for the mixes M1 to M5

From Table 3 it is observed that Split Tensile strength results for M1 mix(base mix), 7 days split tensile strength found as 2.33MPa where as for other mix combinations it is found as M2–2.26 , M3-2.10,M4-2.05 and M5-1.95MPa which is lesser than M1 mix respectively.

As observed from the above results, percentage of split tensile strength decreased in 7 days on M2,M3,M4,M5 mix combinations with respect to M1 mix are found by 3.00%,9.87%,12.01%,16.31% respectively as given in fig 1 and 2.

Similarly for M1 mix 28 days Split tensile strength was found as 3.32MPa where as for other mix combinations it is found as M2-3.23, M3-3.04, M4-2.94, M5-2.90 MPa respectively.

As observed from the above results, percentage of split tensile strength decreased in 28 days on M2,M3,M4,M5 mix combinations with respect toM1mix are found by2.71%,8.43%,11.44%,12.65% respectively.

In the same manner M1 mix 60 days split tensile strength was found as 3.51MPa where as for other mix combinations it is found as M2-3.42, M3-3.18, M4-3.11 and M5-3.06 MPa respectively.

As observed from the above results, percentage of split tensile strength decreased in 60 days on M2, M3, M4, M5 mix combinations with respect to M1 mix are found by 2.56%,9.40%,11.39, 12.82 respectively.

Table 4: Split Tensile Strength values of Cylinders (M6-M10 Mix)

Mix Designations and different proportions							Average Split tensile Strength			Percentage of strength decreased with respect to natural Mix Concrete (M1 Mix)		
Mix Designation	Cement	Fly Ash	HBG metal(CA)	NWS metal(CA)	Sand (FA)	NWS Dust (FA)	7 days	28 days	60 days	7 Days	28 Days	60 Days
M6	90	10	100	0	100	0	2.05	3.21	3.38	12.01	3.31	3.7
M7	90	10	75	25	75	25	1.95	3.07	3.24	16.31	7.53	7.69
M8	90	10	50	50	50	50	1.80	2.84	3.09	22.74	14.45	11.96
M9	90	10	25	75	25	75	1.65	2.71	2.95	29.18	18.37	12.25
M10	90	10	0	100	0	100	1.58	2.61	2.83	32.18	21.38	15.66

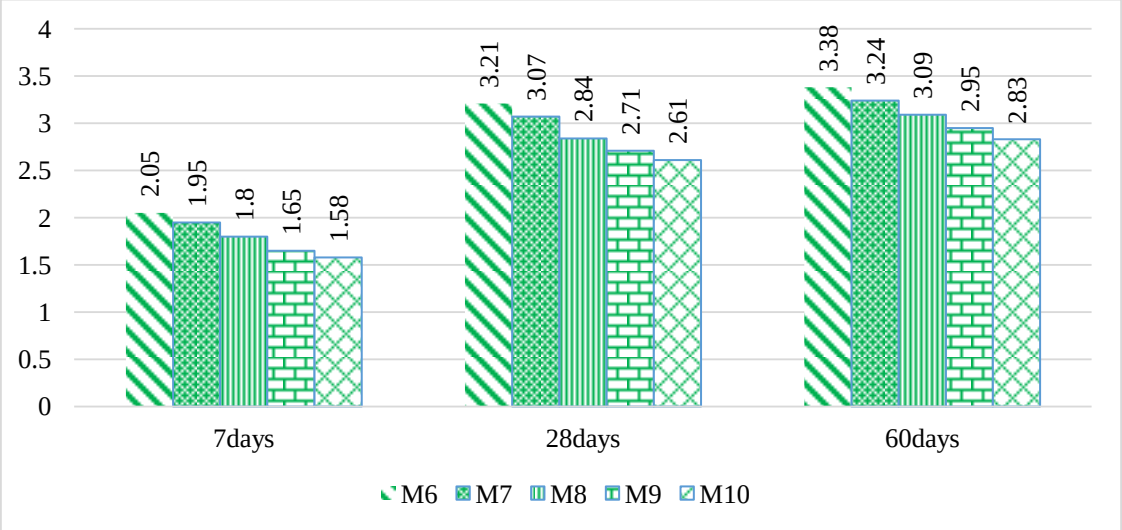

Fig 3: Tabular Analysis of results obtained for the mixes M1 to M5

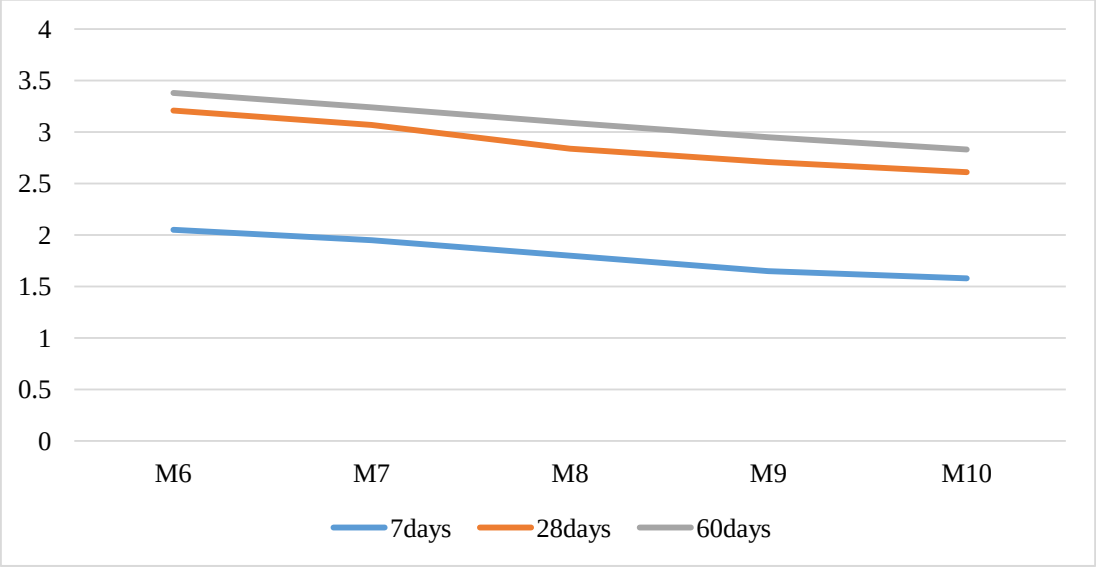

Fig 4: Graphical Analysis of results obtained for the mixes M1 to M5

From Table 4 it is observed that split tensile strength results for M1 mix, 7 days found as 2.33MPa where as for other mix combinations it is found as M6-2.05, M7-1.95, M8-1.80, M9-1.65 and M10-1.58 MPa respectively which is lesser than the M1 mix.

As observed from the above results, percentage of split tensile strength decreased in 7 days on M6, M7, M8, M9, M10 mix combinations with respect to M1 mix, it is foundby12.01%, 16.31%, 22.74%, 29.18%, 32.18% respectively.

Similarly for M1 mix 28 days split tensile strength is found as 3.32MPa where as for other mix combinations it is found as M6-3.21, M7-3.07, M8-2.84, M9-2.71 and M10-2.61MPa respectively as given in fig 3 and 4. As observed from the above results, percentage strength decreased in 28 days split tensile strength on M6,M7,M8,M9, M10 mix combinations with respect to M1 mix are found by3.31%,7.53%,14.45%,18.37%, 21.38% respectively.

In the same manner M1 mix 60 days split tensile strength is found as 3.51MPa where as for other mix combinations it is found as M6-3.38, M7-3.24, M8-3.09, M9-2.95 and M10-2.83MPa respectively.

As observed from the above results, percentage of split tensile strength decreased in 60 days on M6,M7,M8, M9, M10 mix combinations with respect to M1 mix are found by 3.70%,7.69%,11.96%,12.25%, 15.66% respectively.

Table 5: Split Tensile Strength values of Cylinders (M11 to M15 Mix)

Mix Designations and different proportions							Average Split tensile Strength			Percentage of strength decreased with respect to natural Mix Concrete (M1 Mix)		
Mix Designation	Cement	Fly Ash	HBG metal(CA)	NWS metal (CA)	Sand (FA)	NWS Dust (FA)	7 days	28 days	60 days	7 Days	28 Days	60 Days
M11	80	20	100	0	100	0	1.85	2.73	2.87	20.60	17.77	18.23
M12	80	20	75	25	75	25	1.60	2.65	2.80	31.33	20.18	20.22
M13	80	20	50	50	50	50	1.51	2.52	2.65	35.19	24.09	24.5
M14	80	20	25	75	25	75	1.38	2.33	2.47	40.77	29.82	29.63
M15	80	20	0	100	0	100	1.32	2.31	2.45	43.34	30.42	30.20

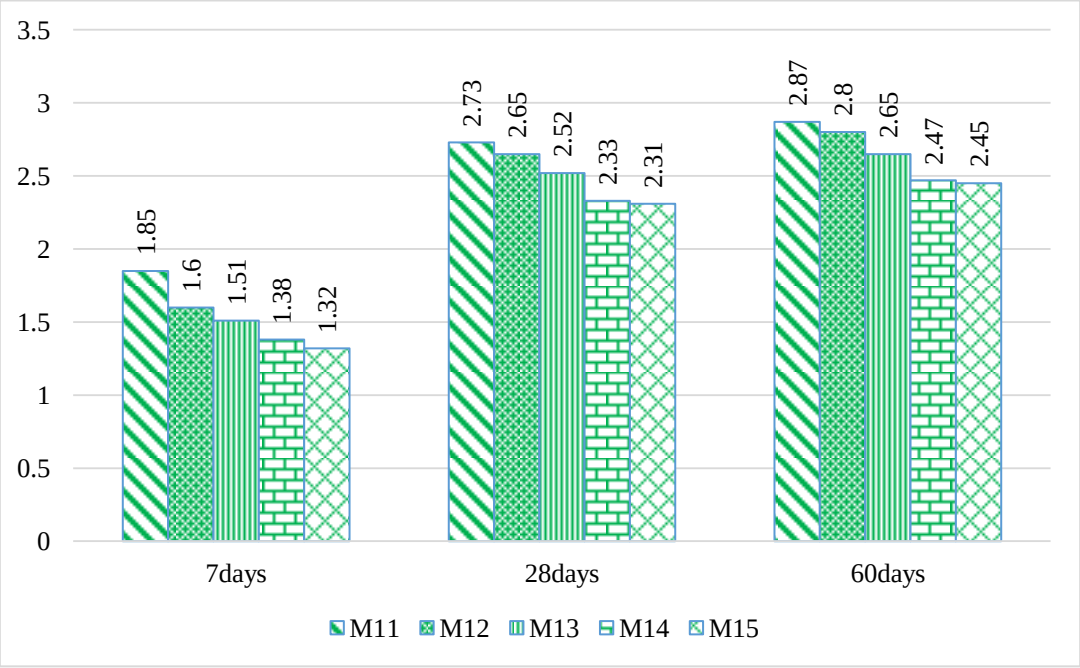

Fig 5: Tabular Analysis of results obtained for the mixes M1 to M5

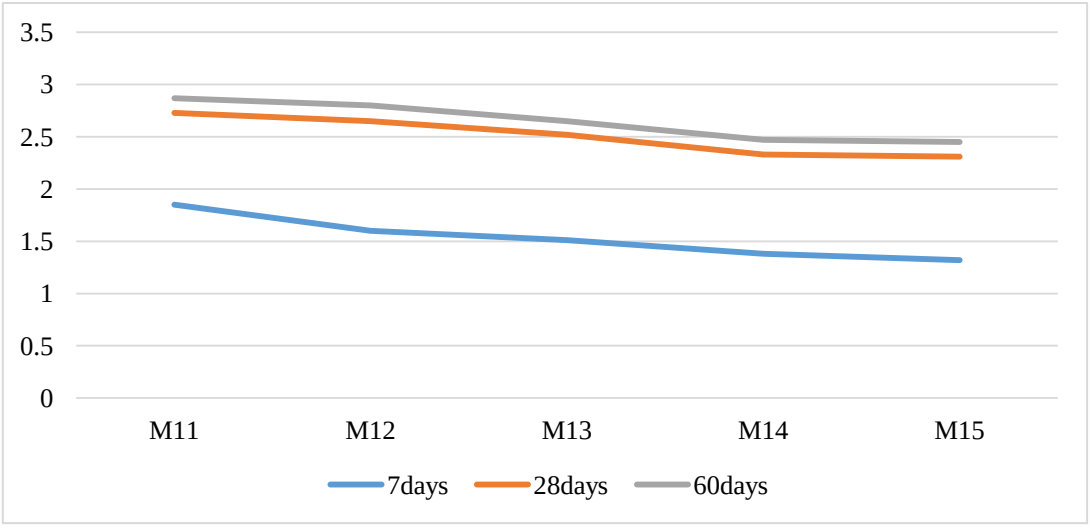

Fig 6: Graphical Analysis of results obtained for the mixes M1 to M5

From Table 5 it is observed that the split tensile strength results for M1 mix (base mix), 7 days split tensile strength is found as 2.33MPa where as other mix combinations M11-1.85, M12-1.60, M13-1.51, M14-1.38 and M15-1.32MPa respectively which is lesser than M1 mix.
As observed from the above results, percentage of Split tensile strength decreased in 7 days on M11, M12, M13, M14, M15 mix combinations with respect to M1 mix are found by 20.60%, 31.33%, 35.19%, 40.77%, 43.34% respectively.
Similarly for M1 mix 28 days Split tensile strength was found as 3.32MPa where as for other mix combinations it is found as M11-2.73, M12-2.65, M13-2.52, M14-2.33 and M15-2.31MPa respectively. As observed from the above results, percentage of Split tensile strength decreased in 28 days on M11, M12, M13, M14, M15 mix combinations with respect to M1 mix are found by 17.77%, 20.18%, 24.09%, 29.82%, 30.42% respectively as given in fig 5 and 6.

In the same manner M1 mix 60 days split tensile strength are found as 3.51MPa where as for other mix combinations are found as M11-2.87, M12-2.80, M13-2.65, M14-2.47 and M15-2.45MPa respectively.
As observed from the above results, percentage of Split tensile strength strength decreased in 60 days split tensile strength on M11,M12,M13,M14, M15 mix combinations with respect to M1 mix are found by 18.23%, 20.22%, 24.50%, 29.63%, 30.20% respectively.

Table 6: Split Tensile Strength values of Cylinders (M16 to M20 Mix)

Mix Designations and different proportions							Average Split tensile Strength			Percentage of strength decreased with respect to natural Mix Concrete (M1 Mix)		
Mix Design ation	Cement	Fly Ash	HBG metal (CA)	NWS metal (CA)	Sand (FA)	NWS Dust (FA)	7 days	28 days	60 days	7 Days	28 Days	60 Days
M16	70	30	100	0	100	0	1.60	2.35	2.51	31.33	29.21	28.49
M17	70	30	75	25	75	25	1.41	2.30	2.42	39.48	30.72	31.05
M18	70	30	50	50	50	50	1.32	2.27	2.38	43.34	31.62	32.19
M19	70	30	25	75	25	75	1.21	2.20	2.31	48.06	33.73	34.18
M20	70	30	0	100	0	100	1.15	2.06	2.18	54.93	37.95	37.89

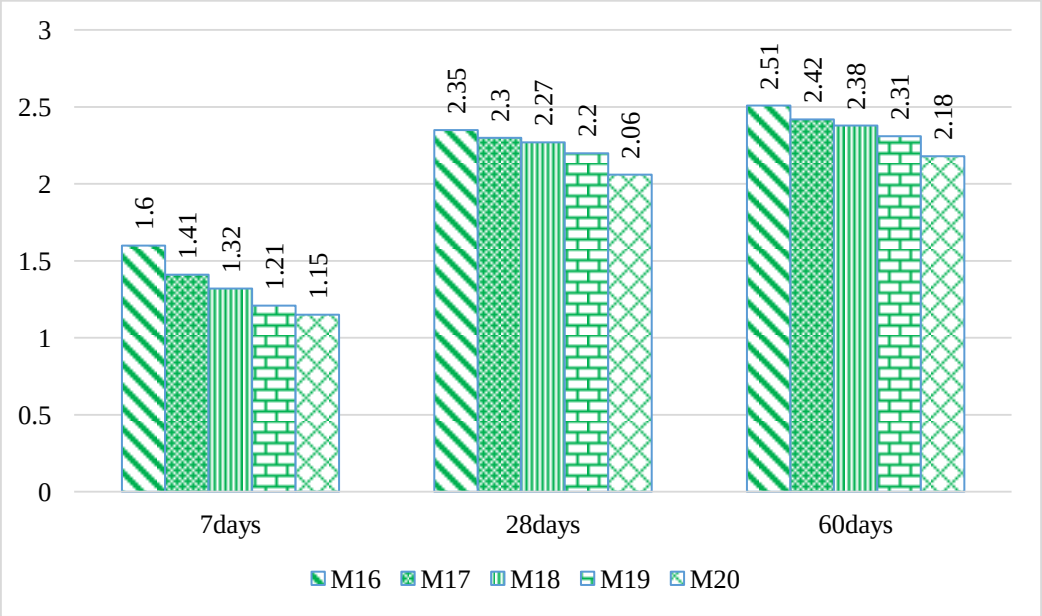

Fig 7: Tabular Analysis of results obtained for the mixes M1 to M5

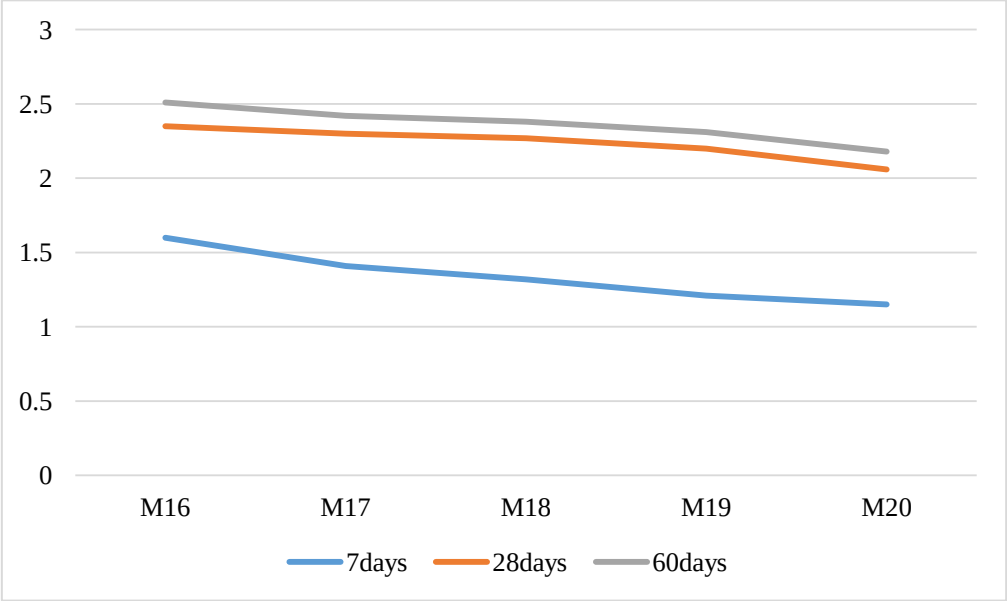

Fig 8: Graphical Analysis of results obtained for the mixes M1 to M5

From Table 6 it is observed that the split tensile strength results for M1 mix 7 days strength is found as 2.33MPa, where as for other mix combinations M16-1.60, M17-1.41, M18-1.32, M19-1.21 and M20-1.15MPa respectively which is lesser than M1 base mix.

As observed from the above results, percentage of split tensile strength decreased in 7 days on M16,M17,M18, M19, M20 mix combinations with respect to M1 mix are found as 31.33%, 39.48%, 43.34%, 48.06%, 54.93% respectively.

Similarly for M1 mix 28 days split tensile strength found as 3.32 MPa, where as for other mix combinations it is found as M16-2.35, M17-2.30, M18-2.27, M19-2.20 and M20-2.06MPa respectively. As observed from the above results, percentage of split tensile strength decreased in 28 days decreased on M16,M17,M18, M19, M20 mix combinations with respect to M1 mix are found by 29.21%, 30.72%, 31.62%, 33.73%, 37.95% respectively as given in fig 7 and 8.

In the same manner M1 mix 60 days split tensile strength was found as 3.51MPa where as for other mix combinations it is found as M16-2.51, M17-2.42, M18-2.38, M19-2.31 and M20-2.18MPa respectively. As observed from the above results, percentage split tensile strength decreased in 60 days compressive strength on M16, M17, M18, M19, M20 mix combinations with respect to M1 mix are found by 28.49%,31.05%,32.19%,34.18%,37.89% respectively.

Casting and testing of cylinders:


VI. CONCLUSIONS & APPLICATIONS

1. As the crushing strength and impact value of Nagalooti waste stone is found lesser than the natural HBG metal compressive strength of cubes was gradually decreased with increase in Nagalooti waste stone aggregate.
2. It is observed that as the percentage of Nagalooti waste stone material is increased, workability is reduced, as the water absorption is found to be more in Nagalooti waste stone material than conventional material.
3. Though other 19 mix combinations were found to have less Split Tensile strength than M1 Mix, but all other mix combinations, has got compressive strength more than the Characteristic strength of M25 Grade Concrete.
4. Finally it can be concluded that Nagalooti waste stone can be used for both FA & CA for construction of single storied buildings where limited live loads are applied on buildings, duly taking proper care on sieving & grading of raw materials.
5. As there is no initial cost for waste stones in Nagalooti near Kurnool, nearby habitations are benefited with cost savings around 20%-30% are observed compared with Traditional/Natural Mix concrete in these areas.

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