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A Comparative Study of Green Concrete Incorporating Rec-Con Aggregate to Develop Sustainable Construction Materials

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***Abstract:** Concrete is one of the most widely used construction material in the world, Increase in population growth may increase in various demands like construction works like residential buildings, bridges, dams and roads etc, so the problem of waste disposal has become a major problem in the developed countries as well as developing countries like India, Recent technology has greatly improved the recycling process for waste concrete and the present study about comparison of properties of natural and recycled aggregates also the effect of mineral admixture (Metakaolin and flyash) on behavior of recycled concrete aggregate prepared with different amount of RCA. Six mixes of concrete with 0%, 10%, 20%, 30%, 40%, 50% replacement of natural aggregate with recycled aggregate were cast respectively in addition to this partial replacement to the weight of cement is done with Metakaolin (0%, 5%, 10%, 15%, 20%, 25%), flyash (0%, 5%, 10%, 15%, 20%, 25%) and weight of fine aggregate with M-sand (0%, 10%, 20%, 30%, 40%, 50) for all mixes. The compressive strength, flexural strength, split tensile strength were determined at the age of 28 days and the study focuses on the possibility of the use of recycled aggregate as a structural material as showed a gradual decrease in compressive strength, split tensile strength, flexural strength as the percentage of recycled aggregate is increases gradually.*

***Keywords:** Metakaolin, Flyash, M-sand, Rec-con Aggregates, Deflection, Durability.*

I. INTRODUCTION

The problem of waste disposal has become a major problem in the developed countries as well as developing countries due to the enormous increase in the amount of disposable concrete materials, the continuous storage of dumping sites, increases the cost of transportation for its disposal, when the construction developments are on its peak in the 21st century around the globe. There are numerous skyscrapers, bridges, roads, underground tunnels and deepwater structures all over the world although there are many other types of structure being constructed every year, To accommodate new structures, many structures built in the past centuries are being demolished and destroyed due to their limit of life span, unsuitable position in an ever growing city and damaged condition caused by natural disaster. The large scale depletion of Natural aggregate resource and increasing amounts of constructional as well as demolition waste are going to fill land sites may cause significant damage to the environment which develops a serious problems on denting the public and the environmentalist's aspirations for a waste free society. The demolition of structures may generate concrete rubbles which cause environmental problems due to unplanned disposal along with scarcity of landfill sites, a large portion of the potentially useful demolition waste is disposed off in landfill sites with the transport and disposal of this waste are both economically and environmentally not sustainable. To avoid these problems now-a-days alternative aggregates are drawing more interest in the construction industry. This situation is not serious in India, but there are some parts in India where crushed stone aggregate are not available within several kilometres of the radius so, these kind of situation may arise in the future, when demand cause a serious thinking on the part of Indian community, especially when the volume of concrete construction is expected to increase manifold in coming decades. Along with construction and demolition waste with the excessive use of cement in concrete is a major cause of concern for environmental issues and cement manufacturing industries are one of the major contributors of global warming through excessive CO_2 emission. Researchers are going on to cut down the use of cement by replacing part of cement with mineral admixtures such as fly ash, zeolite, silica fume and metakaolin, etc., Therefore the concept of recycling the waste material and using it again in some form of constructions has gathered momentum even though recycling not only solves the problem of waste disposal but also reduces the cost and conserves the non-renewable natural sources. Demolition waste generated in many countries had no exception to the above problem and hence, the recycling technology is making considerable headway in the recycling of demolished concrete.

II. EXPERIMENTAL PROGRAMME

A. Materials Used

1) *Metakaolin and Flyash:* Metakaolin is in widespread use all over the world in the concrete industry. The advantages of metakaolin are not only the many concrete performance benefits, both in mechanical and durability properties, but also the environmental benefits. While the production of Portland cement is associated with high CO_2 emissions. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, It is manufactured for specific purposes under controlled conditions but, it is manufactured from high-purity kaolin clay by calcinations at temperatures of 650-900°C. This heat treatment or calcination, serves to break down the structure of kaolin. Fly ash is one of the residues created during the combustion process and comprises the fine particles that rise with flue gases. In the civil and industrial sense the term “fly ash” generally refers to coal fly ash captured from coal-fired power plants which is by far the most predominant fly ash used in construction and industrial applications. Fly ash is a waste by-product material that must be disposed of or recycled. fly ash is a by-product from coal fired electricity generating power plants.
2) *Cement:* Ordinary Portland cement conforming to IS 12269-1976 was adopted in this work. The cement used is 53 grade and it is a generic term that can apply to all binders. There is a wide variety of cements that are used to some extent in the construction and building industries, to solve special problems. The chemical composition of these cements can be quite diverse, but far the greatest amount of concrete used today is made with Portland cements.
3) *Fine Aggregate:* The source for fine aggregate used is from natural river bed, maximum size of 4.75mm. All the details regarding test conducted on it, along with manufacturing sand confirming to zone II as per IS: 383-1970 is used in these project.. When rock is crushed and sized in quarry the main aim has generally been to produce coarse aggregates and road construction materials, M-sand is defined as a purpose made crushed fine aggregate produced from suitable source materials.
4) *Coarse Aggregate:* The N.C.A used here are of below 20 mm size. Preliminary test such as water absorption, moisture content, sieve analysis, specific gravity and crushing strength tests have carried out and the results are as given in Table below along with the recycled concrete aggregate. The coarse aggregate (C.A) is separated from the concrete by hammering. Mortar adhered to the aggregate is also removed from the aggregate as much as possible. Obtained C.A is sieved under 20mm sieve (passing) and 4.75mmsieve (retained), later these aggregates can be used as R.C.A for further work, After obtaining the R.C.A from original concrete, preliminary tests should be done.
5) *Water:* Portable water from local area was used for mixing and curing.

Table 1 Properties Of Material

Property	Cement	Metakaolin	Flyash	NFA	M Sand	Coarse Aggregate	Rec – Con Aggregate
Specific Gravity	3.14	2.54	2.2	2.60	2.68	2.82	2.55
Fineness Modulus	1.9	1.31	1.24	4.45	3.2	7.17	6.34
Water Absorption	-	-	-	3.2%	2.6%	0.6%	1.4%
Grading Zone	-	-	-	II	II	Graded Aggregate	Graded Aggregate
Crushing Strength	-	-	-	-	-	19.67	16.64
Consistency	33%	-	-	-	-	-	-
Initial Setting Time	28 min	-	-	-	-	-	-
Final Setting Time	480 min	-	-	-	-	-	-
Nitrogen Absorption	-	16.8 m^2/g	-	-	-	-	-

B. Mix Proportion:

The concrete mix was designed as per IS 10262-2009. The grade of concrete adopted was M30 with the water cement ratio of 0.38 and 0.42. The target mean compressive strength was 30 N/mm^2. The mix proportions is shown table.

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Table 2 Mix Proportions

Mix Design	Description	Cement	Flyash	Mk	NFA	M-Sand	NCA	RCA	SP	WATER
Standard Mix Design	Quantity in kg/m^3	380	-	-	705	-	1247	-	7.7	160
	Proportion	1	-	-	1.86	3.28	-	-	0.02	0.42
Partial Mix Design	Quantity in kg/m^3	342	19	19	674	68	1192	120	7.7	160
	Proportion	1	0.05	0.05	0.88	0.17	2.82	0.32	0.02	0.42

Table 3 Various Mix Proportions

Description	Unit	Mix	Mix	Mix	Mix	Mix	Mix
Mixing	0	A	B	C	D	E	F
Cement	kg/m^3	380	342	304	266	228	190
Flyash	%	0	5	10	15	20	25
Flyash	kg/m^3	0	19	38	57	76	95
Metakaolin	%	0	5	10	15	20	25
Metakaolin	kg/m^3	0	19	38	57	76	95
NCA	kg/m^3	1247	1192	1072	952	832	712
RCA	%	0	10	20	30	40	50
RCA	kg/m^3	0	120	240	360	480	600
River sand (NFA)	kg/m^3	705	674	606	538	470	402
M-sand	%	0	10	20	30	40	50
M-sand	kg/m^3	0	68	136	204	272	340

C. Specimen Casting and Testing:

The specimens were casted with concrete of characteristic strength 30N/mm^2, the size of cube mould is (150mm x 150mm x 150mm) and of prism mould is (750mm x 150mm x 150mm) and of cylinder is 150mm diameter and 300mm height, The mix design was computed according to the design specification mentioned in IS 10262 – 2009, The mix ratio thus obtained is 1: 1.86: 3.28 with water cement ratio 0.42. For standard concrete, for the partial replacement with metakaolin and flyash the mix ratio was 1: 1.77: 3.14 mixtures with 0, 10, 20, 30, 40 and 50 percentage substitutions of both metakaolin and flyash.

   

D. Compressive Strength of Concrete

Test on hardened concrete is used to find out the complete research data such as compression strength, split tensile strength and flexural strength of concrete at 7, 14 and 28 days of curing and comparing both the convectional concrete with various mixes of partially replaced concrete. The hardened concrete testing is used to determine the structural strength of the concrete specimen to be tested by compression test machine after 7 days, 14 days and 28 days of curing. Load should be applied gradually at the rate of 140kg/cm^2 per minute till specimens fails, load at the failure divided by area of specimen gives the compressive strength of concrete.

Table 4 Compressive Strength Value

S.no	No. of days	Composition of REC-CON aggregate in percentage (N/mm^2)					
		0%	10%	20%	30%	40%	50%
1	7	17.67	18.21	21.64	23.74	15.57	13.57
2	14	26.64	28.32	32.54	34.15	28.46	22.32
3	28	39.26	41.64	43.76	45.32	40.14	36.11

E. Split Tensile Strength of Concrete

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The split tensile strength is directly related to shear and bond strength between aggregate, cement paste and crack resistance, the cylinder is placed in the machine such that load is applied on the opposite side of the cylinder which placed perpendicular to normal axis to the platform of the universal testing machine.

Table 5 Split Tensile Strength Value

S.no	No. of days	Composition of REC-CON aggregate in percentage (N/mm^2)					
		0%	10%	20%	30%	40%	50%
1	7	1.24	1.52	1.64	1.74	1.46	1.12
2	14	1.53	1.66	1.78	1.96	1.62	1.44
3	28	1.83	2.15	2.33	2.47	2.18	1.96

F. Flexural Strength of Concrete

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 inch * 6 inch concrete beam with a span length of at least three times the depth. Specimens were dried in open air before 24 hours of testing subjected to flexural strength test under flexural testing assembly.

Table 6 Flexural Strength Value

S.no	No. of days	Composition of REC-CON aggregate in percentage (N/mm^2)					
		0%	10%	20%	30%	40%	50%
1	7	1.73	2.21	2.45	2.77	1.66	1.42
2	14	2.35	2.84	3.36	3.97	3.24	2.16
3	28	2.87	3.24	3.94	4.38	3.74	2.64

III.RESULTS AND DISCUSSION

A. Recycled coarse aggregate will be used up to 30% to attain greater strength and more than 40% will result in decrease in strength.

B. Recycled coarse aggregate with nominal size (6-20mm) such as in percentage of (6 to 8mm) is 20%, (8 to 12mm) is 35% and (12 to 20mm) is 45% will produce efficient structural strength.

C. In recycled aggregate concrete, M-sand would be used as possible as 30 to 40% and remaining will fulfil with NFA (River sand) to attain more or equal strength compared to normal conventional concrete and usage of M-sand of more than 50% in recycled aggregate concrete will result in decreased in strength gradually compared with conventional concrete.

D. M-sand shows a gradual decrease in strength with combination with Recycled coarse aggregate due to the previous cementitious adhered materials makes surface of coarse aggregate as smooth so, the bonding between both M-sand and Recycled coarse aggregate will be limited strength up to partial replacement with 50% to their both coarse and fine aggregates.

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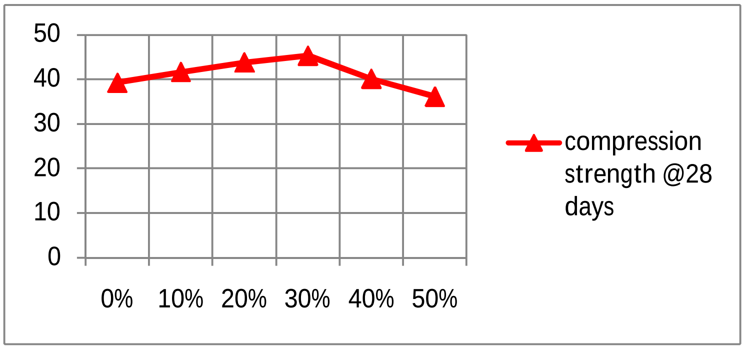
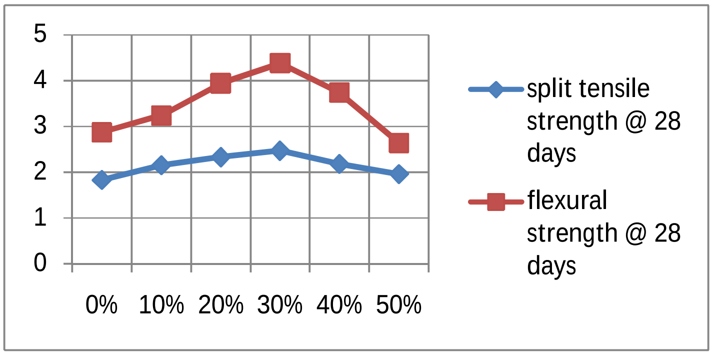


E. The above chart shows that from the metakaolin based recycled concrete aggregate with (0, 10, 20, 30, 40 and 50) percentage and their respective compression strength.



F. The above chart shows that from the metakaolin based recycled concrete aggregate with (0, 10, 20, 30, 40 and 50) percentage and their respective split tensile and flexural strength.

G. In 'D' nomenclature sample with 30% replacement of Recycled coarse aggregate, 15% replacement of both flyash and metakaolin and 30% replacement of M-sand. The sample D shows higher strength compared with other mixture concrete.

H. M-sand is a good effective alternative in terms of replacement with natural fine aggregate (River sand) by comparing the both the physical properties of M-sand and River sand. In terms of good physical properties such as surface texture and grading zone, the River sand would be fully replaced by M-sand for both concreting and in plastering

IV. CONCLUSION

Following conclusions have been drawn from the experimental results of this study:

A. The best suited water-cement ratio for metakaolin base recycled aggregate is 0.30 to 0.42 which produce good workability in concrete, more than 0.42 and below 0.30 will affect the workability of concrete.

B. The w/c ratio is determine based on type of concreting and type of cement used as per the environment and soil seepage conditions, for autonomous metakaolin concrete more suitable is 0.30 w/c ratio.

C. The slump value decreases with increase in metakaolin which decreases the workability, hence metakaolin deminishes workability so, flyash is used as mineral additive and super plasticizers are used with proper dosage with increases workability but their impact is very little.

D. Metakaolin and flyash is limited to 10 to 17% that is exactly 15%, hence more than 20% will result in decrease in structural strength, both the recycled coarse aggregate and M-sand are also limited to 30% and more than 40% will have serious decrease in both compression and flexural strength compared with convectional concrete.

E. The compression strength of cube at 7, 14 and 28 days shows increase in strength from 0% to 30% and gradual decrease in seen from 40% to 50%, serious decreased in strength is compared from normal concrete (0%) with convectional concrete (50%).

F. According to the test results obtained in this project, it was observed that the split tensile strength and flexural strength development of the concrete had similar tendency with compression strength i.e., the strength of these properties are directly proportional to each other.

G. The split tensile strength of cylinder at 7, 14 and 28 days shows increase in strength from 0% to 30% and gradual decrease in seen from 40% to 50%, serious decreased in strength is compared from normal concrete (0%) with convectional concrete (50%).

H. The flexural strength of prism at 7, 14 and 28 days shows increase in strength from 0% to 30% and gradual decrease in seen from 40% to 50%, serious decreased in strength is compared from normal concrete (0%) with convectional concrete (50%).

I. Bulk density of fresh concrete is slightly decreased with increasing quantity of recycled coarse aggregate and also type of coarse aggregate has no influence on the air content in concrete.

J. The bond between recycled coarse aggregate concrete and reinforcement is not significantly influenced by recycled coarse aggregate, because it is realised thought new cement paste, if "water saturated-surface dry" recycled coarse aggregate is used.

K. It is not recommended to apply this type of concrete for structural elements with large deformations can be expected and structures exposed to aggressive environment conditions without appropriate previous testing.

L. Normal concrete samples are compared with convectional concrete samples at 0% as 'A' and 30% as 'D' at 28 days of characteristic strength with replacement of metakaolin based recycled concrete.

M. Load act on concrete cube, cylinder and beam, bending moment due to load, Displacement caused by bending and finally Shear act on concrete cube due to displacement at both normal and convectional concrete were analysed and their reports are generated in staad pro.

N. The concluded result from the staad pro analysis is the convectional concrete at 30% shows much higher strength in terms of compression, tensile and flexural than the normal concrete at 0%, which in terms enable us to understand the green concrete from various replacement levels of materials at sample D3 is effective than the other concrete samples.

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REFERENCES

[1] Anas shahid multani, Nigam, A.K (2017). "An investigation of partial replacement of cement with metakaolin in association with super plasticizer." IJIRSET volume 06, issue 06, e-ISSN: 2319-8753.

[2] Adams joe, M et.al (2013). "Experimental investigation on the effect of M-sand in high performance concrete." AJER volume 02, issue 12, e-ISSN: 2320-0847. Beulah, M Prahallada, M.C (2012). "Effect of replacement of cement by metakaolin on the properties of high performance concrete subjected to hydrochloric acid attack." IREJA volume 02, issue 06, ISSN: 2248-9622.

[3] Gopireddy, A Rajkumar, M.R (2017). "Experimental study on partial replacement of cement with metakaolin and sand with quarry dust of reinforced concrete beam." IJIR volume 03, issue 04, ISSN: 2454-1362.

[4] Halesh kumar, B.T et.al (2017). "Replacement of fine aggregate by M-sand." IJSTE volume 03, issue 12, ISSN: 2349-784X.

[5] Mirjana malesev, vlastimer radonjanin and snezana marinkovic (2010). "Recycled concrete as aggregate for structural concrete production." Article-april2010, DOI:10.3390/su2051204, open access, ISSN: 2071-1050, www.mdpi.com/journal/sustainability.

[6] Narmatha, M Felixkala, T (2016). "Metakaolin – The best material for replacement of cement in concrete." IOSR-JMCE volume 13, issue 4 ver I, 66-71, e-ISSN: 2278-1684.

[7] Pavithra, O et.al (2017). "Experimental analysis on concrete with partial replacement of cement with metakaolin and fine aggregate with quartz sand." IJAERD volume 04, issue 07, e-ISSN: 2348-4470.

[8] Rahul Jadhav, M et.al (2015). " A study on metakaolin base recycled aggregate concrete." IJSCER volume 04, issue 01, ISSN: 2319-6009.

[9] Sunny Jagtap, A et.al (2017). "Effect of metakaolin on the property of concrete." IRJET volume 04, issue 07, e-ISSN: 2395-0056.

[10] Shakir Ahmed, M.D Vidyadhara, H.S (2013). "Experimental study on strength behaviour of recycled aggregate concrete." IJERT volume 02, issue 10, ISSN: 2278-0181.

[11] Somasekharaiah, H.M et.al (2016), "Experimental investigation on the strength properties of high performance concrete using M-sand and metakaolin." IRJET volume 03, issue 09, ISSN: 2395-0056.

[12] Sai kumar, A.V.S Krishna rao, B (2014). "A study on strength of concrete with partial replacement of cement with quarry dust and metakaolin." IJIRSET volume 03, issue 03, ISSN: 2319-8753.

[13] Venkatesh, A.L et.al (2018). "High strength concrete by partial replacement of cement by flyash, metakaolin and alccofine." IRJET volume 05, issue 04, e-ISSN: 2395-0056.

[14] Venkatarama reddy, B.V (2012). "Suitability of manufactured sand as fine aggregate in mortars and concrete." Department of mines and geology, Govt. of Karnataka, CSIC project: CP 6597/0505/11-330 dated 5th july 2011.

[15] Wojciech kubissa et.al (2017). "Ecological concrete based on blast-furnace cement with incorporated coarse recycled concrete aggregate and flyash addition." Article-January 2017, DOI:10.7569/JRM.2017.634103, https://www.researchgate.net/publication/313461998.