Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

EFFECT OF METAKAOLIN ON HARDEN PROPERTIES OF C&D WASTE AGGREGATE CONCRETE.

[1]Mr. Pratik A. Sureja, [2]Prof. Sumit Phugat, [3]Prof. Maulik Panseriya

[1]Parul institute of technology, Limda, Vadodara, India
[2]Assistant professor in civil engg. Dept., Parul University, Limda, Vadodara, India
[3]Assistant professor in civil engg. Dept., V.V.P. Engg. College, Rajkot, India

---

ABSTRACT - *Huge quantities of construction and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because it requires huge space for its disposal and very little demolished waste is recycled or reused. In manufacturing of concrete aggregates are provide about 75% of the body of concrete. The effect of partial replacement of coarse aggregate by demolished waste on workability and compressive strength of recycled concrete for the study at 7 and 28 d. The compressive strength thus, observed was compared with strength of conventional concrete. Test results showed that the compressive strength of recycled concrete up to 30% coarse aggregate replacement (C. A. R.) by demolished waste at the end of 28 d has been found to be comparable to the conventional concrete. The literature study says the decrease the tested data when increase the percentage of recycled course aggregate. So, used Metakaolin as a cement replacement for increase the result of concrete. Metakaolin is obtained by the calcination of kaolinite. It is being used very commonly as pozzolanic material and has exhibited considerable influence in enhancing the mechanical and durability properties of concrete. Various test performed, 10% cement replaced by Metakaolin and then 25%, 50%, 75%, and 100% Natural coarse aggregate replaced with C&D Waste coarse aggregate.*

KEYWORDS - *Demolished wastes, Metakaolin, Mix Design, workability, compressive strength, Split tensile strength, recycled course aggregate*

I. INTRODUCTION

The construction industry in India is booming. Already at 10 per cent of the GDP, it has been growing at an annual rate of 10 percent over the last 10 years as against the world average of 5.5 percent per annum. Almost 70 percent of the building stock in India is yet to come up. Huge quantities of construction materials are required in developing countries due to continued infrastructural growth and also huge quantities of construction and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because on one side it requires huge space for its disposal while on the other side it pollutes the environment. It is also necessary to protect and preserve the natural resources like stone, sand etc. So, the sustainable concept was introduced in construction industry due to growing concern about the future of our planet, because it is a huge consumer of natural resources as well as waste producer. The proportion of concrete rubbles is maximum in the demolition waste. It has been reported by several researchers (Hansen, 1992; Mehta and Monteiro, 1993; Collins, 1994; Sherwood, 1995) that the crushed concrete rubble can be used as a substitute of natural coarse aggregates in concrete or as a sub-base or base layer in pavement, after separating these from the construction and demolition wastes. Some construction projects have been successfully completed using the recycled aggregates (Desmyster and Vyncke, 2000). Hendricks and Pieterson (1998) prepared concrete in which up to 20% natural aggregate was replaced with recycled aggregate and noticed a little effect on the properties of resulting concrete and that the concrete strength decreases when recycled aggregate was used. Dhir et al. (1999) reported that there is no decrease in strength for concrete containing up to 20% fine or 30% coarse recycled aggregates, but beyond these levels, there was a systematic decrease in strength as recycled aggregate content was increased. In other way with the advancement of technology and increased field of application of concrete and mortars, the strength, workability, durability and other characteristics of the ordinary concrete can be made suitable for any situation. For this, definite proportions of cement, water, fine aggregate, coarse aggregate, mineral admixtures and chemical admixtures are required. The demand for Portland cement is increasing dramatically in developing countries. Portland cement production is one of the major reasons for CO2 emissions into atmosphere. Metakaolin when used as a partial replacement substance for cement in concrete, it reacts with Ca(OH)2 one of the by-products of hydration reaction of cement and results in additional C-S-H gel which results in increased strength. Investigated the effect of partial replacement of cement by metakaolin on the properties of concrete. Supplementary cementing materials (SCMs) have been widely used all over the world in concrete due to their economic and environmental benefits. Hence, they have drawn much attention in recent years. There are great concerns on the strength and durability of metakaolin concrete when used as construction materials in the construction industries. If it is proven that the concrete is durable and strong, this will lead to the use of metakaolin to replace part of the cement. After the study on literature, find the solution of recycled course aggregate used in concrete with partial replacement of metakaolin, so no more decrease the result data related to strength due to 10% replacement of metakaolin and also 25%, 50%, 75%, & 100% replacement of RCA in Natural aggregate concrete. In next phase analysis of cost data related to natural aggregate concrete.

A. PROBLEM IDENTIFICATION

- The disposal of C&D waste is a very serious problem because it requires huge space for its disposal.
- Pollutes the environment by C&D waste.
- Continuous use of natural resources, like Mine-field, river and sand is another major problem and this increases the depth of river bed resulting in drafts and also changing the climatic conditions.
- The physical and mechanical results showed that recycled aggregates were weaker than natural aggregates.

B. OBJECTIVE OF STUDY

- To conserve the natural resources by using waste material.
- To reduce Cost and Environmental impact by Recycled Course Aggregate
- To save Landfill area, disposal costs and produce a greener concrete in construction by using C&D waste

II. LITRRATURE REVIEW

- In other country average recycling rate are, in Spain is about 15% of the total production of CDW, in Europe is 50%, Denmark, Estconia and the Netherlands that recycle more than 90% of their CDW. By study analyses the possibility to replace 100% of natural sand with fine aggregate of RA in masonary mortar give some results are, poor density and higher water absorption compared to natural sand, density decrease lineally as replacement ratio of natural sand by RA increases.
- Prepared concrete in which up to 20% natural aggregate was replaced with recycled aggregate and noticed a little effect on the properties of resulting concrete and that the concrete strength decreases when recycled aggregate was used. The observations made during the test of cubes up to 30% of coarse aggregate was replaced by demolished waste which gave strength closer to the strength of plain concrete cubes.
- M-25 grade recycled concrete can be produced by: replacing 10% of cement with waste powder; replacing 20% of fine aggregate with waste fine aggregate; replacing 30% of coarse aggregate with waste coarse aggregate, one at a time. Metakaolin study was conducted to investigate the early age cracking potential due to restraint stresses from incorporating metakaolin in concrete.
- Metakaolin was more sensitive to temperature than mixtures with only Portland cement. Metakaolin showed higher sensitivity to temperature and increased hydration heat, Metakaolin increased splitting tensile strength and restrained tensile stress, the use of metakaolin in concrete mixtures showed greater shrinkage and lower creep. The findings of this study indicate that the use of metakaolin at 10% replacement levels rendered concrete more sensitive to cracking.
- The experimental results show that the hydration of cement is accelerated due to the presence of MK. The MK decreases the volume expansion of steam cured HSC caused by heat treatment as well as the drying shrinkage, leading to a better volume stability and reduction of its porosity. The total porosity is decreased from 14.4% to 11.3% by adding MK. Study on experimental result and the compressive strength of HSC increases with the increasing of MK content. The optimal content of MK is about 10%.
- For this study we need to look at a way to reduce the cost of building materials, Studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete. High performance concrete a set of 7 different concrete mixture were cast and tested with different cement replacement levels (0%, 2.5%, 5%, 7.5%, 10% 12.5% and15%).
- As increase of replacement ratio of Metakaolin, the compressive strength and modulus of elasticity was increase. The compressive strength is an increase of 22.6% in accordance with an increase of replacement ratio of metakaolin from 0% to 20%.

III. MATERIALS AND METHODOLOGY

A. MATERIAL

Cement:

In the present study OPC of Ultratech cement was adopted. The cement used is 53grade. The physical properties of the cement tested according to Indian Standards procedure confirms to the requirements of IS: 122-69.

Fine aggregate:
The sand mentioned here is confirming to zone III as per IS: 383-1970 was used for making concrete and its specific gravity and other data was found out.

Coarse aggregate:
Coarse aggregate was obtained from locally available crushed stone aggregate about 20 mm maximum of single lot size has been used trough out the experiment. Specific gravity and other tests perform on the coarse aggregate as per IS: 383-1970.

Recycled course aggregate:
Recycled course aggregate collect from different sites and mixing of that RCA and after the sieve analysis use in concrete. Some difficulties occurred in breaking them in proper size of requirement.

Metakaolin:
White Metakaolin used in this experimental investigation was obtained from the supplier Bedi village, Rajkot-Morbi highway.

Water:
Potable water is used for mixing and curing. On addition of higher percentage of demolished waste, the requirement of water increases for the same workability. Thus, a constant slump has been the criteria for water requirement, but the specimens having 0% demolished waste, W/C of 0.50 has been used for the study.

B. CONCRETE MIX-DESIGN

Design stipulations:
Grade designation – M25
Characteristic compressive strength required in the field 28 days: 25MPa
Maximum size of aggregates: 20mm
Degree of workability: 0.9 compacting factor
Degree of quality control: Good
Type of exposure: Mild
Type of aggregate: 20 mm (angular)

Test data for stipulations:
Specific gravity of cement: 3.15
Specific gravity of coarse aggregate: 2.67
Specific gravity of fine aggregate: 2.45

Water absorption:
Coarse aggregate: 1.00%
Fine aggregate: 2.00%

Surface moisture:
Coarse aggregate: 0.1%
Fine aggregate: 0.5%

Mix-Design:
Target mean strength of concrete (As per IS 10262 of 1982): The target mean strength for specified characteristic cube strength is
$f'ck = fck + t*s$
Where Fck = characteristic compressive strength at 28 days.
t = risk factor = 1.65 (As per table 11.21 of IS 10262-1982)
s = assumed standard deviation for M25 is 4. (As per IS 456 of 2000)
$f'ck = 25 + 1.65*4$
$f'ck = 31.6$MPa.

Selection of water-cement ratio:
The water-cement ratio required for target mean strength of 31.6MPa is 0.5. And the water-cement ratio for mild exposure is 0.55.
Selection of water and cement content: for 20 mm maximum size aggregate, sand conforming to grading zone III, water content per cubic meter of concrete is 186kg and sand content as percentage of total aggregate by absolute volume is 35 percent.
For change in value in water-cement ratio, compacting factor, for sand belonging to zone III, correction is required.

Change in condition	%adjustment in water content	%adjustment in sand in total aggregate
For sand conforming to zone III	0	-1.5
For decrease in water-cement ratio by(0.6-0.5=0.1)	0	-2.0
0 For increase in compaction factor(0.9-0.8=0.1)	+3	0
Total	+3	-3.5

Therefore, required sand content as percentage to total aggregate by absolute volume is
35-3.5 = 31.5%
Required water content = 186 + 5.85 = 191.85 l/m3.

Calculation of cement content:
Water-cement ratio: 0.50
Water: 191.85 liters
Cement: (191.85/0.50) = 383.7kg/m3
This cement content is adequate for mild exposure condition.

Calculation of fine aggregate:
For the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 per cent.
$V = \{[w + (C/Sc) + (1/P)\ (fa/Sfa)]\ [1/1000]\}$
$0.98 = [(191.85) + (383.7/3.15)\ (1/0.315)\ (fa/2.45)][1/1000]$
$980 = 191.85+121.8+1.29fa$
fa= 516.55kg/m3

Calculation of coarse aggregate:
$Ca = [(1-p)/p]*fa*(sca/sfa)$
Where, V = absolute volume of concrete. (v=100-% of entrapped air)
W = water content.
C = cement content.
Sc = specific gravity of cement.
P = % of sand to total aggregate.
fa = fine aggregate content.
Sa = specific gravity of fine aggregate.
$Ca = [(1-0.315)/0.315]*516.55*(2.67/2.45)$
Ca = 1234.98 kg/m3

Mix proportion:
Water-cement ratio: 0.5
Cement: 383.7 kg
Water: 191.85 kg
Coarse aggregate: 1182.89 kg

Fine aggregate: 516.55 kg

The mix proportion is:
Water : cement : sand : coarse aggregate
192 : 383.7 : 516.6 : 1182.9
0.5 : 1 : 1.346 : 3.1

For 1 bag of cement:
Cement = 50 kg
Sand = 67.3 kg
Coarse aggregate = 155 kg
Water = 25 liters

C. METHODOLOGY

- Ordinary Portland cement is replaced with metakaolin keeping 0, 5, 7.5, 10%, in this experimental result 10% metakaolin fixed for next phase, while the aggregate is replaced with C&D waste at 0, 25, 50, 75 and 100% by weight.
- The compressive and split tensile strength properties are compared among all the mixes at periods of 7 and 28 days.

IV. RESULTS & DISCUSSION

A. NATURAL AGGREGATE WITH DIFFERENT % OF METAKAOLIN

In results and discussions, each result is compared with result of control mix such as 0% replacement for particular mix. All the test results pertaining to compressive strength and split tensile strength of concrete are given different tables and graphs in below:

1. COMPRESSIVE STRENGTH RESULT FOR NATURAL AGGREGATE WITH METAKAOLIN:

- Compressive strength of concrete cubes at 7 days

Sr. No.	Mix	Cement (%)	MK (%)	Compressive strength (MPa)			Average compressive strength (MPa)
				1	2	3	
1	N	100	0	14.22	13.33	16.00	14.51
2	5% of mk	95	5	17.77	23.11	20.44	20.44
3	10% of mk	90	10	21.77	22.22	24.00	22.66
4	15% of mk	85	15	24.88	21.33	22.66	22.96

- Compressive strength of concrete cubes at 28 days

Sr. No.	Mix	Cement (%)	MK (%)	Compressive strength (MPa)			Average compressive strength (MPa)
				1	2	3	
1	N	100	0	31.55	30.66	33.33	31.84
2	5% of mk	95	5	39.55	37.33	36.00	37.62
3	10% of mk	90	10	43.55	40.44	41.77	41.92
4	15% of mk	85	15	46.66	42.22	42.22	43.70

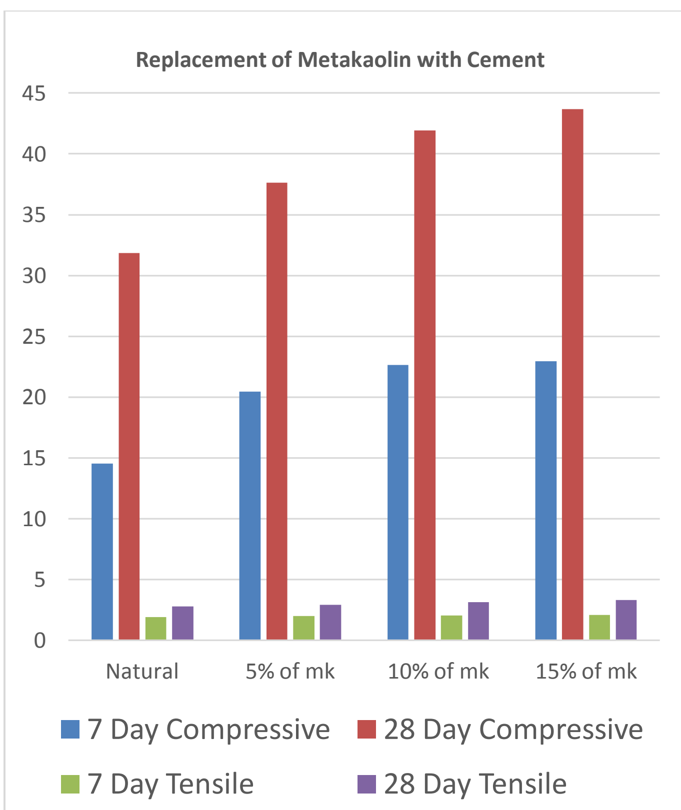
2. TENSILE STRENGTH RESULT FOR NATURAL AGGREGATE WITH METAKAOLIN:

- Tensile strength of concrete cubes at 7 days

Sr. No.	Mix	Cement (%)	MK (%)	Tensile strength (MPa)			Average Tensile strength (MPa)
				1	2	3	
1	N	100	0	1.83	1.83	1.98	1.88
2	5% of mk	95	5	1.98	1.83	2.12	1.98
3	10% of mk	90	10	1.98	2.12	1.98	2.02
4	15% of mk	85	15	2.12	2.12	1.98	2.07

- Tensile strength of concrete cubes at 28 days

Sr. No.	Mix	Cement (%)	MK (%)	Tensile strength (MPa)			Average Tensile strength (MPa)
				1	2	3	
1	N	100	0	2.54	2.97	2.83	2.78
2	5% of mk	95	5	2.83	2.97	2.97	2.92
3	10% of mk	90	10	3.14	2.97	3.25	3.12
4	15% of mk	85	15	3.53	3.15	3.14	3.30



B. FIXED 10% METAKAOLIN WITH DIFFERENT % OF RCA

In this Phase 10% Metakaolin fixed as per the First Phase's Results, Discussion with guide and Properties of RCA. Now we Replace Recycled Course Aggregate as a Replacement of Natural Aggregate, RCA change in 25%, 50% 75% and 100%. Result Data shown in below.

1. COMPRESSIVE STRENGTH RESULT FOR 10% FIXED METAKAOLIN WITH DIFFERENT %OF RCA:

- Compressive strength of concrete cubes at 7 days

Sr. No.	**Mix**	**Cement (%)**	**MK (%)**	**Compressive strength (MPa)**			**Average compressive strength (MPa)**
				1	**2**	**3**	
1	25% RCA	90	10	20.44	20.88	21.77	21.03
2	50% RCA	90	10	18.22	16.00	17.77	17.33
3	75% RCA	90	10	17.55	14.22	16.00	15.92
4	100% RCA	90	10	16.00	15.55	13.77	15.10

- Compressive strength of concrete cubes at 28 days

Sr. No.	**Mix**	**Cement (%)**	**MK (%)**	**Compressive strength (MPa)**			**Average compressive strength (MPa)**
				1	**2**	**3**	
1	25% RCA	90	10	34.22	33.77	33.77	33.92
2	50% RCA	90	10	32.00	30.66	33.33	31.99
3	75% RCA	90	10	29.33	25.77	26.22	27.10
4	100% RCA	90	10	25.77	23.55	26.66	25.32

2. TENSILE STRENGTH RESULT FOR 10% FIXED METAKAOLIN WITH DIFFERENT %OF RCA:

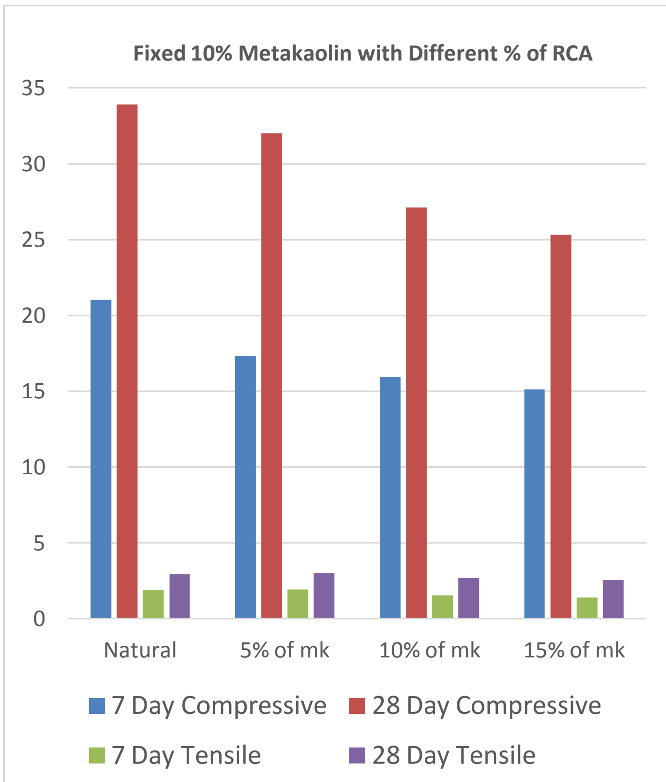
3.

- Tensile strength of concrete cubes at 7 days

Sr. No.	**Mix**	**Cement (%)**	**MK (%)**	**Tensile strength (MPa)**			**Average Tensile strength (MPa)**
				1	**2**	**3**	
1	25% RCA	90	10	1.69	1.98	2.05	1.90
2	50% RCA	90	10	1.84	1.84	2.12	1.93
3	75% RCA	90	10	1.69	1.48	1.41	1.52
4	100% RCA	90	10	1.48	1.55	1.20	1.41

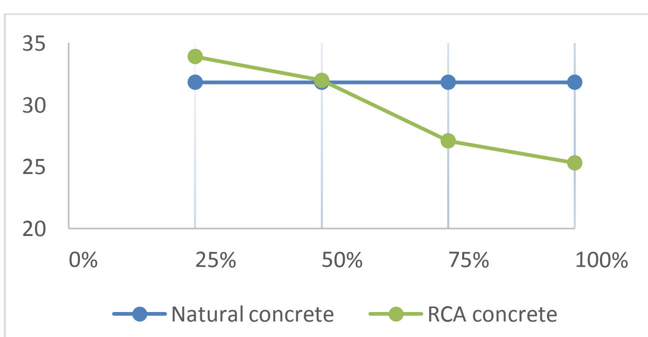
- Tensile strength of concrete cubes at 28 days

Sr. No.	Mix	Cement (%)	MK (%)	Tensile strength (MPa)			Average Tensile strength (MPa)
				1	2	3	
1	25% RCA	90	10	3.25	2.75	2.83	2.94
2	50% RCA	90	10	2.97	3.11	2.97	3.01
3	75% RCA	90	10	2.90	2.54	2.61	2.68
4	100% RCA	90	10	2.33	2.69	2.61	2.54

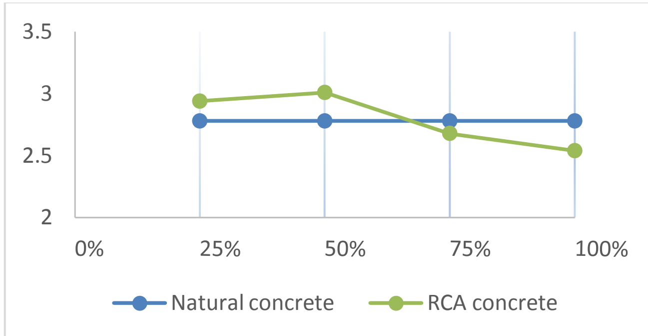


C. DIFFERENT STRENGTH COMPARISION WITH NATURAL AGGTEGATE CONCRETE

1. Compressive Strength of 28-Days compare between natural concrete and RCA concrete
2.



3. Tensile Strength of 28-Days compare between natural concrete and RCA concrete



V. CONCLUSION

Study on this topic and find the problem about replacement of recycled course aggregate in concrete then decrease the strength characteristics and in other way when replacement of metakaolin with cement then increase the strength characteristics. Usage of C&D Waste up to 50% then did not decrease compressive and tensile strength. So combination of both and no various change in strength and also use of C&D waste coarse aggregate material upto 50% that beneficial for the environment and also reduce the cost of concrete and this type of recycled concrete mix easy to obtain on site condition and no more skill person are required.

VI. REFERENCES

1. K. Rajasekhar, K. Spandana, Department of Civil Engineering, Krishna Chaitanya Institute of Technology and Sciences, Markapur, Andhra Pradesh, India
2. Shashikant Dewangan Nidhi Gupta, Experimental Study on Strength of Concrete by using METAKAOLIN, Research Scholar Head of Dept. Department of Civil Engineering Department of Civil Engineering, RKDF Institute of Science & Technology , Bhopal
3. Miss. Bini M J, Mr. Shibi Varghese, Ternary Blended Concrete with Bagasse Ash and Metakaolin PG student, Dept. of Civil Engg. MA College of Engg, Kothamangalam Ernakulam, Kerala, India.
4. Andrew Williams, Ananya Markandeya, Cracking potential and temperature sensitivity of metakaolin concrete, Department of Civil and Environmental Engineering, University of South Florida, 4202 E. Fowler Ave., Tampa, FL 33620, USA
5. Dr. B. Krishna Rao, 2M. Anil Kumar, A Study on Partial Replacement of Cement with Metakaolin and Fine Aggregate with Waste Foundry Sand, P.G student, Department of Civil Engineering, U.C.E.K, J.N.T.U, Kakinada, A.P; India
6. Shahiron Shahidan, Mohamad Azim Mohammad Azmi, Utilizing Construction and Demolition (C&D) Waste as Recycled Aggregates (RA) in Concrete, Jamilus Research Center(JRC), Faculty of Civil and Environmental Engineering, Universitiy Tun Hussein Onn Malaysia,86400 Johor, Malaysia
7. Mohd Monish, Vikas Srivastava, V.C. Agarwal, P.K. Mehta and Rakesh Kumar, Demolished waste as coarse aggregate in concrete, Civil Engg. Department, SHIATS (formerly AAI-DU), Allahabad-211007, UP, India
8. Prakash Somani,Brahmtosh Dubey, Lavkesh Yadav, Jitendra Kumar, Abhishek kumar, Use of demolished concrete waste in partial replacement of coarse aggregate in concrete, Poornima Institute of Engineering and Technology, Jaipur
9. B. Raghavendra K. Holla,Siddhant Anant,Muzzammil Ali Mohammad,Aakash PeriwalP,Aakash Kapoor, Time, Cost, Productivity and Quality analysis of Precast Concrete System, Department of Civil Engineering, Manipal Institute of Technology, Manipal, India
10. Ashraf M. Wagih, Hossam Z. El-Karmoty, Magda Ebid, Samir H. Okba, Recycled construction and demolition concrete waste as aggregate for structural concrete, Building Material and Quality Control, Research Institute, Housing & Building, National Research Center, Egypt.

