Coated Recycled Aggregate Concrete Exposed To Elevated Temperature

Dr. Arundeb Gupta[1]

[1] Jadavpur University, India.

Received: 13 June 2012 Accepted: 4 July 2012 Published: 15 July 2012

Abstract

An experimental investigation has been conducted to study the mechanical as well as micro structural properties of Recycled aggregate concrete (RAC) with uncoated and Geopolymer / Cement coated recycled aggregate exposed to elevated temperature. Fly ash (as replacement of cement) was added while making concrete. Cubes test specimens were prepared and cured under water for 28 days. Test specimens were exposed to different levels of temperature (400oC, 600oC, 800oC) for a period of 6 hours in the muffle furnace. The reduction in compressive strength was observed are in the ranges from 23.4

Index terms— Coated Recycled aggregate, Natural aggregate, Concrete, Fly ash, Elevated temperature, Geopolymer, Mercury intrusion porosimetry, Compressive strength

1 Introduction

se of recycling of concrete waste have already been started all over the world but the use is restricted. Recycled aggregates have some basic problems like excessive absorption phenomena, poor surface texture, formation of weak interfacial zone etc compared with natural aggregates. Different research works are in progress to improve recycled aggregate properties, so that high performance concrete could be developed out of concrete waste (as coarse aggregate) [9] . Pre soaking of recycled aggregate in some acidic medium (HCl, H 2 So 4 / H 3 Po 4) is suggested to improve the quality [1] .But addition of acidic solution may create durability problem in concrete. Ultrasonic cleaning method is reported to remove loose particle from recycled aggregate, for betterment of recycled aggregate [2] .

Two stage mixing approach (TSMA) is suggested to improve the strength of concrete with replacement of recycled aggregate from 0% to 100% [3] . Surface coating over recycled aggregate helps to improve the performance of recycled aggregate as coarse aggregate of concrete. Similar findings are reported using coating of pozzolanic powder on recycled aggregate concrete [7,8] .

This paper deals with the study of mechanical as well as microstructural properties of Recycled aggregate concrete (RAC) with uncoated and Geopolymer / Cement coated recycled aggregate exposed to elevated temperature. Fly ash (as replacement of cement) was added while making concrete. MIP (Mercury intrusion porosimetry) test was conducted to estimate the pore diameter and also to appreciate the change of total pore volume due to change of exposure temperature. Change in microstructure due to temperature was studied using SEM.

2 II.

3 Experimental Details

4 Materials

Cement : Ordinary Portland cement of Grade 53 Conforming to IS 12269-1987 [10] .

Fine aggregate : Locally available natural sand of Zone III as per IS 383-1970 ??11] .

Coarse aggregate : a) Coated recycled aggregate -10mm down recycled aggregates without dust were coated with Cement and geopolymer. Geo polymer is prepared by activating flyash with NAOH solution (4-5% concentration) and Sodium silicate. The aggregates are coated and then kept in the oven for 24 hours at 85 0 C.

Recycled aggregates are coated with flyash based Portland Pozzolana cement slurry and dried in normal temperature for 7 days. b) Uncoated recycled aggregate and natural stone aggregate-10mm down recycled aggregates without dust.

Fly ash : The fly ash was directly obtained from Bandel thermal power plant near Kolkata. The chemical composition of fly ash is shown in Table-1 below. Specification of fly ash as prescribed by IS 3812 -Part-I ??12] are also compared.

5 U

Loss of ignition 8.0 12.0 maximumNa 2 O/K 2 O 1.0

Concrete Mix : There is no standard mix design procedure for recycled aggregate concrete. Hence, trial mixes as per ACI ??13] for natural aggregate concrete (NAC) was adopted. Eight different mixes were prepared as shown in Table 2. In some mixes of RAC (both uncoated and coated) and NAC certain percent of cement was replaced by fly ash like in RAC-10F mix, 10% cement was replaced by fly ash .Similarly in coated recycled aggregate mix, 10% cement was replaced by fly ash. The surface texture of recycled aggregate concrete become rough and cracked when exposed to higher temperature level and the strength decreases with increase in temperature level. Fig. 1 [4] shows that total intruded mercury volume is 0.052cc/gm in RAC-10F sample at normal temperature and major pore diameter lies between .04 µm to 1µm but the same sample (RAC-10F) after heating to 800 o C, the total intruded mercury volume increases to 0.0867cc/gm. These values provide total porosity of RAC-10F at normal temperature and RAC-10F specimen after heating to 800 o C, which are 7.57%, 13.49%. respectively i.e. an increment of total porosity is around 78%, which lead to reduction in strength and modulus of elasticity at higher temperature level [4] . Similar observations are made in case of concrete out of geopolymer coated aggregates exposed to 800 o C temperature level. Here, total intruded mercury volume before heating is 0.0428 cc/gm and after heating it becomes 0.0666 cc/gm. These values provide total porosity of concrete out of geopolymer coated aggregates before and after heating is 6.66% and 10.36% respectively, i.e. an increment of 55% porosity due to temperature. (ref. to Fig 2) . Total porosity in concrete out of geopolymer coated aggregates is 43% less than concrete out of uncoated recycled aggregates (ref. to Fig. ??). This explains the advantage of using geopolymer coated aggregate over recycled aggregate. Cube has been prepared both with flyash replacement and without flyash. The specimens were then cured under water for 28 days. Specimen were heated in a furnace at 400 o C, 600 o C and 800 o C temperature for 6 hours. Compressive strength were determined by testing cubes to destruction. Mercury intrusion porosimetry, SEM study were also conducted. Six cubes were cast from each mix which are exposed to elevated temperature and tested. 40.9% and 48.2% respectively for concrete out of cement coated aggregates. Again, the performance is further improved in presence of fly ash. The drawbacks of recycled aggregate concrete i.e. porous and loose interfacial zone could be improved by using coating recycled aggregates having better surface texture. It is observed that 10% fly ash addition improves substantially the cube compressive strength (at all ages) of both natural aggregate concrete and recycled aggregate concrete. Flyash addition modifies the microstructure of the interfacial zone which leads to a better performance of the concrete.

Similar results are also reported in other different literature [5,6] . After heating to different temperature it is seen that the reduction of cube strength for all types of concrete (ref. to fig. 4) at 600 o C ranges from 23.4% to 41.7% which after heating at 800 o C rises to 31% to 50.3%. At all temperature level percent reduction of strength is smaller in NAC compare to the other mix. This is due to the stronger interfacial bonding between matrix and aggregate. In three different mix of RAC, the performance of coated aggregate concretes are better than normal recycled aggregate concrete. Performance of concrete out of geopolymer coated aggregates is found to some extent better than that of concrete out of cement coated aggregates. At 600 o C and 800 o C reduction in strength is 36.5% and 47.4% respectively for concrete out of geopolymer coated aggregates, and It is already reported in the other literature that RAC-10F sample is much denser than RAC sample after exposed to 800 o C [4] . Comparing RAC-10F sample with geopolymer coated RAC-10F sample after exposed to elevated temperature of 800 o C, it is observed that microstructures of geopolymer coated RAC with flyash are definitely better than RAC sample with flyash. Compressive test result and mercury intrusion porosimetry result also indicates similar findings.

6 Conclusion

Based on test results the following conclusions can be drawn: 1. In general NAC sample performs better than RAC sample with coated or uncoated recycled aggregate, including samples exposed to elevated temperature. 2. Geopolymer coated recycled aggregate concrete showed higher compressive strength (when exposed to different elevated temperature) compared to uncoated recycled aggregate concrete and also cement coated recycled aggregate concrete. 3. Partial replacement of cement by fly ash (10%) in case of coated recycled aggregate concrete showed higher strength compare to coated recycled aggregate concrete without fly ash. [1]

1

Figure 1: Fig 1 :

23

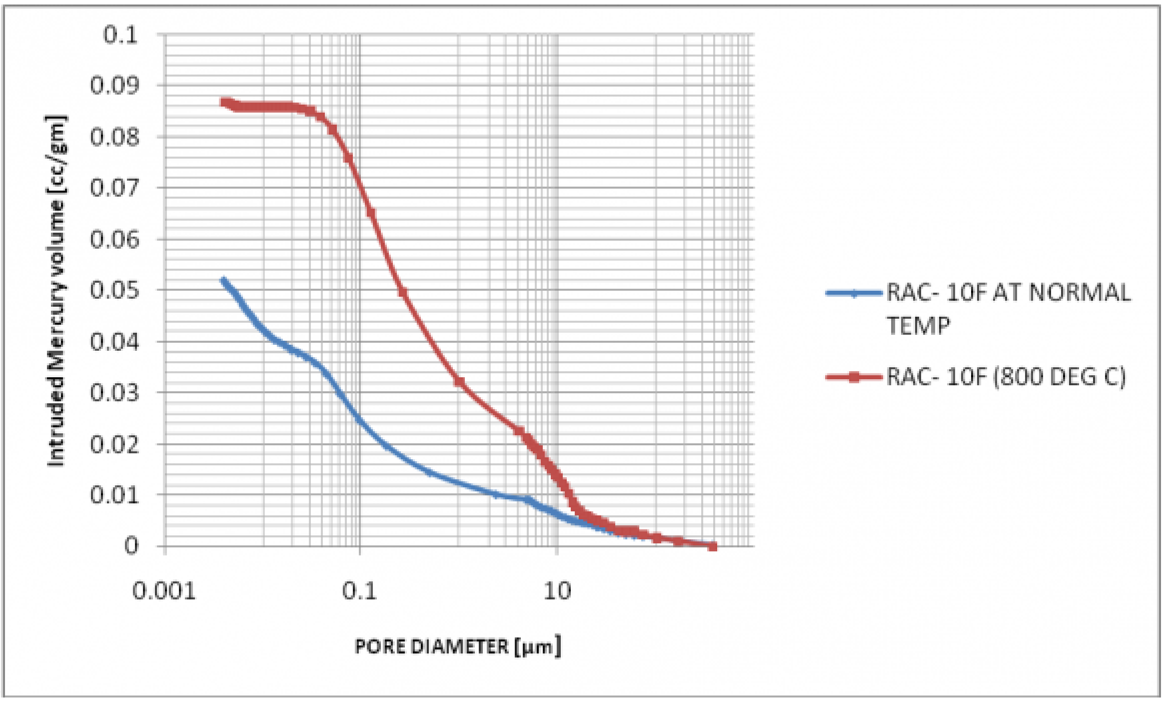


Figure 2: Fig 2 :Fig 3 :

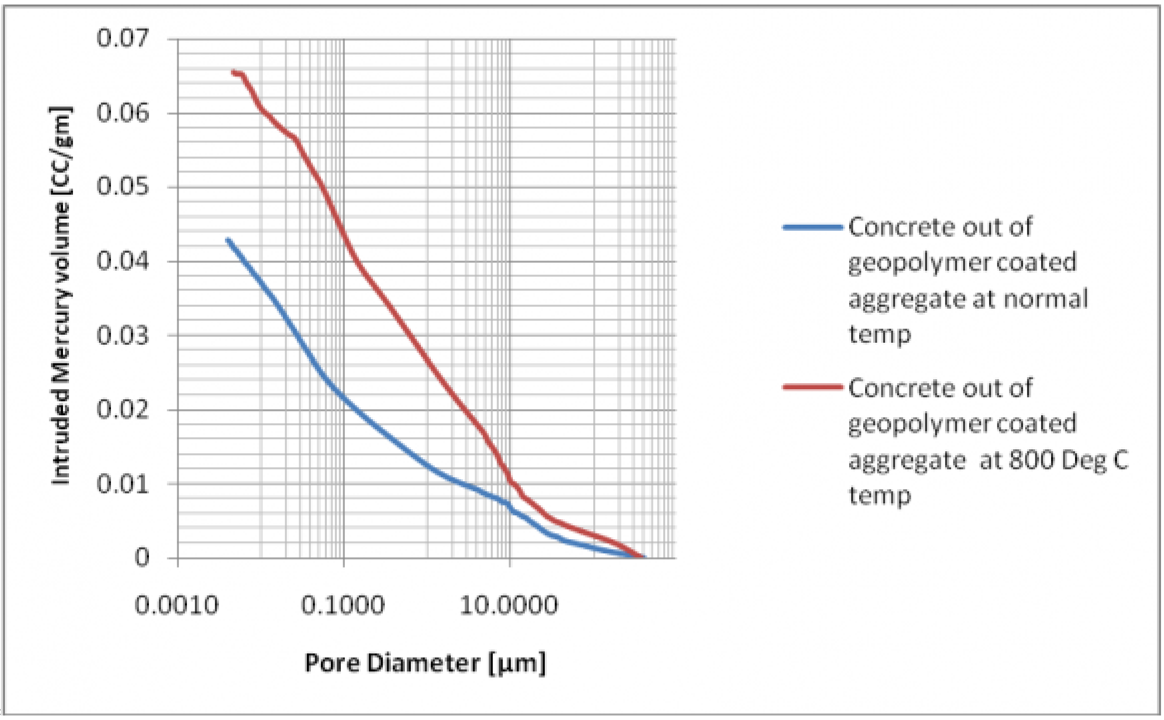
4 

Figure 3: Fig 4 :

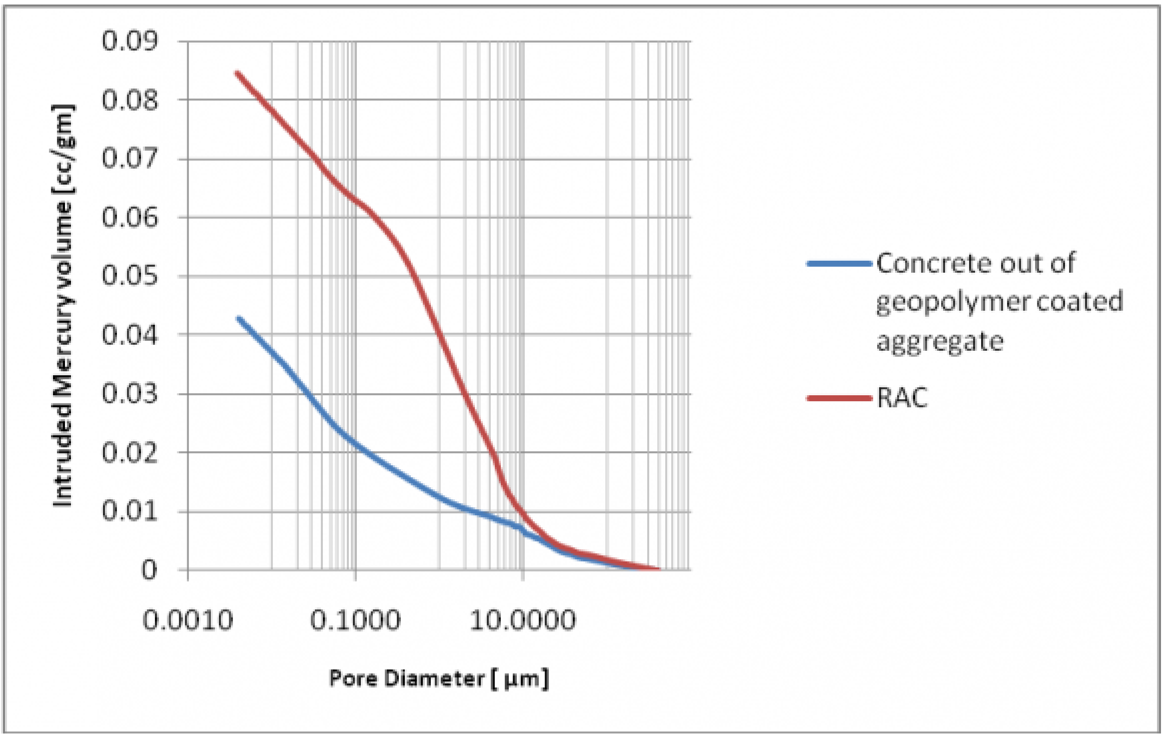
5 

Figure 4: Fig 5 :

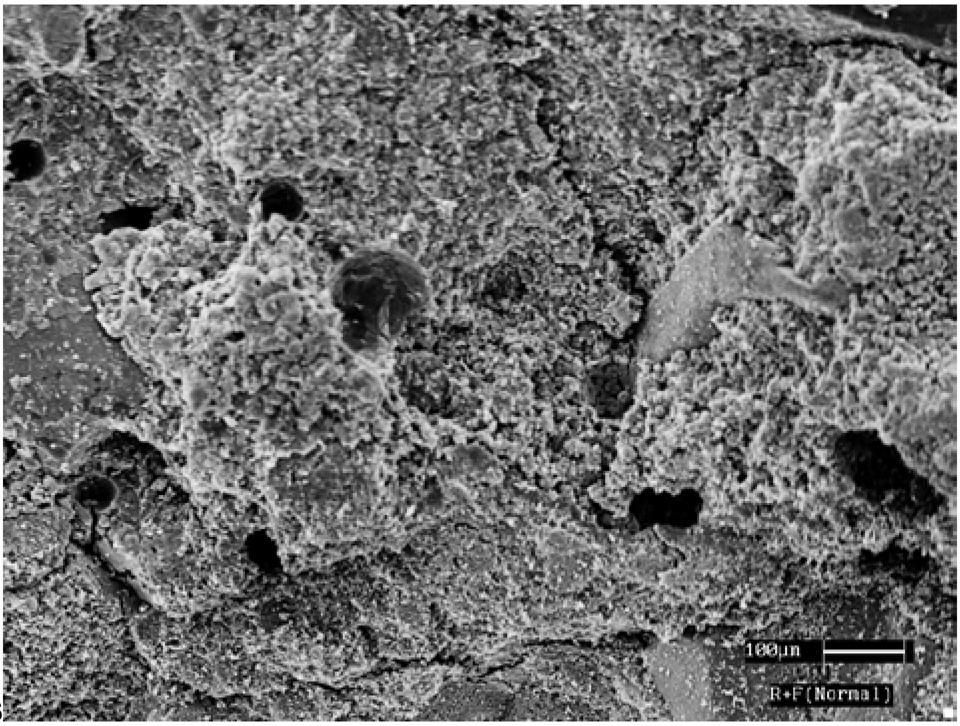
6 

Figure 5: Fig 6 :

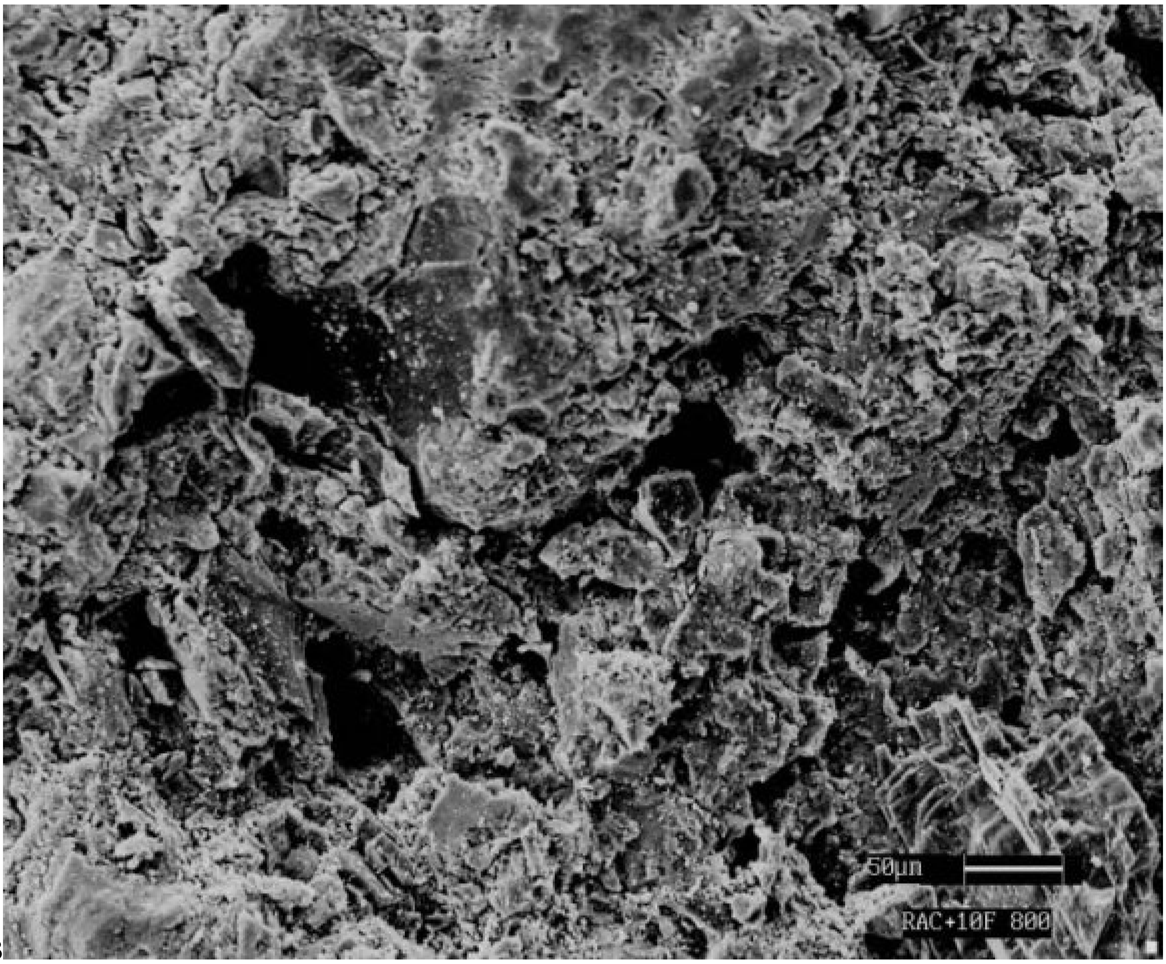
8 

Figure 6: Fig 8 :

2

Mix No.	Mix designation	Cement	Fly ash	Sand	Coated Coarse aggregates	Water binder ratio
1	NAC	1.00	-	1.6	3.3	0.4
2	NAC-10F	0.9	0.1	1.6	3.3	0.4
3	RAC	1.00	-	1.6	3.3	0.4
4	RAC-10F	0.90	0.10	1.6	3.3	0.4
5	Geo polymer coated RAC	1.00	-	1.6	3.3	0.4
6	Geo polymer coated RAC -10F	0.90	0.10	1.6	3.3	0.4
7	Cement coated RAC	1.00	-	1.6	3.3	0.4
8	Cement coated RAC -10F	0.90	0.10	1.6	3.3	0.4

Specimen casting, curing and testing : Cube of 70mm x 70mm x 70mm has been casted with: i) Geopolymer coated recycled aggregate, ii) Cement coated recycled aggregate iii) Uncoated recycled aggregate iv) Natural aggregate.

III. Results And Discussion

a) Behavior of coated recycled aggregate concrete before and after heating

i. Porosity

Figure 7: Table 2 :

1

Chemical properties	Properties of Fly ash weight(%)	Specified requirement weight (%) IS -3812 Part-I
SiO_2	60.0	35.0 minimum
Al_2O_3	20.0	
CaO	8.0	
MgO	1.0	5.0 maximum
TiO_2	0.5	

Figure 8: Table 1 :

[Construction and Building Materials ()] , *Construction and Building Materials* 2009. 23 p. . (on properties of recycled aggregate concrete)

[Arundeb et al. ()] 'Direct Compressive Strength and Elastic modulus of recycled aggregate concrete'. Gupta Arundeb , Mandal Saroj , Ghosh Somnath . *International journal of Civil and Structural Engineering* 2011. 2 (1) p. .

[Kong ()] 'Effect and mechanism of surfacecoating pozzalanics materials around aggregate on properties and ITZ microstructure of recycled aggregate concrete'. Deyu Kong . *Construction and Building Materials* 2010. 24 p. .

[Li] *Influence of coating recycled aggregate surface with pozzolanic powder*, Jiusi Li .

[Ajdukiewicz ()] *Influence of recycled aggregates on mechanical properties of HS/HPC*, Andrzej Ajdukiewicz . 2002. New Delhi. p. . (Cement concrete composite 24. Specification for 53 grade ordinary Portland cement, IS 12269:1987, Bureau of Indian Standards)

[Vivian and Tam ()] 'Optimization on proportion for recycled aggregate in concrete using two-stage mixing approach'. W Y Vivian , Tam . *Construction and Building Materials* 2007. 21 p. .

[Gupta et al. ()] 'Recycled aggregate concrete exposed to elevated temperature'. Arundeb Gupta , Saroj Mandal , Somnath Ghosh . *ARPN journal of Engineering and applied sciences* 2012. 7 (1) p. .

[Vivian et al. ()] 'Removal of cement mortar remains from recycled aggregate using pre-soaking approaches'. Tam Vivian , W Y Tam , C M Le , KN . *Res Conserv Recyl* 2006. p. .

[Mondal and Ghosh (1999)] 'Study on properties of recycled aggregate concrete'. S Mondal , A Ghosh . *ICI bulletin* July-September 1999. Indian Concrete Institute. (68) p. .

[Katz ()] 'Treatments for the improvement of recycled 12. Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)'. A Katz . *J Mater Civil Engineering* 1981. 1982. 2004. Bureau of Indian Standards. 3812 (6) p. . (IS)