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An Experimental study on properties of concrete with Recycled Aggregates and Synthetic Fibres - A Literature Review

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Abstract: *It had been a common practice in the ancient communities to reuse valuable left over materials, e.g. metals and building materials from deconstruction of previous thing or property. But the "use-and-throw-away" philosophy had led to depletion of natural resources and pollution of world. This paper presents the use of Recycled Coarse Aggregate and Recron 3S in Concrete to be used for general building construction-residential, commercial and industrial. Replacing Natural Coarse Aggregate (NCA) with Recycled Construction & Demolition (C&D) Waste Aggregate and adding Recron -3S synthetic fibre. Recycled Coarse Aggregate (RCA) replaces NCA by 40% and adding Recron 3S in 0.125% , 0.25% in concrete. The use of RCA from the C & D waste proposes to be a win-win-win situation, as instead of creating big landfill, saving of natural physical topography and reducing the production of Carbon dioxide by half. The aim of this paper is to discuss the use of Recycled Aggregate Concrete (RAC) with Recron 3S fibre in construction industry.*

Keywords: *Recycled Aggregate Concrete, Recron -3S, Properties, Workability, Compressive Strength, Flexural Strength, Split Tensile Strength, Durability properties.*

1. Introduction

In today's construction scenario concrete is the chief building material. According to Cement Association of Canada [38], the production of concrete was 8,786 billion tonnes of concrete per year, which turns around to be 1.2 ton per person, making it the second most used material in the world by human after water. As a developing country India was producing 210 million tonnes of C & D waste in 2008, according to a report of Ministry of Environment and Forest, India. The World Bank report for Asian countries puts this figure at 1000 kg per capita per year [24], the figure which has increased till 2016- thus putting a huge pressure on its landfills.

In making of concrete the aggregates form 70-75% part [39] i.e. they give body to concrete .About 4000 billion tonnes of CA is used in the production of concrete every year, thus putting a lot of pressure on our natural resources and disturbing the balance of our fragile eco-system by putting the largest amount of carbon blueprint on the planet. So it had become necessary to change the practices within the building and construction industry to reduce, reuse and recycle. Indian Construction Industry is generating about 10-12 million tonnes of C&D waste annually, [36] and with rapid urbanization the quantum of C&D waste will continue to increase and therefore an everlasting solution for this is a necessity.

Although the idea of using RAC had been implemented widely in the United States and European construction industries, its use is limited in most of the developing countries. So for this purpose it is very important to understand the physical, mechanical and durability properties of Coarse Aggregate used in the formation of concrete. Therefore when using Recycled Coarse Aggregate -it is important to understand its properties and in what percentage it can be used without compromising the strength and durability of the resulting concrete. It has been established by previous studies that the strength of recycled aggregate is less than natural aggregate and it varies depending on the properties of previously made conventional concrete. The drying shrinkage, creep & porosity to water increases when RA is added in concrete & compressive strength of concrete decreases [31]. The studies carried out on RAC are mainly on Compressive Strength and not enough data is available on Flexural strength, Split Tensile Strength & Water Absorption.

Fibers have been used for at least 3500 years when straw was first used in sun-baked bricks [20] .The failure of concrete is quasi-brittle in character, it loses its loading capacity, once the failure starts. By adding fibers to concrete mix its properties are modified and it acts in a ductile manner, which prevent and control initiation of cracks. It has been studied that various materials such as Synthetic fibers – polypropylene (micro & macro), nylon, polyester and natural as glass, carbon, and steel fibers can be used in fiber reinforced concrete. Fibers when introduced in concrete improve its mechanical properties [30, 31].

1.1 Recycled Coarse Aggregate (RCA)

Construction and demolition (C and D) waste is the solid waste generated by the construction, remodeling, renovation, repair, alteration or demolition of residential, commercial, institutional and industrial

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buildings, and infrastructure projects like roads, bridges, dams, tunnels, railways and airports. It is high in volume but chemically at low risk of the total C & D waste 65% consists of Concrete waste [25].

- **Advantages of RCA-** The use of RCA has many advantages like it can be used in precast construction; RCA is cheaper than NCA to make and transportation cost are less as the plants are situated locally. The use of RCA reduces pressure on land-fills and helps in preservation of Natural resources. In the production of RCA carbon emissions are half than caused by quarrying of NCA. Lastly the material is readily available.
- **Limitations of RCA-**The limitations of using RCA are that the concrete made with RCA have compressive strength reduced by in the range of 10-30%. The water absorption by RAC is high up to 6% than that of NAC. Drying shrinkage and Creep of RAC are more than NAC. The initial cost of putting the RA plant is quite high, as heavy machinery is required for plant setup.

- **Barriers To RCA In India -** The Indian mentality does not generally accept recycled material in building construction. High initial cost for establishing plant deters in proper Recycling Facilities locally. No Scientific Data or Indian Code is available for how to use RCA and lack of awareness among people about the benefits of RAC are deterrents in the use of RAC.

2. Recron 3S Synthetic Fibre

Recron -3S is a synthetic fibre produced by Reliance Petro Chemical Company. Its Cross-section is triangular. It can be made to length 6mm to 32mm for use in concrete.

The following are the benefits of using Recron-3S in Concrete. There is reduction in intrinsic plastic & drying shrinkage cracking of concrete. The use of Recron-3S helps in controlling plastic settlement in concrete. It helps in improving the post peak ductility of concrete. Its addition increases wet & dry abrasion resistance of concrete surfaces like pavements. The incorporation of Recron-3S in concrete increases its impact / shatter resistance. As addition of fibre helps in uniform bleeding it reduces water percolation thus improving permeability of concrete. There is increase in toughness of hardened concrete by addition of Recron-3S fibre. Its addition reduces damaging effects on concrete due to freeze thaw cycles in cold regions. When Recron-3S fibers are added in shotcrete rebound loss reduces by up to 50-70% [40]. The long term durability of concrete increases with addition of Recron-3S fibres in concrete. It can replace non-structural wire mesh in concrete structures. Further Recron -3S fibres improve flexural fatigue resistance of concrete. It helps in better stress transfer at joints in normal and precast concrete members. Recron 3S can improve height per lift in mass concreting in foundations and dam etc. [1, 22]

2.2 Application of Recron-3S Fiber in Concrete

The failure of concrete is quasi-brittle in character; it loses its loading capacity, once the failure starts. By adding fibers to concrete mix its properties can be modified and it acts in a ductile manner, which prevent and control initiation of cracks. Synthetic fibers are more useful as they are light weight, less abrasive, non reactive, give better structural performance and are economically viable. Recron 3S fibre can be used in structural elements like foundations, beams, roof slabs, columns, etc., in the plastering of underground elements, walls, underground drainage ,in the construction of cement concrete roads , pavements, in the formation of precast members like pipes, beams, water tanks, manhole covers, hollow blocks, etc.

3 Literature Review

3.1 Workability

It is defined as that property of concrete with the desired Mix strength, which helps in placement, compaction of fresh concrete at site.

Singh G. and Goel S. (2016) [2], studied the effect of PET fibre was incorporated in place of Polypropylene fibre and by hybridizing the two fibres in concrete. M-35 concrete was made with no fibres, with 1% Polypropylene fibres, with 1% PET fibres, and by replacing Polypropylene fibre by 0.25%, 0.5% and 0.75% by PET fibres (by Volume of concrete). For workability Slump cone and compaction factor test was conducted. It was found that concrete made with 1% and 0.75% PET fibres had slump of 70% and 60% respectively mix and were more workable as compared to mixes with Polypropylene fibre.

Akib S.M. and Sayyad S. U. (2015) [5], compared the properties of RA and its influence on mechanical and durability properties of RAC. Mix design M-40 was made with replacing NA with RA in 0%, 25%, 50%, 75% and100 %. The workability was observed using by Slump test. As percentage of RA increases workability decreases. At 100% increase in RA, it reduces by 50%.

Gumede M.T. and Franklin S.O. (2015) [8], studied the mechanical properties of M-30 mix of concrete with 0%, 20%, 40%, 60%,80% and 100% replacement of NA with RA. It was found by Slump test that workability reduces by 25%-58.3%.

Larbi *et al*. (2015) [9] , studied the physical and mechanical properties of RAC by adding admixtures by 0%, 0.5%, 1%, 1.5% and 2% by weight of cement in a mix designed with 100 % replacement of NA with RA. The workability obtained by addition of 2% admixture was same as that with NA and it reduced w/c ratio by 24 % among all RAC mixes.

Serder *et al*. (2015) [10], studied polypropylene fibre and recycled tyre polymer fibre in NAC. M-50 mix design was made and it was found that slump decreases with the addition of fibres but addition of 1% RTPF fibres by weight of aggregates did not affect negatively the workability.

Hussein *et al*. (2015) [12], studied the mechanical properties of Normal strength (Cement- 400 Kg/m^3) and high strength Concrete (Cement -600 Kg/m^3) with 0%, 25%, 50% and 100% replacement of NA with RA and adding synthetic fibre (fibre mesh in 0.05%, 0.1% and 0.2% and Polypropylene fibre 0.1%) . To achieve the same workability Super plasticizer was added. It was noticed that with increase in RA volume the dosage of SP increases from 6% to 12% with mixes without fibres and with 0.2% of wire mesh it increased by 18% with the control mix.

Krishna T.S. (2015) [17], investigated flexural behavior of RAC with 1mm dia. steel fibre. The mix was designed with 0%, 25%, 50%, 75% and 100% replacement of NA with RA. It was found that workability decreases with increase in RA

Alca *et al*. (2015) [18], studied the properties of Polypropylene fibre reinforced RAC. NA was replaced in 25%, 30% and 55% RA and 1% and 1.5% polypropylene fibre was added in the above mix designs. Workability reduces as RA content in concrete increases.

Nibudey *et al*. (2015) [23], studied M-20 and M-30 grade concrete. By adding waste PET bottle fibre in aspect ratio of 35 and 50, in proportion of 0%, 0.5%, 1%, 1.5%, 2.0%, 2.5% and 3% into the mixes. It was found that workability of concrete decreases with higher aspect ratio of fibre.

Cherian M.R. and Mathew P. (2014) [26], studied RCA and RFA in structural concrete. They compared NCA and RCA concrete with cement content 380kg/m^3. NCA + RFA concrete with RCA+RFA concrete with cement content 380kg/m^3 and NCA and RCA concrete with cement content 370kg/m^3. NCA aggregate was replaced with 2/3 RCA and NFA was replaced completely with RFA in the mix design. It was found that workability of RAC is less than NAC by 21%, 25% and 36% respectively.

3.2 Strength Properties

3.2.1 Compressive Strength

It is the most important parameter for concrete and it determines the basic compressive pressure a concrete member can take before it fails. It is dependent on water-cement ratio, Cement properties, Aggregate properties, Curing time, specimen's age, shape and size of specimen.

Singh G. and Goel S. (2016) [2], studied replacing of PET fibre in place of Polypropylene fibre, by hybridizing the two fibres in concrete. M-35 was made with no fibres, with 1% Polypropylene fibres, 0.25%, 0.5% and 0.75% with 1% PET fibres, by PET fibres (by Volume of concrete). It was found that concrete made with 1% and 0.75% PET fibres had average compressive strength increased by 5.07% and 8.07 % respectively.

Hanumesh *et al*. (2016) [3], studied the influence of Polypropylene fibres on RAC. M-20 grade concrete was prepared by replacing NA by 25%, 50%, 75% and 100% RA. Polypropylene fibre in 1% and 2% by volume was added. It was found that compressive strength increased from 27.85N/mm2 to 32.88N/mm2 for 25% replacement of NA but later on it decreased for increase in RA to 17.03 N/mm^2.On addition of fibre compressive strength increases with increase in fibre content.

Mohammad *et al*. (2016) [4], investigated mechanical and permeability properties of RAC made by untreated RCA and treated RCA, further polypropylene fibre in 0.3%, 0.6%, 0.9%, 1.2% and 1.5% by volume was added to treated RCA specimens. M-50 mix was designed by replacing NCA by 60% RCA. It was investigated that Compressive Strength of concrete made with untreated RCA was less than the concrete made with treated RCA and it was highest for 0.6% polypropylene fibre by 23% w.r.t. to Control mix.

Akib S.M. and Sayyad S.U. (2015) [5], studied the difference of properties of RA and its influence on mechanical and durability properties of RAC. Mix design M-40 was made with replacing NA with RA in 0% , 25%, 50%, 75% and100% . It was found that compressive strength of Concrete made with upto 50% replacement of NA with RA was greater than NAC. Further addition of RA reduces compressive strength of Concrete and RAC made with 100% RA had 89% strength w.r.t. Control mix.

Yallapa *et al*. (2015) [6], investigated mechanical properties of M-30 grade and M-35 grade concrete made with 1% and 2 %, and random, parallel and perpendicular orientation of Recron 3s fibres and natural coir fibres. Compressive strength decreases with increase in Recron 3s fibre content from 1% to 2%. Perpendicular orientation of fibres reduced strength by 33% in comparison to random and parallel orientation of Recron -3s fibres.

Seo T. and Lee M. (2015) [7] had studied tensile creep of RAC. Mix design M-27 was made with w.c. ratio of 0.65 and 0.45 with 100% replacement of NA with RA. In comparison to concrete made with NA the concrete made with RA showed 20% decrease in compressive strength.

Gumede M.T. and Franklin S.O. (2015) [8], studied the mechanical properties of M-30 mix of concrete with 0%, 20%, 40%, 60%, 80% and 100% replacement of NA with RA. It was found that Compressive Strength reduces by 13.7% to 39.5% with increase in percentage of RA.

Larbi *et al*. (2015) [9], studied the physical and mechanical properties of RAC by adding admixtures by 0%, 0.5%, 1%, 1.5% and 2% by weight of cement in a mix designed with 100 % replacement of NA with RA..The mix design with 2% admixture dosage had 8% more compressive strength compared to NAC.

Serder *et al*. (2015) [10], studied polypropylene fibre and recycled tyre polymer fibre in NAC. M-50 mix design was made and it was found that Compressive strength was not affected negatively by the addition of 1% RTPF fibres by weight of aggregates.

Sukanya D. and Siddi Raju S. (2015) [11], compared Polypropylene and Polyester fibre reinforced concrete with NAC in the construction of Concrete Pavements. M-45 grade concrete was made and it was found that maximum Compressive strength of 60.5N/mm^2 is achieved with Polypropylene fibre designed mix.

3.2.2 Flexural Strength

Singh G. and Goel S. (2016) [2], studied replacing PET fibre in place of Polypropylene fibre, by hybridizing the two fibres in concrete. M-35 grade concrete was made with no fibres, with 1% Polypropylene fibres, with 1% PET fibres, and with replacing Polypropylene fibre by 0.25%,0.5% and 0.75% by PET fibres (by Volume of concrete). It was found that concrete made with 0.75% PET fibres and .25% PP fibres had maximum increase in flexural strength by 13.02 % w.r.t. to control mix.

Mohammad *et al*. (2016) [4], investigated mechanical and permeability properties of RAC made by untreated RCA, treated RCA and treated RCA with polypropylene fibre in 0.3%, 0.6%, 0.9%, 1.2% and 1.5% by volume of cement. M-50 grade concrete was designed by replacing NCA by 60% RCA. Flexural Strength of concrete made with treated and untreated RCA was comparable, but by introducing, 1.5% polypropylene fibre it increased by 14% w.r.t. to Control mix.

Gumede M.T. and Franklin S.O. (2015) [8], studied the mechanical properties of M-30 grade concrete with 0%, 20%, 40%, 60%,80% and 100% replacement of NA with RA. Flexural Strength reduces with increase in % of RA by 8.2% to 48.8%.

Sukanya D. and SiddiRaju S. (2015) [11], compared Polypropylene and Polyester fibre reinforced concrete with NAC in the construction of Concrete Pavements. M45 grade concrete was made and it was found that maximum Flexural strength of 6.8 N/mm^2 is achieved with Polypropylene fibre designed mix.

Hussein *et al*. (2015) [12], studied the mechanical properties of Normal strength (Cement- 400 Kg/m^3) and high strength Concrete (Cement -600 Kg/m^3) with 0%, 25%, 50% and 100% replacement of NA with RA and adding synthetic fibre (fibre mesh in 0.05%, 0.1% and 0.2% and Polypropylene fibre 0.1%) . The flexural strength with RA decreases from 5%, 9% and 17 % respectively with Normal Strength concrete and by 9.3%, 14.2% and 25% respectively with High Strength concrete. By using 0.1% PP fibre 6% increase in Normal Strength concrete and 1.7% increase in High Strength concrete was achieved in all samples. The maximum increase in Flexural strength was for 0.2% of fibre mesh (300) - 13.8% in Normal strength concrete and 9.5 % in high strength concrete (compared to corresponding mixes).

Yehia *et al*. (2015) [14], studied strength and durability of 100% RAC made from RA from different sources and of different sizes. It was found that RA with high water retention and low specific gravity reduced the target flexural strength by 10-15% when a constant w/c ratio between 0.4-0.45 was maintained. It was found that RA of same size from different sources did not affect the flexural strength of RAC.

Gangaram *et al*. (2015) [16], investigated the strength and durability aspects of M-20, M-30, M-40, M-50, M-60 and M-70 RAC with 100%RA. It was found that for M-20 and M-30 grades target flexural strength could be achieved but it failed for M-40 and above mixes.

Krishna T.S. (2015) [17], investigated flexural behavior of RAC with 1mm dia. steel fibre. The mix was designed with 0%, 25%, 50%, 75% and 100% replacement of NA with RA. Flexural strength varies between 8.45 N/mm2-6.42N/mm2 for 0% to 100% replacement of NA with RA.

Alca *et al*. (2015) [18], studied the properties of Polypropylene fibre reinforced RAC. NA was replaced in 25%, 30% and 55% RA and 1% and 1.5% polypropylene fibre was added in the above mix designs. Flexural strength reduces with increase in RA quantity in concrete .With addition of 1% fibre it increases and further addition of fibre it again reduces.

Ramana *et al*. (2015) [19], studied PET fibre reinforced RAC. In M-20 grade concrete NA was replaced by 25%, 50%, 75% and 100% of RA and1% and 2% PET fibre by volume was added. It was found that flexural strength decreases with increase in RA. The decrease was 3% to13% in RAC made with 25% to 100% replacement of NA with RA. With 1% PET fibre flexural strength decreased from 8%-19% with RA content of 0 to100% and with 2% PET fibre it decreased from 19% - 27% with RA content of 0 to100%.

3.2.3 Split Tensile Strength

Singh G. and Goel S. (2016) [2], studied replacing PET fibre incorporated in place of Polypropylene fibre and by hybridizing the two fibres in concrete. M-35 grade concrete was made with no fibres, with 1% Polypropylene fibres, with 1% PET fibres, and with replacing Polypropylene fibre by 0.25%,0.5% and 0.75% by PET fibres (by Volume of concrete). The concrete made with 0.75% PET fibres and .25% PP fibres had maximum increase in Split tensile strength by 14.39%.

Hanumesh *et al*. (2016) [3], studied the influence of Polypropylene fibres on RAC. M-20 grade concrete was prepared by replacing NA by 25%, 50%, 75% and 100% RA. Polypropylene fibre in 1% and 2% by volume was added. The Split tensile strength increased from 1.51 N/mm^2 to 1.98 N/mm^2 for 25% replacement of NA with RA but later on it decreased for increase in RA to 1.32 N/mm^2. Split tensile strength increases with increase in fibre content.

Akib S.M. and Sayyad S.U. (2015) [5], studied the difference of properties of RA and its influence on mechanical and durability properties of RAC. Mix design M-40 was made with replacing NA with RA in 0%, 25%, 50%, 75% and 100%. The split tensile strength of RA mix was comparable to NA mix.

Seo T. and Lee M. (2015) [7], studied the tensile creep of RAC. M-27grade concrete was made with w.c. ratio of 0.65 and 0.45 with 100% replacement of NA with RA. In comparison to concrete made with NA the concrete made with RA showed decrease of 10% in split tensile strength.

Larbi *et al*. (2015) [9], studied the physical and mechanical properties of RAC by adding admixtures by 0%, 0.5%, 1%, 1.5% and 2% by weight of cement in a mix designed with 100 % replacement of NA with RA. The mix design with 2% admixture dosage had 8% more split tensile strength compared to 0% addition of admixture and it is higher than that of concrete made with NA.

Hussein *et al*. (2015) [10], studied the mechanical properties of Normal strength (Cement- 400 Kg/m^3) and high strength Concrete (Cement -600 Kg/m^3) with 0%, 25%, 50% and 100% replacement of NA with RA and adding synthetic fibre (fibre mesh in 0.05%, 0.1% and 0.2% and Polypropylene fibre 0.1%) . The split tensile strength with RA decreases from 6.6%, 10% and 24 % respectively for Normal Strength concrete and by 7.8%, 15% and 29% respectively for High Strength concrete. 0.1% PP fibre increased Split Tensile strength of Normal strength concrete by 6% and high strength concrete by 2% in all the samples.

Yehia *et al*. (2015) [14], studied strength and durability of RAC made with 100% RA from different C & D sites and of various sizes. RA with high water retention and low specific gravity reduced the target split tensile strength by 10-15% when a constant w/c ratio between 0.4-0.45 was maintained. Further RA of same size from different sources did not affect the split tensile strength of RAC.

Ramana *et al*. (2015) [15], studied PET fibre reinforced RAC. NA was replaced by 25%, 50%, 75% and 100% RA and 1% and 2% PET fibre were added by volume in the M-20 grade concrete. Split tensile strength decreases from 1% to 9% in RAC made with 25% to 100% replacement of NA with RA. By increase in PET fibre split tensile strength decreases. Addition of 1% PET fibre decreased split tensile strength from 6%-17% and 2% PET fibre it decreased from 25%-31%.

Gangaram *et al*. (2015) [16], investigated the strength and durability aspects of M-20, M-30, M-40, M-50, M-60 and M-70 grade concrete with 100% RA. M-20 and M-30 grades concrete had target split tensile strength but rest of the mixes failed to do so.

Alca *et al*. (2015) [18], studied the properties of Polypropylene fibre reinforced RAC. NA was replaced in 25%, 30% and 55% with RA and 1% and 1.5% polypropylene fibre were added in the all concrete specimens. Split tensile strength reduced with increase in RA quantity in concrete. With addition of 1% fibre it increases and further addition of fibre reduced it.

4. Durability Properties

4.1 Water Absorption

Mohammad *et al*. (2016) [4], investigated mechanical and permeability properties of RAC made by untreated RCA, treated RCA and treated RCA with polypropylene fibre in 0.3%, 0.6%, 0.9%, 1.2% and 1.5% by volume of cement. M-50 grade concrete was designed by replacing NCA by 60% RCA. Water absorption of concrete made with untreated RCA was the highest. By adding 0.9% polypropylene fibre resulted in 17% reduction (max.) in water absorption w.r.t. to control mix.

Akib S.M. and Sayyad S.U. (2015) [5], studied the difference of properties of RA and its influence on mechanical and durability properties of RAC. Mix design M-40 was made with replacing NA with RA in 0%, 25%, 50%, 75% and100%. Water penetration of recycled concrete was comparable to that of NAC.

Yallapa *et al*. (2015) [6], investigated mechanical properties of M-30 and M-35 grade concrete made with 1% and 2 %, and random, parallel and perpendicular orientation of Recron 3S fibres and natural coir fibres. Durability is improved by addition of Recron 3S fibre.

Larbi *et al*. (2015) [9], studied the physical and mechanical properties of RAC by adding admixtures by 0%, 0.5%, 1%, 1.5% and 2% by weight of cement in a mix designed with 100 % replacement of NA with RA. The mix design with 2% admixture dosage had 7.22% less water absorption compared to 0% admixture dosage.

Krishna T.S. (2015) [17], investigated flexural behavior of RAC with 1mm dia. steel fibre The mix was designed with 0%, 25%, 50%, 75% and 100% replacement of NA with RA. With increase in percentage of RA water absorption increases.

Rai A. and Joshi Y.P. (2014) [27], studied the application and properties of steel fibre, glass fibre, polymer fibre, natural fibre and synthetic fibre in

concrete mix design. It was found that permeability improved with the inclusion of fibres in concrete mix.
Ismail S. and Ramli M. (2014) [28], studied the effects of adding fibres on RAC containing treated RCA. 50 MPa grade concrete was made with 60% replacement of NA with untreated and treated RCA. A constant slump was maintained with Super plasticizer by 0.2% to0.3% by weight of cement. Water absorption of RAC made by untreated RA was more than RAC made with treated RA. Addition of Polypropylene fibre reduced the water absorption.

Nibudey *et al*. (2014) [29], studied the relation between compressive strength and Sorptivity properties of PET fibre reinforced M-20 and M-30 grade concrete. They added waste PET bottle fibre in aspect ratio of 35 and 50, in proportion of 0%, 0.5%, 1%, 1.5%, 2.0%, 2.5% and 3% by volume into the mix. Water absorption decreased up to 1% fibre ratio and increased at higher percentages for both grades of concrete and both aspect ratio of PET fibre. The initial and secondary Sorptivity of M-20 grade concrete with 1% fibre of aspect ratio 50 is reduced by 11.85% and 16.83% respectively.

Yue *et al*. (2013) [33], worked on M-25 grade concrete and replaced NA with RA in 30% and 60% ratio and studied its microstructure and mechanical properties under the effect of sea water at 4,8,12 and 16 months interval. The structure of concrete was studied under micro scope and found that concrete having more percentage of RCA was more porous which made the concrete weak.

5 Conclusions

From the literature survey, the following conclusions can be made:

- Natural aggregates can be saved by using Recycled Coarse Aggregates.
- In the production of Recycled Aggregate less energy is used –thus leading to saving in cost.
- Use of Recycled Aggregate and Recron-3S in RAC helps in disposal problem of the C & D waste.
- Saving of Natural Aggregates leads to reduced quarrying –thus less amenity cost.
- Natural Landscapes are saved –which leads to less bio-diversity loss thus it is eco-friendly.
- Use of Recron-3s fibre helps in disposal problem of plastic bottles.

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