Review study of recycled aggregate with different cementitous material

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Abstract*: *In the last few decades due to the steadily expanding growth of infrastructure, sustainable and financially attainable concrete has been acquired extraordinary consideration for the researcher and various civil engineering department. The present work represents a literature review of different cementitious material that is used in making concrete with the recycled aggregate that helps in developing the sustainable environment. This paper is mainly focused on sustainable concrete in which the different properties i.e. Mechanical Strength, acid attack, sulphate attack, carbonation test concrete of concrete have been reviewed. The X-Ray Diffraction (XRD) results of different cementitious material are also reviewed that is beneficial for many researcher and scholars. The Interfacial Transition Zone (ITZ) structure of different cementitious material is also studied. Using recycled aggregate concrete it's a friendly and new solution for regularly depleted material rather than the ordinary aggregate. It is also indicated that the compressive strength of the concrete decreases by increasing the percentage of recycled aggregate (RA) that promotes the researchers to use various cementitious materials in concrete. This review paper may be recommended for further studies by a researcher in many countries.

***Keywords*: Recycled Aggregate, Ground Granulated Blast Furnace Slag (GGBFS) , Mechanical strength ,cementitious material bout four key words separated by commas.**

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I. INTRODUCTION

The world is developing and urbanizing at an extremely quick rate. This impact of fast urbanization is likewise found in the civil engineering industry. Concrete is very essential material of civil engineering modern society. As written by Copeland and Brunauer in 1947 that no material human consumes except water more than concrete on earth. So from this above statement, it understands clearly that concrete is a very dominant material for the development of human society. Infrastructure Development plays important role in the economic development of any country. So natural resources are consumed a tremendous amount and principal major energy also consumed by this civil engineering industry. The fast and magnificent growth in the construction sector is mainly noted after the Second World War that led to the development of high rise and skyscrapers.

Recycling any material is a very old concept on earth. Like in the Roman culture they dismantle the sculpture and modified it into a new one. [1] As urbanization is occurring day by day the wastes of different construction material are increasing that is the major issue all over the world. [2] The increase in the use of concrete increase the CO2 in the atmosphere. The different results also show that the Construction industry produced the highest effect on the atmosphere. Figure no.1 below shows the emission of CO_2 worldwide as per data issued in 2011[3]

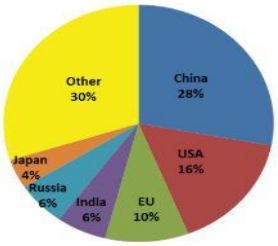

Fig.1. emission of CO2 worldwide [3]

Fig.2. schematic picture of RA and Concrete recycled aggregate (CRA) [4]

As the population grows aggregate demand also gate increase at a tremendous amount which up to 40 billion tons. This will increase the use of C&D waste because it is cheaper, ratification and available in bulk. However, more research is needed to increase the utilization of recycled material in the infrastructure industry. In today scenario many developed economies have started their work on this side also. [5] The C&D waste is further proceeded to recover the recycled aggregate and fine aggregate. This

recycled aggregate helps to reduce the utilization of natural aggregate in the development sector and also a new era of construction in civil industry. At the initial level when we directly utilize the recycled aggregate the mechanical, durability is also less but when it is used in the proper treated way it will help to grow the sustainable industry. As recycled aggregate evolved less CO2 as compared to natural aggregate this is a major benefit to use the recycled aggregate[6]. To detach the mortar from recycled aggregate it needs high cost and high energy for this researcher to develop carbonation modification in which carbon dioxide gas is used to cure the recycled aggregate and by which stick old mortar and ITZ property has been enhanced. In figure no.2 the schematic picture of RA and CRA. [4]

Normally the construction waste is used in land filling and dump disposal that gives arise 55 types of environmental issues. So proper disposal of construction waste and reuses of waste is necessary for the world as infrastructure development is going on all over the globe simultaneously. In recent decades different effects of recycled aggregate have been studied and different research shows the same thing about the micro properties of Recycled aggregate. Recycled aggregate shows the presence of adhered stick old mortar and SEM results also show the multiple transition Zone which is inferior property of recycled aggregate. [4]

The objective of this research work is to review the new art of making concrete in the construction industry with help of waste concrete. This material is available in near industry area as the waste product that is dumped in nalla side for filling purpose, therefore the research focused on waste material to be useful for different construction work which minimizes the waste that it will helpful for the environment. Therefore using recycled waste material from the construction and demolition (c&d) industry and utilized of industrial factory waste as cementitious material is the substitute for natural raw materials that will help to make unique construction material which is also a feasible solution to the prior problems.

II. MATERIALS

Recycled aggregate- They are the aggregate which is found from C&D waste basically as urbanization is going on use of concrete is also increase. But as per actual, the life of concrete is about 100 years is assumed so in future for maintaining or rebuilt part old concrete should be removed and new will placed. This need recycling aggregate, the different physical properties of recycled aggregate are given below in Table 1.

TABLE 1. RECYCLED COARSE AGGREGATE PHYSICAL PROPERTIES

Author Name	WA	D.D	SSD	LAT	FM	CV
Qureshi et al.,[7]	5.31	1374	-	-	-	-
Nuaklong et al., [8]	5.90	1241	2.26	37.1	-	-
Rattanachu et al., [9]	5.26	-	2.49	-	6.56	19.85
Bharadwaj et al., [10]	0.60	-	2.61	-	-	30
Padhi et al.,[11]	-	1325	2.45	30.89	-	26.62
Rais et al., [12]	3.40	-	-	-	3.20	25.83
Wang et al., [13]	5.3	-		-	-	13.4
Muduli et al., [14]	4.32	-	2.35	-	7.00	29.2
Awoyera et al., [15]	1.20	-	2.46	-	-	6.67
Sadeghi-Nik et al.,[16]	2.02	2185	-	-	-	-
Kazemi *et al.*[17]	4.8	2400	-	32.6	-	26.5
Kim et al.,[18]	6.28	-	2.14	-	-	-
Ann et al., [19]	4.25	-	2.48	`-	6.65	-

WA- Water Absorption (%), D.D- dry rodded unit weight (kg/M^3), SSD – Specific gravity ,LAT- Loss Angeles Abrasion test (%Loss), FM-Fineness Modulus(%) , CV- Crushing Value(%)

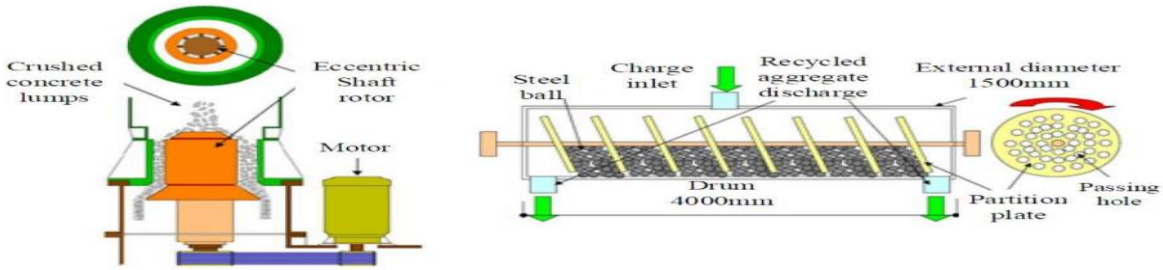

Fig.3. Mechanical treatment procedure [4]

TABLE 2. CHEMICAL COMPOSITION OF RICE HUSK ASH

Sr . No.	Lime (CaO)%	Alumina oxide (Al2O3) %	Magnesia (MgO) %	Iron oxide (Fe2O3) %	Sulfur trioxide (SO3) %	Loss in the ignition (800 °C) %	Specific gravity	Silicon di oxide Sio_2	K_2O
Qureshi et. al. (2020) [7]	1.7	0.91	0.3	0.6	0.4	5.4	2.1	-	-
Nuaklong (2020)[8]	1.7	-	0.9	0.65	0.2	2.3	2.06	81.6	8.9
Rattanachu et al (2020) [9]	-	-	-	0.4	0.2	8.7	1.89	93.5	3.3
Bharadwaj and Ramesh (2021) [10]	1.1	0.42	0.6	0.36	1.26	-	2.06	93.68	1.05
Padhi et al. (2018)[11]	1.12	0.89	0.49	0.24	0.28	5.15	-	87.14	2.51

III. A DIFFERENT METHOD OF SEGREGATION OF RECYCLED AGGREGATE

There are different methods available to enhance the effect of recycled aggregate and the mechanical treatment procedure also shown in figure no. 3. The principal origin of RA are either from development and prepared blended concrete from the road, locales buildings or streets. RA is chiefly created in fixed plant around large urban areas where CDWs are accessible. Be that as it may, for streets and to lessen transportation cost, versatile smashing establishments are utilized. The making of recycled aggregate is not just like natural aggregate it needs some specific machines too. The main part of de attaching from recycled concrete is attached wood, plastics joints sealants, plastics and steel which is easily removed from the blasting of air and steel will remove by electromagnet methods. This all removed then material which is separated as aggregate we wash out and take to open-air contaminations. [1]

A. Rice husk

Rice husk ash is a waste that comes in the category of organic waste and produced in large amount as a by-product of agro-based biomass and the rice milling industry. Rice husk mainly contained cellulose-based fibre and containing approx 20% silica. As rice husk is a having lightweight property with a highly porous structure in nature which has a high specific surface area. The property of rice husk based on chemical composition is shown in Table no.2.

The mixing of 15% RHA with 100% of RCA gives compressive strength about the improvement of 3-17% to the control mix which having here 100% recycled aggregate as the RHA gives us the strength of concrete at the micro level so the elasticity of concrete also goes better which comes around 33GPa for 28 days and it comes to about 28 GPa for the control mix. The split tensile strength also increases in addition to RHA in recycled aggregate as compared to using the recycled aggregate directly. As the RHA works as filler material in recycled aggregate. The effect on water absorption was about 17 % when we incorporate the RHA in the Mixture. As the impact of chloride ion is also great values in any structural failure on the mixing of RHA it will increase the life about 26-31% that's good for any structure. RHA also improves the acid resistance capacity of recycled aggregate

up to 41 % if we add about 15% RHA in the mix. [7] As XRD results show that RHA shown in Figure no 4 content of cristobalite which is used in dentistry work and reactivity decrease but it can be improved by the fine powder of an RHA. As geo-polymer used in making high resistant ceramic tiles and various other projects so mixing RHA result shows it will increase the compressive strength of concrete 36.0 to 38.1 M-Pa due to the improved microstructure. As recycled concrete gives higher workability as compare to mixtures containing 1.2- 3.6% RHA gives about 10 % lower flow values. The results of XRD on mixed concrete also shows an increment of a diffraction peak at 2θ on adding RHA the peak value find at 26.7 that values also go higher if we increase our curing time as the intensity of diffraction also gets higher as shown in Figure no.5.[8]

Rattanachu (2020) replace rice husk ash with cement in ratio of replacement 20%, 35%,50 % by weight, compressive strength increase with a mix of rice husk as compare to normal recycled concrete. They found value 6.56 for fineness modulus of recycled aggregate and water absorption value 5.25%, at 28 days when natural aggregate replace 100% with recycled aggregate and mix with 20 % rice husk it gives 38.4 MPa strength and 60 days mix result with 20 % replacement of gives 41.6 MPa strength, durability of concrete also get increase means the depth of penetration of chloride ion get decrease as we increase the rice husk % in concrete it was about 13.9mm at 20 % rice husk. [9]

Bharadwaj (2021) research on different percentage of RHA having replacement with cement at 6%, 9%, 12%, and 15% , compressive strength when replace100% natural aggregate is 24.6 MPa strength but when bharadwaj introduced RHA 15% replacement with cement it will give 28.20 MPa compressive strength which clearly shows an increase in strength up to 15% also, tensile strength doesn't show much effect on the mix, but when flexural strength tested with 100 % RAC and 15 % RHA values found 3.8Mpa. The SEM and EDS results at 15% replacement of cement and 100 % aggregate gives a better bond structure [10]

Padhi (2018) replace 100% recycled aggregate with natural aggregate, mix with rice husk results show that, as we increase the percentage of RHA the workability goes decrease, but when mix about 10-15% rice husk it will give 30 Mpa compressive strength , split tensile strength and flexural strength both increases, rebound number decrease as we increase the RHA and water absorption of the mix also increases but the density reduced. [11]

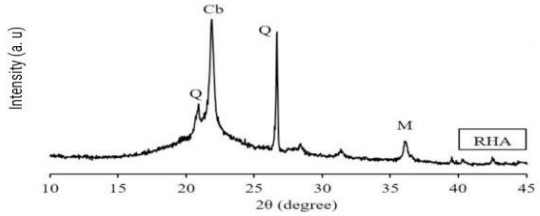

Fig.4. XRD results show that RHA [8]

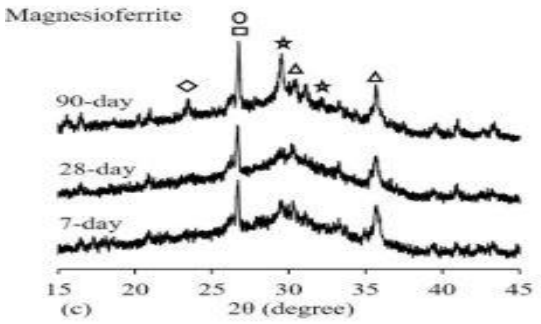

Fig.5. XRD results show that RHA content in Recycled concrete mix [8]

B. Metakaolin(MK)

MK is a highly reactive pozzolana material that come under calcined clay and calcinations of kaolin. It is commonly used in ceramics production and nowadays it is also used as a replacement for cement in some construction area. It's produced by thermal treatment controlling kaolin. Although MK is most favourable in different waste which is used for geopolymer production. The property of metakaolin based on chemical composition is given below in Table no.3

Natural aggregate replace with RCA 50 % and 100 % , mix with cementitious material metakaolin gives good strength and also increase the electrical resistivity of the material, cement replace about 10 % by weight 50 % and 100 % replace of aggregate gives about 105 mm and 85 mm slump respectively, compressive strength increases 22.87% and 9.61% values find about 53.08 MPa and 44.50 MPa , MK work for filler in RCA and hydration reaction also goes increase, water absorption value found of 2.71% and 2.88% for 50 % and 100 % repetively. MK increase the heat of hydration of cement as C-S-H[12] gel helps in filling voids and pores in the mix , we know higher values of Electrical resistivity will increase the durability of concrete because less corrosion occurs. The study of SEM image shown in Figure no. 6 and also gives the results lamellae microstructure in which Hydration also presence gives best results in compressive strength in 28 days. The EDS study shows Figure no.7 main content in the concrete mix is Ca and O, Portlandite and C-S-H gel also present in concrete by this main content. [12]

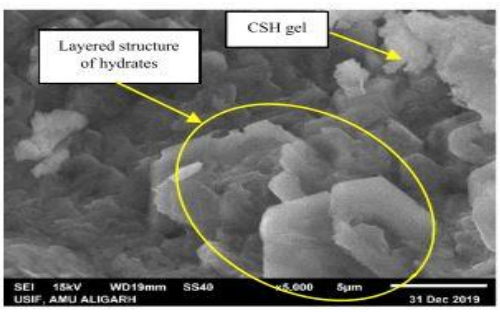

Fig.6. SEM Image [12]

TABLE 3. CHEMICAL COMPOSITION OF METAKAOLIN

Sr.no	Lime (CaO) %	Alumina oxide (Al2O3) %	Magnesia (MgO) %	Iron oxide (Fe2O3) %	Loss in ignition (800 °C) %	TiO_2	Silicon dioxide Sio_2	K_2O
Rais and khan (2020) [12]	0.09	46	0.03	0.6	1	0.65	52.01	0.03
Xie et. al. (2020)[20]	0.67	30.11	0.47	5.24	0.47		63.04	
Muduli and Mukharjee (2020)[14]	0.03	41.5	0.02	1.38		1.54	53.56	0.76
Sadeghi-Nik et al(2018) [16]	0.09	7.44		0.8	0.7		52.1	0.03

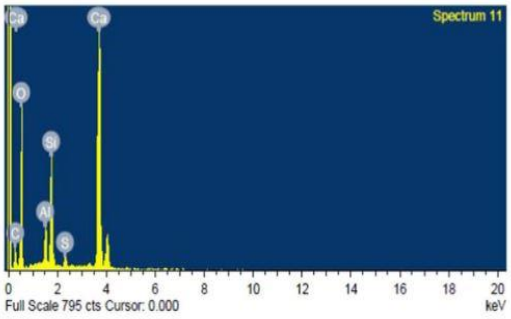

Fig 7. EDS Image, [12]

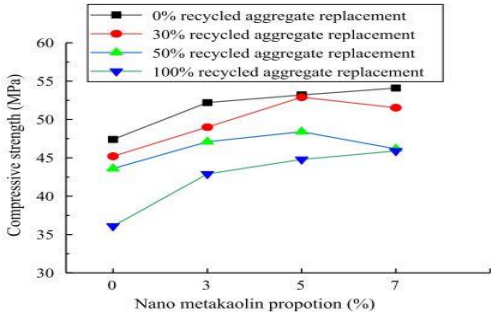

Fig.8. Results between MK and RA showing compressive strength of concrete [20]

Xie et al., (2020) studied to increase the mechanical strength of recycled aggregate by introduction of cementitious product i.e metakaoline which is replaced in different percentage 3%,5%,7 % by weight of cement, results shows that 50 % replaced coarse aggregate and 5 % replace metakaolin gives good results compared to other mix proportion, metakaoline having 7% replacement of cement it will give about 54.1Mpa , research has been done by author suggest that replacement of aggregate about 30 % and 5% adding of cementitious material gives prominent strength for working in the field, Figure no. 8 shows the results of the mix at a different stage of replacement. SEM structure also observed by taking out a 10mm height sample from the centre of every block and C-S-H gel and C-H amorphous also generated by clinker of C_2S and C_3S of cement, ITZ indicate the presence of fracture microcracks and pores inside the structure,Brunauer-Emmett-Teller (BET) test also observed the specific surface area and Barrett-Joyner-Halenda (BJH) theory observed the pore size of the material**,** Figure no. 10 and Figure no. 11 shows the microstructure and morphology of material with a complete replacement of natural aggregate with recycled aggregate 100% specific surface and pore reduced but when we integral the metakaolin in the mix it does not affect the recycled concrete. Figure no. 9 shows the relationship between specific surface area and pore volume and the graph clearly shows that plotting is not linear as all results show metakaolin helps in compactness in the concrete by the help of that overall strength gets increase. [20]

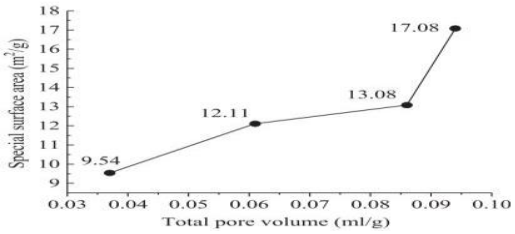

Fig.9. The relation between specific surface area and pore volume[20]

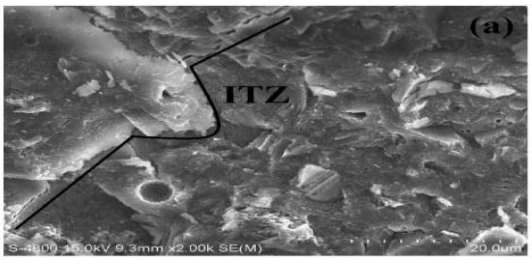

Fig.10. Image shows Microstructure of sample [20]

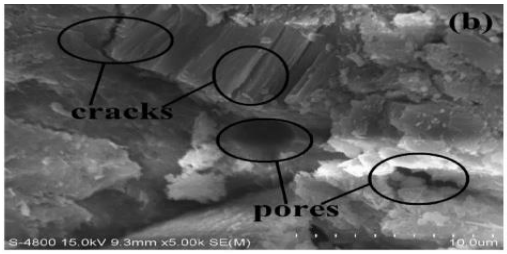

Fig.11. Image shows the morphology of the sample [20]

Muduli and Mukharjee (2020) examine the recycled aggregate 100% replaced by natural aggregate and mix with MK 10%,15%, 20% by weight of cement, grading analysis of natural coarse aggrgetae (NCA) and RCA in Figure no. 13 shows that the property of NCA is far better than that of RCA but the impact value, crushing value satisfy the Indian standard (IS) 383 code of practices, author also test the scanning electron microscope (SEM) for MK microstructure found shown in Figure no.12 reveals that the grains of MK are random in size and their geometry is in rough texture also, sieve analysis prolongs the grading for aggregate both for natural and recycled as per code IS 383, slump value for 100% recycled aggregate with MK 10%,15%,20% is 86mm ,85mm ,81mm respectively, compressive strength for 100% recycled aggregate with MK 10 %,15% ,20% is 36.22 Mpa, 38.05 Mpa and 35.31 Mpa respectively which is increased by 12%, 17.6% and 9.1% higher than RAC without MK. This is because MK work as filler in the recycled aggregate concrete the hydration products calcium silicate hydrate (CSH gel) resulting from the pozzolanic reaction of MK with Ca(OH)2 increase the strength, split tensile strength also increases the strength when we add 10%,15%,20% MK with 100 % of replaced aggregate but when without adding of MK it was about 2.68 MPa and adding MK it will increase the 10.4%, 15.7% and 9%. These results also show as we enhance the percentage of MK in concrete due to scarcity of Ca(OH)2 for pozzolanic reaction and absence of hydrated MK molecule, the flexural strength test gives results 3.9 Mpa but after incorporating Mk in the recycled mix about 15% MK and 100% recycled aggregate it will enhance the strength by about 13.8%. so all results show that the use of 15% MK is appropriate in use for construction use with 100% replacement of aggregate. [14]

Awoyera and Okoro (2019) also tested the recycled aggregate with replacement of natural aggregate ratio in 20%,30%, 50% with 1 kg by weight metakaolin replace by cement, Figure no. 14 a shows the XRD of Metakoaline in which the total of silica (SiO_2), aluminate (Al_2O_3) and ferrite (Fe_2O_3) in the metakaolin are higher than 70 %, workability of concrete reduced when MK was introduced in the mix because due to the presence of rough surface of recycled aggregate the water absorption is also high as compared to normal concrete, compressive strength of concrete goes down when we increase the percentage of recycled aggregate, results clearly incidates in reduction of compressive strength but after 28 days at 20 % it gives up to targeted strength also, XRD image clearly shows the presence of a Quartz pattern which was similar to the control mix shown in Figure no. 15, SEM analysis shows that MK works as filler material in the concrete. [15]

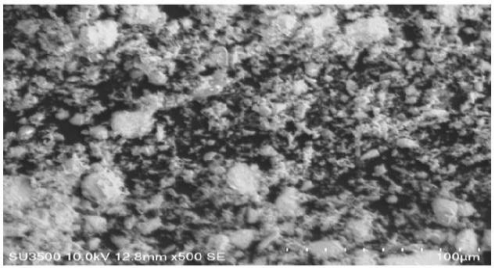
Fig.12. SEM Microstructure Image for Metakaoline & Grading analysis curve of NCA and RCA [14]

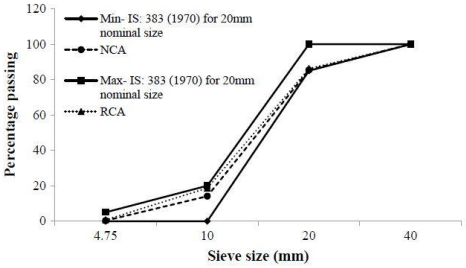

Fig.13. Grading analysis curve of NCA and RCA [14]

Sadeghi-Nik *et al.*, (2019) research on mechanical property of recycled aggregate replaced with natural aggregate with a ratio of 20%, 40%, 60%,80%, 100 %, concrete mix with Mk which is replaced with cement powder for 20 %, results showing that water absorption of recycled aggregate is high as compared to natural aggregate, compressive strength of control mix is 11.15% high as compared to recycled mix, elasticity increase by 11.0 % in comparison to normal recycled concrete, water absorption decreased by 4.5% which is more than the normal control concrete mix, density of the material also decrease as we increase the percentage of mix and apparent porosity increase because they were less dense than normal concrete. [16]

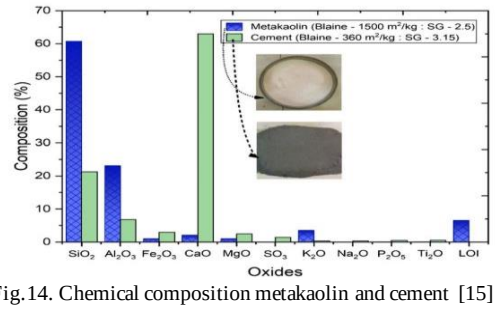

Fig.14. Chemical composition metakaolin and cement [15]

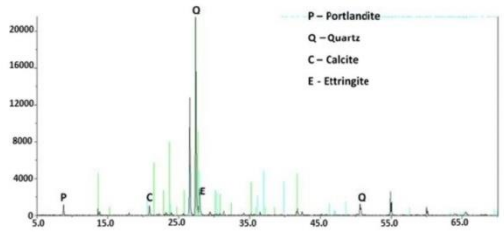

Fig.15. XRD pattern of 20% RCA+MK [15]

C. Silica Fume (SF)

Silica fume is the by-product produced in electric arc furnace as production of silicon or alloy. It contains amorphous silica in the range of 85% having a specific surface area between 13000-30000 m^2/kg. As silica fume consider a very reactive pozzolana material when we indeed in the concrete mix. Table no. 4 below shows the chemical composition of Silica Fume.

Wang et al. (2020) significantly worked for the recycled aggregate mix with silica fume, the best result at 4% with replacement of cement having 1% of steel fibre, authors investigates a total of 90 beams of size 100x100x515mm having a steel fibre diameter of 0.2 mm and 13 mm length with 750 GPa and 2000 as elastic modulus and tensile strength, total of four elevated temperature as been discussed in this study,silica fume helps the Recycled Aggregate concrete to become dense produced second hydration that occurred between Ca (OH) 2 and C-S-H , results also show that stiffness decrease as an increase in temperature and by rising of temperature the peak load get affect vice versa, flexural strength of concrete reduced, contradiction effect appears when we increase the SF beyond the 4% flexural strength also increase, fracture energy steel fibre has a great impact on recycled aggregate reducing the stress concentration,it also says fracture energy is gain by steel fibre and by adding the SF the cement paste becomes more hydrated and become denser too, fracture toughness also gets increase as we increase the SF percentage so 4% of silica fume reaches a peak at 400°, 600° and 800°, which has an improvement of 17.7%, 48.5% and 59.2% by concrete without Silica Fume. [13]

National (2014) replaced aggregate with a ratio of recycled aggregate in two different fractions in which 4mm to 12mm mix used, silica content was replaced in place of cement in 5% & 10 % only having a specific density is 2.3, recycled aggregate having compressive strength with 100% replaced mixing SF for 5% & 10 % gives 46.4 Mpa & 48.4 Mpa values respectively, tensile strength value 3.4 Mpa, & 3.2 Mpa , water absorption was about 13.1% & 12 % in volumetric and the ultrasonic pulse velocity was also equivalent to natural aggregate that means the strength for all mix with silica up to 10% is increase as the time of curing get increase. [21]

Xie et al. (2018) replace cement by silica fume was about 5% ,10% by weight and 57 specimens were tested in this research by authors, XRD image of silica fume is given in Figure no. 16, when the recycled aggregate mix with SF the strength is increased by 11.9% and 32.5 % respectively, stress-strain pattern on 10% gives the curve shape. As the elasticity of RAC is less than NAC but on the addition of 5 & 10 % SF content, it will slightly help the concrete to increase the elasticity. The CO_2 emissions in RAC are less as compare to NAC which great for the introduction of SF which doesn't increase the CO_2 emissions also. So as per research on RAC, it more helps the environment to reduce the harm to surroundings. [22]

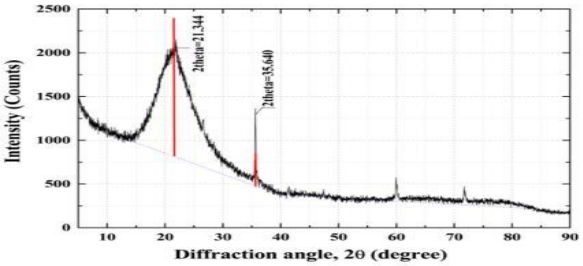

Fig. 16. XRD view of Silica fume [22]

TABLE 4. CHEMICAL COMPOSITION OF SILICA FUME

Sr .No	Lime (CaO) %	Sulfur trioxide (SO3) %	Loss in the ignition (800 °C) %	Specific surface area (m2/kg)	Silicon di oxide Sio_2	color
National et al, (2014)	1	2	-	15000	85	Amber

TABLE 5. DOUBLE K-FRACTURE VALUES OF CONCRETE [23]

Notataion	P_{ini} (kN)	P_{max} (kN)	a_c (mm)	K_k^{ini} (MPa-m $^{1/2}$)	Mean of K_k^{ini} (MPa-m $^{1/2}$)	K_k^{ini} (MPa-m $^{1/2}$)	Mean value K_k^{ini} (MPa-m $^{1/2}$)
RC-R0S3-1[23]	3.6745	5.839	-	0.7071	0.7794	-	1.8
RC-R0S3-2[23]	4.3725	6.415	43.68	0.8414		1.8	-
RC-R0S3-3[23]	4.105	-	-	0.7899		-	-
RC-R0S10-1[23]	4.344	6.352	49.556	0.8359	0.8967	1.9977	2.3057
RC-R0S10-2[23]	5.2445	6.747	60.871	1.0092		2.8452	-
RC-R0S10-3[23]	4.391	6.545	49.91	0.8449		2.0471	-

Xie, Li, *et al.*, (2019) works and compare naural aggrgeate , recycled aggregte compressive strength which is reduced at 100% replacement of aggregate with recycled aggregate but on adding 3% and 10% SF add in replacement of cement gives us about 41.7Mpa and 47.9 Mpa strength which are a good sign for the concrete use as recycled aggregate, in this study steel fibre also mixed with all concrete volume as per requirement because the mixing of steel fibre will increase the stiffness of concrete , when replaced aggregate 100 % with 3% and 10% silica fume. it will reduce the fracture energy 42.9% and 20%. The double k-fracture values of concrete are given in table no.5 [23]

Qureshi et al., (2020) replace cement for 10 % SF and also add 1 % hook-ended steel fibres (HSF) by weight of concrete, results show adding 10 % SF increases the compressive strength 11 %, elastic modulus also improved up to 10 % , SF as cementitious material will reduce the water absorption, increases the binding structure of the material in the ITZ image , adding SF chloride penetration also increase from 21-27%. [7]

D. Polypropylene (PPE) fibre

Polypropylene fibre comes under thermoplastic polymer division which is prepared from a combination of propylene monomers. It was firstly invented in 1951 by an inventor named Paul Hogan and Robert Banks. It is relatively crystalline and non-polar. As it has similar properties as polyethene but it harder and highly resistive with heat. The PPE properties are given below in table no. 6

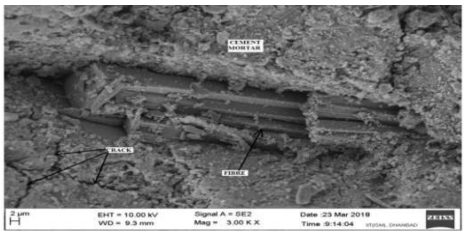

Fig.17. ITZ structure Image[24]

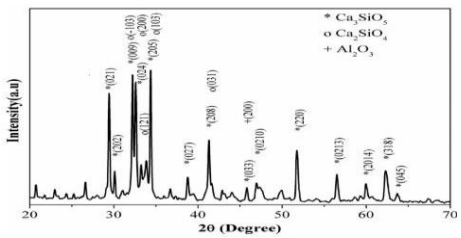

Fig.18. XRD view of OPC cement[24]

TABLE 6. PPE FIBRE PHYSICAL PROPERTIES

Sr. no.	Fibre type	Shape	Length (mm)	Effective diameter (lm)	Specific gravity	Tensile strength (GPa)	Elongation (%)	Young's Modulus (MPa
[24]	PP	Triangular	12	25–40	0.90–0.91	4.6	60–90	>4000
[25]	PP	Fibrillated			0.91	5.5-6.4		6-10

Das(2018) selected the 0.5%, 0.75% and 1% PPE and aggregate was replaced about 100% to natural aggregate, results show that cement has a high content of calcium silicate which is shown in Figure no. 18 , results for density and compressive strength for this above mix was 2219.96 kg/m^3, 2195.81 kg/m^3,2160 kg/m^3 and 38.6 Mpa, 38.2 Mpa, 33.9Mpa respectively, it shows that as we increase the PPE fibre content the density of concrete also goes decrease But as we increase in PPE content strength become decrease , split and flexural strength is 2.93 Mpa, 2.64 Mpa, 2.57 Mpa and 4.24 Mpa, 3.93 Mpa, 3.64 Mpa respectively from above results shows good value on adding 0.5 % PPE fibres only, ITZ structure shown in Figure no. 17 of the mix shows the presence of PPE fibre make a bridge-like structure between cracks that propagate. [24]

Ibrahm et al., (2017) replaced natural aggregate with recycled aggregate in the ratio of 25%,50%,75%,100 %,and by wright of concrete adding PPE fibre 0%,0.25%,0.1%, 0.15%, different results are considered during the study compressive strength goes increase with control RAC mix. The results of 100 % replaced of aggregate with 0.15% for compressive strength, split tensile, flexural strength is 30.85Mpa, 2.82 Mpa, 3.30 Mpa respectively, author used the different percentage of concrete with this PPE fibre to get better results than that of the control plain recycled aggregate mix. [26]

Hanumesh et al., (2017) mix the recycled aggregate in the replacement for natural aggregate 25%,50%,75%,100% it includes the 1% ,2 % mix of PPE fibres in the concrete by volume, compressive strength for 100% concrete is 17.03 but on the addition of PPE fibre 1% ,2 %, it will give 19.70, 23.11 Mpa strength respectively, split strength for 100% replacement 1.35 Mpa and with mix PPE 1%, 2 % 1.78 Mpa ,2.45Mpa respectively, flexural strength with 100 % replacement is 4.07 Mpa with1% ,2 % PPE it become is 5.63, 5.63 Mpa. [25]

Ahmed et al., (2020) research with different proportions of polypropylene fiber (PPE) of 0%, 0.15%, 0.3%, 0.45%, 0.6%, 0.75% ,0.9% and 50%,100 % natural aggregate replace with recycled aggregate, in this SF 10 % by weight of concrete also added, results of the experiment show that mixing of 0.6% PPE with 100% aggregate gives better results as compared to normal concrete recycled, compressive strength, flexural strength, split strength, elasticity is 74 Mpa,4.34 Mpa, 2.44 Mpa, 34503 Mpa respectively. [27]

Kazemi *et al.*, (2020) research with 100% recycled aggregate and 0.1 % PPE fibre having 0.55 water/cement ratio, compressive strength , for 28 days is about 21.4 Mpa, slump value 67 mm, point load test results give 15.5 Mpa values and the Rebound hammer test give the equivalent 21.4 MPa which is the same as we find after compression of the cube, further decrease the water content means0.44 including 0.8 times superplasticizer it will give 66 mm, 17.1 Mpa, 16.3 Mpa, 16.2 Mpa results for the slump, compressive strength, point load test and rebound hammer respectively. [17]

E. Fly ash

Fly ash (FA) is produced by the combustion of coal at the thermal power station. As FA is a soil ameliorator worldwide. FA is the finest coal ash transported by exhaust gases during combustion that's why called fly-ash by name. Normally FA accommodates special plant micro and macronutrients and having physicochemical properties in that. It also contains some hazardous particles like organic pollutants, radioactive elements. Different types of properties of fly ash are given below in Table no. 7.

Damera et al., (2020) work on fly ash and recycled aggregate for their strength and the carbon emission, natural aggregate replaced in percentage of 25 %, 50%, 75%, 100% recycled aggregate. The concrete is design for two mix M35 and M40 results for 100 % replacement are shown below table no.8 [28]

TABLE 8. COMPRESSIVE STRENGTH RESULTS [28]

Property	M35 (28 days)	M45 (28 days)
Compressive strength	40.7Mpa	48.8Mpa
Flexural stregth	4.16Mpa	4.69Mpa
Carbonation depth	6.10mm	5.10mm

Guo *et al.*, (2020) natural aggregate also replaced in the percentage of 50% and 100% with recycled aggregate and cement about 50% and 75% replaced by weight of fly-ash with different water-cement ratio of 0.35, 0.40 and 0.45, compressive strength for this different results of recycled aggregate having 100 % recycled aggregate with 50 % fly ash w/c 0.35 is 21Mpa with 0.40 w/c ratio , 75% replacement it becomes 13.64 Mpa so as the results clearly show that as we increase the content of fly ash it reduced the compressive strength of that mix. [29]

Kim et al., (2013) replaced the fly ash and recycled aggregate in the ratio of 30% of cement and recycled aggregate in 30%, 100% ratio concerning aggregate which is basically from Korea region road pavements as per the availability. The compressive strength clearly shows that at 30 % the strength will same but at 100% replacement it will decrease up to 22 Mpa as the dose of air-entraining admixture goes to increase to 29Mpa for 100% concrete. Now the split tensile strength for the concrete for 30 and 100% replaced with fly-ash is 2.2 Mpa and if the dose of air-entrained admixture gets increase it will give good 2.9 Mpa strength. [18]

Kou et al., (2013) give the research idea on fly-ash with 55 % , 35%, 25 % replace of cement and natural aggregate replace with 50% , 100 % of recycled aggregate, results outcome for compressive strength and split tensile strength for 50 % replace of aggregate with 25%, 35%, 55 % fly ash mix in place of cement is 41.7 Mpa,37.12 Mpa, 31.4Mpa and 3.09 Mpa, 2.78 Mpa, 2.42 Mpa respectively, for 100 % replace of aggregate with 25%, 35%, 55 % fly ash mix in place of cement is 36.8 Mpa, 32.2 Mpa, 26.6 Mpa and 2.96 Mpa, 2.56 Mpa. 2.23 Mpa respectively. The results clearly show as we increase the fly ash and recycled aggregate content the mechanical properties of concrete goes down. [30]

F. GGBFS

GGBS full form is ground granulated blast furnace slag it is amorphous, coarse sand-sized which is finely ground form. The average size of GGBFS is about 1-1.5mm. It mainly produced by quenching molten slag removed from blast furnace mainly from the iron and steel industry. It mainly contains Calcium, silica, alumina, magnesia with other oxides also. The chemical composition of GGBFS is shown in Table no.9

GGBFS is the waste products of in construction industry as increase day by day due to demolitions of the old building which will arise severe environmental problem to the whole world. As sustainable concrete production it is necessary to produce concrete that will not affect the natural resource to overcome this problem researcher start working on recycled products in which GGBFS has also introduced the compressive strength, split tensile strength and flexural strength has been an increase in this percentage which are found to be in the range 14.02% to 19.61%, 9.33% to 14.07%, and 10.74% to 14.71% respectively [31]

TABLE 7. FLY ASH PHYSICAL PROPERTY

Sr .No	Silicon di oxide Sio_2	Density (g/cm3	Blaine fineness (cm2/g)	Flow value ratio (%)	Activity index (%)	Loss in ignition (°C) %
Kim et al. (2103)[18]	48.8	2.14	3360	101	81	3.5

TABLE 9 CHEMICAL COMPOSITION OF GGBFS

Sr .No	Lime (CaO) %	Alumina oxide (Al2O3) %	Magnesia (MgO) %	Iron oxide (Fe2O3) %	Silicon dioxide Sio_2
Hu et al., (2019)[31]	42.6	13.8	5.8	0.3	36
Ali et al., (2019)[32]	43.34	10.78	3.21	0.42	36.74
Ramakrishnan et al., (2017) [32]	--	-	7.73	-	91
Gao et al., (2019)[32]	51.65	12.85	2.95	1.11	25.56
Saha et al., (2017)[32]	34.07	16.98	9.69	1.26	32.57
Duran Atis et al., (2007)[32]	32.61	14.21	10.12	0.98	36.7
Ann et al.,(2008)[19]	33.5	14	4.9	0.8	44.2

results also show that as we include the GGBFS to mix it will reduce the workability and setting time, we add recycled aggregate to the mix it will give sufficient strength to the concrete i.e about 43.1 Mpa and 38.5 Mpa for the ratio of 50 % and 100 % respectively, geo-polymer of recycled aggregate it will denser than the natural aggregate that is shown clearly in ITZ structures [32] now to check the durability of concrete mix the author take high volume GGBFS in which the sulphate test, acid test and chloride test and water sorptivity test has been conducted, result shows the sulphate attack for 50 % and 100 % recycled aggregate is about 0.26% and 0.32%, respectively at 28 days. The acid test on the mix with loss of mass is about 1.16 % and 1.43 % the sorptivity test on concrete gives 0.060 and 0.067 [33].

The investigation of GGBFS with the different test was reviewed by author the strength of concrete in starting days get reduced but if the time of curing higher day by day the formation of C-S-H gel will help in increase the compressive strength and flexural strength. The initial and final setting time of concrete also get change due to GGBFS in concrete it will increase the hydration of the mix. The microstructure of GGBFS helps to make the concrete denser that lead to making concrete more compact also and as GGBFS also utilize calcium hydroxide of that will increase the possibility of an attack of chemicals and reduced the permeability and water absorption of concrete. [34] The compressive strength of recycled aggregate with a mix of fly-ash and GGBs increase but the tensile strength does not give a good result. The mix is about 65% GGBS help in improving the chloride ion attack on concrete due to obstruction of water and oxygen in the mix. [19]

The effect on recycled aggregate with replacement of natural aggregate 50% and 100 % ratio mix with NaOH solution and Na_2SiO_3 solution with a mass ratio of 1:2.5. GGBFS is completely mixed with metakaolin and it was 100 % replacement of cement as we know cement is the limited source so this was a good replacement of that. metakaolin taken about 30 % and 50 % and GGbfs has taken in 50% and 70% a total number of 42 cylinders of size 100 mm (diameter) by 200 mm (height) were prepared. The XRD graph of GGBS and Metakoline is shown below in Figure no. 20. As the results show the increase in compressive strength for 100% recycled aggregate about 35% to the control mix. The elastic property of the material is also increased because GGBFS and metakaolin having higher hydration properties. In the XRD of when we mix GGBFS and metakaolin, there are two major peak mullite and ettringite at a position of 2θ =31° as shown below Figure no. 19[35]

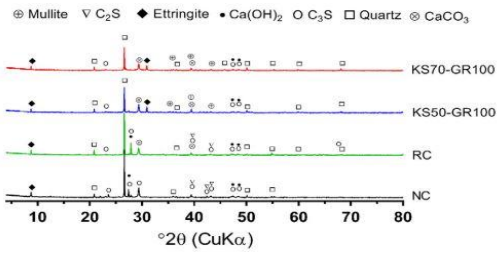

Fig.19. XRD pattern of different mix concrete [35]

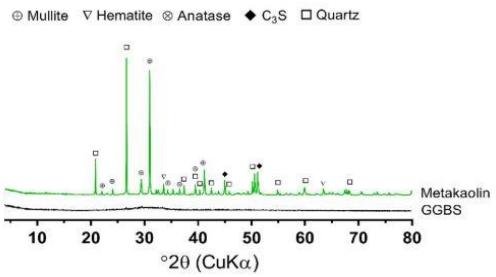

Fig. 20. XRD Pattern of Metakaolin and GGBS[35]

IV. Conclusion

This research review paper defines a complete summary of the production and utilization of recycled aggregate in concrete and recapitulation on the distinct property of Recycled Aggregate Concrete. It'll help the researcher to investigate this area to progress in this field. Therefore, it has been found the performance of recycled aggregate as mechanical and durability properties are inferior in research compared to the traditional mix concrete. So in recent year, there are many studies and widespread attention has been given to use as construction material and also implement in a main structural member.

Therefore the utilization of recycled aggregate from construction and demolition waste helps in sustainable infrastructure development. Although to utilize recycled aggregate as construction and structural material, its quality and properties should be described exactly as the nature of recycled aggregate has a huge effect on the performance of recycled aggregate concrete. Hence, rather than saving construction and demolition waste, it is termed as a future resource for the economic growth of the construction industry. Therefore, recycled aggregate extensively used in a developing country. Although it is limited to non-structural member construction it is because of less research knowledge and not many experiments has been done. Therefore, it is necessary that focused research has to be carried out in this area for the utilization of recycled aggregate as a structural material.

V. The Further Scope of the Research Area is Given Below

- The study of the mechanical and durable performance of recycled aggregate concrete, for long term behaviour, is not known so more research has to be conducted for recycled aggregate.
- Study for ITZ structure and microstructure of nano-particles also needs to study for long term behaviour
- Long term durability of recycled aggregate concrete with both material and structure point of view needs to assessed
- Lack of research on the use of recycled aggregate concrete such as precast concrete, geo-polymer concrete and sustainable concrete
- The mechanical strength and their Different relationship model are to be prepared for long term use of recycled aggregate
- The proper mix design procedure and optimal mix proportioning are to be established.
- Numerical models should be prepared for understating the proper behavior of recycled aggregate concrete.
- The researcher should investigate this RA aggregate for mass concrete production.
- And lastly, limited research on the corrosive properties of recycled aggregate has to investigate.

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