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A STUDY ON MECHANICAL PROPERTIES OF RECYCLED AGGREGATE CONCRETE USING POZZALONIC ADMIXTURE

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Abstract: Recycled aggregate tesare the material obtained from debris and demolition wastes which are being used in the construct on industries oreregularlyinrecenttimes. The environmental beef its associated with recycled coarse aggregates (RCAs)use, such as reduced land filling and natural aggregate quarrying has been identified by industries and government. At present situation resources are extremely shortage, so too overcome the situation RAC concept was established. Recycled aggregate concrete (RAC) is the construction material produced by demolishing and crushing go previously casted concrete cubes.The most important drawback in RAC is low strength due to the adhered mortar on natural aggregates resulting in excess water absorption and decreased workability.

***Index Terms* –Recycled Aggregate Concrete, Pozzalonic, Admixtures**

CHAPTER I INTRODUCTION

1.1CONCRETE

Concretecomprisesofcement, aggregates(stoneandsandofvariousgrades) and water. Concrete is the basic building element for modern society. Concrete has a superior lifespan in compared to other products. There are many benefits associated with using concrete in construction projects. The material can be molded into any shape and used for any purposein construction. Concretecanalsobeusedtocreatesolid.Constructionwaste consists of unwanted material produced directly. Construction waste may is made up of materials such as bricks, concrete etc., damaged or unused for various reasons during construction. Every major construction project uses concrete in one form or another.

The use of construction and demolition waste (CDW) to produce new concrete is becoming an obvious choice. Approximately 25% of all waste generated per annuma rises from CDW and78% of this were concrete, bricks etc. CDW can contribute to reducing the economic and environmental cost so fremoval to dumping round sand more importantly,the excessive demand for natural resources, especially natural aggregates(NA),for constructionwork.

1.1 *Advantagesofflyashandsilicafume*

Flyashis known to be a pozzolanic material and has been used to increasethec ompressivestrengthandworkability offresh concrete. Influence of fly ash as a cement replacement on the compressive strengths value so frecyc ledaggre gate concrete found to be decrease das the recycledaggregate and the fly ash content increased. Fly ash is accepted to be anfine pozzolani cmaterial.Therefore,byusingflyashasacementreplacement in recycled aggregate concrete both the compressive strengthandworkabilityofrecycledaggregateconcretewereincreased.The effects of incorporating silica fume in the concrete mix design to improve the quality of recycle dagger gates in concrete. The use of lashing RCA concrete may significantly improve the service life of concern telex posed to such aggressive environment, providing suitable proportion of FA and low/cisused.The main advantage so fusing flyash and silica fume by replacing the cement in specified ratios Flay sand silica fume canid provecompressi vestrength,workabilityetc.Superplasticizershavevariouseffectsonconcrete,suchascompressivestrengthwereincreas ed,increasingworkabilitywiththesamewater and cement contents, and decreasing permeability.[16]

Compressive strength or compression strength is the capacity of material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In the study, compressive strength can be analyzed independently. Compressive strength is a key value for design of structures. Compressive strength is of tenmeasuredonauniversaltestingmachine.Measurementsof Compressive strength are affected by the specific testand conditions of measurement.

***1.2** Three Stage Mixing Approach forrecycledcoarseaggregates*

In three stage mixing method(TM)or triple mix in method water is divided into two half's, firstly coarse and fine aggregates were mixed for15 seconds by adding certain amount of water to get wet aggregates. Followed by the admixture, was added to the wet aggregates and agitatedforanother15secondstoobtaintheaggregatessurface-coatedwithadmixtureandthecementwasthenaddedandmixedforfurther30seconds. Finally, the rest half water was added together with the SuperPlasticizermixedforanother60seconds.

Here, by using three stage mixing, the voids of aggregate will befilled by fly ash and silica fume because they are much finer than the cement.[4]

1.3 OBJECTIVEOFTHESTUDY

Themainobjectiveofpresentstudyistoachievethetargetcompressivestrengthinrecycledaggregateconcretemixesname lyRAC20, RAC25, and RAC30 using 100% recycled coarse aggregates bypartial sub stitutio no fpozzolani materials to cement.

CHAPTER IILITERATUREREVIEW

2.1LITERATURESREVIEWED

SamiW.Tabshetal, [1]studied oninfluenceof recycled coarseaggre gates on strength properties sof concrete. They investigated the factors that in fluence the compressive and tensile strengths of concrete made with coarseaggrega reobtained from crushed old concrete.
Two concrete mixes with target strengths of 30 MPa and 50 MPawere considered. A total of 80 specimens were cast and cured in water Four different kinds of coarse aggregates were used in these mixes which included aggregates from natural origin, recycled aggregates from dumpsite, crushed stone from 30 MPa concrete and 50 MPa concrete. Concretemadewithrecycledconcreteaggregatehashighbondingstrengthbetweenthe coarse aggregate and the surrounding paste due to angularity of the coarseaggrega teand theresidual cementati ononthesur face of the recy cled aggregate.Five specimens weretested for compression.
They concluded that, the RAC concrete mixes requires more water than conventional concrete tomainta in good slump.The percentage lossin compressive strength due to the useo frecy cledaggregate was observed to be more and a loss of compressive strength was observed mainly due tohigherwater observation.
Wengui Li et al, [2]studied on interfacial transition zones in recycledaggregate concrete with different mixing approaches. Two-Stage MixingApproach(TSMA)wasconsideredintheirstudywhichimprovesthenanomechanical properties. In this study, both recycled aggregates and naturalcoarse aggregate (NCA) were sieved to have the same size graduation.When casting RAC with 100% replacement of RCA, two different mixingapproaches (TSMAandNMA)wereused.

CHAPTER–III

PRELIMINARY INVESTIGATIONS

3.1.INTRODUCTION

The experimental work is carried out in five phases. Phase-1 consists ofCharacteristicsofmaterials.Phase-2consistsofcastingofNaturalconcretecubes. Phase-3 consists of Crushing of Natural concrete cubes using JawCrusher.Phase-4consistsofCharacteristicsofGraniteAggregates.Phase-5 consists of Casting of Recycled Aggregate Concrete cubes with thereplacementofnaturalcoarseaggregatewithGraniteAggregateat different percentages. The overview of various phases of the experimentalprogramisshowninfollowingsections.

3.2 PRELIMINARYINVESTIGATIONS

1.In this phase, necessary tests wereconducted oncement,fineaggregate, coarse aggregate to find out the physical and mechani calproperties.

2.MixDesignwasdoneforM20,M25,M30,M35andM40gradesofconcrete.

Natural aggregate concrete cubes were casted in order obtainingrecycled aggregates bycrushing in jawcrusher.

***3.3** CEMENT:*

Cement is as of tgray powder substance which is used in construction that is mix edwith water and other substance esto make concre teste sandhar den sand can bind the materials together.

Inthisstudy,OPC 53grade (MAHAGOLD) cement was usedandthefallowingtestareconductedasperIScodes-12269-1987.Thefollowing testswere conducted onOPC53Gradecement

1. SpecificGravityofcement [IS: 4031– 1968]
2. Finenessofcement [IS4031 (Part-1)-1996]
3. Standardconsistencyofcement [IS4031(Part-4)-1988]
4. Initialsettingtimeofcement [IS12269-1987]
5. FinalSettingTimeofcement [IS12269 -1987]
6. Soundnessofcement [IS4031(Part-4)-1988]
7. CompressiveStrengthofcement [IS12269-1987]

3.3.1SPECIFICGRAVITY

Specificgravityisusedinmixtureproportioningcalculations.Thespecificgravity of Portland cement is generally around 3.15 while the portland-pozzolanacements mayhavespecificgravitiesnear2.90.

Table3.1: Specific Gravity of Cement(IS 4031-1968):

ObservationsforSpecificGravityofcement	**Sample**
Weightofbottle(W1)*(emptybottle*(g)	34
Weight ofbottle+1/3ofcement (W2)(g)	69
Weightofbottle+cement +Kerosene(W3)(g)	103
Weight ofbottle+kerosene(W4)(g)	78
SpecificGravityofCement(g)	3.15

SpecificGravityofCement=W2-W1/(W4-W1)(W3-W2)X0.79=3.15.

3.3.4 CompressiveStrengthofcement(IS12269 -1987):

Compressive strength of cement is determined by compressive strength test on mortar cubes compacted by means of a standard vibration machine. Standard sand is used for the preparation of cement mortar. The specimen sin the form of cubes70.6mmX70.6mmX70.6mm.

Fig:3.1 CompressiveStrengthofcement

3.4 FINEAGGREGATE:

It is loose granular material that results from disintegration of rocks,consists of partic less mall erthan gravel but coarser than silt and use din mortar. The material which passes through 4.75 IS sieves are termed asfine aggregates (FA). Usually sand is used as fine aggregate, at places where natural sands not available,crush ed stone isuse das fineaggregate.Thesand/FineAggregateusedfortheexperimentalworkislocallyprocured.AccordingtoIS383-1970[28],Fine Aggregate use dinghy present study confirms to Zone– II.

3.4.1 Specific Gravity and Water Absorption of Fine Aggregate:

Fig:3.2

Table3.5: SpecificGravityofFine Aggregate(IS2386–Part3)

Description	**Observations**
Wt.ofthesaturated surfacedry(SSD)sample(A)(g)	636
Wt.Pycnometer+Sample+water(B)(g)	1730
WeightofPycnometerfilledwithwater(C)(g)	1347
Weightofovendry sample(D)(g)	633
Specificgravity=D/A-(B-C)	2.5019
Waterabsorption =100 (A-D)/D	0.47

3.4.3.BulkdensityofFine Aggregates

Table3.6 Observationsforbulkdensityoffineaggregate

Descriptionofmeasure	**FineAggregate**
Volumeofmeasure(V) (l)	3
Weightofmeasure(W1)	6.949
Wt.with compactedaggregate(W2)Kg	12.103
BulkDensity =(W2-W1)/V (kg/m3)	1.718

3.5. *COARSEAGGREGATES*

Natural coarse Aggregate is the component to fa composite material thatresists compressive es tressandprovidesbulktothecompositematerial. The aggregate which retained on 4.75 mm IS sieved used andlocally available coarse aggregate having maximum size of 20mm wasusedinthestudy.

3.6 Pozzolanicmaterials

Pozzolanicmaterialsaresiliceousorsiliceousanaluminousmaterial which, it possess a little or no cementitious value but which will,in finely divided form and in the presence of water, will react chemically with calciumhy droxi deatordinary temperaturetoformcompoundspossessing cement itious Some of the Pozzolanic materials are fly ash and silica fume.

Fig:3.4 Pozzolanicmaterials

3.6.1 Flyash

Fly ash, also known as pulverized fuel ash, it is also one of the coalcombustion products, composed of the fine particles that are driven out of the boile rwith the fluegases.

Fly Ash is a by-product of coal-fired furnaces at power generation and it is typically finer than cement, which provides work ability to concrete because of its shape, and typically allows for strength and durability enhancing lower water contents. Strength and durability results may vary based on the fly ash chemistry. Low oxide/high calcium Class C fly ashmayprovidehigherearlyconcretestrengthsthanahighoxide/lowcalciumClass F fly ash. Class F fly ash is typically superior to a Class C fly ash in mitigating damage from both sulfate and alkali–silica damage to concrete. fly ash includes substantial amounts of silicondioxide(both amorphous and crystalline), aluminum oxide (Al_2O_3)and calcium oxide (CaO). Fly ash used in this study is class F fly ashobtained from Simhadri Thermal Power plant, NTPC. The particlesare in the formo fsolids pheres with sizesranging from less than1µto100µandanaveragediameterof20µ.Thephysical&chemicalpropertiesofflyashwerestudiedforthesuitability of usage in concrete

Table:3.13 Chemicalandphysicalcompositionofflyash

S.No	CHEMICALCONSTITUENTS	CLASSF	Requirements asper IS: 3812 (Part2):2003
1	Silicon Dioxide(SiO_2) +Aluminium Oxide (Al_2O_3)+FerricOxide (Fe_2O_3)	70%	70
2	SiliconDioxide	35%	35
3	Reactivesilica	20%	--
4	MagnesiumOxideMgO	5.0%	5.0
5	Sulphurtrioxide(SO_3)	3.0%	5.0
6	SodiumOxide(Na_2O_3)	1.5	1.5
7	TotalChlorides	0.05	0.05
8	LossonIgnition	6	5.0
Physicalpropertiesofflyash			
S. No	Physicalproperties	Obtainedresults	Requirementsas per IS: 3812(Part2):2003
1	SpecificGravity	1.915	1.9to2.8
2	Finenesstest(%)	33	34

3.6.2 SPECIFICGRAVITYOF FLYASH[IS1727–1967]:

SL NO	DESCRIPTION	SAMPLE	
1	Weightofbottle(W1),gms	29	29
2	Weight of bottle + 1/3 of fly ash(W2),gms	43	45
3	Wtofbottle+flyash+kerosene(W3),gms	80	80
4	Weight of bottle + kerosene (W4),gms	71	71

5	Weightofbottlefilledwithwater(W5),gms	82	82
6	Specificgravityofkerosene,Gk = W4−W1 (_)W5−W1	0.81	0.81
7	Specific gravity of fly ash,G =(W2−W1 -------------------------) X (GK)W4−W1 −W3−W2	1.93	1.90
8	AverageSpecificGravity	1.915	

3.6.2 FINENESSOFFLYASH[IS1727–1967]:CALCULATIONS: Weightretainedon45micronISSieve(Wetsieving) =33gms,RESULT:Thefinenessofflyash =33%

3.6.3 SILICAFUME

Silicafumeisabyproductofproducingsiliconmetalorferrosiliconalloys. One of the most beneficial uses for silica fume is in concrete it is avery reactive pozzolanic. Concrete containing silica fume can have very high strength. Silic afumeis available from supplier so fconcrete ad mix turesand,when specified,issimply added during concrete production.Silica fumeconsists primaril yo famor phous silicondioxide

Table3.14: PhysicalandChemicalPropertiesofSilicaFume

Chemicalcompositionofsilicafume			
1	SiliconDioxide(SiO_2)	85%	
2	Moisturecontent	3%	
3	Caocontent	<1%	
4	AlkalisasNA2O	1.5%	
5	LossonIgnition	4.0%	
Physicalpropertiessilicafume			
S. **No**	Physicalproperties	Obtainedresults	Requirementsas per IS: 3812(Part2):2003
1	SpecificGravity	2.32	2.1to2.8
2	Finenesstest(%)	5	5 to 10

3.7 CASTINGWORKOFSPECIMENS

3.7.1 Casting of natural aggregate concrete for the mentioned mix proportions to produce recycled aggregates.

In this study, as per Indian standard code natural aggregate cub estate busing specified/cratios.Here,Caste cubes for7and28days

Table3.17 Numberof Cubestobe Casted

Gradedesignation	% RA	%NA	Noofcubescasted
M20	0	100	30
M25	0	100	30
M30	0	100	30
M35	0	100	30
M40	0	100	30

150X150X150mmsizeironmouldswereusedforcasting.mouldsshouldbecleanedofdustparticlesandappliedwithmineraloilonallsidesbefore concrete is poured in to the moulds. The moulds are placed on alevel plat form. The well mixed concrete is filled into the mounds and kepton vibration table. Excess concrete was removed with trowel and topsur face is finished level and smooth as per IS 516-1969. Casting wasstartedforeachgradeasperthemixproportions,30cubeswerecastedforM20, M25, M30, M35 and M40 and totally 150 cubes including the wastage.

Fig:3.5 Preparationofconcrete

Fig:3.6 Slumptest

Fig:3.7 Concreteinmoulds

3.7.2 CURING

The specimens were removed from the moulds after 24hr from the time of adding the water to the ingred ients.The specimen then marked for identification. These specimens were then stored in clean water for there quired periodof curing.

Fig:3.8 Cubes inside curing tank

3.7.3 Crushing of Parent Grade Concrete Cubes using Jaw Crusher

Specimens were taken from curing tank after curing period and compressive strength were measured.After getting gthe compressive strength results for 7 and 28 days, cubes were crushed by jaw crusher and sieved. The aggregates which come out of NAC termed as GA gran it econcrete. GA 20, GA25 GA 30 GA 35 and GA 40. Aggregates were separated bysizesi.e.20mm and10mm.

3.7.4 JAWCRUSHER

A Jaw Crusherisone of the majortype of primary crushersinamineorinlab.Size ofa jaw crush erwas designated by there ctangularorsquare openin gatthe to pofthe jaws.A Jaw Crusherreduce slargesizerocksinto small size by compressingit.Byusing Jawcrus her the concrete cube were crushe din to small pieces which were separated in to10mmand20mm.

Fig:3.9JAWCRUSHER

Table:3.18 casting of RAC using three stage mixing approach

Typeof RACMix	Grade ofRA	% ReplacementofRA	no of cubesat days		TOTAL
			7	28	
M20	GA20	100%	3	3	6
	GA25		3	3	6
	GA30		3	3	6
	GA35		3	3	6
	GA40		3	3	6
M25	GA20	100%	3	3	6
	GA25		3	3	6
	GA30		3	3	6
	GA35		3	3	6
	GA40		3	3	6
M30	GA20	100%	3	3	6
	GA25		3	3	6
	GA30		3	3	6
	GA35		3	3	6
	GA40		3	3	6
Total numberofRAC Cubes=90					

3.8 TESTINGOFSPECIMENS:

The specimen sare tested by compression testing machine after 7 days curing or 28day scuring. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimengi ves the compress ivest rength of concrete.
Minimum of three specimen were selected for conducting compressive strengths at 7, 28 days. If strength of any specimen varies bymorethan15 percent of average strength, result so such
Speci men should be rejected.

3.8.1 *Compression Testing Method*

The mould swererem oved from cubes, After 24hours;the Specimens were subjected to curing for 7 days and 28 days in potable water. After curing, the specimens were tested for compressive streng thusing compression test ing machine of 2000KNcapacity(IS:516–1959).The maximum load at failure is taken. Compressive strength is measuredon auniversaltestingmachine ofcapacity200Tonnes.

CHAPTER-4
DETAILED INVESTIGATION

4.1.INTRODUCTION

Present Investigation describes bout the recycledaggregateconcrete materials and explains how the project work was done in detail, properties of all the tests results and the calculated that specific gravity, watera bsorptionandimpactvalues,crushingvaluesandtrailmixetc.Theproperties of natural aggregate and granite aggregate, average results of 7,28 days compressive strength of specimens and also the results of density,water absorption ninthe form of tables are mentionedin this chapter.

4.2 DETAILS OFDETAILEDINVESTIGATION

The detailed investigation of recycled aggregates and concrete made with100%RCAis carriedoutindifferent phases

1. Firstly, detail investigation was bed one on RCA and materials.

2. Secondly, several trail mix esusing differentw/cratios are conducted to finalize the mix design for RAC made with pozza lonas.

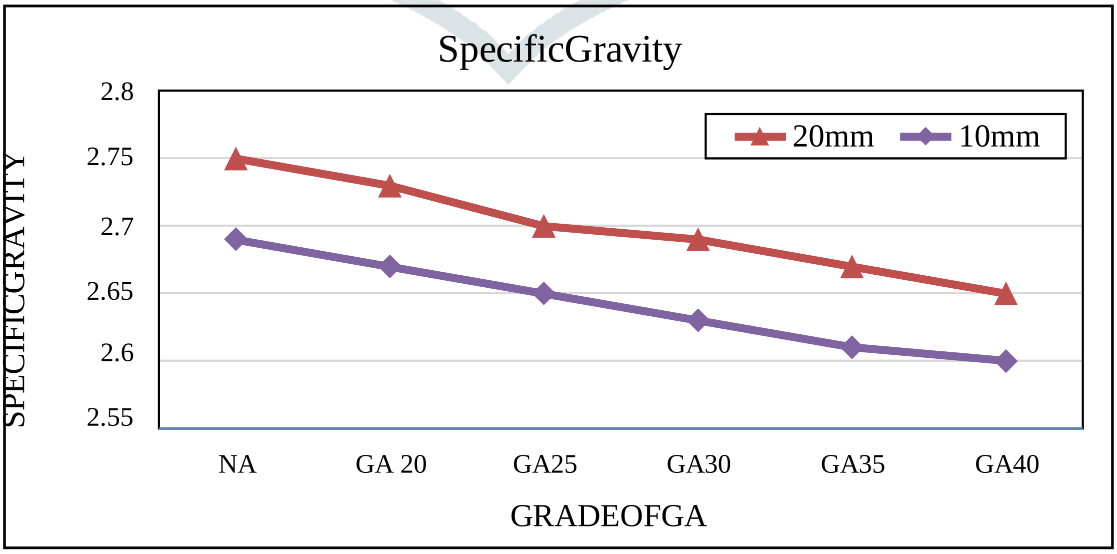
4.3 PROPERTIESOFGRANITEAGGREGATES

	GA25	32	0.32	100	21.92	33.05
	GA30	32	0.32	100	19.85	30.37
	GA35	32	0.32	100	19.70	30.22
	GA40	32	0.32	100	20.14	29.18

Table5.1 SpecificGravity

	Gradeofaggregates					
Size	NA	GA20	GA25	GA30	GA35	GA40
20mm	2.75	2.73	2.7	2.69	2.67	2.65
10mm	2.69	2.67	2.65	2.63	2.61	2.6

Fig5.1: Specific Gravity of Natural and Recycled Aggregates



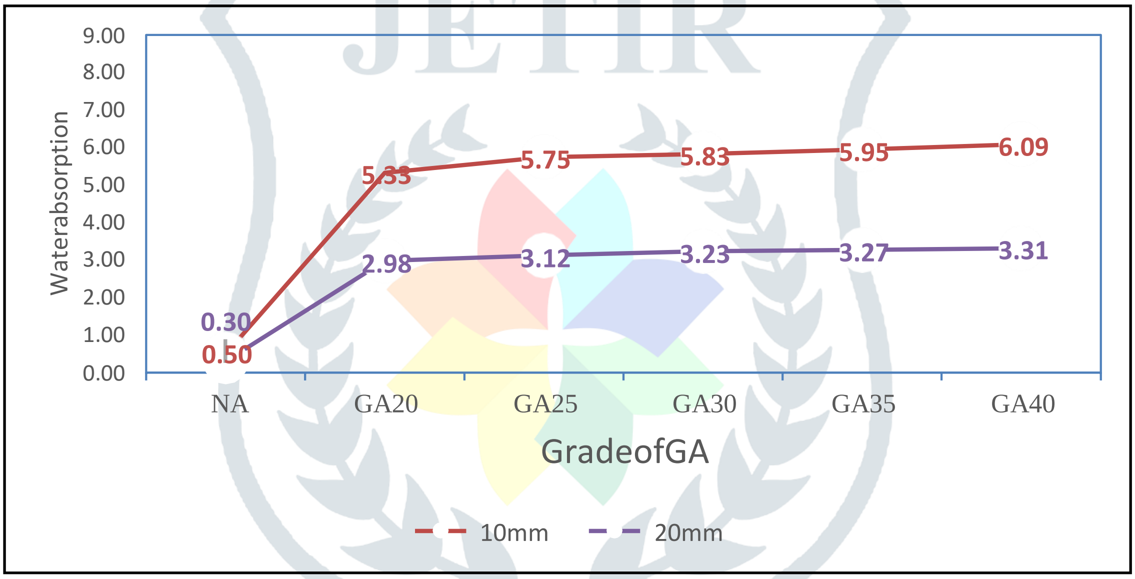
Specific gravity frecycle daggregatede creased with anin crease in the grade of concrete. Specific gravity of recycled aggregates were withintherangefrom2.6to2.8 andweresuitableforproductionofRAC.Specificgravity of recycled aggregate is lower than the natural aggregate. Specific gravity isused to determine the quality of the aggregate sand the percentage of voids in the granite aggregates which are both important in design and quality control.

5.1.1 WATER ABSORPTIONIN NATURAL AND RECYCLEDAGGREGATES

Table5.2 WaterAbsorption

	GradeofGA					
Size ofaggregate	NA	GA20	GA25	GA30	GA35	GA40
20mm	0.5	5.33	5.75	5.83	5.95	6.09
10mm	0.3	2.98	3.12	3.23	3.27	3.31

Fig5.2: Water absorption of Natural and Recycled Aggregates



Water absorption of GA have increased with anincrease in the grade of concrete.When compared to the natural aggregates, recycled aggrega teshighly increased in their water absorption. For reducing water absorption,addition of mineral admixtures(flyash, silicafume)will facilitated eveloped ITZ zone with less voids. As size of aggregate decreased, the water absorption increased due to the porosity of aggregate. Water absorption of 10mm aggregate is more than 20 mm aggregate because smaller the recycled aggregate, greater will be the presence of adhered mortar.

5.1.2 WORKABILITY(SLUMP)FOR100% RAC

Table5.4 Workability

	Workability(Slump,mm)					
Mix	NA	GA20	GA25	GA30	GA35	GA40
M 20	55	52	50	46	47	45
M25	54	49	48	44	44	45
M30	52	46	44	42	38	35

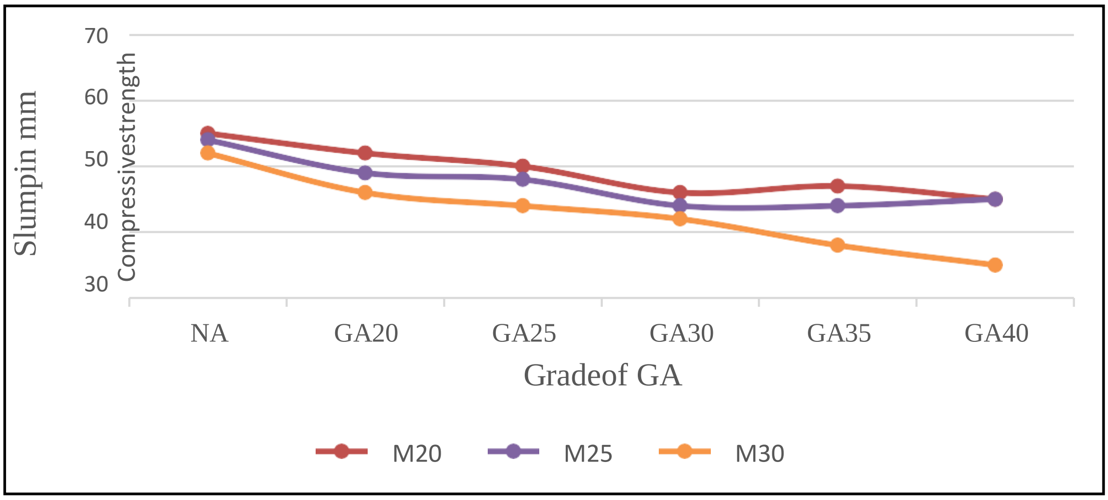


Fig 5.6: Work ability(Slump,mm)forM20,M25,M30.

Recycled aggregate concrete at 100% becomes less workable and hence a reduction in slump is observed when compared to the natural aggregate concrete mixes. In order to obtain good workability with less water absorption, three stage mixing approach was implemented in all theRACmixesi.e.M20, M25,and M30.Due to the addition no fflyashandsilicafume,theITZzonewasfilledwhichfacilitatedgoodworkabilityat the time of cast work. Recycled aggregate concrete has drastic all yr. educed its workability when cast using GA40 grade of aggregate which has more attached mortar content.

5.1.3 Compressive Strength (MPa) in M20 (7, 28 days)

Table5.7 CompressivestrengthofM20at7,28days

Gradeof GA	**CompressivestrengthofM20(MPa)**	
	7 Days	**28days**
NA	27	32
GA20	20.74	28.21
GA25	19.85	26.37
GA30	20.44	25.92
GA35	18.96	25.33
GA40	19.25	25.18

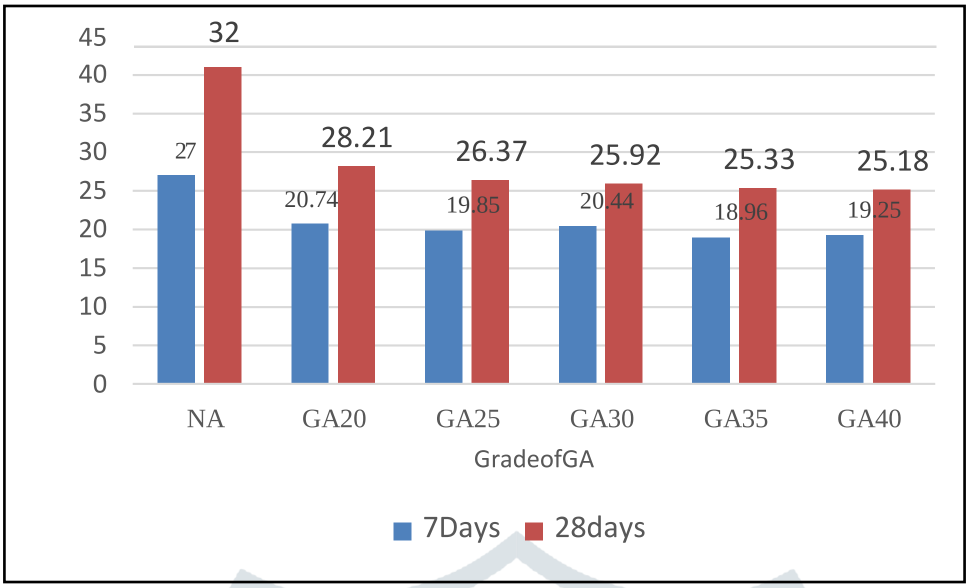


Fig5.9: CompressivestrengthofRACM20withpozzalonas

5.3.6COMPRESSIVESTRENGTH(MPA)INM 25(7, 28DAYS)WITHPOZZALONA ADDITION

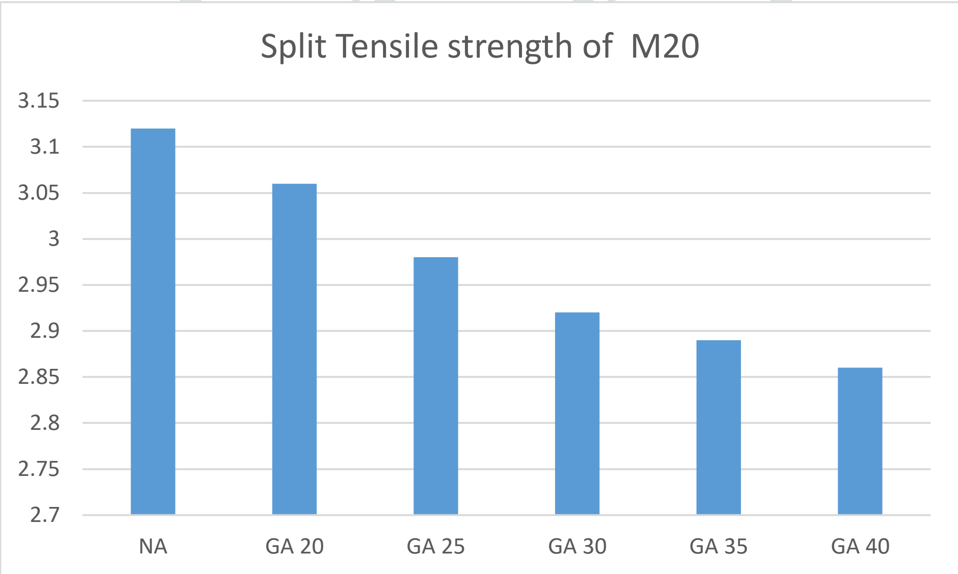


FIG5.11:SPLIT TENSILES TRENGTHOF M20WITHPOZZALONAS

5.3.9SPLIT TENSILE STRENGTH(MPA)INM 25(28DAYS)WITH POZZALONA ADDITION

Table5.8 Split Tensilestrength ofM25at28 days

Gradeof GA	**Split TensilestrengthofM25(MPa)**
	28days
NA	3.8
GA20	3.7
GA25	3.65

GA30	3.62
GA35	3.6
GA40	3.5

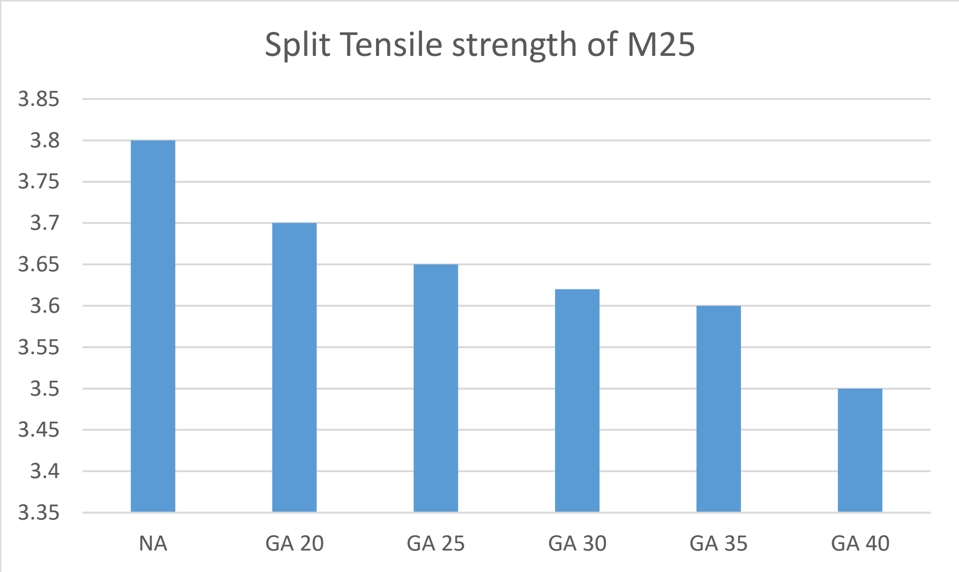


FIG5.11:SPLIT TENSILESTRENGTHOFM25WITHPOZZALONAS

CHAPTER VI CONCLUSIONS

1. With three stage mix in approach(TSMA), it is possible to achieve the workability off reshrecy cledaggre gate concrete made with 100% RCA.Recycled aggregate sper form betterat100 % when saturated surfacedrySSD condition is achieved.

2. The water cement ratio for RAC M20, M25 and M30 must beloweredto0.35,0.32, and0.32respectivelytoachievehighercompressive strengths in recycled aggregate concrete mixes made with100% RCA.

3. Additionofsuperplasticizeratadosageof10mlper1kgofcementwasobserved to improve compressive strengths atearlyages.

4. Three stage mixing approach is possible to achieve the workability offresh recycled aggregate concrete made with 100% replacement ofrecycled coarse aggregate.

5. The 28-days compressive strength in RAC M20, M25, and M30with 100 % RCA mix has achieved the characteristic strength whenGA20 was used and the remaining grades also achieved almost nearlythetargetstrength.

6. Fly ash and silica fume materials at different percent like 20&10,20&20,20&30 percent replacements to cement have improved the workability and compressive strength at early ages because pozzolanic materials fills and controls the water absorption no the recycled aggregate.

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