ISSN (e): 2250 – 3005 || Volume, 07 || Issue, 04|| April – 2017 ||
International Journal of Computational Engineering Research (IJCER)

Replacement Of Aggregate By C & D Waste Concrete

[1]sharmili Routray, [2]subrata Paikaray,
Gandhi Institute of Excellent Technocrats, Bhubaneswar, India
Krupajal Group of Institutions, Bhubaneswar, Odisha, India

ABSTRACT:-Construction and demolitions activitieshaveincreasedphenomenallyforthepasttwodecades.With these construction activities going up, we arefalling short for the construction materials, especiallyaggregates, therefore finding an alternate resource istheneedofhour.Usingrecycledaggregatewillnotonlyconserve rapidly depleting non-renewable resourcebut also provide a sustainable disposal solution foralreadyaccumulatedwaste.Theaggregatescaneitherbe reused directly by giving proper dressing or it canbecombinedwithvirginaggregatesincertainproportionsandusedfordifferentconstructionactivities especially in pavement constructions. TheaimofthisstudyistoevaluatethestrengthandeconomiccharacteristicsofM20concretepreparedbyreplacingnaturalaggregateswithdemolishedconcretecoarseaggregates.Eachreplacementmixwascompared with characteristic propertiesexhibit byconcrete mix prepared using virgin aggregate. In thisstudy replacement of recycled aggregate was done inthreeproportionsi.e.10%,20%and30%.Eachsamplewastestedforcompressivestrength,flexuralstrengthandsplittingtensilestrengthfor7&28daysandcomparedwithstandardconcrete,eachtestwasreplicatedwiththree samples.

KEYWORDS: Demolished concrete coarse aggregate,Compressive strength, split tensile strength, flexuralstrength,sustainable development

I. INTRODUCTION:

Sustainabilitycanbedefinedassatisfyingtoday'sneedwithoutcompromisingthecapabilityoffuturegenerationstomeettheirneeds.Sustainableconstructionisaccomplishedbyusinglessnaturalmaterials, causing low pollution, and reducing wastewhileachievingthesameadvantagesthatcanbeachievedthroughtheuseoftraditionmaterials[1][14].Recyclingistheprocessingtheusedmaterialforuseincreatingnewproduct.Theusageofnaturalaggregateisgettingincreasingwithadvanceddevelopmentin infrastructure area. In order to reduce the usage ofnatural aggregate, recycled aggregate can be used asthereplacementmaterials.Recycledaggregatearecomprisedofcrushed,gradedinorganicparticlesprocessed from the materials the materials that havebeenusedintheconstructionsanddemolitiondebris.Thesematerialsaregenerallyobtainedfrombuildings,roads,bridgesandsometimesfromwarsandearthquakes.Recycledaggregatehavebeenusedintheroadindustryforthelast100yearsinAustralia[13].In2012, the global market for construction aggregateswasexpectedtoincrease5.2%peryearuntil2015,up to 48.3 billion tonnes, and is expected to expandeven further to 66.3billiontonnesby2022 [2]. Asper Rahul, K. (2007), recycled aggregate concrete andnormalaggregateconcrete(NAC)showedsimilartrends in development of compressive strength, withrelatively faster gain of strength in NAC upto age of 7days. The RCA which can be obtained from the sitetestedconcretecubescanbeveryusefulsinceitshowsgoodpotentialascoarseaggregateforthenewproduction of concrete [15]. Concreteup to30% ofcoarse aggregate was replaced by demolished wastewhichgavestrengthclosertothe strength of plainconcretecubesandstrengthretentionwasrecordedinthe range of 86.84-94.74% for recycled concrete mix[16].

Application ofRecycledAggregates

Recycled aggregate have been used as concrete kerbandguttermixinAustralia.AccordingtoBuildingInnovation&ConstructionTechnology(1999),the10mm recycled aggregate and blended recycled sandareusedforconcretekerbandguttermixintheLenthallStreet projectinSydney.

According to Market Development study for RecycledAggregateProducts(2001),recycledaggregateare

used as granular base course in the road constructionandprovedtobebetterthannaturalaggregatesonwetsubgradeintermsofstabilizingthebaseandimprovedworkingsurfaceforpavementstructureconstruction.Recycled aggregate can be used in embankment fill.The reason for being able to use in embankment fill issameasitisusedingranularbasecourseconstruction.Recycledaggregatehavebeenusedaspavingblocksin HongKong. AccordingtoHousingDepartmentrecycledaggregate are used as typical paving blocks (2002).MehusandLillestlfoundthatNorwegianBuildingResearch Institute mentioned that recycled concreteaggregatecanbeusedasbackfillmaterialsinthepipezonealongtrenchesafterhavingtestinginlaboratory.Figure 1 shows the diagrammatic representation ofnaturalandrecycledaggregates.

Figure1.NaturalandRecycledAggregates

Advantagesof RecycledAggregates
Therearemanybenefitstousingrecycledaggregates.

- Useofrecycledaggregatesovernaturalmaterialscansavemoneyastheyarelessexpensivetoproduce.
- Producingrecycledaggregateforresaleismore cost-effective than sending un-wantedmaterialstolandfillandincurringlandfilltax.
- Recycled Aggregate is regarded to be a 'green'constructionmaterial.Usingrecycledaggregatereducestheamountofvirginaggregateswhichare created and therefore means less use ofnaturalresources.
- Thereisincreasingpressureonlandfillcapacity,andpressureonconstructionsitestodivertwasteawayfromlandfillto meetsustainabilitytargets.Souseofrecycledaggregates conserves landfill space, reducestheneed fornewlandfills.
- Studies proved that Recycled Aggregate is asstructurallyreliableasnaturalaggregateandisas safe to use.

IndianStatus
Thereissevereshortageofinfrastructuralfacilitieslikehouses, hospitals, road etc. in India and the need ofquantitiesofconstructionmaterialsforcreatingthesefacilities is large. The planning Commission allocatedapproximately50%ofcapitaloutlayforinfrastructuredevelopmentinsuccessive10thand11thfiveyearplans.CentralPollutionControlBoardhasestimatedcurrentquantumofsolidwastegenerationinIndiaof48milliontonsperannum outofwhich,wastefromconstruction industryonlyaccountsformorethan25%. The total quantum of waste from constructionindustryisestimatedtobe12to14.7milliontonsperannum out of which 7-8 million tons are concrete andbrick waste. According to findings of a survey, 70% oftherespondenthavegiventhereasonfornotadoptingrecycling of waste from construction industry is "Notaware of the recycling techniques" while remaining30% have indicated that they are not even aware ofrecyclingpossibilities.

Necessityfortheuseofrecycledconcreteaggregates
Themajorreasonsfortheincreaseofdemolitionconcretewasteare:

- Many old building and other structures haveovercome their limit of use and need to bedemolished.
- Structures, even adequate to use, are underdemolition,becomestherearenewrequirementsandnecessitiessuchasnewearthquake zones.
- Creation of building wastes which result fromnaturaldestructivephenomenasuchasearthquakes,stormsetc.

The basic composition of demolition waste accordingtoMeddah (2017)isshowninfigure 2.

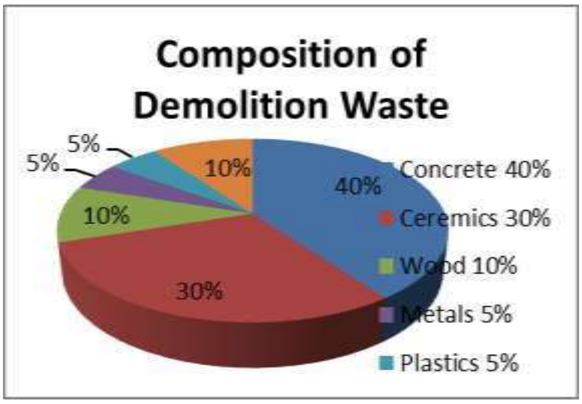

Figure2.CompositionofDemolitionWaste.

II. MATERIALSANDMETHODS

Inthedesignofconventionalconcretetheselectionofproper ingredients, evaluating their properties andunderstandingtheinteractionbetweendifferentmaterials plays a major role in performance of theconcrete.Theingredientsusedinthestudyarecement,natural sand, coarse aggregate, demolished concretewasteinthe form ofcoarse aggregate.

Demolishedconcretewaste

Theconcreteobtainedusingdemolishedwasteaggregatesatisfiestheminimumrequirementsofnewbought aggregates. Concrete using demolished wasteaggregatesresultedinacceptablestrengthrequiredforstructuralconcrete.TheDemolishedwaste-cementcompositeiscompatibleandnopre-treatmentisrequired.

Thedemolishedwastewasobtainedfromaconstruction site. They are dried for few days beforebeing crushed manually. The crushed materials arelater transported to the laboratory where they werewashedandallowedtodryunderambienttemperatureforseveralhours.Coarseaggregatesshowawidediversityinsize,weight,shape,andcolour,dependingonthecrushing.

RecycledAggregate

Aggregatetypicallyprocessedbythecrushingofparent or oldconcretesuchasdemolishedwasteconcreteis regardedas recycledconcrete aggregate(RCA). Generally RCAs are mixed with bricks, tiles,metals and other miscellaneous such as glass, wood,paper,plasticandother debris[17].

Figure3 showstheclear differencebetweentherecycled coarse aggregate and natural virgin coarseaggregate. In recycled coarse aggregate it containoldattached adhered mortar on the surface of aggregatebut surface ofnatural virgin coarse aggregate is freefrom adhered mortar.

Figure 3:Process of using recycled Aggregate inConcrete[17]

PreparationofSpecimens

Concretemixproportionsofratio1:1.5:3(M20)isusedforthepreparationofspecimens.Conventionalspecimenswerecasted.Recycledaggregatespecimensispreparedwherethecoarseaggregateisreplacedbythe recycled coarse aggregate from concrete waste ofabout 10%, 20%, 30%. The specimens were cured byusingtapwateratroomtemperatureandtestedattheageof 7and28days.

III. MIXDESIGN

A mix design is a method of calculating the amount ofcoarse aggregate, fine aggregate, cement content andwater content is calculated by using the experimentalvaluesobtained.

DESIGNSTIPULATIONS:
Mix of concrete is M20. The f_{ck}valve is 20 N/mm^2·Considermaximumaggregatesizeis20mm.Degreeofworkability=0.90 (compactionfactor)
TypeofExposure=Mildexposure

TESTDATAOFMATERIAL:
Specific gravity of cement = 3.15SpecificgravityofCA = 2.63SpecificgravityofRFA =2.45

Waterabsorption:
CA=0.5 %RFA=1.8%
Free(surface)moisture:
CA= nilRFA=1%
SandconformingtoZoneI.
(RFA-RECYCLEDFINEAGGREGTAE)

MIXDESIGNCALCULATIONS:

TARGETMEANSTRENGTH:
f_{ck}'=f_{ck}+(t*s)f_{ck}'= 20 + (1.65*4)
S, t obtained from IS 10262-2009Targetmeanstrength=26.6Mpa

WATERCEMENTRATIO:

FromIS 10260-2009thewater/cement ratioisobtainedas0.50
From the above values the amount of water contentis 186kgandthepercentageof sandis 34.5%

ConcreteMixes

ConventionalCubes:
Volume of each cube = 3.375 x 10 m^3Volume of 3cubes =10.125 x10m^3
Quantityofmaterialsrequired(considering10%loss)Cement=5 kg
Sand =7.7 kg
Coarse aggregates =15.7 kgWater=2.5 lit
Themixdesigniscalculatedandtheamountofaggregate need for 9 cubes is calculated. The mix isdone by hand by adding water at different interval.Table1showsproportionofeachmixmaterialsforsixcubes.

Table1:Proportionofeachmixmaterialsforsixcubes

	Cement	Sand	N.A.	R.A.	Water
30%	9.9kg	21.72kg	14.09kg	9.40kg	5.5 lit
20%	9.9kg	21.72kg	18.79kg	4.7kg	5.5 lit
10%	9.9kg	21.72kg	21.31kg	2.8kg	5.5 lit
0%	9.9kg	21.72kg	23.49kg	-	5.5 lit

IV. TESTSONAGGREGATE

I) **ImpactStrengthTest**(IS:2386(PartIV)–1963)

Aggregates Impact strength is determined by impacttestingmachine.Impactvalueoffreshaggregatesandrecycledaggregate areshownintable2.

Table 2: Impact Value of Fresh Aggregates andRecycledAggregate.

S.NO.	Particulars	ImpactValue
1	FreshAggregates	20
2	RecycledAggregates	23

II) CrushingStrengthTest(IS:2386(PartIV)–1963)

AggregatesCrushingstrengthisdeterminedbycompressivetestingmachine.Crushingvalueoffreshaggregatesandrecycledaggregateareshownintable3.

Table 3: Crushing Strength of Fresh Aggregates andRecycledAggregate.

S.NO.	Particulars	CrushingStrengthN/mm^2
1	FreshAggregates	25
2	RecycledAggregates	29

III) SpecificGravityTest(IS:2386(PartIV)–1963)

AggregatesSpecificGravityisdeterminedbyPycnometer. Specific Gravity of fresh aggregates andrecycledaggregate areshownintable**4**.

Table 4: Specific Gravity of Fresh Aggregates andRecycledAggregate

S.NO.	Particulars	SpecificGravity
1	FreshAggregates	2.65
2	RecycledAggregates	2.53

V. TESTSONCONCRETE

CompressiveStrengthTest(IS:516-1959)

Compressivestrengthswereattainedasaresultofthecompressivetestsconductedonthecubespecimensofsize 150mm x 150mm x 150mm. Cube was placed onthe platform of the compression testing machine. Theload was applied gradually till specimen failure. ThespecimensaresubjectedtocompressiveloadsincompressiontestingmachineasperIS:516-1969andthecrushingloadisnotedwhichgivesthecompressivestrengthofthatcube.Thecompressivestrengthistheratioofcrushingloadtothesurfaceareaofthespecimensexpressedin N/mm2.Similarlythecompressionstrengthvaluesofallthe cubesarefoundfor7 days and28 days.

SplitTensileStrengthTest(IS:5816-1999)

Split tensile strength of concrete is usually found bytesting cylinders specimen of size 150mm x 300 mmwere casting using M20 grade concrete. Specimens oftwodifferentpercentageswerecasted.Duringcastingthe concrete cubes were manually compacted usingtampingrods.After24hours,thespecimenswereremovedfromthemouldandsubjectedtowatercuringfor7,28days. Aftercuring,thespecimensweretestedforcompressivestrengthasperIS:5816-1999usingacalibrated compression testing machine of 2000KNcapacity. The specimen was placed on the plywoodstripandalignedsothat,thecentralhorizontalaxisofthespecimenisexactlyperpendiculartotheloadapplying axis. The second plywood strip was placedlength wise on the cylinder and the top platen wasbroughtdowntillittouchedtheplywood.Theloadwasappliedwithoutshockandincreasedcontinuouslyuntilthe resistances of the specimen to the increasing loadbrokedownandnogreater loadcanbe sustained.

Tensilestrengthofconcreteft=$\frac{2p}{\pi DL}$

Where,P=MaximumloadinNappliedtothespecimenL=Measuredlengthincmofthe specimen
D=Measureddiameterincm ofthespecimen

FlexuralStrengthTest(IS:516-1959)

Theflexuralstrength representsthehighest stressexperiencedwithinthematerialatitsmomentofrupture. It is measured in terms of stress, here giventhesymbolfcr.Theflexuralstrengthsoftherespectivespecimens have been obtained from the flexural testsperformed on the prism specimens of size 100mm x100mmx500mm.Theflexuralstrengtharetestedusingatwopointloadingframemachineasperstandard. The modulus of rupture can be determinedbyusingthe belowgivenformula:

fcr=$\frac{Pmax\, l}{bh2}$

Where,
fcr=Flexuralstrength
Pmax = maximum load in (N) kg.b=widthofthe prisminmm
h = depth of the prism in mml=spanof the prisminmm

VI. RESULTSANDDISCUSSION

The results obtained from the various experimentsconductedtoaccessmechanicalproperties.Theaimofthe study is to determine the compressive strength,flexuralstrengthandspilttensilestrengthsotheresultsoftestspecimensarepresented.Themechanicalproperties ofconcretesuchascompressivestrength,flexuralstrengthandsplittensilestrengtharedeterminedfrom the standardexperiments.

CompressiveStrength
Afterpreparingthecube,Compressivestrengthisdeterminedbycompressiontestingmachine.Compressivestrengthofcubesafterreplacementoftherecycledcoarseaggregateindifferentproportionsfor7days and28 daysareshowninTable 5**.**

Figure4showstheBarChartforCharacteristicCompressive strength and replacement percentage ofrecycledaggregateasproportionof0%,10%,20%and 30%.

Table 5: Compressive Strength of Recycled CoarseAggregate at Different Replacement % for 7 And 28Days.

S.NO.	**Replacementof recycled Aggregates(%)**	**Compressivestrength(N/mm^2)for 7days**	**Compressivestrength(N/mm^2)for 28days**
1	**0**	**12.72**	**19.42**
2	**10**	**9.96**	**18.33**
3	**20**	**12.88**	**18.11**
4	**30**	**13.92**	**19.35**

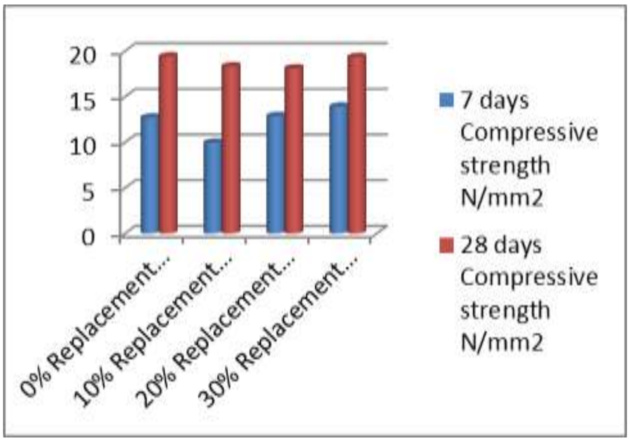

Figure 4: Characteristic Compressive strengthand replacement percentage of recycledaggregate

TensileStrength

Afterpreparingthecube,Tensilestrengthisdeterminedfor7daysand28days.Tensilestrengthofcubes after replacing the recycled coarse aggregate indifferentproportionsfor7daysand28daysisshowninTable **6.**

Figure5showstheBarChartforTensileStrengthandreplacementpercentageofrecycledaggregateasproportionof 0%, 10%, 20%and30%.

Table 6: Tensile Strength of Recycled CoarseAggregate at Different Replacement % for 7 And 28Days.

S.NO.	Replacementof recycledAggregates(%)	TensileStrength(N/mm^2) for7days	TensileStrength (N/mm^2)for28days
1	0	2.50	3.14
2	10	2.43	3.37
3	20	2.39	3.25
4	30	2.35	2.94

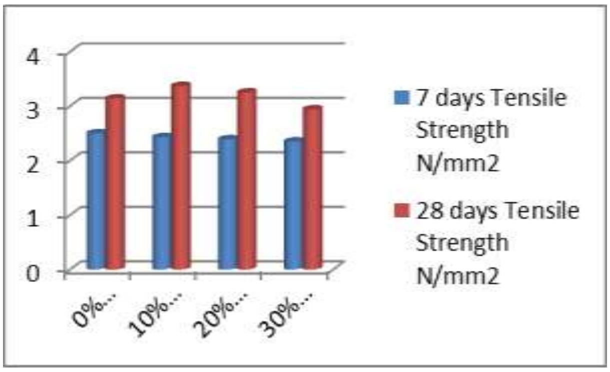

Figure 5: Tensile Strength and replacementpercentageof recycledaggregate

FlexuralStrength
Afterpreparingthecube,Flexuralstrengthisdeterminedfor7daysand28days.Flexuralstrengthofcubes after replacing the recycled coarse aggregate indifferent proportions for 28 days is shown in Table 7.Figure6showstheBarChartforFlexuralStrengthandreplacementpercentageofrecycledaggregateasproportionof 0%,10%, 20% and30%.

Table 7: Flexural Strength of Recycled CoarseAggregateatDifferentReplacement%for28Days.

S.NO.	ReplacementofrecycledAggregates(%)	FlexuralStrength(N/mm^2)for28 days
1	0	3.91
2	10	3.85
3	20	3.67
4	30	3.74

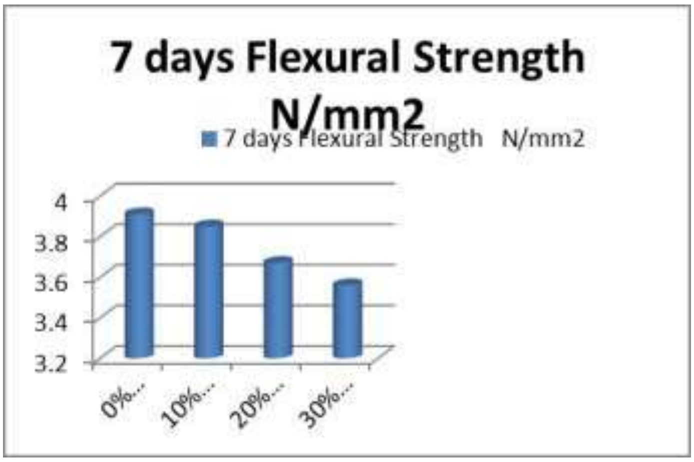

Figure 6: Flexural Strength Split and replacementpercentageof recycled aggregate

VII. CONCLUSION

M20 grade of concrete is used in this study and testsareconductedondifferentproportionofrecycledaggregate 0%, 10%, 20% and 30% in concrete. Basedonstudybelowconclusionaredrawn:

1. The28dayscompressivestrengthoftheconcrete increases with the increases in thepercentageoftherecycledaggregatereplacement.Thevalueofthecompressivestrengthisfoundtobemaximumat30 %replacement of the aggregates by the recycledaggregates.At20%replacementofcoarseaggregate compressive strength is decreased,theproblemcanbeovercomebyaddingmineraladmixture.
2. TheFlexuralstrengthandsplittingtensilestrengthofallthreesetsofreplacedconcreteisdecreasingasproportion ofrecycledaggregateis increased.
3. Replacement of demolished concrete waste innewconcretewilldecreasethecostofmakingconcreteandreducethewastegeneratedfromtheold demolishedconcrete.
4. By the analysis it is clear that the individualproperties of the recycled coarse aggregatesare slightly lower than the natural aggregatesbutdoesnotaffectthestrengthcharacteristicsathigh extent.
5. Recycledaggregatemustbeusedathigherreplacementlevels,maximumbenefitintermsof compressive strength and bond strength isachieved.

REFERENCES

1. AkmalS.AbdelfatahandSamiW.Tabsh(2011)"ReviewofResearchonandImplementationofRecycled Concrete Aggregate in theGCC,"AdvancesinCivilEngineering,vol.2011,Article ID 567924, 6pages.https://doi.org/10.1155/2011/567924.
2. Freedonia,Worldconstructionaggregates.IndustryStudyNo2838.Cleveland,Ohio,USA:TheFreedonia Group, 2012.
3. 'HandbookonConcreteMixes(BasedonIndianStandard)', Indian Standard Institution, NewDelhi,SP:23-1982
4. IS:2386,"MethodofTestforAggregates",Bureauof IndianStandards, 1963
5. IS: 383-1970. Specification for coarse and fineaggregates from natural sources for concrete(Secondrevision).
6. IS: 2386-1963 part-III (Eighth reprint march1997). Indian standards code of practice formethods oftestfor aggregateforconcrete.
7. IS:2386-1963part-I(EighthreprintAug1997). Indian standards code of practice formethods of test for particle size and shape ofAggregate.
8. Jianzhuang, X.and FalknerH. (2007) 'Bondbehaviourbetweenrecycledaggregateconcrete and steel rebars', Construction andbuildingmaterials, 21,pp.395-401.
9. Khatib,J.M.(2005)'PropertiesofconcreteIncorporatingfinerecycledaggregate',CementandConcreteResearch,V.35,pp.763-69