International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

EXPERIMENTAL STUDY ON COARSE AGGREGATERECYCLED CONCRETE

Gaddameedi Sushma, K.Mallikharjuna Rao
PG scholar, Department of civil, ST. Mary's Group of Institutions
Assistant professor, Department of civil, ST. Mary's Group of Institutions

ABSTRACT

The objective of this study is to know the strength of concrete made with recycled concrete coarse aggregate. The consideredvariables in the study includes the source of the recycled concrete and concrete strength. The toughness and soundness test results on the recycled coarse aggregate showed higher percentage loss than natural aggregate, but remained within the acceptable limits.. The compressive and splitting tensile strengths of concrete made with recycled coarse aggregate depend on the mix proportions.

For the conservation of natural resources, reuse and recycling of Construction and Demolition Waste is the most obvious way to achieve sustainability in the construction sector. Currently, recycled aggregate (RA) is produced from Construction and Demolition Waste in modern recycling facilities, under good quality control provisions which could lead to improve its performance compared with the earlier days of recycling. Recycling concrete wastes will lead to reduction in valuable landfill space and savings in natural resources.

Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world, and most of it is used in landfills. Research by concrete engineers has clearly suggested the possibility of appropriately treating and reusing such waste as aggregate in new concrete, especially in lower level applications.Recycled coarse aggregate (RCA) is the most common idea, but it does not gain wide acceptance among practitioners due the adhered mortar poses which deleterious effects on the concrete. However, a suitable concrete mix design enables the recycled aggregate concrete (RAC) to the achieve target strength and suitable for wide range of applications in construction. .

In this study recycled coarse aggregates obtained by crushed concrete were used for concrete production. Four different recycled aggregates concrete produced; made with 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively. The mix proportions of the four concretes were designed in order to achieve the same compressive strengths. Recycled aggregateswere used in wet condition, but not saturated, to control their fresh concrete properties, effective w/c ratio and lower strength variability. The necessity to produce recycled aggregate concrete with low- medium compressive strength was verified due to the requirement of the volume of the cement.

INTRODUCTION

Much of our Nation's infrastructure (roads, buildings,and bridges) built during the middle twentieth century is inneed of repair or replacement. A large volume of cement- and Asphalt-concrete aggregates will be required to rebuild thisinfrastructure and support new construction. Use of construction and demolition debris and reclaimed asphalt pavement as sources of aggregates is increasing.

Urbanization has generated a high demand for constructionaggregates and increased quantities of constructiondebris that may provide an additional source for aggregates.Recycling is impacted by local and regional conditions andmarket specifications. Relative transportation distances and costs among construction and demolition sites, recyclers,competing natural aggregate producers, local landfills, andmarkets influence howmuch material is available for recyclingand set local pricing and fee structures. Plant location, design, andefficiency can have significant impact on economicperformance. The quantity, consistency, quality ofmaterial and a skilled labour force also affect plant efficiencyand market options available to the recycler. Costsassociated with equipment, labour, and overhead are importantto operational economics, but revenues generated by-product pricing and tipping fees are even more significant.There will continue to be opportunities for new entrants, butadding new recycling capacity to a market with limitedresources impacts the profitability of all participants.

1.2 OBJECTIVE

Although recycled aggregates are complicated to specify their properties, following properties are well-known factors of recycled aggregate concrete (RAC): a lower density, elastic modulus, strength and a higher water absorption capacity. Due to the fact thatrecycled aggregate has a proportional mortar which attached to aggregate, it gives a higher porosity and a lower strength to RAC than the normal concrete. To improve these weakness of RAC, this experiment was performed and different initial moisture contents of recycled coarse aggregate. In addition, since recycled aggregates require a more amount of water than natural aggregate, shrinkage issue could be a problematic to use RAC in practically.This study was undertaken to provide an understanding of the options for aggregates supply in construction. Technical and economic information on the aggregates recyclingindustry is developed in order to analyse the factors influencing aggregates recycling, determine why recycling is occurring, and assess the effects of recycling on the natural aggregates industry. Although data on aggregates recycling are available, no concise data source exists for this important.

2. LITERATURE REVIEW

In recent years certain countries have considered the reutilisation of construction and demolition waste as a new construction material as being one of the main objectives with respect to sustainable construction activitiesIt also presents a review of available literature on physical, mechanical and durability properties of RC aggregates, and mechanical, durability and structural properties of RCA concrete This thesis focuses on recycling of concrete waste as an aggregate in structural concrete in flexure and punching shear. Many researchers have dedicated their work to describe the properties of these kinds of aggregate, the minimum requirements for their utilisation in concrete and the properties of concretes made with recycle aggregates.

. The literature review presents the current state of knowledge and examples of successful uses of alternative materials in concrete technology, and in particular the use of Recycled Concrete (RC) aggregate as a coarse aggregate fraction in non-structural and structural concrete.

FIG 2.1: DISMANTLED COARSE AGGREGATE

It has been estimated that approximately 180 million tones of construction & demolition waste are produced each year in European Union. The Netherland produces about 14million tons of buildings and demolition wastes per annum in which about 8 million tons are recycled mainly for unbound road base courses. The volume of construction waste in Kuwait was estimated at 4.1 million tons at a rate of 11,000 tons per day in 2010, which is considered high compared to international figures.

In general, in EU, 500 Kg of construction rubble and demolition waste correspond annually to each citizen. Indicatively 10% of used aggregates in UK are RCA, whereas 78,000 tons of RCA were used in Holland in 1994. Guide for Cement & Concrete Association of New Zealand (CCANZ) 8 has show that the charges applying $10/ton on land fill dumping often make recycling concrete aggregate (RCA) a preferred option. The use of RCA to conserves natural aggregate & the associated environmental cost of exploration & transportation waste

It has been estimated that approximately 13 million tons of concrete is demolished in France every year whereas in Japan total quantity of concrete debris is in the tune of 10-15 million tons each year

USA is utilizing approximately 2.7 billion tons of aggregate annually out of which 30-40% are used in road works and balance in structural concrete work

- **Indian Status**

There is severe shortage of infrastructural facilities like houses, hospitals, roads etc. in India and large quantities of construction materials for creating these facilities are needed.

In view of significant role of recycled construction material and technology in the development of urban infrastructure, TIFAC has conducted a techno-market survey on 'Utilization of Waste from Construction Industry' targeting housing /building and road segment. over 12 to 14.7 million tons per annum out of which 7-8 million tons are concrete and brick waste. According to findings of survey, 70% of the respondent have given the reason for not adopting recycling of waste from Construction Industry and remaining 30% have indicated that they are not even aware of recycling possibilities.

Abdel-Hay [7] studied three groups of mixes containing different water to cement ratios (w/c), and each of these groups involved five mixes with different amounts of recycled aggregate. He found that all the concrete mixes had low workability, and the workability decreased with increasing percentage of recycled aggregate content because of the high-water absorption of the recycled aggregate and its rough surface texture.

METHODOLOGY

3.1 USE OF RCA IN HIGH VALUE APPLICATIONS

Demolition chain supply chain consists of a series of key processes. Particularly the supply chain for processing RCA includes demolition, segregation and sorting, transportation, recycling and final residue treatment from the recycling process. Demolition is the first key process in the supply chain and the method used for demolition is critical as that is the process, which generates demolition waste. The demolition outcome and the output of the demolition process need to be predicted for a given building data. The process following demolition would be sorting and segregation prior to assigning them for different treatment or disposal methods. Presence of a site waste management plan, prior planning adopted on managing the demolition activity are pre-requisites to

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conduct sorting and segregation operations effectively.

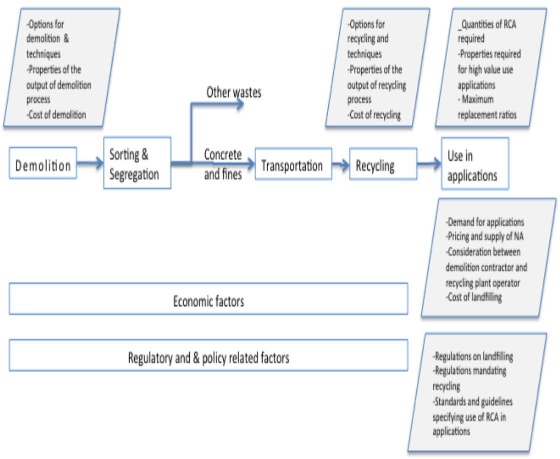

Figure 3.1: Framework for analysis of demolition supply chain to optimize use of RCA in concreting

Facility following segregation, and may be stored at site. It is assumed that different recycling practices.

3.2 USE OF RCA IN HIGH VALUE APPLICATIONS

Use of RCA typically accounts for low value and high value uses. High value use of RCA include use for concrete, pre-cast concrete blocks and in clinker manufacturing. The low value uses include use of RA and RCA as a road filling material in use in pavement sub-bases. One significant advantage of using crushed concrete as a road sub-base is that the same weight of recycled material may offer 10-15% higher product volume. This means the user will get more volume for less value if recycled material is purchased (Hider Consulting, 2011).

RCA is different in physical properties to the commonly used crushed natural aggregates (Lori G. et al.) mainly due to the presence of very fine particles. Presence of fines affect the hydration and water absorption properties generally (Kernel et al.2007). Sulphate content is another limiting factor in determining replacement ratios of recycled product. RCA can be used in concrete for structural and non-structural applications.

Plain cement concrete (PCC) & reinforce cement concrete is collected from sites (i.e MangaolGrampanchyat School, Mangaol, Haveli, Pune) respectively. This collected material is crushed by hammer to separate the aggregates & reduce their sizes in smaller fraction. On these separated aggregates various testes are conducted in laboratory as per Indian Standard code & their results are compared with natural aggregates. Recycled aggregate reduces the impact of waste on environment. By using some percentage in construction sector, cost is saved, due to reduction of transportation & manufacturing process.

RCA to be used in concrete has been established which recommends use of RCA for specific structural and non-structural applications. For aggregate characterisation composition tests of aggregate, absorption, density, and sulphur content and soluble sulphates in acid have been carried out. Depending on the concrete and ceramic particles, the RCA is recommended to be classified into 3 categories by (Agrela et al., 2011).

1. Concrete Recycled aggregate (CRA) - Concrete content >=90%,
2. Mixed Recycled Aggregate (Mix RA) - Ceramic content >10% and <=30%, 6
3. Ceramic recycled aggregates (CerRA) - Ceramic content >30% in the above CRA is suggested for concrete applications whereas Mix RA is recommended for non-structural applications.

One limiting factors identified in using MixRA for applications of non-structural use are high water absorption which result in a need for regulation of the total amount of water in the mix. The sulphate content in the MixRA limits the maximum replacement in the mix, which typically amount to about 40%. Literature suggests further investigations on compressive and tensile strengths with additions of MixRA in concrete for non-structural

While use of RA and RCA in concrete in a closed loop is the most desirable in terms of conservation of material and hence sustainability, there are a few key challenges identified and measures suggested in current literature(Soutsos et al., 2011). They are developing technology and conduct research and development on improving the quality of RA with better recycling methods, specification of RA in concrete in standards and expand specifications for the use of RCA in concrete for specific applications, conducting confidence building among users, influencers and other stakeholders by demonstrations and sharing of results in use and facilitate flow of information on the use of RA in concrete.

3.3 ECONOMIC AND DEMAND FACTOR OF RCA

The economic factors include the economic incentives and consideration applied in the demolition supply chain. If the economic incentives are the main driving force for decisions specifically for the demolition contractor, recycling plant operator and RCA buyer, the dynamics of the supply chain will be influenced greatly by economic incentives. Duran et al. (2005) established that out of the two policy instruments, namely the command and control measures and market based instruments, the market based instruments are the best method for policy makers to increase economic viability of recycling. Market based instruments could work in two main ways applicable to RCA. By imposing a tax on landfilling the incentive to recycle increases for the generators of waste. The tax on landfilling here is a reflection of environmental damage and hence the social cost associated with landfilling (Duran et al., 2005).

The second is to impose a tax on NA which makes NA costly for purchasing and makes RCA price competitive with NA for the user of aggregate product. This works ideally when there AR underlying assumptions that the user does not perceive a difference between NA and RCA for concreting and all other factors are indifferent towards the use of RCA.

When RA is used for low value uses such as a road sub base aggregate, usually the cost of supplying the recycled material to the market including the cost of crushing, exceed the price of material for the particular use (Soutsos et al., 2011). In that context, the demolition contractor needs to pay the recycling plant operator a fee for the recycling of concrete and fines. This acts as disincentive for concrete and fines to be diverted to recycling, when land filling is also an expensive option and when little or no regulations exist mandating diverting of recyclable waste in the C&D stream to recycling.

CONSTRUCTION WASTE

4.1 WHAT IS CONSTRUCTION WASTE

Construction waste& Demolition (C&D) waste account for 30-40% of waste generated on a worldwide average. It is considered as a large volume single waste stream.

The extent of the C&D waste stream differs from country to country and differs considerably between countries worldwide. The differences are significant even among developed countries such as Japan (16%), United States (29%), Australia (42%) and UK (>50%). Per capita waste generations also show large variations such as Norway with 0.2 tons/

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capita, Australia with 0.88 tons per capita and UK with 2 tons/ per capita approximately. The variations could be explained by the economic activity, differences in building tradition and materials, the maturity and the current phase of the construction industry and differences in data collection with inclusion and exclusion of specific streams such as earth excavations.(Hiete et al., 2011) Typically demolition activity accounts for less than 10% of total C&D activity, yet demolition waste accounts for about 50% of total C&D waste stream(Tam et al.,2012). This could vary significantly from country to country and the stage of development of the area under concern.

The total construction and demolition waste generated in Australia was 19 million metric tonnes in 2008-2009 and of this 55% was recovered and recycled.(Hyder Consulting, 2011) Fairly high C&D recycling has been achieved by countries such as Denmark and Germany (Above 90% in late 1990s) and Ireland also achieved rates above 80% by 2005/2006. Japan had a goal of 95% of recycling of C&D in 2010. The present rate for Australia remains at 57%(Hiete et al., 2011).

Urbanization growth rate in India is very high due to industrialization. Growth rate of India is reaching 9% of GDP. Rapid infrastructure development requires a large quantity of construction materials, land requirements & the site. For large construction, concrete is preferred as it has longer life, low maintenance cost & better performance. For achieving GDP rate, smaller structures are demolished & new towers are constructed. Protection of environment is a basic factor which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development, play an important role in modern requirements of construction works. Due to modernization, demolished materials are dumped on land & not used for any purpose. Such situations affect the fertility of land. As per report of Hindu online of March 2007, India generates 23.75 million tons demolition waste annually. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment.

. For production of concrete, 70-75% aggregates are required. Out of this 60-67% is of coarse aggregate & 33-40% is of fine aggregate. As per recent research by the Fredonia group, it is forecast that the global demand for construction aggregates may exceed 26 billion tons by 2012. Leading this demand is the maximum user China 25%, Europe 12% & USA 10%, India is also in top 10 users. From environmental point of view, for production of natural aggregates of 1 ton, emissions of 0.0046 million ton of carbon exist where as for 1ton recycled aggregate produced only 0.0024 million ton carbon is produced. Considering the global consumption of 10 billion tons/year of aggregate for concrete production, the carbon footprint can be determined for the natural aggregate as well as for the recycled aggregate.

The use of recycled aggregate generally increases the drying shrinkage creep & porosity to water & decreases the compression strength of concrete compared to that of natural aggregate concrete. It is nearly 10-30% as per replacement of aggregate. Recycling reduces the cost (LCC) by about 34-41% & CO2 emission (LCCO2) by about 23-28% for dumping
at public / private disposal facilities.

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Out of the total construction demolition waste, 40% is of Concrete , 30% Ceramic 5% plastics, 10% wood, 5%metal, & 10% other mixtures. As reported by global insight, growth in global construction sector predicts an increase in construction spending of 4800 billion US dollars in 2013. These figures indicate a tremendous growth in the construction sector, almost 1.5 times in 5 Years

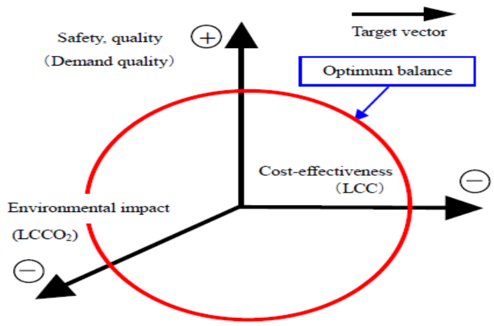

FIG 4.1: OPTIMUM BALANCE

Most natural aggregatesare derived from crushed stone and sand and gravel,recovered from widespread, naturally occurring mineraldeposits. Vertical arrows represent losses to the environment which occur throughout the flow system. More than 2billion metric tons (tons1) of crushed stone and sand andgravel were consumed as aggregates in the United States in1996, much of which was used in road construction andmaintenance (Tepordei, 1997a; Bolen, 1997). Recycledmaterial used to produce construction aggregates for concretecomes from two primary sources: (1) road constructionand maintenance debris, and (2) structural construction anddemolition debris (for example, from demolished buildings,bridges.

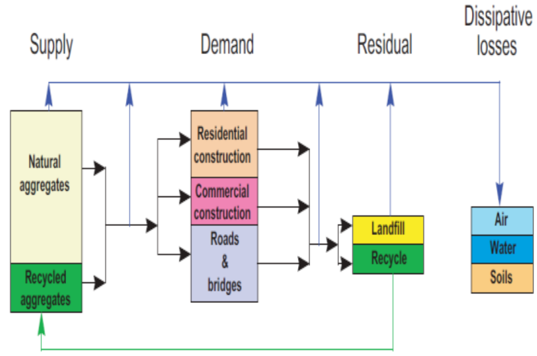

FIG 4.2: FLOW CHART FOR THE AGGREGATE SEPARATION

5.EXPERIMENTAL WORK

5.1 PROPERTIES &CHARACTERSTICS OF RECYCLED AGGREGATES

A concrete pavement's strength and performance is very dependent on the aggregates used to Produce the concrete. Recycled concrete aggregates are different in many ways from virgin
Aggregates as shown in Table 1.

Properties	Natural aggregates	Recycled aggregates
Shape and Texture	Well rounded, smooth (gravels) to angular and Rough (crushed rock).	Angular with Rough surface.
Absorption Capacity	0.8 – 3.7 percent	3.7 – 8.7 percent
Specific Gravity	2.4 – 2.9	2.1 – 2.4

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L. A. Abrasion Test Mass Loss	15 – 30 percent	20 – 45 percent

5.2.1Workability

Concrete mixtures with both coarse and fine recycled aggregates can be very harsh and difficult to Swork due to the highly angular and rough surface of the RCA. Additional water is required in order to obtain the same degree of workability as a mix containing conventional aggregates, especially when both coarse and fine recycled aggregates are used. Increasing the water content will necessitate an increase in the cement content to produce a cement paste that is design.

Workability can be improved by reducing or eliminating the amount of recycled fines in favour of natural fines, using water reducers, adding fly ash or a combination of all three. Using fly ash alone may not provide a workable mix and a reduction in the percentage or elimination of the recycled fines may be necessary. Slump loss is commonly observed for mixtures containing RCA due to its high absorption characteristics. Solutions include pre soaking the aggregatesorpre-wetting the stockpile.

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FIG :5.8SLUMP CONE TYPICAL SLUMP CONE

5.2.2 Water Content

Increased water contents are required for mixtures containing RCA due, as mentioned previously, the high absorption capacity of the paste clinging to the aggregates. The higher and more variable absorption capacity also makes it difficult to determine the water content which in turn leads to variation in the strength of the hardened concrete.

5.2.3 Air content

Higher and more variable air contents are common in fresh concrete made with RCA. This is due to the higher porosity of the recycled aggregates themselves and to the entrained air in the original mortar. Therefore, the target air content of mixtures containing RCA must be higher to achieve the same durability as conventional mixes

5.4WORKING PROCESS

Presence of Construction & Demolition waste and other inert material (e.g. drain silt, dust and grit from road sweeping) is significant about a third of the total municipal solid waste generated. Construction & Demolition waste needs to be focused upon in view of:
(i) The potential to save natural resources (stone, river sand, soil etc.) and energy.
(ii) Its bulk which is carried over long distances for just dumping.
(iii) It is occupying significant space at landfill sites.
(iv)Its presence spoiling processing of bio-degradable as well recyclable waste.

Construction & Demolition waste has potential use after processing and grading. Utilization of Construction & Demolition waste is quite common in industrialized countries but in India so far no organized effort has been made.

Raw materials for production of the natural aggregates and RC aggregate contribute to some differences and variations of aggregate properties. Recycled concrete aggregate consists of natural aggregate coated with cement paste residue, pieces of natural aggregate, or just cement paste and some impurities. Relative amounts of these components, as well as grading, affect aggregate properties and classify the aggregate as suitable for production of concrete. There is a general consensus that the amount of cement paste has a significant influence on the quality, and the physical, mechanical and chemical properties of the aggregates and as such has potential influence on the properties of RC concrete

Concrete waste, which falls into the Construction and Demolition (C & D) waste category, is generated when creation of new, or modifications to existing urban infrastructure such as transport systems, communication networks and buildings are made. With the increased urbanisation of the worlds growing population there is also an increase in C & D waste generation. This prompts a realisation that built-in urban infrastructure along with C & D waste contains a large stock of materials, and that efficient management of concrete, steel, bricks, their waste, is necessary to sustain the future growth and increased demand for construction materials.

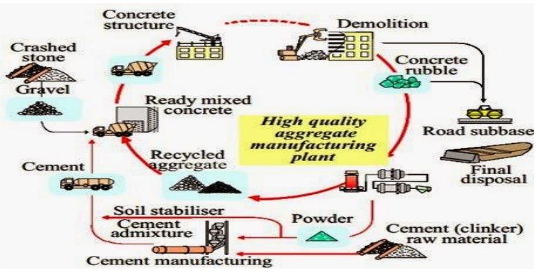

FIG :5.13SCHEMATIC FLOW OF RECYCLING PROCESS

Subject	Quantity
Cement	**450**
Fine aggregate (sand)	**835.5**
Coarse aggregate	**869.5**
Water	**225**
Density	**2400**

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RESULTS AND DISCUSSIONS

7.1 TEST RESULTS OF RECYCLED AGGREGATE

Demolished material of reinforced cement concrete (RCC) & PCC is used for recycling in foundation. The life of RCC demolish material is 25 yrs. Such mated crushing, sieving & separation process are done by manual crushing method. On demolish material, aggregate tests are conducted which are mentioned in Indian Standard code for natural aggregate & check feasibility.

7.1.1 Results in properties of Recycled Concrete Aggregate:-

- **Particle Size Distribution:-**

Sieve analysis is carried out as per IS 2386 for crushed recycled concrete aggregate and natural aggregates. It is found that recycled coarse aggregate are reduced to various sizes during the process of crushing and sieving, which gives the best particle size distribution. The amounts of fine particles less than 4.75mm after recycling of demolished waste were in the order of 5-20% depending upon the original grade of demolished concrete. The best quality natural aggregate can be obtained by primary, secondary & tertiary crushing, whereas the same can be obtained after primary & secondary crushing incase of recycled aggregate. The single crushing process is also effective in the case of recycled aggregate. The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

- **Specific Gravity:-**

The specific gravity in saturated surface dry condition of recycled concrete aggregate was found from **2.35 to 2.58** which are less but satisfying the results. If specific gravity is less than 2.4, it may cause segregation, honeycombing & also yield of concrete may get reduced.
The specific gravity (saturated surface dry condition) of recycled concrete aggregate was found from 2.35 to 2.58 which are lower as compared to natural aggregates. Since the RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it.

Our result for recycled aggregate – 2.5

- **Water Absorption:**

The RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from **1.5% to 7.0%,** which is relatively higher than that of the natural aggregate.

Thus the water absorption results are satisfactory.The water absorption ranges from 3.05% to 7.40%, which is relatively higher than that of the natural aggregates. The Table 4 gives the details of properties of RCA & natural aggregates. In general, as the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry (SSD) conditions of aggregate before start of the mixing operations.

Our result for recycled aggregates – 3.34

7.2DISCUSSION

There does not seem to be any roadblocks to the use of RCA in pavements in Washington

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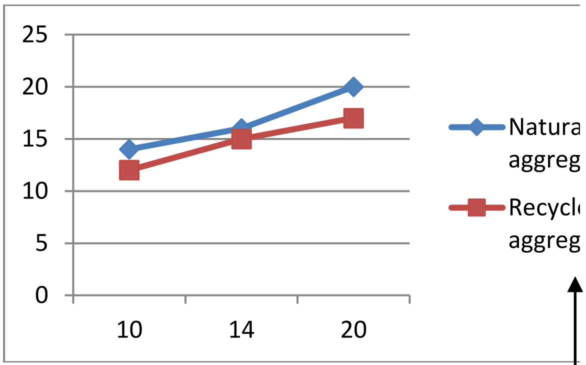
State. The performance problems experienced by other states that have used RCA would not
Likely happen in Washington if we continued to employ our current standard practices with our mix designs, pavement designs and construction control methods. Table 9 lists problems noted by the reference materials and the solution proposed for overcoming or minimizing the problems.

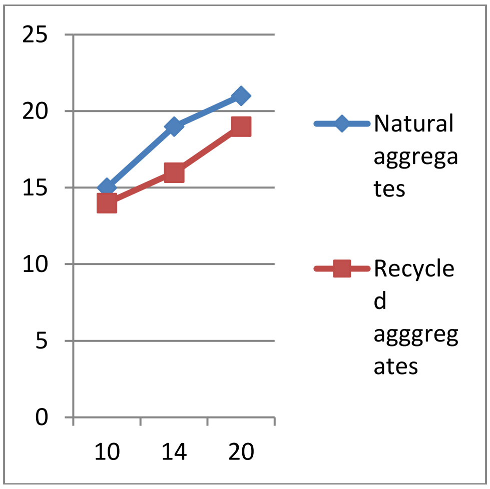
GRAPHS

FOR M25 MIX PROPORTION

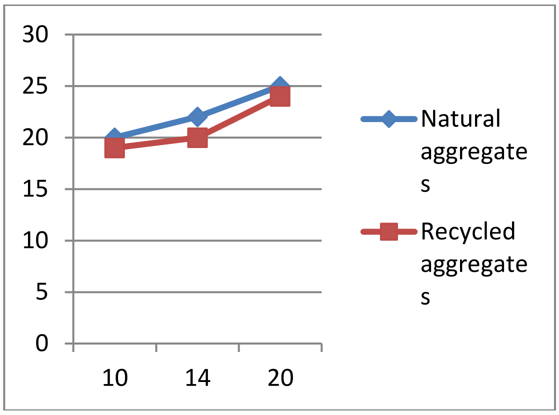


Size (mm)

FOR 3DAYS



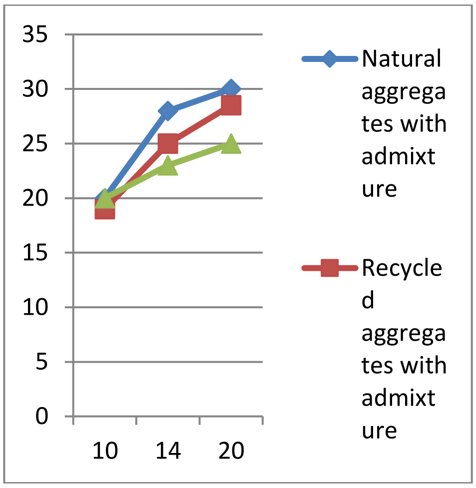
FOR 7 DAYS **Size mm**



Size(mm)

FOR 28 DAYS

FOR M30 MIX PROPORTION



FOR 3 DAYS Size(mm)

CONCLUSION

This chapter was set out to represent the conclusion of this project. Before the conclusion
Is list, the achievement of objectives set in beginning of the project was also discussed and achieved. Lastly, some testing, investigations and studies were also recommended after the conclusion, to further the strength characteristics of recycled aggregates for the application in high strength concrete.

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8.1 Achievement of Objectives

The project achievements are as follows:

• In this project, the review and research of current usage to the use of recycled aggregate in the concrete was discussed into different sectors, such as constructions, industries, applications, recycling process, previous research and investigation.
• Total of six batches of concrete mixes required by the scope of the project. The concrete mixes consisted of every 20% increment of recycled aggregate replacement from 0% to 100%.
• The investigation and laboratory testing on recycled aggregate concrete specimens such as compression test, indirect tensile test and modulus of elasticity. However, not all the specimens had achieved to the high strength requirement.
• All the result for the tests was recorded in an appropriate manner. Moreover, result of each test was analysed in detail. All of this was discussed in chapter 5.

• With extra time permit, two extra 100% recycled aggregate concrete mixes on were cast which is water/cement ratio of 0.36 and fly ash cement. These two mixes were compared to 100% recycled aggregate concrete mix (0.43 water/cement ratio)

8.3 Recommendations for Further Studies

Further testing and studies on the recycled aggregate concrete is highly recommended to indicate the strength characteristics of recycled aggregates for application in high strength
Concrete. Below are some of the recommendations for further studies:
• Although by decreasing the water/cement ratio, recycled aggregate can achieve high strength concrete. But the workability will be very low. Therefore, it is recommended that adding admixtures such as super plasticizer and silica fumeinto the mixing so that the workability will be improved.
• More investigations and laboratory tests should be done on the strength characteristics of recycled aggregate. It is recommended that testing can be done on concrete slabs, beams and walls. Some mechanical properties such as creeping and abrasion were also recommended.
•More trials with different particle sizes of recycled aggregate and percentage of replacement of recycled aggregate are recommended to get different outcomes and higher strength characteristics in the recycled aggregate concrete.

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