Reuse of Coarse Aggregate as Recycled Aggregate in Concrete

R. Krishnakumar[1,a], M. Krishnagopal[1,b], P. Vishnu[1.c], O.P. Deepak[1,d*]

[1]Department of civil engineering, Bannari amman institute of tech., Erode, Tamilnadu, India

[a]krishnakumar.ce18@bitsathy.ac.in , [b]krishnagopal.ce18@bitsathy.ac.in , [c]vishnu.ce18@bitsathy.ac.in,*[d]deepak@bitsathy.ac.in

Keywords: Recycled Concrete Aggregate (RCA), Slump Test, Compaction, Compression, Ultrasonic Pulse Velocity, Physical and Mechanical Properties

Abstract: In the latest period, the volume of building material has greatly extended, raising social and environmental concerns surrounding waste recycling. Construction and demolition waste is a significant factor in global generated waste. Construction necessarily requires the use of massive quantities of aggregates. When the structure's useful life is up, it will be demolished, and all of the demolished waste will disposed of in landfills. It became increasingly difficult to identify large areas for landfills. Crushed, graded inorganic particles that have been processed from construction materials and demolition debris make up recycled aggregates. Aggregates that have been recycled for use in high-strength structural concrete. In this work, recycled coarse aggregate was employed to replace virgin coarse aggregate. The properties of both fresh and hardened concrete made from 100 % recycled coarse aggregate which has been internally or externally replaced found, and the effects are compared to concrete by applying the virgin coarse aggregate.

Introduction

Due to industrialization, India's urbanization rates are generally high. India's GDP is increasing at a rate of 9% each year. Infrastructure that is built quickly. Development needs a great number of resources, construction materials, land requirements, and the site. Concrete is preferred for huge construction projects. It takes a greater lifespan, lower operating costs, and better performance. Smaller is superior when it comes to achieving a GDP rate. Structures are now being demolished and high rise apartments are now being built. Protection of the environment is a must a factor that is intimately connected to survival the race of humanity Biological influences, for eg.sustainability, natural resource protection play an important role in long production. Construction needs with in modern period due to demolished materials are dumped during modernization on terrain that's not being used anywhere. Situations such as these have an influence on the land's fertility as per a Hindu report, India generates 23.75 billion us dollars online as of March 2007.Each year, massive amounts of demolition waste are produced. As per Central Pollution Control Board report. Concrete compensates 40% of total construction demolition garbage, following by ceramics at 30%, plastics at 5%, wood at 5%, metal at 5%, & unspecified mixes at 10%. As according global insight, expansion in the global construction sector is expected to occur in a 4800 billion $ increase in construction spending in 2013. These statistics show a tremendous growth in construction sector.

Aggregates are probably going to represent 70-80% of the totals utilized in substantial assembling. The coarse total records for 60-67 percent of the aggregate, while the fine total records for 33-half of the aggregate. As indicated by the Fredonia gathering's new exploration, worldwide interest for development totals is relied upon to surpass 26 billion tons by 2012. China is by a wide margin the most dynamic client, representing 25% of all clients, trailed by the United Kingdom (12%) and

the United States (10%). (10%). India is likewise among the best ten clients. As far as ecological effect, one ton of regular total produces 0.0046 million tons of carbon dioxide, yet one ton of reused total discharges just 0.0024 million tons. The carbon impression of both regular and reused total might be determined because of the worldwide use of 10 billion metric huge loads of total each year for substantial creation. While contrasted with regular total concrete, the utilization of reused total upgrades drying shrinkage creep and porosity to water while diminishing pressure strength. To the extent that total substitution concerned, it was around 10-30%. Reusing brings down costs (LCC) and Carbon force (LCCO2) by 34-41 % and 23-28 %, as needs be.

Fig 1, Recycled coarse aggregate

Advantage of recycling materials

- Precast and set gutters and kerbs are created with from this materials
- Potential savings: - Concrete is undisturbed, and the new cost in cement is expected to be compensated by the minimal price of Recycled Concrete Aggregate (RCA). By replacement 20% of the cement with fly ash, the alkali silica reaction might be reduced (ASR).
- Eco friendly: - Resources are not extracted, and transportation is minimized. There is also a reduction in the number of land required.
- Save time: Thus, there is no compelling reason to trust that assets will open up. Because of less pounding, fossil fuel byproducts is diminished. As indicated by Dutch standard VBT 1995, all substantial with a trademark strength of 65 MPa can have up to 20% of normal total supplanted with RCA or reused blended totals (RMA) without additional testing.

Disadvantages

- Less quality (for example, compressive strength drops by 10-30%).
- The average time it takes to purchase materials could have an effect on the project's life cycle.
- Land, as well as specialised machinery and equipment, are required (more cost).
- Water absorption is exceptionally high (up to 6 percent).
- It shrinks and creeps more because it cures.

Objectives

- To specify the maximum number of construction which can be performed with the resources available.
- To minimize the environmental effects of waste material.
- To compare the results of various tests performed on recycled and natural aggregates.
- To discover expense solutions such as transportation and excavation.

Methodology

The plain concrete cement (PCC) and the buildup concrete cement (RCC) were bought from different sources. This material is squashed to isolate the totals and diminish their size to minuscule pieces. In the research center, test methods are applied to these isolated totals as per Indian Standard code, and the discoveries are contrasted with regular totals. Reused total assists with decreasing the ecological effect of waste. At the point when transportation and assembling processes are limited, development costs are significantly lower while using a rate.

Testing of Recycled Aggregate

Particle size distribution: For the coarse and fine aggregates which could be used in the concrete, sieve analysis was conducted. Fine aggregate sieve sizes varied from 2.36mm to 75mm for coarse aggregate and 40mm to 4.75mm for coarse aggregate.

Table 1, PHYSICAL PROPERTY OF FINE & COARSE AGGREGATE

AGGREGATE	FINENESS MODULUS	DENSITY (kg/m^3)	SPECIFIC GRAVITY
Fine aggregate	2.77	1752	2.50
Coarse aggregate	7.086	1805.62	2.84
Recycle C.A	7.476	1660.44	2.74

Slump Test: The slump test is used to determine whether or not fresh concrete is practical. The test is simple and affordable. It could be used both in the lab and on the work site. Although the test is simple, it must be performed out together with precaution since any disturbance in the method could result in a substantial fall.

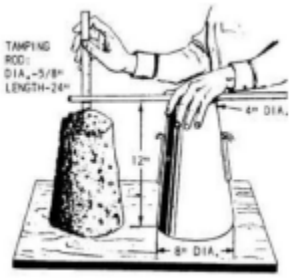

Fig 2, Slump Test

Compacting Factor Test: The compacting factor test, which is far more accurate than the slump test in detecting the workability of fresh concrete, was also used to determine its workability. The compacting factor test, commonly known as the "drop test," measures the weight of fully compacted vs partially compacted concrete.

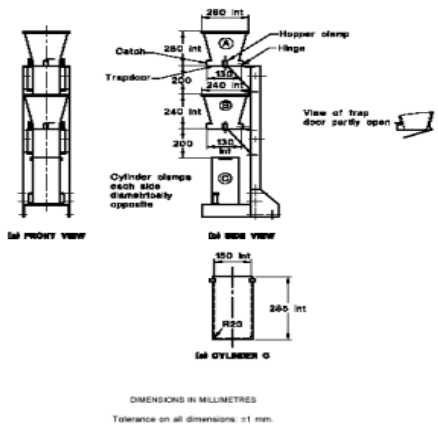

Fig 3, Compacting factor test

Table 2,THE COMPACTING FACTOR FOR MIX CONCRETE

Percentage of Recycled aggregate (w/c=0.55)	0%	20%	40%	60%	80%	100%
Compacting factor	0.839	0.897	0.933	0.875	0.851	0.879

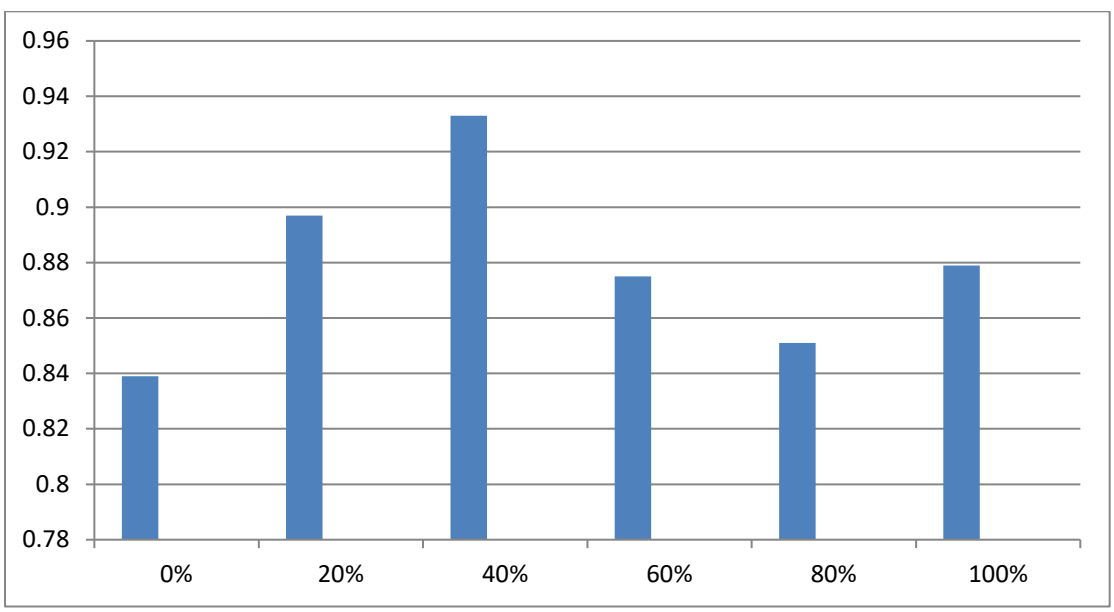

Fig 4, Compaction factor results(0.55w/c)

Non-destructive test

1. **Schmidt's Rebound hammer test**: Schmidt's Rebound Hammer, made in 1948, is perhaps the most broadly utilized surface hardness indicator. It contains a rounded packaging with an

unclogger coasting spring control hammer. The protuberance returns when the unclogger is squeezed against the substantial's surface. It withdraws against the draw of the spring. Therefore, when the sledge hits the substantial, the spring control mass pulls it back, driving the rider to haul along the directing scale. By squeezing a button, the rider can be held set up while the perusing is taken. Each mallet has a special trademark that necessities be altered prior to utilizing on substantial that contains total from a specific provider.

Table 3, RESULTS OF REBOUND HAMMER TEST

Percentage of recycled aggregate	0%	20%	40%	60%	80%	100%
Days	Compressive Strength (MPa)					
3	15.46	20.45	10	15.33	14.3	12.8
7	14.16	15.9	14.76	16.93	12.46	14.16

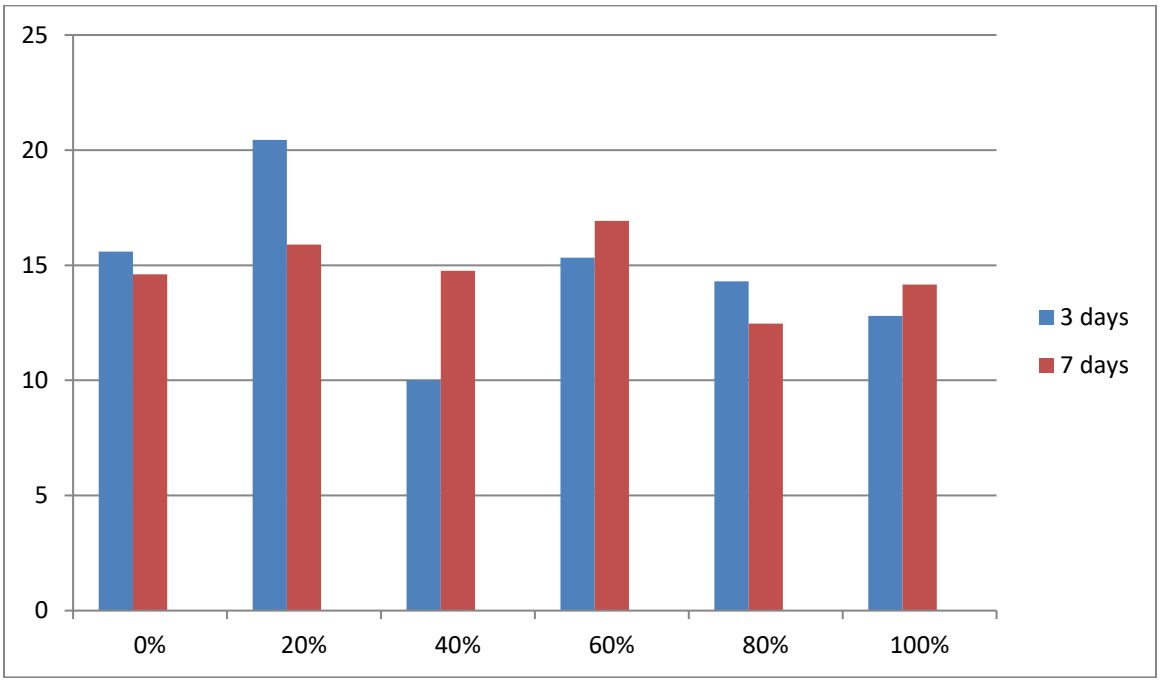

Fig 5, Rebound hammer test

2. **Ultrasonic pulse test**: The ultrasonic pulse velocity method is used to determine the time of travel of an ultrasonic pulse propagating through the concrete to be analyzed. This test is used to assess the internal strength of concrete.

Fig 6, Ultrasonic pulse test

Table 4, ULTRASONIC PULSE TEST RESULTS

Percentage of recycled aggregate	0%	20%		40%	60%	80%	100%
Days		Velocity (m/s)					
3	4110	4210		4190	3860	4020	4120
7	4160	3960		4160	4250	4230	4010
Days		Compressive strength (Mpa)					
3	20.4	19.06		18.0	13.5	16.1	17.3
7	21.7	15.2		19.2	23.6	19.3	19.8

3. **Compressive Test**: The measured maximum resistance of a concrete to axial loading is defined as in its compressive strength. Because compression testing is simple to operate, it is the most common test for hardened concrete specimens. The compression test could be used to assess the strength of concrete specimens with various proportion of recycled aggregate replacement. The compression test utilized specimens that have been 150mmx150mmx150mm in dimension

Table 5, COMPRESSIVE STRENGTH (Mpa) WITH AGE

Percentage of recycled aggregate	0%	20%	40%	60%	80%	100%
Days	Compressive strength (Mpa)					
3	23.11	26.14	25.3	28.96	25.07	21.41
7	29.78	31.11	31.4	33.92	27.63	31.4

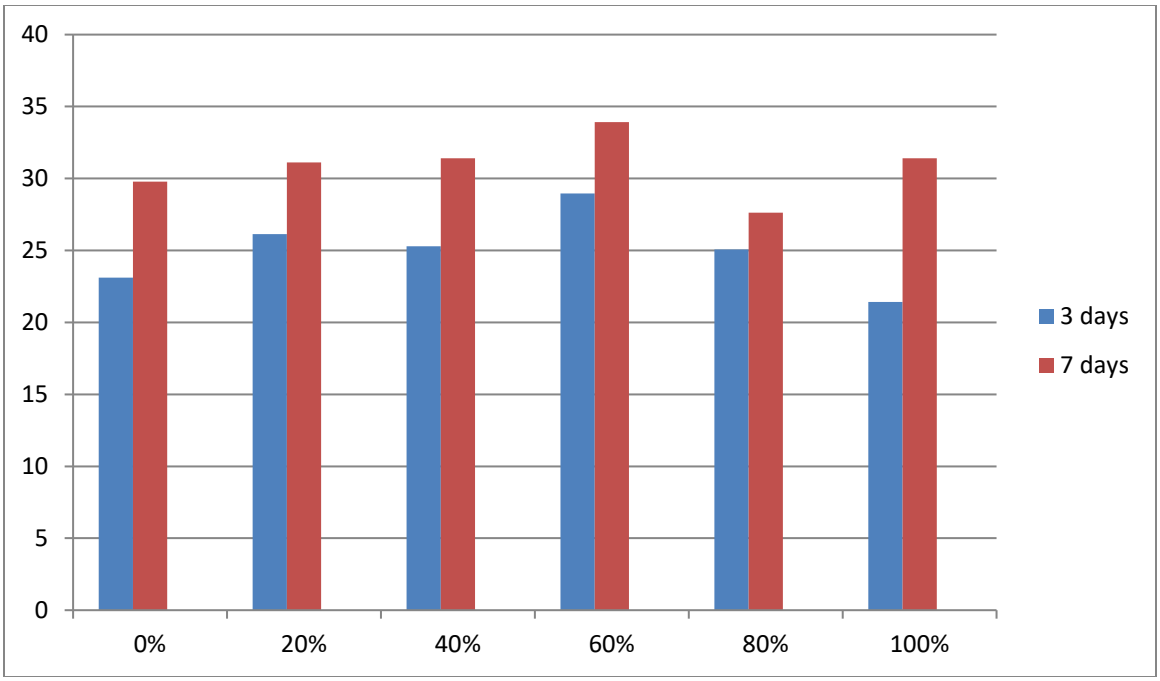

Fig 7, Compressive strength

Results and Discussion

Size distribution: The natural coarse aggregate is coarser than the recycled coarse aggregate. Like a consequence, the fineness modulus of 95 percent recycled coarse aggregate is 7.476, slightly higher than the fineness modulus of natural coarse aggregate, which is 7.086.

Physical and Mechanical Properties: Table 1 shows that the bulk density and specific gravity of recycled coarse aggregate are 1660.44 kg/m3 and 2.74, correspondingly. The figures are lower than the density of natural coarse aggregate, which is 1805.62 kg/m3 and has a density of 2.84. In the recycled coarse aggregate, the original material was bonded with mortar. This is paired with a light and porous mortar. As a result, as compared to natural aggregate, recycled aggregate's specific gravity and density are often lower. Since recycled coarse aggregate has a lower specific gravity, the amount of recycled coarse aggregate used in concrete has reduced. Concrete's mechanical qualities are influenced by aggregate mechanical properties. The mechanical properties of RCA are lower than those of NCA, according to the literature (ECCO 1999; López-Gayarre et al. 2009; Maleev et al. 2010; Poon et al. 2003; Hansen 1992).

Workability: The higher angularity and surface hardness of RCA particles reduce concrete workability and make proper finishing more difficult (Yrjanson 1989). Topçu and Günçan (1995) found that when the proportion of RCA in the concrete increases, the degree of workability decreases. As a result, RCA concrete requires more water to provide the same workability as NCA concrete. As per the outcomes of the workability tests, the greatest workability were obtained in a new concrete mix with 40% RCA replacement.

Compressive strength: As demonstrated, the strength of concrete of RCA concrete is often lower than that of NCA concrete. The strength of concrete of RCA concrete is typically 5 to 10% less

than of NCA concrete (ACPA 2009). It can, however, be reduced by up to 25% depending on the RCA's quality. If the RCA is generated from an old concrete source that was originally created with a lesser water cement ratio than the new concrete, it may have similar, if not higher, concrete strength than NCA concrete. Concrete's compressive strength can also be affected by fine RCA. The strength of concrete of RCA concrete, according to Tavakoli and Soroushian (1996), is influenced by RCA's source concrete's coarse aggregate to fine aggregate ratio. The coarser the lower. The higher the mortar-to-fine-aggregate ratio, the more mortar is bonded to coarse RCA particles. As a result, the strength of RCA concrete is diminished. The graph depicts the variation in RCA compressive strength as a function of age. It was discovered that recycled coarse aggregate concrete with such a high proportion of RCA achieved higher force more quickly than normal concrete. When the recycled coarse aggregate is 60 percent replenished, the compressive strength is at its highest. The findings of the Rebound hammer test and Ultrasonic pulse velocity tests agree with the compressive strength of the concretes produced with varied percent substitutions of RCA.

Conclusion

There is a great need to protect our environment and finite natural resources for future generations on a global scale. To assist safeguard public capacity and land area, construction and demolition materials can be recycled. This could help us reduce the need for quarrying and other forms of environmental degradation. Recycled aggregates could benefit a variety of applications, including concrete making. The many elements of recycled aggregates and their application in concrete have been discussed in this study.

Reference

[1] M.Chakradhara Rao “Recycled coarse aggregate and its use in concrete”, ICI journal January-march 2011, pp. 27- 40.

[2] Bureau of Indian standards (1970) Indian standard specification for coarse (IS:2863) and fine aggregate (IS:383) from natural sources.

[3] Bureau of Indian standards IS:10262(1982 & 2009) Indian standard recommended guide line for concrete mix.

[4] M.S.SHETTY, Book on concrete technology.

[5] RILEM (1994) Specifications for concrete with recycled aggregates, materials and structures, 27, pp. 557- 559. https://doi.org/10.1007/BF02473217

[6] F. Yuan, L.-Y. Shen, and Q.-M. Li, “Emergy analysis of the recycling options for construction and demolition waste,” Waste Management, vol. 31, no. 12, pp. 2503–2511, 2011. https://doi.org/10.1016/j.wasman.2011.07.001

[7] K. P. Verian, W. Ashraf, and Y. Cao, “Properties of recycled concrete aggregate and their influence in new concrete production,” Resources, Conservation and Recycling, vol. 133, pp. 30–49, 2018. https://doi.org/10.1016/j.resconrec.2018.02.005

[8] V. B. M. Kumar, H. Ananthan, and K. V. A. Balaji, “Experimental studies on utilization of recycled coarse and fine aggregates in high performance concrete mixes,” Alexandria Engineering Journal, vol. 57, no. 3, pp. 1749–1759, 2018. https://doi.org/10.1016/j.aej.2017.05.003

[9] F. Yuan, L.-Y. Shen, and Q.-M. Li, "Emergy analysis of the recycling options for construction and demolition waste," Waste Management, vol. 31, no. 12, pp. 2503–2511, 2011. https://doi.org/10.1016/j.wasman.2011.07.001

[10] R. Neves, A. Silva, J. de Brito, and R. V. Silva, "Statistical modelling of the resistance to chloride penetration in concrete with recycled aggregates," Construction and Building Materials, vol. 182, pp. 550–560, 2018. https://doi.org/10.1016/j.conbuildmat.2018.06.125

[11] M. Buhamad, Effect of Recycled Aggregate on the Chloride Diffusion in Fully Saturated Concrete, Kuwait University, Kuwait City, Kuwait, 2012

[12] J. Wang, H. Yuan, X. Kang, and W. Lu, "Critical success factors for on-site sorting of construction waste: a China study," Resources, Conservation and Recycling, vol. 54, no. 11, pp. 931–936, 2010. https://doi.org/10.1016/j.resconrec.2010.01.012

[13] N. Kartam, N. Al-Mutairi, I. Al-Ghusain, and J. Al-Humoud, "Environmental management of construction and demolition waste in Kuwait," Waste Management, vol. 24, no. 10, pp. 1049–1059, 2004. https://doi.org/10.1016/j.wasman.2004.06.003