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Experimental Study on Compressive Strength of Recycled Coarse Aggregate Concrete

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Abstract— The following project report is a experimental demonstration of the comprehensive use of (RCA). It state that recycled concrete aggregate (RCA) are only suitable for non-structural concrete application. This research however, shows that the recycled aggregates that are obtained from concrete specimen make good quality concrete. Concrete waste from demolished structure has been collected and coarse aggregate of different percentages is used for preparing fresh concrete. In this study, for the 7, 14, 28th days cube compressive strength using Ordinary Portland Cement (OPC) of grade 53 is used; for the strength of replacement for 30%, 60% and 100% RCA. The use of the construction and demolition waste in concrete a a replacement of the natural aggregate is recognized as a viable way to effectively utilize this waste. This study proves that, though the strength of concrete is affected by addition of recycled coarse aggregate with natural aggregate, thus providing environmentally friendly and economically viable solution as substitute for virgin aggregate as well as provide saving in the final cost of projects.

Keywords— Recycled concrete aggregates, Natural aggregates, Compressive strength, Ordinary Portland cement, High performance concrete, Recycled coarse aggregate.

I. INTRODUCTION

According to the Building Material Promotion Council (BMPTC), In 2020 India generates an estimated 150 million tons of construction and demolition (C&D) waste every year. But the official recycling capacity is a meagre 6500 tons per day (TPD)-just about 1 per cent. Recycled Aggregate Concrete is one of the most important use of waste concrete and is being used throughout the world. It is manufactured by using previously prepared concrete as aggregate with fresh cement matrix. It was obtained from the various sources such as demolished structure. It is sustainable and environment friendly as it recycles the concrete which world have been discarded as waste and had to be dumped off. It reduces the construction cost and when used properly gives similar performance as virgin aggregate concrete. This material is generally used for roads, bridges etc.

The water content, water absorption, and crush index of RAC are significantly higher compared with NAC. However, NAC has a much larger bulk density and apparent density than RAC, which is mainly attributed to the existence of old mortar adhered around recycled coarse aggregate particles. In addition, recycled coarse aggregate has microcracks caused by crushing.

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 whereas for 1ton recycled aggregate produced only 0.0024-million-ton carbon is produced. 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.

Only one researcher found recycled aggregate concrete has higher compressive strength. He claimed that recycled aggregate has more angular shape and rough surface texture compare to natural aggregate. The angular shape and rough texture of RA leads to better bond and higher strength of concrete. To increase the compressive strength, RA should be oven dried condition that will create the interfacial bond between cement paste and aggregate particles. This study investigated the properties of RA according to BS 882:1992, and evaluated the compressive strength and workability of the concrete using recycled aggregate.

In developing countries like India, the generation of construction and demolition(C&D) waste is up to tune of 150 million tones annually and this are likely to double fold in next 7 years.

II. REVIEW OF LITERATURE

Hamed Dabiri, Mahdi Kioumarsi, Ali Kheyroddin, Amirreza Kandiri, Farid Sartipi has research that In the recent decades, researchers have shown an increased interest in the reusing recycled concrete aggregate generated by buildings demolitions because of the undeniable economic and environmental benefits. The main objective of this research is therefore to evaluate the influence of replacing natural fine and coarse aggregate on the 3-, 7- and 28-day compressive strength of concrete using machine learning-based approaches. Finally, reduction in long-term strength of the concrete containing recycled fine aggregate is less than those containing coarse aggregate or both fine and coarse aggregate.

Surya , Kanta Rao, Lakshmy, has state that With rapid urbanization and development in the field of construction the demand for natural aggregates is increasing day by day with a corresponding increase in concrete production. Extraction of natural aggregates from mother earth leads to destruction of environment. Also, in the process of urbanization, the buildings and other structures which no-longer serve the intended purpose are often demolished. However, the disposal of this construction debris is becoming a major concern in the current era. The solution for these concerns are interdependent and inter connected. The use of the construction and demolition waste in concrete as a replacement of the natural aggregates is recognized as a viable way to effectively utilize this waste. These aggregates are known as recycled concrete aggregates. Though the idea of using construction and demolition waste in concrete in infrastructure projects has been in practice for a long time around the world, its use in India is limited till date.

Shahiron Shahidana, Mohamad Azim Mohammad Azmib, Kumanan Kupusamyc Sharifah Salwa Mohd Zukid , Noorwirdawati Alie has investigated that 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 aggregates in new concrete, especially for lower level applications. This study discusses recycled aggregates (RA) produced from C&D waste and their use in concrete construction. Along with a brief overview of the engineering properties of recycled aggregates, the study also gives a summary of the effect of recycled aggregates on the properties of fresh and hardened concrete. Recycled aggregates are treated with epoxy resin to reduce the water absorption. This research, however, shows that the recycled aggregates that are obtained from site-tested concrete specimen make good quality concrete. The influence of aggregates of varying sizes on the compressive strength, split tensile and water absorption of concrete is presented in this paper. Recycled aggregate concrete was in close proximity to normal concrete in terms of split tensile strength and compressive strength. The slump value of recycled aggregate concrete was low and that can be improved by using saturated surface dry (SSD) coarse aggregate.

O.A.U UCHE- This paper presents the findings of an investigation on the influence of recycled aggregate concrete (RCA) as a substitute for virgin coarse aggregate in the compressive strength of `plain concrete. Recycled aggregate concretes were produced together with virgin coarse aggregates and subjected to empirical tests which include grading, specific gravity, bulk density, water absorption, aggregate impact value (AIV) and aggregate crushing value (ACV) to ascertain their performances. Mix design was carried out for grade 30 concrete according to DoE (1975) and RCA percentages of 0, 25, 50, 75, and 100 were used in replacing the virgin aggregate proportion in the mix. The test results showed that the use of recycled concrete aggregate (RCA) reduces the compressive strength and this reduction increases with the increase in percentage of the RCA. Maximum decrement of about 33% in strength or about 67% of compressive strength development occurs when 100% of RCA was used as substitute to virgin coarse aggregate. It also reveals that about 25% of virgin coarse aggregate can be replaced with RCA in structural concrete work with out compromising the characteristic strength of the concrete. This result will not only eliminate the development of waste stockpiles of concrete as recycled material but also elicit the use of RCA in concrete work, thus providing environmentally friendly and economically viable solution as substitute for virgin aggregate as well as provide savings in the final cost of projects.

Ismail Abdul Rahman, Hasrudin Hamdam, Ahmad Mujahid Ahmad Zaidi has investigated that the Used of recycled aggregate (RA) in concrete can be described in environmental protection and economical terms. The application of recycled aggregate to use in construction activities have been practice by developed European countries and also of some Asian countries. This paper reports the results of an experimental study on the mechanical properties of recycled aggregate concrete (RAC) as compared to natural aggregate concrete (NAC). The effects of size of RA on compressive strength were discussed in this paper. The 100% of RA used in concrete mix to replace the natural coarse aggregate in concrete with 100 x 100 x 100 cube mm were cast with target compressive strength is 25 MPa. The 28-day compressive strength was crushed at 3, 14, 28 days are reported. It was found the size of 10mm and 14 mm of RA in RAC is quite similar performance with 10mm and 14mm size of natural aggregate (NA) in natural aggregate concrete (NAC).

C.S. Poon, Z.H. Shui, L. Lam has state that Concrete specimens were prepared with a recycled normal-strength concrete (NC) aggregate, a recycled high-performance concrete (HPC) aggregate and a natural aggregate (NA) as control. The influence of these aggregates (recycled and natural) on the microstructure and compressive strength of the new concrete were studied. SEM observations revealed that the NC aggregate– cement interfacial zone consisted mainly of loose and porous hydrates whereas the HPC aggregate–cement interfacial zone consisted mainly of dense hydrates. The compressive strength results

that the concrete prepared with natural aggregates was higher than that of the recycled aggregate concrete. Also, the strength development of the HPC recycled aggregate concrete was faster than that of the NC recycled aggregate concrete. At 90 days, the HPC recycled aggregates concrete achieved similar strength values to the natural aggregate concrete. The results are explained by the differences in porosity and pore structure of the two types of aggregates, and possible interactions between the aggregates and the cement paste.

A.K.Padmini, Dr.K.Ramamurthy, and Dr.M.S.Mathews has investigated that the properties of recycled aggregates derived from parent concrete (PC) of three strengths, each of them made with three maximum sizes of aggregates. The relative physical and mechanical properties of fresh granite aggregate are discussed. Using these nine recycled aggregates, three strengths of recycled aggregate concrete (RAC) were made and studied. Typical relationship between water-cement ratio, compressive strength, aggregate-cement ratio and cement content have been formulated for RAC and compared with those of PC. RAC requires relatively lower water-cement ratio as compared to PC to achieve a particular compressive strength. The difference in strength between PC and RAC increases with strength of concrete. The relative evaluation of tensile and flexural strengths and modulus of elasticity has also been made.

III.MATERIAL AND METHODS

All the materials are collected from various sources like suppliers and demolished structures.

A. Cement

In concrete mix, Ordinary Portland Cement of 53 grade was used in this project.

Cement is a binder, a substance used in building that binds other materials together by setting, hardening, and adhering to them. It has cohesive and adhesive properties in the presence of water.

It is a product obtained by grinding clinker made by calcining raw materials consisting mainly of lime (CaO), silicates (SiO_2), alumina (Al_2O_3), and iron oxides (Fe_2O_3).

The standard density of cement is 1440 kg/m³.

Care was taken to ensure that it was recent supply and free from adulteration.

B. Sand

Sand is made up of small, loose pieces of rock, soil, minerals, and even gemstones. It may also contain the remains of living things. Sand particles called grains, are smaller than gravel. They are larger than particles of mud or clay. Sand is used of 2.36mm passed particles. Sand is obtained from supplies for laboratory work in Civil Engineering department. Sand is an important building material. It abundantly occurs in nature and is formed by the decomposition of rocks. Sand particles consists of small grains of silica (SiO_2). It forms major ingredient in concrete. Lime mortar cement mortar etc.

C. Aggregates

The fine aggregates used are clean sharp sand and the virgin coarse aggregates are crushed boulder of maximum size of 20mm, both obtained from supplies for laboratory work of Civil Engineering department of Shri Shankaracharya Technical Campus Bhilai.

1) Fine Aggregate: This is the aggregate for which its size ranges between 4.75mm to 0.075mm. This are also called sand. This are the natural particles that the mining process can generate. It consists of particles of the crushed stones or the sandy material.

2) Coarse Aggregate: This aggregate have a size of more than 4.75mm. these aggregates are used in the construction of concrete structures. Such aggregates include river gravel and stone particles made from rock stratum.

D. Recycled Concrete Aggregate (RCA)

Natural aggregates and recycled aggregate were reduced to maximum size of 20mm by the help of crushing and hammering. Then sieve analysis was done according to IS 2386:1963 (Part 1)

Recycled Concrete Aggregate is also known as crushed concrete aggregate. It is an alternative to use waste concrete having a low amount of dust particles or building waste. The building waste must be less than a few percent.

The recycle concrete aggregate were obtained from a (C&D) waste collected from demolished structure located at near Durg Road bypass at Durg. The demolished structure was mainly used for public and residential purpose. It was old about 25-30 years.

E. Experimental studies

Test Set-up: In present experimental work, various concrete mix batches have been prepared such as, normal concrete - 0% replacement, 30% replacement, 60% replacement and 100%. The testing of mechanical properties were conducted on Universal Testing machine after 28 days.

Parameter Studied: During the experimental work, generally two parameters were studied – first is compressive strength and second is workability.

Evaluation of compressive strength:
Compressive strength is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. To evaluate the compressive strength cubes of size 150 mm x 150 mm x 150 mm were casted using C.I. mold.
A test was conducted on the cubes of grade M25 at 28 days. Total four concrete mix batches were tested in which one mix was of normal aggregate concrete at 0% replaced by RCA and other are of
Recycled aggregate concrete at 30%, 60% and 100% replaced by RCA.

Fig. 1 Mixing of Concrete

Fig. 2 Compressive test of cube

F. Mixing of concrete for cube test

Mix the concrete either by hand or in a laboratory batch mixer .

- *Hand Mixing*

  Mix the cement and fine aggregate on a watertight none absorbent platform until the mixture is thoroughly blended and is of uniform colour.

  Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.

  Add water and mix it until the concrete appears to be homogeneous and of the desired consistency. (As shown in figure 1).
- *Curing of cubes:* The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear freshwater until taken out prior to the test.

G. Compressive strength

Compressive strength for hardened concrete cube was determined by using compression testing machine. (Figure 2 shows) the compressive strength at 7, 14 and 28 days after taking out the specimen after curing. Three cubes of each mix were tested as per IS 516.

H. Workability

Workability of concrete refers to the ease with which the concrete can be mixed, transported, placed and compacted fully. This test method is used to determine the slump of freshly mixed concrete. Slump is the relative measurement of workability of concrete. The test may be done in the laboratory and in field.

Workability of concrete defined as physical property of concrete alone without referring to the circumstances of a particular type of construction. Workability is a property of fresh concrete and this is measured by slump test and describes as a measure consistency.

In figure 4, It is clearly shown that the slump obtained by RAC is between 220mm-280mm when water cement ratio is 0.4%-0.45% and for NAC, it shows the slump values is higher than RAC between 280-290mm when water cement ratio is 0.4%. the main factor affecting the workability of recycled concrete aggregate are higher rate of water absorption. This condition will affect the workability of the concrete mix.

I. Concrete Mix Design

Concrete mixtures of grade M25. The recycled coarse aggregate are used as replacement of natural aggregate as 0%, 30%, 60%, 100% replacement by volume.

Fig. 3: Slump of Concrete at 60% Replacement

IV. RESULT AND DISCUSSIONS

A. *Compressive Strength*

The test result of different concrete specimen is presented in Figure.5 shows the variation of strength of various mix with age. It may be seen that the compressive strength of all the samples increased with age. The strength of NAC was higher during the early days, but the strength of other mixes (containing RAC with 30%, 60% and 100%) was higher at later days. Referring to figure 5, the result of compressive strength in 7 days increased dramatically from 13.77 N/mm2 at 30% replacement of (RCA) and 17.77 N/mm2 at 60% replacement with (RCA) and 18.22 N/mm2 at 100% (RCA). The specimen tested at 14 days highest strength recorded as 33.77 N/mm2 of 60% replacement of RCA and at 30% replacement it is recorded as the second highest strength as 28.44 N/mm2. The RCA 100% replacement was achieved approximately 23.11 N/mm2. At the age of 28 days strength achieved approximately as target strength the highest strength recorded was 33.77 N/mm2 at 28 days for 60% replacement. The RCA 30% was also among the highest rank in the category at 31.55 N/mm2. The compressive strength of concrete mix was found to be greater than the target strength indicating towards safe and effective use of recycled aggregates in construction practice other than heavy structure requiring greater strength. The size of 20mm aggregate was recorded the highest strength that is used maximum in these specimens.

B. *Workability*

The result of workability test conducted with various percentage of RAC replacement of virgin aggregate in concrete specimen shows that 0% RAC has slump of 20cm, while the slump values for 30%, 60%, and 100% RCA are 29cm, 28cm, 26cm respectively (as shown in figure.6). This value shows the percentage of RAC replacement of virgin aggregate increase the slump value.

It is found that slumps are true and zero slump with water cement ratio of 0.4%-0.45%. This test is mostly used in road construction work.

C. *Water absorption*

The water absorption increases with increase in proportion of recycled aggregates. This may be attributed to higher water absorption of recycled aggregates. In the present case water absorption of RCA is about 6 times higher than that of NA.

The main factor of water absorption is that the mortar attached at the surface of recycled aggregate that were obtained from debris from demolished structure.
It is porous in nature and is capable of holding more water as compare to NA.

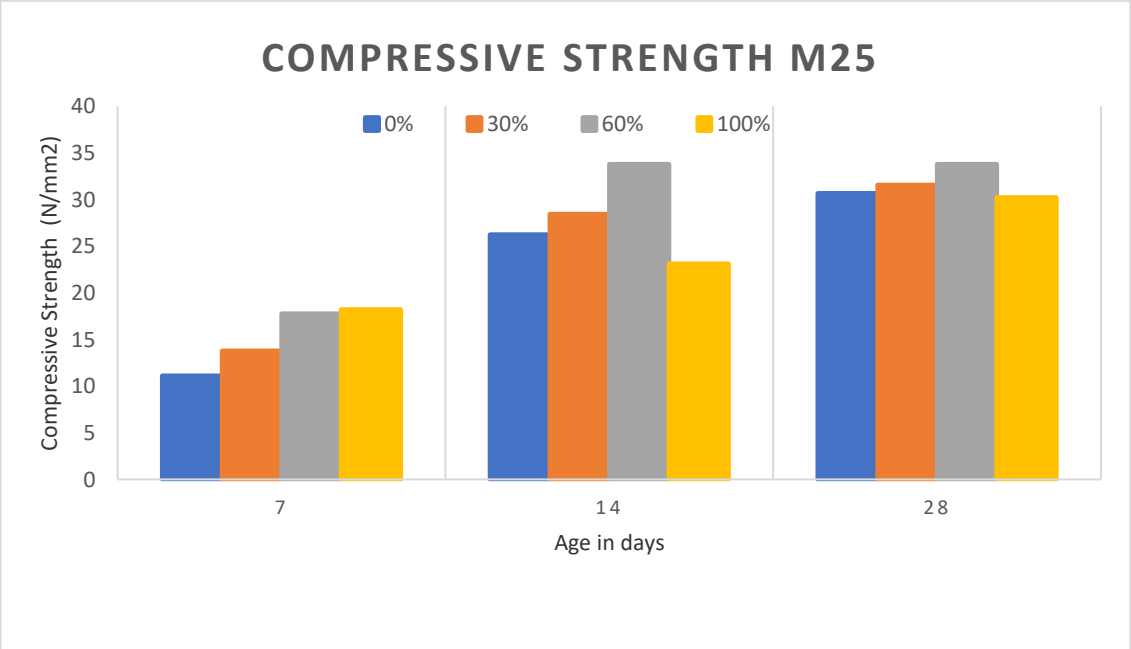

Fig. 4: Variation of strength of mixes with age

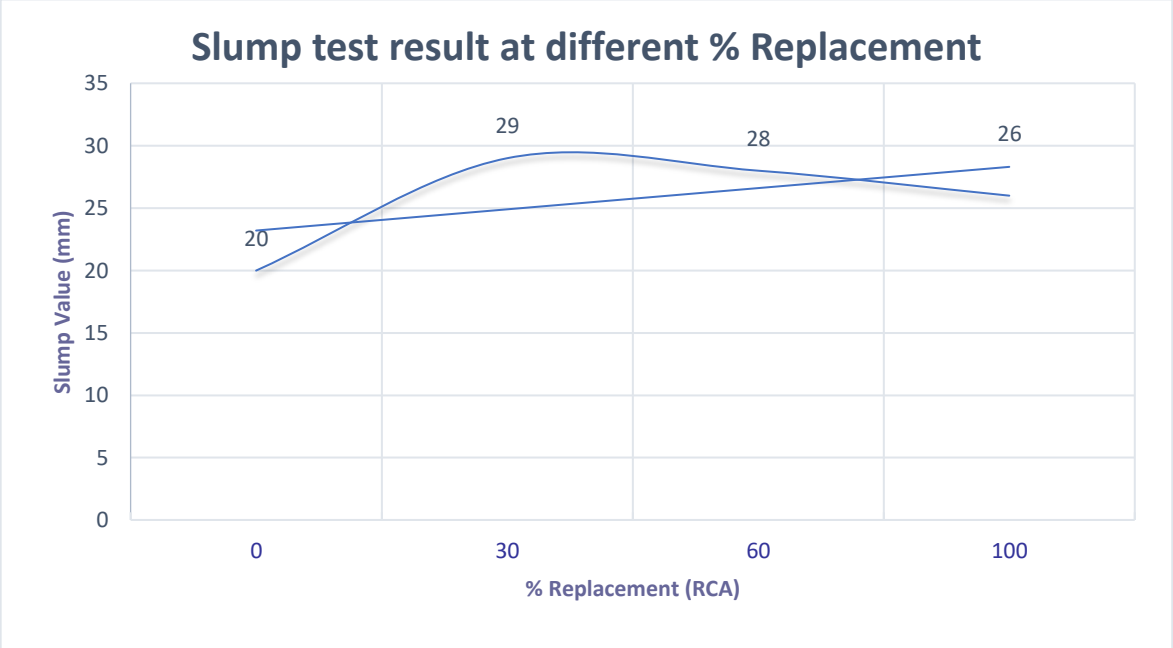

Fig. 5: Slump Test

V. CONCLUSIONS

From the experimental work study of compressive strength of recycled aggregate concrete the following conclusion can be made

A. Recycling and reusing of building wastes have to been found to be an appropriate solution to the problems of dumping hundred of thousands tones of debris from construction and demolition waste accompanied with shortage of natural aggregates.
B. The use of recycled aggregate in concrete proves to be a valuable building material in technical, environmental respect. Use of recycled coarse aggregate in concrete save the disposal and land filling cost and produce a sustainable concrete for construction.
C. From the material testing, it can conclude that, recycled coarse aggregate exhibits comparatively more water absorption as compared to natural aggregate NA, because of adhering mortar and cement past. This need to be compensated during mix design.
D. This study shows that the compressive strength decrease as the RCA content increases. However, 30% replacement of RAC with NA has no major impact on the compressive strength of concrete mix design of M20.

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REFERENCES

[1] Hamed Dabiri. Mahadi KIoumarisi, Ali Kheyoddin, Amirreza Kandiri, Farid Sartipi “Compressive strength of concrete with recycled aggregate; a machine learning-based evaluation”2772-3976/2022/100044
[2] Surya, Kanta Rao, Lakshmy, “Recycled aggregate concrete for Transportation Infrastructure” Bridges and Structures Division, CSIR-CRRI, New Delhi, doi: 10.1016/j.sbspro.2013.11.212.
[3] Shahiron Shahidana, Mohamad Azim Mohammad Azmib, Kumanan Kupusamyc Sharifah Salwa Mohd Zukid, Noorwirdawati Alie “Utilizing Construction and Demolition (C&D) Waste as Recycled Aggregates (RA) in Concrete” Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia,86400 Johor, Malaysia, doi: 10.1016/j.proeng.2017.01.255.
[4] O.A.U UCHE “Influence of recycled concrete aggregate (RCA) on compressive strength of plain concrete” Civil Engineering Department, Bayero University, Kano, 3: 30-36, 2008.
[5] Ismail Abdul Rahman, Hasrudin Hamdam, Ahmad Mujahid Ahmad Zaidi “Assessment of Recycled Aggregate Concrete” Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia 86 400 Parit Raja, Johore, Malaysia, vol.3, no10, oct 2009.
[6] C.S. Poon, Z.H. Shui, L. Lam “Effect of microstructure of ITZ on compressive strength of concrete prepared with recycled aggregates” Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, PR China, doi:10.1016/j.conbuildmat.2004.03.005.
[7] A.K. Padmini, K.Ramamurthy, and M.S.Mathews “INFLUENCE OF PARENT CONCRETE ON THE PROPERTIES OF RECYCLED AGGREGATE CONCRETE” Construction and building material 23 (2009) 829–836.
[8] Rahul, K. (2007). Mechanical properties of concrete with recycled coarse aggregate. Building and environment, 42(1), 407-415
[9] Y.P .Gupta, “Use of recycled aggregate in Concrete Construction: A Need for Sustainable Environment” 34th Conference on OUR WORLD IN CONCRETE & STRUCTURES: August 2009.
[10] Jorge de Brito, Fatima Alves, “Concrete with recycled aggregate” Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, DOI: 10.1617/s11527-010-9595-7.
[11] Pavin P.S, Babitha Rani H, Deepak Girish, Raghavendra K M, “A Study on Recycled Concrete Aggregates” Department of Civil Engineering, SET, Jain University, Volume 118 No. 18 2018, 3239-3263.
[12] S. Reza Salimbahrami, Reza Shakeri, “Experimental investigation and comparative machine-learning prediction of compressive strength of recycled aggregate concrete: https://doi.org/10.1007/s00500-021-05571-1
[13] Tushar R Sonawane “Use Of Recycled Aggregate In Concrete” MIT Pune:Vol. 2 Issue 1, January- 2013
[14] Akash Rao, Sudhir Mishra “ Use of aggregates from recycled construction and demolition waste in concrete” : pp.71-81,2007.
[15] IS Code 2386, IS Code 516 , IS Code 12269