Use of Dismantle Building Material in Concrete: A Review

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Abstract— India is a developing country and in various developing countries like India economical construction along with economical construction material plays a vital role in the development of country. Waste material in construction can play tremendous role to make it economical and durable due to some of its specific properties relevant to construction materials. The present paper work was made in interest of studying various research works involved in use of different substitute materials in construction or in concrete to minimise the cost of construction and to save the natural resources.

Keywords: Recycled coarse aggregates, RCA, Concrete, Workability, and Compressive Strength

I. Introduction

Concrete is one of the major materials used in construction industry and also most important materials used in public works and construction project. Concrete is used in b structure construction since ages now which shows that we have used million tons of concrete and also will continue to use it. As concrete is widely used construction material but at the same time as it is not an environment friendly material as it vanishes and use abundant quantity of natural resources and it is also has a environmental impact as after its use it is deposited in land as a filler material.

The main components of concrete are cement, fine and coarse aggregate and water. Aggregate is a broad group of materials used in structure which includes sand, gravel, trodden stone, and slag, recycled concrete and geo-synthetic aggregate. Aggregate are one of the highest mined materials on earth. Fine and coarse aggregate are part of natural resources which implies that these resources are depleting at a very high rate. Due to this depletion of natural resources and problems of waste disposal of demolished concrete has become a major concern of engineers and environmentalist which has resulted in making efforts to use this waste material produced from demolition of structure as a substitute of natural aggregate. Various researchers have suggested the possibility of properly treating and reusing concrete as aggregate in concrete, especially in lower level applications.

To make this possible, a tremendous amount of experimental works had been carried out across the world. Previously investigations were mainly involved in processing of demolished concrete, mix design, physical and mechanical properties as well as its durability improvements.

Although there studies on use of recycled coarse aggregate for preparing new concrete in west and various eastern countries like Japan, Korea etc. There is relatively less awareness of such potential application of such aggregates in India. After many countries, our India is the largest user of cement in globe which implies that India is one of the largest user of concrete production materials like aggregates, since aggregate is non reproducible, it is essential to propagate awareness about the essential use of recycled coarse aggregates in generation of concrete in India.

II. Literature review

Roller compacted concrete has rapidly become a common material used for the construction dams and massive structures. It can also be used for overtopping and erosion protection of various embankments and for heavy duty pavements. In general we can say that RCC dams are a series of bonded pavements or parking lots stacked on top of each other. Roller compacted concrete added a new vision to the concrete industry and offers numerous advantages in comparison to normal concrete. Using recycled coarse aggregate as a substitute for natural coarse aggregate widens the area for the studies of RCA mixed roller compacted concrete for various purposes and especially for low strength concrete. Various experimental studies were undertaken on roller compacted concrete and recycled coarse aggregate which are summarized below.

Hansen (1985) [5] shown that use of supplementary cement admixtures, such as silica fume, etc. helps in improving the properties of RCA. Generally, concrete made from recycled coarse and fine aggregates has reductions in tensile strengths of less than 10% and a maximum of 20% reduction for the worst case.

Neville (1995) [14] stated that various mixing conditions such as w/c ratio, water-reducing admixture ratio, grading and volume of recycled aggregates can control the initial slump of recycled coarse aggregate concrete.

Sun et al (1998) [24] studied about the effects of fly ash on the fatigue performance of roller compacted concrete. The fatigue equations of RCC with and without fly ash which can be used for designing of pavement were analyzed through regressive analysis and it was compared with common concrete pavement of same grade. The size of concrete specimen was 100x100x400 mm, where specimens were casted with pressure of about 500 g/cm^2 was imposed on the upper surface of the mould during vibration. Fatigue tests were performed on four series of specimen, fly ash content was varied between 0%, 15%, 30% and 45%. To examine the pore structure of mortars made from concrete specimens after the coarse aggregates were rejected. As a result of the study, authors concluded that both fly ash RCC and RCC gives excellent fatigue performance as compared to the common concrete in pavement subjected to same number of fatigue cycles. The mechanism due to which fly ash improves the fatigue performance of RCC lies in combined effect of the densification provided by the roller compacted technology and the pozzolanic reactivity and micro aggregate effect of fly ash.

Kocak E.S. (1998) [10] investigated about local materials in Kahramanmaraş region that are technically good RCC materials to be used in Suçatı Dam in Kahramanmaraş. Mainly two types of ordinary Portland cement, one type of fly ash, one type of ground granulated blast furnace slag, various Portland cement-fly ash and Portland cement- slag combinations, and aggregates were prepared during the research. It was concluded that using slag-cement mixtures as cementious materials are more appropriate material combination than fly ash-cement mixtures or to cement without any finely divided mineral materials.

Abdel-Halim et al. (1999) [1] reported rehabilitation for the spillway of Sama El-Serhan dam with the help of RCC. The foundation of the spillway was damaged due to erosion of soil and it needed repairing work as fast as possible before the next winter season. The aim of the investigation was to evaluate the RCC used in the rehabilitation work by locally available materials. Maximum aggregate size taken was 38 mm. Pozzolana Portland cement was used. Natural pozzolana was used since natural pozzolana deposits exist in huge amount in the neighborhood areas. In order to improve workability of RCC and reduce the free water content, plasticizers were used. The 90 day compressive strength of the RCC section was 10 MPa. Initially, the mixing was done in the laboratory. The project started with a fixed aggregate gradation and cement/pozzolana ratio. Then mortar samples were made using 100 mm cubes mounted on Vebe apparatus and compacted up to full consolidation. Then RCC mixes were prepared by mixing the cementious content and aggregate proportion with varying water content of the mixes. The Vebe time for each mix was determined by compacting the RCC mix using Vebe apparatus. The graph between the Vebe time and the water content of the RCC mix was drawn. In the next step, keeping the paste content (cement, pozzolan, water) constant; the fine aggregate/total aggregate ratio was varied. Different samples were made and compacted with the help of Vebe apparatus. The graph between the Vebe time and the fine aggregate/total aggregate ratio of the RCC mix was made. The ratio with minimum Vebe time was calculated. A series of Vebe tests were conducted on the primary design and good workability was achieved as a result. Then the RCC sections were constructed for the protection of the foundation of the spillway. The authors concluded that the rehabilitation work showed the feasibility of using Roller compacted concrete for repair work of existing dams and also for the construction of new dams in Jordan. The feasibility of this method is attributed for its low cost, ease and rapidity of construction.

Cheng Cao et al. (2000) [4] reported that the strength at early ages of HFRCC was poor, while the fly ash effect was less or negative. The strength of HFRCC increased rapidly as followed by its curing age; meanwhile, the fly ash effects were gradually improved and it was more beneficial for increase flexural strength. Also with the increase in proportion of fly ash, its effect on HFRCC at long curing age was more remarkable.

Katz (2003) [8] the use of RCA in concrete induced a large shrinkage due to the high water absorption capacity of these aggregates. Some studies also showed that in RAC at the age of 90 days, the shrinkage could be about 0.55–0.8 mm/m, whereas the compared to the value for NAC is only about 0.30 mm/m.

Poon et al. (2004) [17] concluded that the moisture condition of the aggregates on initial slump shows that the initial slump of recycled coarse aggregate concrete can significantly be affected by the moisture content of aggregates.

Khatib et al (2005) [9] studied that the absorbed water in the recycled coarse aggregate can be helpful with internal curing by providing a source of water to react with the cement. The relative compressive strength of recycled coarse aggregate concrete decreases when the relative water absorption of aggregate increases and the relative compressive strength may also be significantly affected by the w/c ratio and curing conditions.

Rao (2005) [20] a number of concrete mixes were prepared with varying percentage of recycled coarse aggregate preparation, in favor of saturation. It was concluded that, extra water related to absorption of the aggregate mixes during 22 concrete preparations produces the most efficient results as far as workability is concerned.

Atiş (2005) [2] researched about the strength properties of high-volume and fly ash roller compacted and super-plasticized workable concrete in dry and moist curing conditions. Two different Classes of fly ashes were used by 0%, 50% and 70% replacement of Portland cement. Water/cement material ratios were varied from 0.28 to 0.43. The author explained that blending of cement with fly ash, silica fume, slag or natural pozzola material and use of fly ash in concrete or in roller compacted concrete for pavements and dam applications are globally in construction practice. In addition to this by using super-plasticizer in concrete or RCC makes it possible to generate a workable concrete in lower water/cement ratio. This provides results of greater strength and greater durability properties. It was also explained that the use of super- plasticizers in concrete provides high early compressive strength and relatively same strength in long term as compared to concrete that is without super-plasticizers. The main reason of high early compressive strength is because of cement dispersing mechanism in the super-plasticizer. Cement dispersing mechanism produces bigger cement grain surface availability for water, which implies early hydration in concrete. The author also explained that the use of super-plasticizer increases the use of mineral admixtures in concrete. The OWC concept is followed by designing a zero slump roller compacted concrete and super-plasticized, workable concrete contains high volume of fly ash. Atiş concluded that it is possible to change a RCC concrete to a workable concrete by using a suitable super-plasticizer. Further, because of its high strength properties, high volume fly ash Roller compacted concrete is an alternative to plain Portland cement concrete which is used for different pavement applications and large industrial floors.

Qasrawi et al (2005) [18] explained that the use of RCC for pavements is a new technology and is still under study and development. Roller compacted concrete pavement (RCCP) is defined as a stiff mixture of aggregates, cement materials and water which can be compacted by vibratory rollers. The concrete must have low consistency and workability for RCCP. Based on the concept that RCCP concrete has low water content and hence may segregate which is why the nominal maximum aggregate size is selected as 20 mm. Due to the fact that higher cement content can cause heating problems in hot weather because of heat of hydration, the amount of cement used was 12-15% and pozzolana was not used in the mixes. RCCP mixes were mixed with the help of a soil compaction method in which the optimum density had been considered the aim of the mix design. The authors explain that there are no standard methods for preparing RCC test specimens. However because of its stiff consistency, conventional concrete specimen procedures cannot be used for the preparation of RCCP test specimens. The compaction of the test specimens was done with the help of California Kneading Compactor. Total five different water/cement ratios were considered in the study. Four levels of all aggregates to cement ratio and two level of coarse aggregate to fine aggregate ratios were used for the study. Also three comp active efforts were used for compaction. The main conclusion can be summarized that the cement content is the major factor that affects the fresh and hardened properties of concrete. Further, unlike conventional concrete, when we lower the water/cement ratio below the optimum it will not result in increase in the strength of concrete.

Rahal et al (2007) [19] studied that when relative water absorption of aggregate is below 1.8%, the compressive strength of recycled coarse aggregate concrete maintains more than 80% of that of the controlled concrete with natural aggregates mixes, whereas the compressive strength of recycled aggregate concrete have relative water absorption of aggregate above 5.5% drops significantly, by as much as nearly 40% that of the controlled concrete with natural coarse aggregates. Insufficient hydration and a weak interface-zone was formed between different components of the concrete matrix resulting in to a large amount of old cement paste on the surface of recycled aggregates, which may be the cause of a poor development of the compressive strength of concrete.

Poon et al. (2007) [16] showed that the initial slump slightly increases due to increase of the replacement level of recycled coarse aggregates that are used in a saturated surface dry state.

Ganesh Babu et al. (2011) [27] concluded that with increase in fly ash content in RCC at high workability and with low cement content decreases the water cement ratio.

Michael Henry et al (2011) [13] they used different low-grade recycled aggregates mixing with different water binder ratios and analysis of different properties was done. Three different water– binder ratios (0.3, 0.375, and 0.45), two different binder combinations (C50%-FA50% and C50%- FA25%-BS25%), and three different recycled aggregate replacement ratios of 0%, 50%, and 100% were selected for this experimental research. The mixing water content was also reduced from the standard 170 kg/m^3 to 135 kg/m^3 to reduce content of binder. The 50% replacement of cement was done with mineral admixtures and decreased binder content conditions were made for all mix proportions based upon previous experimental results which showed the balance between mechanical and environmental performance considering binder composition and content. A control concrete that had a water–binder ratio of 0.5 and no waste or recycled materials was also made to serve as a reference for normal-used concrete.

Butler et al. (2011) [3] concluded that recycled coarse aggregate concrete have higher compressive strength values than that of natural aggregate concrete. This is may be due to the strong mortar–aggregate bond between the RCA and the new mortar.

Henry et al (2011) [12] studied Compressive strength development from 7 days to 91 days for different proportions of RCA concrete. The control series had the highest strength level at 7 days but, from 7 to 28 days, the strength development was greater for the W/B = 0.3, W/B = 0.375, and W/B = 0.45 with the blast furnace slag proportions, regardless of aggregate type. In the 31 case of the W/B = 0.3 and W/B = 0.45 with blast furnace slag, the strength level was comparable to the control by 28 days, but for W/B = 0.375 the strength level was still lower than the control even though the strength development was higher. And finally, from 28 to 91 days the strength development shows a similar rate as the control proportions. For the W/B = 0.45 proportions, the strength development is similar to the control from 7 to 91 days, but at a much lower level.

Xiao et al. (2012) [26] concluded that the compressive strengths of recycled coarse aggregates are normally lower than that of conventional concrete. Further, compressive strength values decreases with the increase in RCA content .Several reasons may be responsible for the reduction of the compressive strength for RCA, which may include an increased concrete porosity and a weak aggregate-matrix interface bond.

Qasrawi et al. (2013) [7] stated that results of the air content for the different types of mixes. Generally, the air content increases in case of RCA or SSA was introduced. It had been observed that replacement up to 25%, the increase in air content is very less and nearly the expected value of ACI 211.1 for maximum size of aggregate of 20 mm. For the increased percentage replacements, the air content was 1.5–2 times the expected value. The increase in air content in RAC is a result of the mortar adhered to the aggregates. The increase in air content in SSA may result in difficulties in compaction because of the higher angularity of the aggregate when it is compared to natural aggregate.

Radonjanin et al. (2013) [25] studied the comparison between the compressive strength for different concrete type mixes proportions. The results of compressive strength testing of related RAC concrete of that concrete group were higher values of compressive strength. Author also concluded that a rapid strength development in the period up to 7 days, then a slower strength gain after 28 days. However, there are smaller differences depending up on the type of highly reactive mineral admixture applied in mixtures. The results of compressive strength testing of GRAC composites with fly ash, in comparison to referent RAC concrete, there are significant differences in between the reference concrete and all concretes that are with fly ash, but also there are also significant differences in strength values within the group of concretes that contains fly ash, depending up on the presence of super plasticizer and highly reactive mineral admixtures. Reference concrete has fast strength development in the initial period; while all concretes that are with high content of fly ash shows tendencies of a significant increase in strength after 28 days.

Ali Mardani et al. (2013) [11] investigated that when cement was replaced by fly ash in RCC mix, increasing the fly ash content produces reduction in compressive strength, split tensile strength and flexural strength values at all ages and even till 180 days.

Pavan et al. (2014) [15] stated that the mixtures in which cement was replaced with fly ash, with increase in the fly ash content it resulted in reduction in compressive strength, splitting tensile strength and flexural strength values at all of the ages till 28days.

S.Krishna Rao et al (2014) [22] studied Evaluation of Properties of Roller Compacted Concrete Pavement (RCCP). They stated that RCCP mixes can be proportioned using soil compaction method also RCC is a stiff, zero-slump concrete mix that has the same ingredients similar to conventional concrete. This is mixed, placed, and compacted by the same type of equipment which is used for asphalt pavement construction. Compressive strength increased with increase in cement content. At initial stage the increase in the strength was stable but at 28 days strength variation was quite considerable. Flexural strength was increased with increase in cement content. 14 % cement content gave a flexural strength of 4.5MPa which may be suitable for construction of rigid pavements in India. Corresponding cement content is 295.5kg per one cubic meter of concrete which showed the economical advantage of RCCP as compared conventional concrete. Split tensile strength was increased with increase in cement content. From the strength behavior of RCC, it was recommended for paving applications.

S. Krishna Rao, et al (2015) [21] studied Strength and Compaction Characteristics of Fly Ash Roller Compacted Concrete. From the experimental investigations that were conducted on RCC with fly ash as mineral admixture they concluded that RCCP mixes can be proportioned using soil compaction method, The Optimum moisture content of the fly ash mixtures is increased with increase in fly ash content when compared to those of control mixtures, this was due to the fact that the differences between the specific gravities and fineness of cement and fly ash. The maximum dry density is decreased with increase in Fly ash content when compared with the control mixtures. When cement was partially replaced with fly ash, strength values were decreased with increase in fly ash content. This is attributed to the increase in water binder ratio of the mix due to fly ash addition and in part to the lower contribution of fly ash than cement to strength even up to 180 days.

S. Pavan and S. Krishna Rao (2014) [23] studied the effect of Fly ash on Strength Characteristics of Roller Compacted Concrete Pavement. For the materials used and test methods applied authors concluded that While increasing the fly ash content and increasing water cement ratio of the mixture the unit weight of mixes decreases. In mixes where cement was partially replaced by fly ash, strength was decreasing with increase in fly ash content. The effect, in parts was attributed to the increase in water/binder ratio of the mixes because of fly ash addition and in part to the lower contribution of fly ash than cement to strength in 28days. When fly ash was replaced by 60% with the cement it caused reduction in 7-day strength and the mix gained only 50% of its 28-days strength. However, at later age the rate of strength of mix was increased and was close to each other and independent of fly ash content of the mix.

Harris Angelakopoulos et al (2015) [6] studied Fibrous roller-compacted concrete with recycled materials for its feasibility. In which results revealed that the addition of fibers in a concrete matrix of low cement content (200 kg/m^3) results in void formation, which impacts negatively on early-age compressive strength (reductions in strength of 20–70%). Manufactured fibers had less negative impact as compared to reused tyre steel fibers (RTSF). Mixes with higher cement contents (300 kg/m^3) were less adversely affected due to the extra cement paste availability to fill any voids and prevent fiber agglomeration, results in a denser concrete matrix configuration. Fiber integration in RCC at an industrial scale can to be feasible. RTSF fibers integrated better in RCC as compared to larger manufactured fibers, which had a tendency to appear on the surface.

III. Conclusion

From the above literature, it is seen that the research are in interest to introduce different kind of materials to reduce the cost of construction, as well as to change the properties of the material according to their type of use. In developing countries like India, where economic construction plays vital role. Researcher used the different materials like fly ash, silica fumes, fibres, chemicals and many more material to enhance the property of the material with reduction in manufacturing or construction cost. In India the life span of the structure is very low as compared to other countries therefore the new structures are built in place of old structure day by day. So use of wastage material of old structures to new construction will very helpful in economic point of view. We can use this demolished material in place where low strength concrete is required. The review shows that there is ample scope to research in area of usage of waste or disposed of building materials in new construction.

References

[1] Abdel-Halim M.A.H., Al-Omari M.A., Iskender M.M., “Rehabilitation of the spillway of Sama El-Serhan dam in Jordan, using roller compacted concrete”, Engineering Structures, 1999, 497-506.
[2] Atis C.D., “Strength Properties of high-volume fly ash roller compacted and workable concrete, and influence of curing condition”, Cement and Concrete Research, 2005, 1112-1121.
[3] Butler L., 2012, “Evaluation of Recycled Concrete Aggregate Performance in Structural Concrete”, thesis, The University of Waterloo, Canada, Viewed April 2013.
[4] Cao C, Sun W, Qin H (2000). The analysis on strength and fly ash effect of roller- compacted concrete with high volume fly ash. Cement and concrete research, 30(1): 71-75.
[5] Hansen TC, Bøegh E. “Elasticity and drying shrinkage of recycled-aggregate concrete”. ACI Material Journal 1985; 82(5) pp648–52.
[6] Harris Angelakopoulos, Kypros Pilakoutas, Panos Papastergiou “Fibrous roller- compacted concrete with recycled materials – feasibility study” magazine of concrete research 2015, 67, 801 – 811.
[7] Hisham Qasrawi, 2013 the uses of steel slag aggregate to enhance the mechanical properties of recycled aggregate concrete and retains the environment pp 298-304.
[8] Katz A. Treatments for the improvement of recycled aggregate. J Mater Civil Eng 2004; 16(6) pp 597–603.

[9] Khatib, J.M., 2005. Properties of Concrete Incorporating Fine Recycled Aggregate. Cement and Concrete Research, V. 35, pp.763-69.
[10] Koçak, E.S., "A Suitable Roller Compacted Concrete for Kahramanmaraş- Suçatı Dam", METU Civil Engineering Department, January 1998.
[11] Mardani-Aghabaglou A, Ramyar K (2013). Mechanical properties of high-volume fly ash roller compacted concrete designed by maximum density method. Construction and Building Materials, 38, 356-364.
[12] Michael Henry, German Pardo, Tsugio Nishimura and Yoshitaka Kato (2011) Balancing Durability and environmental impact in concrete combining low grade recycled aggregates and mineral admixtures " resources conversation and recycling 55(2011) pp1060-1069.
[13] Michael Henry, German Pardo, Tsugio Nishimura and Yoshitaka Kato (2011) Balancing Durability and environmental impact in concrete combining low grade recycled aggregates and mineral admixtures " resources conversation and recycling 55(2011) pp1060-1069.
[14] Neville, A.M., 1995. "Properties of Concrete" UK: Longman. p844.
[15] Pavan S, Rao SK (2014). Effect of Fly ash on Strength Characteristics of Roller Compacted Concrete Pavement. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 11, Issue 6 Ver. II (Nov- Dec.2014), PP 04-08.
[16] Poon, C. S., Kou S. C., Lam, L., 2007. "Influence of Recycled Aggregate on Slump and Bleeding of Fresh Concrete". Materials and Structures, V. 40(No. 9), pp981-88.
[17] Poon, C.S. et al., 2004. "Influence of Moisture States of Natural and Recycled Aggregates on the Slump and Compressive Strength of Concrete". Cement and Concrete Research, V 34, pp31-36.
[18] Qasrawi H.Y., Asi I.A., Wahhab H.I.A., "Proportioning Roller Compacted Concrete Pavements mixes under hot weather conditions for a specified tensile strength", Cement and Concrete Research, 2005, 267-276.
[19] Rahal, K., 2007. "Mechanical Properties of Concrete with Recycled Coarse Aggregate. Building and Environment", V. 42, pp 407-15.
[20] Rao A., Experimental Investigation on Use of Recycled Aggregates in Mortar and concrete. Thesis submitted to the Department of Civil Engineering, Indian Institute of Technology Kanpur (2005).
[21] Rao et al. Strength and Compaction Characteristics of Fly Ash Roller Compacted Concrete International Journal of Scientific Research in Knowledge, 3(10), pp. 0260- 269, 2015.
[22] S.Krishna Rao et al, "Evaluation of Properties of Roller Compacted Concrete Pavement (RCCP)" IJEAR Vol. 4, Issue Spl-2, Jan - June 2014.
[23] S.Pavan, S. Krishna Rao, "Effect of Fly ash on Strength Characteristics of Roller Compacted Concrete Pavement", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 11, Issue 6 Ver. II (Nov- Dec. 2014).
[24] Sun W., Liu J., Qin H., Zhang Y., Jin Z., Qian M., " Fatigue Performance and Equtions of Roller Compacted Concrete with Fly Ash", Cement and Concrete Research Vol. 28,No. 2, pp.309-315, 1998.
[25] Vlastimir Radonjanin , Mirjana Malesev, Snezana Marinkovic , Ali Emhemd Saed Al Malty 2013 "Green recycled aggregate concrete" Construction and Building Materials 47 (2013) pp1503–1511.
[26] Xiao J, Wengui Li, Yuhui Fan, Xiao Haung (1996-2011). An overview of study on recycled aggregate concrete in china Construction and Building Materials 31 (2012) pp364–383.
[27] Yerramala A, Babu KG (2011). Transport properties of high volume fly ash roller compacted concrete. Cement and Concrete Composites, 33(10): 1057-1062

