

# A Review on Recycled Aggregate Based Thermal Insulated Concrete

N. Anuja<sup>1</sup> and M. Balaji<sup>2</sup>

<sup>1</sup>Assistant Professor, <sup>2</sup>PG Student,

<sup>1&2</sup>Department of Civil Engineering, Mepco Schlenk Engineering College, Sivakasi, Tamil Nadu, India  
E-mail: anu\_priya1031@yahoo.com

**Abstract** - One of the major challenges of our present society is the protection of environment. Therefore concrete must be such that, it can conserve resources, protect the environment through the utilization of waste materials, economize and lead to proper utilization of energy. In India, the approximate rate of production of construction and demolition wastes is reported to be 14.5 million tonnes annually. The most preferable method of managing these solid wastes is to dump them into the landfills. This creates problems such as pollution in landfill areas and highly increased disposal cost in urban areas. Therefore, recycling and re-using these demolition wastes as recycled aggregates to produce the concrete has been identified as a fruitful way to mitigate the scarcity of natural resources, waste management and environmental issues. Another existing problem is of heat balance, heat always flows from warmer to cooler surfaces. This flow does not stop until the temperature in the two surfaces is balanced. Recycled aggregate alone with thermal insulation material reduce the rate of heat transfer. In this paper a study has been made on the past researches carried out by the different scholars and their results have been studied.

**Keywords:** Recycled Aggregate Concrete, Performance of Recycled Aggregate Based Thermal Insulation Concrete, Expanded Perlite, Steel Fiber

## I. INTRODUCTION

Due to the critical shortage of natural aggregate, the demolished concrete of the structures has been used as Recycled Concrete Aggregate (RCA) now-a-days. Using the waste concrete as RCA conserves natural aggregate, reduces the impact on landfills, decreases energy consumption and can provide cost savings. Recycled aggregates are the materials for the future. The application of recycled aggregate has been started in many countries for construction projects. It is found that an average amount of 40 billion tons of natural aggregates has been used annually around the world. This tremendous rate of consumption of natural aggregates causes depletion of these resources leading to scarcity of natural aggregates in several countries across the globe. Moreover, the production and processing of natural aggregates contribute greatly to the emission of dust, noise and greenhouse gases which exhibit serious negative impact on the environment. Thus, the need for developing an alternative source of aggregates is an important matter of concern for today's society. Besides, a substantial quantity of construction and demolition (C&D) wastes have been generated annually from the construction industries across almost all countries in the globe. The overall C&D waste production around the globe exceeds

three billion tonnes annually. The major contributors to this waste generation are China, India, and USA producing approximately two billion tonnes of wastes. Possibility of using recycled concrete aggregates (RCA) derived from construction and demolition waste (CDW) has received enormous research interest over the past few decades, owing to its potential to reduce the carbon footprint of concrete manufacturing. Moreover, paucity in the reserves of natural aggregates in many parts of the world is leading to the use of recycled aggregates derived from CDW for construction. Partial or full substitution of natural coarse aggregates (NCA) with RCA in concrete production may solve several pressing issues such as environmental and social problems, severe scarcity of natural reserves and waste disposal.

Another existing problem is of heat balance, heat always flows from warmer to cooler surfaces. This flow does not stop until the temperature in the two surfaces is balanced. This heat is transferred by the means of Conduction, Convection, and Radiation. Recent years have seen a myriad of ways to modify the thermal conductivity (TC) of concrete. The fundamental idea is to introduce materials with very high insulation to bring down the Thermal conductivity of the resulting composite. This can be achieved using thermal insulation material expanded perlite. Expanded perlite is a well-established insulation material used for various applications as it has light yet rigid foam with good thermal insulation and high impact resistance. This study will broaden the application field of recycled coarse aggregate blended with expanded perlite for thermal insulation usage and energy saving as well as improving the mechanical properties.



Fig. 1 Benefits of RCA

### A. Recycled Aggregate Concrete

Recycling is the act of processing the used material for use in creating a new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. Recycled aggregate is comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. Recycled Concrete Aggregate (RCA) contains not only the original aggregates, but also hydrated cement paste. So it has to undergo pre-processing to ensure higher quality.

#### Pre-Process of Recycled Coarse Aggregate

Construction and demolition (C&D) debris recycling facilities are very much similar to aggregate crushing facilities.

1. *Crushing:* Demolition and construction waste from the site is crushed in pre-process plant.
2. *Segregation:* To separate out the concrete from brick and impurities such as wood, plastic and glass.
3. *Sorting:* Size of the concrete particle is reduced then coarse aggregate and fine aggregate is separated.
4. *Contaminant Elimination:* Removal of ferrous metals, silts and clay particle.



Fig. 2 Typical C&D recycling plant for Recycled Coarse Aggregate (RCA)

### B. Expanded Perlite

Perlite is a siliceous volcanic glass, the volume of which can expand substantially under the effect of heat. When heated above 870 °C, its volume increases 4-20 times of the original volume and an inner porous structure is formed, which allow to increase the thermal insulation characteristics of the material.

## II. LITERATURE SURVEY

Loghmani *et al.*, (2019), studied the thermal conductivity and compressive strength of expanded perlite aggregate concrete with mineral admixtures. Silica fume and fly ash were added as replacement for cement by decreasing the cement weights in the ratios of 10, 20 and 30% by weight. Super plasticizer was used 1.5% by weight of Portland cement to reduce w/c ratios. The thermal conductivity decreased with the increase of silica fume and fly ash as

replacement for Portland cement up to 14 and 18%, respectively. Densities of all samples decreased from 522 to 483 kg/m<sup>3</sup> with the increase of both admixtures. The compressive strengths decreased 12, 19, 29 for 7 days, and increased 9, 13%, 4%, for 28 days due to 10, 20 and 30% silica fume, respectively.

Filiz Karaosmanoglu *et al.*, (2020) presented the effect of expanded perlite on the mechanical properties and thermal conductivity of lightweight concrete. In the experimental program, mixtures were prepared by partially replacing natural aggregate by expanded perlite. Unit weights of lightweight concretes in fresh state varied between 700 and 2000 kg/m<sup>3</sup>. The compressive strength and modulus of elasticity decreases with increasing in perlite content. The test results indicate that the thermal conductivity is substantially improved with the use of perlite.

Hemalatha G. *et al.*, (2019) presented the effect of expanded perlite aggregate on the properties of lightweight concrete. In this study, initially 30% replacement ratio of EPA was used to determine the effects of cement types. In experiments, the minimum unit weight of concrete mixture was 1800 kg/m<sup>3</sup> and compressive strengths of EPAC (expanded perlite aggregate concrete) were obtained between 20 and 30 MPa at the replacement ratios of 30%. It was observed that the compressive strength, splitting-tensile strength and the dynamic elasticity modulus increased with the increase in dosage.

Liang Guo *et al.*, (2019) studied about the strength properties and thermal conductivity of concrete with the addition of expanded perlite filled with aerogel. In this study, expanded perlite filled with aerogel is used as a new material as the aggregate in concrete. The mechanical strength and the thermal conductivity of the concrete decreased when the new material's content increased concrete with a 100% volume content of graded expanded perlite filled with aerogel has a thermal conductivity of 0.098 W/mK.

Gang Ma *et al.*, (2018) studied the basic properties of fly ash-based lightweight geopolymer concrete prepared using pumice and expanded perlite as aggregates. The effects of expanded perlite (EP) and acidic pumice (AP) aggregates were discovered for the production of lightweight geopolymer concretes. The Microstructural properties of each produced geopolymer concrete were characterized using SEM, EDS and laser particle size analyses. Uniaxial compressive strength of the lightweight geopolymer concretes were in a range of 10-50 MPa and their unit weights changed between 1250 and 1700 kg/m<sup>3</sup>. Lighter concretes were obtained by the addition of expanded perlite aggregates rather than acidic pumice ones.

Jesika Rahman *et al.*, (2020) studies the flexural response of fiber reinforced concrete beams with waste tires rubber and recycled aggregate. This paper investigates the combined influence of RCA, CR, and polypropylene (PP)

fiber on the physical and mechanical properties of Fiber Reinforced Rubberized Recycled Concrete (FR3 C). Several combinations are designed where the variables are crumb rubber (CR) content (5% and 10%) and steel ratio (0.59% and 1.60%) with contents of recycled coarse aggregate (RCA) and fiber fixed at 30% and 0.5%, respectively. Concrete beams with 30% RCA, 5% CR and 0.5% PP fiber showed improved flexural capacity, ductility, and toughness.

Rakesh Muduli *et al.*, (2019) presented the performance assessment of concrete incorporating recycled coarse aggregates and metakaolin: A systematic approach. For this investigation several combination of concrete were made by replacing the natural coarse aggregates (NCA) with 25%, 50%, 75% and 100% recycled coarse aggregates (RCA) and cement with 0%, 5%, 10%, 15% and 20% metakaolin. Strength of concrete reduces with increase in % replacement of natural coarse aggregates. Utilization of metakaolin improves the strength of recycled aggregate concrete due to the combined action of pozzolanic and filler effect of metakaolin. Durability of recycled aggregate concrete also gets improved by the use of metakaolin. Utilization of 15% metakaolin and 50% recycled coarse aggregate is recommended.

Hossein Sasanipour *et al.*, (2019) studied the durability properties evaluation of self-compacting concrete prepared with waste fine and coarse recycled concrete aggregates. In this study, the effect of fine and coarse recycled concrete aggregates (RCA) was evaluated by replacing 25%, 50%, 75% and 100% in self-compacting concretes (SCC) on mechanical properties and durability properties. Replacement of 25% RCAs improves the tensile strength. However, by the increase in the replacement of RCAs, a reduction in tensile strength may occur. Replacement of 25% coarse RCAs had no significant effect on the durability properties of self-compacting concrete including electrical resistivity and chloride ion resistance, while with the increasing fine and coarse RCAs the electrical resistivity and resistance to chloride ion penetration decreased.

Meng Chen *et al.*, (2020) studied about mechanical and stress-strain behavior of basalt fiber reinforced rubberized recycled coarse aggregate concrete. Recycling scrap tyres and concrete as the alternatives of natural aggregates to produce rubberized recycled concretes will result in a considerable conservation of natural resources. The effects of recycled coarse aggregates, rubber particles and basalt fibers on mechanical and stress-strain behaviors of concrete are investigated. The failure patterns of the specimens under uniaxial compression are analyzed. Compared with normal concrete, rubberized recycled concrete with 10% rubber particles and 40% recycled coarse aggregates has better strength and deformation performance.

Stephen O. Ekolu *et al.*, (2020) performed the comparative analysis on costs and benefits of producing natural and

recycled concrete aggregates. Presently, most demolition wastes are dumped in landfills or used in low quality applications such as road-based construction etc. One of the mitigation measures employed is the reuse of demolished concrete as recycled concrete aggregate. Production of recycled concrete aggregates is less expensive than that of natural aggregates. The long-term cost of producing one tonne of coarse recycled concrete aggregate was about 40 % less than that for coarse natural aggregate. Also, the environmental benefit of producing one tonne of recycled concrete aggregate was approximately 97 % higher than that for natural aggregate.

### III. APPLICATION OF RECYCLED AGGREGATE BASED THERMAL INSULATION CONCRETE

1. RCA reduces the impact on landfills; decreases energy consumption and can provide cost savings.
2. Thermal Insulation Concrete (TIC) provides comfort as it keeps room. Cool in summer and hot in winter.
3. It saves fuel by minimizing heat transfer.
4. It also produces environmental friendly and durable concrete.
5. Recycled Aggregate Based Thermal Insulation Concrete represents a new kind of 'green' concrete that reduces thermal consumption and improves the energy efficiency of buildings.

### IV. CONCLUSION

From the above study the following conclusions can be drawn

1. Expanded perlite can be used as fine aggregate in concrete with appropriate replacement ratios along with the lightweight property.
2. Expanded perlite increase the insulation characteristic of concrete.
3. Recycled aggregate is an ideal substitute for natural aggregate in structural concrete.
4. Recycled aggregate up to 25% replacement does not affect the functional requirements of the structure.
5. By recycling and replacing the construction and demolition wastes in concrete, the area of the landfill for dumping the construction wastes can be reduced.
6. Commercial production of recycled concrete aggregates should be promoted as a cost-effective and environmentally beneficial approach for implementation in the construction industry.

### REFERENCES

- [1] P. Loghmani, Ramazan, Demirboga and RustemGul, "Thermal conductivity and compressive strength of expanded perlite aggregate concrete with mineral admixtures," *Energy and Buildings*, Vol. 35, pp. 1155-1159, 2019.
- [2] Ozkan Sengul, Senem Azizi, Filiz Karaosmanoglu and Mehmet Ali Tasdemir, "Effect of expanded perlite on the mechanical properties and thermal conductivity of lightweight concrete," *Energy and Buildings*, Vol. 43, pp. 671-676, 2020.

- [3] G. Hemalatha, Ilker Bekir Topc and Burak Isikdag, "Effect of expanded perlite aggregate on the properties of lightweight concrete," *Journal of materials processing technology*, Vol. 204, pp. 34-38, 2008.
- [4] Liang Wang, Peng Liu, Qiangshan Jing, Yuanzhen Liu and Wenjing Wang, "Strength properties and thermal conductivity of concrete with the addition of expanded perlite filled with aerogel," *Construction and Building Materials*, Vol. 188, pp. 747-757, 2018.
- [5] Gang Ma, Mahmutaltiner and Dogan kaya, "Properties of fly ash-based lightweight geopolymer concrete prepared using pumice and expanded perlite as aggregates," *Journal of Molecular Structure*, Vol. 199, pp. 74-57, 2019.
- [6] M. Shahjalal, Kamrul Islam, Jesika Rahman and Khondaker Sakil Ahmed, "Flexural response of fiber reinforced concrete beams with waste tires rubber and recycled aggregate," *Journal of Cleaner Production*, Vol. 278, pp. 123842, 2021.
- [7] Rakesh Muduli and Bibhuti Bhusan Mukharjee, "Performance assessment of concrete incorporating recycled coarse aggregates and metakaolin: A systematic approach," *Construction and Building Materials*, Vol. 233, pp. 117223, 2020.
- [8] Hossein Sasanipour and Farhad Aslani, "Durability properties evaluation of self-compacting concrete prepared with waste fine and coarse recycled concrete aggregates," *Construction and Building Materials*, Vol. 236, pp. 117540, 2020.
- [9] Meng Chen, Xiaoyu Wang, Zhihao Wang and Tengeng Guo, "Mechanical and stress-strain behavior of basalt fiber reinforced rubberized recycled coarse aggregate concrete," *Construction and Building Materials*, Vol. 260, pp. 119888, 2020.
- [10] O. Stephen, A. Ekolu, Eric and Ohemeng, "Comparative analysis on costs and benefits of producing natural and recycled concrete aggregates," *Case Studies in Construction Materials*, Vol. 13, pp.e00450, 2020.