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Use of recycled concrete aggregates in the production of concrete composites

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Abstract
Chasing sustainable construction practices, recycled concrete has become a model of environmental responsibility and resource efficiency. Traditional concrete production is a major source of carbon emissions, so switching to recycled concrete is a necessary step towards a greener future. This blog explores the growing potential of recycled concrete, its environmental benefits, technological advances and the transformative impact it can have on the construction industry.

Keywords: Concrete demolition waste, concrete laboratory waste, natural aggregates, concrete scrap, waste disposal

Introduction

The construction industry is an important sector, the purpose of which is to introduce new design solutions that create an artificial human environment that helps improve the level of human life. In this sense, the natural environment is considered in terms of protecting buildings, structures and people functioning in them from the negative and aggressive effects of external environmental factors. The process of aggressive interaction between human construction activities and the environment on nature has fully become the subject of consideration relatively recently [1]. Meanwhile, construction is one of the strongest factors of anthropogenic impact on nature, including humans - an integral part of nature. The anthropogenic impact of construction on the natural environment is diverse in nature and occurs at all stages of construction activity, from the extraction and production of building materials and structures to the processing and reuse of construction waste from the demolition of buildings and structures [2, 3]. After demolition of old roads and buildings, tons of construction waste are thrown away, destroyed concrete is also often considered useless and disposed of as demolition waste [4]. The main task of scientists around the world is to create a comfortable human environment or optimize the "man-material-habitat" system [5]. However, most construction waste is considered inert and can potentially be used as raw material for the production of construction materials. Natural resources are typically consumed in significant quantities in the construction sector, and a significant amount of construction and demolition waste is also generated, constituting the largest volume of all solid waste [6]. The huge amount of construction waste in different countries has highlighted the importance of countries' actions to manage, recycle and reuse the waste generated throughout the life cycle of a particular infrastructure [6]. The generation of construction waste and the unsustainable use of dwindling natural resources for construction materials are also associated with the adverse environmental impacts of the construction industry. Globally, it is estimated that approximately 10–30% of waste disposed of in landfills comes from construction and demolition activities [7]. In addition, the overuse of natural resources for the production of crushed stone and gravel is an increasingly serious environmental problem that requires the development of sustainable integrated management programs and suitable recycling processes to achieve economic returns from these wastes. Increasing the recycling and reuse of demolition and construction waste within the industry will help conserve dwindling natural resources [8]. Thanks to the development of effective building materials and mandatory rules for the disposal of demolition and construction waste, environmental goals can be achieved as there is a great need to develop suitable recycling processes to protect the environment as well as to obtain economic returns from waste. In many parts of the world there is growing interest in recycling and reusing waste from the construction industry, with the Netherlands having the highest recycling rate of construction waste at 93%, followed by Turkey, where effective waste management has allowed almost 90% of demolition and construction waste to be recycled [9]. Australia achieved 87% recycling of demolition and construction waste [10], followed by Denmark at 82% [11] and Germany at 18% [12]. The total use of demolition and construction waste for England in 2008 was estimated at 86.9 million tonnes, of which 53 million tonnes were recycled and a further 11 million tonnes were distributed on vacant sites for land reclamation, agricultural improvement or infrastructure projects [13]. Reuse and recycling of concrete waste, which constitutes the largest proportion of demolition and construction waste, is proposed as a solution to the problem of waste management and conservation of natural resources, while 40% of the crushed stone, pebbles and sand used in the world are used in the construction industry, the amount of materials is adequate quality is constantly decreasing [14]. In addition, members of the European Union produce about 50 million tons of waste concrete each year, compared to 60 million tons in the United States and 10–12 million tons in Japan, which has reduced its use of aggregates by 2.5 million m3 by recycling concrete waste into production ready-mixed concrete [15]. 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1. Environmental benefits of recycled concrete

The environmental benefits are as follows:

Reduced carbon footprint

The use of recycled concrete is key to the sustainable building revolution as it significantly reduces carbon footprint in traditional concrete production. The environmental impact of concrete production is enormous, with carbon emissions resulting from the extraction of raw materials and the energy-intensive processes involved. Recycled concrete breaks this traditional model by recycling discarded concrete as aggregate, reducing the need for large-scale mining and resource extraction.

Carbon dioxide emissions are reduced by half. First, it reduces the demand for new aggregates, usually obtained from quarries and mines, preventing further depletion of natural resources. Second, energy-intensive processes for producing virgin concrete are minimized because recycled concrete requires less energy.

This environmentally conscious approach aligns with broader sustainable building goals, focusing on the end product and the entire material life cycle. By choosing recycled concrete, construction practices can actively help create a more environmentally responsible industry, promoting a circular economy that minimizes waste, conserves resources and advocates for reduced carbon emissions for a greener future.

Reduce waste

Waste reduction is at the forefront of sustainable construction, and recycled concrete has become a powerful ally in mitigating the construction industry's environmental impact. In its relentless pursuit of progress, the construction sector unintentionally produces huge amounts of concrete waste, resulting in overcrowded landfills and negative environmental impacts. This challenge is where the transformative potential of recycled concrete comes into play.

By repurposing demolished structures and underused concrete, recycled concrete breathes new life into materials that would otherwise contribute to the growing waste crisis. This innovative approach not only diverts a significant amount of construction waste from landfills, but also turns it into a valuable resource for future projects.

Recycling concrete aligns seamlessly with the principles of a circular economy, in which materials are reused and repurposed, minimizing the need for continuous extraction of finite resources. As the construction industry faces pressure to reduce its environmental footprint, using recycled concrete is becoming a practical and effective solution, turning what was once considered waste into a sustainable asset for the future. Essentially, recycled concrete represents a tangible step towards a more responsible and resource-efficient building paradigm, promoting a circular approach that benefits the industry and the planet.

Many cities, settlements and houses were destroyed as a result of natural and man-made disasters that occurred on Earth. This process of generating waste from destroyed buildings in the form of RCA is shown in Figure 1. The problem is how to rebuild these cities and use some of their destroyed buildings and structures [16]. One method is to remove everything to relatively low forms of land, store it, fill it with land, plant forests on top, produce new building materials and use these materials to rebuild cities and settlements [17].

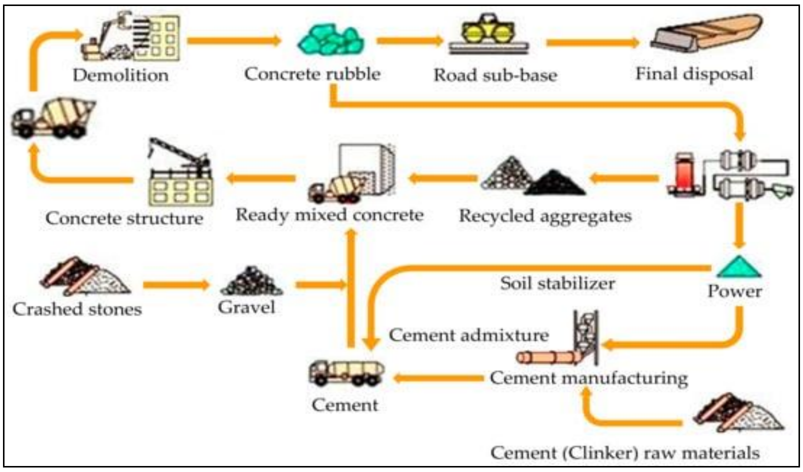

Fig 1: The process of generating waste from destroyed buildings in the form of recyclable waste

2. Technological advances in concrete processing

Technological advances are as follows:

Advanced crushing methods

Advanced crushing techniques represent a significant advance in sustainable construction, especially in the recovery of aggregates from old concrete structures. Innovations in crushing technology have simplified the process, allowing materials to be efficiently recovered for reuse. This transformative approach ensures that recycled concrete retains the essential qualities of strength and durability, meeting or even exceeding the standards set for conventional concrete.

The key to the success of these advanced methods lies in their ability to selectively extract high-quality aggregates from the existing concrete matrix. The resulting recycled material maintains the structural integrity required for use in a variety of construction projects due to the precision and control of the crushing process.

Moreover, these advances contribute to the development of a circular economy by extending the life cycle of concrete materials. Instead of discarding old structures as waste, advanced crushing techniques make it easier to extract

valuable aggregates, reducing the need for virgin resources when producing new concrete.
As the construction industry continues to prioritize sustainability, these innovations are playing a key role in improving the viability and performance of recycled concrete, ushering in a new era where green practices and high standards come together to shape the future of construction.

3. Advantages of using recycled concrete as aggregate

Concrete is made up of aggregates. In most cases, about 70% of the concrete volume is aggregates [18]. In most cases, most of these aggregates are coarse aggregates [19]. However, the construction sector has a high demand for coarse aggregate [20]. To meet these high demands, increasing extraction of raw materials from natural resources is necessary [21]. The constant increase in the use of natural coarse aggregates leads to an imbalance in the environment [22]. Thus, the use of alternative materials is critical for the construction industry [23]. One method to achieve this goal is to use RCA obtained from demolished concrete buildings [24]. The use of reclaimed concrete in structures reduces the need for natural coarse aggregate. As a result, the natural recovery of the aggregate reduces the harmful effects on the environment [26]. Disposal costs and lack of NCA have also led to the use of RCA in concrete [27]. Additionally, contractors have considered replacing NCA with RCA due to the increased distance between the construction site and the NCA quality source [28].
The widespread use of recycled concrete in the construction industry is showing promise as a substitute for natural aggregates. This can save natural resources, reduce the space required for landfill, and bring environmental and economic benefits. Concrete aggregates are generally divided into two types: untreated concrete aggregate and treated aggregate.
The first means that the concentrate waste is only crushed, so RCA concrete may contain impurities. Treated concrete aggregate is typically a smooth, fine-grained aggregate.

Fig 2: Application of RCA treated concrete aggregate (https://link.springer.com/article/10.1007/s40069-013-0032-5)

- Used for various structural works in bridge decks.
- Aggregate in lean concrete
- Aggregate in bituminous concrete
- Construction of curbs, median barriers, sidewalks, curbs and gutters
- Smaller RCA of less than 5mm can be used for road trench restoration.

Fig 3: Application of RCA raw concrete aggregate (https://link.springer.com/article/10.1007/s40069-013-0032-5)

- Used for volumetric filling
- River bank protection
- Foundation filling for drainage structures
- Road construction unit

Introduction of additional cementitious materials

The integration of additional cementitious materials into concrete represents a major advance in sustainable construction practices. Builders improve the resulting material's performance and environmental sustainability by mixing recycled concrete with materials such as fly ash or slag. This innovative practice not only improves the durability of concrete, but also helps significantly reduce its overall environmental impact.
Additional cementitious materials, like fly ash, are by-products of other industrial processes, and their inclusion serves a dual purpose. First, it reduces demand for traditional cement production, a process associated with high carbon emissions. Second, these materials often have pozzolanic properties, which increase the strength and durability of concrete.
Combining recycled concrete with additional cementitious materials transforms a once discarded resource into a high-performance, environmentally friendly building material. This sustainable approach is consistent with the growing global emphasis on reducing carbon footprint and promoting a circular economy in the construction industry. As a result, this practice not only extends the life cycle of concrete, but also helps create a more responsible and sustainable foundation for the structures of tomorrow.

4. Transformative impact on construction

The transformative impact on construction is as follows:

Economical construction

Using recycled concrete is cost-effective because it often costs less than traditional concrete. This availability makes it an attractive option for construction projects, promoting a sustainable approach without compromising financial feasibility.

LEED certificationand green building practices

Recycled concrete adheres to green building principles, which contributes to LEED (Leadership in Energy and Environmental Design) certification. This recognition highlights the material's role in sustainable construction, encouraging its use in projects seeking to meet high environmental standards.

Infrastructure rehabilitation

Recycled concrete plays a critical role in infrastructure rehabilitation, offering a sustainable solution for the repair and renovation of aging structures. This approach minimizes the need for new resources while meeting the maintenance needs of existing infrastructure.

Conclusion

The growing potential of recycled concrete marks a paradigm shift in the construction industry, providing a viable and environmentally friendly alternative to traditional concrete. As technology advances and environmental awareness increases, the use of recycled concrete may become standard practice. This transformative material promotes sustainable construction and is a testament to the industry's commitment to building a greener, more sustainable future.

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