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A review of recycled aggregate in concrete applications (2000–2017)

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HIGHLIGHTS

- The paper reviews the production and utilisation of recycled aggregate in concrete.
- Critically analysed the globally published data on recycled aggregate standards.
- This review may help to alleviate the concerns of consumers.
- This paper can encourage and further promote the use of recycled aggregate.

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ABSTRACT

Solid waste has been an inevitable by-product of the operations of industrialised societies. One result of economic growth is an increase in generation of solid waste which normally was dumped in landfills and caused contamination of soil, water and air from toxic substances such as polychlorinated bi-phenyls (PCB's), asbestos, construction chemicals, heavy metals, but the scarcity of land-filling areas, industrial growth as well as strict environmental regulations in developed and developing economies has led to the global re-assessment of the methods employed to recycle and utilise construction and demolition (C&D) waste as recycled aggregate for civil engineering projects i.e. construction and infrastructure development. Depending on their quality, recycled aggregate produced from C&D waste can be employed in various civil engineering works, which can help in a long way the economic and environmental sustainability of respective countries. With further research and development into overcoming technical as well as market barriers, considerable increase in recovery rates can be achieved with the existing technologies in developed economies. The main aim of this study is to review the literature on the production and utilisation of recycled aggregate in concrete, concrete pavements, roadway construction, and other civil engineering works and some discussion on the savings on CO₂ emissions have been included. The globally published data on recycled aggregate standards (normative documents) of various countries have been systematically analysed and evaluated, and some barriers mentioned. This review may help to alleviate the concerns of consumers and encourage and further promote the use of recycled aggregate on a larger scale in civil engineering projects.

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1. Introduction

Population growth, continuous industrial development, construction of infrastructure and house building activities create huge amounts of the C&D waste and hence, dire need for waste recycling. Construction industry is a major consumer of natural resources and the global aggregate production almost doubled

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from 21 billion tons in 2007 to 40 billion tons in 2014. Countries such as China, India, Indonesia, Malaysia, Thailand, Gulf States, Turkey, Russia, Brazil and Mexico have recorded some of the strongest increases in the demand for waste recycling. Hence, progressive depletion of natural resources and growing awareness of sustainable waste management by the developed and emerging economies, have given ever-increasing relevance to recycle and re-use C&D waste in civil engineering projects.

Although much higher portion of construction material could be replaced by recycled and re-processed C&D waste, these options are not yet considered and applied in most of the developing

economies, due to insufficient regulatory frameworks and lack of knowledge. Meanwhile, in developed countries, the process of stimulus on the utilisation of C&D waste varies in scale from country to country, it is hoped and expected that the utilisation of recycled aggregate coming from C&D waste will increase and become substantial part of the market in the near future.

The global aggregate production of 40 billion tons (Fig. 1) is an indication of the vast development projects which are materializing around the world [1]. As the land for landfill becomes scarce and the world demand of aggregate reaches to an enormous 40 billion tons annually, ways to use C&D waste is gaining importance due to legislation, it is cheaper and available. However, research & development is highly needed to sustainably utilise alternative materials in the production of concrete containing recycled aggregate. The current tendency in several developed economies is to view waste as resource or by product that can be used for a variety of useful purposes.

In the developed economies, the first initiatives for minimizing and recycling C&D waste began in the 1980s, In Germany, the Federal Quality Association for Recycled Building Materials was established in 1984 and had its headquarters in Berlin. The main function of the association was to unite the major recycling companies in Germany and in 2006 it also became the headquarters of the European Quality Association for Recycling, which is the umbrella organization of quality associations of the European Union.

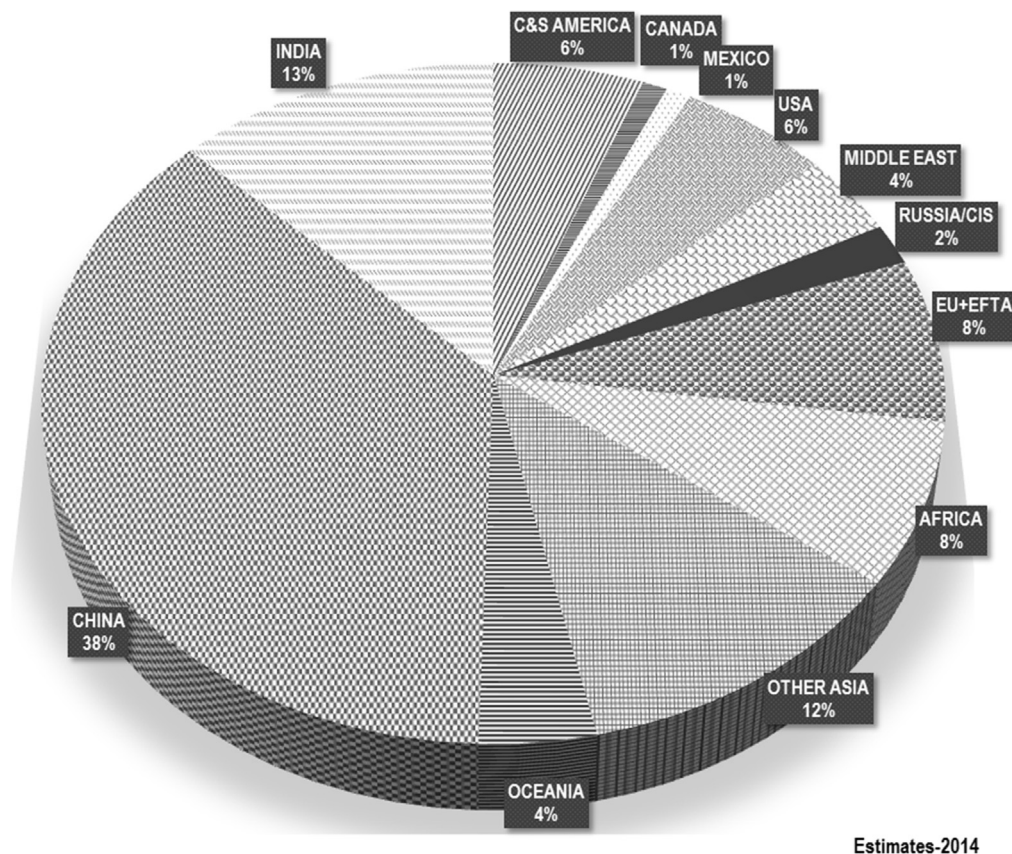
Since 1980's, there has been considerable progress in C&D waste management systems in the developed economies, particularly in Australia, Western Europe and North America.

In the present decade, Asia/Pacific, Russia and South American regions have demonstrated as one of the largest producers of aggregate as well as its sales, because of its rapidly rising construction activity, particularly in China, India, Indonesia, Malaysia, Thailand, Gulf States, Turkey, Russia, Brazil and Mexico. China alone accounts for half of all the new aggregate demand worldwide during the 2010–2015 periods [2]. The global recycled aggregate consumption estimates (by regions) are shown in Fig. 2 [3].

The tendency of environmentally conscience communities and enterprises is not only to recycle a large percentage of C&D waste, but to aim for zero waste, which means ensuring that all products are made to be reused, repaired or recycled back into the marketplace or nature and eliminating all discharges to land, water and air. While this concept first emerged in California, USA, in 1975, zero waste plans have been adopted around the world, especially by local governments in Australia and New Zealand.

As the plentitude of research work shows, there has been notable increase not only in the methods of recovery from C&D waste into recycled aggregate but on the ways and techniques of its utilisation in construction industry [4].

Regulations and legislation by the governments in various countries around the world have structured and constituted a market for building material and products derived from the C&D waste streams. According to [5] the C&D waste generation occurs during all the main phases of the building life cycle: construction, renovation and demolition. The demolition phase therefore seems to be the specific key to be considered for the adoption of more sustainable practices, to contribute higher percentages of the C&D waste generated.



GLOBAL AGGREGATE PRODUCTION -- 40 BILLION TONS

Fig. 1. Global aggregate production [1].

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