USE OF SCC AND RCA FOR SUSTAINABLE CONSTRUCTION –- AN OVERVIEW

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Abstract

This paper presents a brief review on the sustainability in building construction, environmental protection with respect to construction industry, constitutional provisions of environmental act and issues of environmental management plan (EMP). Also, Special emphasis is given on use of Self-Compacting Concrete (SCC) and Recycled Concrete Aggregate (RCA) for sustainability. SCC has significant environmental advantages in comparison to the vibrated concrete; absence of noise pollution and vibrations during construction provides a healthier working environment. In this paper, the potential for usage of coarse recycled aggregate obtained from crushed concrete for making self-compacting concrete was discussed, emphasizing its ecological value. The use of RCA contributes to the environment by solving the issue of waste disposal due to the demolition of old structures and also conserving the natural resources (Coarse Aggregate).

Keywords: *Sustainability, Self-Compacting Concrete (SCC), Recycled Concrete Aggregate (RCA), Construction and Demolition (C&D) Waste, Environmental Act, Environmental Management Plan*

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1. INTRODUCTION:

The construction industry has become one of the main contributors to the environmental pollution due to the emission of carbon monoxide and other pollutants which are the bi-products of many construction materials, operation of equipment and other construction processes. Sustainability in general terms is to create an economic system with enhanced performance with long term safety. Sustainability mainly focuses on the climate change, energy conservation, protection of natural resources and environmental enhancement. Pollution is anything that damages and destroys the surrounding atmosphere causing health hazards to human beings and animals. The presence of unnatural elements such as gas emissions, solids, liquids, harmful waste, and high sounds turns atmosphere polluted.

The Indian Construction industry today is amongst the five largest in the world and at the current rate of growth in the industry, the production and supply of natural aggregates has also emerged as a problem in some of the metropolis & fast growing cities in India. The major work is being done on researches on various parameters of the environment but a little attention is being paid on enforcement of the environment laws.

The recycling of Construction and Demolition (C&D) Wastes has long been accepted to have the possibility to conserve natural resources and to protect environment. In some nations it is a standard substitute for both construction and maintenance, particularly where there is a scarcity of construction aggregate. Studies reveal that recovered concrete can be used as aggregate in new concrete production but new cement is always needed and in most applications only a portion of recycled aggregate content can be used. These sustainable concepts should be incorporated at the design time itself by the structural engineers and it can be understood that the construction professionals play a key role for implementing the use of recycled concrete aggregate in fresh concrete. Use of RCA also helps in reducing CO2 emission and leads towards sustainability. Furthermore, researches need to be carried out on implementing the use of recycled coarse aggregates in self compacting concrete mixes so as to make it more environmental friendly material.

Environmental issues associated with the CO2 emissions from the production of portland cement, energy demand (six-million British thermal unit (BTU) of energy needed per ton of cement production), resource conservation consideration, and economic impact due to the high cost of portland cement manufacturing plants demand that supplementary cementing materials in general and fly ash in particular be used in increasing quantities to replace portland cement in concrete [Malhotra 1997, 2004]. This paper describes about the sustainability in building construction, environmental protection with respect to construction industry, constitutional

provisions of environmental act and issues of environmental management plan, and the use of RCA and SCC for sustainability.

2. BACKGROUND:

In the early 1980's at the University of Japan along with the collaboration of leading concrete contractors, SCC was developed by making use of simple concrete along with the addition of the super plasticizer and viscosity modifying agent. The main intention of developing this type of concrete is to achieve homogeneity by compacting of cast in place concrete within intricate structures and thus to improve durability of concrete. In 1983 at Japan there has been a serious problem faced on durability of concrete structures that were built at that time due to gradual reduction in number of skilled labour which in turn lead to reduction in quality of construction works. SCC has proved to be a better solution as it could be placed into every corner of formwork purely by means of its own weight and there is no need of skilled labour at the time of pouring concrete. Grdic, et al [13] reported environmental advantages of SCC in comparison to the normal concrete.
Many researchers since decades have tried different proportions of SCC by adding different admixtures so as to attain strength of the concrete by partially replacing cement content. Research on SCC with different admixtures is still going on since last decade as environmental impact has become one of the prime concerns.

3. CONSTRUCTION AND DEMOLITION WASTES:

Kartam et al. (2004) found that in many developed countries the amount of building and construction waste literally being generated is about 500-1000 Kg/capita per annum. The root cause for the generation of the C&D waste is inherently due to the never ending process of using lands for carrying out newly proposed constructions, re-construction and stretching of the road for transportation network works.

4. USE OF RECYCLED CONCRETE AGGREGATE:

Concrete is indisputably the inherent construction material, that is used in different construction works and the facts reflect that around 800 factories are producing about 36 million tonnes of precast concrete products every year which is the main contributor for pollution. The use of RCA in construction of tall buildings would be a positive approach in reducing the carbon foot prints in these buildings. Recycled aggregates are composed of original aggregates with adhered mortar. To obtain good quality concrete using recycled aggregate, acceptable properties of aggregates are elemental base; however adequate mix proportions and concrete production methods are also highly important in concrete quality.

The physical properties of recycled aggregates depend on both adhered mortar quality and the amount of adhered mortar. The adhered mortar is a porous material; its porosity depends upon the w/c ratio of the recycled concrete employed. Crushing concrete to produce coarse aggregate for the production of new concrete is one common means for achieving a more environment-friendly concrete. This reduces the consumption of the natural resources as well as the consumption of the landfills required for waste concrete. The crushing procedure and the dimension of the recycled aggregate have an influence on the amount of adhered mortar. The density and absorption capacity of recycled aggregates are affected by adhered mortar and they must be known prior to the utilization of recycled aggregates in concrete production in order to control properties of fresh and hardened concrete.

By using recycled concrete aggregate in SCC, there can be a maximum chance to reduce the global CO2 emission as the construction industry is one of the main contributors to environmental damage and CO2 emission. Ravindrarajah (2013) investigated on the use of ultra fine slag and RCA in SCC and concluded that the use of ultra-fine slag improved the stability of self-compacting concrete independent of the type of coarse aggregate. The use of recycled coarse aggregate decreased the strengths and modulus of elasticity and increased the chloride permeability for the high strength self-compacting concrete. Noriega (2011) concluded from his studies that the conventional concrete aggregate can be confidently replaced by recycled concrete aggregate as it exhibited similar compressive strength and bearing. Fathifazl, et. al (2009) found that the compressive and splitting tensile strength of RAC may be higher or lower compared to companion natural aggregate concrete (NAC) and only the quality of RCA determines the strength of RAC is not universally valid. An experimental investigation was carried out on the use of RCA in concrete and the suitability of use of recycled concrete aggregate for new concrete is judged (Neela Deshpande . et. al , 2011).

5. SUSTAINABILITY IN BUILDING CONSTRUCTION:

Use of 'Metals' in the construction industry is environmental friendly because these are recyclable and long lasting building materials which also offer excellent solar reflective benefits. It is energy efficient choice for roofing and wall panels when constructing a building envelope. The energy generation systems are the most expensive materials of green building. The initial cost of construction of green building is high but it is worthy and justified when these attain the energy savings for the building on long term basis.

A building can be termed as sustainable building if the building design is in such a way that it incorporates a balance between social, economic and environmental issues in all the

stages such as in design, construction, operational and till the end of its life. A sustainable tall building is also defined as the one which reduces the emission of CO2 and a building which has less impact to pollution of land, air and water throughout its life span and is economical to the social community.

So the main challenge is to make sure that in future, the construction industry should focus on sustainable tall buildings with zero emission of CO2 and every country having its own building regulations must look into these aspects as well into regulations. Generally these tall buildings are less sustainable when compared to low rise buildings as these tall buildings have more consumption of natural resources besides having some advantages like lesser land usage for accommodating large number of people in it. Therefore, balancing of both advantages and disadvantages is achieved only by construction of these high rise buildings with sustainability concept.
When considering a recyclable material, three major areas need to be taken in to account:

- Economy
- Compatibility with other materials
- Material properties

6. SUSTAINABLE BUILDING MATERIALS AND APLLICATIONS:

A sustainable concrete structure is one that is constructed so that the total societal impact during its entire life cycle, including during its use, is minimum. Designing for sustainability includes considering the short-term and long-term consequences of the societal impact in the design. Therefore, durability is the key issue [Moriconi 2003]. Bhattacharjee1. et. al. (2011) concluded from their investigations that crushed over-burnt brick aggregates can be used as an alternative to stone aggregates in concrete mix where there is scarcity of conventional coarse aggregates.

Construction of sustainable buildings by using energy efficient lighting units, plumbing elements and passive solar design, the use of natural resources like water, raw materials, and aggregates is limited and also use of environment friendly materials in the construction of walls, floors, ceilings, etc leads to sustainable growth. All these materials keep the building sustainable for all types of weather and by constructing such buildings we can reduce the carbon monoxide footprint of the building on environment and even it provides the direct cost savings to the building owners. Green Building addresses factors such as resource use (energy, water, and materials), waste reduction including re-cycling, and efficiency in processing and construction, storm water re-use strategies, preservation of biodiversity and the natural environment. Sustainable construction will enhance the resilience of building and construction industry by using materials and resources that are available from many sources in the world. It also means adopting construction methods that are environmentally friendly, faster, quieter and less labour-intensive. It challenges our builders to use innovative materials and products that meet the ever rising quality expectations of their clients. And with sustainable construction, more materials that can be readily recycled and reused for the same or similar purpose will be put into use. This reduces waste and promotes environmental sustainability.

7. IMPACT ON ENVIRONMENT, HEALTH AND SAFETY:

The SCC has a positive impact on the environment and is best in terms of health and safety issues, as this reduces the noise by as much as one tenth of the noise levels produced when traditional vibrated concreted is used. SCC leads to an improved environment both for concrete workers and for the people in the neighborhood due to a considerable reduction in noise levels. Also, the mineral admixtures used in the production of SCC will not only reduce the industrial waste but also enhance the properties of the concrete.

8. INDIAN ENVIRONMENTAL PROTECTION-CONSTITUTIONAL PROVISIONS:

The Constitution 42nd Amendment Act, 1976 made the express provision for the protection and promotion of the environment, by the introduction of Article 48-A and 51-A (g) which form the part of directive principles of state policy and the fundamental duties respectively. Thus the Indian Constitution makes two fold provisions: "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures".

a) On one hand, it gives directive to the state for the protection and improvement of environment.
b) On the other hand the citizens owe a constitutional duty to protect and improve natural environment.

The Parliament of India has legislated various acts for meeting the international obligations in the direction of protection of environment. The laws have to be enforced by the State Pollution Control Boards, Central Pollution Control Board and Ministry of Environment and Forests. There are three principal Acts to be enforced by the regulators. Those are

- The Water (prevention and control of pollution) Act, of 1974,
- The Air (prevention and control of pollution) Act, 1981; and
- The Environment (protection) Act, 1986.

The Ministry of Environment and Forests issues certain guidelines pertaining to the Environment (Protection) Act, 1986 which have to be followed by Central Pollution Control Board and State Pollution Control Boards.

9. OBJECTIVE OF ENVIRONMENTAL MANAGEMENT PLAN (EMP):

The major objective and benefit of utilizing Environmental Impact Assessment (EIA) in project planning is to prevent avoidable losses of environmental resources and values through the development of a judicious and appropriate Environmental Management Plan (EMP). EMP includes protection / mitigation / enhancement measures as well as monitoring.

In the process of planning , it is essential for every project to formulate an EMP to ensure that resources are used with maximum efficiency and that each of the adverse impacts identified and evaluated, attenuated or where required compensated. Possible mitigation measures generally include:

- Changing project sites, routes, production technology, raw materials, disposal methods, engineering designs, safety requirements.
- Introducing pollution controls measures, recycling and conservation of resources, waste treatment, monitoring, phased implementation, personnel training, special social services or community awareness and education.
- Devising compensatory measures for restoration of damaged resources, monetary compensations for project affected persons, off-site programs to enhance some other aspects of the environment or quality of site for the community.

Monitoring is required to evaluate the success or failure (and consequent benefits and losses) of environmental management measures and subsequently to reorient the EMP. Regardless of the quality of an EIA and consequent environmental management measures, they are of limited value unless implemented. As experience has increased in using EIA process for environmental planning, the need and justification for periodic monitoring in order to establish meaningful data bases has become obvious.

The following are the measures to be taken for best practice in the construction industry:

9.1 During Construction Phase:

Measures to mitigate the adverse impacts due to the following during construction phase.

a) Site preparation
b) Sanitation
c) Noise control
d) Construction equipment & waste
e) Storage of hazardous material/ dumping materials
f) Site security and Safety
g) Displacement of Population

9.2 During Operation Phase:

a) Collection and disposal facilities for emission, wastewater and solid waste.
b) Routine monitoring of selected parameters.
c) Laboratory facilities.
d) Data handling, reporting, storage and retrieval facilities, and feedback to facilitate future planning.
e) Emergency action procedures and disaster management procedures.
f) Manpower for Environmental management.

CONCLUSIONS

One of the construction sector's major contributions to the preservation of the environment and sustainable development is reducing, reusing and recycling of the waste materials it generates. Self-consolidating concrete is a promising technology that has found many successful applications. Although the concept of self consolidating concrete has been around for a few decades, new products are still emerging and better mix proportioning strategies are yet in development stage. The use of RCA in SCC provides dual advantage by deriving the benefits of both the materials as these materials reduce the impact of CO2 emissions apart from improving properties and thus making environmental friendly materials. The absence of an established industrial standard for SCC allows more creativity in tailoring a mix to specific job requirements. At the same time, due to the lack of standards, producing successful mix depends on the expertise of the producer/contractor. Therefore, it is clear that educating manufacturers and contractors is the first and crucial step in expanding the use of RCA and SCC's promising technology for sustainable development. Also, it is required to incorporate the sustainable construction standards in building regulations.

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BIOGRAPHIES

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