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Engineering Towards a Sustainable Future

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ABSTRACT—*The population of the world is increasing at an alarming rate demanding the large volume of construction work resulting in various environmental impacts and threatening the availability of resources for future generation. The production of large volume of waste products, release of GHGs and energy consumption by construction activities is increasing day by day. There is an immediate necessity to act promptly for the better future by changing today's world i.e. switching to sustainable development. There is considerably a greater responsibility in the hand of civil engineers for the change through effective use of minimal available resources, various alternative uses, reduction and reuse principle and effective management of present resources. Steel and cement, being the chief building material, effective action must be taken for the minimum use of these construction materials either by reducing the use through effective design or by using the alternatives.*

Keywords—sustainability, cement, steel, carbondioxide, population.

1, INTRODUCTION

The world population hit the mark of 7 billion on October 2011 and will reach 8 billion with the year 2014 and has a growth rate of 1.14% per year. Such an alarming rate of population growth is demanding the exploitation of huge amount of natural resources in the field of construction industry.

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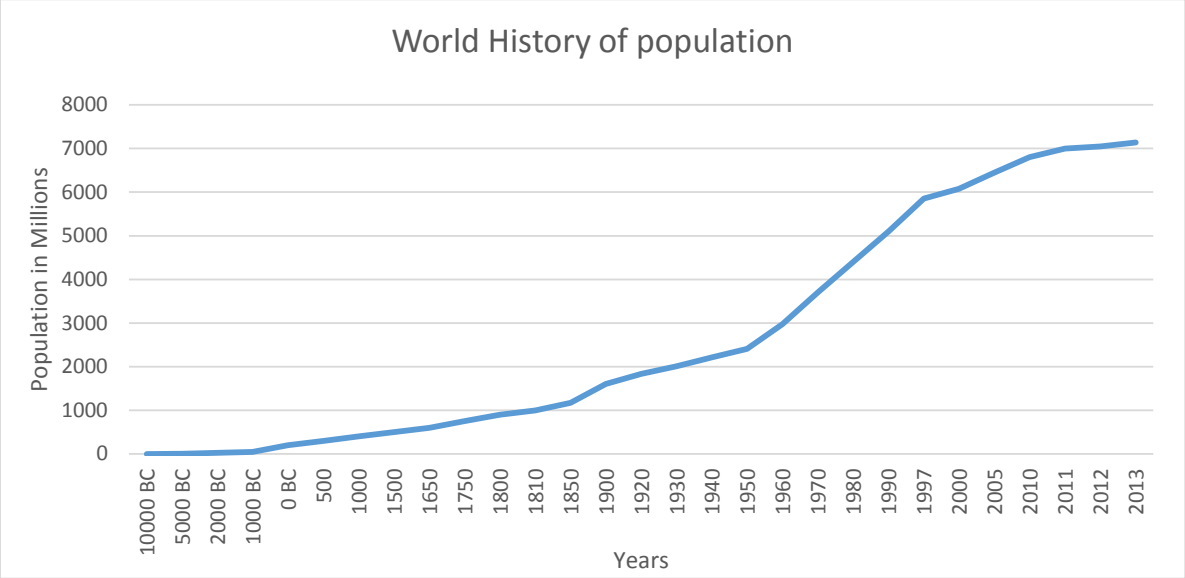
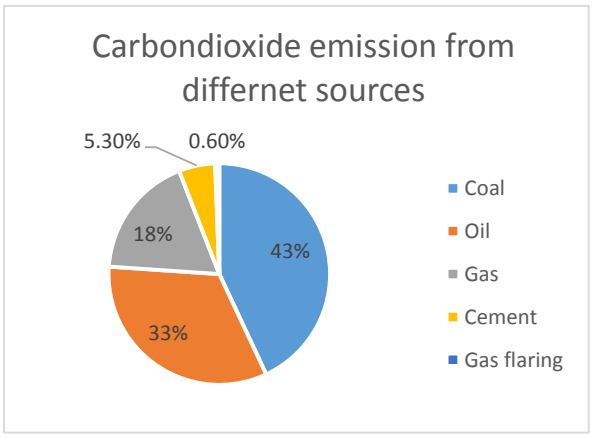
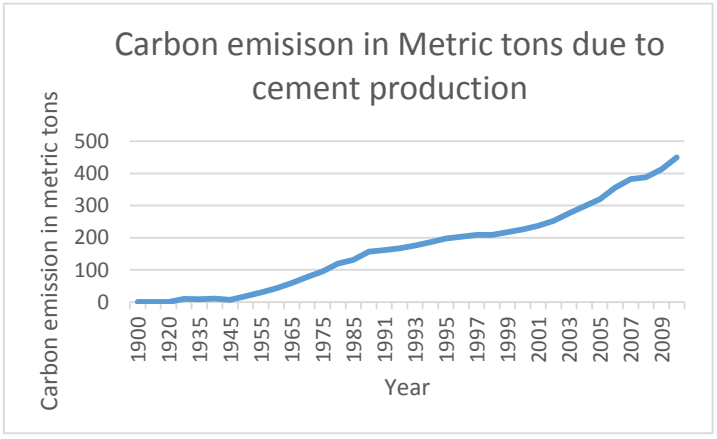


With the increase in the construction work, the most fundamental construction material, cement and steel (that are used in construction of nearly everything) are used in greater quantity. It won't be wrong to say that there is not any better substitute of these materials in terms of both performance and economics. The major drawback with these two is that they have very high embodied energy and a large amount of GHGs (mainly CO_2) are released in the atmosphere during the various process of manufacturing and transportation.

The global CO_2 emission has reached 36 billion tonnes in 2013. The cement and steel industry contributes significantly to this emission. About 900 kg of CO_2 is released into an atmosphere for every ton of cement produced out of which 50% is directly emitted from the processing of limestone in kiln. About two tons of Carbondioxide is emitted from the production of one ton of steel.





In addition to the Cement and Steel, the construction materials that are in use and practice today have a very large embodied energy. Some of the construction materials and their embodied energy are listed below.

S.No.	Construction Materials	Embodied energy (MJ/Kg)
1	Adobe block	0.47
2	Concrete block	0.94
3	Ceramics brick	2.5
4	Glazed brick	7.2
5	Cement	7.8
6	Glass	15.9
7	Structural steel	36

According to Victoria University of Wellington, Newzealand

In account of such a large amount of energy consumption and emission of CO_2, it becomes an immediate necessity for the shift of construction industry into the world of sustainability. According to UN world commission on environment and development, "Sustainable development is development that needs the needs of the present without compromising the ability of the future generations to meet their own needs"

2, WHY SUSTAINABILITY?

It is important to recognize that today`s developmental prospects should not deprive future generations of their legitimate needs. Sustainable development is possible through suitable integration of ecology, economy, society and culture with the environment to develop a cost efficient, energy efficient, environmentally-benign management system. The reasons to go after sustainable developments can be summarized into the following points:

- Effective use of available resources
- Maintain integrity of the environment
- Low carbon emission
- High quality of living
- Reduction of Greenhouse gases
- Prevent global warning
- Handover clean and green earth to the future generation

Sustainable engineering can be applied in civil engineering in mainly three phases:

- Pre Building phase
- Building and service phase
- Post service phase

2.1 Pre Building Phase:

It is the phase where the material for steel and cement are extracted from the natural environment, processed for the conversion of raw materials into usable form, packed and transported to the Site. It also constitute of transportation of raw materials from natural environment to processing site. Designing of the structure also comes under pre building phase.

2.2 Building and Service Phase:

The operation of the building should be such that it should utilize minimum resources with, maximum efficiency. It should have a considerably longer life. Construction must be done with materials that are environment friendly and at the same time economical. It can be achieved by using recycled materials, CRD waste (concrete from construction renovation and demolition), use of composite lumber made from waste wood, use of recycled glass which has lower embodied energy than glass from fresh raw materials. Several design aspects like openable sunlight for natural lighting, natural ventilation, vacuum toilet system, double panelled glass window for better insulation etc. can be implemented. To obtain the sustainability target, the operating features of the structures should be designed to be efficient with minimum environmental impacts. The operation of the building can be made efficient by the following methods:

- Energy efficient through photovoltaic cells, solar panels and wind mills
- Longevity by making structures fire resistant and providing enough protection from corrosion.
- Conservation of water and waste water treatment
- Rain water harvesting for general use and ground water recharge
- Minimisation of carbon foot prints
- Natural lighting and ventilation

2.3 Post Service Phase:

After the service life of the structure is completed, the demolition waste and debris must be recycled and reused with less energy expenses. Structural steel, glass,aluminium,bricks etc. can be reused again and again. The debris which can’t be reused and recycled should be disposed with lesser environmental impacts.

3, EXAMPLES OF SUSTAINABLE STRUCTURES AROUND THE WORLD:

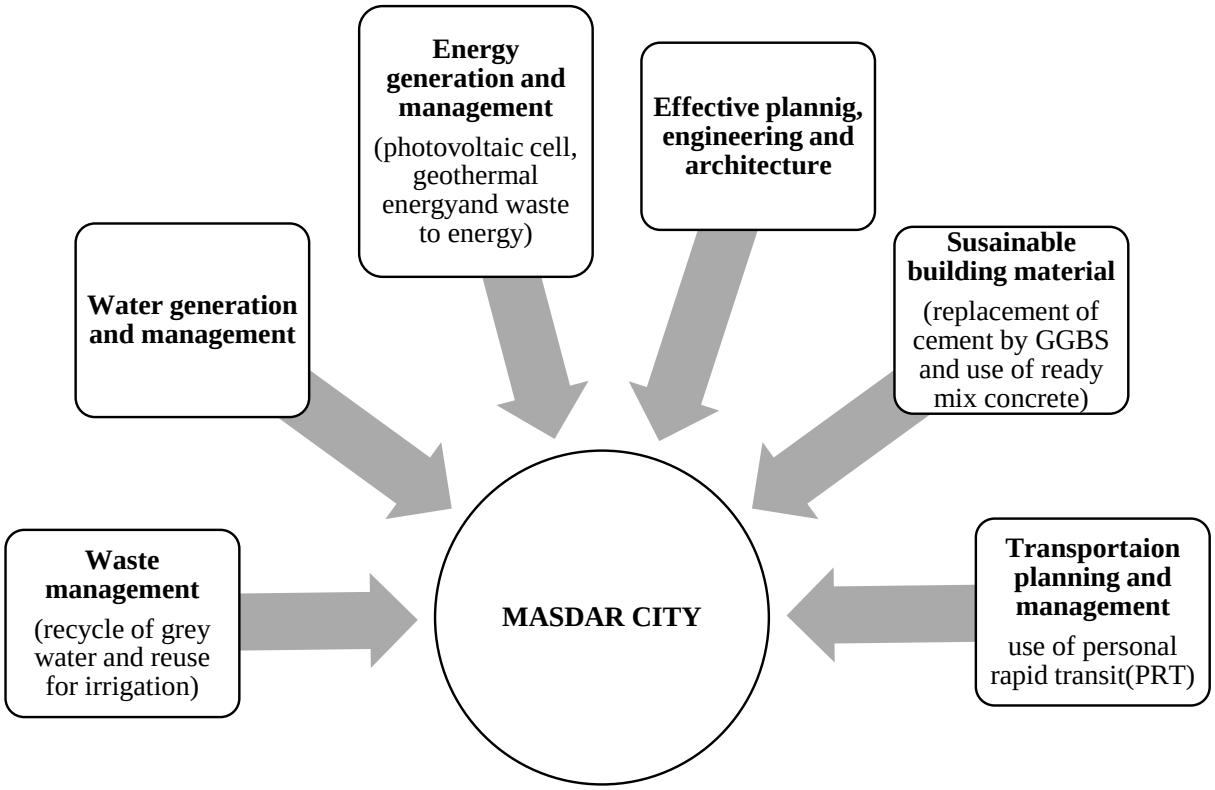
Several countries in the world are making attempts to shift the construction industry into the path of sustainable development. Some of the examples of the sustainable structures around the world are as follows:

S.NO.	Structures	Sustainable feature
i.	**Erie on the Park**, Chicago, USA` (25 storeyed residential building)	• Steel and glass as chief construction material • without concrete core
ii.	**ING House**, Amsterdam, Netherland (Bank headquarter at southern Amsterdam)	• Steel and glass as predominant construction material • Climate controlled outer walls to prevent outside noise and let in clean air
iii.	**National Aquatic centre**, Beijing, China (Recreation Building constructed at the time of Beijing Olympic)	• Constructed from organic network of steel tubular members • Clad with translucent ETFE* cushion
iv.	**Manchester Civil Justice Centre** in North west England headquarter for the department of constitutional affairs	• Natural ventilation • Environmental veil to control solar gain and maximize natural daylight • Groundwater cooling (energy consumption reduced by 15-20%)
v.	**Vulcan House**, Sheffield (New base of the home office)	• Heat reclaim and circulation system • HFC** free cooling and heating plant • Prefabrication of plant • Recycling of grey and rain water
vi.	**Chineham Energy Recovery Facility**, Hampshire, England	• Produce 8 MW of power from waste (1.25 MW is used for self-operation and 6.75 MW supplied to 10000 homes) • 420000 tons of household waste converted into electricity.
vii.	**Bank of America Tower**, One Bryan Park, New York	• Reuse of rain water and waste • Heat reclaimed from sunlight • Natural daylight • Construction material obtained from renewable and recycle sources
viii.	**India Tower**, Mumbai	• Solar shading • Natural ventilation

		• Natural daylight • Rainwater harvesting • Green interior finishing

ETFE- Ethyl Tetra Floro Ethylene (recyclable material with durability of more than 20 years)*
*HFC**- Hydro Floro Carbon (Green House gas and chief cause of Ozone layer depletion)*

Sustainable principle can not only be applied into small scale project like individual buildings and structures but also in a large scale magnitude like whole city and development of town. The best example of such kind is **Masdar Initiative**, Abu Dhabi, UAE.



Masdar city and its sustainability features

4, CONCLUSION

The big responsibity to preserve the better future for next generation lies in the hand of innovative and dedicated civil engineers and other professionals. Sustainable development is not a fixed state of harmony but rather a gradual process of change in which the exploitation of resources, the direction of investments, the orientation of technological developments and institutional changes are made consistent with future as well as present needs. It can be achieved only with the thorough

knowledge and creative idea that can be applied in every phase of design and development of the structure. The emphasis should be given on life time of the structure rather than the initial cost. The minimization of the use of construction materials mainly cement and steel cuts off a lot of environmental impacts and this can be achieved through efficient design, innovative ideas, alternative uses and mainly through the principle of 3R's: Reduce, Recycle and Reuse. The efficient application of these principal is a key to preserve the environment and at the same time to enjoy the modern day luxury and comfort of science and technology, thus creating the sustainable world.

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