CREATING ECO EFFICIENT TOWNSHIP INFRASTRUCTURE PROJECTS WITH THE USE OF GREEN ENGINEERING SOLUTIONS AND SUSTAINABILITY CRITERIA

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Abstract

Globally, the construction industry is one of the main contributors to the depletion of natural resources and a major cause of unwanted side effects such as air and water pollution, solid waste, deforestation, health hazards, global warming, and other negative consequences (Harvey and Wayne, 2008[4]).
As we face significant planetary issues such as global warming, it is clear that the engineering profession has a significant part to play in affecting the future of our planet.
In order to stay competitive and to meet upcoming stricter environmental regulations and customer requirements, designers have a key role in designing civil infrastructure so that it is environmentally sustainable. These and other factors have compelled the engineer to design with greater care and in more detail. The changing roles of engineers will be highlighted, in order to react to changes in climate. Mainstreaming environmental aspects and incorporating the eco-efficiency concept into various stages of infrastructure development have not been considered as much as they should have been. Engineers need to look at greener technologies rather than just using traditional engineering solutions. This paper looks at the effects of climate change on infrastructure and the changing role of engineers. It aims to demonstrate the use of sustainability criteria on infrastructure projects.
The use of the proposed criteria would ensure a sustainable design for township infrastructure services through the consideration of scare resources, ecological sensitivity in the design and planning of infrastructure projects.
This paper focuses on the concept of eco-efficiency in infrastructure design that promotes the use of the greener engineering options, enabling him/her to choose the one likely to yield the best performance with the least environmental impact. It looks at a number of recommended green practices on infrastructure services design, that are environmentally sound placing, fewer burdens on the environment.

Keywords: Green Technology, Infrastructure design, Eco-efficiency, Sustainable development, Green infrastructure

Objectives

In view of the inadequacy of tools to assess the environmental impacts of infrastructure design decisions, the aims of this paper are as follows:

- To emphasis the influence of climate on sustainability and the changing role of engineers;
- To highlight the need for environmentally friendly, ecologically sensitive innovative design, at the design stage of township infrastructure projects;

- To establish sustainability criteria on civil engineering projects;
- To define green infrastructure solutions amongst engineers by establishing a common language and standard of measurement;
- To raise awareness of green engineering benefits and the environmental impact of consultants' design decision, in order to reduce the environmental impact of development;
- To introduce environmentally conscious design decisions at inception stage, where they are influenced the most.

Climate Change , Sustainability and the Changing Role of Engineers

Climate change is introducing many uncertainties into the management and planning of township infrastructure projects. In the area of sustainability, there is an urgent need to apply technologies and methods that deliver better and more sustainable performance in a way that is cost effective
With the potential for disasters increasing dramatically, engineers are expected to highlight the potential events, assist in the development of mitigation initiatives, and ensure appropriate design and construction. Measures adopted will have to explore shifts in paradigms to find innovative solutions that allow man to work with nature rather than against it.
Engineers will have to be at the forefront of developments finding ways to maximise water capture, ensuring conservation of the resource from supply through to distribution, and the issues of innovation, technology and design (Kilian and Gibson, 2007[5]).
It has been established that municipalities are not delivering infrastructure service in a sustainable manner. Most of the challenges are due to planning, implementation and monitoring systems failure. Further assessments revealed that municipalities do not comply with basic principles for sustainable service delivery (DPLG, 2007[1]).
Engineers urgently need to find innovative solutions that meet the required social and planning objectives whilst being energy efficient, sustainable, of high value in terms of quality and efficiency, and remain cost effective (FIDIC, 2009[3]).
The lack of appropriate tools and skills for sustainable design was often quoted as a barrier to sustainable design (Richardson et al., 2005[6]).

The need to implement green technology on civil engineering infrastructure projects

As the custodians of existing infrastructure and the developers of future infrastructure, consulting engineers recognise a responsibility to innovate and improve the products of their efforts and to understand the importance of instituting a dialogue with the rest of society on these subjects (FIDIC, 2009[3]).
Relatively few designers have as yet explored the transformative potential of ecological design and have preferred to remain apolitical and unconcerned with the distributional impacts of design as they affect the health of humans and ecosystems (Van Wyk, 2009[7]).
Infrastructure elements such as roads, water and sewage and stormwater can result in loss of critical ecosystems and biodiversity. There is a need to create an eco sensitive infrastructure design that encourages and promotes the use of ñsofterò design solutions.
By utilising improved environmentally friendly-seeking design methods, this study aims to introduce environmentally friendly design decisions prior to the infrastructure design approval process. This increases overall competitiveness by bringing a whole new class of productive solutions to problems while at the same time adding a fresh perspective to the traditional infrastructure design process.

The declining influence of environmental interventions on infrastructure projects

It is essential that the environmental issues be integrated into achieving the most appropriate solutions. A sustainable project is managed by taking control of the clientôs decision making processes as early as possible, to provide the certainty of decision making. This should be done by totally involving clients in the decision making process. Diligent attention to greener infrastructure solutions from the very earliest phases of a project will help guarantee that quality design environmental solutions are "built in" from the beginning. Figure 1 shows the declining influence of environmental interventions on a project.

It is important to implement the environmental management from the early stages of the process, since the ñfreedomò to make decisions, of importance for the environment, decreases with the progress of the project.

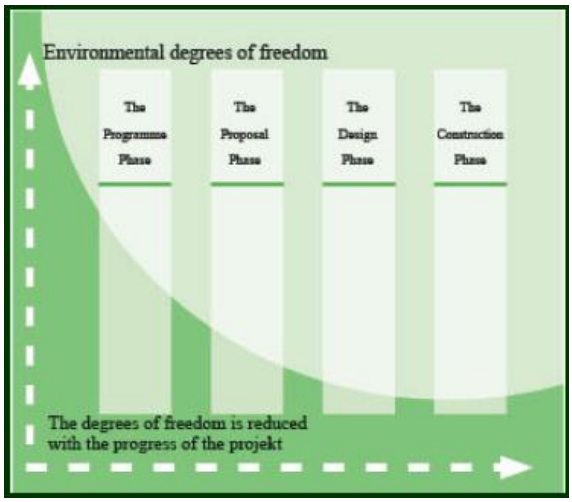


Figure 1: The environmental degrees of freedom (European Green Cities Network, 2004[2])

Eco Efficienct Criteria for infrastructure projects

The role of criteria on infrastructure projects are tools which can be used in the conceptualization, implementation, and monitoring of progress in sustainable township infrastructure projects. The criteria define the essential components of the proposed Green infrastructure toolkit against which sustainability may be assessed. Through the measurement and monitoring of these indicators, the overall effects of the proposed Green infrastructure toolkit, can be assessed and evaluated, and action can be adjusted to meet stated aims and objectives more effectively.
Each criterion relates to a key element of sustainability. Collectively, the criteria provide an implicit definition for the concept of eco efficient infrastructure solutions.
The clientôs vision, goals and objectives for eco efficiency on a project can be translated into a core set of project criteria. While project goals set the direction, the project eco efficiency categories provide the means to measure a project. They enable clients, engineers and stakeholders to gauge progress toward sustainable development by comparing the performance achieved on a project with the intended performance.
Table 1 proposes the Eco Efficient Infrastructure Criteria. The criteria Efficient Layout Planning ensures that infrastructure is placed in environmentally responsible ways. The Resources criteria encourage an efficient utilisation of materials/ resources. Environmental Quality mitigates environmental impacts of infrastructure. Functional Efficiency ensures that infrastructure is designed optimally. Future Maintenance maximizes the opportunities for integrating capital and operation of infrastructure. Economy maximizes the opportunities for integrated, cost effective adoption of green infrastructure options. Safety minimises the environmental impact of infrastructure by incorporating safety into the design. Social sustainability of infrastructure promotes the use of social resources, encourages public participation and the placement of infrastructure in the most convenient manner.

Table 1: The Eco Efficient infrastructure performance criteria

Eco-efficient infrastructure Sustainable criteria	**Measure**
1. Efficient layout planning	Placement of infrastructure in environmentally responsible, efficient ways, conserve land.
2. Resources	Encourages the efficient utilisation of materials/ resources, selection of environmentally friendly materials.
3. Environment quality	Design features that mitigate environmental impacts of infrastructure, by reducing effects of pollutants
4. Functional efficiency	Design of infrastructure that maximizes functional efficiency of infrastructure.
5. Future maintenance	Maximizes the opportunities for integrating capital and operation of infrastructure, ensuring reliability of level of service
6. Economy	Maximizes the opportunities for integrated cost effective adoption of green infrastructure options.
7. Safety	Minimizes the environmental impact of infrastructure by incorporating safety into the design.
8. Social	Ensuring social sustainability of infrastructure, promoting convenience, social resources and public participation.

The Infrastructure eco efficient criteria were developed to:

- Determine the means by which eco- environmental efficiency can be assessed, monitored, quantified and verified at any stage of the project, to ensure a value-added, quality driven, green approach to infrastructure design;
- Provide a basis for the consultants and clients to work together on creating and evaluating sustainable infrastructure solutions, thereby ensuring comprehensive infrastructure planning with maximum stakeholder involvement;
- Achieve the required balance of sustainability, expenditure, value for money and quality, between the various elements of the project;

Greener design solutions that will improve the environmental performance on township infrastructure projects

Engineers must be prepared not only to react to changes in climate and resource availability, but also to help manage that change through sustainable engineering solutions.
Civil infrastructure has various opportunities to undertake innovative, efficient and sustainable design instead of conventional design but this rarely happens in practice. Incorporating this perspective into civil engineering infrastructure design, planning, and building stages can have significant effects on the outcome
Innovative approaches to planning and design can greatly mitigate the negative impacts of infrastructure services on the environment. Various green technology concepts were researched and modified to suit township infrastructure projects, with the aim of reducing the impacts of civil engineering infrastructure on residential developments.
Green Technology that can be used on infrastructure projects may include the utilization of natural or engineered systems that mimic natural landscapes in order to capture, cleanse and reduce stormwater runoff.

Greener stormwater infrastructure solutions can include rain gardens, rain barrels, green roofs, wetlands, permeable pavements and other methods intended to significantly reduce the amount of stormwater runoff entering the sewer system and our waterways.
Roads present many opportunities for green infrastructure applications that incorporates a wide variety of design elements, including street trees, permeable pavements, bioretention, and swales. Greener Water infrastructure opportunities include a reticulated recycled water supply, water efficient fittings, intermediate storage, etc.
This various eco-efficient design sustainable infrastructure solutions were broken down into various sustainability criteria and are briefly tabled, under various elements in the Figure 2 below:

Advantages of using the Eco approach to infrastructure design

Green township infrastructure technologies will contribute to greenways and green corridors and provide linkages between habitats, and wetlands. Green technologies have a number of environmental, economic benefits and community benefits. The benefits of this approach are as follows:

- Conservation of natural resources;
- Reduces the ecological footprints of roads, sewer, stormwater and water, allowing ecosystems to function more naturally;
- Uses energy-efficiency systems and materials;
- Minimized impervious surfaces, reducing soil erosion;
- Enhance and protect ecosystems and biodiversity;
- Conserves and reuses water and treats stormwater runoff on-site;
- Recharged ground water flow for streams, conserving water supplies.

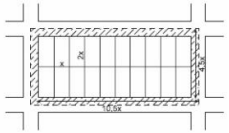
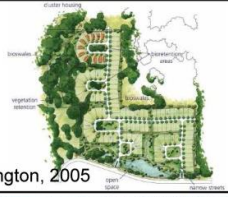
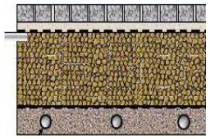
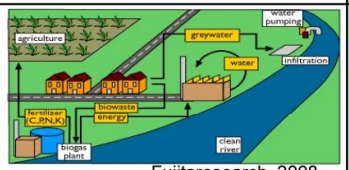
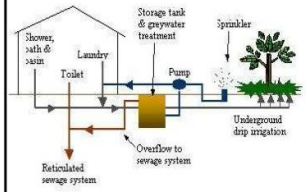
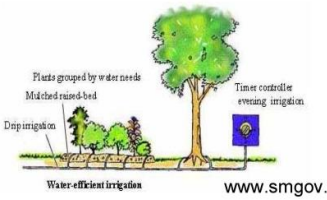
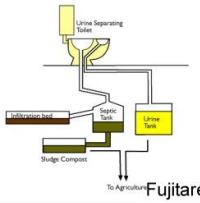
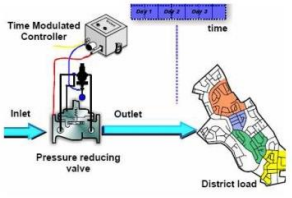
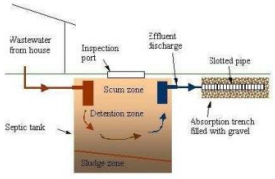
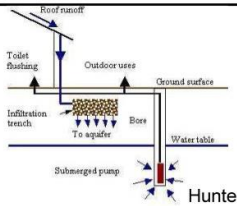
SUSTAINABILITY CRITERIA	GREENER TOWNSHIP INFRASTRUCTURE TECHNOLOGIES			
	ROADS	SEWER	STORMWATER	WATER
1. LAYOUT PLANNING	 Washington, 2005		 Washington, 2005	 http://tslr-infra.blogspot.com/
2. RESOURCES		 Fujitaresearch, 2008		 www.unhabitat.org
3. ENVIRONMENT QUALITY	 Center for Watershed Protection, 2007	 Hunter Council, 2007	 Maryland county, 2009	 www.smgov.net
4. FUNCTIONALITY	 San Mateo County, 2009	 Fujitaresearch, 2008	 Australia, 2007	
6. ECONOMY		 Maryland county, 2009		 Hunter Council, 2007

Figure 2: Green infrastructure technologies that can be used on infrastructure projects

Conclusions

By using this green approach, sustainable design of township infrastructure services can be achieved by enforcing the consideration of resources, environmental impacts of design decisions, ecologically sensitivity, innovation, maintenance and materials, at the design stage of a project.
This paper highlights the numerous opportunities for improving eco-efficiency in infrastructure design. A new paradigm for infrastructure design is required in order to maintain environmental sustainability and mitigate flooding or drought.
Engineers need to look at greener technologies rather than just using traditional engineering solutions. Green techniques provide adaptation benefits for a wide array of circumstances, by conserving and reusing water, promoting groundwater recharge, and reducing surface water discharges that could reduce to flooding.
Taking a greener approach to infrastructure development not only mitigates the potential environmental impacts of development, but makes economic sense as well. By softening the environmental footprint, avoiding waste and finding efficiencies, clients and local governments can increase their long term sustainability.

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