December 2013, Volume 4, No.6
International Journal of Chemical and Environmental Engineering

Designing environmentally sound engineering solutions on infrastructure projects

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Abstract:

There is a growing complexity of infrastructure planning and the need for coordination of design and environmental requirements. The lack of appropriate tools and skills for sustainable Infrastructure design is often seen as a barrier to sustainable design. Infrastructure development has been focused mainly on financing issues and engineering aspects in the region. 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. Improvement in the awareness of eco-efficiency concepts is urgently needed among policy-makers, planners and decision-makers. However, the criteria applicable to, and measures for developing eco-efficient and sustainable infrastructure are yet to be fully identified (United Nations Economic and Social Commission for Asia and the Pacific, 2006). Engineers need to look at greener technologies rather than just using traditional engineering solutions. The 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. This paper discussed the application of 'green technology' on infrastructure design projects. It gives an overview of the proposed Green Township Infrastructure Design toolkit and looks at a number of recommended green practices on infrastructure services design, that are environmentally sound placing, fewer burdens on the environment. It would ensure a sustainable design of township infrastructure services enforcing the consideration of resources, environmental impacts of design decisions, ecologically sensitivity, innovation, maintenance and materials, at the design stage of a project.

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

1. The need to implement green technology on civil engineering 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. Sustainability and adaptive and mitigative approaches to climate change, in the design of infrastructure are therefore important steering elements (FIDIC, 2009: p44).

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).

The external bulk infrastructure that contributes significantly to suitability of a development also needs to be considered. These include infrastructure requirements such as road construction, water and sewage as well as stormwater and layout planning 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 "softer" 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.

2. 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 ensure greener infrastructure with minimal impact to the environment;
- To incorporate environmentally friendly, ecologically sensitive innovative design, at the design stage of township infrastructure 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 establish a means of identifying environmental leadership on civil engineering projects;
- To introduce environmentally conscious design decisions at inception stage, where they are influenced the most.

3. The influence of early design decisions on the environmental impact and sustainability on infrastructure projects

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.

The easiest way to reduce environmental impacts on projects is to take the environmental issues into account early in the planning and design phase. Environmental management in project design introduces new aspects to both the project and the basis for decision-making during the project. It is essential that the environmental issues be integrated into achieving the most appropriate solutions.

Figure 1.1 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 "freedom" to make decisions, of importance for the environment, decreases with the progress of the project.

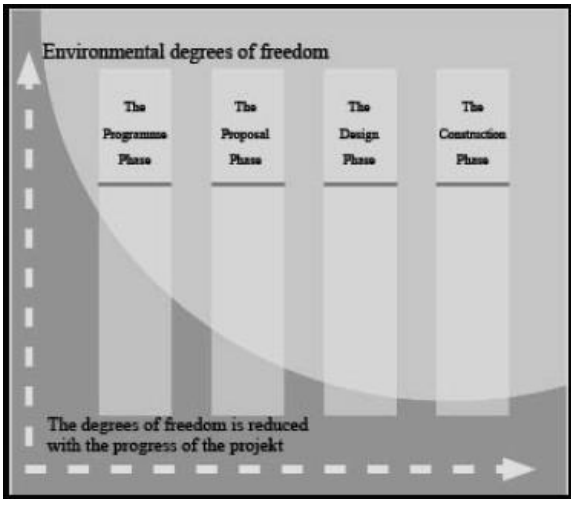

Figure 1.1 The environmental degrees of freedom (European Green Cities Network, 2004)

4. Green design elements that will improve the environmental performance on township infrastructure projects

Innovative approaches to planning and design can greatly mitigate the negative impacts of infrastructure services on the environment. Various green technologies 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 pavement 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 application that incorporates a wide variety of design elements including street trees, permeable pavements, bioretention, and swales. The various design solutions of a township were broken down into various elements in order to identify alternative ways in which greener solutions can be achieved.

This eco-efficient design various sustainable infrastructure solutions are categorized into various sustainability criteria, under various elements in the Figure 1.2 below:

GREEN TOWNSHIP INFRASTRUCTURE TECHNOLOGIES				
	ROADS	SEWER	STORMWATER	WATER
1. LAYOUT PLANNING	- Optimised Route alignment	-Layout promote midblock sewer	- Natural drainage paths considered	- Curvilinear roads increases the cost retic
	- Promote concept of greenstreets	-Trench depth <2m	- Land use intensities	- Pipe route alignment
	- Earthworks- balanced-Cut / Fill <3m	-Can pumpstations be avoided	- Open spaces for retarding/ponding sw	- Looped mains
	- Open spaces for wildlife	- Route alignment	- Use of green corridors	
			- Reduce stormwater concentration	
			- Attenuation/ retention facilities planned	
2. RESOURCES	- Surfacing - permeable, asphalt, block paving	- Backfill - non/commercial source	- Pipe material - pvc/concrete/hdpe	- Pipe material - pvc/concrete/hdpe
	- Pavement Layerworks- cemented base/grav	- Source/type of Bedding	- Source/type of Bedding	- Source/type of Bedding
	- Kerbing-asphalt/concrete	-Manhole types- brick/precast	- Manhole types- brick/precast	- Type of fittings
	- Recycled pavement material	-Pipe material - pvc/concrete/hdpe	- Rain water harvesting	- Manhole types- brick/precast
			- Recycling of stormwater	- Use of pumpstations
				- Monitor water supply by metering
3. ENVIRONMENT QUALITY	- No. of valley crossings	- No. of valley crossings	- Post Development < Predev Flow	- Usage of boreholes
	- Erosion control measures	- % of sewer in the floodline	- Recharge rates maintained	- Spring protection
	- Mitigate impacts on env.	- No. of manholes in the floodline	- Reduce velocity	
		- Flood protection of pumpstation	- Water quality	
		- Protection works	- Protection works	
4. FUNCTIONALITY	- Surfacing- impermeable/porous concrete	- Separate grey water	- Rain water harvesting	- Balance loss of water pressure;
	- Drainage and storage functions of roads	- Separate black water	- Use of open channels vs piped	- Use of Roof tank
	- Pedestrian / bicycle paths	- Use of Septic tanks	- Outlet erosion protection,	- Plumbing intermediate storage
	- Can it function as an activity corridor	- Irrigation of effluent	- Stilling basin, geo cells, gabions	- Reduced pipe sizes
	- Gradients as flat as possible on roads	-Self-cleaning sewers	-Use of soakaways	- Reticulation pipes are looped
	- Public transport facilities	-Use of pumpstations	- Detention pond / parks	- Optimised velocity in pipe
	- Road hierarchy	-Sewer attenuation	-Velocities exceed 3m/s	
5. FUTURE MAINTENANCE	- Maintainance of grass	-Design of manholes accessible	-Design consider maintenance needs	- Life span of the pipes and materials
	-Bank slopes must be gentle	-Life span of the pipes and materia	-Flood plain accessible	- Services watertight
	- Adequate pavement design	-Access for maintenance	-Life span of the pipes and materials	-Positioning of trees - proximity of services
		-Erf have a rodding eye	- Large open spaces	- Reduced velocity in pipe
		-Services watertight	-Inlet/outlet design to reduce blockages	
6. ECONOMY	- Type of system	-Type of system	-Type of system	- Type of system
	- Minimize the number of road intersections	-% mid-block sewer	-Multipurpose stormwater facilities	- Use of shared trenches
	- Reduced road widths, lenghts & pavement	-Maximum manhole spacing	-Use of shared trenches	- Max. hydrants, airvalve spacing
		-Use of shared trenches	- Maximum manhole spacing	- Apropriate water demands
		-Curved roads > no of manholes	-Curved roads > no of manholes	
7. SAFETY	-Traffic calming measures	-Trench depths <3m	-Safe discharge routes	- Fire risk
	- Signage and pedestrian friendliness		-Velocity /depth of stormwater flowing	- Sufficient supply capacity
	-Safe street and unique public space		-Trench depths <3m	-Trench depths <3m
	-Safe intersection/site distance			
8. CONVENIENCE	- Public transport facilities	-Access to sewers	-Inconvenience of overland flow	- Valves located in convenient positions
	-Convenient pedestrian crossings	- Accessibilty during the repair	-Temporary storage facilities	- Meters located in convenient positions.
	-Pedestrian crossings and roads convenient	of services		- Standpipes located in convenient positions.
	-Tree planting- leaves falling			- Accessibilty during the repair of services
				- Sleeves used where pipes cross the road

Figure 1.2 Green infrastructure technologies that can be used on infrastructure projects

5. Advantages of using the Eco approach to infrastructure design

The Eco-approach to infrastructure design takes a "design with nature" approach, to mitigate the potential impacts of a development. The benefits of this approach are as follows:

- Uses natural resources efficiently, maximizes the use of local materials, and eliminates waste;
- Reduces the ecological footprints of roads, sewer, stormwater and water, allowing ecosystems to function more naturally;
- Uses energy-efficiency systems and materials;
- Plans for future maintenance;
- Reduces, reuses, and recycles materials;
- Conserves and reuses water and treats stormwater runoff on-site;
- Recharged ground water flow for streams, conserving water supplies.

6. Conclusions

There is an urgent need to apply eco-efficiency concept into township infrastructure development.

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. In addition to this, vegetation improves urban aesthetics and community livability, by providing recreational and wildlife areas. Green infrastructure may save capital costs associated with paving, creating curbs and gutters, building large stormwater conveyance systems, other hard infrastructure and energy costs.

Though eco friendly design is a major component of the green value assessment, several other basic sustainability requirements are also assessed. 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.

As can be seen in this paper, there are numerous opportunities for improving eco-efficiency in infrastructure design. A new paradigm for infrastructure design is required in order to maintain environmental sustainability infrastructure.

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