Integrating Landscape, Ecology and Urbanism in Urban Transportation Corridors Planning and Design: Measuring Infrastructure Sustainability in Melbourne's EastLink

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Abstract

The interrelationships between ecological and landscape urbanist approaches and engineering practice in planning, design and delivery of transportation corridors, i.e. urban highways are studied in the current research. The aim of the research is to link theories of landscape, ecology and urbanism to infrastructure projects to find out how and to what degree these can be integrated in planning, design, construction, and operation process and help the project sustainability.

In order to determine the values of urban built infrastructure, specifically movement corridors, at the scale of an urban project, and measure the sustainability criteria for that, a case study is conducted on EastLink, a large scale infrastructural transportation project in Melbourne, Australia, to present a framework for observing and mapping actual design and delivery process. The case study is done using Infrastructure Sustainability (IS) rating scheme developed by the Australian Green Infrastructure Council (AGIC). As a result, the research presents an approach for urban infrastructural projects based on the sustainable development principles and provides a framework for assisting planner, designers, and builders of urban infrastructure to enhance them from an ecological and urban perspective in interaction with other urban land uses for multiple functions at regional and local scales.

Keywords: ***infrastructure, transportation corridor, landscape, ecology, urbanism, sustainability***

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1. Introduction

“Infrastructure, no longer belongs in the exclusive realm of engineers and transportation planners. In the context of our rapidly changing cities and towns, infrastructure is experiencing a paradigm shift where multiple-use programming and the integration of latent ecologies is a primary consideration. Defining contemporary infrastructure requires a multi-disciplinary team of landscape architects, engineers, architects and planners to fully realize the benefits to our cultural and natural systems” (Aquino et al., 2011). As an intrinsic characteristic of urban infrastructural plans, many disciplines and factors influence the planning and design of urban infrastructure and numerous criteria should be taken into consideration during their design process and a team of experts should utilize and integrate their expertise in the a project design and delivery. The significant roles of landscape architecture, landscape ecology and landscape urbanism in the urban infrastructure design process are the core of this research to find out how urban infrastructural projects can be built more sustainably and multifunctional.

The potential of infrastructure systems for performing the additional function of shaping architectural and urban form and helping ecology of the city is largely unrealized. The planners and designers have most often been charged with hiding, screening and mitigating infrastructure. They are rarely asked to consider infrastructure as an opportunity. Infrastructure has the capacity to serve as the material of design or establish a local identity with tangible synergic relationship to the region and can be designed with a formal clarity that expresses its importance to society and environment, at the same time creating new layers of spaces and connections (Strang, 1996). The landscape urbanism as a school of thought in design and planning (Weller, 2008) and urban landscape ecology that investigates the structural and functional interrelationships between the abiotic, biotic and cultural aspects of the environment (Forman, 1995a, Forman, 1995b, Forman, 1998, Niemela, 2011) can provide the theoretical background for the study of urban infrastructural projects due to the numerous factors and elements that influence these large scale plans where landscape, ecology and urbanism (Mostafavi et al., 2010, Mostafavi and Najle, 2003) meet to increase the ecosystem services at the landscape scale (Müller et al., 2010).

Approaches such as an urban design approach to road infrastructure development (Raeburn, 2005) indicate a shift in values from a traditional engineering approach and instead adopting an urban design and landscape approach to the development of road and related transport infrastructure. As well as achieving its transport objectives in moving people and goods, road networks and infrastructure projects should contribute to the form of human settlements and their accessibility.

Raeburn (2005), using several case studies in Australia, emphasizes that such projects should regard the natural ecology as well as the built, natural and cultural heritage by urban design. Similarly, landscape ecological thinking can potentially play important roles in the planning and designing of urban infrastructure and landscape architecture can act as a driving force for physical application of the ecological principles in urban projects. Ideas such as green infrastructure (Benedict and McMahon, 2006, Davies et al., 2006, Gill et al., 2008, Ignatieva et al., 2011) and urban infrastructural design (Bélanger, 2009, Meyboom, 2009, Strang, 1996, Tatom, 2006) increasingly confirm the crucial role of landscape and landscape architecture in urban infrastructure. The interaction of ecological sciences and methods such as landscape ecology with architecture, landscape architecture and urban design seem as a logical solution for solving many of the today's environmental concerns.
In the utilitarian approach to urban infrastructure design process, mostly the blue (water), grey (urban built) and green (natural or built) infrastructure for the cities are designed separately at different periods of time or are planned and utilized incompatibly. Sometimes the green infrastructure is built after a long time of the initial grey and blue infrastructure or very often the grey infrastructure destroys environmental potentials during construction. The urban built infrastructure can provide other opportunities for landscape architects similar to that of the natural infrastructure in the city. In other words, the transportation systems across landscapes including urban landscapes can provide ecological flows and biological diversity in addition to safe and efficient human mobility (Forman and Deblinger, 2000). Therefore, in investigating the influence of large scale infrastructural projects on the ecology of cities, and their interrelationships, ecological concepts and methods can be used by built environment professions to present new planning and design frameworks. This approach helps the sustainability of these projects in the urban context.

2. Problem identification, aims and objectives

Due to the vital and inevitable roles of both natural and built infrastructure in the livability of the cities, an integrated approach towards designing and building the infrastructure is necessary and landscape urbanism and ecological approach can be of great help to solve this problem by their comprehensiveness to bring the potential services and roles of the ecologically designed infrastructure into urban environments. The current research tries to find out how urban infrastructure can be designed more ecologically sound, sustainable, and responsive to the living urban environment based on landscape ecological/urbanist approach. In ecological urbanism studies, there is a gap between the concepts and methods

presented in the ecological sciences and the current planning and design process. The research tries to fill out this gap and more specifically focuses on built urban movement corridors, i.e. highways within urban settings.
The research is seeking to answer one basic question; "How can urban infrastructure, specifically movement corridors, be designed to improve the ecology of the city, and delivered in practice?" Within the proposed urban ecological approach urban infrastructural projects, the environmental features and processes play important roles and should be considered in the design and delivery process of built infrastructure along with engineering factors. The main focus of this research will be on the built corridor and the natural aspects will be studied according to their relationships and impacts on and the form and function of highway corridors.

3. Materials and Methods

In order to evaluate the effectiveness of the design and delivery of a built infrastructural project in an ecological sense, a case study is conducted and several aspects including ecologically important landscape elements and urban features and their functions in the project are studied and analyzed using IS (Infrastructure Sustainability) rating scheme. From a landscape architectural point of view, the current research will explore the theoretical and practical knowledge in that field of activity in EastLink, Melbourne, Australia.
EastLink, a large scale infrastructural transportation project in Melbourne, is regarded unique and extreme by the authorities and can be considered as a critical case in theorization of the ecological urban design and delivery framework. The project is the largest road ever constructed in Victoria and Australia's largest urban road project. It is an integration of both built and natural features and it is also a fundamentally important connecting element to the eastern part of the city region and acts as crucial urban transportation corridor, a vital connection for 1.5 million people living in Melbourne's eastern and south-eastern suburbs, completed and opened to traffic in 2008 (Fig 1).

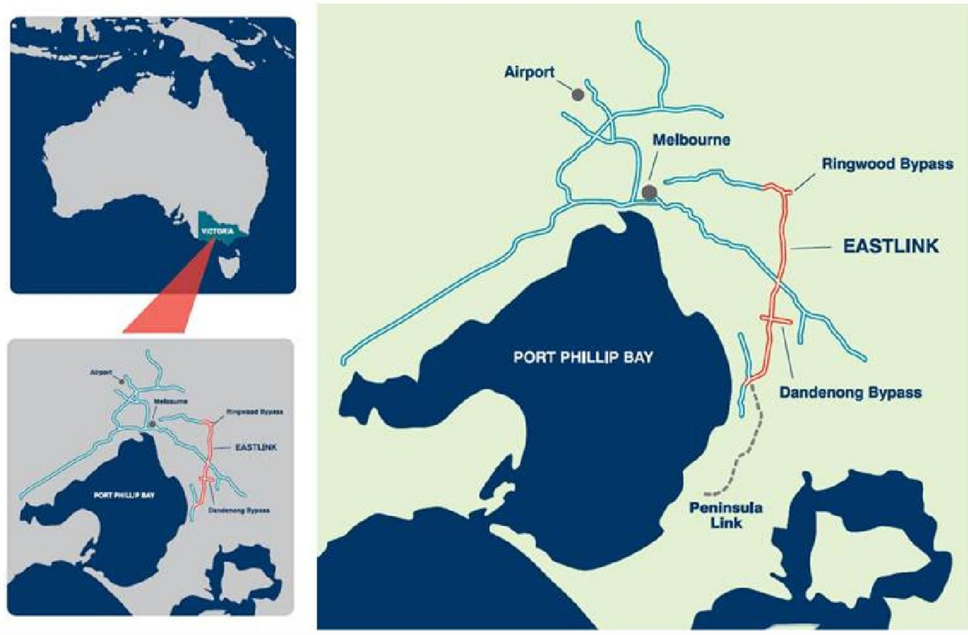

Fig 1. The location of EastLink in Melbourne, Australia
(http://*www.linkingmelbourne.vic.gov.au*)

Many recent environmental considerations are applied in its design and construction process regarding the contextual natural and built features including wetlands and water quality treatment systems and tunnels to preserve parklands. The 39km motorway is connected to the surrounding urban fabric by a network of bridges, cycling and walking pathways. The project involved construction of 45km of new roadway including 6km of bypass roads and 35km EastLink Trail for walking and cycling. More than 3.6 million plants are being used along the corridor in an area of 480 hectares which is larger than the parks and gardens in the City of Melbourne combined.

More than 60 wetlands and water quality treatment systems are located along the way to treat water runoff from the motorway. The 1.6km Melba and Mullum Mullum Tunnels preserve the Mullum Mullum Parkland above, including significant Valley Heath Forest species. A natural wetland was successfully relocated during the construction phase (*http://www.eastlink.com.au*). It has been awarded by the Australian Institute of Landscape Architects (AILA) for the landscape architecture and urban design section of the project (Fig 2).

Fig 2. EastLink project and its relationship to the environmental context
(*http://www.connecteast.com.au*)

EastLink incorporates an extensive shared use path network for cyclists and pedestrians, which will connect with Melbourne's existing paths. The pathway route was refined after an extensive review process involving discussions with the Department of Sustainability and Environment (DSE), VicRoads, Bicycle Victoria and representatives from city councils and local environmental groups. Several walks through the area were conducted with these groups to identify further small areas of sensitive plant life. As a result of these inspections, a final pathway design was determined which protects areas of greatest ecological significance. The shared use path route through the valley section of EastLink will stretch 2.75 kilometers.

ConnectEast, the owner and operator of EastLink, established around 70 constructed wetlands, water retention basins and bioretention strips along EastLink's route, representing a degree of wetland provision unparalleled for a roadway project of this magnitude in Australia. These wetlands function as a north-south string of new aquatic habitats within the road corridor, connecting to existing waterways, drainages and creek channels. The wetland ponds will create a safe ecosystem for frogs, water birds, insects and small mammals in these areas. They have been designed for the capture and treatment of all road surface water run-off throughout the freeway standard motorway. The series of wetlands has been designed to accept all of this water before it is safely released into the waterways nearby.

The case study is done through a post-construction evaluation using IS (Infrastructure Sustainability) rating scheme which is developed and administered by the Australian Green Infrastructure Council (AGIC). IS pays special attention to planning/design phase and evaluates this phase as a separate section of the rating tool in addition to construction and operation phases. The three modes of the rating tool (Design, As Built, and Operation) cover a wide range of multi-criteria and multi-functional aspects of infrastructural projects (Fig 3).

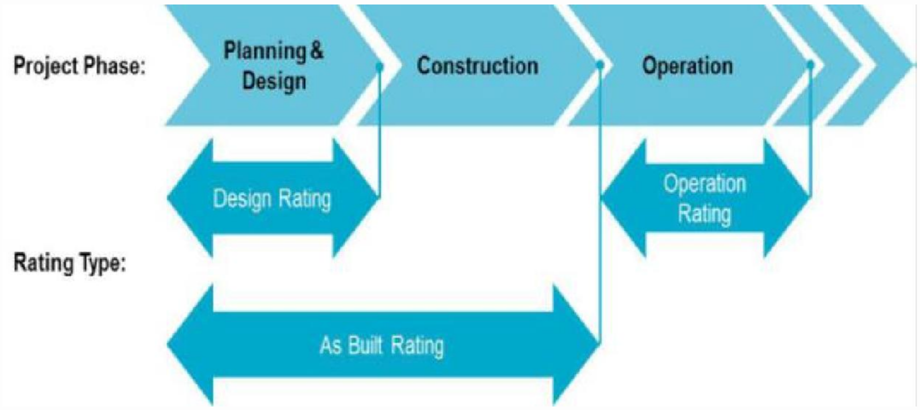

Fig 3. Different modes of IS rating tool and project phases
(*http://www.agic.net.au*)

4. Results

As the sustainability of the infrastructure gains increasing attention worldwide (Pollalis et al., 2012) and many stakeholder in Australia feel the need for a new trajectory and paradigm shift in their projects, IS rating tool is developed by AGIC to influence infrastructural design, construction and operation. Infrastructure Sustainability is similar to Leadership in Energy and Environmental Design LEED (United States Green Building Council, 2009), Envision rating tool (Harvard University Graduate School of Design, 2010) applied by Institute For Sustainable Infrastructure (ISI) (*www.sustainableinfrastructure.org*), and Sustainable Sites Initiatives (SITES) (American Society of Landscape Architects et al., 2009). However, different types of LEED cover a wide spectrum of projects and spaces, SITES is basically designed for sites and landscapes, Envision and IS are specifically designed for infrastructural plans and projects. The IS rating scheme has the following 15 categories of measures and a number of sub-categories and credits in different physical, biological and cultural themes (*http://www.agic.net.au*).

1- Management Systems (Man)
2- Procurement and Purchasing (Pro)
3- Climate Change Adaptation (Cli)
4- Energy and Carbon (Ene)
5- Water (Wat)

6- Materials (Mat)
7- Discharges to Air, Land & Water (Dis)
8- Land (Lan)
9- Waste (Was)
10- Ecology (Eco)
11- Community Health, Well-being and Safety (Hea)
12- Heritage (Her)
13- Stakeholder Participation (Sta)
14- Urban and Landscape Design (Urb)
15- Innovation (Inn)

The IS rating tool uses a 100 point scale to measure performance and this score determines the rating level achieved as follows: Scores <25 points are not eligible to apply for a certified rating. Scores from 25 to <50 points are eligible to apply for a "Good" rating. Scores from 50 to <75 points are eligible to apply for an "Excellent" rating. Scores from 75 to 100 points are eligible to apply for a "Leading" rating. Available and achieved points and levels are calculated and portrayed in tables and graphically displayed for each mode of the model which is defined for different phases of the project. Site and context analysis, site planning, urban design and urban design implementation and management in the urban and landscape design category of IS rating measures are extremely important from a landscape architectural and urban design point of view and the expertise that can be brought to design and delivery teams from these build environment professions.

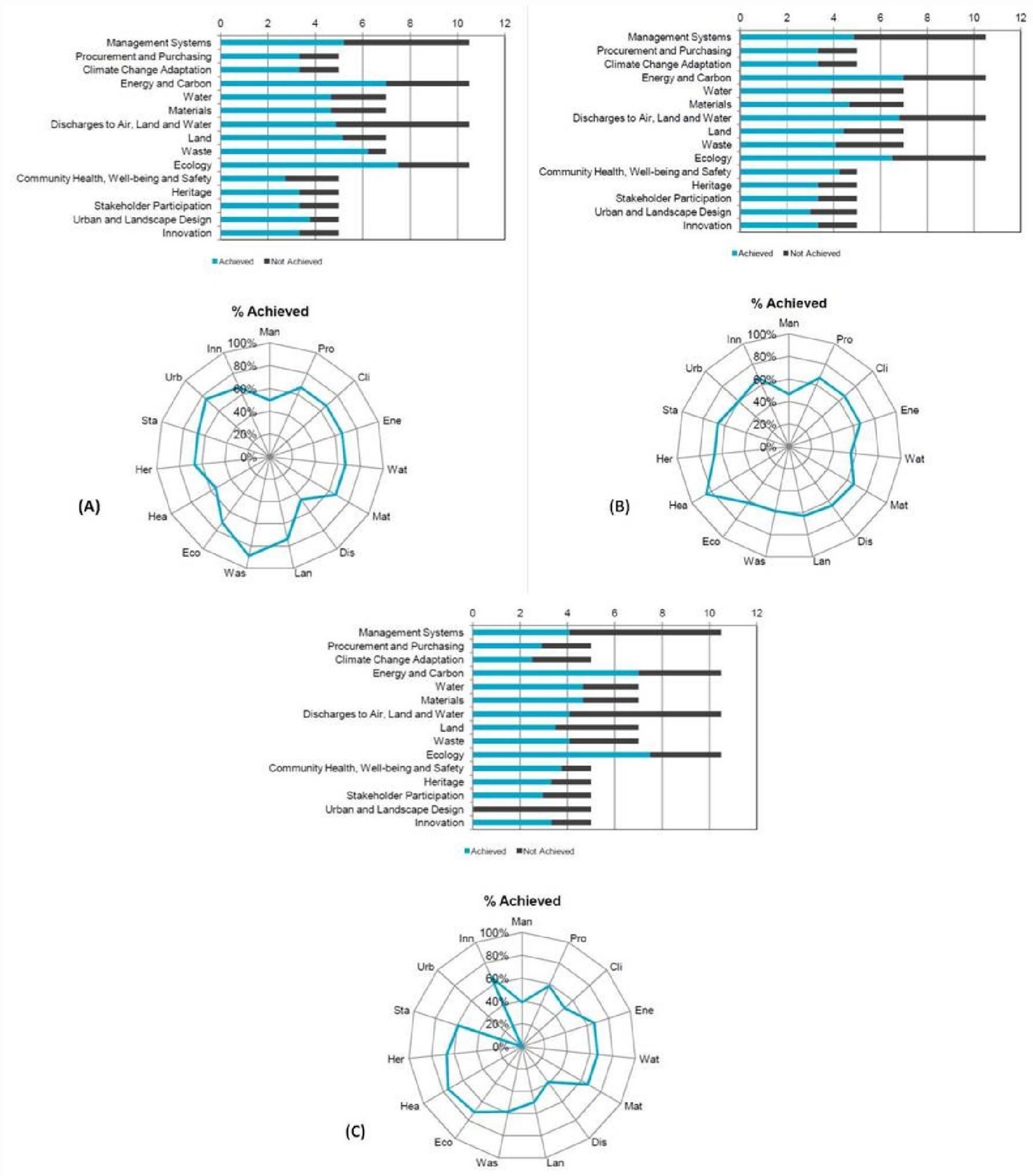

Fig 4. EastLink transportation corridor design and delivery phases rating using IS tool; Design (A), As Built (B), and Operation (C)

During the course of the case study, the Environment Effects Statement (EES) from the 1990s, the legislation and acts from 2000s, and project planning and design documents, were reviewed to find out the embedded sustainability and landscape ecological and urbanist concerns and use them in evaluation and rating. In addition to that, interviews were conducted with different stakeholders, especially designers and planners, who were evolved at different stages of the project. A number of site visits were done as sources of information for the post-construction evaluation and design and delivery process analysis. After filling out the spreadsheets and tables for different modes of the rating Design (A), As Built (B), and Operation (C) for EastLink, the project achieved 65%, 65%, and 55% of points in each phase respectively (Fig 4). In other words, the project is eligible to apply for an "Excellent" rating. The results can be interpreted for every category of measures and each phase of the project separately and comparatively in more details regarding the references, aims and levels of achievement at IS rating scheme. Detailed calculation and spreadsheets and tables for different modes of the rating are not presented here in the paper.

5. Conclusions

With the increasing urban population and the need for more built infrastructure to support this population, infrastructure sustainability has become fundamentally important. It has gained much expert attention among different built environment professions and policy makers. The research presents a design approach for urban infrastructural projects based on sustainability issues and provides a framework for assisting designers and planners of built urban infrastructural corridors, i.e. urban highways, to enhance the projects and plans from an ecological perspective in interaction with other urban land uses especially green and open spaces, water features and alternative modes of transport such as walking and cycling, to add to the project's multi-functionality. In this approach, the whole project and its periphery is regarded as a constructed ecology.

The results will be applicable both in planning, design and construction of new projects and evaluation of similar existing constructed projects. The product of applying landscape ecology and landscape urbanism approaches to the urban infrastructure corridors design and delivery is more than just urban "Green Infrastructure", it is about "Greening the Infrastructure", specifically urban built transportation corridors of highways as pathways to urban sustainability.

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