



Comparative analysis of environmental impacts of selected underground construction technologies using the analytic network process

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ABSTRACT

This paper describes a multiple criteria assessment experiment using the Analytic Network Process (ANP) and the Super Decisions software. The assessment experiment was based on a case study of an underground construction project in the city of Osnabruck, Germany. The project involved construction of a new 700 m long sewer in the city centre. Three alternative underground construction technologies (open cut, conventional tunnelling, and microtunnelling) were evaluated using a set of multi disciplinary criteria that reflect impacts of the project on the urban environment. Results of the assessment experiment suggest that the ANP can be successfully used for assessing the environmental impact of underground construction technologies. Multiple criteria decision analysis, and the ANP in this particular assessment experiment, is relevant for evaluating construction technologies because of (1) the similar technological and economic performance of the alternative technologies; (2) the need to consider a large number of criteria reflecting the urban environment; (3) the possibility of needing to deal with incomplete data; and (4) the need for clear presentation of the results in a numerical form.

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1. Introduction

Global urbanisation [1] and ever increasing demands for higher living standards among the world's population are underlying causes for the need to develop urban infrastructure. Such infrastructure includes transport, water supply, sewerage, solid waste management and telecommunications. Many components of the infrastructure are installed underground. Urban underground space (UUS) has been developed intensively during recent decades due to the high demand for urban land and the availability of construction technologies that allow installation of underground structures in densely built urban settings, as demonstrated by Belanger, 2007; Pasqual and Riera, 2005 [2,3].

Underground structures, and underground construction works in particular, have a significant impact on the environment [4–7]. These environmental impacts cover a wide range, and vary from direct impacts on groundwater to indirect ones on cities' landscapes and intangible assets. Given the wide range of modern underground construction technologies (UCT) and equipment available (for an overview see e.g. Maidl et al., 1996, Mathewson and Laval, 1992 [8,9]), there is an increasing need to consider the environmental impacts of different technologies and to integrate fully environmental issues into any decision-making process relating to UCT choice for a particular

development project. Many UCTs provide similar technological and economic performance and can be viewed as competitive alternatives in many projects. In some projects different UCTs have almost identical costs, e.g. Hydro shields and Earth pressure balance shields, as shown by Thewes and Bielecki, 2007 [10], so that a decision on which UCT to use should to be taken solely on the basis of its impacts on the urban environment.

Thus there is a great need for a methodology that would systematically consider environmental impacts of different UCTs and assist in the decision-making process for a particular UUS development project. Since the environmental impacts can be described by a wide array of criteria, multiple criteria decision analysis (MCDA) is an appropriate basis for this methodology.

Table 1 summarises the reasons for and the importance of a multiple criteria decision methodology to address environmental concerns related to UUS development and UCT choice.

UUS development is a complex task that needs to be considered from many perspectives: economic, environmental, security, etc. Very often criteria that correspond to these areas of concern are mutually conflicting, and there have to be tradeoffs.

Environmental decisions involve detailed studies of UCT impacts on the environment, the interrelations between these impacts, evaluation of the impacts and prioritising issues of concern. The design of a comprehensive decision making methodology for environmental assessment of UUS development would depend on: (1) the scale of the project; (2) the phase of the project design at which a decision must be taken; and (3) the phases of project implementation that the decision

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