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Improving the design of urban underground space in metro stations using the space syntax methodology

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ABSTRACT

This article explores the potential use of the space syntax methodology for evaluating user wayfinding, orientation and visibility in urban underground space. Two case studies from the Brussels-Capital Region are presented: the Bockstael metro station and the Anneessens premetro station.

The use of the space syntax method is proposed to produce measurable or 'hard' parameters on design aspects that might otherwise be perceived as qualitative or 'soft' design aspects.

Four space syntax analyses are conducted: an axial analysis, an orientability analysis, an isovist analysis, and agent-based modelling. A comprehensive, but effective, method using space syntax is developed to optimise design and renovation alternatives.

We conclude that space syntax can provide a tangible contribution to the qualitative design of urban underground spaces.

1. Introduction

Wayfinding, orientation and visibility are key user requirements in the design and construction of underground spaces. However, wayfinding and orientating are more difficult underground because of the lack of reference points, such as landmark buildings, and the absence of direct sunlight. Visibility is often hampered by labyrinth like corridors characterised by a "hyper-accumulation of signs, media, symbols, lights, materials, displays, and proportions" (Bélanger, 2006). These conditions influence the spatial legibility and social safety of underground stations.

Discussions on design issues and problems regarding underground spaces began in the 1980s (Carmody et al., 1994). The spatial configuration of an underground space may even influence crime. Incidence of crime in metro stations is not just a matter of organisational measures but of situational measures as well (López, 1996). There "is a need for a more systematic approach to the design and assessment of quality of underground spaces so that a better quality of underground spaces can be obtained" (Durmisevic and Sariyildiz, 2001).

Poor wayfinding, orientation and visibility in underground public spaces are not necessarily the result of deliberate planning choices or a lack of either design skills or knowledge. The design and construction of underground structures are ruled by several, sometimes conflicting, factors. There is a gap to be bridged between the traditional engineering sciences and the architectural design disciplines. "The design of underground infrastructure is often dominated by civil engineers but the aspect of social safety requires a different view point that can be best realised by the involvement of an architect" (Bosch, 2011).

Argumentation in the engineering sciences is often based on 'hard' quantitative evidence, visualised through complex diagrams and graphs that may appear quite solid in the eye of decision makers. Designers, however, tend to illustrate their vision through 'soft' evidence, such as architectural renderings of situations 'before and after' or 'with and without'. Expert opinion is required to judge which design is preferable and much of that judgement may sound like only 'opinions' to non-designers. Tool sets that can successfully measure these 'soft' parameters are now available. Space syntax is such a collection of tools, but it is still rarely used in the field of tunnelling and underground space technology. The purpose of this article is to demonstrate the use of these tools in this field. This article describes the outcome of a study commissioned for the renovation of two underground (pre-) metro stations in the Brussels-

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Capital Region, Belgium. In addition, the applicability of space syntax analysis to improve wayfinding, orientation, navigability and visibility in underground spaces is explored.

The Brussels public transport authority STIB commissioned the Yellow Design Foundation to conduct a feasibility study for the upgrade of the (pre-) metro stations. The Yellow Design Foundation is an independent, multidisciplinary and interregional platform for research and information on design and visual communications, based in Brussels, Belgium (Yellow Design Foundation, 2012). Yellow Design subcontracted the space syntax analysis to TU Delft. The Brussels case provided the authors a strategic opportunity to apply the space syntax method and test its applicability in an environment described as "urban underground space (UUS)" (Bobylev, 2010).

This article briefly discusses the main features of the space syntax method. It describes the two Brussels underground (pre-) metro stations that were analysed: Bockstael and Anneessens. It presents an effective and simple method that is applied to optimise the two Brussels stations. The six-step research methodology consisted of the following: mapping the underground urban space (1), performing visibility, axial, isovist and agent-based analyses (2), evaluating the outcome (3), reconfiguring the floor plans (4), reanalysing the improved floor plans (5), and conducting a side-by-side comparison of the original and improved floor plans (6). The article concludes with a discussion of the applicability of space syntax for evaluating and improving the design of urban underground spaces.

2. The space syntax method explained

The space syntax method used to evaluate the Bockstael and Anneessens stations was developed by Bill Hillier and his colleagues at the University College London (Hillier and Hanson, 1984). Over the past three decades, Hillier and his team have applied space syntax to urban studies and to complex buildings. In the last decade, numerous improvements have been made to various types of spatial analyses and software development. The evaluation of design proposals for the Tate Britain in London, 2002, provided a prominent showcase of the use of space syntax for buildings (Dursum, 2007) (see Fig. 1).

Space syntax is used in assessing and rearranging the interior spatial structure of complex buildings, such as offices, retail (shopping malls), hospitals, museums, railway stations and cultural buildings. However, there are currently no references found in scientific literature for the use of space syntax on urban underground spaces.

Space syntax is based on three concepts: the convex space, the isovist field and the axial line (see Fig. 2). Convex maps are used for analysing buildings and the public spaces between buildings. Convex space is defined as: "all points within a space that can be joined to all others without passing outside the boundary of the space" (Hillier, 1988).

In urban analyses, the convex space analysis has been replaced by the point depth and the all-lines analyses. No significant convex space analysis software improvements have been made since the 1990s.

An isovist field represents the panoptical view a person has from a given point in an urban space. It is used for orientation or wayfinding in the urban fabric. Initially the isovist analyses were conducted manually. Now, both one-point and all-points isovist analyses can be conducted using Depthmap, an open source application developed by University College London.

An axial line represents the longest sight line one has in an urban space or building. It represents the way human beings move in lines through streets and roads, or rooms and corridors.

During the past two decades, the axial line has been the basic spatial element in the methodology and theoretical development of space syntax in urban studies.

The main premise behind these three basic spatial elements is that human beings move in lines, interact in convex spaces and experience changeable panoptical views when moving around in a built environment. As such, it can be instrumental to test the requirements of undeground urban spaces.

The space syntax methodology has been verified during decades of research; consequently, the case studies presented in this article do not aim to verify the tool set. Instead, the aim of this study is to draw conclusions on the spatial configurations of two specific (pre-) metro stations and find generic leads to promote the use of space syntax in future research and design of urban underground spaces.

3. The Bockstael and Anneessens stations in Brussels, Belgium

In 2012, Yellow Design received a commission to evaluate two underground stations and advise on their renovation. The commission included the Bockstael metro station and the Anneessens premetro station. The Brussels premetro is a light rail system that was built with the option to upgrade to a full metro system in the future.

Typically, a design consultancy conducts a number of analyses to obtain a better understanding of the qualities and problems of the spatial configuration, the use of materials, the programming, the load-bearing structure, and the uses of a building, facility or space. The types of analysis and the methods used may differ from office to office as they are linked to the unique architectural styles and design concepts that the designer or the design consultancy embraces.

Our experience in the field of underground space technology has shown weaknesses in analysing wayfinding, orientation and visibility. We suggested that Yellow Design conduct a number of space syntax measurements to gain detailed insights in these areas. The objectives of this research could then be defined using the following four research questions:

1. Can space syntax be effectively used to assess wayfinding, orientation and visibility in urban underground space?
2. If yes, what is the current state of wayfinding, orientation and visibility in the two Brussels (pre-) metro stations?
3. What intervention(s) can be proposed for the investigated Brussels (pre-) metro stations to improve wayfinding, orientation and visibility?
4. Which generic approach can be applied to these and other underground stations to investigate and improve wayfinding, orientation and visibility?

3.1. Bockstael

The Bockstael station is situated along metro line 6 (Roi Baudouin – Simonis) in the Brussels municipality Laeken (see Fig. 3). The metro station is connected to an underground train station with the same name. The Bockstael train station is situated along rail line 50 (Brussels – Ghent). Rail line 50 is an above ground rail line covered with a deck structure at Bockstael. The Bockstael metro station is located underneath the train station. The metro station was inaugurated in 1982 and includes two tracks and two side platforms. The train station has a similar configuration. The Bockstael metro station includes two intermediate (ticket) halls or mezzanines (north and south) between the street-level and platforms. An additional passageway, which provides access to the metro station, runs underneath the train station. The train station is located at the north side of the metro station (see Fig. 4 (a–c)).