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Procedia - Social and Behavioral Sciences 222 (2016) 458 – 464

Procedia
Social and Behavioral Sciences

ASLI QoL2015, Annual Serial Landmark International Conferences on Quality of Life
ASEAN-Turkey ASLI QoL2015
AicQoL2015Jakarta, Indonesia. AMER International Conference on Quality of Life
The Akmani Hotel, Jakarta, Indonesia, 25-27 April 2015
"Quality of Life in the Built & Natural Environment 3"

A Method to Analyze the Living Spaces of Wheelchair Users Using IFC

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Abstract

Full physical adequacy for individuals is a temporary condition. Everyone has some limitations on the part of his life.
Disabled people have some special needs. However, design for disabled are still made generic. The conventional methods are used to control the design and results are not satisfactory. BIM (Building Information Modeling) is such a good option to control the design. In this study, a method that analyzes the living spaces by using BIM model was developed. While using proposed model, it is possible to define all incompatibilities properly and use them as design feedback to create effective living spaces for wheelchair users.

Peer-review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers) and cE-Bs (Centre for Environment- Behaviour Studies, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.

Keywords: IFC; BIM; universal design; code checking

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Peer-review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers) and cE-Bs (Centre for Environment- Behaviour Studies, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.
doi:10.1016/j.sbspro.2016.05.136

1. Introduction

The United Nations Convention on the Human Rights of People with Disabilities recognizes “the importance of physical accessibility to the social, economic and cultural, health and educational buildings”. It is important to achieve physical accessibility to allow people with disabilities to enjoy all human rights and fundamental freedoms.

Full physical adequacy for individuals is a temporary condition. Everyone has some limitations on the part of his life. A child, a pregnant woman, a person with a broken leg, a mother with the pram, an elderly person can be given as examples. Very few people are healthy all his life.

Disabled people have some special needs. However, design for disabled are still made generic, and the needs of them do not identify clearly. If the built environment is not intended considering the needs of persons with disabilities, the quality of life is affected negatively. The social integration of disable people is one of the most important factors to improve the quality of life. Design decisions that are taken by considering the needs of people with disabilities should create more compatible and high-quality living space. The conventional methods are used to control the design and results are not satisfactory for compatibility checking. As a new building design and documentation method, Building Information Modeling (BIM) is such a good option to control the layout.

The usage of BIM in Architecture, Engineering and Construction (AEC) sector has been increasing rapidly. The concept of BIM contains the formation and the usage of the design, construction and management knowledge of buildings. The computational model of BIM forms an environment that serving the various disciplines of the design process to work together (Turkyilmaz, 2013).

BIM is the use of the computer-generated model to simulate the planning, design, construction and operation of a facility. It is a technology that allows users to create a visual simulation of a project with a digital prototype of a building prior to construction. The deployment of BIM in construction can make the industry more efficient, effective, flexible, and innovative (Takim et al., 2013).

Information sharing should be starting point when it comes to applying information technology to architectural design, construction and use. Information sharing requires a software environment in which computer programs can exchange data automatically regardless of software and data location. To achieve this, the IAI proposed a standard that specifies object representations for AEC projects. Today, Industry Foundation Classes (IFC) is the fundamental file type of AEC industry. IFC is an object-oriented data information model. It contains all kind of information on AEC projects. These data located in IFC data files. IFC data file creates a neutral file type to share and to change project information efficiently (Turkyilmaz, 2013).

IFC includes object specifications or classes and provides a useful structure for data sharing among applications. For instance, an IFC door is not just a simple collection of lines, and geometric primitives recognized as a door. It is an intelligent object door that has a door’s attributes linked to a geometrical definition (Vanlande et al., 2008).

In this study, a method that analyzes the living spaces by using BIM model was developed. Rules for wheelchair users were generated according to the National TS9111 standards. Rules defined in Solibri Model Checker (SMC) software. The BIM model transferred to SMC as IFC (Industry Foundation Classes) files. After the compatibility analyze made with SMC, a detailed compatibility report was prepared. The results of the compatibility checking can used for design feedback.

2. Disability in Turkey

Current disability system in the world recognizes that there are various types of disabilities, and there is increasing in the number of the disabled population. About the physical environment, people with disabilities may be categorized to wheelchair-bound, sensory disabled, ambulant disabled, and temporarily disabled.

- Wheelchair-bound people, who are unable to walk, either with or without assistance and who depend on a wheelchair for mobility.
- Sensory disabled, Those who experience, partially or wholly, impaired sight or hearing.
- Ambulant disabled people, who are able, either with or without personal assistance, to walk provided that convenient facilities such as handrails be available.
- Temporarily disabled people, who are sick or victims of an accident. Pregnant women also included in this category (Kadir, Jamaludin, 2012).

According to Turkey Statistical Institute (TUIK, 2012), 13.45% of Turkey population consists of disabled people. In developed countries, the rights of people with disabilities are always on the agenda, and there is continuous work to make further progress on the arrangements of disabled and the elderly. Planning and designing only some parts of spaces for persons with disabilities is an unacceptable design approach for today. Regarding fundamental human rights and freedom, the physical environment should design for equitable use (Sungur Ergenoglu, 2013).

In Turkey, due to lack of physical arrangements and the presence of various obstacles, disabled people can use the built environment either with difficulty or assistance. Spatial arrangements are crucial to enable disabled people participating public life with equal opportunities. Disabled people in Turkey still have difficulties to use the most vital public facilities such as health, education, to take part in sports and cultural activities, to spend time in parks and garden. Some examples of the lack of built environment in Turkey can summarized as follows:

- In outdoor spaces, level differences for wheelchair users, non-standards ramps, dangerous objects in the pedestrian ways, staircases in overhead bridges, inaccessible child playground,
- In transportation, incompatible buses, inaccessible bus stations,
- In buildings, non-standards ramps or lack of ramps, non-standards staircases and elevators, lack of disabled WC, lack of orientation signs for blind people.

3. Case study

Home is one of the most significant parts of the built environment. The quality of life starts at home. The design of suitable housing, where individuals spent a long time in their lifetimes, is one of the most significant factors to increase the quality of life. The problems experienced by disabled people on the accessibility of their housing are caused the difficulties of integration into society. When disabled people live accessibility problems in their houses, they have some worries to reach and integrate other parts of built environments as well. Accessibility in housing design is also crucial to generalize the attitude of equality in society.

Home is where an individual grows physically and develops essential values as a human being and builds a family. In a broader context, a single home is what creates a neighborhood, and an individual is what composes a community (Kadir, Jamaludin, 2013).

The principles of Universal Housing Design are as follows:

- Equitable to use,
- Flexible in use,
- Simple and intuitive to use,
- Easy to interpret,
- Safe and sensible to use,
- Requires low physical effort,
- Promotes ease on approach to housing features and elements (Ali et al. 2012).

3.1. Selected projects

Mass Housing Administration (TOKI) depending on the Prime Minister of the Republic of Turkey, is a public institution that was established specifically for the production of social housing in Turkey. The aim of the Institution is to meet the needs of qualified housing of small and middle-income citizens. Three housing projects that conducted by TOKI has chosen as case studies.

- 1st Project, Avrupa Houses TEM-2 Project: 414 homes exist in three blocks that have 22 floors in each (Fig. 1.). The project is one of the most valuable projects of TOKI. There are a private car parking and a shopping mall directly connected to the apartments. The housing units are built according to national standards.
- 2nd Project, Hoşdere Houses 1st. Section: 682 housing units exist in 13 blocks. The project exists in new settlements of Istanbul. The middle-income range is the primary users of the housing units.
- 3rd Project, Körfez Kent Mass Housing: Project is in Kocaeli, main industrial zone close to Istanbul. 3500 homes exist in 5 districts. Low-middle income range is the primary users.

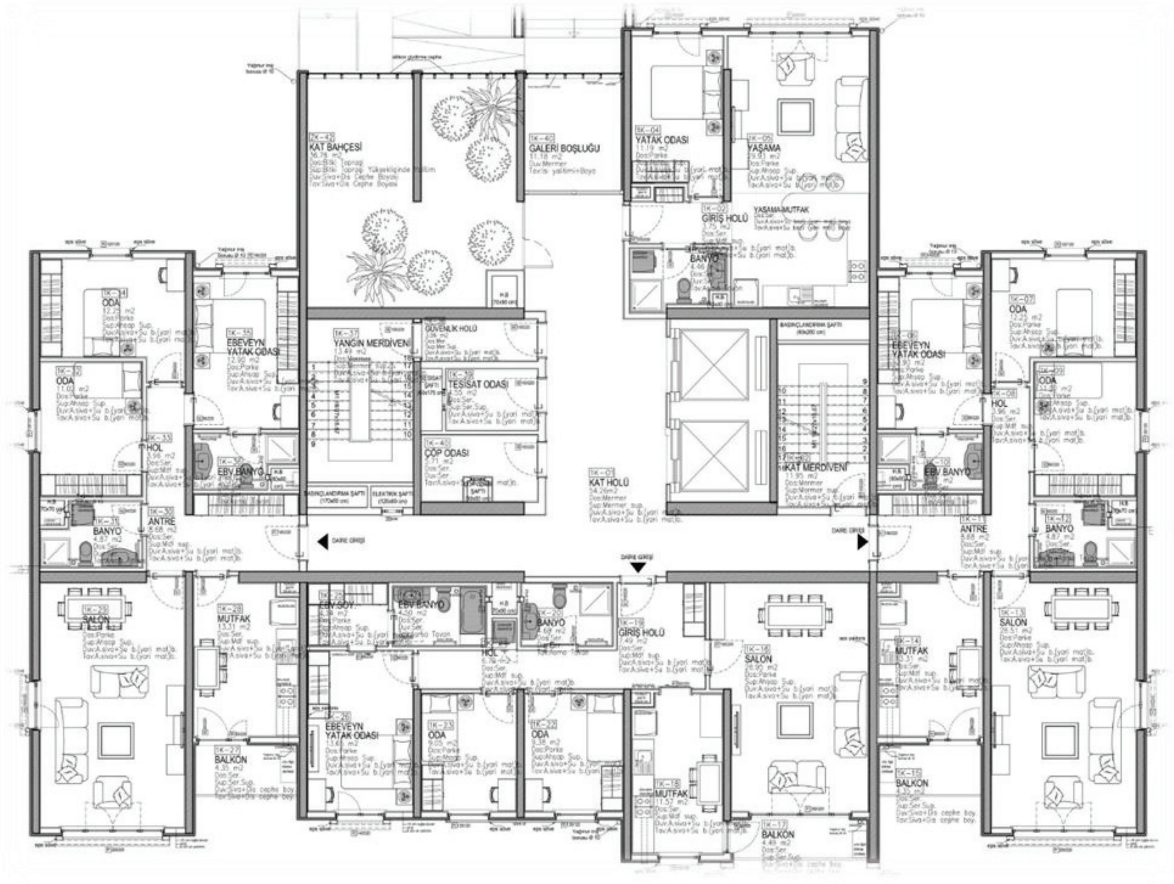

Fig. 1. Sample floor plan for 1st Project

3.2. National standards

Turkish Standards is the national standards of Turkey that defines rules in diverse fields of the quality infrastructure. According to the Turkish Standards (TS), the architectural rules for accessible space used in this research are as follows:

- There should be a same level entrance or a ramp for the entrance,
- The incline ratio should be 8% up to 10m,
- The incline ratio should be 6% after 10m long areas,
- The width of the ramp should be 90cm at least.
- The dimensions of landing of ramps should be 100x120cm at least,

- No threshold is preferred,
- If there is the threshold, the height of the threshold should not be more than 25mm,
- The dimension of the entrance door should be 91,5cm at least,
- No revolving door is preferred,
- The width of entrance hall should be 122cm at least,
- There should be at least one elevator,
- The dimension of the door of the elevator should be 91,5cm at least,
- The dimension of the door of wet areas should be 85cm at least,
- There should be 86cm between the closet and the washbasin,
- The shower should locate on grade crossing,
- The dimension of the shower should be 90x90cm.

3.3. Rule checking

BIM models of selected projects were created using Archicad software. Those models exported as IFC file format. Solibri software was used to make rule checking for disabled-friendly built environment IFC models were imported to Solibri that could read information of building elements and spatial data (Fig. 2).

New rule sets could be defined in Solibri such as checking the width of the doors (Fig. 3). IFC model could be checked according to those rules.

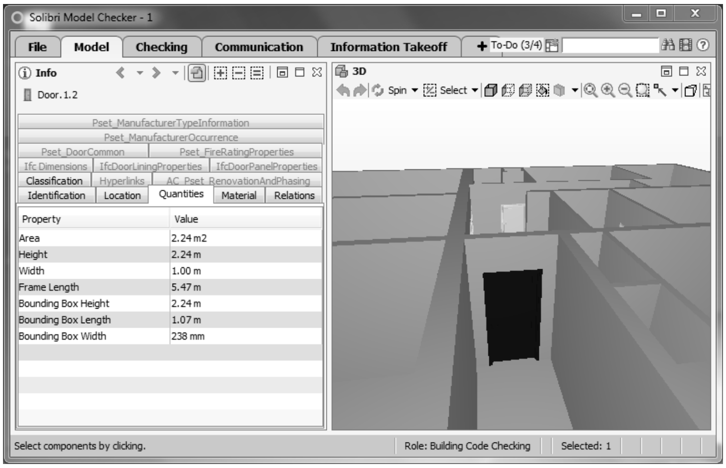

Fig. 2. Imported IFC model in Solibri

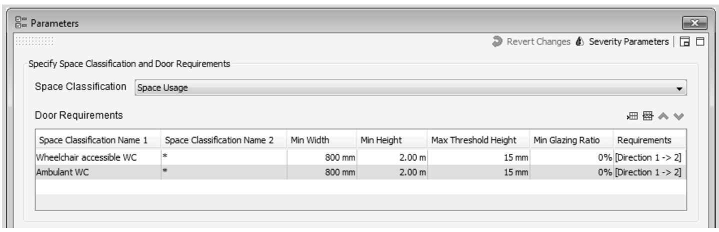

Fig. 3. Defining new rule set in Solibri

3.4. Discussions

Checking the rule sets with conventional methods is time-consuming and open to failure both. Some difficult tasks can handle by using the proposed method. It is also possible to make an extremely fast evaluation of the rule sets compared to human time. Besides working the proposed method, more accurate data are obtained compared to the human effort. Effective design feedback is achieved with the proposed method and used to improve design (Table 1).

Table 1. Rule sets and results

Rule sets	1st Project	2nd Project	3rd Project
The availability of ramps	-	Convenient	Convenient
The incline ratio of ramps	-	Convenient	Inconvenient
The width of ramps	-	Inconvenient	Convenient
The size of landings of ramps	-	Inconvenient	-
The availability of thresholds	-	-	-
The height of thresholds	-	-	-
The dimensions of the entrance door	Convenient	Convenient	Convenient
The type of the entrance door	Convenient	Convenient	Convenient
The width of maneuver area of the entrance door	Convenient	Convenient	Convenient
The availability of elevator	Convenient	Convenient	Convenient
The dimensions of the elevator door	Convenient	Convenient	Convenient
The dimensions of the elevator cabin	Convenient	Convenient	Inconvenient
The width of maneuver area of floor corridors	Convenient	Inconvenient	Convenient
The dimensions of the door of WC and bathrooms	Inconvenient	Inconvenient	Inconvenient
The width of maneuver area of WC and bathroom	Inconvenient	Inconvenient	Inconvenient
The usability of furniture of wet areas	Inconvenient	Inconvenient	Inconvenient

With conventional methods, designers should focus problem identification more than the problem-solving. Using the proposed method, designers can spend working time more efficiently and, therefore, create more solutions. Critical uses regarding compatibility checking are not clear enough for non-experts with conventional methods. Clear display of critical issues has achieved with the operation of the proposed method also for non-experts.

More features of working with SMC program can be summarized as follows:

- Reducing the time of repetitive actions, such as checking door dimensions,
- Enabling accurate 3D model visualization,
- Evaluating the objects and their positions in the model more precisely, such as the location of the closet in WC,
- Producing clear and complete compatibility report.

On the contrary, it is rather difficult to identify the required data to the IFC model for many designers compared to conventional methods. The designer should capable to think in a technical manner and also have knowledge on some issues such as computational models, information sharing, BIM, IFC to work with proposed method. As the creators of built environment, designers have taken the responsibility and therefore they should consider more on this issue

4. Conclusion

On the one hand disabled people asserting themselves to the society, they try to deal with the built environment on the other side. The problems of the quality of life will progressively increase if disabled people are forced to give battle both sides. The profession of architecture has a direct effect on the quality of life. It is rather difficult to return inconvenient arrangements made at the design phase of the built environment. The accuracy of accessibility evaluation and compatibility checking will broaden the living area of disabled people and increase the quality of life.

Computer-based methods used in an impressing and exciting way in various fields of architecture. Incorporating Building Information Modeling into the design process utilizes the full potential of computational methods in architecture. BIM technology is such a powerful tool to make accessibility evaluation and compatibility checking.

The proposed method generates promising results in compatibility checking for the disabled-friendly environment. The accuracy of compatibility checking relates to the BIM software tools. It also linked to the working capabilities of software and the technical knowledge of the designers.

Even it is at the very beginning of using BIM technology for accessibility evaluation and compatibility checking; there is no doubt that BIM technology will help to design more accessible spaces for all people.

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