Places and Technologies 2015

KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

Nova Gorica, Slovenia, 18.–19.6.2015

PT2015

BOOK OF CONFERENCE PROCEEDINGS

A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential.
Health Promotion Glossary (1998)

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Nova Gorica, Slovenia

Contents

SUSTAINABLE DESIGN FOR IMPROVEMENT OF HEALTHY BUILT ENVIRONMENT

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ABSTRACT

Buildings as main consumers of energy and resources are responsible for waste and greenhouse gasses creation for which they have caused serious implications to the environmental and human health. Sustainable architecture considers reasonable resource exploitation and improvement of the built environment, human wellbeing and health. Its implementation in a building's design is a demanding task due to multitude of aspects it grasps.

This paper proposes a design process, tested on a case-study, which integrates the projects participants and determines common indicators on the buildings environmental, social and economic performance. The chosen indicators are of various importance for the buildings design. Thus, for each of them respective weights are determined by the project team. During the design process three alternatives of the case-study are proposed and analysed.

The results have shown that supporting the design process with tools for decision making enables choosing the most sustainable design alternative for creation of a healthy built environment.

Keywords*: sustainable design, design process, health, analytic hierarchy process.*

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INTRODUCTION

That our buildings are the largest contributors to the detrimentation of the human's built environment has been identified in numerous scientific studies, (Daily 1997; Kibert 2012). Poor building design, intensive non-renewable energy consumption, materials and other resources are amongst the human activities that threaten the future of the planet, (Smith 2005).

Lack of high-quality building design has contributed in creation of `sick buildings syndrome`. The overwhelming use of mechanical devices for heating and air conditioning, increased airflow and other active design techniques have been identified as cause for asthma, allergies, eye , fatigue and etc. (Fisk 2000). These causalities despite infringing the built environment health aspects decrease productivity of the buildings users.

Sustainable architecture in its essence considers reasonable resource exploitation not neglecting the human wellbeing and health as well as the economic and social circumstances in which it occurs. Many authors have stressed the benefits of sustainability in the creation of healthy built environment and the benefits to the mental and physical health of the habitants, (Handy et al. 2002; Northridge, Sclar, and Biswas 2003; Evans 2003; Jackson 2003; Srinivasan, O'Fallon, and Dearry 2003).

The measurement of design's sustainability has been extensively researched, (Ding 2005; Szokolay 2014; Azhar et al. 2011). The most widely used approach of tackling sustainability issues is by means of indicators, though potential problems occur, such as interaction between indicators, dynamic aspects, hidden nonlinearities etc., (Diaz-Balteiro and Romero 2004).

The integration of the indicators and their measurement in a building's design is a demanding task due to their heterogenic nature. The different aspects of the building's design and the different goals of the project team require new techniques to control and direct the design and decision-making process in order to create a healthy environment.

The goal of this study is to propose an approach for assisting the decision-making during the early design stage in order to achieve more sustainable and healthier built environment. Given that the most important part of the buildings life-cycle is the early design phase, (Bogenstätter 2000), the project indicators for the research are extracted from this phase. The results have shown that by utilizing the proposed approach the design process is guided towards development of the most optimal design alternative.

METHODOLOGY

An approach is proposed in order to select a design alternative in the early design stage which has most compliance with the sustainability principles and creation of healthy environment. It is based on several steps such as: defining sustainability indicators; assigning weight factors; design alternatives performance evaluation; choosing most optimal design solution.

Sustainable indicators relevant for the early design phase are chosen according to a charrette where the stakeholders, i.e. the investor, architect and mechanical engineer have agreed on the most important aspects of the housing building, Table 1.

Table 1: Project Indicators.

Stakeholders		Investor	Architect	Mechanical Engineer
Sustainability Criteria	Social	Functionality	Functionality	
	Economic	Investment	Investment	
	Environmental		Energy performance	Energy performance
		South-West Views, glazing 90%	South-East wall 12-15% glazing	

The investor was most concerned with the functionality of the building plan, the investment and had wanted a south-west wall glazed by 90%. The architect was more concerned with the energy performance thus requiring a south orientation with an optimal 12-15%, (Petrovski and Samardzioska 2013).

The sustainable design process is based on the integration of the project indicators and considering that each of them has a certain influence on the projects outcome it is necessary to determine their influence. Therefore an Analytical Hierarchy Process (AHP) is utilized, (Saaty 1987), based on three principles – hierarchy of the indicators, prioritization and consistency check.

Table 2: Criteria Weights.

	Functionality	Costs	En. Perf.	Views	Glaz. Perc.	Weight
Functionality	1	7	6	1	1	.319
Costs		1	6	7	8	.032
En. Perf.			1	3	4	.096
Views				1	1	.264
Glaz. Perc.					1	.289

In order to assign criteria weights a pair-wise comparison is conducted, thus for n number of criteria there are total of $n(n-1)/2$ comparisons, Table 2. For conversion of the qualitative values of the criteria into quantitative a scale of 9 to 1/9 is utilized. The stakeholder's goals are reflected onto the weight assignment onto the sustainability criteria, Table 2.

The inconsistency measure is useful for identifying possible errors in judgments as well as actual inconsistencies in the judgments themselves. The Consistency Ratio (CR) is 0,05 less than 0.1 which is deemed reasonable, (Saaty 1987).

RESEARCH

The decision making approach integrating several sustainability goals is tested on an on-going design process of housing building where three design alternatives are analysed. The case study is a ground floor housing building where the walls, floors and roof are super-insulated with U value of 0,15 W/m^{2}K and windows with U value of 1,8 W/m^{2}K, and they are the same in all of the design alternatives. The variables in the alternatives are shown in Table 3.

Table 3: Design alternatives performance.

Design alternatives	En. per. (kWh/m^2.a)	Costs (eur)	Views	Funct.	Glaz.%
Alternative 1	28	55.000	South-East	excellent	12%
Alternative 2	40	60.000	South	good	90%
Alternative 3	48	60.000	Sout-West	moderate	90%

As stated by Bentivegna et al., (Bentivegna, Brandon, and Lombardi 2003), it is a major problem to evaluate the quality of the built environment and to apply a measurement system in the planning process due to the different aspects of the building.

The parameters of the indicators are described as S_2 which represents the maximum value of an indicator of a category and S_1 is the minimum value. The normalized scale is defined by a range from 0 to 1, where 0 point gets the lowest indicator (P_2) between the alternatives for a given indicator and the maximum 1 point gets the highest performance indicator (P_1) among the alternatives. S_i is the value of the third indicator of a given category and P_i represents the value of the interpolated indicator. Results are shown in Table 4 and calculated with Eq. 1.

$$P_i = \frac{(S_i - S_1)(S_2 - S_1)}{S_2 - S_1} + P_1 \qquad (1)$$

Table 4: Point scale interpolation.

Design alternatives	En. per. (kWh/m^2.a)	Costs (eur)	Views	Funct.	Glaz.%
Alternative 1	1	1	0	1	0
Alternative 2	0.4	0	0.5	0.5	1
Alternative 3	0	0	1	0	1

To make the ranking of the alternatives the values of the matrix from Table 4 are multiplicated with the criteria weight values from Table 2. The aggregation of the points of the three alternatives, as well as the ranking is shown in Table 5.

Table 5: Aggregation of points and ranking.

Design alternatives	Aggregated points	Ranking
Alternative 1	0.447	3
Alternative 2	0.638	1
Alternative 3	0.553	2

It could be concluded that the most optimal design alternative reflecting the project team goals are incorporated in design alternative 1, followed by alternative 2 and 3.

CONCLUSIONS

Applying the proposed approach during the design process enabled the project team in delivering optimal design that incorporates certain aspects of the sustainability concept that were defined as feasible. Structuring the defined goals and making the process transparent enabled quick iterations of design alternatives intended to drive the design towards creation of healthy built environment. In order to rank the alternatives multi-criteria decision-making tool was used which was concluded as convenient for efficient decision making, speeding-up the design process.

To further improve the proposed approach it is necessary to incorporate sensitivity analysis. Also in order to speed up the process it is recommended to implement automation of the computation, starting from the weight assignment, pair-wise comparison, linear interpolation, multiplication of the matrices and ranking. Therefore this research could serve as a layout for building such an automated tool.

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