Leadership in Sustainable Infrastructure

Leadership en Infrastructures Durables

Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

QUANTIFYING THE IMPACT OF ARCHITECTURAL DESIGN FEATURES ON BUILDING COST AND PERFORMANCE IN HOT WEATHER REGIONS

Abdullah Al-Saggaf[1,] Hassan Nasir[1, 3] and Tarek Hegazy[2]
[1] Department of Civil Engineering, King Abdulaziz University, Jeddah, Saudi Arabia
[2] Department of Civil and Environmental Engineering, University of Waterloo, Canada
[3] hnasir1@kau.edu.sa

Abstract: Architectural design decisions are subjective in nature, yet have an enormous impact on the esthetics, performance, and the life-cycle cost of projects. This research identifies and evaluates seven key Architectural Design Features (ADFs) that can mitigate the negative impact of hot weather, while providing esthetics and good performance. To quantify the impact of any combination of ADFs, a decision support system has been developed to efficiently evaluate a building design in terms of: (1) space functionality; (2) construction time and cost; (3) operational performance; and (4) esthetics. To determine the criteria weights, expert architects were asked to subjectively specify the degree (low, medium, high) by which each ADF adds to, or reduces from, the performance of each criterion. Compilation of all inputs is then used to calculate the comparative impact of each ADF, and the impact of any combination of ADFs. Experimenting with the developed decision support system on a case study proved that the system is capable of estimating how clients value each design. This research is expected to assist designers in understanding the cost implication of the key ADFs, and presents a scientific decision-making approach to quantify the design alternatives that contain subjective features.

1 INTRODUCTION

Proper decisions at the early design phase are essential to optimize building performance and reduce costs. The best opportunities for project stakeholders to achieve significant cost reductions occur during the early concept stage. Williamson (1994), for example, reported that design decisions have 85% impact on total costs, although they contribute to only 15% of the total life-cycle cost. In contrast, the construction and the operation phases which contribute to 85% of the total life-cycle cost, only have 10% and 5% impact on the total costs, respectively. The same study also reported the importance of putting cost at the same level as all other design parameters that form the project goals early in the design phase.

In hot regions like Saudi Arabia, the extremely hot environment forces the architectural designers to use few design solutions and ignore many others. For example, most buildings use few small windows to avoid the heat, which are not sufficient to provide the needed sun light to the space users. On the other hand, some architects who design buildings with fancy glazing facades need to consider the cost of additional HVAC load in their designs. Both these situations are shown in Figure 1. Therefore, the objective of this research is to identify the key Architectural Design Features (ADFs) that expert architects use to mitigate the hot environment of Saudi Arabia, while providing high functional esthetic design that has little or no impact on energy use. Based on the identified ADFs, the research targets to develop a Decision Support System (DSS) for evaluating the quality, life-cycle cost, and expected performance of the designs that contains any combination of the ADFs.

Figure 1: Few small windows and massive glazing uses in Saudi Arabia buildings

Architectural design is an iterative process that requires experience, knowledge, skills, and designer imagination. Architectural design, therefore, is a multiple-criteria decision problem (Chan, 1990). Gann et al. (2003) reported that architectural design is a complex process that includes tangible and intangible facts and objective-subjective parameters. These include the building's use, material type, esthetics, building orientation, local climate, as well as local politically imposed factors by stakeholders. The American Institute of Architects (AIA, 2013) states that ADFs are one of the eight influence factors that lead to effective control of the building costs. In the literature, few efforts were found that identify key ADFs that can be used in hot weather environments like Saudi Arabia, where the temperature in summer can reach more than 50 degrees Celsius. Shash and Ibrahim (2005) conducted a survey among 19 Architectural/Engineering (A/E) firms in the eastern Saudi province to investigate various architectural features that impact building construction costs. The results indicated that the most important ADFs are: (1) plot plan shape; (2) total number of storeys; (3) average storey height; (4) amount of circulation area; and (5) percentage of exterior wall area to be glazed. The study, however, did not address the impact of a combination of these features on construction cost or operational energy use.

In very hot climates, large amounts of energy (cooling load) are required to operate air conditioning in residential buildings. According to Saudi Energy Efficiency Center (SEEC, 2013), the three buildings sectors (Residential – Governmental – Commercial) consume more than 75% of the total electrical power, with approximately 7% annual growth rate. Around 50% of the electricity power is consumed in the operation of residential buildings (Aldossary et al., 2014). In addition, SEEC also reported that more than 70% of Saudi residential buildings lack proper thermal insulation and architectural solutions that can reduce energy consumption in cooling devices. It also estimated that proper architectural design solutions can save around 250 million barrels of oil equivalent over a five year period. However, early estimating of the energy consumption of a building during operation is often challenging due to the dynamic nature of this phase (Inyim et al. 2013). The evaluation of an architectural design that includes a combination of ADFs can be challenging. Incorporating the stakeholders' judgements and their value is a key to arrive at best design (Lifson and Shaifer, 1982; El-Rayes and Kandil 2005). Thus, a comprehensive Decision Support System (DSS) is important to incorporate the stakeholder's judgement and the impact of a wide range of ADFs on design quality and building life-cycle cost.

2 RESEARCH METHODOLOGHY

The study of ADFs and their impact on design quality and cost involves the following four aspects:

- Identifying the key ADFs that suit hot weather residential buildings.
- Identifying and weighting design evaluation criteria that determine the overall design quality.
- Developing a simple-to-use decision support system to facilitate the selection of any desired ADF to be used, and automated design-quality evaluation.
- Creating various design alternatives that have different feasible features.

3 DECISION SUPPORT SYSTEM (DSS)

3.1 Architectural Design Features (ADFs)

Based on literature analysis and consultation with expert architects, this research identified seven architectural features that can mitigate hot weather: (1) building orientation; (2) building envelope; (3) plan shape and complexity; (4) storey and height; (5) windows and glazing; (6) floor spans and (7) circulation space. Each design feature has several perspectives (all considered in a design, not mutually exclusive), and each perspective has possible options (mutual exclusive), as shown in Table 1. For example, in the "Building Orientation" feature, the designer has two perspectives to consider: orientation with respect to wind (beneficial in hot weather areas), where two options are available: facing likely wind, or facing unlikely wind; and (2) orientation with respect to view, where two options are available: good view, or bad view. The ADFs, perspectives, and options in Table 1, thus, serve as design parameters, where a design can have any combination of them. Accordingly, the impact on design quality and cost can be evaluated.

Table 1: Architectural Design Features (ADFs)

Design Features & Perspectives	Description and Options
1. Building Orientation	
a. Related to Wind	The building is oriented to face the likely and unlikely winds - Likely Wind (N/W) - Unlikely Wind(N/E)
b. Related to View	The building is oriented to have natural or not natural views - Good Natural View - Bad Natural View
2. Building Envelope	
a. Building Massing Form	The degree of how different building masses interlocking to the whole form - Simple (Regular) - Normal (Moderate) - Complex (Sharp)
b. Facade Material	The exterior wall materials used to enclose the building façade and form - Precast Concrete - Block (Concrete) - Brick (Stone)
c. Glazing Percentage (G/W)	The ratio of façade glazing area to the same façade of wall area - Small (<20%) - Medium (20-50%) - Large (>50%)
3. Plan shape and Complexity	
a. Plan Efficiency (W/F)	The ratio of building exterior walls area to the building Gross Floors Area (GFA) - Not-Efficient (<70%) - Acceptable (70-90%) - Efficient (>90%)
b. Plan Shape Complexity	The proportion degree of building plan dimensions and its setting out - Simple (Regular) - Normal (Moderate) - Complex (Irregular)
4. Storey and Height	
a. Number of Storey	The number of storeys that building contains to the same floors area - Low-Rise (1-2 Storeys) - Medium-Rise (3-4 Storeys) - High-Rise (>4 Storeys)
b. Average Storey Height	The different range of the storeys heights that give the average building height - Low (<3.00m) - Normal (3.00-4.00m) - High (>4.00m)
5. Windows and Glazing	
a. Glazing Shape	The outline configuration shape of different building façade windows - Regular Shape - Semi-Regular Shape - Irregular Shape
b. Glazing Efficiency	The glazing elements features (Panel number, Reflectivity, Thermal Break, U-value) - Low Efficiency - Medium Efficiency - High Efficiency
c. Sun-Breakers Geometry	The sun-breakers panels configuration and shading areas - Simple Shape (1-Panle) - Normal Shape (2- Panels) - Complex Shape (3-Panels)
6. Floor Spans	
a. Span Dimension	The longest distance of usable area between exterior wall and interior element - Short (<4.50m) - Medium (4.50-6.50m) - Long (>6.50m)
7. Circulation Space	
a. Circulation Area (C/F)	The ratio of building circulation space area to the building Gross Floors Area (GFA) - Low (<15%) - Normal (15-25%) - High (>25%)

3.2 Impact of ADFs on Design Quality

After consulting with expert architects, architectural design quality has been defined by four criteria:

1. Space functionality (accessibility, inter-relationships, and sizes);

2. Construction performance (time and cost);
3. Operational performance (energy use, and maintenance cost); and
4. Aesthetics.

To determine the contribution of each ADF to each of the four design-quality criteria, a five point scale (Table 2) is used. The scale allows for both positive and negative impact to be specified, as well as the degree of impact both in letters (VH, H, M, L, and VL) and also in equivalent numbers. For example, Very High positive impact, means an impact value of +0.90, while a Very High negative impact means an impact value of -0.90. Using this scale, expert architects were able to provide the assessment values in Table 3. In the table, the assessments related to two design features (building orientation, building envelop and plan shape and complexity) are shown as an example.

Table 2: Assessment scale

No.	**Scale**	**Discerption**	**Positive Impact**	**Value**	**Negative Impact**	**Value**	**Importance Value**
1	Very High (VH)	Extremely Important /Reliable/Severe	(+VH)	+0.90	(-VH)	-0.90	5
2	High (H)	Very Important/Reliable/Severe	(+H)	+0.70	(-H)	-0.70	4
3	Medium (M)	Important/Reliable/Severe	(+M)	+0.50	(-M)	-0.50	3
4	Low (L)	Somewhat Important/Reliable/Severe	(+L)	+0.30	(-L)	-0.30	2
5	Very Low (VL)	Not Important/Reliable/Severe	(+VL)	+0.10	(-VL)	-0.10	1

Table 3: Example of ADF impact on Design-Quality criteria

	Design Evaluation Criteria and Sub-Criteria							
Architectural Design Features	**Space Functionality**			**Construction Performance**		**Operational Performance**		**Esthetics**
	Accessibility	**Relation**	**Size**	**Cost**	**Time**	**Energy**	**Maintenance**	
1. Building Orientation								
a. Related to Wind								
- Likely Wind (N-W)	+0.50	+0.70	+0.90	+0.50	+0.70	+0.90	+0.50	+0.10
- Unlikely Wind (S-E)	-0.30	-0.50	-0.70	-0.30	-0.50	-0.90	-0.30	-0.10
b. Related to View								
- Good Natural View	+0.50	+0.70	+0.90	+0.30	+0.50	-0.50	+0.70	+0.90
- Bad Natural View	-0.50	-0.50	-0.70	-0.10	-0.70	+0.70	-0.50	-0.70
2. Building Envelope								
a. Building Massing Form								
- Simple (Regular)	+0.90	+0.90	+0.90	+0.90	+0.70	-0.50	+0.70	-0.70
- Normal (Moderate)	+0.50	+0.50	+0.70	+0.50	+0.50	-0.30	+0.50	+0.50
- Complex (Sharp)	-0.70	-0.70	-0.90	-0.90	-0.90	+0.70	-0.90	+0.90
b. Facade Material								
- Precast Concrete	+0.30	+0.30	+0.50	+0.70	+0.90	-0.50	+0.50	+0.70
- Block (Concrete)	+0.10	+0.10	+0.30	+0.50	-0.50	+0.50	+0.30	+0.50
- Brick (Stone)	-0.10	+0.50	-0.10	-0.90	-0.70	+0.90	-0.70	+0.90
c. Glazing Percentage (G/W)								
- Small (<20%)	+0.50	+0.50	+0.70	+0.70	+0.50	+0.90	+0.30	-0.90
- Medium (20-50%)	+0.30	-0.30	-0.50	-0.50	-0.30	-0.70	-0.50	+0.70
- Large (>50%)	-0.10	-0.50	-0.70	-0.90	-0.50	-0.90	-0.70	+0.90
3. Plan Shape and Complexity								
a. Plan Efficiency (W/F)								
- Not-Efficient (<70%)	-0.30	-0.90	-0.70	+0.70	+0.90	-0.50	+0.70	-0.30
- Acceptable (70-90%)	+0.50	+0.50	+0.50	-0.70	-0.50	+0.70	-0.50	+0.10
- Efficient (>90%)	+0.70	+0.90	+0.90	-0.90	-0.70	+0.90	-0.70	+0.50
b. Shape Complexity								
- Simple (Regular)	+0.70	+0.90	+0.90	+0.90	+0.70	-0.90	+0.70	-0.30
- Normal (Moderate)	+0.50	+0.70	+0.50	-0.50	+0.50	+0.50	+0.50	+0.50
- Complex (Irregular)	-0.70	-0.90	-0.90	-0.90	-0.70	+0.90	-0.90	+0.70

Based on the values in Table 3, the importance index of each design feature is calculated using Equation [1]. Table 4 shows the results of ADFs evaluation. Based on these results, “plan shape and complexity” has the most significant impact on design quality, with 76.67% importance index. This is also consistent with majority of previous studies (Kouskoulas and Koehn, 1974; Seeley, 1996; Ferry and Brandon, 1999; Shash and Ibrahim, 2005; Ibrahim, 2007; Staedman et al., 2009; Zima and Plebankiewicz, 2012; Safiki et al., 2015). On the contrary, “windows and glazing” is the design feature with the lowest impact, with 61.67% importance index because it is only has a significant effect on energy and esthetics aspects. The close values of the Importance Indices are also an indication that they represent significant options for the decision maker to choose from.

$$[1]\ \text{Importance Index} = \left(\sum_{i=1}^{5} a_i x_i \Big/ 5 \sum_{i=1}^{5} x_i \right) {*}100\%$$

Where, a_i = constant, as follows: a_1 = 1 for “Very Low”; a_2 = 2 for “Low”; a_3 = 3 for “Medium”; a_4 = 4 for “High”; and a_5 = 5 for “Very High”

Table 4: Summary of the importance indices for the ADFs

No.	Architectural Design Feature (ADF)	Importance Index (%)	Relative Index (%)	Rank
1	Building Orientation	65.63	13.49	6
2	Building Envelope	69.44	14.28	4
3	Plan shape and Complexity	76.67	15.76	1
4	Storey and Height	72.08	14.82	3
5	Window Glazing	61.67	12.68	7
6	Floor Spans	66.67	13.71	5
7	Circulation Space	74.17	15.25	2

To complete developing the DSS, the second step is to evaluate and weight the criteria/sub-criteria. Similarly, the importance index Equation [1] is also utilized to perform this step. Table 5 shows the complete evaluation results. As it is shown in this table, space functionality criterion has the highest weight and importance of 32.50% in the early design process. This is because; most of owners and designers are concerned to develop a design that has an efficient functionality to facilitate building user’s occupation. That is confirmed by Harputlugil et al. (2014) study which stated that the space functionality criterion is preferred by the designers with 52% weight in the design.

Table 5: Criteria weights

Criteria	Criteria Weight (%)
Space Functionality	32.5
Construction Performance	27.0
Operation Performance	27.0
Esthetics	13.5

Having any combination of ADFs used in a particular design, it is possible to determine an overall quantitative score using Equation [2], as follows:

$$[2]\ P_i = \sum_{j=1}^{n} w_j p_{ij}$$

Where, P_i is the overall design quality score; w_j is the weight for each quality criteria; and p_{ij} is the assessment score for design option i on criterion j. The p_{ij} scores can be positive or negative.

3.3 System Implementation: A Case Study

After developing DSS, the system becomes ready to be run and validated. As previously mentioned, the designer has to select 14 options to build one design alternative in the system. The main advantage of this system is that it can be utilized in two different situations: (1) before preparing the design, in case to create many design alternatives; (2) after preparing the design alternatives, to compare them in terms of life-cycle performance. Another main advantage is that the alternatives comparison process could be performed at the level of criteria, sub-criteria, or/and the total building life-cycle. Table 6 shows three different design alternatives (A, B, and C). The design features in these three alternatives in this case study are selected randomly for simplicity. However, the architects can select these features based on the owner's requirements, such as high esthetic value, low cost, storey and height, and so on.

Table 6: Architectural features in three design alternatives

Design Feature	Design A	Design B	Design C
1. Building Orientation			
a. Related to Wind	Likely Wind (N/W)	Likely Wind (N/W)	Unlikely Wind(N/W)
b. Related to View	Bad Natural View	Good Natural View	Good Natural View
2. Building Envelope			
a. Building Form	Simple (Regular)	Normal (Moderate)	Complex (Sharp)
b. Facade Material	Block (Concrete)	Brick (Stone)	Precast Concrete
c. Glazing Percentage (G/W)	Large (>50%)	Medium (20-50%)	Small (<20%)
3. Plan Shape and Complexity			
a. Plan Efficiency (W/F)	Efficient (>90%)	Acceptable (70-90%)	Not-Efficient (<70%)
b. Shape Complexity	Simple (Regular)	Normal (Moderate)	Complex (Irregular)
4. Storey and Height			
a. Number of Storey	Medium-Rise (3-4 Storeys)	High-Rise (>4 Storeys)	Low-Rise (1-2 Storeys)
b. Average Storey Height	Low (<3.00m)	Normal (3.00-4.00m)	Low (<3.00m)
5. Windows and Glazing			
a. Glazing Shape	Semi-Regular Shape	Irregular Shape	Regular Shape
b. Glazing Efficiency	Medium Efficiency	High Efficiency	Low Efficiency
c. Sun-Breakers Geometry	Normal Shape (2-Panels)	Simple Shape (1-Panel)	Complex Shape (3-Panels)
6. Floor Spans			
a. Span Dimension	Long (>6.50m)	Short (<4.50m)	Medium (4.50-6.50m)
7. Circulation Space			
a. Circulation Area (C/F)	Normal (15-25%)	High (>25%)	Low (<15%)

The alternatives final scores can be calculated directly by the cumulative sum of each selected design options scores or by using the following Equation [3]:

$$[3]\ S_i = \sum_{j=1}^{n} w_j s_{ij}$$

Where, S_i is the overall score for each alternative, w_j is the weight for each criterion, and s_{ij} is the preference score for alternative *i* on criteria *j.*

The final alternatives scores and results that are generated by DSS are shown in Table 7. It shows that design B obtained the highest scores of 1.67, while design A and C obtained scores of 1.26 and 1.57 respectively. Thus, design B is the best design that achieves the owner's objective in terms of the building project life-cycle performance. With DSS, the designer and his/her teams can get the best possible design by selecting different architectural design features.

Table 7: Results of evaluating design alternatives

	Space Functionality			**Construction Performance**		**Operational Performance**		**Esthetics**	
	0.325			**0.270**		**0.270**		**0.135**	
Design	**Accessibility**	**Relation**	**Size**	**Cost**	**Time**	**Energy**	**Maintenance**	**Esthetics**	**Score**
	0.102	**0.106**	**0.116**	**0.140**	**0.131**	**0.143**	**0.127**	**0.135**	
A	3.40	3.40	1.40	0.00	-0.40	1.60	-2.20	3.60	**1.26**
B	3.40	3.80	1.20	-2.80	0.00	2.20	-1.60	7.80	**1.67**
C	-0.80	-1.40	0.20	3.60	4.20	2.00	3.00	0.40	**1.57**

The system also enables the architect and the owner to select the best design that improves a specific quality aspect. For example, from Table 8, if the owner's objective focuses on space functionality, then, design B is the most appropriate design. Similarly, if his/her objective is to obtain a design with lowest construction cost, then, design C is the best design choice.

Table 8: Best design for each quality criteria

Quality Criteria	**Best Design**	**Relative Index (%)**
Space Functionality	B (8.40)	48.31%
Construction Performance	C (7.80)	72.50%
Operation Performance	C (5.00)	68.09%
Esthetics	B (7.80)	66.10%
Total Life-Cycle	B (1.67)	37.13%

4 CONCLUSION

Selecting the best architectural design features in the early design phase is one of the many challenges that an (A/E/C) firms' has to tackle. This can be done by clearly identifying the owners' multiple objectives and selecting the set of features that maximize design benefits and minimize negative impacts. In this paper, seven cost-effective architectural design features were identified by expert architects as having large impact on improving design quality in hot weather regions. A detailed analysis of the positive and negative impacts of each design feature was conducted to quantify its impact on design quality and building life-cycle performance. It was found that "Plan Shape and Complexity" is considered the most important architectural design feature in influencing the building life-cycle performance. In terms of design quality, it was also found that “Space Functionality” is the criteria with the highest impact. To support architects’ decision on selecting the best architectural features that suit the requirements of a particular design, a Decision Support System (DSS) has been developed to evaluate design alternatives and select the one with the highest score. The system's primary objective is to facilitate the design process and provide quantitative evaluation of different design alternatives. The designer has the ability to select any combination of design features and the DSS will automatically generate a total score, to be compared with other alternatives. The DSS also enables the designer to select the best design with respect to a specific quality dimension. The case study discussed in this paper proved that the proposed DSS can be used effectively by (A/E/C) firms to reduce the design process challenges and assist in making rational decisions towards a better building design. Ongoing extensions to the DSS include integration with building information modeling and further experimentation on real-life case studies.

References

Aldossary, N., Rezgui, Y., & Kwan, A. (2014). Energy Consumption Patterns for Domestic Buildings in Hot Climates Using Saudi Arabia as Case Study Field: Multiple Case Study Analyses. *Journal of Computing in Building and Civil Engineering*, 1986-1993.

American Institute of Architects (AIA) (2013). Construction Costs, USA: Emerging Professionals Companion (EPC).

Chan, C.S. (1990). Cognitive Processes in Architectural Design Problem Solving*, Design Studies,* **11**(2), 60-80.

El-Rayes, K. & Kandil, A. (2005). Time-Cost-Quality Trade-off Analysis for Highway Construction*, Journal of Construction Engineering and Management,* **131**(4), 477–486.

Ferry, D. & Brandon, P. (1999). Cost Planning of Buildings, *Blackwell Science*, no. 7th Edition.

Gann, D.M., Salter, A.J., & Whyte, J.K. (2003). Design Quality Indicator as a Tool for Thinking*, Building Research and Information,* **31**(5), 318-333.

Harputlugil, T., Gültekin, A.T., Topçu, İ. (2009). Architectural Design Quality: the Practitioners’ Perspective - An AHP Based Approach for Assessment, *Changing Roles Conference*, The Netherlands; 259-68.

Harputlugil, T., Gültekin, A.T., Topçu, İ., Prins, M. (2014). Architectural Design Quality Assessment Based on Analytic Hierarchy Process: A Case Study (1), *Journal of the Faculty of Architecture (JFA),* **31**(2), 139-161.

Ibrahim, A.D. (2007). Effect of Changes in Layout Shape on Unit Construction Cost of Residential Buildings, *Samaru Journal of Information Studies*, **7** (1), 24-31.

Inyim, P., Rivera, J., & Zhu, Y. (2014). Integration of Building Information Modeling and Economic and Environmental Impact Analysis to Support Sustainable Building Design, *Journal of Management in Engineering,* **31** (1).

Kouskoulas, E.V. & Koehn. (1974), Predesign Cost-Estimation Function for Buildings, *Journal of construction Division, ASCE*, **100**(12), 589–604.

Lifson, M.W., & Shaifer, E.F. (1982). Decision and Risk Analysis for Construction Management, *New York: Wiley.*

Safiki, A., Solikin, M. & NurSahid, M. (2015). Cost Implications of Building Design Plans: A Literature Review Anlysis, *ICETIA 2015 Conference*, 51-56.

Saudi Energy Efficiency Center (SEEC) (2013). Energy of Buildings Sector*, Available at: http://www.seec.gov.sa* (Accessed: 22th January 2017).

Seeley, I.H. (1996). Building Economics, London: Macmillan.

Staedman, M., Evans, S. & Batty (2009). Wall Area, Volume and Plan Depth in the Building Stock, *Build. Res. Inf.*, **37** (5), 455 – 467.

Shash, A.A. & Ibrahim, A.D. (2005). Survey of Procedures Adopted by A/E firms in Accounting for Design Variables in Early Cost Estimates*, Journal of King Saud University for Engineering Science,* **18**(1), 1-17.

Williamson, O. (1994). Research Needs and Opportunities in Transaction Cost Economics, *International Journal of the Economics of Business, Taylor & Francis Journals,* **1**(1), 45-46.

Zima, K. & Plebankiewicz, E. (2012). Analysis of the Building Shape Erected in Krakow and Its Impact on Organization, *International Journal of technology and management in construction*, **4** (1).