ANALYSING COST IMPLICATIONS OF BUILDING DESIGN VARIABLES AS AREAS OF MODELLING TO ACHIEVE VALUE FOR MONEY

A Study on Selected Buildings in Surakarta and Surrounding Areas

Submitted as a partial fulfilment of the requirements for the Master’s Degree of Civil Engineering Department of Civil Engineering, Graduate School of Universitas Muhammadiyah Surakarta

By:

AINOMUGISHA SAFIKI
S100150005

CIVIL ENGINEERING PROGRAM
GRADUATE SCHOOL
UNIVERSITAS MUHAMMADIYAH SURAKARTA
2016
ANALYSING COST IMPLICATIONS OF BUILDING DESIGN VARIABLES AS AREAS OF MODELLING TO ACHIEVE VALUE FOR MONEY
A Study on Selected Buildings in Surakarta and Surrounding Areas

Article Publication

By:

Ainomugisha Safiki
S100150005

Have been inspected and approved to be examined

By:

Supervisor 1
Dr. Mochammad Solikin

Supervisor 2
Ir. H. M Nur Sahid, MM. MT
APPROVAL

ANALYSING COST IMPLICATIONS OF BUILDING DESIGN VARIABLES AS AREAS OF MODELLING TO ACHIEVE VALUE FOR MONEY

A Study on Selected Buildings in Surakarta and Surrounding Areas

By:
AINOMUGISHA SAFIKI
ID No. S100150005

Has been defended in front of Board of Examiners
Program Study Masters in Civil Engineering
Universitas Muhammadiyah Surakarta
on 2nd November 2016
And approved it to have satisfied the requirements

The Board of Examiners:

1. Dr. Mochamad Solikin
   (Head of Board of Examiners)
2. Ir. H. M Nur Sahid, MM, MT
   (1st Member of Examiners’ Board)
3. Dr. Ir. Dhani. Mutiai, MT
   (2nd Member of Examiners’ Board)

Director of Graduate School,
Prof. Dr. Khudzaifah Dimyati
STATEMENT OF DECLARATION

I hereby confirm in this article there is no work study that has ever been done to obtain a post graduate study award in an high institution of higher learning and to the best of my knowledge, there are no works on opinions ever written or published by another author, except what has been duly expressed and references in this article and talked of in the references.

In case it’s proved that it’s not authentic and as stated in my statements above, I take full responsibility.

I confirm that this thesis has not been submitted for the award of any previous degree in any tertiary institutions in Indonesia or abroad.

Surakarta, 2nd November 2016

Ainomugisha Safiki
ID No. S100150005
ANALYSING COST IMPLICATIONS OF BUILDING DESIGN VARIABLES AS AREAS OF MODELLING TO ACHIEVE VALUE FOR MONEY

A Study on Selected Buildings in Surakarta and Surrounding Areas

Abstract

The deployment of construction economics has become more desirable today, as efforts of establishing how building costs are spent, in order to determine on the best way of cost improvement. This research article therefore explores 1) the various costs inputs called design variables used by design consultants, plus underlying factors, then 2) how the practice of value engineering (VE) impacts on projects in Indonesia. A qualitative methodology, was used inform of a questionnaire, designed based on a 5 pointer liker scale approach, and distributed among 30 respondents in areas of Surakarta, consisting of 23 consultants and 7 clients. The collected data was processed using statistical methods of product moment and relative importance index, followed by descriptive analysis inform of bar and pie charts. The results obtained were that building plane shape (index 83.2), was mostly used, which itself depended on external features of building membrane and shape of building site (80.0 each), then other variables were building complexity (82.1); and building façade (77.9), meanwhile the least being sharing walls (index 62.1). Lastly, VE was found to highly positively result into designs meeting time, cost and quality targets, on the other hand material wastages and loss of confidence once VE was neglected.

Key words: Building design variable, value engineering design, building costs

Abstrak

Penarapan ekonomi pembangunan telah menjadi lebih terpercaya, sebagai cara menentukan bagaimana dana satu proyek digunakan. Hal ini disebabkan karena pentingnya menentukan cara yang paling baik dalam peningkatan pemakaian sumberdaya. Artikel ini maka bertujuan 1) mencari beberapa massukan biaya yaitu desain perancangan biaya serta faktor-faktor yang mempengaruhi pemakaiananya, dan 2) apa dampak penarapan VE pada proyek bangunan di Indonesia. Metodologi yang dipakai adalah kualitatif yaitu berupa kuesiner berdasarkan 5 poin skala likert, disebaran bagi 30 responden diwilayah Surakata dan sekitarnya terdiri dari 23 konsultan perencanaan dan 7 owner. Metode data analisa digunakan adalah statistik deskriptif dari product momen dan relative importance indeks, disertai dengan analisis dengan menggunakan bar chart dan pie chart. Hasilnya, bentuk bangunan (indeks 83.2) adalah yang paling digunakan sementara variabel tersebut dipengaruhi oleh karakteristik eksterior berlandaskan fasade dan bentuk lahan. Variabel yang lain adalah kerumitan rancangan (82.1) dan fasade (membran bangunan), sedangkan penyambungan dinding antara bangunan yang paling minimal. Akhirnya untuk VE, penarapan responden mengatakan bahwa...
desain dapat diselesaikan sesuai waktu, mutu dan biaya, sementara berakibat pemborosan bahan-bahan dan kepercayaan terhadap konsultan perencana telah hilang jika tidak diterapkan.

Kata kunci: Variabel perancangan bangunan, Rekayasa Nilai VE, Biaya

1.0 INTRODUCTION

In more recent studies under design economics, it can be seen that there is an attempt to represent as closely as possible how costs are actually spent (Beeston, 1987). Furthermore, it was established by (Zainuddin H., 1997.) and (Rochmanhadi, 1992) that the level of influence on these building costs goes on declining as project develops through the various stages of its life cycle. On that note, these economic studies have led to new phenomena such as building design variables, which are generally viewed as an attempt to have a representation or form of geometry of a building, project how they impact on costs as early as possible before most of the decisions are spent. They have been generally organized in form of a list of alternative design proposals, and quality specifications, which in away help the building client to be made aware of the likely financial commitments before extensive work is undertaken.

This whole process or movement towards construction economics has bread into two concepts but which are merely similar i.e. Value management (VM), being about getting the right project, and Value Engineering (VE) as what is done to get the project right. According to the research that was made in United States of America (USA) by (Palmer, A., Kelly, J., and Male, 1996), results indicated that with this application of VE on construction project, a great deal of savings amounting up to between 34-36 % of total costs of a project could be realized. Furthermore, this concept is in line with this, a famous quote usually used is John Ruskin’s (1819–1900), who said, ‘It is not the cheaper things in life that we want to possess, but the expensive things that cost less’, (Landow, 2000).

In Indonesian perspective development of VE begun to be realized when Departemen Pekerjaan Umum (DPU) released National Standard competence of works (Standar Kompetensi Kerja Nasional Indonesia) (SKKNI) to the value engineering professionals. This was followed with establishment that this phenomena is not fully realized, that’s why from their report in 2008 it led to issuance of bye law 06/PRT/M/2008 on 27 June 2008. The law decreed that in case of discovery of existence of inefficiencies or wastages resulting from unnecessary construction costs, poor type of form of construction, poor cost estimates, and even the method of construction itself, then it becomes incumbent on owners and service providers to do VE.
Therefore it’s upon this background that the author sought to undertake research survey so as to achieve the following objectives: 1) firstly to establish the various design variables used by architect consultants in Indonesia, plus underlying factors for their selection, then 2) seeks to find out how the practice of VE impacts of project in Indonesia.

1.1 Related literature study
1.1.1 Design variables theory

In trying to meet client requirements and external constraints brought about by matters like statutory requirements, environmental factors and construction process among others, the architects have started to model their designs using parameters called design variables. The building design variables have been suggested as part of helping in the field of economics especially during modelling on the constraints of cost analysis and forecasts of the project under the concept of providing value for money products or VE. It’s from these design variables therefore that, design decisions are normally established, as they give solutions of challenges to do with form, time and economy for buildings (Pena. W. and Parshell, 2001). According to (Ashworth, A. and Skitmore, 1983), also it’s these variables which form designers’ forecasts, this is because they give the information for forecasting and determining whether value can be achieved at an acceptable cost (Morton, R. & Jagger, 1995), because the practice is so important in that, clients are able to get reliable cost advice to enable them assess and choose viability of a project when it is still early (Fortune, C. and Lees, 1994). The following have been established in previous studies:

1.1.2 Building Plan Shape

It generally defined to stand for the spatial feature which defines the outline of the building. It impacts on the areas and sizes of the vertical members like walls their accompanying finishes, windows, partitions and the finishings used, etc, plus the perimeter details which include ground beams, fascias, and the eaves of roofs.

Over the years, studies focusing on the problems of plan shapes and construction cost have been on the increase, resulting in large number of publications. They generally established that the cost of building construction increased due to increases in external walls, ceilings, floors or the roof ((Ashworth, 2004); (A. D. Ibrahim, 2007); [12]; (Ferry, D., Brandon, P., and Ferry, 1999); (Kouskoulas, V and Koehn, 1974); and (A.D Ibrahim, 2004). Therefore, the various previous researchers all have concluded that, perimeter-to-floor ratio unit construction cost and overall project costs vary with plan shape complexity or irregularity. This has been attributed to the fact that a particular shape of the building affects significantly costs of a great number of building elements like foundations, walls, building structure frame, finishes and
decorations, roofing, electrical and mechanical services, which later alone also impact on costs of operating and maintaining the building hence overall life cycle costs affected.

1.1.3 Average Storey Height
It’s defined as height from finished floor to next finished floor or from finished floor to ceiling or head room height (bungalow. Generally the following items may experience increases as a result of changes i.e. decrease or an increase in storey height: 1). The amount of heat energy may increase due to volume of building increasing plus the length supply cables have to run it may also be increased. 2) Longer service and waste pipes may be required. 3) Chances of having expensive roof costs due to cost of hoisting. 4) The costs for circulation elements like staircases and lifts also increase as they are vertical elements whose quantity depend on headroom height. 5) Chances are high of cost increases in applying finishings and decorations due to very high ceilings, sometimes calling for additional scaffolding.

1.1.4 Number of Storey
This is much related to the average storey height of a building is the number of storeys. In reference to this constructing of tall buildings, it generally affects four major building elements significantly because of the number of storeys of high-rise building i.e. frame structure construction, external wall (curtain walling in most case for office buildings), lift installation and fire protection (as in services), and they are mainly vertical elements of the building.

Previous studies like (Flanagan, 1978) pointed out that construction cost generally falls as the number of storeys increases. In the United States, for (Clark, W. and Kingston, 1930), on the elements components of eight office buildings from 8 to 75 storeys on a hypothetical site. It was found out that generally unit building cost tended to rise moderately with building height. [18], found out, minus the lower floors, the unit office building cost was almost constant building height was varied.

1.1.5 Mechanical and Electrical Services Elements
Buildings, especially commercial buildings form the biggest consumers of energy. In developed countries, buildings account for between 30% and 40% of the energy consumed [19] and [20].

Therefore with these possibilities [21] asserted that a cost modelling system, which takes into consideration the building function, level of services provision, and parameters, plus describing the form of the building, would improve the level of accuracy of the cost plans during early cost advice of building services.
Lastly, among the other designs identified over the years also included: Circulation Space; Grouping of Buildings; Column Spacing; Building Size; Sharing walls; Floor spans and Constructability.

1.2 Theory of Construction Costs
The term cost in general terms can be defined as the value of any currency given in to obtain a product, or service, to expend labour and use equipment and tools or to operate a business. For the case of construction it was defined by (Skitmore, R.M. and Marston, 1999) in their book called, ‘Cost Modelling’, as; the cost of the contract incurred by the client. Furthermore, it was seen that what is one person’s price is another ones cost, i.e. ‘price’ and ‘cost’ of a building which stand for the amount received by the contractor and the amount paid by the owner respectively.

Meanwhile, the source for construction costs were generally grouped into two basic sources according to (Ferry, D. and Brandon, 1991) and (Lowe, D J, Emsley, M W and Harding, 2007), i.e. the owner-designer costs i.e. come up as a result of, owner’s requirements and the design, and the contractors’ and subcontractors’ costs, through the competitive market and their own organizations.

2.0 METHODOLOGY
This research study took approach of exploring the literature of previous studies; and then later surveyed of the practices by consultants and views of clients in the building industry. It should be noted that, this research was developed as an extension of the previous studies, hence, it was mainly focused on enhancing on these previous studies, basing on their discoveries about design variables, helping to prove if it’s the same conditions that exist within the Indonesian industry, with sample study area being Surakarta and areas around it.

Thirty participants (30), consisting of 23 design consultants and 7 clients were sampled, basing on Roscoe in his book Research Methods for Business (Sugiyono, 2009) about determination of sample respondents. Meanwhile, the sampling technique applied was stratified purposeful sampling, which enabled to use information rich cases for in depth study depending on their characteristics (Basheka, 2010).

The data collected from the questionnaire for easy analysis, was done using Microsoft excel and further descriptive analysis technique i.e. using formula of Product Moment $r_{xy}$ below, then compared with standard table with error of 5%. This descriptive analysis statistics method, analyses data by using descriptions or illustrations of the data collected from the questionnaire (Sugiyanto, 2004).

Furthermore, under analysis it included the responses that were received from the survey participants being tabulated and analyzed individually, after that
the findings displayed by tabulation or using bar charts, pie charts etc. This further analysis was done with usage of the following formula as suggested by (Bubshait, A.A. and Al-Musaid, 1992):

\[
\text{Index} = \left( \frac{\sum_{i=1}^{5} a_i x_i}{\sum_{i=1}^{5} x_i} \times 100\% \right)
\]

Where \( a_i \) = constant expressing the weight given to \( i \);
\( x_i \) = variable expressing the frequency of each response for; \( i = 1, 2, 3, 4, 5 \)

3.0 RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th>Table 1. Product moment ( r_x ) computation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>19</td>
</tr>
</tbody>
</table>

It follows that, out of the total 30 questionnaires that were issued out, 25 were successfully filled and returned back. This represents 83.3% which was a good percentage to reflect the sample. However, from the 25 respondents only 19 were construction consultants and were the ones considered for reliability test, since they are the ones who provided responses for two sections of the questionnaire as reflected in table 1.

The data reliability test as seen above obtained product moment \( r_{xy} \) of 0.531 which lies in between 0.40 and 0.60 according to (Sugiyono, 2009) guide, this represents that the connection between the responses given is enough.

Meanwhile, the test for correlation significance of product moment for \( N = 19 \) respondents, at a significance level of 5% shows that obtained \( r_{xy} = 0.531 \) is greater than standard from table i.e. \( r_l = 0.456 \), hence \( H_0 \) is rejected and alternative \( H_1 \) is accepted.

3.1 Building design variables/parameters used for modification in application of VE

The building design variables as applied in decision making to modify designs so as to have value for money, were given to respondents and asked to assess them on their rank of importance and severity, in accordance to their experience. In connection with that, 10 design variables which are available, obtained from previous studies were used.
The finding as shown in figure 1 were that in the Indonesian construction, building shape and its complexity is mostly used represented by importance index of 83.2 and 82.1 respectively, this means design consultants in Indonesian like any other building industry ought to pay to great attention determinants of these parameters and their impact of any on costs. This is in agreement with previous researchers like (Ashworth, A. and Skitmore, 1983); (Allsopp, K. (1983)Journal Vol. 177(4), n.d.); (Coombs, 1983) among others.

This is basically explains why these two parameters on construction costs i.e. plan shape layout and complexity are also becoming important of recent because many building projects, with many especially hotels and commercial buildings having a big portion of its outer wall as glazed area or aluminium cladding. Hence, in this phenomena, optimizing this shape may go a long way in saving a great deal of these new expensive building materials.

3.1.1 Underling factors considered while adjusting designs

Thereafter, their factor considerations underlying their application were also sought for. The rating obtained were as indicated in proceeding figures;
For the building plan shape, however much as it may be and its complexity as seen in figure 1 the most common used design parameters during modelling and adjustments of designs to save costs, they did not work in isolation but had other factors influencing which shape to use.

As seen table 1, the building plan layout mainly depended on how external characteristics of a building membrane are and the shape of the available building site where it was to be constructed, as represented by importance index of 86.3 and 85.3 respectively. This means the design architect should make through survey of the building site so as to make a design is buildable on the available plan lay out and fits with in resultant shape membrane.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Importance Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Shape of building site</td>
<td>85.3</td>
</tr>
<tr>
<td></td>
<td>External characteristics of building membrane and building structure</td>
<td>86.3</td>
</tr>
<tr>
<td>B</td>
<td>Building Function</td>
<td>80.0</td>
</tr>
<tr>
<td>C</td>
<td>Symbolism</td>
<td>68.4</td>
</tr>
<tr>
<td>D</td>
<td>Structure in relation to light control</td>
<td>75.8</td>
</tr>
<tr>
<td>E</td>
<td>Cost saving of a particular building shape</td>
<td>72.9</td>
</tr>
</tbody>
</table>

Table 1. Factors affecting choice of shape of a building

For the building plan shape, however much as it may be and its complexity as seen in figure 1 the most common used design parameters during modelling and adjustments of designs to save costs, they did not work in isolation but had other factors influencing which shape to use.

As seen table 1, the building plan layout mainly depended on how external characteristics of a building membrane are and the shape of the available building site where it was to be constructed, as represented by importance index of 86.3 and 85.3 respectively. This means the design architect should make through survey of the building site so as to make a design is buildable on the available plan lay out and fits with in resultant shape membrane.

Table 2. Factors affecting choice of building height

<table>
<thead>
<tr>
<th>Factor</th>
<th>Importance Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Natural wind circulation control</td>
<td>74.7</td>
<td>6</td>
</tr>
<tr>
<td>B Easy of excess in the building</td>
<td>82.1</td>
<td>1</td>
</tr>
<tr>
<td>C Considerations of standard height</td>
<td>75.8</td>
<td>5</td>
</tr>
<tr>
<td>D Cost saving of height</td>
<td>76.8</td>
<td>4</td>
</tr>
<tr>
<td>E Functional use of space</td>
<td>80.0</td>
<td>2</td>
</tr>
<tr>
<td>F Cooling system to be used</td>
<td>77.9</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Factors affecting choice of building height

Meanwhile, with the underling factors for a particular building height, it’s mainly ease of excess with in the building spaces and function use of a building by importance index of 82.1 and 80.1 respectively.
As for the design variable of number of storeys again it was established that also non-economic considerations were given more attention as indicated in result of figure 2, i.e. building rules and regulations followed by quality and type of soil at indices of 86.3 and 83.5 respectively. Under this design variable, when it came to economic consideration i.e. to do with how the raise in height influences cost of construction, it was rated as number 3 with index of 61.1. In this case therefore, there is tendency of interplay of non-economic factors, such as regulations and tendency to follow standards.

3.2 Consequences of applying design variables as part of VE practice

Basing on the study discoveries as shown in figure 3, the concept of applying value engineering is the way to go, because also respondents surveyed agreed with previous researchers that this practice leads to outputting designs which are cost, and time effective as well as being on quality represented by 81.1 importance.
index. Secondly, design cost optimization can be attained with using this approach during design shown by index of 80.0.

Meanwhile, on the negative not once this practice is not applied with the growing complexities in designs, it could impact in a way that leads to material wastages and loss of confidence and consequently customers for the design consultant involved as shown by severity index of 80.0 each.4

5. CONCLUSION

1) The top most five design variables often used by the architect consultants to modify building designs to meet client demands on costs identified in the survey were; building plane shape, building complexity, building façade, circulation space, and suspended flats.

2) On the other hand the decision on which building shape plan to use, as the most common design variable, depended on a number of factors, like external characteristics of building membrane, building site shape.

3) Value engineering as an approach which when used by building practitioners would increase efficiency and reduce unnecessary costs during designs. This would solve challenge of PU which led to issuance of by law, Nomor: 06/PRT/M/2008

Lastly, the author recommends further research on the topic focusing on establishing to what extent each of the design variables influence the building costs of any project.

REFERENCES


Carroll. (1982). Mechanical and Electrical Services Elements,


