Scan to know paper details and author's profile

The Fastest Lap for Cost Reduction in Construction Considering the building Life Cycle

Ivan Luiz P. Basile, Andre Luiz Gonçalves Scabbia & Eduardo Ioshimoto

ABSTRACT

The objective of this paper is to present the methodology that enables cost reduction in construction with the structured application of the value engineering tool, considering all phases of the building lifecycle. It was adopted in the study of twenty commercial properties that have undergone remodeling to meet a specific use. The steps which composed their lifecycle were identified, examining all functions, whether primary or secondary, of each stage, such as design, construction, use, maintenance and disposal, analyzing the cost for performing these functions and classifying them according to their importance. By applying this method, cost reduction opportunities were revealed through the elimination, reduction or replacement of unnecessary activities.

Keywords: value engineering, cost reduction, life cycle of the building, construction.

Classification: FOR code: 299999p

Language: English

London Journals Press

LJP Copyright ID: 392861
Print ISSN: 2631-8474
Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 19 | Issue 3 | Compilation 1.0

The Fastest Lap for Cost Reduction in Construction Considering the building Life Cycle

Ivan Luiz P. Basile [α], Andre Luiz Gonçalves Scabbia [σ] & Eduardo Ioshimoto [ρ]

ABSTRACT

The objective of this paper is to present the methodology that enables cost reduction in construction with the structured application of the value engineering tool, considering all phases of the building lifecycle. It was adopted in the study of twenty commercial properties that have undergone remodeling to meet a specific use. The steps which composed their lifecycle were identified, examining all functions, whether primary or secondary, of each stage, such as design, construction, use, maintenance and disposal, analyzing the cost for performing these functions and classifying them according to their importance. By applying this method, cost reduction opportunities were revealed through the elimination, reduction or replacement of unnecessary activities.

Keywords: value engineering, cost reduction, life cycle of the building, construction.

Author α: Post-graduate program, professional Master of Housing Planning and Technology - IPT - Sao Paulo

σ: Institute of Technological Research of the State of São Paulo - IPT

ρ: University of São Paulo Escola Politécnica, Department of Construction Engineering

I. INTRODUCTION

The expansion of the working population puts Brazil on the path of developed economies, where economic growth reflects the number of citizens included in the financial system, enabling the increase of credit [1]. The expansion of banking institutions, with the expansion of their business locations, enables this context, strengthening the economy, supporting the credit and promoting economic distribution in different regions of the country. The construction sector aggregates a set of major activities for the Brazilian economical and social development, impacting on the operating costs of banks on the expansion or renovation of buildings. [1].

In this context, the construction industry has a fundamental importance, given that the buildings are to be renovated and adapted so that this expansion occurs. However, the cost to renovate a property and implement a bank branch becomes costly, jeopardizing the whole process. Therefore, finding a method that allows reducing the cost, generating saving, enabling the expansion, becomes decisive for decision making.

The value engineering (VE) emerges as a method that enables this cost reduction, not only in the construction or renovation stage, but also in all phases of the building lifecycle. It arose during the Second World War due to the massive usage of materials such as metal and copper for the defense industry, resulting in the search for new options with a lower value and easily accessible, without compromising the quality of the products [9].

Every building has a lifecycle that consists of five stages, which are design, construction, use, maintenance and disposal, as well as having a useful life, which means a period of time after the construction or renovation in which the building or its elements equate or exceed the minimum requirements of performance [2]. The evaluation of the building lifecycle (LCA) stands out as a management model for analysis of the stages, as well as its main items, encouraging the implementation of the VE method.

The purpose of this paper is to obtain cost savings in construction, analyzing all phases of the building lifecycle, applying the value engineering method (VE). industry, resulting in the search for new options with a lower value and easily accessible, without compromising the quality of the products [9].

II. THE BUILDING LIFECYCLE

The definition of lifecycle analysis (LCA), developed by the International Organization for Standardization (ISO), is the assessment of inputs and outputs, raw materials and energy resources, and potential environmental impacts of a product through its lifecycle [2]. LCA can assist in making decisions related to strategic planning, priority setting, and product design, among others. In construction, the concept of LCA has been applied in the evaluation of construction materials for process and product improvement purposes or information for designers, assessment schemes or environmental certification of buildings, among others [4].

Considering the remodeling of a commercial building, it is important to check all stages of the building lifecycle as well as its main items, analyzing the design (survey, preliminary study, etc.), construction (finishes, etc.), use (useful life of the materials), maintenance (predictive, preventive, etc.) and disposal (waste, recycling, etc.). Figure 1 illustrates the full lap considering all stages of the lifecycle of the building.

Figure 1: The life cycle of the building and its stages. Source: prepared by the author with data from ISO 14044 (2009)

2.1 Stages of the building lifecycle

To a better understanding of these stages, in the building context, they shall be further detailed. The design phase defines the technical elements that compose the information necessary for its development and it can be defined as a set of characterized and qualified actions needed to the accomplishment of the construction. The design is composed of a preliminary study, or draft, basic design, detailed design and legal design [5]. The construction phase consists of the construction system, planning, cleaning, assembly of the building site, demolition, walls and fences, roofing, installations, finishing and coating, door and window framing, ceiling and painting, sanitary ware and metals, internal and external visual communication, auto attendant panel and final cleaning.

The phase of use is characterized by the correct use of the installed systems in the building, noting that changes should not be made in the purpose, in assigning overload not contemplated by the builder by means of the building use and operation manual, or in making changes in the conditions laid down originally in the projects.

The phase of maintenance, which involves planning and can be predictive, preventive, corrective and detective, seeks to perform activities to preserve or restore the functional capacity of the building and its constituent parts to meet the needs and safety of its users [6].

Ending the lifecycle of the building, the phase of disposal, contemplates waste generated from the losses during the process of construction or demolition.

In this way, it is necessary to analyze all the costs involving the building lifecycle.

2.2 The cost of building lifecycle

The analysis of the cost of building lifecycle (LCCA) is a process of economic evaluation of projects, in which all costs related to the acquisition, development, operation, maint-enance and decommissioning are contemplated, as they are considered potentially important for decision taking [7].

The structuring cost of the building life cycle is presented as follows:

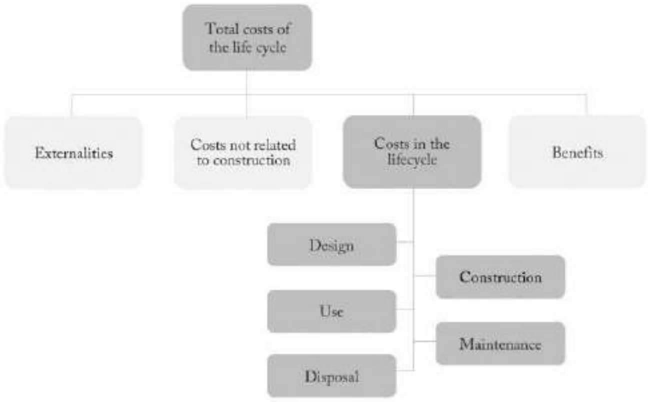
Initial costs: Design - involve the costs of early projects, architecture and civil engineering design, consulting, regulation and administration.

Construction- involve operating costs, acquisition of materials and equipment, adaptations, among others.

Operation: involves all the costs related to the operation of facilities, excluding maintenance costs. Maintenance - involves the costs for maintenance plan associated with minor repairs, painting, cleaning, and inspections, among others.

Demolition: corresponds to the last phase of the life cycle, it includes the decommissioning of the facilities, disposal of the materials, cleaning, and waste removal.

LCCA is commonly applied to assess constructive alternatives fulfilling the level of performance, with different costs of operation, maintenance and repairs, by selecting the most efficient maintenance system, analyzing the design or building system, based on their costs over the building lifecycle. It is essential to justify measures that may require higher initial investment, but result in lower operating costs over time [7]. The cost structure is effective for LCCA since identifies and organizes the costs to be considered in the analysis as shown in Figure 2.



Source: prepared by the author based on ISO 15686-5 (2008)

Figure 2: Identification of the steps to be considered in the cost analysis of the building lifecycle.

In this study, the total cost of the building lifecycle phases were considered and the values were based on historical data from similar applications.

III. THE CONCEPT OF THE FASTEST LAP

The term fastest lap, which named this paper, correlates to the World Championship Formula 1, where the pilot seeks ideal conditions for the fastest lap and thus gets the pole position in the race. For the work presented here, it will be demonstrated how to achieve the fastest lap (by analyzing the LCCA) considering the lower cost of each stage of the building lifecycle, after applying the cost reduction method called value engineering (VE).

IV. VALUE ENGINEERING - VE

The value engineering (VE) is a method used to identify and remove unnecessary costs on development of projects, products or service execution. It is a problem management methodology related to costs and services in companies, employing techniques that enable cost reduction, increasing the value to the user.

Its origin began during World War II, which caused a shortage of materials for the war industry.

During the years of conflict, the technique [3] was directed to the research of new materials with lower cost and greater availability by replacing others with higher cost and limited availability [8]. The methodology was developed by Lawrence D. Miles, engineer at General Electric (GE), which had the mission to find new materials with lower cost and easily obtained, which replaced those used for the production of war equipment. In his research, Miles found that each material has unique properties that could improve the product when modifying its design to take advantage of these particularities, reducing the production cost, addressing the intended function of the product. In the work development, Miles named it the value analysis process (VA), which evolved into a team work aiming to reduce the high costs of products and their components while maintaining its basic functions [9].

In 1945, the potential results of this method called the attention of the US Navy, which invited Miles to apply the process in person. Due to the fact that the engineering activity is navy's core one, the VA methodology was then named VE, with VA being more used in production, and VE in product development [8] as shown in Figure 3.

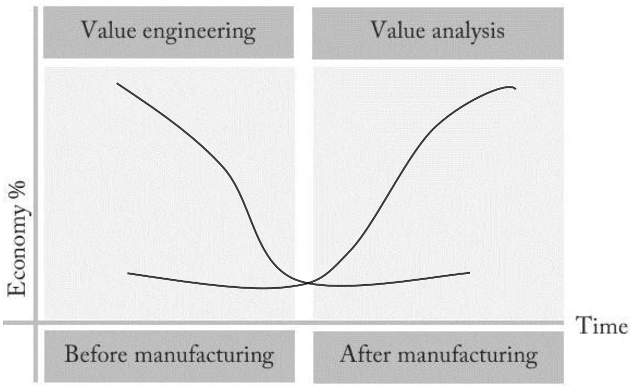


Figure 3: Engineering and analysis value: results before and after

Source: Prepared by the author based on Griebel data (2008)

A new concept, which considers the analysis of a set of activities conducted by companies considering technical, productive, administrative sectors, among others, henceforth was termed value management [13]. It is part of the value management:

Value criteria: approaches that regulate the adherence of the value disciplines such as education and training, policies and procedures, among others.

The analysis value: touches on problems or opportunities involving the management, administrative analysis systems and resolution processes.

Value engineering: touches on problems or opportunities involving the physical sciences as the principle of the discipline in the resolution.

Figure 4: illustrates the components that are part of the value management.

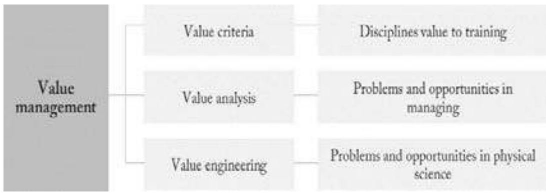


Figure 4: Components of value management.
Source: prepared by the author based on Kaufman data (2008)

4.1 Function and value

When reviewing a product or service, it is necessary to understand the difference between function and value. Function is defined as an activity performed by a product or service that aims to meet the user's needs [10], it is defined by a verb and a noun. As an example, a lamp function is transmitting (verb) light (noun). Functions can be classified into types and classes, as Table 1.

Table 1: Function types and classes

Types function	Description
Function use	It raises the cost of using the product or service analyzed. It is a measurable function
Esteem function	Generates the desire to own the product and relates to aesthetics. It is a subjective function, difficult to measure.
Function class	**Description**
Main Function	It is the main purpose of a product
Secondary function	This is the function that helps the performance of a product or service. This is the main function to ensure
Unnecessary function	Role played by the product that the user does not value or do not use

Source: prepared by the author based on Csillag (1994).

Value, by definition, is related to something, merchandise, product or service, and can be easured in monetary terms, in this way, value is the minimum cost of a part or finished product that will reliably perform the functions [8]. Table 2 shows the value types and their definitions.

Table 2: Types value

Types	Description
Cost Value	Total resources measured in money
Use value	Monetary measure of the properties or qualities that enable the performance of a product or service
Estimated value	Measurement of monetary properties, or attractiveness characteristics that make it a desirable product
Exchange value	Monetary measure of the properties or qualities of an item that enables it to substitute another

Source: prepared by the author based on Csillag (1994).

It is important to highlight that, in the corporate vision, value is the total cost to produce and sell and, thus, the profit that can be obtained. In the consumer's vision, value is the combination of the function of the activity that the object will play, the quality and durability, the price and the similar products available in the market. So we can represent value as the ratio between function and cost and corresponds to the lowest expenditure of resources to perform a certain function, both for manufacturers and the user [11].

4.2 Work plan

The VE methodology application requires a structured work plan, forming a multidisciplinary group with a leader, involving areas that are part of the process, aiming to analyze and select the best alternative value, setting an implementation schedule, as well as the monitoring procedure [12]. In this paper, the work plan is divided into six sequential phases that organize the methodology implementation process, depicted in Figure 5.

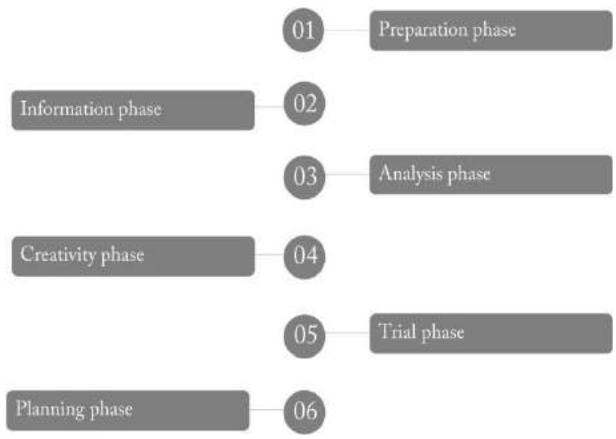


Figure 5: Stages of the work plan.

Source: prepared by the author based on Csillag (1994).

4.3 Value engineering in construction

The construction sector is one of the major responsible for the economic growth and is also a nation's growth index. Demand for retail space has been growing and expanding and establishments become strategic to business. Currently, the construction industry employs 20 million workers in Brazil, directly and indirectly. Keeping lower costs using traditional methods has been a common practice to improve competitiveness [1].

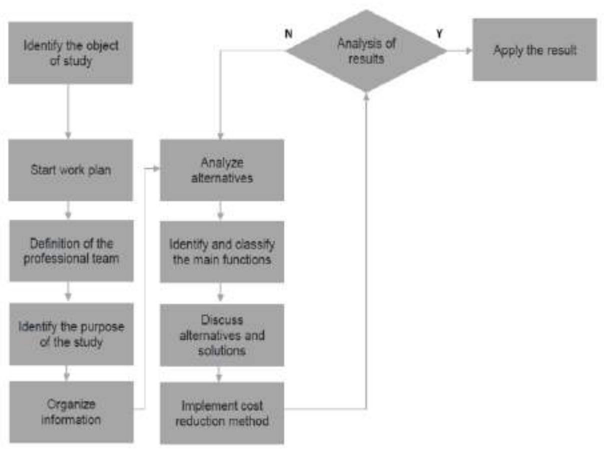
Saving money and at the same time providing better value is a concept that attracts everyone. The VE is widely used in different areas of the economy, especially the automotive, information technology, oil, machinery and services, paper and cellulose industries, among others. But its usage in the construction industry is limited to the finishing phase [13].

Companies in the construction sector seek to maintain costs at the lowest level, decreasing its reserve price compared to its rivals; nevertheless, they try to complete the construction at the lowest cost aiming to make high profits. The application of VE in construction has two purposes, first, provide a rigorous methodology to reduce the cost without degrading performance, reliability, maintenance or security, and secondly, provide an efficient method of management [15].

The VE does not replace effective techniques to reduce costs that have been used, but these techniques do not consider the yield or quality of a product, while the value engineering approach seeks the lowest cost to perform the desired function, rather than finding a way to produce at lower cost. The difference between the VE and cost reduction techniques is that the VE is driven by function, primary or secondary, while other techniques are guided by the method [10].

V. WORKING METHOD

The scientific methodology used was the case study method that aims at simulating the application of the theory to real examples for the steps of the building lifecycle. Figure 6 shows the flow of the application process of the VE method for the case study.



Source: prepared by the author based on Griebel data (2008).

Figure 6: Flow VE application processes.

5.1 *Case study of the environment*

The case study is based on the application of the value engineering method (VE) at all stages of the building lifecycle, considering the decision to remodel commercial buildings in order to expand the service network. In this context, the company's identity will be preserved, but some features will be mentioned, since it is a company in the financial sector, which encourages investment by expanding the range of products and services, promoting banking inclusion and social mobility, through its service network, present in all regions of the country, including branches, banking centers, among others. The method considering all its phases and subsequently the results analysis will be presented.

5.2 *Application of the method*

The VE method will be applied at all stages of the building lifecycle, identifying the key of each step and eliminating functions, replacing or reducing the ones not considered relevant [14]. For this purpose, in the next items, all the phases that compose the method application will be demonstrated:

5.2 *Preparation phase*

It represents the first stage of the process in which the resources to be studied should be determined in the building lifecycle, such as design, construction, use, maintenance and disposal. The group of professionals and the work plan are also defined based on the goal to be achieved. Experts from different areas are consulted, suggesting ideas for cost reduction.

5.3 *Information Phase*

Data and information are identified on the current resources such as the amount of executed projects, finishes used in the work, the correct use of the building, type of maintenance and manner of performing the disposal. Then the main and secondary functions of each resource are identified, its costs and its value in terms of utility for the user needs.

5.4 *Analysis Phase*

At this stage, an examination of the current situation should be made, evaluating functions by comparison of each feature, for example, defining the main function of the projects, if the concept has a pattern, and if some projects can be eliminated, or in the construction phase, setting the primary function of finishes such as flooring, among others.

5.5 Creativity phase

With the information properly interpreted the alternatives that disregard unnecessary functions are generated, focusing on core functions, as well as their cost, aiming alternatives that enable cost reduction, without losing functionality and keeping the final quality, all duly considered by the technical working group.

5.6 Trial phase

Phase in which proposals are quantified in each area for analysis and judgment to proceed with the alternative of cost reduction. The proposals were analyzed, with the suggestion of a possible reduction, replacement or disposal of any item of each stage of the building lifecycle, as well as simulations to verify the average reduction achieved.

5.7 Planning phase

The data obtained in the previous phases are analyzed technically and economically, checking the proposals set for each stage, enabling a control plan that has all the information to reach the expected results.

VI. ANALYSIS OF RESULTS

All information collected was grouped by the steps that compose the building lifecycle. The costs presented were organized using the Pareto diagram, classifying the items of greatest importance in relation to the cost, focusing on the value of each item at every stage, grouping the elements and defining them as priority and non- priority items.

Table 1: Identifies all the phases and the respective values.

	Building Life Cycle Stages					
Amount	project	Construction	Use	Maintenance	Discard	US$/Total
Obra 1	19.474	351.467	10.526	18.421	21.053	420.941
Obra 2	9.001	291.096	10.526	18.421	21.053	350.097
Obra 3	9.084	236.766	10.526	18.421	21.053	295.850
Obra 4	9.989	227.743	10.526	18.421	21.053	287.732
Obra 5	9.084	225.205	10.526	18.421	21.053	284.290
Obra 6	9.002	169.571	10.526	18.421	21.053	228.573
Obra 7	11.701	164.838	10.526	18.421	21.053	226.539
Obra 8	10.945	164.745	10.526	18.421	19.737	224.374
Obra 9	9.001	166.614	10.526	18.421	18.421	222.984
Obra 10	7.406	164.856	6.579	13.158	11.842	203.841
Obra 11	6.736	155.162	6.579	13.158	11.842	193.477
Obra 12	5.464	147.171	6.579	13.158	10.526	182.898
Obra 13	6.535	145.223	6.579	13.158	10.526	182.021
Obra 14	6.736	119.697	6.579	13.158	10.526	156.697
Obra 15	6.736	111.219	6.579	13.158	10.526	148.218
Obra 16	6.736	106.135	6.579	13.158	10.526	143.135
Obra 17	6.535	104.705	6.579	13.158	10.526	141.504
Obra 18	6.736	100.759	6.579	13.158	10.526	137.759
Obra 19	4.934	95.496	6.579	13.158	10.526	130.694
Obra 20	5.993	85.034	6.579	13.158	10.526	121.290

Source: prepared by the author.

Subsequently, the data was classified and organized to display the set of values, as illustrated in Figure 7.

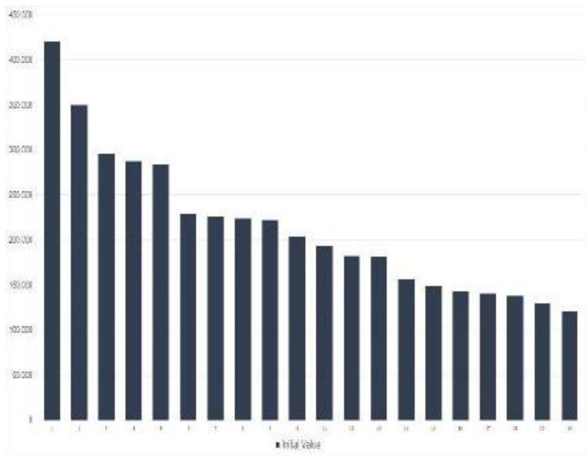
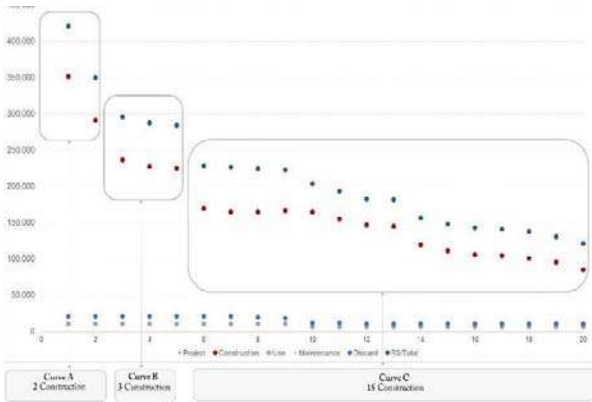


Figure 7: Classification of works according to their values.

Source: prepared by author

When elaborating the ABC curve, categories were pooled, making the identification of the most representative economic costs easier considering each stage of the cycle, as illustrated in Figure 8.



Source: prepared by author

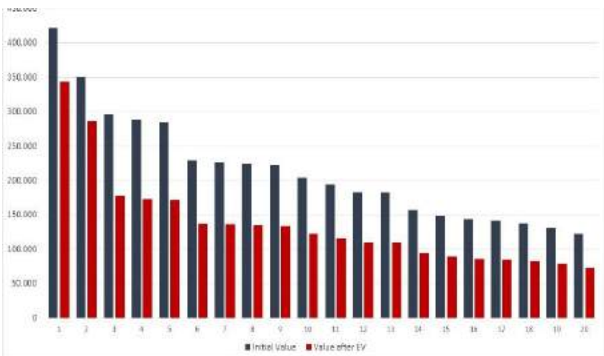
Figure 8: ABC curve of the works analyzed

Once data is identified, the VE method is applied for all the steps, in other words, for the design phase, the information is organized, the categories are grouped, the highest value items are identified, excluding, substituting or reducing functions considered not relevant [15]. This procedure should be applied to all stages of the lifecycle. The generated economy can be observed in Table 2.

Table 2: Lifecycle phases, estimated reduction, initial and final cost

Life cycle stages	Estimated reduction (%)	Cost early	cost end
Design	40	167.831	100.689
Construction	15	3.333.503	2.833.477
Use	10	167.105	150.394
Maintenance	30	310.526	217.368
Disposal	50	303.947	151.973
Total	19	4.282.912	3.453.901
Total economy (US$)	19	829.000	

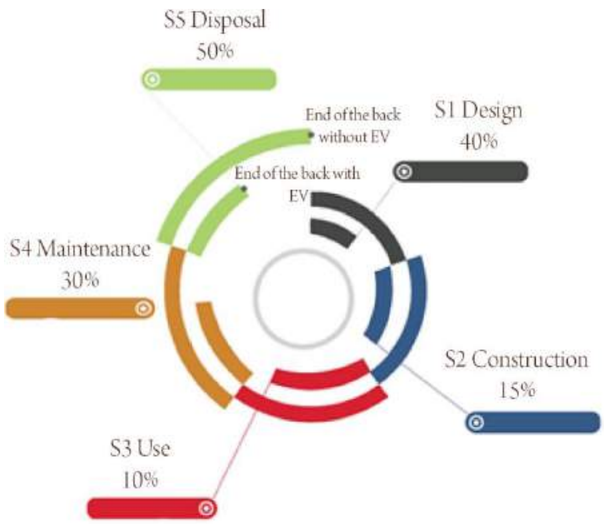
When comparing the cost reduction obtained to the original data, the difference can be observed, as shown in Figure 9.



Source: prepared by author

Figure 9: Cost reduction (in red) in each analyzed work

From this analysis it is observed that with the application of the VE method, considering each defined phase, the economy is relevant, as well as the reach of the fastest lap, considering the cost reduction, as illustrated in Figure 10.



Source: prepared by author

Figure 10: Representation of the theoretical fastest lap with the cost reduction in all sectors of the building lifecycle

VII. CONCLUSIONS

This paper presents the application of VE method for cost reduction in construction, analyzing every stage of the building lifecycle. The case study discusses the decision of the expansion, via remodeling, of twenty establishments of a financial institution.

Examining the collected data, it was found that the VE proved to be a useful method in achieving cost reduction, analyzing the design, construction, use, maintenance and disposal, identifying the main functions of each phase, minimizing, replacing or eliminating unnecessary functions and maximizing the main functions.

The survey pointed out that it is possible, through the correct application of the VE method, to reduce costs in all stages of the building lifecycle, which assists in the investment decision.

REFERENCES

1. FILHA, Dulce Corrêa Monteiro; COSTA, Ana Cristina Rodrigues da. Civil construction in Brazil: Investments and challenges. São Paulo: Perspectiva, 2014. 356 p.
2. GUO, H L; LI, Heng; SKITMORE, Martin. Life cycle management of construction projects based on Virtual Prototyping technology. Journal Of Management In Engineering. Indiana, p. 41-47. 10 set. 2010.
3. ABNT. Brazilian Association of Technical Standards. NBR ISO 14044:2009. Environmental management - Life cycle assessment - Requirements and guidelines. ABNT. Rio de Janeiro, 2009.
4. GUO, H L; LI, Heng; SKITMORE, Martin. Life cycle management of construction projects based on Virtual Prototyping technology. Journal Of Management In Engineering. Indiana, p. 41-47. 10 set. 2010.
5. CAMBIAGHI, Henrique; AMÁ, Roberto. Architecture and urbanism: manual scope of projects an services. São Paulo: Asbea, 2012. 131 p.
6. ABNT - Brazilian Association of Technical Standards. NBR 5674 - Maintenance of buildings - Procedure. Rio de janeiro, 1999.
7. BULL, J.W. (Ed). Life cycle costing for construction. 2 ed. Glasgow: Taylor & Francis e-library, 2003. 159p.
8. CSILLAG, João Mario. Analysis value: Value Engineering; Management Value; Cost reduction; Increase the value perceived by the customer; Continuous improvement; Business process reengineering; The company viewed as system. 4. ed. São Paulo: Atlas S.a., 2012. 370 p.
9. KAUFMAN, J. Jerry. Value Management. Ontário: Sakura House, 2008. 96 p.
10. LEE, Min Jae; LIM, Jong Know; HUNTER, George. Performance-Based Value Engineering Application to Public Highway out. 2009.
11. GRIEBEL, Susan; MACCAUSLAND, Janet. Value Methodology: A Pocket guide to Reduce Cost and Improve Value Through Function Analysis. 2. ed. Salem, New Hampshire, Usa: Goal/qpc, 2008. 198 p.
12. PEREIRA FILHO, Rodolfo Rodrigues. Value Analysis: Continuous improvement process. São Paulo: Nobel, 1994. 187 p.
13. KELLY, John; MALE, Steven; GRAHAM, Drummond. Value Management of Construction Projects. 2. ed. Oxford: Wiley Blackwell, 2015. 546 p.
14. YOUNKER, del L. Value Engineering: Analysis and Methodology. 10. ed. Florida: Marcel Dekker, Inc., 2003. 326 p.
15. KELLY, John; MALE, Steven. Value Management in Design and Construction: The economic management of projects. 3. ed. London: Taylor & Francis, 1998. 181 p.
16. INTERNATIONAL STANDARD. ISO 15686-1: Buildings and constructed assets – Service life planning. Part 5: Life-cycle costing. Switzerland, 2008.

This page is intentionally left blank