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VALUE METHODOLOGY OF VERTICAL SLIP FORM CONSTRUCTION SYSTEM IN HIGH RISE BUILDINGS

Khaled M. Heiza[1], Nagwan E. Abo El enen[2] , Ibrahim M. Mahdi[3]

[1]*Professor of RC Structures, Vice Dean, Faculty of Engineering, Menofia University, Egypt.*
[2]*Phd candidate, Al-Delta University, Egypt.*
[3]*Associate Prof., Dept. of Str. Eng. and Mgmt., Faculty of Engineering, FUE Egypt*

ABSTRACT

The value of a product or service is recognized according to the appropriateness level of its performance and cost. It can almost truthfully be said that, by this definition, value can be increased by either increasing the performance or decreasing the cost. While, a product is considered has insignificant value if it lacks either appropriate performance or cost. Therefore technology factor which has impact on the performance and cost of products or services in construction should be considered in their identification to gain optimum value. The objective of this paper is to assess the value of Slip Forming (SF) technology using value engineering by investigating its performance, cost, constructability and productivity in construction projects that are matching modern construction technology. SF is one of these new techniques that have improved itself in the construction industry for decades around the world. The basic concept and approach of Value Engineering (VE) is implemented in this paper for achieve its objective. VE is a methodology used to analyze the function of the goods and services to obtain the required functions of the user at the lowest total cost without reducing the necessary quality or performance. The approach of VE implemented is concerned with function improvement, time reduction, and improving performance through lesser consumption of energy, as well as, cost reduction. VE technique provides us with a systematic approach take in its account the design and construction projects, not making cost cutting while maintaining or improving the value. The application of VE principles causes people to work better as a team, searching always to improve their system of production and services. It helps any organization to improve and investigate its resources with the optimizing cost.

Key Words

Slip-forming, value engineering, value management, job plan, function analysis, function analysis systematic technique, value index, life cycle cost

INTRODUCTION

Starting from the beginning of the 20-century, SF is widely used in formwork due to fast concrete work, and because of superior speed and productivity; SF is one of the potential concrete formwork methods that improves speed and productivity of repetitive vertical concrete work. Zayedet al (2008). "SF is an economical, rapid and accurate method of constructing reinforced concrete, or post-tensioned concrete structures. SF, continuous poured, continuously formed, or SF construction is a construction method in which concrete is poured into a continuously moving form"Nawy(2008). At its most basic level, SF is a type of movable formwork which is slowly raised, allowing the continuous extrusion of concrete"Risser(1995). "It differs from conventional concrete formwork because it moves semi-continuously with respect to the concrete surface being formed,A.P.C. Harrington Co.(2013)."SFwas extensively used in concrete silos and tall structures in the last few decades". [A.P.C. Harrington Co.(2013), Hurd(1990),Jaafari*et al* (1989), Anon(1987)]. "SF construction technology has also become very important in high-rise concrete structures" A.P.C. Harrington Co.(2013). It is one of the most common methods of construction in concrete silos Peurifoy and Oberlender (1996). "SF is not only used on straight vertical concrete structures but, also structures where the geometry of structures and the wall thickness are changed during the operations" Fossa(2001). Typical projects that employ this technique are: silos, core of high-rise buildings, telecommunication towers, cooling towers, heavy concrete, offshore platforms, etc. "For silos higher than 15m, the SF method is the most economical and time saving technique" Jaafari*et al* (1989). "Construction by SF makes certain architectural benefits possible. One is the possibility of having a structure free from horizontal joints, formwork tie holes and surface voids; another is the considerable freedom of form in plan at very small construction cost"Camellerie (1978). Current research aims at assessing SF productivity by applying the "VE technique". Where; Value = Quality/Cost Dell'Isola(2003). The term quality or performance expresses about the value of the project, product, service, or the system. The results obtained from the study improve the efficiency of the VE as a powerful tool to enhance the quality or the performance of the project, product, service, or system with optimizing the cost. The savings that achieved from the study confirm that the SF system is more economical and efficient than the traditional system. "FA is the foundation of a value methodology and is the key activity that differentiates this body of knowledge from other problem-solving or improvement practices. During the FA phase of the JP, functions are identified that describe the work being performed within the scope of the project under study. These functions are described using two words, active verb and measurable noun pairings" SAVE International. (2007). VE is not a new concept. Its origin dates back to World War II. The evolution of VE from is beginning in the manufacturing industry, into government procurement sections, and eventually into the construction industry" Zimmerman and Hart (1982). VE can be used in many fields such as construction phase, government, and privet sector construction. As illustrated in the studies of [Al-Nsour, *et al*(2011),**El-Badry (**1997), **Heggade**(2002),**Simpkins (2000)**]. Also On transportation and bridges; as in the studies [**Clark**(1999), **Mansour**(2013)]. In the report of **DoTFHA**(1993) to the Congress by the secretary of transportation, recommended to use VE through highway projects development, construction, operation, and maintenance for all the Federal Highway agencies. Also as the study of the Environmental Services **DoEPAOWP**(1997); which make a study on five waste water projects the results improved the effect of VE application on such projects. **CGUSA**(1975)Discussed and improved the need for the environmental protection agency to establish and implement a VA program to reduce the costs of waste treatment plants funded under the federal water pollution control. **OIGDoD**(1997)Recommend in its report on the importance of inserting the VE programs in the military departments and the defense logistics agency confirming on the benefits of applying the VE procedures and recommendations by applying it. **DoDATLO**(2006)reported how the VE be effective and important in DOD programs. **PCIE**(1991) presented the consolidated results of the President's Council on integrity and efficiency (PCIE), sponsored VE project withrecommendationof the requirementof use of VE in federal programs. "VM provides a structured, challenging, analytical and mediated process that permits value systems to coalesce to the benefit of the client **Kelly, *et al* (2005)**.

Design and Construction of the Form

"A vertical SF system consists of five basic elements: Forming panels (SF), Whalers, Yokes, Jacks and jack rods and Work or storage decks and scaffolding" A.P.C. Harrington Co.(2013).

"The SF is raised on jacks that climb on vertical rods or tubes that remain buried in the concrete. The jacks are mounted in upside-down U-shaped steel assemblies called yokes. The SFis attached to the yoke legs; scaffold brackets and work deck joists are attached to or bear on the SFwalers. The yokes resist hydrostatic concrete pressure (replacing form ties) and transmit vertical scaffold and work deck loads to the jacks. Once the vertical SF process is started, concrete is placed continuously in the form in 4- to 10- inch layers (6 to 8 inches is average) at a constant rate. Vertical rebar, horizontal column ties, and through wall ductile ties can be placed in advance of form movement. However, horizontal rebar cannot be positioned until the cross beams of the yokes are raised above the location of the reinforcing steel" A.P.C. Harrington Co. (2013). As shown in figure (1). "In vertical SF the concrete form may be surrounded by a platform on which workers stand, placing steel reinforcing rods into the concrete and ensuring a smooth pour" Washington Post (1971). The SF rises at a rate which permits the concrete to harden by the time it emerges from the bottom of the form"Nawy(2008).Slipping rate is directly related to the concrete setting time. Because setting time is influenced by weather conditions (temperature, humidity, etc.), cement ratio, type of cement, slump, and admixtures" Hurd (1990). Fossa (2001) studied the friction between concrete and SF panel. The results obtained cleared that the rate of lift slide and the concrete mixtures affect, effectively on operation of construction by the SF system.

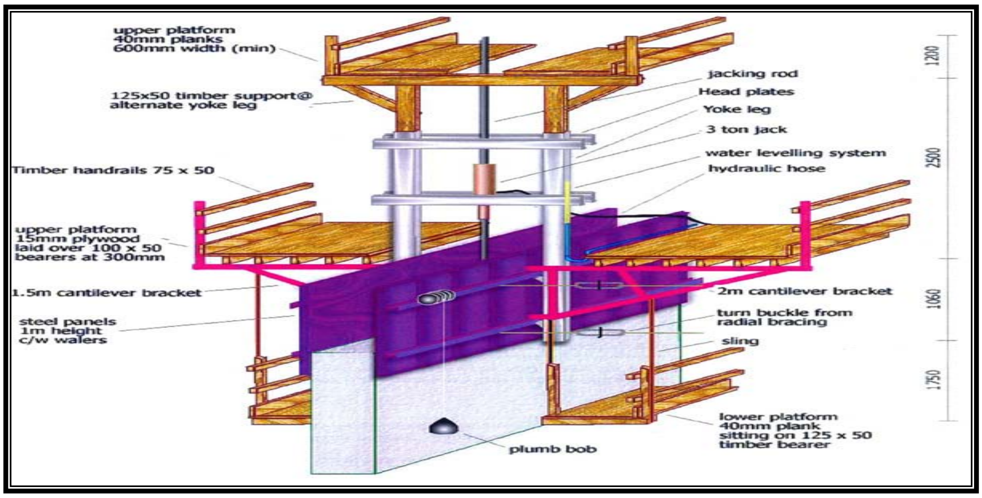

Fig. (1) The Components of the Slip Form. [29]

Value Engineering Methodology

The value methodology is a systematic process that follows the JP. A value methodology is applied by a multidisciplinary team to improve the value of a project through the analysis of functions. The JP consists of the following sequential phases, as shown in Fig. (2). "Value Methodology can be applied during any stage of a project's development cycle, although the greatest benefit and resource savings are typically achieved early in development during the conceptual stages Fahmy (2011).

Value Methodology Standards, SAVE International. 2007

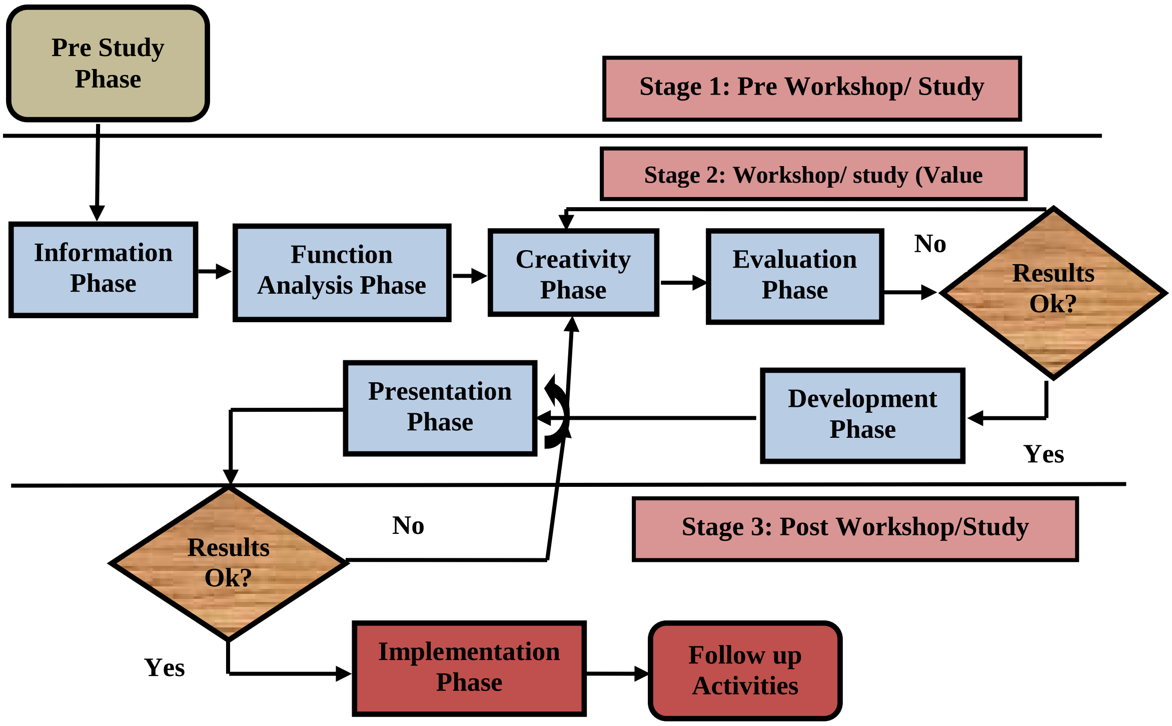

Fig. (2) Value Study Process Flow Diagram

Value Engineering of Slip Form

The Pre Study Phase.

In this phase was determined the criteria of study which help to achieve the objective of the VE study, these criteria express about the costumer priorities. There are many numbers of parameters (non-measure criteria) which have impact on the SF system such as the following in table (1)

Table (1) Parameters which have Impact on the Slip Forming System

(**A**) Construction Time**,**	(**F**) Finishing Surface**,**	(**K**) Friction,
(**B**) Durability,	(**G**) Safety,	(**L**)Depredation,
(**C**) Productivity**,**	(**H**) Labor Saving,	(**M**) Ease of O&M.
(**D**) Economy**,**	(**I**) Weather Effect**,**	
(E) Accuracy System,	**(J)** Workability,	

By applying the (Study Area Selection Matrix) to determine the criteria of the VE study. Found that the parameters which in the concern cycle of figure (3) which have the high importance and high satisfaction that are laying in the hatched area are the parameters which express about the priorities of the study therefore will be taken in to account on the study to compare the alternatives with respect to their.

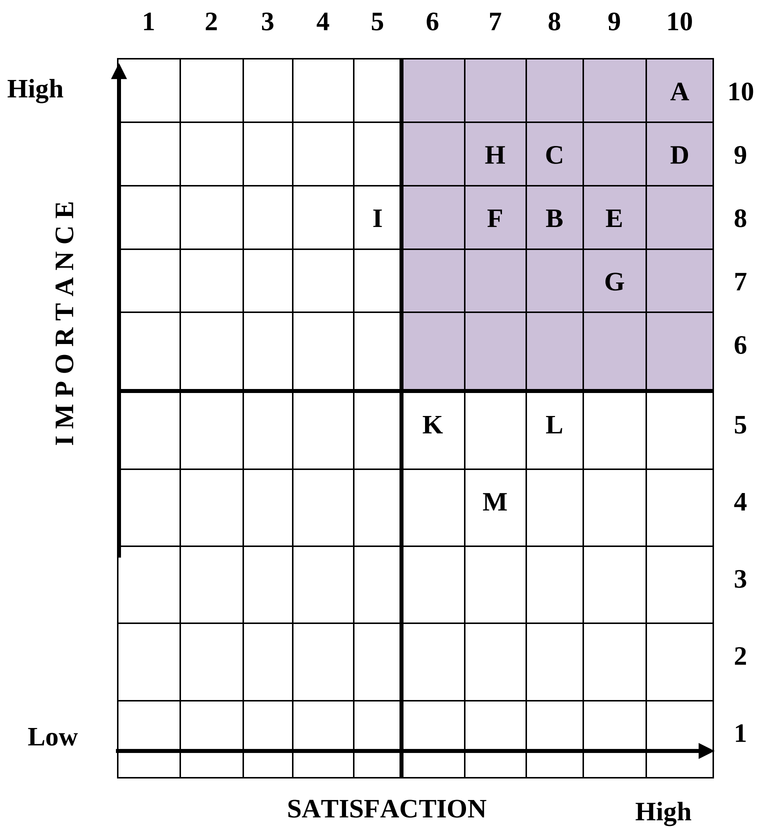

Fig. (3) Area selection matrix for criteria

The parameters which will be selected for the VE study are that criteria which laid in the hatched area these criteria are in Table (2).

Table (2) the Studying Criteria Ranking

ID	CRITERIA	RANKING	ID	CRITERIA	RANKING
A	Construction Time	10	**E**	Accuracy System	9
B	Durability	9	**F**	Finishing Surface	6
C	Productivity	8	**G**	Safety	7
D	Economy	7	**H**	Labor Saving	5

Applying the Six phases of the JP of the study as SAVE international slandered procedures

1. Information Phase

In this phase the main concept is to trying to determine the high cost areas for detailed study in the following phases of the VE study.

2. Function Analysis phase

In this phase was made the FA for the SF system by applying the FASTdiagram procedure to understand the functions of the system, and determining the scope of study as shown in figure (4). This made by identifying the objectives of the value study, the high order function, the basic function, the required secondary functions that help to achieve the basic function and so the low order function by using the how and why logic path technique which is; from the left to the right direction the function have to response on the question of how to achieve the previous function for this function. And in the direction from the right to the left the function have to response on the question of why making its previous function. So it will be applied the FAST diagram on the SF system to determine the items which help to improve the system through it to achieve this study its objective.

Function Analysis for the slip forming system

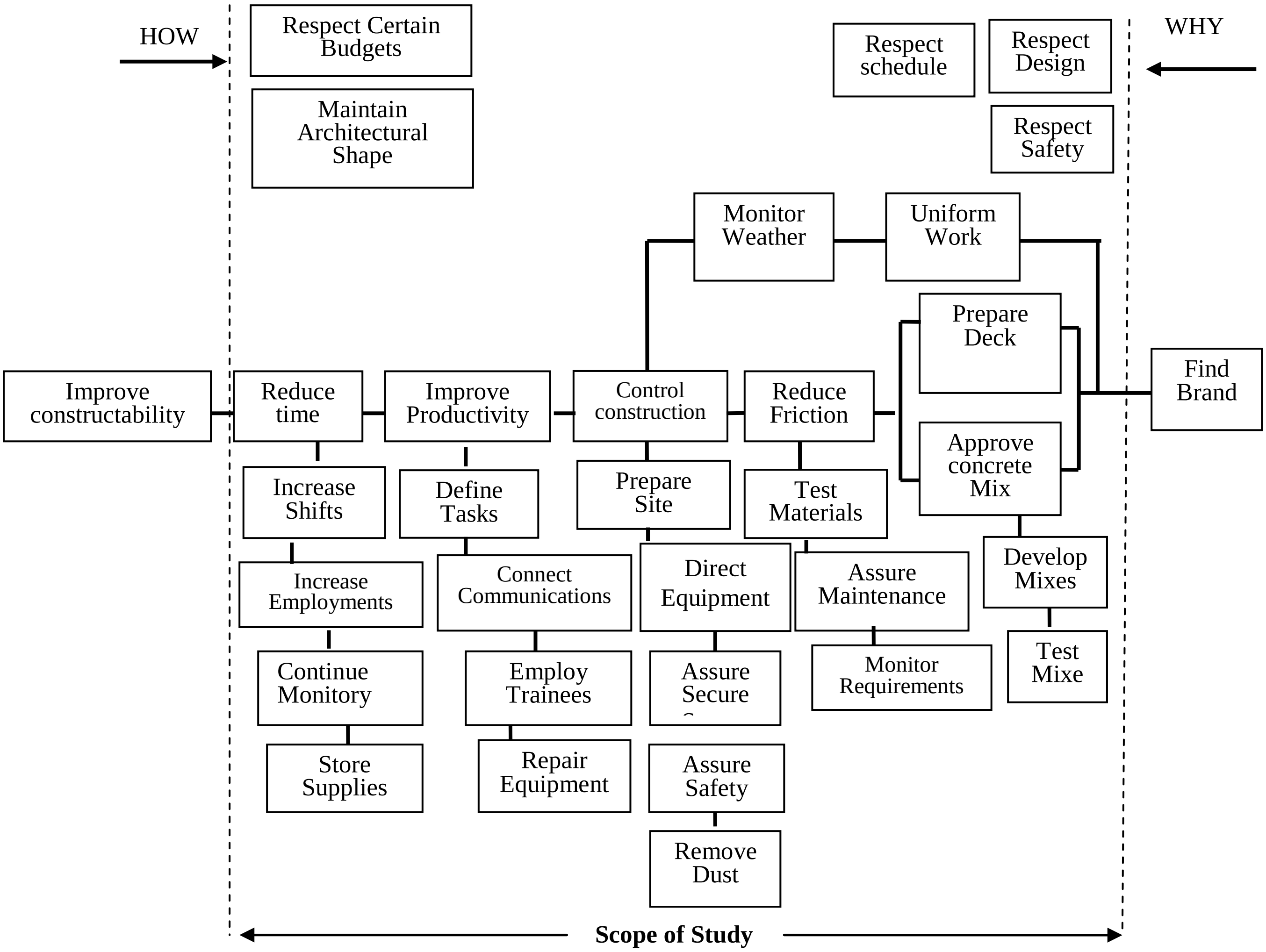

Fig. (4) FAST Diagram for The SF System

From the scope of study found that the concrete type, deck material, and the brand name are the items which considered the variabels of study. So will make FA for each one of them to find the alternatives for each one of them separately as following in figures (5 & 6 &7)

i. Function Analysis for Concrete Type

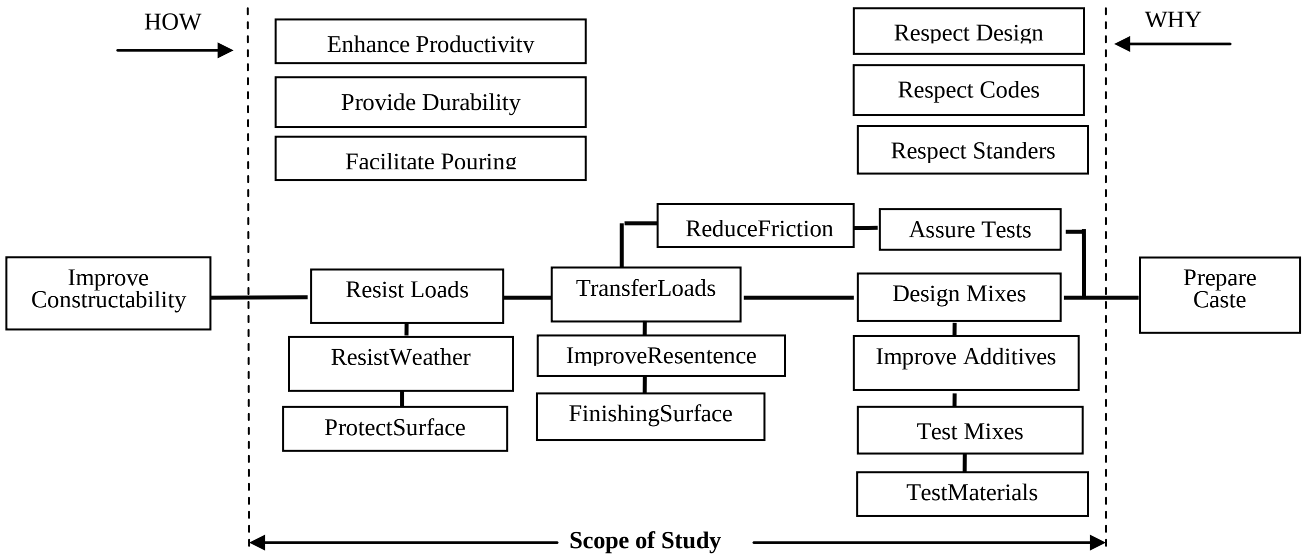

Fig. (5) FAST Diagram for concrete type

From the FAST diagram for the concrete type found that;The high order function is: improve constructability; The basic function is: resist loads and The low order function is: prepare caste

whith some of activeties which layed under the critecal path that help to achieve the basic function.So that it should to keep in mind that, when selecting the alternatives of the concrete mixes that will be studied in the next phase, selsect these alternatives that shall be met in these characteristicsof fresh concrete properties and hardened. That to choice the optimal aternative that fit with the objectiv of the value study.so and in the next and by the same way will be applied the FAST diagram on the material deck and the brand name as following respectivly:

ii. Function Analysis of the Material Deck

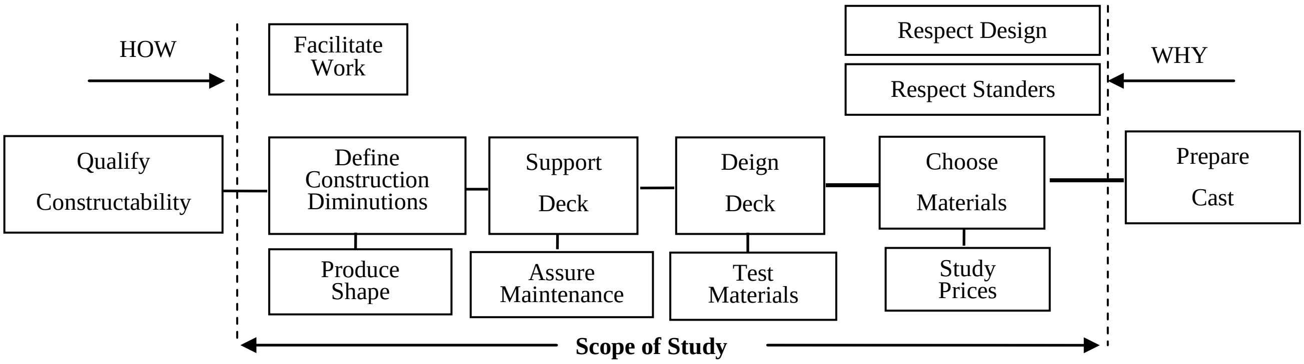

Fig. (6) FAST Diagram for The SFsystem

From the fast diagram for the deck material;
The high order function is: Qualify Constructability; The basic function is: Define Construction Diminutions; The low order function is: prepare caste
And with some of secondary functions (activities) that even being accessed to the basic functionand the objectives of the study**.**
So in the creativety phase must choose alternatives that may be available by the qualities required in line with the HOF functionality and the basic functionfrom flexibility in work, ease of operation, the availability of the market and that need for less labors to filtrate them in the next stages and choose the best alternative among them, which achieves the objectives of the study.

iii. Function Analysis for the Brand Name

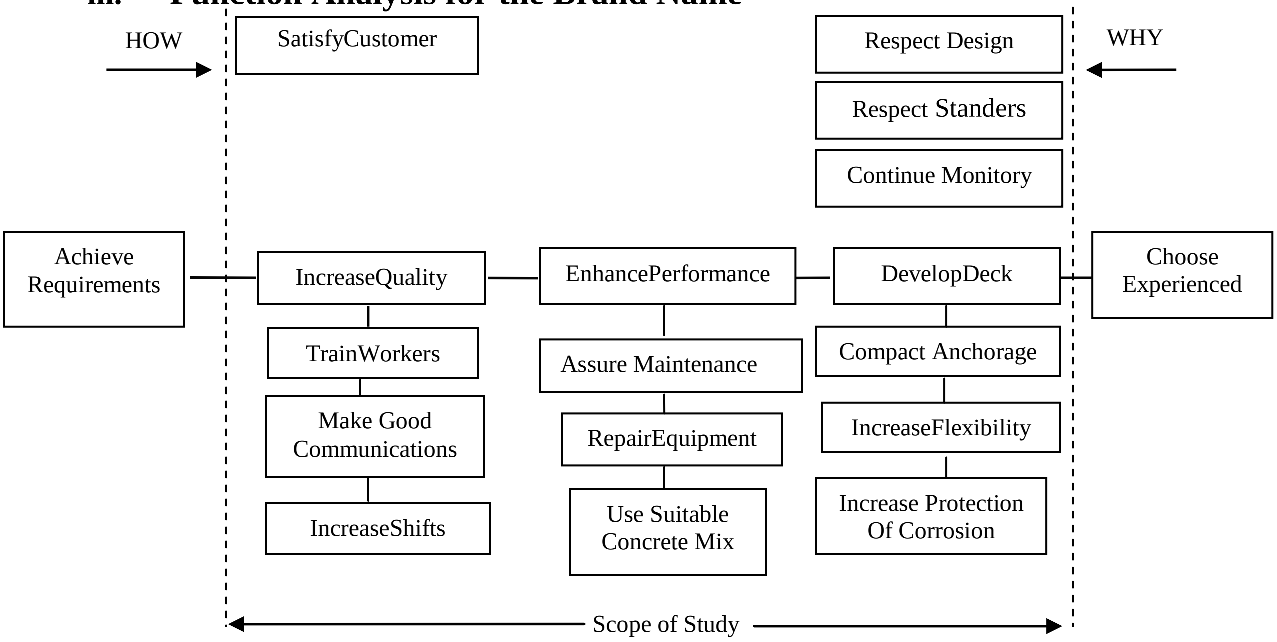

Fig. (7) FAST Diagram for The SF System

From the FAST diagram for the brand name;
The high order function is: achieve the requirements
The basic function is: increase quality
The low order function is: chose experienced
From the scope of study; the brand is the important item of the study that through it can the study achieve and improve its objectives. By the good choice of the brand we can already get the high quality materials and mixes from its experiences in the field. So in the next phases of the VE study (the creativity phase) will identify alternatives for each item of the previous three items, taking into account the above mentioned in the previous phase.

The Speculation/Creativity Phase
Through this phase is determined the alternatives for each item of those items under study, taking into account the special considerations required availability and characteristics that have been realized through the scope of study from the fast diagram of each item. So it will be as following:
For the Concrete Mixes
There are a lot of mixes of concrete that used in the construction field but was selected these types that may be fit with the consideration for the characteristics desired that have been mentioned previously in the function analysis phase from the fast diagram approach. These alternatives are;

1. Normal Concrete,
2. Self-Compacted Concrete,
3. High Strength Concrete,
4. Ultra High Strength Concrete,
5. The High Performance Concrete.

For the Material Deck

In the market of construction there are many types of materials that may be use in the construction field, but there are five types of materials that may be fit with the considerations that have been observed previously. These are:

1. The Timber Formwork,
2. The Steel Formwork,
3. The Aluminum Formwork,
4. The GFRP Formwork,
5. The Combined Formwork.

For the Brand Name

In the labor market of the construction field there are five companies are the most popular and prevalent in this field around the world. These are;

1. The Doka system,
2. The PERI system,
3. The VSL system,
4. The MIVAN system,
5. The RMD system.

The function of this phase only to find alternatives and then an assessment is made in the next phase.

The Evaluation/Analysis Phase

In this phase were applied two procedures;

The first procedure is the break down analysis for each item for the items under study. Through this procedure will work analysis for each one of the alternatives identified in the previous phase for each item under the study in its individual components and determine its price based on market prices and on previous experiences; and then ranking them up to on their costs. So it will apply this procedure on the concrete alternatives, the deck material alternatives and on the brand name alternatives.

a. Break down Analysis and Ranking for Concrete Type Alternatives

It was analyzed each alternative of the five alternatives to determine its components and determine the price of each of them and thus the total cost is determined for each one of them, then ranking them on the cost of building work until the check from them in the next phase of the study.

Table (3) Break down analysis and ranking for Concrete typealternatives

Type of Concrete	Components	Cost/ Item/$	Total Cost	Ranking
	C.A = 0.8 **F.A** = 0.4 **Cement**=350 Kg **Water** = 0.4 Litter/m3 **Mix + Pouring** =	10.5 $ 1.5 $ 28.0 $ 1.5 $ 13.5 $	**55.0 $**	1
Self-Compacted Concrete	**C.A** = 0.5 **F.A** = 0.5 **Cement** = 239 Kg/m3 **Water** = 0.2 Litter/m3 **F.A**= 204 Kg/m3 **S.P** = 3.0 Litter/m3 **Mix + Pouring** =	7.0 $ 2.0 $ 19.0 $ 1.0 $ 55.0 $ 12.0 $ 10.0 $	**106.0 $**	3
High Strength Concrete	**C.A** = 0.6 **F.A** = 0.4 **Cement** = 400 Kg/m3 **Water** = 0.27 Litter/m3 **F.A**= 60 Kg/m3 **S.P =** 8 Kg/m3 **Mix + Pouring** =	8.0 $ 1.5 $ 32.0 $ 1.0 $ 16.0 $ 24.0 $ 10.0 $	**92.5 %**	2
Ultra High Strength Concrete (Pre – Fabricated)	**C.A** = 0.6 **F.A** = 0.4 **Cement** =500 Kg/m^3 **Water** = 0.27 Litter/m3 **S.F**= 50 Kg/m3 **F.A**= 50 Kg/m3 **S.P** = 8 Kg/m3 **Mix + Pouring** =	8.0 $ 1.5 $ 40.0 $ 1.0 $ 10.0 $ 13.0 $ 32.0 $ 10.0 $	**115.5 $**	4
High Performance Concrete	**C.A** = 0.8 **F.A** = 0.4 **Cement** = 500 Kg/m^3 **Water** = 0.27Litter **S.F**= 50 Kg/m3 **F.A**= 50 Kg/m3 **S.P**= 8 Kg/m3 **Mix + Pouring** =	10.5 $ 1.5 $ 40.0 $ 1.0 $ 10.0 $ 13.0 $ 32.0 $ 10.0 $	**118.0 $**	5

b. Break Down Analysis for Materials Deck Alternatives

In the same way were analyzed each alternative under study identifying its components to determine the cost of each alternative based on its market price and the amount used for each cubic meters of concrete, taking into account the number of times to use for each one of the alternatives back to previous experiences

Table (4) Break down Analysis and Ranking for Deck Type Alternatives

Type of Materials	Cost/m3 $ for const. thickness	Using Times	Impact	Ranking
Wood	135 $	About 30 times	4.5	4
Steel	160 $	About 100 times	1.6	5
Aluminum	420 $	About 50 times	8.4	2
GFRP	440 $	About 50 times	8.8	1
Combined	340 $	About 50 times	6.8	3

Normal Concrete

c. Break down Analysis for Brand for each Alternate:

From the creativity and the data collected from the combines; The analysis had been made taking into account the price of the deck material by article that use for each company as contained in its catalog for each one of them, the price of the self-compacting concrete as is recommended in all companies, plus the cost of the hydraulic system, and the overhead of the company.

Table (5) Break down Analysis and Ranking for Brand Alternatives.

Brand	Using Material	System	Cost/m3 $	Ranking
DOKKA	Wood + Steel	Cast in Place	680 $	4
MIVAN	Aluminum	Cast in Place	792 $	3
PERI	Steel	Cast in Place	428 $	5
VSL	Steel	In Site Post tensing System	428 $	5
RMD	Wood + Steel	Cast in Place	680 $	4

Next will apply the weighted evaluation matrix; this to determine the best alternative that will be fit with the objective of the study. In this technique the idea that would evaluated by comparing the alternatives with the esthetics factors criteria, each one to the others (criteria scoring matrix – upper part of the table), and the second to evaluate the chosen alternative to each criteria or aesthetics factors decided in lower part of the table. The analysis matrix is designed to take the criteria and weights developed and to establish a format for evaluation of the response of various alternatives against the criteria. Total weighted evaluation score aid the decision maker in the selection of the best alternative. The input data consist of the criteria and weights taken from the criteria weighted process form, and the alternatives developed up to this point. After listing the input data, the present way and each alternative is then evaluated against each criterion and ranked as the following:

* Excellent - 5   * Very Good - 4
* Good - 3   * Fair - 2
* Poor - 1

So it will compare between the criteria which selected previously from the area selection matrix and study the alternatives of each item of the VE study by the weighted evaluation matrix (the concrete type, the deck material and the brand name).

1. Weighted Evaluation Matrix for the Concrete Alternatives

When applying the quantifying quality matrix on the concrete types by comparing each alternative with the non-measure criteria found that the self-compacted concrete have the high value index when applying the value equation (VI= Q/C) following it the high strength concrete, then the ultra-high strength concrete (pre-cast), and then the high performance concrete, where the normal traditional concrete is the lowest VI. As shown in figure (8) although when looking at the quality box only find that the high performance concrete is the one who follows the self-compacted concrete in place not the high strength concrete, but when entering the cost factor and compare quality, we find that the value will vary and this is what aims to it in this procedure of access to the alternative, which achieves compatibility between the desired quality and cost disbursed.

Criteria						For Criteria					
(A) Construction Time	A		How Important?								
(B) Durability	a/b	B							2- major importance		
(C) Productivity	a/c	b/1	C						1- minor importance		
(D) Economy	a /d	b/2	c/d	D					1- letter/letter, no		
(E) System Accuracy	a/e	b /e	c/e	e/1	E	importance, each scrod one point					
(F) Finishing Surface	a/2	b/2	c/f	d/f	e/2	F					
(G) Safety	a/1	b/1	c/g	d/g	e/g	g/1	G				
(H) Labor Saving	a/2	b/2	c/h	d/h	e/2	f/1	g/1	H	Q	C $	Vi=Q/C
Weight	9	10	6	5	9	3	5	2			
% of the total	18	20	12	10	19	7	10	4			
Normal Traditional concrete	2	2	2	5	2	2	1	1			0.25
	36	40	24	50	38	14	10	4	216	55.0	
Self Compacted concrete	5	5	5	3	5	5	5	5			4.53
	90	100	60	30	95	35	50	20	480	106.0	
High Strength Concrete	3	4	4	4	4	4	5	4			4.24
	54	80	48	40	76	28	50	16	392	92.5	
Ultra High Strength Concrete (Pre-cast)	3	5	4	3	4	4	5	4			3.33
	36	100	48	30	76	28	50	16	384	115.5	
High Performance Concrete	5	4	5	3	4	5	5	5			3.74
	90	80	60	30	76	35	50	20	441	118.0	
For Ranking											
5- Excellent	4- Very good			3- good		2- Fair		1- Poor			

Fig. (8) Weighted Evaluation Matrix for Concrete Alternatives

2. Weighted Evaluation Matrix for The Deck Alternatives

From the quantifying quality of the material deck cleared that the steel is the best alternative which have the high (VI). Comes in ranked next the wood then the combined then, aluminum and in the last the GFRP. But and as explained previously, we find that the value given box arrangement differs from that produced from the box representing the calibrated value by getting into the cost factor in the assessment. As shown in Fig. 9.

Criteria				For Criteria How Important?							
(A) Construction Time	A									2- major importance	
(B) Durability	a/b	B									
(C) Productivity	a/c	b/1	C						1- minor importance		
(D) Economy	a /d	b/2	c/d	D		1- letter/letter, no importance, each scrod one point					
(E) System Accuracy	a/e	b /e	c/e	e/1	E						
(F) Finishing Surface	a/2	b/2	c/f	d/f	e/2	F					
(G) Safety	a/1	b/1	c/g	d/g	e/g	g/1	G				
(H) Labor Saving	a/2	b/2	c/h	d/h	e/2	f/1	g/1	H	Q	C $	Vi=Q/C
Weight	9	10	6	5	9	3	5	2			
% of the total	18	20	12	10	19	7	10	4			
Wood	3	3	5	3	2	1	2				2.14
	60	36	50	57	14	10	8	289	135.0	55.0	
Steel	4	5	5	4	5	5	4	5			2.88
	72	100	60	40	95	35	40	20	462	160.0	
Aluminum	5	4	4	3	5	5	5	5			1.07
	90	80	48	30	95	35	50	20	448	420.0	
GFRP	4	4	5	3	5	5	5	4			0.99
	72	80	60	30	95	35	50	16	438	440.0	
Combined	3	4	4	4	4	4	4	3			1.11
	54	80	48	40	76	28	40	12	378	340.0	
For Ranking											
5- Excellent	4- Very good			3- good			2- Fair		1- Poor		

Fig. (9) Weighted Evaluation Matrix for Deck Alternatives

3. Weighted Evaluation Matrix for BRAND Name Alternatives.

From the quantifying quality matrix; The VSL system is the higher value index followed by PERI, then MIVAN, MIVAN but RMD is the lowest one as illustrated in Figure (10). And also as explained previously different ranking of alternatives because of the box that represents the quality that all we get from value box. This shows an efficient procedure and its usefulness in helping to get the optimal alternative that achieves the best quality at cost optimal reward for this quality.

Criteria	A	B	C	D	E	F	G	H	Q	C $	Vi=Q/C
					For Criteria How Important?						
(A) Construction Time	A								2- major importance		
(B) Durability	a/b	B									
(C) Productivity	a/c	b/1	C						1- minor importance		
(D) Economy	a /d	b/2	c/d	D						1- letter/letter, no importance,	
(E) System Accuracy	a/e	b /e	c/e	e/1	E	each scrod one point					
(F) Finishing Surface	a/2	b/2	c/f	d/f	e/2	F					
(G) Safety	a/1	b/1	c/g	d/g	e/g	g/1	G				
(H) Labor Saving	a/2	b/2	c/h	d/h	e/2	f/1	g/1	H	Q	C $	Vi=Q/C
Weight	9	10	6	5	9	3	5	2			
% of the total	18	20	12	10	19	7	10	4			
DOKKA	4	4	3	4	4	4	3	3			0.55
	72	80	36	40	76	28	30	12	374	680.0	
MIVAN	5	4	4	3	5	5	5	5			0.56
	90	80	48	30	95	35	50	20	448	792.0	
PERI	4	4	4	4	5	4	4	4			0.98
	72	80	48	40	95	28	40	16	419	428.0	
VSL	4	5	5	5	5	5	5	5			1.13
	72	100	60	50	95	35	50	20	482	428.0	
RMD	4	4	3	4	3	4	3	3			0.53
	76	80	36	40	57	28	30	12	359	680.0	
For Ranking											
5- Excellent	4- Very good		3- good		2- Fair		1- Poor				

Fig. (10) Weighted Evaluation Matrix for the BRAND Name Alternatives

Results and Discussions

During applying the VE study on the construction industry it was found that the method of construction have the high impact on the study that because it considered the basic function of this industry. So by making a FA of the construction method with the new construction technique (the SFsystem) we found that:

- The climbed (hydraulic) systems which act the basic function of the SF system have the most impact on the non-measure criteria such as: (construction time, productivity, economy, accuracy, and labor saving). Which express the stakeholders needs which consider the objective of the VE study. Also it will effect on the life cycle costing for the system.
- The material of deck, type of concrete and the brand name consider the variables items of the construction industry that also effect on the construction method and on the non-measure criteria.

Having The Previous Evaluation Techniques Resulted That:

1. The climbed (hydraulic) system (SF system) is more benefiting from the traditional system for the mega structures whatever with respect to the value or the LCC.
2. The steel deck achieve savings on the LCC if is it compare with the traditional system with timber.
3. The self-compacted concrete is the best alternative of the concrete mixes that may be use.
4. The VSL system is the best alternatives for the brand name in this scope.

So these alternatives will complete to the following phases of the value study. The next is:

Development phase

The main purpose of this phase of the JP is to select the ideas and prepare descriptions, sketches, and LCC estimates to support the recommendations that be chosen for presentation as formal VA proposals. In this phase will apply two procedures to determine the savings that achieved from the value study.

These techniques are:

1- Function Worksheet – SFsystem

It makes to determine the functions of the SF as the estimated system to determine the functions and its degree with its cost as shown in Table (6).

Table (6) Function Worksheet – SFsystem

Item Description	Cost/m^3	Function		Function Class	Worth
Climbed (Hydraulic) System	40 $	Lift	Deck	Basic	20 $
		Guide	Movement	Sec	
		Drive	Motion	Sec	
Deck	160 $	Define	Dimensions	Sec	
Concrete	106 $	Resist	Loads	Sec	
		Transfer	Loads	Sec	
Brand Name	122 $	Choose	Experienced	Sec	

Function-Cost Matrix: SF System

This procedure, which follows the previous, made to determine the total cost bonus of this system on the grounds that it is the proposed system.

Table (7) the Function -Cost Matrix

Function → / Component ↓	Lift Deck	Guide Movement	Drive Motion	Define Dimensions	Resist Loads	Transfer Loads	Choose Experienced	Total Cost
climbed (hydraulic) system	40 $							40 $
Deck				160 $				160 $
Concrete					106 $			106 $
Brand Name							122$	122 $
Function Cost	40 $			160 $	106 $		122 $	428$

1- The Cost Model for The System

This procedure applied to determine the costs for the estimated and the traditional systems to determine all the costs for each one of them separately with respect to the LCC. All the costs that fall in the cost of the LCC of the project are considered; the labor cost, finishing surface and the salvage cost not only the initial cost. This measure takes into account all the costs in the LCC of the project under study. Where the salvage cost is the realizable value of any intended or used items can be sold after amortized.

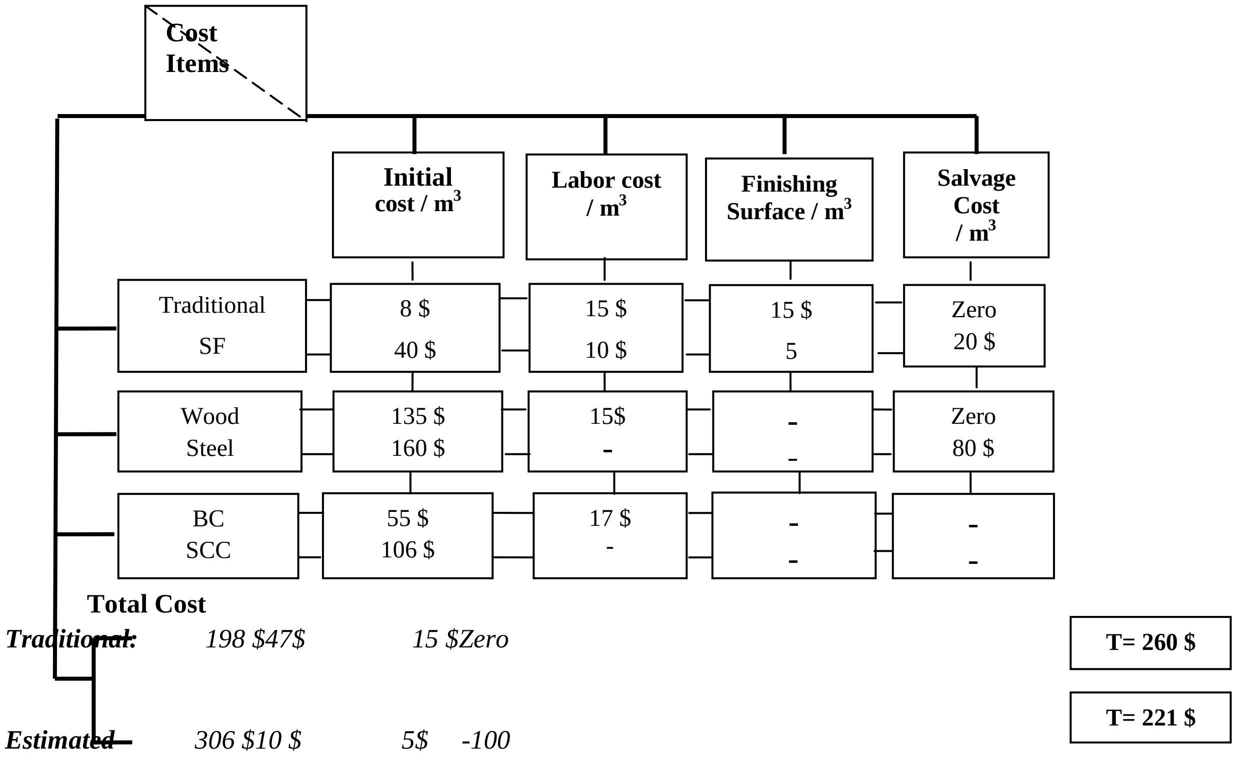

Fig. (11) The Cost Model for the System

Conclusion

From the cost model it is clearing that the savings that can be achieved from using the estimated system by comparing its total costs (LCC) with the total cost of the traditional system is equal to 39 $ percubic meter of concrete which represents the percentage of 15.6% that improve the efficiency of this system of construction. Figure (12) shows the savings in (the cost and the effort), the implementation and the acceptance level which express about the estimated and traditionally system all over the Project LCC for the construction projects.

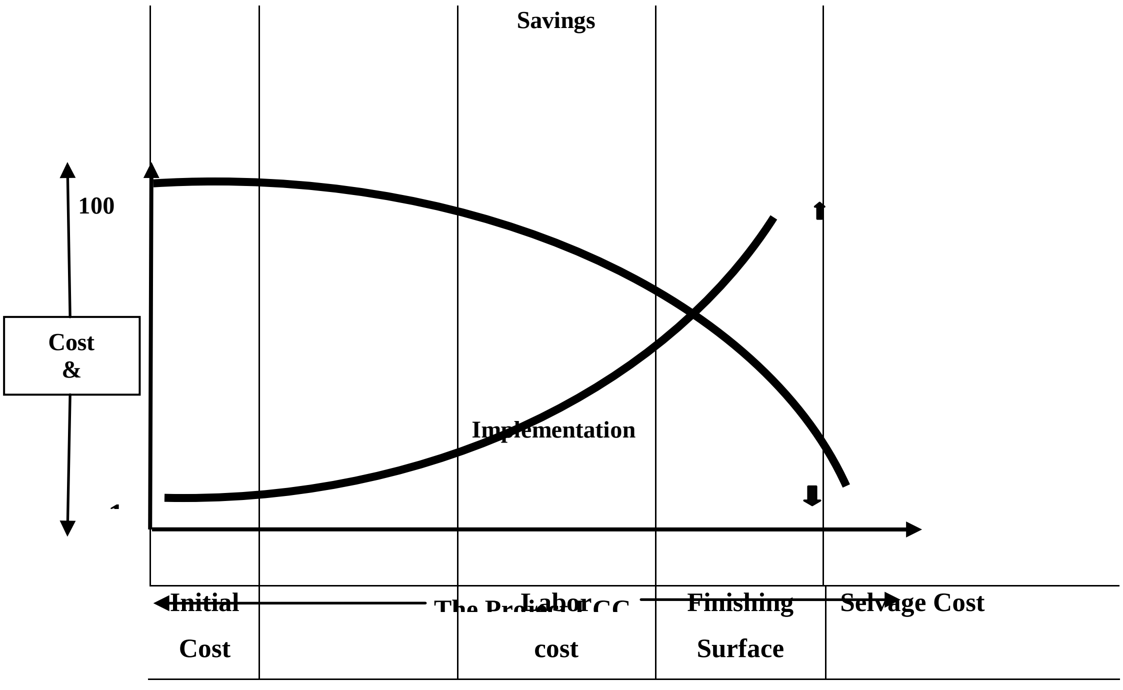

Fig. (12) The Savings and Implementation of the System

Recommendations

Recommendations are within the follow-up phase and the preparation of the final report, which is the final stage of the study. The results obtained from this study showed many of the topics that must be taken into account in future studies. So the recommendations of these studies are as the following:

1. For major projects whatever construction projects or others which its budget greater than (10 M $) should have the VE study according to what has been done work in many countries of the world.
2. For gigantic construction projects (high rise building, silos, bridges, dames, planets… etc); recommended to:
   a. use the slip forming system
   b. Use the steel as the material of the deck with the SF system.
   c. Use the self-compacting concrete with the SF system.
3. The VSL system consider the best system in this field which achieve the best results in the weighted evaluation matrix (the high VI), in addition with its special advantage of using the post tension system. The VSL Company is considering the commander of using the stay cable system for the bridges.
4. For any VE study should consider the constructability point of view, owner priorities, requirements, life cycle cost into the account during the workshop of the VE study and not account only on the initial cost.

General Recommendations for the Future Studies and Universities

- Applying the FASTdiagram concept during studying the project, or system give a good chance to determine the items which will need to study, and aid to the creativity to find alternatives and solutions for these items laid under study, that lead to reduce the project duration.
- Insert VE in the universities courses or by specialize courses educational/ training to assist the concept and importance of the VE to enhance our qualification to accomplish with the market whatever national or international place. This professional training is a way of raising the capabilities, and performance of the engineers, workers. And so it would raise the professional level of the construction industry, by preparing specialized courses to serve a certain demand in the market.

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