Implementation Value Engineering In Diaphragm Wall at High Rise Building

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ABSTRACT
Diaphragm Wall is a retaining wall which is also used for basement floor walls which are part of a lower structure which contributes 8% of the total cost of high-rise building construction is a job that has a high enough level of difficulty so that it has the potential to experience cost overrun. According to World Bank data that 63% of 1,778 projects experienced Over-run Cost Value Engineering (VE) used to produce more efficient and effective costs and time so as to increase profit and revenue for contractors and owners. Statistical analysis uses the Relative Importance Index (RII) method to get the ranking of the 10 most influential factors on cost savings including: Location, Picture completeness and specification, Cost efficiency, Improving function value, Better project value, Mature planning, Hole ground collapse drill, Low productivity tools, Cost Model and price fluctuations. From the results of the study Analysis of the case study obtained cost optimization of 18.83%.

Keywords *- Value Engineering, Diaphragm Wall, Cost Optimization*

I. INTRODUCTION

The demand for an area in the basement on the construction of commercial buildings is already a must. Parking problems are also key in determining the success or failure of the sale and operation of a building. The construction of a basement (lower structure) is an attempt to overcome this problem.
Diaphragm Wall is a retaining wall and is also used as a basement floor wall in the initial process of building a multi-story building.
Diaphragm wall has the main function to resist the movement of the soil when the soil is dug up and as a cut of wall so that the basement can be worked dry. Sometimes the walls are also designed to support building loads, depending on the bearing capacity of the wall itself and the structure of the soil above [1], as a soil retention structure, there are various variations of diaphragm walls, which are adapted to local needs and conditions. The second function is the cut offwall, the depth of the diaphragm wall is very important because if the wall is not deep enough and the flow of groundwater below the wall is too high to overcome with the drainage system under the deepest basement slab, the slab must be designed to be able to withstand water pressure (uplift). Whereas a wall that is lacking in depth can cause settlement around the wall.
Difficulties that are quite high in implementation if not planned properly will result in delays in project completion time and high costs (cost overrun). Projects in various countries that experience cost over-runs, according to World Bank data show that 63% of 1,778 projects experience cost over-run, meaning that cost over-run not only occurs in developing countries but also in developed countries [2], So that good project management is needed especially for controlling triple constraints.
Current construction project activities are faced with very complex problems, short periods of time and demands to maximize functions with timely schedules, minimal costs and good quality. To deal with these challenges, a method is needed to increase efficiency and effectiveness in increasing competitiveness in the competition in the construction industry. then by optimizing the work of diaphragm wall based on Value Engineering in this study, it is expected to generate alternatives to work items with better or equal functions with lower costs as recommendations and so that strategic steps can be taken to eliminate the risks to the project.

II. LITERATURE REVIEW

The basement construction method is a method of implementation which in principle is a reference for the executing agencies in implementing/managing a project basement so as to achieve the desired outcome as efficiently as possible [3].

Basement functions to hold the stability of building construction on shear forces or rolling forces that may occur. The wall in the basement must be designed to be sturdy and strong, considering its function as a retaining wall (retaining soil and water pressure loads). The thickness of the concrete wall ranges from 15-17.5 cm, depending on the depth of the basement floor. Meanwhile, to anticipate water seepage, absolute walls are given a layer of waterproofing.

A diaphragm wall is a reinforced concrete wall that is made in situ. The trench is prevented from collapsing during excavation, reinforcing and casting by the use of supporting bentonite slurry. The slurry forms a thick deposit (the cake) on the walls of the trench which balances the inward hydraulic forces and prevents water flow into the trench. A slurry made of polymers can also be used [4]. Basically the process of making diaphragm walls consists of making slots (longitudinal holes) in the soil that remains open and stable because inside it is filled with bentonite slurry. Reinforcement is inserted into the slot, then casting is done with the Tremi System starting from the bottom of the hole and the bentonite mud is gradually pushed out until it runs out. The length of the slot (or usually referred to as a panel) is generally around 5 m [5]. By constructing such panels, a continuous wall is formed. Diaphragm wall is very necessary in deep basement construction with high ground water level. The combination of the diaphragm wall and the Basement construction method provides various advantages and innovative solutions to local dewatering on surrounding land. The diaphragm wall can be considered as a continuous row of tight wall panel units along the edge of the excavated area. As shown in figure 1

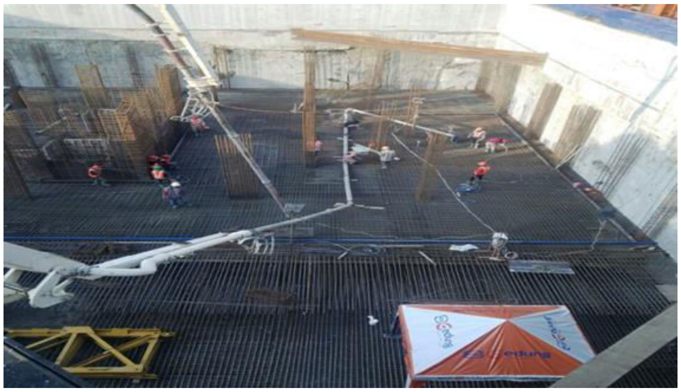

Fig 1. Wall Basement

Value Engineering (VE) method this is the method arises because there are many costs that are not needed in a project plan, in Value Engineering (VE) an evaluation method is used to analyze the resources of a project, where new alternatives are sought for produce more efficient and effective costs and time so that it will increase profit and revenue for contractors and owners. This method has been systematically tested in analyzing a system to produce new technology[5] and stimulates innovation and efficiency to get maximum value from a project [6]. Applying VE to construction projects has considerable savings potential from the side of the project cost budget, based on research conducted in America by Palmer, Kelly, and Male (1996) showing that the savings achieved in implementing VE on construction projects are quite large, can reach 34-36% of the total project budget.

III. RESEARCH METHODS

The initial stage of the RII analysis is to collect the questionnaire components to be distributed to the respondents. All components are prepared based on previous similar research. The questionnaire component in this study consisted of three parts, namely variables, main factors and sub-factors.

By using the Relative Importance Index (RII) statistical analysis method, the calculation of the results of the questionnaire is learned and will get the most influential factors with the ranking system based on the weight of the value given from the respondents.

RII is operated using Microsoft Excel 2013 application program, with several tests such as validity, reliability and hypothesis testing H1 and H0. Through the Hypothesis Test in this study, the results show that the application of the Value Engineering method to the D-Wall work has a significant relationship.

It can be seen in table 1 the variables of this study are the independent variables (Value Engineering Method) and the dependent variable (D-Wall) along with the main factor and sub-factor sub factors according to the ranking results.

Table 1. Main Factors, Sub Factor and RII Result

Rank		Sub Factor	Main Factor
1	X14	Locations	Technique
2	X17	The completeness of drawings & spec	Technique
3	X10	The cost efficiency	Function
4	X7	Increase the value of the function	Function
5	X5	Better project value	Function
6	X3	Careful planning	Function
7	X34	Soil borehole collapse	Technical doc.
8	X35	Low productivity tool	Technical doc.
9	X20	Cost Model	Budget plan
10	X24	Fluctuations in the price	Budget plan
11	X29	Availability of resources	Resource Management
12	X19	Demands low construction costs	Budget plan
13	X2	The commitment of the parties who are involved	Function
14	X1	Support line executive of Owner	Function
15	X15	Analysis function	Technique
16	X18	Impact of Life circle cost	Technique
17	X8	Method in use	Function
18	X26	Selection of materials	Resource Management
19	X39	Delayed repay Owner	Non-Technical Risks
20	X4	Quality information	Function
21	X12	Characteristics of the building	Technique
22	X16	Availability of time and costs	Technique
23	X11	Lack of knowledge about VE	Function
24	X23	Cash flow	Budget plan
25	X21	The price increase of resources	Budget plan
26	X30	Price/rent Peralta eminence	Resource Management
27	X27	Subcontractor election that competent	Resource Management
28	X32	Ground data which is inaccurate	Technical doc.
29	X9	Conflicts of interest between the parties	Function
30	X13	Thinking creative	Technique
31	X6	His lack of guidance on VE	Function
32	X22	The value of work	Budget plan
33	X25	Power quality	Resource Management
34	X31	time preliminaries	Resource Management
35	X28	Ease and care requirements	Resource Management
36	X37	Quality of material that isn't within spec	Technical doc.
37	X36	Damage tool	Technical doc.
38	X33	Mud excavation	Technical doc.
39	X41	Sequencing poor	Non-Technical Risks
40	X38	Less qualified subcontractors	Another method
41	X40	Weak-time control system	Another method

IV. RESULTS AND DISCUSSION

4.1. Implementation VE Methods on D-Wall Works

Value Engineering (VE) is the systematic review of a project, product, or process to improve performance, quality, and/or lifecycle cost by an independent multi disciplinary team of specialists [6]. Optimizing Value Engineering (VE) Based Diaphragm Wall (D-Wall) in High-rise Residential Buildings seen in the following flowchart in Figure 2.

The VE Method Implementation and Implication in D-Wall work can be seen in the stage or value engineering phase of the D wall work stage in the Validation of this study case

4.2. Phase Information

The case study in this study is the construction of apartments and commercial areas located in the business center close to government and private office facilities and the Old City area. Seen in Figure 3.

The existing technical problem is that D wall excavation and strengthening method is a potential threat to the smooth work in the field, the delay in material arrival is one of the potential impacts on the smoothness and speed of work in the field, and there are some images from the consultant planners that are immature for design clarification. The period of implementation of 480 calendar days.

The information phase performed data processing and information to determine high-cost work items that have the potential to do value engineering, through the breakdown of cost models, Pareto charts, and analysis functions.

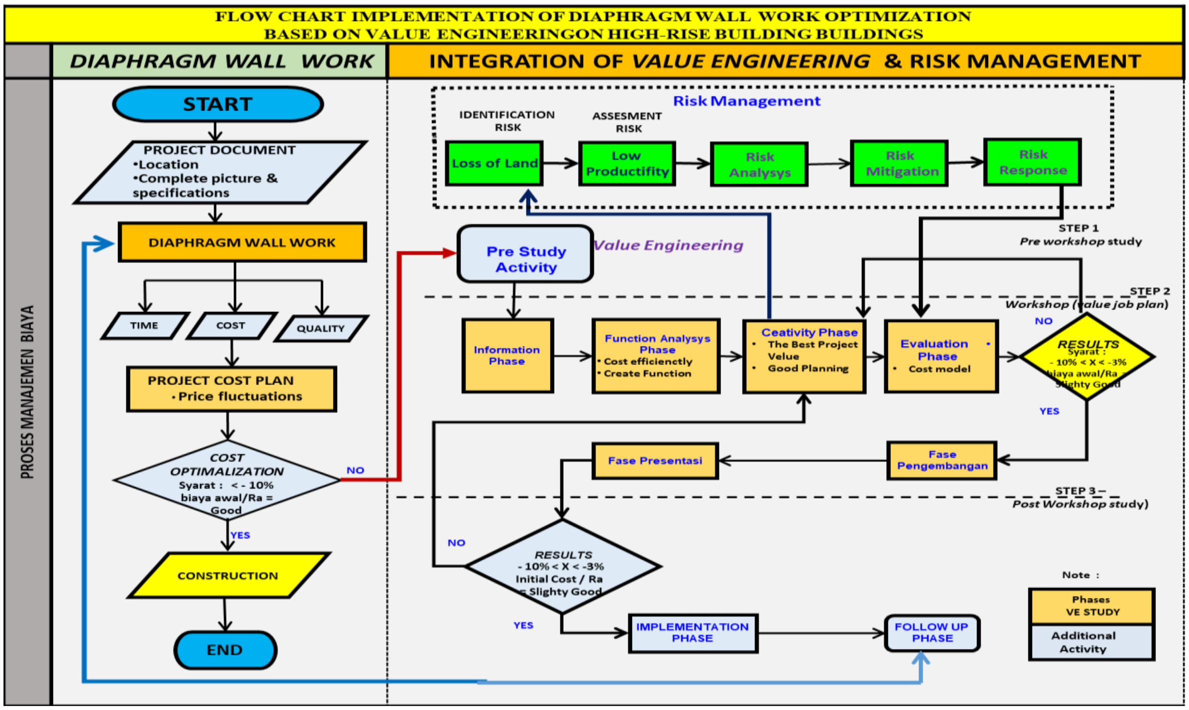

Fig 2. Implementation VE at D-Wall works

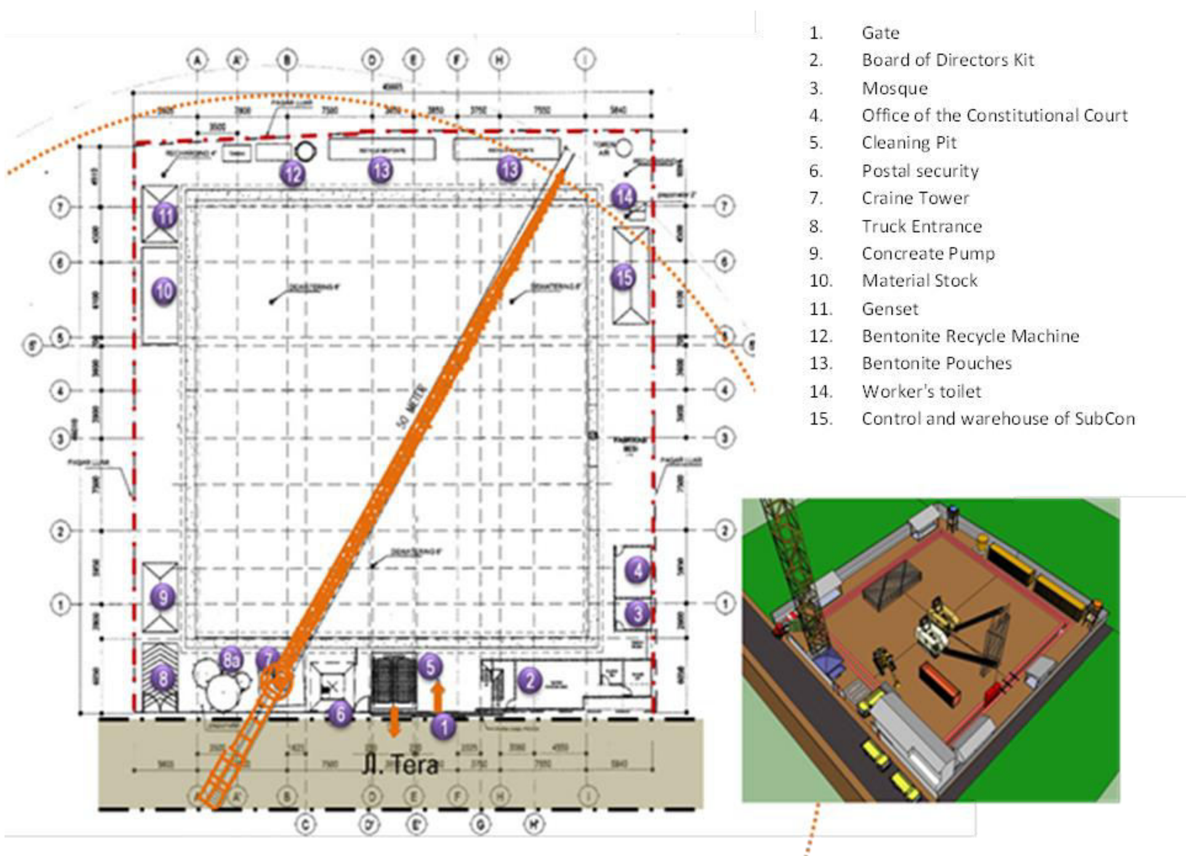

Fig 3. Site Area D-Wall Project Works

Work items and recap the cost in jobs Diaphragm Wall and the breakdown of work items and weights work can be seen in Table 2, 3, and 4 the following :

Table 2. Project Costs Recapitulation

	DESCRIPTION	AMOUNT (IDR)
Bill No. 1	Preparation, Infrastructure and support work	5.904.028.122
Bill No. 2	DPT, Land & foundation work	19.978.052.657
Bill No. 3	Structure work	25.293.06.592
Bill No. 4	Architectural work	34.047.704.162
Bill No. 5	MEP work	19.169.350.320
Bill No. 6	Other work	4.500.000.000
Bill No. 7	Less work added	
	SUBTOTAL	108.628.441.854
	TAX VAT 10 %	10.862.844.185
	TOTAL	119.491.286.039
	ROUNDED	119.491.000.000

Table 3. Bill of Quantity

Description	Unit	Quantity	Unit Price (IDR)	Total (IDR)
Bill. No. 2 DPT, Earth and Foundation Work				
Bill. No. 2.1. EarthWork				
Land Clearing	ls	1	7,875,000	7,875,000
Cut, Fill and dismantling existing buildings works				
Basement and Existing Buildings	m³	15,262.50	57,750	881,409,375
Pile cap and tie beam. STP, GWT & Pit Lift	m³			
Fill including compaction	m³	5,408	79,275	428,719,200
Termite	m²	2,220	18,375	40,792,500
Bill. No. 2.2. Foundation work				
DIAPHRAGMA WALL WORK				
Diameter of Θ 80 m - L 16 m				
○ Mob Demob and Management	ls	1	562.000.000	562.000.000
○ Gabbing includes Bertonite	m³	1,920	2,247,618	4,315,426,560
○ Iron Handling	kg	354,375	1,680	595,350,000
○ Concrete casting wages	m³	1,620	236,250	382,725,000
○ Bentonite Casting Wages	m³	-		
○ Dispose of mud	m³	1,782	88,859	158,346,738
○ Guide Wall Work	m'	300	888,593	266,577,900
○ Construction Joint & Water Stop Works	m'	240	328,647	78,875,280
○ Tidying Work Diaphragma Wall	m²	1,305	188,283	245,709,315
Concrete And Reinforcement Work				
○ Bekesting	m²	-	-	-
○ Concrete	m³	2,106	1,072,815	2,259,356,814
○ Steel U 40	kg	382,725	11,341	4,340,484,225
Concrete Retaining Wall Anchor Raft Job				
○ Steel bar	kg	28,710	11,341	325,600,110
○ Concrete	m³	174	1,072,815	186,670,506
○ Bekesting	m²	435	115,517	50,249,895
JOB OF RAFT FOUNDATION				
Concrete And Reinforcement Work				
○ Steel bar	kg	252,525	11,341	2,863,886,025
○ K300 concrete	m³	1,942.50	883,366	1,715,938,824
○ Bekesting	m²	253.75	115,517	29,312,469
○ Check	nos	2,000	95,238	190,476,356
Test Fee				
Curring and Protection	ls	1	26,135,471	26,135,471
Thermocouple	ls	1	26,135,094	26,135,094
			TOTAL	**19,978,052,657**

Table 4. Weightings Project Costs Recapitulation

Work item	Cost		Cumulative	
	IDR	%	IDR	%
Iron U-40	4,340,484,225	32.87	4,340,484,225	32.87
Grabs including Bentonite	4,315,426,765	32.68	8,655,910,990	65.55
Concrete	2,259,356,288	17.11	10,915,267,277	82.66
Handling Iron	595,350,000	4.51	11,510,617,277	87.17
Mob Demob & Management	562.000.000	4.26	12,072,617,277	91.43
Casting concrete works	382,725,000	2.90	12,455,342,277	94.32
Guide Wall works	266,577,961	2.02	12,721,920,239	96.34
Diaphragm Fireplace Wall Works	245,709,388	1.86	12,967,629,627	98.20
Remove mud Works	158,347,309	1:20	13,125,976,936	99.40
Joint & Water stop construction	78,875,274	0.60	13,204,852,210	100.00
TOTAL	13,204,852,210	100.00	13,204,852,210	100.00

Similar work items are sorted from the highest cost to the lowest cost to be made a Pareto distribution graph by determining the amount of cumulative costs that are changed in the form of percent, obtained 8 items of high-cost work that are potential to be able to be effected by making various alternatives.

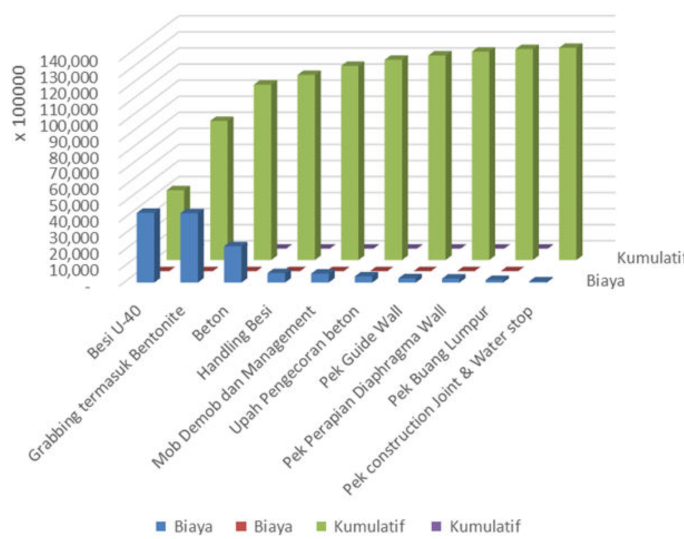

Fig 4. Pareto Diagram

4.3. Phase Analysis Functions

Stages of analysis do the main functions and supporting functions of each item of work so knowing the function of the need to increase the value.

In this function analysis method used is the method FAST (Function Analysis System Technique) outlined by the format of verbs and nouns are divided into two functions: Main Function (basic) and Support functions (secondary).

Table 5. Identify the function analysis

Analysis Functions		
D Wall Work - **Gabbing Work** - **Wall Surfaces Work** - **Sparing / Sleeve Pipe Work**	Retaining wall Wall basement floor	Main Function (basic)
	Watertight Integration of structure. Basement floor anchor, pipe Adding to the aesthetic surfaces simplify treatment	Support function (secondary)

Further into the development stage using the analysis method function FAST (Function Analysis System Technique) which aims to facilitate the understanding of the related functions.

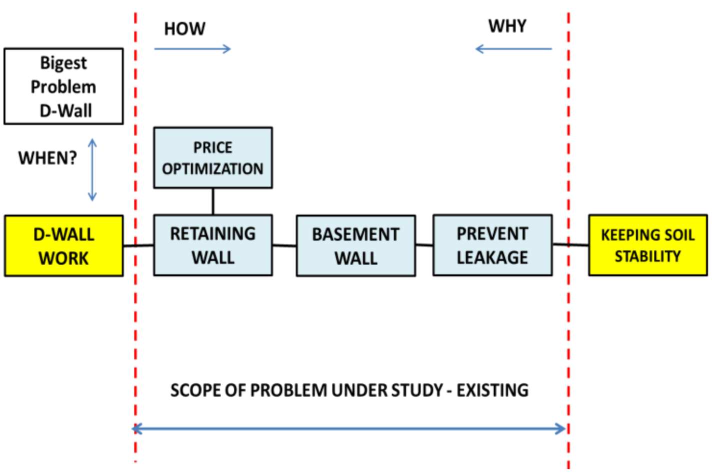

Fig 5. FAST Diagram (Existing)

4.4. Creative stage

The creative phase involved the development of several alternative methods to achieve the base functions [8]. At this stage of the development phase selected from the previous stage including alternative design ideas compared with the initial design and then analyzed and evaluated. The result of development is that there are additional functions as shown in the following tables and figures:

Table 6. Results Development and Function Additions

Design Object & Risk	The main function	Support functions	Extra Functions
D Wall Work : - **Grabbing Work** - **Wall Surface Work** - **Guide Wall Work**	Retaining wall Stabilize soils	integration of structure basement *Watertight* add to the aesthetics	*Sparing & Sleeve plumbing pipe*

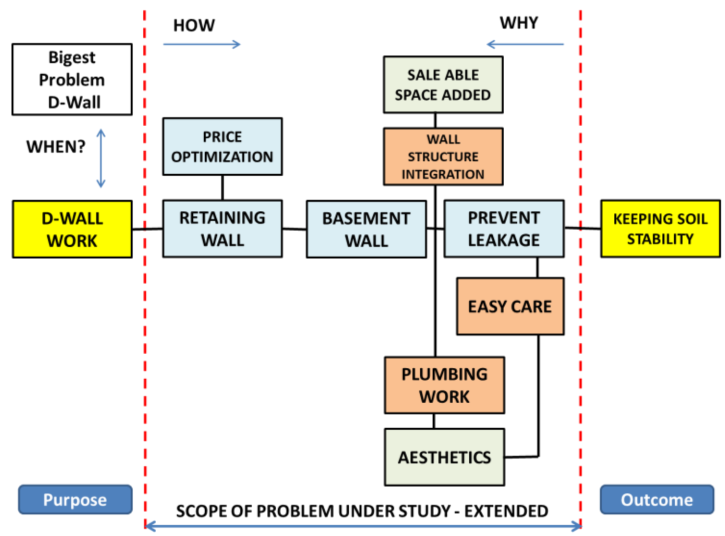

Fig 6. FAST Diagram (Extended)

4.5. Evaluation phase

This phase begins with the assessment of alternative solutions based on the criteria analysis function as follows:

a. The evaluation of the productivity time

Start by calculating the productivity of the tools used. While worker productivity is derived from results in the field. To calculate the duration of each job in both methods, namely by dividing the volume of work with the productivity of tools/workers.

Volume gabbing on the Bill of Quantity (BOQ) = 1,920 m^3 were completed within 50 days. So grab the plan obtained daily productivity is = 1,902 m^3/50 days = 38.40 m^3/day, while the working time is 8 hours grab machine, to obtain productivity plan is = 38.40 m^3/day/8 hours = 4.80 m^3~5 m^3/h was to cost her productivity is = IDR 4,315,426,765/38.40 = IDR 112,380,905

b. Alternative replacing grab machine of type gravity-type hydraulic
Productivity hydraulic grab by comparison count of gravity grabs the estimated cost and time of the tool: Volume gabbing is = 1,920 m^3 with 150 m length and 16 meters into a myriad of basic basement level 1 with a thickness of 80 cm, then the extent of the work area is a wall D = 150 x 16 = 2,400 m^2. Retrieved duration of work when using hydraulic grab engine is = 2,400 m^2/75 m^2/day = 32.00 days. Then the evaluation of the time by using hydraulic grabs as time efficiency obtained in the following table:

Table 7. Evaluation of Time

Description		Capacity	Duration
Gravity Grabs	Early Design	38.40 m^3/day	50 days
Hydraulic Grabs	Redesign	75.00 m^2/day	32 days
		Ffficiency time	18 days (36%)

So that the efficiency of the time for 18 days is 36% of the work item grab then it is obtained = IDR 4,315,426,765 x 36% = IDR 1,553,553,635. As in the following table :

Table 8. Evaluation of Cost

Description	Grab (USD)	Crawler (USD)	Total (USD)
Gravity Grabs	40,310	210	250,310
Hydraulic Grabs	303,000		303,000
		Extra Cost	52,690 (21.05%)

From the grab of the grab machine, there was an additional cost of USD 52,690 (21.05%) if at that time the price of 1 USD = IDR 12,440, then the cost of the grab item was = USD 52,690.00 x 12,440 = IDR . 655,463,600. So with the proposed alternative replacement of grab machines from gravity type to hydraulic type for grabing work items including bentonite resulting in cost savings of IDR 1,553,553,635 - IDR 655,463,600 = IDR 898,090,035 from the initial cost of IDR 4,315,426,765 or 20.81% as shown in the table below :

Table 9. Cost Efficiency

Description replacement Engines	Total (IDR)
Saving time / duration	1,553,553,635
Extra cost / price	655,463,600
Cost efficiency	898,090,035 (45.7%)

c. Replacement Wall D Wall
With the proposed alternative substitute for fireplace / pair work items using alternative brick replacement including plaster and finishing resulting in a cost savings of IDR 112,299,238 from the initial cost of IDR 245,709,388 or 45.70% as shown in the table below :

Table 10. Couple Cost Efficiency Concrete Brick

Description	Unit	Qty	Uniy Cost (IDR)	Total (IDR)
Fireplace / Partner Work	m^2	1,305	288,750	245,709,388
Incl adobe pilaster Work	m^2	1,305	102,230	133,410,150
		Cost efficiency		112,299,238 (45.7%)

c. Saleable space savings
Preliminary design :

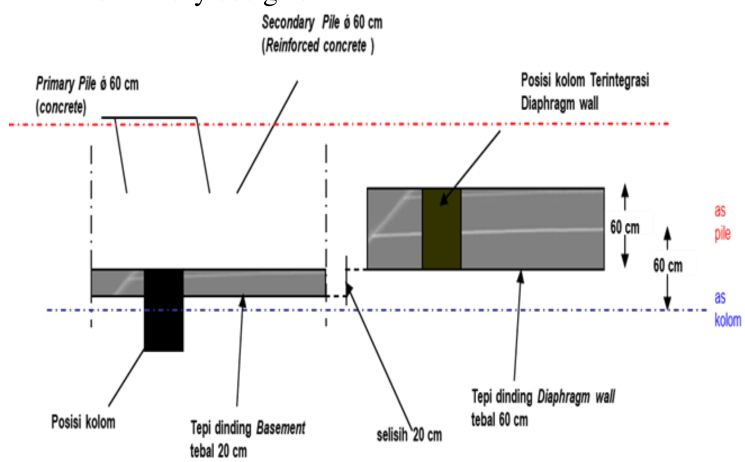

Fig 7. F Column integration and Diaphragm Wall D

The basement walls and columns were originally not in line with the Diaphragm wall Replacement Design for the Wall and the basement column structure was integrated into the wall of the Diaphragm wall so that the column was no longer visible because it blended with the diaphragm wall. If it is known from the previous volume above the length of the wall perimeter of the D-wall: 150 m Then the new area is 150 x 0.4 = 120 m^2 x 3 floor. The basement will have an area of 180 m^2 from the property price table for the space per square meter of IDR 8,200,000/m^2 then 180 m^2 x IDR 8,200,000 = IDR 1,476,000,000 as shown in table 11.

4.6. Phase Recommendations

Of the two work items plus the savings in able sale of space basement, a cost savings of: IDR898,090,035 +IDR112,299,238 +IDR1,476,000,000 = IDR 2,486,389,273 from the initial cost of IDR 13,204,852,210 or 18.83%

Results from cost savings on the job description above the diaphragm wall can be seen at 4:37 the following table:

Table 11. Saving Results

ITEM		Total (IDR)
Grabs Works		898,090,035
Wall Substitution		112,299,238
New extents Floor		1,476,000,000
	Total	2,486,389,273 (18.83%)

4.7. Recapitulation results Cost Savings

The second item of work they will be produced cost savings of :

IDR 898,090,035 + IDR 112,299,238 = IDR 1,010,389,273 while saving space basement IDR 1,476,000,000 so that the total cost efficiency amount IDR 2,486,389,273 of the initial cost of IDR 13,204,852,210 or 18.83%.

Results from cost savings on the job description above the diaphragm wall can be seen at the following table:

Table 12. Results of Cost Savings

Description	Cost (IDR) Before	After
Diaphragm Wall		
Iron U-40	4,340,484,225	4,340,484,225
Grabs incl. bentonite	4,315,426,765	3,417,336,730
Concrete	2,259,356,288	2,259,356,288
Handling of Iron	595,350,000	595,350,000
Mob Demob & Management	562,000,000	562,000,000
Wages concrete casting	382,725,000	382,725,000
Guide wall work	266,577,961	166,577,961
Fireplace D-Wall Work	245,709,388	133,410,150
Remove mud	158,347,309	158,347,309
Joint & Water Stop	78,875,274	78,875,274
Total Initial Cost	13,204,852,210	12,194,462,937
Saleable Space Added		(1,476,000,000)
		10,718,462,936
	Total Efficiency	2,486,389,273 (18.83%)

V. CONCLUSION

The results of the implementation stages of Value Engineering study in the work of the D-Wall-based Value Engineering include :

1. Pre-Workshop Stage (a) the Project Coordination (b) Preparation of data; (2) Stage Workshop specifications (a) Information, (b). Function, (c). Creative; (D) evaluation, (e) Development, (f) presentation; 3. Stage Post Workshop (a) The final report (b) Implementation, (c) Project Follow-up, can be seen in Figure 2.

2. 10 of the most influential factors affecting the cost optimization on D-Wall job-based Value Engineering includes: (1) Location; (2) Completed drawings and specifications; (3) The cost efficiency; (4) Increase the value of the function; (5) The value of better project; (6) Careful planning; (7) The collapse of the ground borehole; (8) Low productivity tools; (9) Cost Model; (10) Fluctuations in the price

3. From proven research of case studies that optimize the work of D-Wall-based Value Engineering increased performance at the failure by the cost with savings of 18.83%

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