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Application of Value Engineering on the Construction of Tertiary Irrigation Channel

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Abstract: This study intends to find the construction material which can be used for changing masonry lining on the irrigation channel and to know the cost saving by changing the construction material on the tertiary irrigation network in Jengglong Village-Sutojayan District-Blitar Regency-East Java of Indonesia. The methodology consist of to determine the research objective such as the person, event, background and document and then to carry out depth study about the research objective as a totality due to each background and contex for understanding the available relation among the variables. The result is hoped as the solution for the government of Blitar Regency in selecting the construction material for building tertiary irrigation channel as an effort for saving the government funding. In addition this research is intended to keep health the environment without taking the masonry so there is no degradation on river bed. At least, the result can be used for completing the regulation about construction material for building the tertiary, secondary and primary irrigation channel.

Key words: Construction material, irrigation channel, engineering value, tertiary, degradation

INTRODUCTION

Irrigation development in Indonesia has been going on more than one century so there can collect the valuable experiences which are very useful for incoming irrigation development (Hoesein, 2011). Irrigation as one of the supporting component on the development successful of agricultural sector has a very important function. The sector has a significant donation in forming Brutto domestic product, the increasing of devision and farmer prosperity, so the agricultural development can be said as the moving motor and supporter of national economy. Supplying of irrigation water for agriculture is naccessary to be managed with a wise and sustainable manner so the successful and the function is more and more maintained. The management and the function has to be carried out wisely and fairly distribution so it can give any benefit in agricultural field (Hoesein, 2011). As an effort to increase the food production, it can be carried out through the management of irrigation water allocation accurately and efficiently (Hoesein, 2011). In order to obtain the accurate and efficient management of irrigation water, irrigation water discharge has to be well managed so that the volume ia fixed due to the plan. An important thing for keeping the continuity of irrigation water discharge is to keep the irrigation channel is not leaking such as by developing the water proof construction on the wall and bed of irrigation channel.

The number of irrigation network development included to develop and to rehabilitate irrigation channel in Blitar Regency is more due to the government program about food holding and increasing of farmer harvest product. In developing physical irrigation network, there are some constraints. One of them is the availability of raw material especially the masonry lining which during the time there is using the very limited availability of masonry tiumes. In addition there is very diffiocult permit of mining and entrenchment. The development of irrigation network is not only considering the raw material but it is also considering the other things although, the raw material is as a very urgent consideration because there is no guarantee the availability of raw material during the development process until development finishing. For being able to carry out the irrigation network development, the difficulty to obtain the masonry lining can be changed by technology and optional changed material or the other alternative which has quality value and proportional strength and it can give the guarantee during the development period which has more effective cost if compared with the construction cost of masonry lining.

Base on the problem as above, it is needed to study the change alternative of masonry lining construction by using the other material that is more optimal and effective in cost and has the same strength as the previous construction material. Therefore, this study intends to

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apply the value engineering on the tertiary irrigation network in Blitar Regency-East Java Province of Indonesia.

MATERIALS AND METHODS

This research uses the descriptive method. According to Bogdan and Biklen (1998), case study is as the detail evaluation to one subject or a certain event. Surakhmad (1986) made a limitation of case study approach as an approach by making attention on a case intensively and detail. Meanwhile, Yin (1994) gave a more technical limitation by emphasizing on its characteristic. Ary *et al.* (2006) explained that in case study, a researcher had to evaluate unit or individu depthy. Based on the limitation, it can be understood that case study consisted of the research objectives caould be as human, event, background and document; the objectives were studied depthly as a totality due to each background or background that was intended to understand the relation among variables.

Before carrying out the research process, a researcher has to carry out the step of preparation which consists of collecting or finding the data of project. The finding of data can be carried out on consultant, contructor as well as on Water Resources Department of Blitar Regency which handles the project. After obtaining the project data, then the researcher will survey to project location for getting the general illustration about field condition. Besides it, the researcher also carries oit literature study through the reference book, internet, rules of General Work Department (now is as the Ministry of General Work and Society residence of Indonesian Republic) and the other rules which can be become as additional reference. This research conducted in Jengglong Village-Sutojayan District-Blitar Regency and the location of study is as in Fig. 1.

Irrigation area set is meaned as a setting of lands which will be flowed in some part areas and the setting of water flow network by building the structure that can regulate water distribution to the part of land and also the developing of channels and structures which can fluent the flowing and drainage of water. Irrigation area consists of pimary, secondary, tertiary and quartery irrigation area. Lay out of irrigation network is as in Fig. 2.

Ferro-cement is as a variant material of reinforced concrete but the thickness is only about 10-40 mm. Ferro-cement as a reinforcement is used as wiremesh. So far the wiremesh has been as the main option on ferro-cement. In implementation, the using of channel lining with ferro-cement is cheaper and more economic

Fig. 1: Location of study

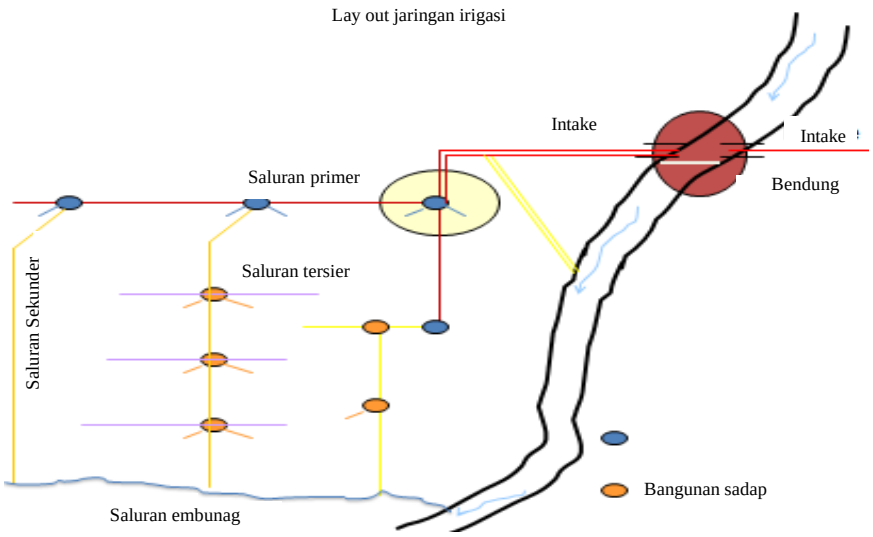

Fig. 2: Map of irrigation network; KP-01

than with masonry lining. Ferrocement is a construction material that proved to have superior qualities of crack control, impact resistance and toughness, largely due to the close spacing and uniform dispersion of reinforcement within the material. One of the main advantages of ferrocement is that it can be constructed with a wide spectrum of qualities, properties and cost, according to customer's demand and budget (Fahmy *et al*., 2014) There are two implementation methods on channel lining by ferro-cement as follow:

To print the concrete for channel lining in certain placeand there is different understanding about channel lining by ferro-cement. In general locationthere is reinforced concrete with the mix of sand, breaking stone, portland-cement and reinforce while it is really has to be as ferro-cement with the mix of sand, portland cement, reinforced iron and wiremesh without breaking stone as suggested in Technical Rule of Rehabilitation (JITUT, Irrigation Network of Farmer Effort Level and JIDES, Village Irrigation Network).

Reinforced concrete is casted in location or channel (*in-situ*). On the first method can be carried out by the conditional that there is a wide area for casting and there are needed enough employers for moving the casted concrete to the channel. While for the second method, the implementation of casting is directly in the channeland it is needed the special expert and some dimension of casting which has been prepared before. However, it is faster in implementation and there is not needed a wide area as in the first method.

In the implementation of construction by giving lining, it is good if the channel dyke is formerly compacted, so the lining is more stable. The thickness of masonry lining is about 7-10 cm. The lining has to be given the coperant in the end or bed. The ferro-cement lining which consists of sand, Portland cement, reinforced iron and wiremesh without breaking stone is stronger to the tensile strength, so the available wiremesh will gives double strength. Therefore, the implementation of channel lining is said to be accurate by using ferro-cement because it is practice. The using of ferro-cement has not been more to be applied because the society in many places work as usual as possible and they feel not too fixed with ferro-cement compared to masonry lining with bigger dimension and it is seen strong. There are more material that can be used for channel lining but in Indonesia there is only four material that are suggested to be used such as lining by stone, concrete, land and it can also be used the ferro-cement. The process of selecting suitable ingredients of concrete and determining their relative quantitieswith the objective of producing a concrete of the required strength, durability and workability as economically as possible, is termed the Concrete Mix Design (Sharma, 2015).

Ferro-cement has still not more used so it is needed scientific research so it is can be widely used. There is not suggested to make lining with the other material because it is difficult to get the available material, technique of implementation is so difficult and the weakness of the material itself. Ferro-cement material consists of the mix of cement, sand which is given the reibforcement concrete with the diameter of 6 or 8 mm and wiremesh. The ratio between cement and sand is safely determined in

laboratory. The advantages of using ferro-cement are construction cost is lower than the other conventional lining; ferrocement is stronger in concrete strength; ferro-cement has lighter construction so it can be used in the land with low carrying capacity.

To analyze the channel dimension of ferro-cement lining, it remain uses the parametres of Strickler formula with the roughness number for concrete is 70 (k = 70). Maximum dimension of ferro-cement reinforcement is determined empirically on the same type of construction that has been implemented before. Minimum radius of ferro-cement (r) is 0.45 m or maximum of b is 0.90 m, freeboard is 0.1-0.2 m, minimum velocity of flow (v) >0.6 m sec^{-1}, so sand or mud is not settled along the channel.

The characteristic of value engineering: Value engineering is one of the most effective techniques available to identify andeliminatun necessary costs in design, testing, manufacturing, construction, operations, maintenance, procedures specifications and practices (Singh and Jagdeep, 2016). The engineers have always tried to reduce the cost of construction without affecting the quality and the functional utility, however their approach was based mainly on the past experience. Keeping the costs low with trad itional cost management has been a commonly applied measure to improve competitiveness. However, keeping cost down alone is not enough, there is an increasing need for improve in schedule as well as efficiency and effectiveness. Saving money at the same time, providing better value is a concept that everyone emphasizes (Rane and Prof, 2016).

In value engineering, there are three items which become as the implementation key for making decision. The three items are as follow:

Value: The meaning of value is difficult to be differentiated with cost or price. Value has subjective content moreover if it is related to moral, estetica, social, economy, etc. in the discussion of value engineering; value is only related with economy. The meaning of value is differentiated with cost because of as follow (Soeharto, 1999):

- The size of value is determined by function or usage. However, price or cost is determined by the substance of goods and the price of components that forms the goods
- The size of value has a subjective trend but cost is depended on monetary value, the spending that has been carried out for the goods

Cost: Cost is as the number of the whole effort and spending that is carried out for developing, producing and applying the product. Producen always produce as the impact of cost due to the quality, reliability, maintenance. Therefore it will be affected to the cost for user. Developing cost ia as the big enough component of the cost total. However, the attention to production cost is very naccessary because it often contents a number of unaccessary cost (Soeharto, 1999). As the other controlling activity, cost analysis is also naccessary as the base or comparison for measuring the collected factson the information stage. The more important of cost analysis which is needed and to give the way of dicesion making about the effort that is needed for the next such as if based on the value engineering is estimated that cost for producing a product is too more expensive, it is very possible to stop the production or to find the other alternative.

Function: The understanding about function is very important in studying value engineering because function will become as the main object in the relation with cost. To identify, LD Miles presented as follow (Soeharto, 1999); A system has variety of function which is classified into 2 categories as follow; Basic function is the main reason of implemented system such as road, the main function ia as a tool for fluentiung the traffic and it is stimulating to maintain. The characteristic of basic function is after determining it can not be changed. If a toll is missing the basic function, it means the missing of sale value in market that sticks on the function.

Secondary function is the indirect usage for fulfilling the basic function but it is needed to support it. Secondary function can seldom cause the unlike things. To identify function with easy way is by using verb and noun. If it has not to be able to explain with the two words, it means that the available information is still less for identifying the function.

RESULTS AND DISCUSSION

Based on the determination process of alternative by using Zero-one method, there is obtained the selected alternative is ferro-cement lining as the changing of masonry lining. Ferro-cement uses concrete with the quality of K175 and it has been carried out the test of concrete pressure strength in laboratory of concrete construction. The selection of ferro-cement with the concrete quality of K175 is in order to get the production of concrete manually is easier because the higher quality of concrete needs the more accurate control in producing it.

For the lining of wall and channel bed of tertiary irrigation channel in Jengglong village-Sutojayan District-Blitar Regency is enough by using ferro-cement

lining with concrete quality of K175. The strength or quality of willing concrete is depended on the component of concrete base material mix. For concrete of K175 will be used the mix of 326 kg of cement, 760 kg of sand, 1,029 kg of gravel and 216l of water. The value of concrete pressure strength is obtained from the test of sample which is generally used such as in the form of cylindric with the height of 300 mm and diameter of 150 mm with time of test during 28 day. Result of concrete test is the concrete pressure strength = 175 kg cm^{-2}.

Before analyzing the cost budget plan of ferro-cement lining, at first there is analyzed the construction strength of ferro-cement. The section of existing channel is remaining hold and it is given the ferro-cement lining with the thickness of 5 cm. By using Strickler formula as follow:

$$V = kR^{2/3}I^{1/2};\ A = (T+b)^{h/2}$$

$$Q = VA;\ R = A/P;\ P = b+2h$$

Where:

V = Mean velocity (m sec^{-1})
R = Hydraulic radius (m)
I = Slope of channel bed
A = Area number of section (m^2)
P = Roving wet (m)
b = Base width (m)
m = Slope of talud
h = Water depth (m)
Q = Channel discharge (m $sec^3 sec^{-1}$)
K = Rouighness coefficient of Strikler

There is obtained the section and maximum water depth then it is used as the analysis of ferro-cement lining and cost budget plan. Result of channel dimension analysis is presented as in Table 1 and the long section of ferro-cement lining is presented in Fig. 3.

Table 1: Dimension of channel with slope of talud (m) = 1

B (m)	H (m)	F1(k – 25)	F2 (k - 30)	F3 (k – 35)	A (m^2)
0.400	0.340	2.041	2.449	2.857	0.252
0.400	0.350	2.160	2.592	3.024	0.263
0.400	0.360	2.284	2.740	3.197	0.274
0.400	0.370	2.411	2.893	3.376	0.285
0.400	0.380	2.542	3.051	3.559	0.296
0.400	0.390	2.678	3.213	3.749	0.308
0.400	0.400	2.817	3.381	3.944	0.320
0.500	0.100	0.271	0.325	0.379	0.060
0.500	0.120	0.370	0.444	0.518	0.074
0.500	0.140	0.483	0.579	0.676	0.090
0.500	0.160	0.609	0.731	0.853	0.106
0.500	0.180	0.750	0.900	1.050	0.122
0.500	0.200	0.904	1.085	1.266	0.140
0.500	0.220	1.074	1.288	1.503	0.158
0.500	0.240	1.257	1.509	1.760	0.178
0.500	0.260	1.456	1.747	2.038	0.198
0.500	0.280	1.669	2.003	2.337	0.218
0.500	0.300	1.898	2.278	2.658	0.240
0.500	0.320	2.143	2.572	3.001	0.262
0.500	0.340	2.404	2.885	3.366	0.286
0.500	0.360	2.682	3.218	3.754	0.310
0.500	0.380	2.976	3.571	4.166	0.334
0.500	0.400	3.287	3.944	4.601	0.360
0.500	0.420	3.615	4.338	5.061	0.386
0.500	0.440	3.961	4.753	5.545	0.414
0.500	0.460	4.325	5.190	6.055	0.442
0.500	0.480	4.707	5.648	6.590	0.470
0.600	0.100	0.323	0.388	0.452	0.070
0.600	0.120	0.440	0.528	0.616	0.086
0.600	0.140	0.573	0.687	0.802	0.104
0.600	0.160	0.721	0.865	1.010	0.122
0.600	0.180	0.885	1.062	1.239	0.140
0.600	0.200	1.064	1.277	1.490	0.160
0.600	0.220	1.260	1.511	1.763	0.180

The bold value is being used

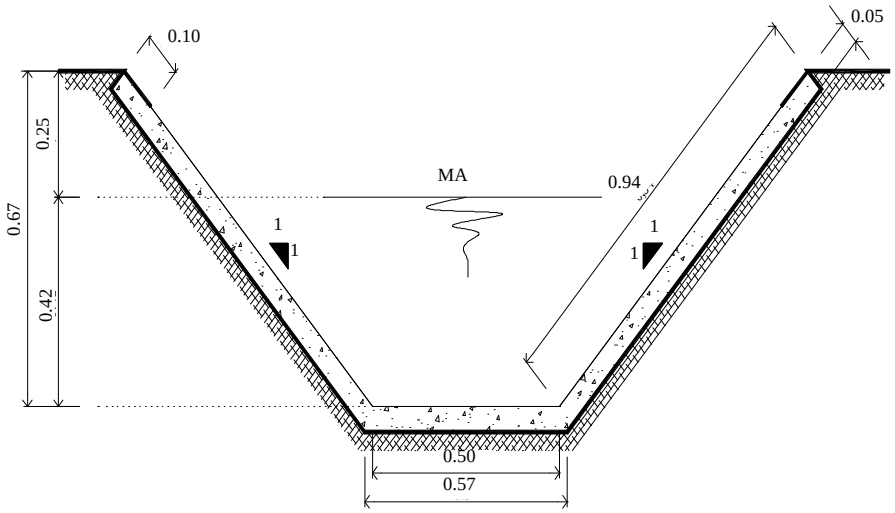

Fig. 3: Long section of ferro-cement lining; Source: analysis result

Table 2: Price quantity list of ferro0cement lining

No.	Description of activity	Unit	Code of analysis	Vol.	Unit price (Rp)	Number (Rp)
A	**Preparation work**					
1	Bouwplank	Ls		1.00	75,000.00	75,000.00
2	Board of name	Unit		1.00	450,000.00	450,000.00
3	Rent of director kit	Month		1.00	500,000.00	500,000.00
4	Cleaning	Ls		1.00	350,000.00	350,000.00
B	**Lining work**					
1	Cast concrete f'c = 7.4 Mpa (K.100) Slump (12±2) cm, w/c 0.87	m^3	B.02b	4.20	856,129.58	3,595,744.22
2	Begesting lining	m^2	B.22	65.8	148,842.20	9,793,816.76
3	Plestering mix. 1 pc : 3 psr	m^2	P.04e	7.00	61,352.73	429,469.11

Total A = 1,375,000.00; Total B = 13,819,030.09; Total (A+B) = 15,194,030.09; PPN 10% = 1,519,403.01; Total = 16,713,433.10; Rounding off = 16,710,000.00; Name of work: Tertiary channel design of LT, T2; Location of study; Lodoyo Irrigation area Sutojayan District-Blitar Regency; In words: 16 millions 7 hundred and 10 thousands rupiah

Table 3: Recapitulation of price quantity list on ferro-cement lining

No.	Description of work	Total
A	Preparation	1,375,000.00
B	Lining	13,819,030.09

Total (A+B) = 15,194,030.09; PPN 10% = 1,519,403.01; Total = 16,713,433.10; Rounding off = 16,710,000.00; Name of work: Tertiary channel plan of LT, T2 Location of study: Lodoyo Irrigation Area-Sutojayan District-Blitar Regency; In words: 16 millions, 7 and 10 thousands rupiah

Table 4: Cost comparison between masonry and ferro-cement lining

Lining (Length of channel = 50 m)	Cost (Rp)
Masonry	31,890,000.00
Ferrocement	16,710,000.00
Saving	15,180,000.00
Percentage	47.60

After obtaining the result of concrete test and the composition of mix which has been determined, then there is carried out the analysis of cost budget plan. List of quantity price for the construction of ferro-cement lining on tertiary irrigation channel in Jengglong Village-Sutojayan District-Blitar Regency is presented as in Table 2. Rcapitulation of price quantity list is presented in Table 3 based on the analysis by using masonry and ferro-cement lining, there is produced cost comparison between both of them as presented in Table 4.

To make easier, the ferro-cement lining can be carried out by at casting it at first as ferro-cement plaque and then installing it in the selected location or it can also be done by casting in place.

CONCLUSION

Based on the value engineering analysis on tertiary irrigation channel in Jengglong Village-Sutojayan District-Blitar Regency-East Java Province of Indonesia, it is concluded as follow: Based on the analysis and comparing some changing material of masonry lining on tertiary irrigation channel in Jengglong Village-Sutojayan District-Blitar Regency-East Java Province of Indonesia, the most accurate changing is ferro-cement lining such as concrete lining with quality of K175 and the thickness of 5 cm. The cost saving of construction material changing on tertiary irrigation channel in Jengglong Village-Sutojayan District-Blitar Regency-East Java Province of Indonesia is Rp. 15,180,000.00 or 47.60% for tertiary irrigation channel along 50 m.

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