Optimization the design of irrigation and drainage networks using value engineering - case study; Jofair irrigation and drainage network, south west of Iran

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Abstract:

According to united nation Food and Agriculture Organization estimates, the extent of irrigated lands in developing countries between the years of 1999 and 2030 should increase by 20 percent or 40 million hectares for these countries to be able to cope with their ever increasing population (FAO 2002). One of the effective methods of ensuring the success of such irrigation and drainage projects is value engineering. reviewing on the reasons of success or failure of numerous irrigation and drainage projects shown that using the experiences of under operation irrigation and drainage networks and consider them in under study project can play a significant role in optimizing and improving the irrigation and drainage systems. The structure of group work in the value engineering method makes it possible to consider the operation phase experiences to be implemented during the design stage of the project. All the other factors such as the experts with valued opinions and all the other factors involved during the development of the project such as the employer of the project, the projects designer, contractor, the value engineering consultants, operators,

university professors, financial experts and investors all can be gathered in a defined structure so that the project can become the subject of the study and optimized in this way.

Jofair irrigation and drainage project, part of Karun River's basin, with a gross area of 40000 hectares is located in Khuzestan plain, south western of Iran. Because of delays between the design and construction stages, also due to change of the department responsive for the project (its responsibility was transferred from agriculture ministry to water and power ministry), it was decided to carry out value engineering studies for this project. The value engineering studies of Jofair irrigation and drainage network were carried out as the following list shows: Pre study, data Analysis, function analysis, determining the areas for improvement, gathering ideas and opinions, and expansion and development of all above and for optimizing this design the experiences gathered from the neighboring irrigation and drainage networks of sugar cane development were also used.

As the result of this value engineering studies nine changes in this project were suggested which result in reduction in costs and investment which comprise of the following: Revaluation of cropping pattern and cropping density, irrigation requirement, use of artificial filters instead of mineral filters in subsurface drainage, revaluation of layout of irrigation and drainage network, reduction in canals freeboards, using low pressure irrigation systems, redesigning the canals taking into consideration of the soil used in their construction, use of relative grading over parts of the land with an eye to the heavy leaching, revaluation of flexibility coefficients, reduction in depth of drainage and decreasing the space between the drains: Also by replacing the scattered drainage pump stations with a central station for disposal of drain water. There is the possibility of reducing operation costs.

Apart from the changes which result in reducing the costs there are also other changes which have no role in reducing costs in the life of the project but promote the operations of the project; change in diameter and material of drainage collectors and use of hydro flumes instead of head ditches. The reduction rate in cost by implementing these ideas has been estimated at more than thirty percents.

Keywords: value engineering, Hydro flume, low pressure pipelines, drainage depth, collector, drain water, system layout, flexibility coefficients

1- Introduction

The upward trend in investment in national projects, and the limitation in these resources, has resulted in paying particular attention to specializing in optimization of resources as an essential process in project management. A reflection on the success and failure reasons of numerous experiences brings this clear and important conclusion that paying attention in the various stages of design and eradication of any obscurities plays significant role in the success of the projects and attaining the objectives with the minimum possible cost and maximum possible available quality. Sufficient deliberation in design stages of the project and making use of experienced and innovative designers and consultants, not only reduces the cost and improves the quality, but it also makes it possible to achieve the goals of the project according to the needs and requirements of all the concerned parties benefiting from the project one of the effective and practical approaches in project studies, for the purpose being on of the effective and practical approaches in project studies, for the purpose being certain of achievement of the correct details desired by the beneficiaries, certain of achievement of the correct details desired by the beneficiaries, is through value engineering. Value engineering is one of the methods with a systematic application and by relying on innovation and team work, while studying the project thoroughly and meticulously, which provides opportuniti8es to improve the project economically and in quality as well as savings in time.

Since the studies of " Jofair irrigation and drainage network" project was done in 1998 by the designer consultant taking into consideration the prolonged elapse of time since then, for the execution of this project as well as change of employer (from agricultural regeneration organization to Khuzestan water and power organization) after the expert studies and justification studies of conditions of the project, it was decided to do value engineering studies for this project.

2- An introduction to the Jofair irrigation and drainage network project

Eesargaran cooperative irrigation and drainage network project (Jofair) is an irrigable part of Karun River; with a gross agree of 40000 hectares, situated 25 kilometers south west of town of Ahvaz, in the lands east of river Karun. The rate of designated water rights to the project has been determined at 40 m^3/second and the design of this irrigation network project is based on these figures and the cost of this project has been estimated at 500 million US dollars.

For the purpose of taking water and supply of energy for the transfer of the water needed by these lands from the river a pump station will be used. This water will be transferred to the beginning of land through a canal, which is at the earth work stage at the moment, and then it will be pumped from there to the project lands by a second pump station. Due to the very low angle of slope of the lands in this area all the irrigation canals of the network have been designed at earth work stage. These canals comprise of a range of main canal, 5 series of grade one and 32 series of grade two canals. The main network of Jofair drainage comprises of a series of main canal, one of grade one drains and 12 series of grade two drains with a total length of 230 km. the waste water of the grade one drains is discharged into the main drains of the project and then it is transferred to the outside of the bounds of the network by the pump station of the main drainage. This station is situated at the very for end of south west of the project lands near the border guard sation of Koushk.

3- Value engineering of the project, the principle and the outcomes:

The value engineering workshop of Jofair irrigation and drainage network project was installed with the participation of value engineering team members comprising of the project's employer, the consultant designer, the contractor, the value engineering consultant, the exploiters, the university lecturers, free lance experts and financial experts. This work shop studies the feasibility of optimizing and reducing the costs of this project in three arguments of: location establishment of irrigation and drainage network, the principles of design of irrigation system and also the underground drainage system. This article will review the resulted outcomes of application of value engineering method in the principles of design of surface irrigation networks of Jofair irrigation and drainage network.

According to the value engineering system, the effective and key factors in the success of the project from the team member's point of view should first be identified and defined. These criteria will be the evidence in valuing and grading the ideas in the process of optimizing in value engineering. The standards emphasized by the value engineering team members in Jofair irrigation and drainage

Network is as out lined in the following list:

1- Protection of the environment
2- Ease of exploitation
3- Ease of operations

4- Reduce the costs in the investment

5- Possibility of producing the materials at the location or the chances of their supply locally in the area.

6- Availability of operational technology for the project

7- The possibility of operation and exploitation of the project in different phases.

8- Reduce the costs of exploitation.

3-1- Using hydro flumes instead of grade four canals:

The descriptions of preliminary design: In the preliminary design a range of grade 4 canals are used on the upstream of each farm (in an approximate area of 10 hectares) for irrigation each section or watering rows.

The description of suggested design: A range of flexible pipes equipped with gates will be used in place of the earth canals. If seems that it takes only a third of the time to do the suggested design in comparison to the preliminary design taking into consideration the fact that the hydro flumes are already built. To executer this project around 600 km the existence of foundation installations and the production technology of this product in the local sugar industries lateral companies, there does not seem to be any problems in supply of the needed product for this project. Considering the 3 years useful working life of hydro flumes, in comparison with 3 times demolition and construction of grade four canals in that period there is no difference in the investment costs with the original design

Advantages and quality outcomes:

1- Improvement in water distribution efficiency.

2- Elimination of grade four canal costs at the end of each cultivation cycle.

3- Ease of exploitation

4- Speed of implementation of operations

5- Elimination of application of siphon.

6- An average useful working life of 3 years

7- Better control and regulation power over distribution of water in the farms

8- Reduction in the wasted area of the farms

9- Reduction in labor costs.

The pitfalls and the risks of execution:

1- The blockage problems caused by low quality of water

2- The problem of breakage by animals or inappropriate exploitation

3- The increase in the height needed in the canal and consequently the extra earth work needed because of this excessive height, in the grade three canals.

3-2- using a low pressure irrigation system

Description of preliminary design:

For irrigation of the agricultural regions (in an approximate area of 120 hectares) the trapezium concrete canals of grade three are used in the preliminary design over a length of 1000 m for each area.

Description of suggested design:

PE or GRP pipes measuring 60 cm in diameters can be used instead of grade 3 canals, because for the first 70 percent of grade two canals, there is sufficient head for the low pressure irrigation system to be used. The speed of water in such pipes is about 0.8 m/s and the speed of the module in use is 2 l/s/h. the technology of manufacturing these pipes already exists in Khuzestan province and the country. A bout 300km in total of grade three canals has been forecasted for the whole project. Taking into consideration that low pressure irrigation system can be used in 70% of these canals (210 km) and the duration of 4 years period execution, about 53 km of pipes in needed in a year. According to the estimations carried out, the cost of executing this method in comparison to the preliminary design, there will be a 14% reduction it is estimated that there will be 60% reduction in the time taken for execution of secondary irrigation network in the method using this technique.

The advantages and quality out comes:

1-Improvement in the transfer efficiency due to reduction in subsidence

2- Reduction in wasted agricultural lands

3-Ease of protection of pipes against the natural elements

4- Ease and speed of implementation.

5- Elimination of grade three canal’s excavation operations and reduce the need for material loan resources.

The pitfalls and the risks of execution:

1- The need for excessive head height at the beginning of the canal in comparison to the canal.

2- The need for a structure at the junction of grade three and grade four canal for regulating the pressure.

3- Taking into consideration that agriculture with the above forecasted module of (2 l/s/h) may not materialize in a 100 hectare farm, thus the speed is reduced and sedimentation may occur.

3-3- Reflection on the transfer canal design taking note of earth quality:

Description of preliminary design: The transfer canal will be constructed at a depth of 4 meters and the produced earth from the excavation will be used as a source of material loan for other earth work operations.

Description of suggested design: Taking into consideration the existence sliding sandy layers in depths of between 2.5 and 4 m in the canal route, some solution for feasibility of maintaining the falling slope in the route of the canals must be reached. In order to obliterate this problem it has been suggested to keep the depth of the transfer canal to only 2.5 m at most and to make up for the lost depth, widen the canal itself. As a result of implementation of this solution, not only the problem of facing with the layer of sliding sand will be eradicated and there would not any sustainability problems in the transfer canal any longer, but also due to widening of the canal a higher volume of earth suitable for loan resource in other parts for the project will be obtained as a result of this excavation according to the executed laboratory tests the local soil lacks the problem of divergence too. These changes will result in a nearly 40% reduction in the duration of transfer canal operation execution and almost 15% savings in costs.

Advantages and the quality outcomes:

1- Ease of operations

2- No need to carry away the unsuitable extra sand

3- Improvement in the quality of extracted earth as loan material resource.

4- Reduction in unnecessary costs incurred by longer periods of operations execution.

5- Reduction in keeping costs and renovation cost during exploitation period.

6- Elimination of sandy bed fixing costs.

7- Reduction in leakage of underground waters into the canal construction area during the operations and reduce the problems and costs associated with pumping out the extra water.

8- Reduce the costs of operations execution at underground sub water levels.

9- Sustainability and stability of structures during exploitation period due to reduction in pressure increases caused by underground water levels.

The pitfalls and risks of execution:

1- Reduction in efficiency of water transfer of water caused by larger wet area.

2- Increase in problems associated with dredging and exploitation

3- Increase in owner ship of lands.

3-4-Use of a relative leveling in some sections of lands:

Description of preliminary design:

Basic leveling operations project in the whole land in order to create a suitable slope for irrigation operations

Description of suggested design:

The leveling operations will be eliminated, due to the suitable general slope over the project area and from the previous experiences gained from sugar cane cultivation farms of Khuzestan sugar cane cultivation industry units, because of the necessity of leach ate operations following leveling activities and also because of application of irrigation method in bottom enclosed sections of the farms, the leveling operations will be completely eliminated in areas of less need for leveling activities, except in places where constructions have been built by human hand. In order to be absolutely certain of this decision, it is necessary to implement this method in a few pilot farms and by taking notice of the collection of factors, effecting the application of irrigation operations, the level of elimination of leveling operations studied and then the decision in regard to necessity or lack of necessity in leveling operation will be taken accordingly.

Advantages and the quality out come:

The soil of the farms will remain untouched and would not be subjected to changes in its shape after the very first irrigation operations

The pitfalls and the risks of execution:

Will be reduced where proper irrigation is not possible due to the unsuitable topography of the land.

3-5- Reflection on determining the capacity of canals:

Description of preliminary design: As rice is a popular product for consumption by the people, the canal capacity has been determined based on this fact of highly needed product and this basically 2.73 l/s in each hectare of cultivation land. In addition to that the flexibility coefficient, relative to the land covered by the canal has been considered in designing the canals which is between 1 and 2.33.

Description of suggested design: it is suggested that the calculation of hydro module irrigation is low based on patterns used in multi cultivation farms and reduce the flexibility coefficient to its minimum because based on patterns used in multicultivation farms and reduce the flexibility coefficient to its minimum because based on previous experiences the abundance and availability of water is a cause for reduction in efficiency of consumption and taking into consideration the water shortage crisis throughout the world, especially in dry and semi dry terrains of the world that Iran is part of, it is recommended that the flexibility coefficient and hydro module of lower figures are forecasted.

It seems that reduction of about 20% in hydro module of the farm can produce saving of about 15% in the whole operational costs of secondary canal in the form earth canals excavation operations. This would materialize when the construction of secondary network in the shape of low pressure pipes occurs and reduction of this rate of discharge would necessitate the use of pipes with lower diameter and would resulting more substantial savings in the costs too. Application of hydromudule and new coefficients in the main canal will create reductions of about 15% in the dimensions of canals and savings of about 10% in the main network, while this would reduce the rate of taking of water, this would also result in costs of exploitation of the network

Advantages and the quality out come:

1- Increase in efficiency of irrigation because of inaccessibility of extra water.

2- Reduction in subsidence and prevent the stagnation of water in the grounds

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