J. Appl. Environ. Biol. Sci., 4(5)263-270, 2014

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Financial and Time Management of Reassembling and Exiting Gavoshan OPEN T.B.M from the Value Engineering Point of view

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Received: January 14,2014
Accepted: April 30,2014

ABSTRACT

Gavoshan water carrying tunnel with a length of over 20.139 km is located in the south of Kurdistan province. At the end of the studies, after examining various option and procedures of implementation, tunnel option with broken and drilling route by using a combination of semi mechanized and explosive procedures from the input side and drilling machine open T.B.M from the output side was chosen. facilitate the drilling operation of the tunnel, during the time of the excavation, 4adit tunnels called kachaleh, Sarbenav, Haltoushan and Tavankash with a total length of 3666 meters were dug in the route.The exit of T.B.M device after completing the drilling process from the main tunnel was another objective of drilling the auditing tunnel of Haltoushan. Due to the large cross section of the tunnel, the method of implementation intended included the phase of excavation on the top step taken at first and bench (floor taking) at the end. Accordingly to accelerate the drilling operation of the main tunnel only the excavation of the access tunnel was done in the first phase.Excavation of the access tunnel bench (floor taking) was to be carried out. According to the efficiency of workshop on the other fronts, floor tunnel operation throughout the remainder of 1385 meters had to be done and the time required was only about 4 months. Due to this and in order to expedite the exit of machine from the tunnel and to start the concrete lining operation of the main tunnel, the workshop management was determined to use value engineering techniques to reduce the time of this operation and to meet the objectives of the approved schedule.One of the proposals of value engineering to improve the project is the financial and time Reassemble management and the exit of open T.B.M of Gavoshan in value engineering which by giving proposed procedure of value engineering workshop conditions were provided to save a considerable amount of 3 month time and monetary.

KEYWORDS:T.B.M, value engineering, tunneling, Gavoshan water carrying tunnel.

INTRODUCTION

Every year, significant resources are allocated to developmental works. Progressive increase of the executive costs has made it obligatory to omit a part of those costs which has no influence on quality improvement and unnecessaryin terms of application. By increase of the task complexity and demand pressure on this industry which is becoming more difficult, geometric application of value in executive projects could be changed to the tool of management discussion to control the costs. (Emami, 2006)Applying this method in Gavoshan project from the first place, a great deal of economy was managed. In fact, after approval of the plan designers and agreement of the project employer, the positive results of these changes have came to executive process that the role of each factors including the employer, consultant, and contractor in performing these revisions and realization of the application of value engineering is deemed considerable so that appropriate and on time operation of each one made the value engineering to be accomplished fluently in the collection and to be accepted as a logical procedure in the system. (KhademiHamidi, 2006) As the owner and responsible of the work, the employer factor has played a very fundamental and important role in value engineering. The employers' attempt to optimize the project in terms of costs and time is of utmost important problems and leading the collection in line with his legal demand has guaranteed the mentioned changes. (Jabalameli, 2010)Reforming the contractor's project and analyzing different options and holding expertise meetings and its comparison with the aims of the project and corresponding the options with other components of the project, the consultant system has had a pivotal role the process of value engineering. (Amberg, 2001)Providing the project of value engineering, the contractor has allocated the biggest optimization contribution in the project and in fact he has had the responsibility to start the process of value engineering from the basic point. (Nelson,2003)One of the proposals of value engineering to optimize the project is financial and time management of the dismantling and exit of the system OPEN T.B.M of Gavoshan. By introducing the proposed procedure of value engineering workshop those conditions were provided so that thesignificant timesaving of 3

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months and financial saving be carried out. (Saleheli, 2007) This paper attempts to illustrate on the procedure of the held value engineering workshop and finally to explain the applied procedure.

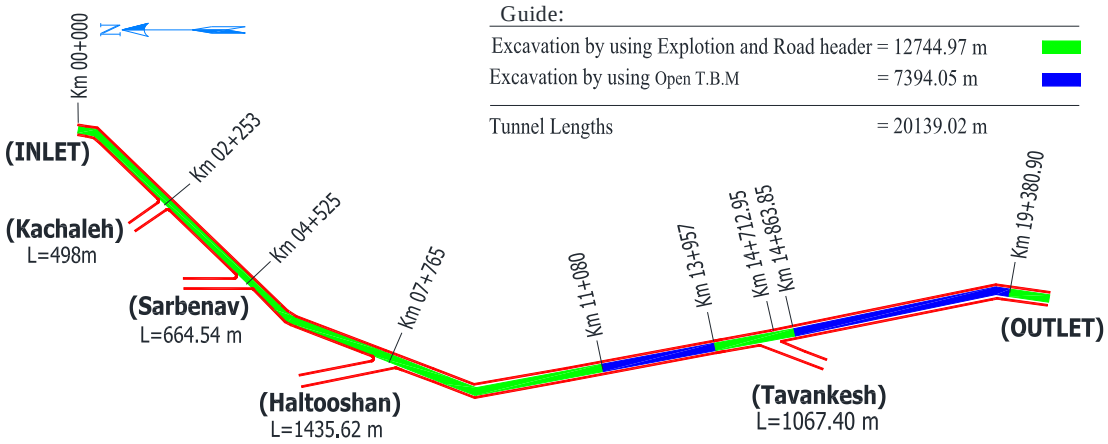
Outline

About the Project

Gavoshan national project includes a rock fill dam with a clay core of 123 meters high, hydro-electric power plant and a water transferring tunnel with length of 20/139 kilometers and a collection of diversion dams as well as irrigation-drainage networks. The aim of the project is supplying the agricultural water of Miandarband and Bilevar plains and supplying a part of drinking water of Kermanshah city, about 63 million cubic meters in a year and finally supplying hydro-electric energy of 11 megawatt. The area of this project encompasses a part of north of Kermanshah and south of Kordestan provinces in Iran. The northern part is within basin of the big SirvanRiver(the fifth river of Iran in terms of water flow rate) and the southern part includes northern branches of the Basin of Kahkhe River. Excavation of this river has been accomplished with three explosive, drilling and semi-mechanized methods by Roodhar and the drilling machinery was done by Open T.B.M.

In order to facilitate the excavation operation, strengthening and cementing the tunnel, creating more work fronts, aerating inside of the tunnel, traffic and proper discharge of the tunnel materials four branches of access tunnels were provided.

- ✓ Kachaleh Access with length of 489 meters in 2+253chainage
- ✓ Sarbanav Access with length of 664/54 meters in 4+525chainage
- ✓ Heltoushan Access with length of 1435/62 meters in 7+765chainage
- ✓ Sarbanav Access with length of 1067/40 meters in 14+712/95chainage



Picture 1.Gavoshan water transfer tunnel excavation plan

Specifications of the excavation device Open T.B.M

The device Open T.B.M of Gavoshan (S112) is a hard rock type which has been purchased from German Hernknscht Company and based on the constructor's declaration, the specifications of this device are as follows:

Main drive: 180 ton
Cutter disc: 7 double & 20 single & 6 Scraper plate
Advanced cylinders: 4 * 1600 mm / 340 mm
Max pressure nominal: 400 bar &**Fix :** 250 bar
Weight (hydraulic pump): 2 ton
Gripper cylinders: 8 * 500 mm / 450 mm
Max pressure nominal: 400 bar &fix : 220 bar
Weight of gripper: 4*7.5 ton
Weight of cylinder: 8*1.5 ton
Rear support: 2 * 1000 mm / 260 mm
Max pressure nominal: 250 bar &fix : 110 bar
Total force nominal: 12710 KN & fix: 6000 KN
Weight of cutter head: 70 ton
Weight of dust shield: 30 ton

Conveyer belt No: 1 @ 250 m^3/h & 14.5 m & 65 cm & 2.5 m/s
Conveyer belt No: 2 @ 240 m^3/h & 8 m & 80 cm & 2 m/s
Conveyer belt No: 3 @ 240 m^3/h & 90 m & 80 cm & 1.6 m/s
Water tank: 800 liter
Oil tank: 1200 liter
Oil tank + circuit: 3000 liter
Gear oil: 1500 liter

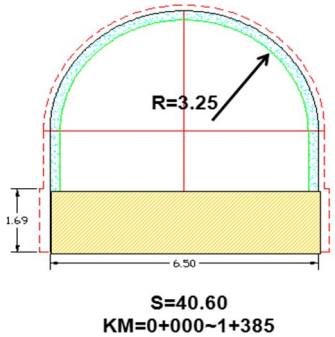
The initialexiting performance of the T.B.M drilling machine from the tunnel

According to the document of the contraction, the aims of the tunnel excavation of Heltoushan access (one of the four access tunnels) are as follows:

- ✓ Exit of T.B.M machine from the tunnel after finishing the excavation
- ✓ Passing through Morvarid fault zone during the excavation
- ✓ Aerating the tunnel because of changes in flow regime located on the access link to the transfer tunnel during exploitation of the transfer tunnel

Considering these aims, after finishing the excavation, the inside path of the transfer tunnel to the intersection of access tunnel and after that of the whole of the access length was laid the track and using the provided rail, the machine was taken out of the tunnel. Excavation of Heltoushan access was began from the beginning of the project in order to achieve chainage of 7+765. Because of the large cross-section of the tunnel including stage excavation the, the taken procedure in the first stage was Top removal and at the end it was Bench removal. Accordingly, in order to begin the excavation operation fast, the first stage of the operation was accomplished and then, excavation of the main tunnel began from two fronts. In order to exit the second stage machine of the excavation, Bench access tunnel was needed to be excavated too. According to the efficiencies of the workshop in other work fronts, and keeping an eye on the rest of the length of 1385 meters, the floor taking would last about 4 months. Based on this fact and in order to exit the device fast and beginning the concrete lining operation of the downstream segment of Heltoushan, the management of the workshop was determined to employ value engineering techniques to reduce the time of this activity and to achieve the scheduled program goals. The present paper and its documentation analyzes the conducting procedure and results of value engineering workshop and finally, it deals with the proposed method for exiting the device from the tunnel as well as the financial saving due to this change for the employer.

Picture 2. Finished T.B.M excavation in kilometer of 11+080 of the tunnel



Picture 3. The remained average level of the access tunnel in Bench area

The stages of value engineering workshop and choosing a method to exit the device

According to technical terms, value engineering could be defined as a way towards creating balance between expense s and functions of a product or project. Maintaining the functions, value engineering provides some methods by which the extra expenses could be removed and low-cost methods with higher quality and function could be used instead of the previous methods. In value methodology, a systematic schedule is used. The agenda proposes certain steps for effective analysis of a product or service to produce the maximum number of different options to achieve the required functions of that product or service. This agenda includes some stages as following Table:

Table 1.Value methodology agenda

Pre-study	Value study	Post-study
Collecting the requirements and the customer / applicant's needs	Data phase	Completing the changes
Providing data collection	Function analysis phase	Applying the changes
Determining the evaluation factors	Creativity phase	Supervising the changes and conditions
Determining value study area	Evaluation phase	
Determining the data model	Development phase	
Determining the members and management of the group	Proposing phase	

Having this aim, a value engineering team including workshop experts and specialists was made and it was attempted to find a strategy to exit the device fast and begin the concrete lining operation of the tunnel based on value engineering.

The first stage (pre-study phase)

At first and in the pre-study phase the required data for formation of value engineering workshop including the following ones were prepared with cooperation of the technical and mapping team of the office so that way will be paved to enter the study phase.

- ✓ Providing excavation of the downstream Heltoushan area after finishing the floor taking.
- ✓ Providing excavation of the Heltoushan access tunnel
- ✓ And …

Also, in this phase, the management of the workshop was introduced as the leader of the study and the value engineering team including the experts of the workshop and senior personnel of the device were determined. Then, it was decided that within the shortest possible time, the best proposal with the highest identifying value index be proposed and to be carried out.

The second phase (study phase)

By preparation of the conditions, the second stage (study phase) was began. According to the definition of SAVE International, this stage of value study includes 6 phases [1]. In the provided workshop to exit the device from the tunnel, the procedures were based on passing through each phase of this instruction which will be explained briefly in the following:

-Data phase

The benefits of a value engineering workshop are highly due to accuracy of the collected data. Considering this fact, the following cases to deliver the data to the workshop were taken into account in this section:

- ✓ Data collection and modeling focusing on exiting the device
- ✓ Complete understanding of the certain usages and functional requirements of the components
- ✓ Explicating the aim and structure of the study

Completing the data and relying on data presuppositions of each member of the team some of whom were present from the beginning of the project or a long time has passed from their presence in the workshop, the work shopbegan the second phase i.e. the study stage.

-The function analysis phase

The function analysis phase is the heart of the structure of value engineering. Having a right understanding in this phase, the answers to the following questions were answered in a collective brainstorming.

- ✓ What is the problem?
- ✓ Why is this matter a problem?
- ✓ Why is a solution necessary for this problem?

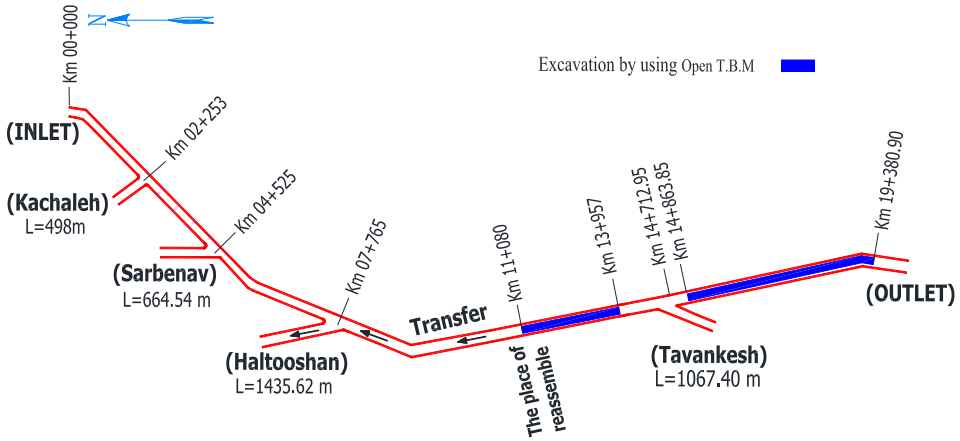
Then, accordingly, the related FAST diagram was formulated.

- Creativity, evaluation, development and proposing phase

After the above steps and formulating the related FAST diagram, the workshop entered into the creativity phase. In this stage, 6 suggestions were proposed from the workshop among which and keeping an eye on all of the opinions and considering value index of each one of the suggestions (based on EN definition) two following suggestions were introduced to the proposing phase.

- ✓ Transferring the device bogies into the tunnel and putting them under the main shaft of the device and then dismantling the device inside the tunnel and finally, after finishing the lining to the exit and laying the track of the path, transferring the device and its accessories through the rail line to the exit of the tunnel during 15 days.
- ✓ Dismantling the device inside the tunnel and transferring all pieces of the device through downstream Heltoushan and Heltoushan access to exit of the tunnel by a special bogie for transporting the heavy pieces.

After the required analyses of this phase with inviting the senior managers of the company and the representative of a specialist company in transportation of heavy pieces etc, the results of the development phase were evaluated and ultimately, the second option i.e. dismantling the device inside the tunnel and transferring all of the pieces through downstream Heltoushan and Heltoushan access to exit of the tunnel by a specific bogie for transporting heavy pieces was accepted and was submitted to the employer of the project to be examined.



Picture 4. The path of transferring the device based on the results of the workshop

The third phase (post-study)

In this stage, with agreements of the employer and supervision system of the project, the results of the value engineering workshop was prepared to be carried out. In the following, in order to become familiar with the used procedure the summary of this method will be explained.

The implemented method for exiting the Open T.B.M device from the tunnel

As it was noted I the previous section, according to the results of value engineering workshop and agreement of the employer of the project, the executing method of dismantling the OPEN T.B.M device inside the tunnel and transferring all of the pieces through downstream Heltoushan and Heltoushan access to the exit of the tunnel was chosen. Its executing stages were as follow:

According to the weight of the main head and shaft system of the device which is about 200 tons and the need of certain measures for its exit from the tunnel, the workshop conducted a contract with a transportation company in order to transfer a bogie along with the related trailer to the workshop.Inbogie system, the transferring path must have the least amount of bumps. For this, to move the device inside the access tunnel, the path was leveled and covered by lean concrete.

The first phase of dismantling

According to the high weight and large diameter of the collection, before transferring operation, like assembling time on the existing welds, after its separation from the cutting discs, the head of the device was divided to five pieces and then transferred on the floor and to the exit of the tunnel.

Picture 5. Dismantling the head pieces in the tunnel

The second phase of dismantling

In order to lightening the shaft and head systems, the maximum possible pieces were separated. After ensuring that the path is ready, the transferring operation of the shaft was begun by the bogie.

According to the space limitation of the tunnel and lack of maneuvering the crane to hold the main shaft in the tunnel and to transfer it on the bogie, a creative method of grippers of the device was used. In this phase, leaning the grippers with the maximum pressure (220 bar) to the wall of the tunnel and harnessing the shoes of the device using welding and metal supports to the frames of the tunnel, the bottom cleaner and rail support were opened, and the bogie was moved under the device. With releasing the grippersthe main shaft of the device will be put on the bogie and then the transfer operation to the exit was accomplished by pullers.

Picture 6. Dismantling the main shaft transference by bogie to the exit of the tunnel

The third phase of the dismantling

Exiting the shaft and head from the tunnel, at first different pieces of Backup unit including pipelines, cables and connectors were separated from each part and the support units were prepared separately for the transference to exit. After that, the support pieces were transferred to the exit one by one by relying on their ski bases and using the pullers.

Picture 7. Exit of the supporting system from the tunnel

Comparison of the first procedure and the employer's suggestion for dismantling and exiting the OPEN T.B.M device and its related time and financial saving

Based on the original plan to excavate Heltoushan access, the defined section was in detail of picture 3. These sections were considered with assumption of the exit of the TBM excavation device from the tunnel.

According to the above-mentioned things, excavation of the access tunnel was carried out. It was based on NATM method and stage excavation (because the defined excavation section for access was large) in form of removing the ceiling and a part of the wall in the first place, and finally, the removal of the rest of the wall along with the floor in the second stage (floor taking).in the suggested method, floor taking operation was omitted and the financial amount was saved.

Time saving

Risk management is the required set of processes to identify and to analyze and to react against risk of activities of a project in order to maximize the positive results and to minimize the negative consequences.

In fact, the executing time schedule of every development project is prepared based on the predicted risk of the employer, equipment, and the mentioned conditions on the contract and its ultimate goal is completion of project during the specified time. In most of the cases, according to the executing conditions and delay of the specified time, the schedule is revised based on the work conditions.

As it was mentioned earlier, in the beginning of the project, in order to dismantle and exit the excavation device, the rail of the transfer tunnel and Heltoushan access was seen and accordingly, based on the achieved results from the value engineering workshop and accepting the risk, the executive management embarked on changing the predicted method in the contract documentation to exit the T.B.M device. Change in the executing method might lead to financial and capital risks which could be emerged as three time, cost and quality forms.

Table 2. Comparison of advantages and disadvantages of the primary procedure and the proposed procedure

	Advantages	Disadvantages	Executing time/ month(s)
The primary procedure based on the plan documentations	-complete exit of the device from the tunnel	-floor-taking of the access tunnel with average height of 1.5 meters -laying the track in the tunnel with length of 4695 -increase in time of the project -high cost for the employer	4
The proposed procedure	-high speed in executing and reducing the executing operation time about three months -reducing the cost of executing operation and saving for the employer -higher safety during executing operation -removal of the tunnel rail with length of 4695 meters	-loss of some parts of the device -the need of using bogie for transporting the heavy pieces for the main shaft of the device -dismantling in a limited space with particular equipment	1

Financial saving

Based on the price list attached to the contract documents, the financial estimation of floor-taking of Heltoushan access tunnel is attached according to the primary plan and based on micro-meter of the attachment and financial tables.

According to this table it is clear that if the first procedure was performed (the predicted method in the tender documents), the employer would have paid a cost equal to 1256462$. But executingthe proposed method to exit the device, this amount of money was saved.

Table 3. Calculating the reward of the contractor and real saving of the employer

The performance cost of the first plan (dollar)	The costs of preparation, planning the changing suggestion by the employer (dollar)	The executing costs of the employer (dollar)	The contractor's reward (dollar)	The real saving of the employer after deducting all of the expenses (dollar)
1256462	125646	62823	427197	766442

With performance of this operation after analysis by the project's employer, based on the currency of Iran, the contractor's reward is 40 percent of the above amount i.e. 427197 $.

Conclusion

Potential equipment of applying value engineering analysis in execution of various constructions of big developmental projects is frequent and undoubtedly, according to its advantages in executing projects and its potential capacity to reduce the expenses and also according to limitation of the resources to execute the projects, this technology and its implementation must be in the focus of the duties of the project managers.

Since most of the usages of the technical methods of the value engineering are within the execution stage, the lack of the contractors' belief on this process and lack of the required motivation to contribute in this task might cause preventing problems against realization of value engineering results. Therefore, predicting the value engineering implementation during execution of developmental, building, industrial projects and motivational movements for implementing value engineering and applying its results in order to improve quality, reduction of the expenses and time of the process is very important. In applying the value engineering, maintaining the time for revision and implementing changes are necessary, therefore, to apply the correct management and on time decision-makings of the employer and presence of motivation in the related organizations have effective roles on realization of this plan.

In the project of Gavoshan tunnel, after completion of the excavation and according to the results of the value engineering workshop which had been confirmed by the elements of the plan, some conditions were emerged that prevented to carry out the floor-taking operation of the access tunnel. By reform and adjustment of the path of the access tunnel and using lean concrete based on the explained method, 3 months were saved in time of the project execution. Having a correct understanding of the conditions and paying the contractor's reward, the project employer provided the ground for execution of the project.

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