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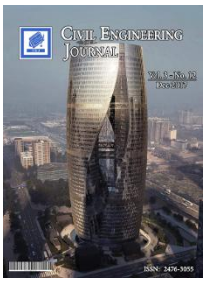
Civil Engineering Journal

Vol. 3, No. 12, December, 2017



Investigating the Causes of Delay in Construction of Urban Water Supply and Wastewater Project in Water and WasteWater Project in Tehran

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Received 05 October 2017; Accepted 27 December 2017

Abstract

It is obvious that providing drinking water in cities, especially in metropolises such as Tehran, as a political-social-economic center of the country is important. During the last decades, climatic changes, the decrease of raining, the increase of water harvesting from groundwater as well as the increase of population have intensified the importance of water in Tehran. Therefore, every change from water consumption to collecting, purifying and storing drinking water in the city reservoirs is highly critical. In the present study, the causes of delay in such projects have been determined based on experts' opinions about several concrete implemented reservoirs obtained by questionnaire and the related literature. Given to three classes pertained to such projects (employer, consultant and contractor), an initial questionnaire was provided to poll the experts' opinions and distributed among the sample of the study. In this regard, 45 Likert-scale questionnaires were equally distributed among three population; after gathering, the items with higher mean scores were selected for the main questionnaire (totally, 17 items). Using AHP method, the most important factors were identified and ranked through Expert choice Software. As the research findings revealed, failure of employer to pay to contractor timely, failure to obtaining the necessary permissions by employer before noticing to contactor to proceed, and uncertainty and buying project site by employer are the most important factors respectively.

Keywords: Prioritizing Effective Factors; Delays in Reservoirs Construction; Concrete Reservoirs of Drinking Water; AHP.

1. Introduction

Three factors including quality, cost and time are the most important and determinant factors in every project. All managers try to complete their projects with the least cost and the highest quality in the least time. Unfortunately, most of civil projects in Iran suffer from delay in project implementation. It is also obvious that delay in project implementation increases construction cost and decreases quality. In general, one of the characteristics of successful projects is completing it with desirable cost and quality in proper time. Lengthening project implementation time as excusable and non-excusable delays imposes heavy cost to employer. Project implementation is sometimes lengthen so that it is not worthy to complete it any longer.

2. Literature Review

Zarei et al. (2018) in their study entitled "Delay causes analysis in complex construction Projects: a Semantic Network Analysis approach", presented the following findings.

An important contribution of this paper is the adoption and application of SNA in the identification and analysis of

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http://dx.doi.org/10.28991/cej-030958

construction project delays in OGP industry. The method's capacity to identify and rank delay causes can assist managers in selecting appropriate measures for eliminating them. Furthermore, this method is able to account for interrelationship between delay causes, which compensates for the weakness of previous methods. The application of analytical tools and methods in addressing industry and projects problems has been an established research exercise for many decades. The increasing complexity in firms and their projects has however called for advancing interdisciplinary approaches that can handle such complexities. This research attempted taking the existing project delay studies, which have generally approached project analysis using techniques such as Structural Equation Modelling (e.g. studies done by Atteveldt 2008; Yang and Ou 2008; Kao and Yang 2009; Yang and Kao 2012) further by applying an analysis method which is used in social and technological fields. The successful outcome of this method in analysing project delays and their causes showed that research in project management can be further enriched and extended through introducing interdisciplinary approaches [1].

In their study titled "Causes of Delays in Iranian Construction Projects", Khoshgoftar et al. (2010) reported the following results:

This study assessed the factors contributing to delays in the Iranian construction industry by grouping the various factors according to Odeh and Battaineh (2002), and Sambasivan and Soon (2007). The result of the research shows that there are many reasons for delay in Iranian construction projects. The most important are finance and payments of completed work, improper planning, site management, contract management, lack of communication between the parties and subcontractors, equipment availability and failure, shortage in material, inadequate contractor's experience, and change orders. The focus of this study was on causes of delays according to the opinions of clients, consultants and contractors. Eighty four questionnaires were returned out of one hundred and twenty five questionnaires distributed. Respondents gave their viewpoints on 28 causes of delay used by Odeh and Battaineh (2002), and Sambasivan and Soon (2007) according to a scale of (1=not important to 5= extremely important). Furthermore, they indicated their opinions and recommendations about this study by open-ended questions at the end of the questionnaire. There are clear implications for the Iranian construction industry. This study found a fresh perspective on an old problem in the construction industry by ranking the various delay causes from the perspectives of clients, consultants, and contractors. In addition, the study found the most significant delay causes in the Iranian construction industry as well as those least significant causes. As another important contribution, the results of this study will be useful to both practitioners (clients, contractors and consultants), and academics. The practitioners can use the results of this study to reduce the incidence of delays. The academics can conduct further studies in other countries to find the causes and effects of delays. As mentioned earlier, the results in other countries maybe the same or different in terms of their economic situation, political situation, culture, and level of experience and knowledge Finally, although this study is specific to the Iran, in respect of the similarities between selected causes and large construction projects in developing countries, its results can be generalized to other developing countries facing similar problems in their construction industry.

There are some recommendations for future studies to find a ways of reducing or eliminating financial problems in construction projects such as:

1) Finding new financial resources,
2) Suggesting ways to correct and improve, and a study to find problems in contracts and laws of the construction project,
3) Paying more attention to capabilities and past performance of contractor than the lowest bidder before awarding the contract,
4) Developing human resources in construction industry through proper training programs for personnel in the industry to update their knowledge and be familiar with project management techniques and processes [2].

In their research entitled "Investigating Causes of Delay in U.S. construction Projects", Tafazzoli and Shrestha (2017) concluded as following:

This article explains why it is crucial to prevent the occurrence of delays in construction projects. It emphasized that two fundamental steps to mitigate the risk of delays are knowing the causes of delay and knowing the relative criticality of causes. The causes of delay may differ in various regions based on the characteristics of the construction industry and the rules and regulations in the region where a project is in progress.

Based on this, the causes of construction delays in the United Stated were investigated, using a national survey. The analysis of the data revealed that owner collaboration with the construction team, quality of design, and communication among parties were among the most significant factors regarding delays. The list of the most critical factors could be used by construction companies and project owners to maximize their budget planning to reduce or prevent delays [3].

Assaf and Al-Hejji (2006) in the study entitled "Causes of delay in large construction projects" concluded as following:

The delay in construction projects in Saudi Arabia is discussed in a field survey. It studied frequency, severity and importance of the causes of delay. The importance index of each cause is calculated as a product of both frequency and severity indices of each cause. 73 causes of delay were identified through research. The identified causes are combined into nine groups. The field survey included 23 contractors, 19 consultants, and 15 owners. Data collected were analyzed by frequency, severity and importance.76% of the contractors have indicated that average of time overrun is between 10% and 30% of original duration, while about 56% of the consultants specified the same percentage.25% of the consultants have indicated from 30% to 50% average time overrun. Owners specified that causes of delay are related to contractor and labours. Study indicated that owners and consultants realize that awarding to the lowest bidder is the highest frequent factor of delay, while, contractors considered severe causes of delay are related to owners [4].

Najafi and Rashidi (2006) investigated the causes of delay in waste water projects' engineering sector and reported that delays are of the most important problems in projects implementation. They also reported that delays have sometimes caused some problems for employer and contractor. In this study, they analyzed the importance of engineering sector and the causes in implementation. Using fuzzy multi-criteria decision making method, the status of the alternatives and criteria for delays causes with verbal variables were evaluated. Then, the causes were ranked by considering fuzzy numbers appropriate with the variables [5].

Mahdavi et al. (2012) studied the role of consultant engineers in waste water projects delay using questionnaire. As they concluded, consultant engineers' services highly affect time, cost and quality of various states of waste water projects' life cycle; therefore, these stages should be especially considered. Delay is one of the serious damages of civil projects in which every contract agents play role. Given to the place of consultants' place in projects' management, it is expected that it shows its effect on delay creation; however, this study revealed that the role of consultant engineers on waste water projects is unfortunately intangible and unforgivable. In the study, the factors causing delay have been also identified in the phases of planning and implementation. The identified factors respectively include lack of enough experience and appropriate consultant, the effort of consultant to obtain more benefit for less quality, benefiting consultant from lengthening the time and cost of projects [6].

Using TOPSIS, Amiri and Dehghani (2015) also investigated the causes of lengthening the time of implementing some civil projects of Gheshm free zone compared to 17 projects in other provinces. In this study, the sample included 280 mangers, consultants, engineers, and supervisors of civil projects. To gather required data, a questionnaire was used. The validity and reliability of the questionnaire was confirmed and distributed among the population. Finally, 37 factors were selected as the causes of delay in civil projects. The most important identified causes included managers' (senior, middle, operational) work ethic, warm weather, motivation (superior, middle, operational), employers' and technicians' motivation and work. According to the obtained results, it can be concluded that the necessity of avoiding traditional management and implementing new management especially the presence of project management system in cities is very obvious. Also, employing the knowledge of managing time, cost and quality, coalition, risk, communications, procurement, and human resources are the categories which are necessary to be considered in project management system. Considering these categories can lead urbane management to creating a sustainable city [7].

Anari et al. (2015) used ANP and regression model to prioritize the causes of delay in waste water of Yazd city. They divided the causes in 3 groups of internal and management causes, technical causes, and external and urban management causes [8].

Given to the basic need if Tehran city, Vosoughi et al. (2016) attempted to identify and investigate the causes and factors affecting delay in waste water civil projects. They also attempted to present strategies to decrease the delay in the projects. In this regard, with respect to lack of properly registering data and pertained characteristics, the factors casing delay in civil projects were identified using experts' opinions and related literature. The 17 important identified causes of delay included inflation, failure to properly select contract type to assign projects, failure to pay to contractors, lack of credit and failure to pay contractors' statements, structural problems and bureaucracy in employer organization, financial supply by employer, changes in plan during project implementation, failure to pay to contractors on time, climatic conditions of the site and incidental events, rush in opening projects due to political-social issues and its reverse results, error and defect in plan by consultant, defect in initial studies by consultant, delay in decision making during sensitive periods and necessary cases by consultant, environmental issue such as sanction, unknown underground factors, lack of accordance between balance and inflation and so on, lack of enough experienced human resources regarding implementation method leading to unreal implementation time, land ownership problems, and delay in providing required maps by consultant [9].

Due to causes of delay in civil projects of Arabia, Assaf et al. (1995) have studied errors and changes in planning, delay in contractors; payment, financial problems of contractor, structural problems and bureaucracy in employer organization. Chan and Kumaraswamy (2002) compared causes of delay in projects in 11 countries and concluded that delay causes are identical in developing countries. For example, in these countries, improper planning and estimation, weak project management and lack of materials are of the most important delay causes. However, delay causes in developed countries such as The United States and Britannia are justified delay factors like unfavourable weather and

human resources performance [10].

In 2013, 3112 agreements were exchanged on the operations of the National Capital Asset Procurement Project between the Deputy Director-General for Strategic Planning and Control of the President and executive agencies. According to the exchanged agreements, 537 trillion Rials were considered for the implementation of 6488 projects. 320 thousand billion Rials is financed by credits, general resources and 217 trillion Rials is financed by other resources of credit. In 2013, 81.5% of construction credits were allocated for economic affairs projects implementation and 12.3% for social affairs projects [11].

3. Method

3.1. Causes of Delay in National Civil Projects in 2013

Causes of delay in the projects can be divided into the three following sections:

1) Executive factors (executive organization, contractor, planer and supervisor consultant) with 7.8%
2) Credit factors (approved credit, credit allocation, treasury payment, and credit absorption) with 78.8%
3) Environmental and social factors (lack of materials, social problems, supplying land, etc.) with 13.7%

In the following, the causes of delay in concrete reservoirs construction projects are investigated:

3.2. Sohanak 78 Reservoir Construction Project

Sohanak 78 reservoir has been designed and located in northeast of Tehran, on the southern slope of the Alborz mountains in Sohanak region in order to watering downstream lands as well as pumping into upstream reservoir (reservoir 79). This reservoir is made of concrete with a nominal capacity of 21,000 cubic meters and a water holding capacity of 20,000 cubic meters and has been constructed in two separate compartments. The level of the reservoir is 1764 and the height of the reservoir is 5 meters. The water of this reservoir is provided by the fifth water treatment plant in Tehran.

Other Contract Specifications:

1) Initial amount of the contract: 21,000,000,000 Rials
2) Initial duration of the contract: 16 months
3) The final amount of the contract without adjustment is 22,000,000,000 Rials and with adjustment is 8,000,000,000
4) Real project implementation time: 35 months

The presence of barrier in the northeast and south of the reservoir and preventing fencing the enclosure.

1) The major changes in the maps and the displacement of the reservoir layout as well as the removal of the pump house building
2) Failure to pay in due time
3) Failure to pay the claims of the contractor including temporary and adjustment statements in due time
4) Lack of adequate and accurate study of topography and underground water level by plan consultant
5) Inappropriate atmospheric conditions and high elevation code area
6) Failure to timely issue the agenda and making decision about project problems by the employer
7) Offering low price (unreasonable minus) by contractor
8) Defective estimation by plan consultant and employer
9) Failure to obtain necessary licenses and permissions from the municipality
10) End of workshop supervision contract during the project implementation and introducing new consultant engineers to supervise the workshop (2010)

3.3. The Project of Reservoir 119 of Darake

Darake reservoir located in Kuhsar district of Darake and at a height of 1804 m above sea level for water supplying to downstream area of Darake and Kohsar area with a nominal capacity of 9000 cubic meters and a water holding capacity of 8000 cubic meters is constructing.

Other Contract Specifications:

1) Initial amount of the contract: 32,000,000,000 Rials

2) Initial duration of the contract: 12 months
3) The final amount of the contract (led to an addendum to contract): 38,000,000,000 Rials plus 9,000,000 Rials for addendum and totally 5,000,000 Rials adjustment
4) Contract coefficient: 1.164
5) Unit price 2014 (buildings, water transfer lines and mechanical and electrical installations)
6) The site delivery: November 2014
7) The project accomplishment: probably March 2017
8) Implementation time: 35 months

In the following, there are some of the problems which lead to lengthening the contract time:

1) Failure to obtain permission from the municipality of the region and the headquarters before starting the project and delivering the land to the contractor
2) The obvious mistake made by the project plan consultant in determining the reservoir floor code and increasing the height of excavation such that the floor code was originally 1812 and changed into 1804
3) The significant change in project values led to an increase in the values up to 25% of the contract as well as protocol conclusion
4) Failure to predict the strength of the trench excavated by the planer consultant, led to the collapse of the northern side of the project
5) Failure to pay for the contractor's claims in due time
6) Lack of equipment and facilities for the reservoir construction by the contractor
7) Inappropriate climatic conditions of the region
8) Delay in presenting agenda and maps by the employer
9) Long renewal time of the contract, protocol and the change of values by the employer
10) Failure to timely and complete deliver pipes and fittings required for the project
11) The difficult-to-pass road and the streets leading to the project site caused problems such as carrying iron, concrete and pipework.

3.4. Babaei's Reservoir 48

The reservoir 48 has been located at the north of Shahid Babaee Highway in Hakimiyah district of Tehran, Iran. With a water holding capacity of 18,000 cubic meters, this reservoir has been constructed to provide water at downstream as well as pumping water into reservoir upstream (the reservoir 49). The water of this reservoir is supplied from the third and fourth Hakimaye water treatments.

Other Contract Specifications:

1) Initial amount of the contract: 12,000,000,000 Rials
2) Initial duration of the contract: 18 months
3) The final amount of the contract: 14,000,000,000 Rials
4) Implementation time: 34 months
5) Adjustment amount: 3,300,000,000 Rials

The most important causes of delay in this project included:

1) Delay in paying deposit to the employer
2) Delay in paying the contractor' claims such as statement and adjustment
3) Lack of technical and informational ability of the contractor in the reservoir construction
4) Frequently replacing technical and executive contractor resource during the project implementation
5) The presence of barrier with respect to locating neat to military region
6) Estimating contractor's error and low price offered by the contractor
7) High fluctuation of currency and inflation in the country
8) Eliminating energy and fuel subsidy and high inflation in the country
9) Lack of financial ability of the contractor
10) Low communicated modification coefficients
11) Violation in maps planed by the employer
12) Lack of providing accurate estimation by the employer

13) End of workshop supervision contract and new supervision establishment

3.5. The Fifth Treatment Plant Development Reservoirs (Reservoirs 99)

The fifth treatment plant development reservoirs are near to the 5th treatment plant at the end of Artesh highway including two reservoirs with a total water holding volume of 17,500 cubic meters and a total of 35,000 cubic meters, each reservoir composed of two separate compartments. These reservoirs are drained by a concrete channel fed by a treatment plant gallery. These reservoirs are responsible to store and supplying water to upstream, as well as pumping water into the reservoirs 78 and 79. These reservoirs have been located at the level of 1700. Construction of these reservoirs was initially started by the contractor in November 2007; however, 37 months after recording the contractor's guarantee, in spite of incompleteness of the project with about 70% progress, after 14 months, another tender was held for to continue the work. The new contractor attempted to waterproof the reservoirs and implement water transfer channel as well as landscaping and constructing the chambers.

Other Contract Specifications:

1) Initial amount of the contract: 25,890,000,000 Rials + 23,000,000 Rials;
2) Initial duration of the contract: 18 months + 10 months;
3) Contract coefficient: 1.18 and 1.334;
4) Total amount of the project: 23,500,000,000 Rials + 15,000,000,000 Rials;
5) Total time: 37 months + 17 months (14 months holiday).

The most important causes of delay in this project included:

1) Technical and executive weakness of the first contractor in the reservoir construction;
2) Severe inflation during 86 and 87 due to the subsidies elimination;
3) Low communicated moderated coefficients;
4) Disadvantages of the plan and plans provided by the plan consultant;
5) Lack of coordination between workshop supervision, superior supervision and project execution;
6) Workshop robbery;
7) Lack of accurate estimation by the planer;
8) Failure to implement similar work by the contractor;
9) Failure to properly plan by the contractor;
10) 1Weak direct workshop supervision and lack of flexibility and workshop management leading to seizure at the workshop;
11) Replacing three consulting engineer companies to supervise the workshop (during 2007, 2009, and 2011).

Given to the related literature and the responses of the interviewees involved in concrete reservoirs construction in Tehran purification and supplying company, the causes of delay in these projects construction were identified. After summarizing the causes and omitting some relatively similar causes, a 35-item questionnaire in five point Likert-scale form was planned and distributed among experts and managers involved in the project. Questionnaire 1 included demographic information (individual characteristics, education, and experience) as well as question evaluating delay cause from the perspectives of the testes.

After planning the questionnaire 1 and selecting some experts among employers, consultants and contractors, the questionnaire was sent them. In this study, it was tried to homogenize the sample to obtain far and generalizable results. Therefore, 45 questionnaires were distributed among and collected from the sample.

Table 1. The sample of the study

Sample	Employer	Consultant engineers	Contractor
The number of distributed questionnaire	15	15	15

After collecting the distributed questionnaires, the average of each delay cause mentioned in the questionnaire 1was determined. Table 2. shows the average of the total results. After determining the total average, the causes with the average higher than the total average were selected for the main questionnaire and the causes with the average below the total average were omitted (Appendix 1) .Totally, 17 questions were used to construct questionnaire 2 (main questionnaire). The data obtained from the main questionnaire were analyzed using AHP method through Expert Choice Software to identify the causes of delay in the concrete reservoirs construction.

Socio-Demographic Analysis of the Respondents

The work experience and education of the respondents is one of the important factor in researches. Questionnaire 2 was distributed among 12 people of the sample including employer, consultant and contractor. Out of 12 people, there were 9 males and 3 females. Figure 1 specifies demographic information of the sample based on gender.

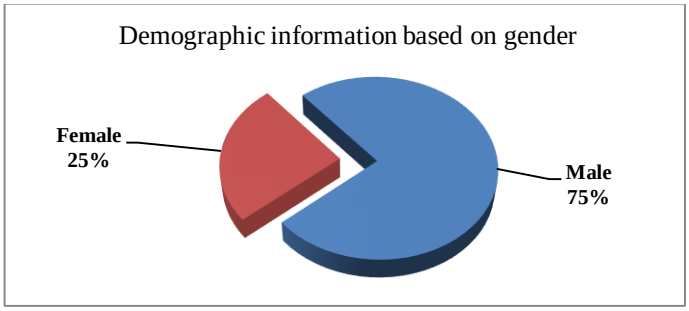

Figure 1. Specifies demographic information of the sample based on gender

As shown in Figure 2, 16% (2 people) of the sample was contractor, 42% (5 people) was consultant and 42% (5 people) was employer.

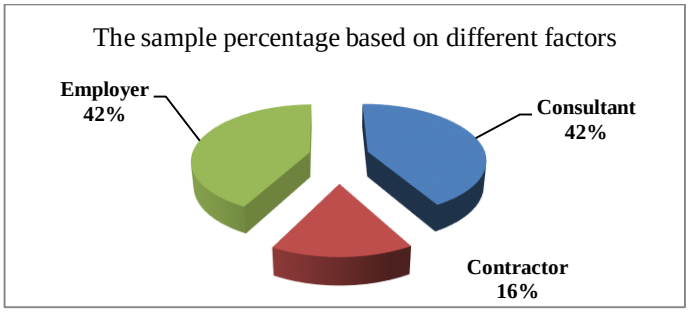

Figure 2. Specifies demographic information of the sample based on different factors

Regarding age and work experience, the sample included 3 people (25%) between 35-45 years old, 7 people (58%) between 45-55 and 2 people (17%) were above 55 years old (Figure 3).

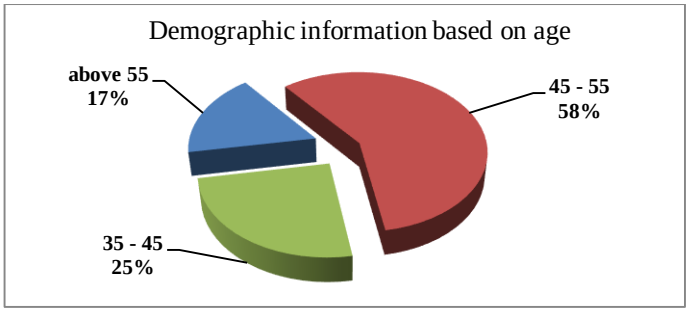

Figure 3. Specifies demographic information of the sample based on age

4. Questionnaire Analysis

Questionnaire is one of the most common instruments of data gathering. Responses to questionnaire reveal people's attitudes and opinions. Measurement scale includes a set of principles to assign tastes to a category. Relative scale is the scale used in the present questionnaire. Relative scale is the most accurate measurement scale which has a real zero value. Using this scale, the difference between the numbers and their relative importance can be compared. Also, to determine the validity of the questions after designing the questionnaire, they are distributed among 3 experts (piloting). The accuracy and clarity of the designed questions, the review of the questionnaire 2 was prepared for distribution (Appendix 2). 14 questionnaires (No. 2) were distributed among the experts to poll their opinions and 12 completed forms were returned and evaluated.

Using a spreadsheet in Excel software, the information of each questionnaire was entered into the page. Designing questions and analysing responses was done using Analytical Hierarchy Process (AHP). This hierarchical analysis method is used to convert qualitative views of the experts into comparable values. The main purpose of using this method is to rank the causes of delay in the reservoir construction, which is the purpose the questionnaires distribution. As mentioned earlier, using EXPEART CHOICE software used for classification, the results of each questionnaire have

been presented in (Appendix 2).

To evaluate the reliability of the questionnaire, Cronbach's alpha is used. This method is used in the humanities and behavioural sciences, which is mostly based on the questionnaire. Quality control issues results of a questionnaire include a wide range of subjects. If questionnaire is considered as a test, it can generally be said that a good test and questionnaire should have desirable features such as objectivity, ease of implementation, practicality, ease of interpretation, and validity and reliability to achieve accurate results. Out of these features, validity and reliability of questionnaire are more important. The Cronbach's alpha coefficient is obtained as follows:

$$\alpha = \frac{K}{K-1} * \left(1 - \frac{\sum_{i=1}^{K} S_i^2}{S^2}\right) \quad (1)$$

Where K is the number of items; S_i^2 is the variance of each item and S^2 is the variance of total items.

If the obtained alpha coefficient is greater than 0.7, the test is acceptable; it the value is between 0.5 and 0.7 , it is relatively acceptable and if the value is less than 0.5, it is not acceptable. Obviously, the closer the Cronbach's alpha index is to 1, the greater the correlation between the questions will be (more homogeneous). Also, if the alpha value is low, it should be checked that eliminating which questions can increase its value.

In the last row of the next page table, the Cronbach's alpha value of each questionnaire has been given. As observed, Cronbach's alpha values in the questionnaire are more than 0.7 and their mean is 0.87, indicating that the reliability of the questionnaires is at an acceptable level.

To calculate Cronbach's alpha, IBM SPSS STATISTICS software has been used.

5. Results

Using AHP, the identified causes of delay in the concert reservoirs construction were ranked as following (Appendix 2).

1) Failure to pay to the contractor by the employer in due time
2) Failure to obtain the necessary permissions by the employer before communicating the contract to the contractor
3) Uncertainty and buying the project site by the employer
4) Failure to pay deposit to the contractor by the employer in due time
5) The weakness of the consulting engineers in terms of plan and supervising implementation
6) Lack of the planer's consultant knowledge about the location of the project
7) The weakness of the contractor's executive force
8) Failure to choose the appropriate plan consultant engineers by the employer
9) Lack of enough plan experience similar to the consulting engineer's experience or lack of executive view
10) Lack of mastery and awareness about the general terms and conditions of the contract and directives
11) Economic inflation in society
12) Offering unreasonable low price in tender by the contractor
13) Failure to properly estimate the duration of the project implementation by the employer
14) Low financial power of the contractor
15) Delay in processing and preparing documents such as minutes and so forth by the consultant
16) Failure to promptly issue necessary warnings and control the scheduling by supervisor
17) The incomplete estimation of the project by the employer

6. Conclusion

According to the research findings, the five following causes are the most important causes of delay in the concrete reservoirs constructions in Tehran Waste Water Company:

1) Failure to pay to the contractor by the employer in due time
2) Failure to obtain the necessary permissions by the employer before communicating the contract to the contractor
3) Uncertainty and buying the project site by the employer
4) Failure to pay due advance to the contractor by the employer
5) The weakness of the consulting engineers in terms of plan and supervising implementation

With respect to the obtained data and the most important causes of delay in the concrete reservoirs construction identified, the following strategies can be presented to decrease the causes of delay:

1- Delay in paying contractors' claims (such as statements, modification, deposit, etc.)

To remove this cause of delay, there are various ways:

1-1 Finance contract from international resources: which is possible through company financing or project financing. In the former, financing is accompanied with full commitment and financial commitments payback is possible through all the company assets. In the later, financing is considered with limited commitment or without commitment and the project's payback resources is the income from selling products related to the project.

1-2 Method of build-operate-transfer: it is one of the accepted methods for private sector participation at global level. In this method, the project is implemented for a certain period by the company and the plan is transferred by the employer after a certain period and earning necessary income.

1-3 Using (Engineering, Procurement and Construction) EPC: This method of project management and implementation which is sometimes referred to build and procurement, is appropriate for accelerating project implementation. Since, despite creating certain restrictions for the employer, the contractor is responsible for all project activities including plan, equipment purchasing, construction, and installation. Also, and the employer is free from heavy management and executive responsibilities. By the way, it is possible to start executing the work before the planning affairs; accordingly, the time of the project implementation is decreased and if the employer can provide his plan's execution cost, EPC is an appropriate solution.

2- Obtaining the necessary permissions from pertained organizations and municipality by the employer before starting to work

3- Most of projects faces with some barriers as soon as excavating and equipping the workshop. In the most optimistic case, this delay leads to obtaining permission and coordination to get started the work; however, the project is temporarily extended for a while as allowed delay. In some projects, the problem is not resolved and ultimately leads to terminating the contract according to article 48 of the General Conditions and paying damages to the contractor.

4- The project site ownership before doing tender by the employer

5- The initial time of the contract should be reasonably determined based on the geographical location of the project. Due to some ownership problems of the land, the project time is allowed to be extended and will be resulted in financial burden. Therefore, it is suggested that definitive land ownership is determined or at least a project is firstly defined based on fencing the project limit to impose less damages to minimize any damage to the employer (due to the low cost of the contract and the costs of suspension and damage to the contractor).

6- Rational and accurate estimation of the initial time of the project

7- In this case, access to the region, excavation rout, materials carriage, etc. are estimated without any rush.

8- Selecting appropriate consulting engineers by the employer to supervise by the employer

9- Consulting engineer is one of the main elements of the project. Employing weak consultant causes many problems for the contractor and the employer. Carefully holding tender and properly selecting consultant engineer will have a significant impact on the contractor's work and will lead to project progress.

10- Completely and accurately planning the project by the consultant engineers

11- Consultant engineers should be patient in planning the project and do not shallowly perform due to the pressures imposed by the employer. One of the problems of internal projects is the short time to plan. It causes a lot of problems for implementation. Spending more time for planning and estimating will lead to less delay in the projects implementation.

12- Employing experienced consultant engineers for workshop supervision

13- Workshop supervision is one of the most important factors of the project progress. Employing experienced consultant engineers for workshop supervision will lead to the project progress as well.

14- Commitment to and good knowledge of circulars by the consulting engineers

15- Full awareness of the consulting engineers about circulars and their proper and timely implementation will be effective to direct and manage the plan.

16- The low and unreasonable price offered by the contractors cause many problems to build concrete reservoirs. Merely to get a project and to survive in the market is not a good reason to offer a low price and loss. Providing unrealistic prices will cause delay in the project. In addition to causing trouble for the contractor and other project partners, it is also important for other project elements. Therefore, the employer should be careful at the stage of selecting contractor in terms of machine precision, financial background and contractor's work experience, and the proposed price.

17- As stated in Article 50 of the General Conditions of the Contract, the Contractor should pay fine for delay in the contract finality; in the special conditions of article 50-A, to accelerate the completion of the executive operations. Accordingly, the contractor show more tendency to complete the project before the deadline.

18- Regarding the issues related to the contractor and applying inexperienced labour force, the labour forces' work experiences should be investigated more carefully by the consultant and employer. Employing less experienced labour force by the contractor may seem cost effective to the contractor because of low wages, but it increases the cost due to the increased time, unauthorized delay, fine, and reworking in the contractor's statements during the project and impose more cost to the contractor.

19- Documenting the records of the reservoirs construction projects

Generally, one of the most important factors reducing the time of concrete reservoirs construction is to use the history and records of similar work in Tehran supply and refining company. For example, with the experience of constructing more than 9 reservoirs in Tehran, I have experienced quite different situations in every reservoir. All the reservoir construction problems are archived in the same reservoir, and the employer, consultant and contractor can use these records and documentation to complete information and problems with the concrete reservoir construction in Tehran Supply and Treatment plant Company for the next reservoirs.

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Appendix 1

The causes of increasing delay in concrete drinking water reservoir construction in Tehran water and wastewater Company from the perspective of people involved.

Row	Index Description	Total Score			Total View	
		Employer View	Consultant View	Contractor View	Total score	Causes Priority
1	Failure to obtain necessary licenses and permissions from the municipality	3.5	4.36	3.1	3.44	2
2	lack of enough experienced human resources	3	2.8	2.95	2.75	
3	Uncertainty and buying the project site by the employer	3.1	3.82	3.85	3.38	1
4	Failure to obtain and present the maps of infrastructure installation passing places by employer	2.52	3.12	3.15	2.76	
5	Delay in paying deposit to the contractor in due time	3.73	3.9	2.98	3.34	3
6	Delay in paying statements to contractor by employer in due time	3.92	4.07	3.5	3.61	4
7	Failure to supply materials and resources committed by employer	2.44	2.75	2.95	2.56	
8	Incomplete estimation of the project by employer	2.7	3.7	2.9	2.93	5
9	Lack of providing accurate estimation of project implementation time by the employer	2.62	3.83	3.332	3.07	6
10	Failure to timely issue the agenda and making decision about project problems by the employer	2.63	2.63	3.1	2.63	
11	Changing plan executor, workshop supervision, superior supervision during project implementation	2.54	2.34	2.1	2.20	
12	improper project management by employer	2.45	3	3.3	2.75	
13	Improper selection of plan consultant by employer	3.78	3.05	3.12	3.13	7
14	Failure to present benchmarks by employer in due time	1.7	1.98	3.06	2.12	
15	Employer disturbance in consultant engineer's tasks	2.36	2.6	3	2.50	
16	Lack of enough plan experience similar to the consulting engineer's experience or lack of executive view	3.35	3.53	3.02	3.11	8
17	Lack of knowledge of consultant with the site's spatial conditions	3.26	3.35	3.8	3.27	9
18	The weakness of the consulting engineers in terms of plan and supervising implementation	3.98	2.12	3.32	2.96	11
19	Failure to promptly issue necessary warnings and control the scheduling by supervisor	3.83	3.8	2.98	3.34	16
20	Designing error by consultant	3.68	2.03	3	2.74	
21	Poor knowledge of consultant about general conditions of contract and agreements	2.86	3.22	3.8	3.11	10
22	Delay in processing and preparing documents such as minutes and so forth by the consultant	3.35	2.7	3.5	3.00	17
23	Following non-professional commands of employer by consultant	2.6	2.55	3.62	2.576	
24	Offering unreasonable low price in tender by contractor	3.38	3.4	3.01	3.08	12
25	Low financial ability of contractor	3.12	3.46	3.01	3.02	15
26	Weak executive force of contractor	2.93	4.18	2.92	3.15	14
27	Lack of contractor's good knowledge about maps and contract's documents	3.9	3.25	1.6	2.75	
28	Human errors of contractor during implementation due to employing inefficient personnel	3.92	3	1.45	2.63	
29	Lack of appropriateness between machineries and equipment and type and volume of contractor work	2.9	2.75	2.55	2.58	
30	Ignoring consultant and employer remarks regarding observing technical characteristics by contractor	2.63	2.38	2.51	2.37	
31	Ignoring the safety and security issue by contractor	2.4	2.6	2.96	2.50	
32	Error in planning implementation and controlling project by contractor	3.32	2.90	1.88	2.55	
33	Economic inflation in society	3.50	3.46	2.9	3.10	13
34	Foreign and domestic political issues such as sanction	2.66	2.85	3.02	2.68	
35	Unexpected natural events such as flood, earthquake, etc.	2.56	2.45	2.13	2.25	
	Average	107.12	107.93	103.33	318.41	
	Total	3.06	3.08	2.95	2.86	

Appendix 2

The results of indices importance based on AHP for each respondent.

Factors / Respondents	1	2	3	4	5	6	7	8	9	10	11	12	Average	Percentage	Priorities
Offering unreasonable low price in tender by contractor	0.028	0.057	0.08	0.031	0.070	0.02	0.014	0.105	0.029	0.063	0.072	0.02	0.049	2.62	12
Incomplete estimation of project by contractor	0.029	0.029	0.036	0.034	0.044	0.017	0.05	0.024	0.017	0.011	0.007	0.059	0.03	1.6	17
Uncertainty and buying the project site by the employer	0.07	0.157	0.012	0.049	0.16	0.016	0.044	0.127	0.021	0.057	0.08	0.07	0.072	3.85	3
Delay in paying statements to contractor by employer in due time	0.028	0.106	0.214	0.124	0.124	0.02	0.096	0.109	0.019	0.079	0.043	0.092	0.088	4.7	1
Low financial ability of contractor	0.02	0.045	0.042	0.04	0.02	0.094	0.048	0.041	0.023	0.023	0.088	0.070	0.044	2.46	14
Failure to obtain necessary licenses and permissions from the municipality	0.042	0.119	0.139	0.136	0.112	0.034	0.048	0.129	0.021	0.107	0.086	0.066	0.087	4.65	2
Lack of providing accurate estimation of project implementation	0.041	0.067	0.05	0.04	0.038	0.038	0.033	0.023	0.045	0.036	0.124	0.049	0.049	2.62	13
Economic inflation in society	0.058	0.055	0.14	0.112	0.082	0.039	0.032	0.056	0.03	0.033	0.018	0.046	0.059	3.15	11
Failure to promptly issue necessary warnings and control the scheduling by supervisor	0.011	0.055	0.049	0.026	0.056	0.054	0.038	0.02	0.038	0.032	0.035	0.026	0.037	1.98	16
Delay in processing and preparing documents such as minutes and so forth by the consultant	0.049	0.061	0.05	0.031	0.042	0.058	0.08	0.017	0.066	0.028	0.014	0.013	0.042	2.24	15
Improper selection of plan consultant by employer	0.106	0.050	0.026	0.057	0.031	0.053	0.067	0.062	0.044	0.043	0.136	0.070	0.062	3.31	8
Delay in paying deposit to the contractor in due time	0.196	0.043	0.03	0.043	0.036	0.067	0.076	0.05	0.065	0.097	0.044	0.082	0.069	3.69	4
Lack of enough plan experience similar to the consulting engineer's experience or lack of executive view	0.046	0.023	0.033	0.068	0.03	0.088	0.069	0.071	0.199	0.016	0.099	0.045	0.06	3.21	9
Lack of knowledge of consultant with the site's spatial conditions	0.049	0.026	0.052	0.03	0.066	0.089	0.053	0.04	0.105	0.18	0.025	0.062	0.065	3.47	5
Weak executive force of contractor	0.045	0.022	0.017	0.055	0.036	0.106	0.048	0.043	0.092	0.084	0.0553	0.173	0.065	3.47	6
Poor knowledge of consultant about general conditions of contract and agreements	0.085	0.067	0.01	0.055	0.03	0.102	0.119	0.018	0.145	0.066	0.012	0.036	0.062	3.31	7
Failure to understand and understand the general terms and contracts and directives	0.097	0.018	0.021	0.048	0.023	0.109	0.084	0.067	0.12	0.043	0.063	0.021	0.04	3.21	10
	0.851	0.882	0.896	0.926	0.74	0.916	0.754	0.927	0.78	0.889	0.944	0.931	0.87	0.851	0.882

The diagram of indices importance based on AHP for each respondent.