

## The Role of Engineering Insurance in Risk Controlling of Dams

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### Abstract

Dam safety is very important, especially from financial points of view. Therefore, scholar has studied the role of engineering insurance covers in the process of assessment and control of project's risk in the country. In this paper, at first, data was gathered by the studying of related books and papers in engineering insurance, respectively. Then, the influential variables were extracted and approved by the experts in Mazandaran province of Iran. Finally, SPSS and LISREL were used for necessary analysis. The results of the study suggest a significant positive impact of the independent variables (insurance, legal, structural, safety and training factors) on the dependent variable (risk control). According to the results, it can be maintained that safety factors have the strongest impact, and then insurance factors, structural factors, educational factors and legal factors exist, respectively.

**Keywords:** Engineering Insurance, Risk Control, Dam Construction, Project

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## Introduction

Considering uncertainty in such big projects as making dams and using resources, risk assessment and analysis of them have become the main part of project management process. Nevertheless, these days, most of the big projects run in constructional implementation have had delay. This delay is the main factor imposing an exorbitant number of expenses on economic and social systems of our society. Therefore, risk assessment and analysis of them become more important. (Kartam, et al., 2001). Although some research studies have been carried out in the field of risk assessment for dam's projects and using risk management in controlling them, there are not comprehensive studies on the relation between risk management in constructional projects and engineering insurance and their impact on risk controlling.

Each project has close relation with quiddity and kind of recognized risk. Therefore, by the side of engineering insurance, risk assessment of dam's projects can help improve projects and decrease possible damages. Also, we can make better situation with studying existing circumstance and then we can produce new insurance covers with consideration of project's needs.

## The concept of insurance

In French (Assurance), English (Insurance) and, Arabic terms (Altamin) it is shown that etymologists believe the word is derived from Latin (Seruus), which means \_a guarantee\_, providing trust and confidence. Alfred Marshall in 1980 in economics book states that insurance will be a price for getting rid of uncertainty. (Iari & Sameti, 2008).

Engineering insurance based on the definition of S. Shabal as follows: Engineering insurance is a subset of property insurance, covering Projects under construction and Installations in operation or machinery and technical equipment. Engineering insurance is the non-life insurance. (Karimi, 2014). Insurance as a mechanism for transferring risks, plays a pivotal role in creating peace and confidence in constructional and infrastructural projects. Engineers' peace of mind are provided by obtaining appropriate cover around their activities. Engineering insurance is unique in terms of diversity and inclusivity. Construction of dams, tunnels, schools, universities, sewage network, a residential home or tallest towers, sports stadiums, installing machines to install a small workshop biggest factories manufacturing, as well as used machinery contractors loaders, bulldozers, cranes, appliances and electronic equipment, etc can be covered by engineering insurance or damage to be compensated by the insurer. (Peters, et al., 2011). Today, engineering insurance is one of the indicators of manufacturing activities and their increase in every country shows an increasing in manufacturing activities. On the contrary, decreasing the engineering insurance covers show the stagnancy on these kinds of activities. All kinds of engineering insurance in all industries become a necessary thing, and, also, every industry can not improve without insurance covers. (Grčanil, et al., 2009).

## Risk and the necessity of its being studied

Risk is the probability of occurrence of an event that is due to two factors of uncertainty and inaccuracy. (Bart, 2001). Risk in general, is not desirable because it is mixed with uncertainty. As a result, reduces the predictive power. In fact, the financial viability of a project depends on predictable and stable financial conditions in the project. It is more important than technical issues such as design and construction. And also, On the other hand, regarding high length of exploitation of most infrastructural projects, predicting a large number of effective factors which affect process of project financing is very difficult and uncertain. (Sabt, et al., 2004)

The dam which is studied in this research is Shahid Rajaei dam, also called Soleiman Tange which is located in Dodangeh, 45 km of southwest of Sari city, Mazandaran, Iran. Construction of the dam began in 1957 with the start of operations in November 1991 and continued till 1996. This dam is concrete double-arch dam with free spillway, unlike weighted concrete dam whose capacity of dead-bearing is simply provided by the dead load. In concrete arch dam, the thin

concrete shell is transferring horizontal and vertical pressure to its foundation and sides. Precise identification of the bedrock as the interface between bedrock and concrete of dam has great importance. Risk of bad design, inappropriate equipment selection, and non-skilled contractor can threaten the implementation of concrete arch dam. Mastering the complexity of the work, proper planning and proper coordination of work are necessary to complete projects on time. Similarly, quality control of concrete, concrete mix design and cooling system is important, in implementing this type of dams. Rock drilling problems, especially at sides slope, failure to conduct a comprehensive survey of land, and using equipment and machines are other risks during the implementation of this type of dam. (Amirsadooghi, 2008)

### **Common risks during the implementation of dams**

Some risks are common during implementation of all dams. As an example, all kinds of dam projects are at risk of natural disaster. Torrential rains cause severe flooding that may exceed the flood that diversion system is designed based on and even overpass on the upstream cofferdam. This can conduce to complete upstream cofferdam failure and serious damage to the structures that are being built. Heavy rainfalls also have serious effects on the stability of slopes and unprotected access roads. Landslides from other natural disasters that happen in dam construction projects threaten access roads, temporary structures, warehouses and equipment in the vicinity of the exotic masses. Fire is not a serious danger in dam construction projects, but camps, warehouses, workshops and equipment must be equipped with fire-fighting facilities. The risks which are related to design are the most obvious risks that can be observed in the body design of the dam, spillway and river diversion system, and the general types of structures.

In short, some risks during the execution of all types of dams are classified as follows:

Natural disasters (earthquakes, floods, flooding, storms, frost, landslides)

Fire, lightning

Wrong design of the dam, spillway, stilling basin, river water diversion systems, power plants, hydro mechanical and electromechanical equipment

Third party liability

Damage to the machine, hydro mechanical and electromechanical equipment and instrumentation.

Human errors, defective materials and improper construction methods

Workshop damage to all property, theft and looting

The penalties for failure to comply with the objectives of optimum performance

Damage caused to the employer's loss of profit resulting from delay in operation or in situations where none of the parties is not responsible contractor

Any damage during the course Elimination of defects

Penalties for delay (Amirsadooghi, 2008)

### **From a legal perspective**

According to research conducted in engineering insurance contract terms may affect risk control. Also, the rules governing the engineering insurance and enforcement of existing laws by the contractors could affect dam construction projects that will be discussed. Engineering insurance is part of property insurance. Based on the principle of compensation, it compensates for physical damage and unpredictable incident. The main research question is what factors in relation to engineering insurance are effective in risk control in dam construction project. After identification, prioritization of the factors is performed. Given that the engineering insurance, constructional project, production, industrial and electronic equipment are covered and also according to the sensitivity of this research (dams) this type of insurance may not be got by employers and contractors. Huge financial losses occur when disasters inflict upon them. Also according to the field of engineering insurance is one of the most original and the most important fields of insurance in the insurance industry and according to figures published by the

Central Insurance, this insurance branch has not made significant progress and has not won public approval. A research study has been done by Mahmoudi.M, & Bozorgi. H by the title of “studying the impediments of growth and development of engineering insurance in the insurance industry of Iran”. In this research, legal factor is one of the factors identified. One part of this study is to examine the issue: studying whether there is any significant relationship between development of engineering insurance and the law enforcement authorities or not. Regarding the growth and development of engineering insurance if there is link through law enforcement officials, consequently, it has great effect on buying engineering insurance by the project authorities. Finally, it plays important role in risk controlling. Therefore, legal factors are maintained as one of research factors.

### **Rules and Regulations**

Engineering insurance exactly to address this concern and make desired construction activities has come into existence, and it can be a good place for investors. Engineering insurance rules and regulations are divided into two categories:

Insurance policy that for the period of construction or installation (construction period) will be issued.

Insurance policies that are issued for the period of operation.

At the global level, to support the realization of the payment of premiums and distribution of insurance policies, laws and regulations are constantly being amended. Always new arrangements for doing so is growing. (Lee, et al., 2009). Therefore, proper etiquette and monitoring it are important.

### **Implementing rules and regulations**

The implementation of regulations for the growth and development of engineering insurance has particular importance. If the law is very well-designed but does not have the proper execution of the operation, it will fail.(Chapman, 2006)

### **Human resource selection based on merit**

The aim of HR selection is to find the most qualified person to fill the vacant post of job candidates for the positions. Effective choice, based on the principle that the position of the organization depends on to have the human resources expert, committed and wanting to work.(Mamoudi & Bozorgi, 2007)

According to, a research done, educational factor is considered as one of the factors, which has some sub-factors including staff training and qualifications of human resources.

### **Insurance factors**

Another factor is insurance factor which has 4 sub-factors, and it should be checked to what extent the following factors are important in controlling risks of dam's construction.

Taxes is a social cost which the people of a nation in the utilization of the resources of a country are obliged to pay. In fact, the transfer of tax revenues to the state and society or economic activity that is part of the profit goes to the government because the government provides the tools and resources through which achieving revenues and profits are made possible. (Van Staveren, 2012)

### **Safety factors**

Other factors include two sub factors of health insurance and veracity of statistical information. With special attention to insurance contracts, each of the contracting parties, including insurers and policyholders, is required to fulfill the obligations that they have been labeled with the name of the principles governing insurance contracts. Given the differences that exist in the various fields of insurance, different insurance contracts follow the principles and various standards. In general, the principle of good faith and the possible insurance benefit applies to all branches of

insurance, while the principle of compensation and subrogation in property insurance is invoked. In liability insurance, although the principle of compensation is governing the subrogation is not invoked. (Karimi, 2014).

In addition to the original principles of insurance, the veracity of statistical information is considered (Dong, 2002). Also, previous data should be studied again.

The most dangerous stage in the construction of the dam is, first, the river's diversion to dam run and, second, closing the main dam and diverting channel so that winemaking in the area behind the dam become possible. Scheduling and organizing this work is often sensitive. The study of historical figures of river flows, forecasts the possibility of water flow during the construction and selection criteria for the design of the temporary diversion dams, and diversion structures is vital. The less historical information is available, the more careful selection of design data is required, and the risk of inadequate design of temporary work and the damage are more. ( Liu,et al., 2007)

### Structural factors

Factors relating to the structure of the dam include dam height and width, the capacity of water output, the cracks in the dam, and geographical situation of dam. Dams have different constructions divided into several categories: Concrete, rock, and arch, each having their own structure. The materials used for the manufacture of dams are different. For each type of dam, structural shapes and different maps existed. Required tunneling barrier may be significant and also often includes a network of access roads with a high risk of loss and washout during storms in tropical countries (Bowel, et al., 1998)

The majority of dams are made in river valleys. Consequently, the prediction is necessary for ordinary levels of river in construction period. Dam foundations are built on land as much as possible. It is therefore essential natural mainstream of the river be changed.(Bowel, et al., 1997)

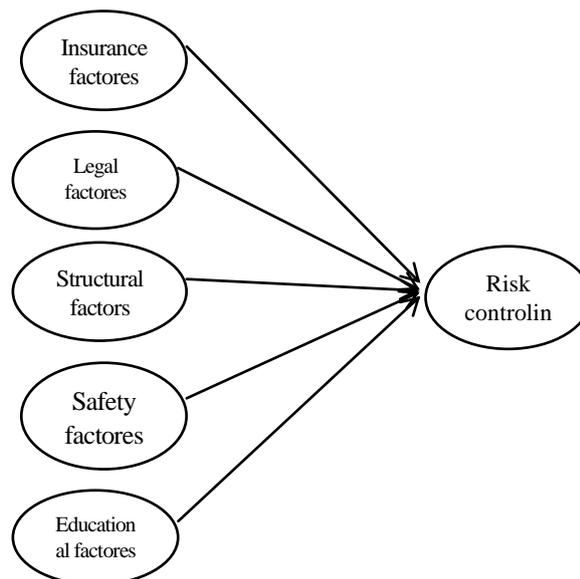


Figure1: reference researchers

### Hypotheses

1. insurance factors in the control of large dam projects have a significant positive impact.
2. Legal factors in the control of large dam projects have a significant positive impact.
3. Structural factors in the control of large dam projects have a significant positive impact.
4. Safety factors in control of large dam projects have a significant positive impact.
5. Educational factors in the control of large dam projects have a significant positive impact.

## Research methodology

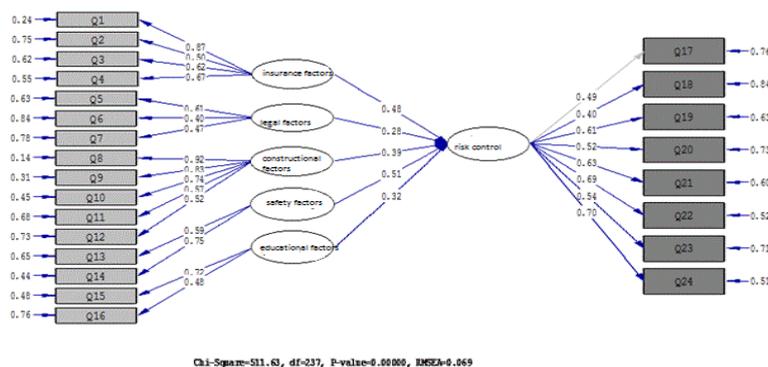
This article is the result of research which has an applied target and also descriptive-analytic method. The population of this research is managers and insurance experts from all insurance companies in the Mazandaran province that specialize in engineering insurance and risk. The research community according to the information obtained from central insurance and Mazandaran regional water authority are 176. The sample for this study based on a sample of 121 people from finite population across the 05/0 error is calculated. The questionnaire consists of 24 questions (index) . To ensure validity, the views of professors and experts in the field of management were used, and construct validity was measured by confirmatory factor analysis and using LISREL 51/8 version for each index, also indicators were eliminated if they were weak. In order to determine the reliability of the questionnaire, internal consistency was used with the help of Cronbach's alpha coefficient; coefficient obtained is 0.755. Therefore, the findings illustrate the reliability of the instrument. In analyzing the collected data, the Pearson correlation coefficient was used to determine the relationships between variables and structural equation modeling for testing the hypothesis. In structural equation model, on the one hand the conceptual model fitted to the data and indicators and on the other hand, the research hypotheses were examined.

**Table 1: the correlation matrix between the variables**

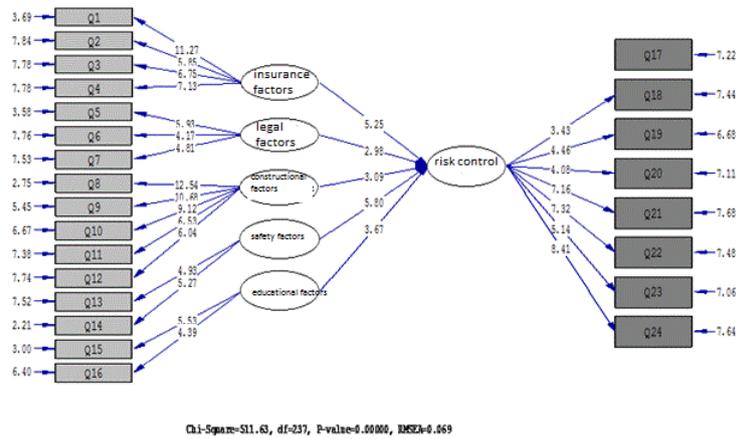
Risk control	1.00					
Insurance factors	0.437**	1.00				
Legal factors	0.360**	0.308**	1.00			
Structural factors	0.455**	0.391**	0.324**	1.00		
Safety factors	0.479**	0.432**	0.353**	0.293**	1.00	
Educational factors	0.346**	0.424**	0.482**	0.515**	0.336**	1.00

$p < 0.05$      $*p < 0.01$  \*\*

The table of the correlation between variables shows that all variables have positive and significant relation at the confidence level of 99%.



**Figure 2: confirmatory factor analysis model variables (standard estimate)**



**Figure 3: confirmatory factor analysis model variables (significant coefficients).**

**Table 2 :path coefficient, t statistic and the coefficient of determination (dependent variable: risk control)**

Predicting variable	(β)	t	R <sup>2</sup>
Insurance factor	0.48	5.25**	0.75
Legal factor		2.98**	
Constructional factor	0.39	3.09**	
Safety factor	0.51	5.80**	
Educational factor	0.32	3.67**	

\*\*p<0.01 \*p<0.05

The results of structural equation modeling show that insurance factors, legal, structural, safety and educational factors have positive and significant impact on the major projects of dam construction with the confidence level of 99%; all hypothesis are confirmed.

### Indicators of conceptual model

The various measures to evaluate the fit of the model was used in this study include Root Mean second error of approximation: the first criterion for determining the fit of the model. The root mean square error of approximation is shown as RMSEA. When the value of this statistic is less than 05/0, it can be concluded that the model is a good fit, and absolute fitting indicators include GFI & AGFI which appeared in output. This index should be between zero and one and values above 9.0 indicate an acceptable fit model. Relative indexes are includ NFI,NNFI,CFI. All index values, except NNFI, in this group are between zero and one. If they are closer to one, it can be declaimed that they are more fit. (the amount of NNFI can be higher than one).In general, working with LISREL program, each of the indexes obtained for the model is not the reason of fit; but next to one another indexes should be interpreted together.

**Table 3: Indicators of model**

Indicator's name	Limit	The value obtained
X <sup>2</sup> /df	Less than 3	2.15
RMSEA	Less than 0.08	0.069
GFI	Above 0.9	0.93
AGFI	Above 0.9	0.90
NFI	Above 0.9	0.92
NFII	Above 0.9	0.94
CFI	Above 0.9	0.95

### Conclusion and Recommendations

Risk control of dam projects, given the importance of these structures in human life, have particular importance. Also, risk assessment and analysis is one of the most important steps in project management. So should seek to reduce risk. In this study identification of risks in dam construction, projects was completed, and then the relationship between engineering insurance covers and the impact of them on risk controlling in dam projects was studied. According to studies, five factors were identified. The five factors were associated with insurance, and they were impressive on risk control of engineering projects such as dam construction. These five factors include insurance, legal, constructional, safety and educational factors. Also, Control of risk factor was identified as an independent variable. Ultimately, these factors were prioritized. As mentioned before, according to the first research question, these factors were identified. Each of the six factors includes some sub-factors or index. Safety factors have the greatest impact and afterwards, insurance factors, structural factors, educational factors and legal factors have the greatest importance, respectively. However, after Identifying and prioritizing the factors, there are suggestions:

According to the independent variable (risk control )which contains eight indicators, the indexes of observers skills and the way observers do their responsibilities and the correct recording of risk, it makes sense that history of dam construction engineers and specialized training to engineers insurance contribution will reduce the risk. As a result, it is recommended that the dam engineers with relevant experience and skills be applied more. A measure for specializing training about insurance to engineers should be taken. According to the educational factors, this has been interpreted as : two indexes include human resources and also human resources training is particular importance based on the information obtained through the questionnaire. As a result, investments in this sector will contribute to reducing risk. Consequently, it is suggested that care be taken in training of insurance employees companies and better educational facilities and up to dated facilities should be provided, especially for specialized areas with high sensitivity. On account of importance of educational factors, holding educational seminars at home and abroad in order to gain information for staff and participants is recommended.

Another indicator of risk control factor is healthy alarm systems in the downstream which have significant importance. Also, it has great share risk controlling in dam's project. Providing updated facilities for more accurate prediction can reduce the risk of flood and storm seems to be workable. Suggestions for future research, including:

Future researchers can add new variables to the model to measure the impact of this variability. In future research population can be extended if possible and, studies like this can be done. Assess and mitigate risk control models and its relation to engineering insurance.

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