HAZARD RISK ANALYSIS AND MANAGEMENT IN CONSTRUCTION SECTOR OF PAKISTAN

1. **Muhammad Haseeb - College of Public Administration, Huazhong University of Science and Technology, Wuhan, China**
2. **Prof. Xinhailu - College of Public Administration, Huazhong University of Science and Technology, Wuhan, China**
3. **Aneesa Bibi - College of Public Administration, Huazhong University of Science and Technology, Wuhan, China**
4. **Wahab Rabbani - COMSATS University Pakistan**

Abstract
Risks are very common in construction sector. Risk is the possibility of suffering loss and the impact of loss on the involved parties. Firstly risk is identified and then risk assessment and analysis is done. Then Risk management and risk mitigation is carried out. Risks affect construction sector negatively and focusing on risk reduction measures is important. Hazards like earthquakes are also main risks affecting construction sector in Pakistan. To counter earthquake risk, the measures of sustainable and improved resilience and resistance of building structures is required. The appropriate building design, good quality construction materials and better construction practices are very important for the strength and resistance of building structures. The improper design and poor construction work damages the architectural reliability and quality of the building structures. The hazard management policy of Pakistan is more focused towards rescue and relief and there is lack of integration and coordination between hazard management, environmental management, development planning and other hazard risk related organizations. There are some stage-wise procedures and considerations for the construction and strengthening initiatives of hazard resistant construction. There also is some success measures needed to be achieved and accomplished to ensure the construction of safer and hazard resistant building structures. Hazard resistant construction technique is needed to be linked with other hazard and risk mitigation techniques. For better understanding of building structure, construction materials, construction practices, hazard risks and their impacts, more structural and hazards research is needed. There is also some measures recommended for completion of safer, low risk and hazard resistant building structures.

Keywords: Risk, Risk Assessment, Hazard Risk, Construction, Strengthening, Management, Pakistan

INTRODUCTION

There are many risks encountered in the projects particularly construction projects Flanagan R, Norman G (1993). The possibility of encountering loss and its impacts is known as risk. Risk is a negative term referring to loss and impacts of loss, but there are is also positive risk involving favorable results and their impacts is known as opportunity Vaughan EJ (1986).Risk factor is a possible issue or event causing or may cause loss and harm to the project, so identification of risk factors is an important requirement. According to Baloi D, Price ADF (2003). Risk analysis is required for increasing the success chances of project and for lessening problems and issues. Questionnaires, decision trees, predictions, cost analysis, duration analysis, financial measures and computer simulations are the tools used for risk analysis Flanagan R, Norman G (1993), Raftery J (1994), Byrne P (1996), Grey S, (1998), Smith NJ (1999). Quantitative and qualitative risk analysis is also carried out. Risk is value based and its perception depends on space and time. A risk management strategy is developed and implemented and agreed risk mitigation initiatives are managed. In risk response, some actions are needed such as insurance, uncertainty reduction, reevaluation, transfer of risk elements and avoiding risk factors. In final assessment of risks, effectiveness of process is assessed, some improvements are proposed and results are analyzed Flanagan R, Norman G (1993). For the construction and strengthening of hazard resistant buildings, there are some stage-wise considerations. In responsibilities and participations, the consultation, cooperation and coordination is needed among and within government, development organizations, builders, engineers, researchers and affected population. In hazard assessment, likeliness, frequency and intensity of hazards, their sources, hazard maps and their impacts are assesses and risk analysis is carried out. In legislation and building codes, the design criteria, existing codes, code development, hazard inclusion and adequacy of codes is assessed and the performance and resistance of buildings is observed. In capacities and methodologies, the construction practices, code compliance, strength and durability, structural weaknesses, resistance and resilience of buildings is assessed. In safety objectives, clear objectives based on risk level, diverse performance objectives, impacts on clients and accountability issues are considered and assessed. In location of site, the availability, suitability, economic criteria, topographical features and risk level is considered. In procurement and design, the procurement strategy and design of sustainable and socially acceptable buildings and their strengthening is required and limitations of finances, materials and skills are considered. In competency assessment, the guidelines for building materials, resistance and strength, construction skills and quality are developed and the level of site inspection and assessment is considered. In construction stage, the checking of specifications, construction materials and multidisciplinary inspection of building works is required and quality assurance system is implemented properly. In operations and maintenance, a management and financial structure for operations and a procedure for structural changes and alterations is established and the maintenance guidelines are presented to maintain designed hazard resistance level. In evaluation stage, functionality, adequacy, sustainability, social acceptability and project cost with potential benefits of hazard resistant construction design and construction skills are considered Raftery J (1994), Ribakoff S (1979), Perry JG (1986), Flanagan R, Norman G (1993), William CA, Heims RM (1989), Toakley AR, Ling SMC (1991), Norris C, Perry J, Simon P (1992), To lessen risks and for safer constructions, there are some measures needed to be done for successful completion and working of safer constructed building structures. The enforcement of good construction practices, checking of designs and inspection of construction quality should be required throughout the construction the construction process CDMP, USAID (2001), Gibbs T (2002). The hazard experts and structural engineers should be engaged in the coordination and process of construction design and works. Land use planning and implementation of adequate and improved building codes should be done. The improvement of practices and training of technical people and appropriate training materials is accomplished by the consultation of hazard experts and construction engineers. Local community and population participation and consultation are needed for hazard-proof construction, strengthening and repair techniques Gibbs T (2002). The building structures are required to have better performance based structural design SEOAC (1995). For ensuring continued operation and for proper maintenance, the designed resilience and resistance of buildings to the hazard is required. More structural and hazards research is needed at different degrees and levels. Hazard-proof construction is required to be linked with other hazard mitigation measures EEFIT (2005). The hazard and risk management policy of Pakistan is focused more on rescue and relief work LEAD (2003).There is also lack of sufficient knowledge and information about risk management, risk assessment and hazard risk mitigation. There is lack of coordination and integration between hazard management, development planning and environmental management. There is also absence of coordination between and within hazard and risk related organizations Blaikie P, Cannon TI, Davis B, Wisner (1994), Hewitt K (1997), CRPRID (2006).

LITERATURE REVIEW

A risk engineering approach for project risks and their identifications was presented by Chapman C, Cooper D (1983). In this different techniques and tools are integrated including probability distributions and decision trees. Risks were structured as Risk Breakdown Structures (RBS) in a method for the analysis of projects cost risk by Cooper DF, Macdonald DH, Chapman CB (1985). where project cost was a top of hierarchy. Risk and its impacts are assessed in monetary terms by proposing a common use of risk cost and modeling risk as the probability of occurrences and consequences as suggested by Franke A (1987). An assessment tool for risks using Fuzzy Sets Theory (FST) particularly for construction risk assessment was illustrated by Kangari R, Riggs LS (1989). Construction risk from both duration and cost points of view was assessed introducing different models based on PERT and Monte Carlo Simulation (MCS) by Hull JK (1990). Construction project risk was assessed adopting Analytic Hierarchy Process (AHP) in which probability and impact of risk was assesses by weight and value concept and also AHP suitability was evaluated by Mustafa MA, Al Bahar JF (1991). Probabilities were assigned to decision tree and a technique for integration and quantification of schedule,

cost and technical risks as utility function was proposed by Riggs JL, Brown SB, Trueblood RB (1994). P-I model and AHP was used with minor changes for assessing levels of risks in construction projects by Zhi H (1995). A FST based risk management approach identifying risks, their dependencies, their likelihoods and their interdependencies was presented by Wirba EN, Tab JHM, Howes R (1996). The duration of a project and randomness of the cost was combined in a scholastic model developed by Tavares LV, Ferreira JAA, Coelho S (1998). The PERT technique and variance of project duration distribution was used to measure project duration risk by Mulholland B, Christian J (1999). The consideration of multiple impacts of risks on the construction project for calculation of overall risk impact was done for improvements in risk assessment as advocated by Ward SC (1999).

Since 2000, construction risk modeling and assessment became more intensified, sophisticated and capable because of the availability of computers and decision support systems. The utilization of P-I models for calculation of risk score for project time, cost and quality for projects ranking based on the risk scores was presented by Baccarini D, Archer R (2001). The assessment of both threats and opportunities together within P-I models of construction risks quantitatively and qualitatively was proposed by Hillson D (2002). Risk associated with construction projects was modeled by probability, exposure and severity, which affects personnel or/and property and software was used to generate risk scores by Jannadi OA, Almishari S (2003). FST was recommended as a effective solution for assessment of construction uncertainty by Baloi D, Price ADF (2003). MCS is used for assessment of project duration and cost in the risky environments by Oztas A, Okmen O (2004). Overall risk level of project was calculated by multiplying the relative probability with relative impact for every risk and then adding risk scores in multi-criteria decision making (MCDM) framework for assessment if risks and opportunities in construction projects by Dikmen I, Birgonul MT, Han S (2006). Fuzzy-Delphi method and fault tree was used for modeling various scenarios of risk for assessment of risk probability and impacts by,Thomas AV, Kalidindi SN, Ganesh LS (2006). The sources of uncertainty, risk impacts and affected activities were identified and controllability as ratio between predicted risk impacts and after mitigation activities was modeled and assessed by Cagno E, Caron F, Mancini M (2007). When risk event occurs, risk consequences are determined through interaction of project with risk events, as discussed in project vulnerability concept introduced by Zhang H (2007). The lower is the project risk if higher is the utility value and usage of AHP and utility theory was proposed in a multi criteria risk assessment model for construction projects by Hsueh SL, Perng YH, Yan MR, Lee JR (2007). The capabilities of AHP (prioritize and structure various risk factors) and FST (subjective assessments) were combined to assess construction risks by Zeng J, An M, smith NJ (2007). A fuzzy risk assessment method for risks of construction projects introduced concepts of manageability and controllability and stressed that the company's ability to manage risks should be taken into consideration during design and modeling stage, it was proposed by Dikmen I, Birgonul MT, Han S (2007). The sum of weighted risk impacts of risk factors was determined through usage of AHP for assigning weights to risks before calculation of overall risk level of project by Zayed T, Amer M, Pan J (2008). Risk significance is defined as degree of risk feeling intuitively including identification of risk, implementing risk management skills, direct or indirect loss, and relationship between profitability and attitude to risks as explained by Han SH, Kim DY, Kim H, Jang WS (2008). Risk impacts are combined and total impact is estimated for reaching appropriate contingency budget was presented by Cioffi DF, Khamooshi H (2009).

RISK

Risk is the possibility of suffering loss and the impact of loss on the involved party. The probable occurrences of events adversely or favorably as a consequence of uncertainty, affecting the project is also a definition of risk Mustafa MA, Al Bahar JF (1991). Risk is characterized in terms of severity and severity is likelihood multiplied by magnitude of the impact. According to Dias A, (1994), there are two types of risks which are: (a) pure risk, possibility of losses but no possibility of gains, and (b) speculative risk, possibility of both losses and gains.

Subjective analytical methods relying on background information and the experiences is used for the assessing the construction risk and uncertainty and their impacts Bajaj D, Oluwoye J, Lenard D (1997) . Opportunity is also known as positive risk Porter CE (1981), Heale JR (1982), Perry JG, Hayes RW (1985), Opportunity is the possibility of favorable results and impact of these results on the involved party. Uncertainty is the gap between the information possessed by decision maker and the information required for estimation of outcome CII (1989). Risk analysis is the identification of risk factors and the quantification of these risk factors (by estimation of magnitude and likelihood of impacts). Risk Mitigation is the development of a plan to deal with risks on projects.

RISK IDENTIFICATION

Every possible issue or event causing or that may cause harm to the project is risk factor Royal Society (1992).Identification of risk factors is fundamental requirement. Risk identification can be done by following approaches such as standard checklists, expert interviews, Delphi technique, comparing to other projects and facilitated brainstorming sessions.

RISK ANALYSIS

Risk analysis is required for lessening problems and surprises and avoiding crisis. Risk analysis is also needed for increasing the chances of project success and for better handling of schedules and costs by proper estimation of contingencies Uher TE, Toakley AR (1999). Not just designing it, but studying and analyzing the project in an orderly manner is required. The clear understanding of all objectives, issues and alternatives are needed to be considered in the design and construction of the project. Tools used in risk analysis are questionnaires, predicted values of severity and contingency, decision trees, financial measures, and cost analysis and computer simulation for schedule analysis and range estimation. According to Raftery J (1994). Qualitative risk analysis is done by using subjective assessment of high, medium and low or color coding the various factors of risk. Quantitative risk analysis is done by assigning probabilities to various factors and then assigning a value for each impact and then afterwards identifying severity for each factor of risk Flanagan R, Norman G (1993), Ward SC, Chapman CB (1991).

RISK CHARACTERISTICS

Risk is value-based and dependent on magnitude and time. As a future event, the perception of risk is affected by time and space. Every party has a different tolerance level for risk. The risk is more acceptable, if there is more pay off. The risk should be associated with certain degree of possibility or uncertainty. It is impossible to avoid all risks, but risks can be transferred or reduced to some extent.

RISK MANAGEMENT

Firstly, evaluation of risk factors is done by assessment of each factor with its impact, determination of likelihood and magnitude and interpretation of scores. An outline is needed in management plan, such as what is to be done, when to do it, which is responsible and other related information. A risk strategy is developed and implemented through integrating with mainstream management according to Raftery J (1994). The risk mitigation initiatives which are agreed upon are managed. The management plan is revised periodically to consider the changes in information, conditions and results Vaughan EJ (1986).

RISK RESPONSE

There are some actions which needed to be taken responding to residual risk comes in the risk response. The insurance against the probable occurrence of risk factor is needed. Uncertainty is reduced by using more data and information. Sometimes reevaluation is needed. The risk elements are transferred by contracting out the affected work. A different method or strategy and partial or complete re-design is done for the elimination or avoiding of the risk factors. In case of intolerable risk and no way for mitigation of damages, the project is aborted. Finally, the response plan and mitigating strategy is communicated to the review team.

FINAL ASSESSMENTS

The investment outcomes are assessed such as results of investment with original objectives are considered. Real risk impacts are compared with the anticipated risk impacts. Effectiveness of the process and its applications are assessed. Important lessons are drawn for future projects and some improvements for the process are proposed. The results are communicated and analyzed.

HAZARD RISKS IN CONSTRUCTION SECTOR

This study is focused on risk reduction measures. Hazards like earthquakes are major risks, so the measures like sustainable and improved resilience and resistance of buildings is required. Most of the risk reduction measures and proposals lack a business model making these less effective. After earthquake, the authorities in Pakistan relied more on economically, socially and culturally inappropriate standard reconstruction and centralized control. Most researcher are more concerned with economic and political perspectives leading to differential vulnerability Watts MJ (1983), Blaikie P, Cannon TI, Davis B, Wisner (1994), Mustafa D (1998-2000), Pelling M (2003). The policy and working circles of DRR are focused on vulnerability and risk mitigation. Hazard researchers Blaikie P, Cannon TI, Davis B, Wisner (1994), Hewitt K (1997), Mustafa D (2002). Involve same kind of policies in different sectors and organizations working on risk mitigation. Buildings are affected by hazards in many ways. The kind of hazard, construction technology and buildings materials should be considered in the construction, reconstruction and repairing of the buildings and infrastructure affected by hazard. This is applicable for risk mitigation measures for engineered and non-engineered building structures UNDP, NCPDP (2008). The Pakistan's construction sector suffered and is suffering from risks like lack of control, lack of quality, poor performance, increased cost, time delay and many other problems. Risk appears in different shapes and the objectives of the construction project are mostly related to client satisfaction, cost, time, function and quality.

A sector's economic growth and productivity is determined by labor workforce if the better workforce protocols and measures are in place YEM (2006). The construction industry plays an important role in the economy and is a main employment source. The construction industry also suffers accidents and problems resulting in loss of productivity, absenteeism, disabilities and fatalities Fung WH, Tam CM (1994), Mohamed S (1999), Niza C, Silva S, Lima ML (2008), Mohamed S, Ali TH, Tam WYV (2009). Construction sector is a high risk sector now a days Liao CW, Perng YH (2008), C, Silva S, Lima ML (2008). The main reasons for these are low education level of construction workforce and risks associated to building structures and construction work. The effective way to improve the performance of construction and building structures should be lessening uncertainty and also lessening risks before happening Cooke RM (1997), Gambatese JA, Behm M, Rajendran S (2008). Risk assessment and risk management is founded on risk analysis for safety and these risk management and risk assessment are critical in construction sector Langford D, Rowlinson S, Sawacha E (2000), Low SP, Sua CS (2000), Cheng EWL, Li H, Fang DP, Xie F (2004), Jung Y, Kang S, Kim YS, Park C (2008). The professionals and experts are needed to carry out on site risk assessment to improve the performance of the construction and building structures Aksorn T, Hadikusumo BHW (2008), Aneziris ON, Papazoglou IA, Baksteen H, et all (2008), Visscher H, Suddle S, Meijer F (2008). The reliability and quality of risk assessment is affected by the perception and considerations of professionals and experts. Some tools and techniques were developed for helping construction designers and risk experts in Australia Cooke T, Lingard H, Blismas N, Stranieri A (2008). In previous researchers, it was seen that most of the risk professionals are doing less reliable risk assessment based on their knowledge and experience, and there is lack of systematic techniques for risk assessment. Good practices are very important for the achievement of better performance. The construction workforce needs effective safety instructions and more awareness about safety and risks.

RISKS AND WEAKNESSES IN CONSTRUCTION SECTOR

There is lack of sufficient knowledge about better construction practices and appropriate building design. Specialized expertise about buildings and construction methods is not commonly available. There is inflation of prices and shortage of supply of skilled labor and building materials. There is poor construction quality in most building structures which results in more fragile and vulnerable buildings. Increased costs and negative environmental impacts are due to more energy requirements of imported modern building materials and technologies HKU (2010), Hui SCM (1999), Lam JC, Hui SCM (1996). The building structures are poorly adapted to the probable risks or their adaption is focused on a few risks ignoring other risks. There is incompatibility between modern building designs or methods and the local culture or local community interests. Design and construction works also have a contribution in environmental damage. Extended time for reconstruction, negative environmental impacts and loss of cultural traditions is due to demolition or destruction of reparable building structures. The architectural reliability and quality of the buildings is damaged by the improper design and implementation of retrofitting and repair programs. Donor organizations not like to finance low standard reconstructions and retrofitting approaches. Building codes and regulations do not appropriately incorporate the usage of local building materials, technologies and practices. (e.g. Anderson, 1979; Robison and Barry, 1987; Fleisher, 1990; Anderson and Dillon, 1992).

POLICY FOR HAZARD MANAGEMENT IN PAKISTAN

In Pakistan, there is a hazard management policy which exhibits some features which are as follows.

The hazard management in Pakistan is focused or concentrated mostly on rescue and relief. In the aftermath of every hazard, the government directs a considerable amount of expenditure on rescue, relief and rehabilitation LEAD (2003). Some hazard management policies have strategic biases focused at protecting sites and infrastructure of greater strategic, political and economic importance at cost of lesser importance and influenced areas and population. There is lack of sufficient knowledge and information about risk assessment, risk management, identification of hazards and relationship between hazard preparedness and livelihoods. There are no coherent, inclusive and long-term arrangements for addressing hazards and issues related with hazards with long-term vision and future perspective. Hazards are not considered in the processes of development projects and poverty alleviation programs. There is a lack of integration between hazard management, environmental management and development planning. There is absence of coordination between and within hazard related organizations. High level hazard mitigation and preparedness measures are more focused towards structural aspects and sometimes the local people and livelihood protection issues are ignored. Relief and hazard organizations and departments are not given the required importance within administrative hierarchy and they mostly remain under-resourced Blaikie P (1994), Hewitt K (1997), CRPRID (2006).

A STAGE-WISE APPROACH

Based on the success or failure of past construction projects, many organizations have suggested techniques and procedures for the construction and strengthening initiatives of hazard resistant construction. By reviewing these past initiatives, procedures and engineering sources Blaikie P (1994), Ribakoff S (1979), Perry JG (1986), Flanagan R, Norman G (1993), William CA, Heims RM (1989), Toakley AR, Ling SMC (1991), Norris C, Perry J, Simon P (1992). There are some considerations that need to be made stage-wise.

Stage-wise Considerations

Stage	Key considerations
Responsibilities and participations	A system or network of cooperation and consultation with the government, researchers, engineers and affected population is needed to be established.
	The other humanitarian or relief organizations need to be coordinated with for avoiding the replication of research work in hazard-resistant construction structures.
	Corresponding hazard-resistant construction codes and standards are needed to be used.

	The full participation of engineers and other service providers is needed in the designing of construction projects.
Hazard assessment	Likeliness, frequency and intensity of all probable hazards and their sources (geographical, hydrological, meteorological or geological) in the area is needed to be assessed to be considered in the infrastructure and building structures design.
	An overview of importance of hazard risk specific to the country is provided in the organizations country strategy information.
	For hazard assessment, it is needed to carry out risk analysis or micro-zoning studies in addition to the prevalent hazard maps and academic studies
	The secondary effects (such as landslides or ground-shaking) and their probability is needed to be considered.
Legislation and building codes	Prevalent codes, code development, hazard inclusion level and adequacy of codes for usage in construction is assessed.
	The performance and resistance of building structures and infrastructure constructed according to the codes during past hazards is needed to be observed and looked upon.
	The design and loading criteria is compared to the building codes developed for different countries with similar construction type or similar hazard.
	International building codes and design guidelines are reviewed and their appropriateness and applicability is assessed.
Capacities and methodologies of construction	Main construction practices are identified for building structures and relevant infrastructure, and rapid assessment is made in new constructions but detailed analysis is required for retrofitting.
	Structures weaknesses and the resilience and vulnerability of building structures and infrastructure to the hazards are assessed.
	The durability, resistance and strength of building structures and construction materials is needed to be determined.
	The code compliance and who carrying out construction (engineered or non-engineered) and design is identified.
Safety objectives	Measurable and clear objectives, based on the risk level supported by government and affected population, for hazard resistance are established.
	Organizational accountability issues are taken into account.
	Diverse performance objectives are considered for important structures and infrastructure.
	Possible impact on the clients or users who could be negatively affected to different extents is factored in.
Location of site	The government or organization defines the site for construction project based on availability, suitability and economic criteria.
	Whether additional works are required to make the site ready for construction or the land use is need to be restricted for less vulnerability is determined.
	The option of land swap or re-shifting of site having low risk level is considered.
	Landscape and topographical features can be utilized for reduction of hazards probable impact.
Procurement and Design	To satisfy the hazard safety objectives, the design of a sustainable and socially acceptable building/strengthening solution is needed. Also ensure the acceptance of environmental and social impacts of proposed solution.
	Limitations of finance, material availability and construction skills are considered.
	The performance objectives of the proposed solution are ensured through research and testing.
	A procurement strategy is developed to present overall values of resources and finances for entire lifetime of building/facility.
Competency assessment	The level of essential site inspection, assessment and supervision is considered.
	Training and skills issues needed for implementation of proposed solution are addressed.
	The guidelines for building material characteristics, construction quality and skills are developed.
	The guidelines and building aids accounting for hazard conditions are developed.
Construction stage	It is ensured that the construction quality should not be comprised if design intent.
	A procedure is needed to be implemented for checking specifications and multidisciplinary inspection of building works throughout the construction process.
	Checks and test materials are adhered to the design guidelines.
	The proper implementation of quality assurance system is ensured.
Operations and maintenance	Guidelines for the operations and maintenance are needed to be provided.
	The maintenance guidelines should be presented to maintain the designed hazard resilience and resistance level.
	A management and financial structure for operations and maintenance is established.
	A procedure should be followed for the structural changes or alterations carried out through the lifetime of the structure.
Evaluation stage	The success of the overall project and the adequacy of the structure or infrastructure design should be carried out. Functionality, sustainability and social acceptability should also be considered.
	Project cost with potential benefits of hazard-resistant construction design with construction skills and new construction guidelines is introduced.
	The performance of the building structure or infrastructure under the hazard events should be reported.
	Studies related to strengthening hazard resistance and resilience should be summarized and drawn on for future perspectives.

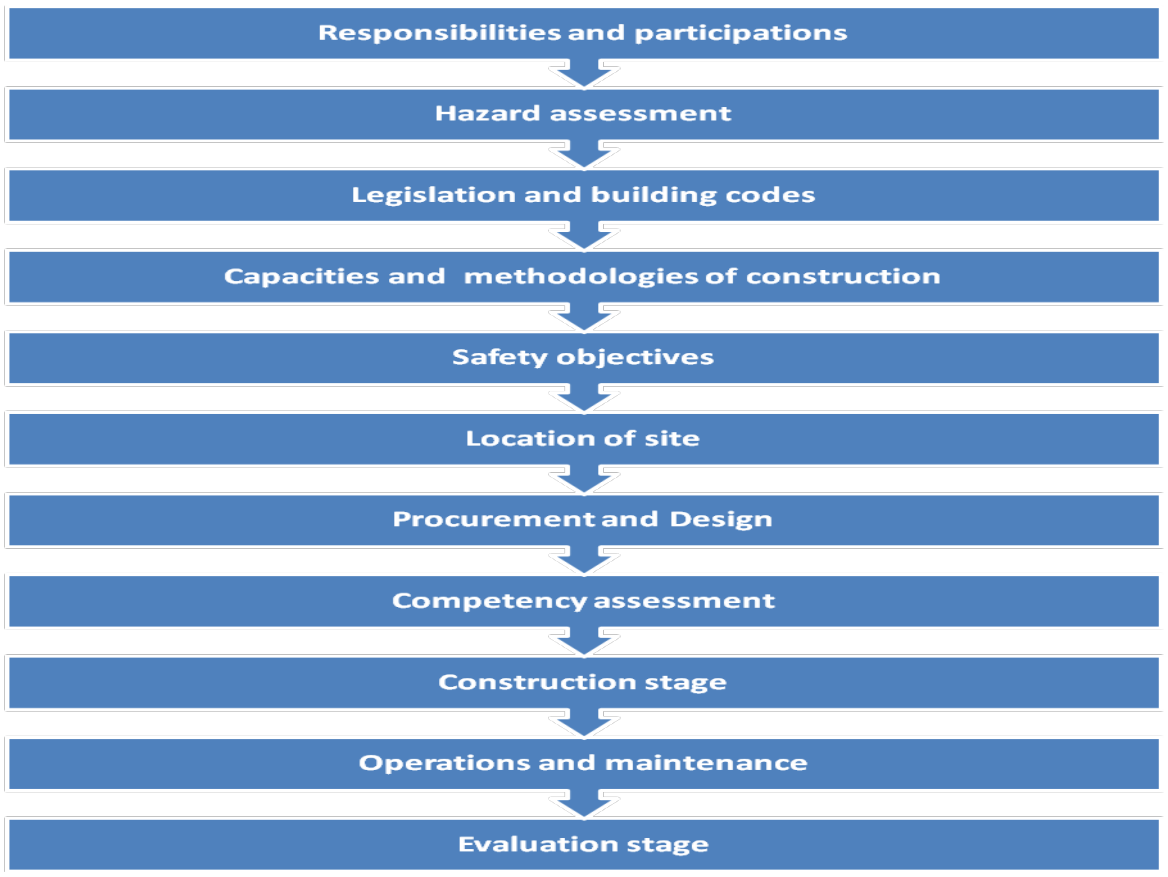

Figure 1. Stage-wise approach for construction and strengthening

IMPORTANT SUCCESS MEASURES

For safer constructions, there are important success measures to be done for the successful completion of safer construction targets and objectives.

1. **Design checking and quality control:** The checking of designs, enforcing the good building practices and inspection of construction quality is needed throughout the building or construction process. For these, well trained technical personnel, appropriate policies and effective implementation measures are required. Lesser allocation of human and financial resources and political interference makes it the weakest part in the construction process or system. To save some maintenance cost and for the lifetime of the constructed building, a little important additional cost is needed. This is the weakest part of construction system, because of political interference and less allocation of human and financial resources CDMP, USAID (2001), Gibbs T (2002).
2. **Construction and hazard experts:** The structural engineers and hazard specialists should be engaged in the design and coordination of the construction project and works. Their recognition by development and funding agencies is the major factor for the success and mainstreaming of hazard-proof measures in the construction projects. The reliance on these experts is better than the local practices. The input by structural engineers and hazard experts leads to good risk management and risk mitigation.
3. **Land use and building codes:** The governments, professional institutions and other national bodies need support from development organizations and experts to improve hazard assessment and representation in building codes and modifications in building codes for countering increasing hazards and for improving structural designs and land use planning and zoning.
4. **Practices improvement**: In Pakistan, local engineers, builders and architects need to be provided with the appropriate technical guidance and training. By the consultation of hazard proof construction experts, the development of appropriate educational and training materials and trained technical people for the transfer of knowledge is accomplished.
5. **Local and community participation:** The hazard-proof construction, strengthening and repair techniques are needed to be developed with the consultation of the local affected population. This is needed to be done because sometimes the proposed solutions are very expensive or some new materials and techniques are introduced for the local inadequate skills or the materials and designs are inappropriate for the social, economic, cultural or climate conditions.
6. **Performance-based structural design:** This includes the determination of acceptable risk levels for various types of building structures and their desired performance subjected to different frequencies and intensities of hazards. Consideration of desired post-hazard performance at design stage would results to the more strengthened hospitals, schools and other important infrastructures. Mostly it comes in earthquake engineering but it is also needed to be extended to multiple hazards and policies ensuring that the schools, hospitals and other important buildings are designed with increased resilience and resistance to the hazards SEOAC (1995).
7. **Operation and maintenance:** This is required to maintain the designed resilience and resistance of infrastructure to the hazard. The maintenance of the buildings needs additional cost and time Gibbs T (2002). To ensure the continued operation and maintenance, it is needed to relate the expenditure with insurance which would cover the future eventual damage due to a natural hazard.
8. **Structural and hazards research**: Research for the better understanding of the performance of non-engineered and traditional building structures, materials and technologies under natural hazards is needed. The effects of natural hazards on the building structures are needed to be researched at different levels and degrees EEFIT (2005).
9. **Linkage with other mitigation measures:** Hazard-proof construction is one risk reduction technique, and it is needed to be linked to other types of disaster mitigation techniques including evacuation planning and community preparedness measures.

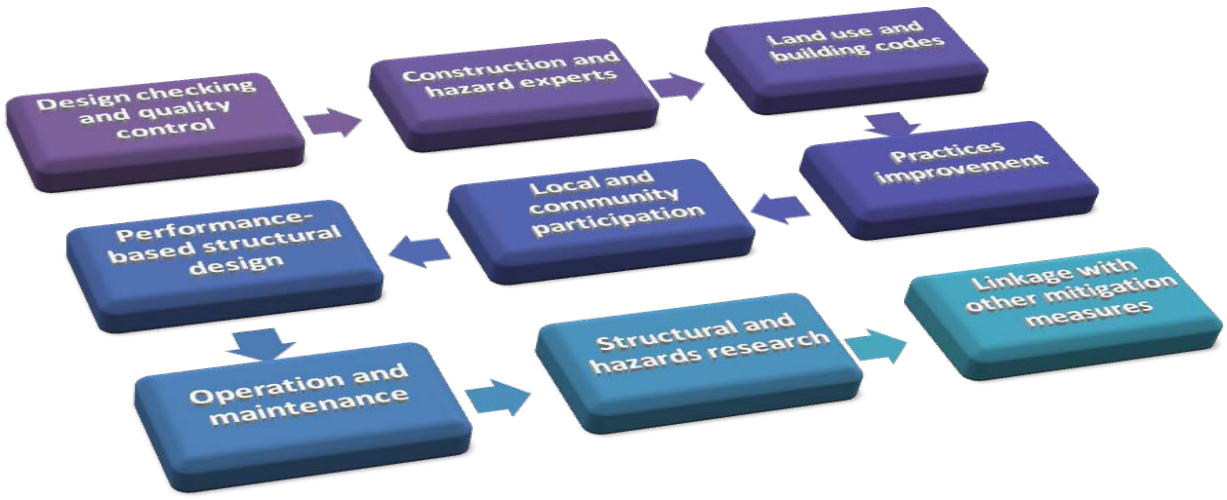

Figure 2. Success measures for safer construction objectives

CONCLUSION

Risk analysis and assessment is very important in construction sector. Firstly, risks are identified and then the risk analysis and assessment is done. Quantitative and Qualitative risk analysis id carried out by using tools like predicted values of severity and contingency, questionnaires, decision trees, financial measures and computer simulations. Risk is dependent on magnitude and time and risk is also associated with degree of uncertainty. A risk strategy is developed and implemented for managing risks. The response plan and risk mitigation strategy involves the actions taken in response to risks. The real risk impacts are compared with the predicted risk impacts and effectiveness of the risk analysis and mitigation process is assessed. There are many kinds of potential risks affecting construction sector. In case of Pakistan, natural hazards like floods and earthquakes are major risks affecting construction sector. For earthquake risks, the risk mitigation needs the measures like sustainable and improved resistance of building structures to the earthquakes. In the construction, reconstruction and repairing of building structures, the details of earthquake, construction methods and building materials are required for engineered and non-engineered building structures. There is lack of better construction practices, suitable building design and specialized expertise for earthquake resistant building structures. The most building structures have poor adaption to the risks like earthquakes. Good construction practices are very important for the better performance of buildings in response to the earthquakes.

There is a stage-wise approach for the techniques and procedures for the construction, reconstruction and strengthening initiatives of hazard resistant building construction. There are some considerations to be done stage-wise in following stages: responsibilities and participations, hazard assessment, legislation and building codes, capacities and methodologies, safety objectives, location of site, procurement and design, competency assessment, construction stage, operations and maintenance and evaluation stage. The hazard management policy of Pakistan is focused more on rescue and relief work. Some policies have strategic biases and there is no clear and long-term vision. There is insufficient information about hazards, risk assessment and risk mitigation. There is lack of coordination and integration between and within hazard risk related organizations like hazard management, environmental management and development organizations. Hazard preparedness and mitigation measures are more focused towards structural aspects ignoring community and livelihood. For safer and earthquake resistant constructions, there are some success measures to be considered are as follows: design checking and quality control, construction and hazard experts, land use and building codes, practices improvement, local and community participation, performance-based structural design, operations and maintenance, structural and hazards research and linkage with other mitigation measures. The building structures will be more safer and resistant to earthquakes by considering and implementing these success measures.

RECOMMENDATIONS

Risk mitigation is very important in construction sector. For risk mitigation and reduction of risks, the good quality of risk assessment and analysis is needed. For earthquake risk mitigation, the construction of earthquake resistant building structures is needed. The resilience and resistance of building structures should be sustainable. A well organized network of quality assurance is needed for the construction materials and supervision or monitoring of construction. It is needed to introduce cost effective construction techniques keeping view of the financial status of the area or community. The technology and materials used should conform to the natural environmental conditions. More efforts are needed for the sustainability of the natural environment. The required construction materials should be easily available at discounted rates and should be easily accessible.

It is needed to be physically and mentally prepared and aware of the dangers related or near fault line. Top priority should be given to main buildings and infrastructure restoration. Building codes should be related to local requirements, public friendly and easy to understand. Local governments should promote local culture and needed to be well equipped. Emergency support services and medical facilities are needed to be aligned with their task and performance. Deep rooting and capacity building is needed to strengthen the institutions such as Red Crescent, civil defense and NDMA. It is needed to undertake the pre-planned storages for food, medicines and other necessary commodities. Priority should be given to the adaptation of local construction methods and usage of local materials should be preferred. The locals should be trained in the new construction technologies introduced in the area. There should be sufficient knowledge and awareness about the better construction practices and building designs. The construction systems introduced should be environment friendly and whose maintenance and repair services are easily available. Specialized expertise about better construction methods should be commonly available and shortage of skilled labor and construction materials should be avoided. Increased costs and negative environmental impacts should be lessened. The building structures should be well adapted to the risks like earthquakes. There should be compatibility between the better construction designs and the local community interests and culture. The building codes and designs should incorporate the usage of local construction materials and technologies. There should be proper design and implementation of design in the construction, retrofitting and repair programs to keep the architectural reliability and quality of the building structures. There should be sufficient knowledge and information about risk assessment, risk management and hazards and there should be long-term vision and perspectives for addressing hazards and hazard related issues. Hazard risks should be considered in the development projects and there should be no biases in the hazard management policies. There should be coordination and integration between the hazard management, environmental management, development organizations and other hazard risk related organizations. The hazard management should also focus on risk and hazard mitigation measures. There should be design checking and quality should be ensured throughout the construction process. The consultation of structural engineers and hazard experts should be in the design and construction works. Building codes should be appropriately implemented and there should be well planned land use. The structural design should be performance based and improvement of construction practices is also needed. The hazard resistant construction techniques should also be linked with other risk and hazard mitigation measures.

There should be participation of all related parties and organizations in the construction process and each should properly complete its

responsibilities. The hazard assessment should be carried out in detail. The effective building codes according to the legislation should be implemented in the construction design and work. The capacities should contain the durability, resistance and strength of building structures and methodologies of construction should lessen or avoid the structural weaknesses. The safety objectives should be considered for the better performance of buildings. The site location should depend on the availability, suitability and economic criteria and where topographical features favor the resistance and strength of building structures. The performance objectives of the building design should be ensured through research and testing. Competency assessment should contain the guidelines for construction materials and methods and essential site assessments, inspection and supervision is done. At construction stage, the proper implementation of construction quality and methods according to the design is ensured and checking of specifications and multidisciplinary inspection is done throughout the construction process. The operations and maintenance guidelines should well present the designed the hazard resilience and resistance of building structures and a proper procedure should be followed for the structural changes or alterations of the building structure. The success, adequacy and performance of the building structure or infrastructure should be evaluated considering functionality, sustainability and social acceptability. The studies and research related to strength and resistance of building structures and for better understanding of the performance of different building structures under hazards should be carried out.

REFERENCE

Aksorn T, Hadikusumo BHW (2008). Critical success factors influencing safety program performance in the construction projects, safety science 46(4), 709-727.

Aneziris ON, Papazoglou IA, Baksteen H, et all (2008). Quantified risk assessment for fall from height, Safety science 46 (2), 198-220.

Blaikie P, Cannon TI, Davis B, Wisner (1994). At risk, Natural hazards, People's vulnerability and disasters, New York.

Baccarini D, Archer R (2001). The risk ranking of projects methodology, IJOPM 19,139-145.

Baloi D, Price ADF (2003). Modeling global risk factors affecting construction cost performance, IJOPM 21, 261-9.

Byrne P (1996). Risk, Uncertainty and decision making in property development, 2nd ed London UK.

Bajaj D, Oluwoye J, Lenard D (1997). An analysis of contractor's approaches to risk identification in New Wales, Australia.

Cooke RM (1997). Uncertainty modeling examples and issues, Safety science 26 (1-2), 49-60.

Cooke T, Lingard H, Blismas N, Stranieri A (2008). The development and evaluation of a decision support tool for health and safety in construction design, ECAM 15(4), 336-351.

Cheng EWL, Li H, Fang DP, Xie F (2004). Construction safety management an exploratory study from china, construction innovation, information, process management 4(4), 229-241.

Chapman C, Cooper D (1983). Risk engineering basic controlled interval and memory models, JOORS, 34(1), 51-60.

Cooper DF, Macdonald DH, chapman CB (1985). Risk analysis of a construction cost estimate, IJOPM 3(3), 141-149.

Cagno E, Caron F, Mancini M (2007), A Multi dimensional analysis of major risks in complex projects, Risk Management 9, 1-18.

CII (1989). Management of project risks and uncertainties, CII publication 6-8, Austin , TX.

Cioffi DF, Khamooshi H (2009). A practical method of determining project risk contingency budgets, JORS 60, 565-571.

CRPRID (2006). Earthquake, An assessment of impoverishment risks Islamabad Pakistan.

CDMP, USAID (2001). Hazard resistant construction, Caribbean disaster mitigation project, Sustainable development and environment, USA.

. Dikmen I, Birgonul MT, Han S (2006). An analytic hierarchy process based model for risk and opportunity assessment of international construction projects, JOCE 33(1), 58-68, Canada.

Dikmen I, Birgonul MT, Han S (2007). Fuzzy risk assessment to rate cost overrun risk in international construction projects, IJOPM 25, 494-505.

Dias A, (1994). A managerial and financial study on the involvement of private sector companies in the development, construction, operation and ownership of infrastructure project, Ann Arbor.

EEFIT (2005). Earthquake engineering field investigation team report, Ocean Tsunami India.

Fung WH, Tam CM (1994). Effectiveness of safety management strategies on safety performance in Hong Kong, Department of building and construction, China.

Franke A (1987). Risk analysis in project management, IJOPM 5(1), 29-34.

Flanagan R, Norman G (1993). Risk management and construction, London.

Gambatese JA, Behm M, Rajendran S (2008). Design's role in construction accident causality and prevention, Safety science 46 (4), 675-691.

Grey S, (1998). Practical risk assessment for project management, New York (USA).

Gibbs T (2002). How can the resilience of infrastructure be increased, Proceedings of the 682nd Walton Park Conference, UK.

Han SH, Kim DY, Kim H, Jang WS (2008). A web based integrated system for international project risk management, Automation in construction 17, 342-356.

HKU (2010). Building energy standards and codes (BESC), www.arch.hku.htm.

Hsueh SL, Perng YH, Yan MR, Lee JR (2007). Multi criterion risk assessment model for construction joint ventures in China, Automation in construction 16, 607-619, China.

Heale JR (1982). Contingency funds evaluation, American association of cost engineers B3.1-B3.4

Hillson D (2002). Extending the risk process to manage opportunities, IJOPM 20, 235-240.

Hull JK (1990). Application of risk analysis techniques in proposal assessment, IJOPM 8(3), 152-157.

Hewitt K (1997). Regions of risk, A geographical introduction to disasters, UK.

Hui SCM (1999). Development and analysis in energy efficiency in buildings in Hong Kong, China.

Jung Y, Kang S, Kim YS, Park C (2008). Assessment of safety performance information systems for general contractors, safety science 46 (4), 661-674.

Jannadi OA, Almishari S (2003). Risk assessment in construction, JOCEM 129(5), 492-500.

Kangari R, Riggs LS (1989). Construction risk assessment by linguistics, JOTEM 36(2), 126-131.

LEAD (2003). Presentation by the project management unit, workshop on Lai nullah flood Hazard management, Islamabad Pakistan.

Liao CW, Perng YH (2008). Data mining for occupational injuries in the construction industry, Safety science 46(7), 1091-1102, Taiwan.

Langford D, Rowlinson S, Sawacha E (2000). Safety behavior and safety management influence on the attitudes of workers in the construction industry, ECAM 7(2), 133-140, UK.

Low SP, Sua CS (2000). The maintenance of construction safety riding on ISO 9000 quality management systems, JOQME 6(1), 28-44.

Lam JC, Hui SCM (1996). Review of building energy standards and implications for Hong Kong BRAI 24(3), 131-140

Mulholland B, Christian J (1999). Risk assessment in construction schedules, JOCEM 125 (1), 8-15.

Mustafa MA, Al Bahar JF (1991). Project risk analytic assessment using the hierarchy process, JOTEM 38(1), 46-52.

Mohamed S, Ali TH, Tam WYV (2009). National culture and safe work behaviors of construction workers, safety science 47 (1), 29-35, Pakistan.

Mohamed S (1999). Empirical investigation of construction safety management activities and performance, Safety science 33, 129-142, Australia.

Mustafa D (1998). Structural Causes of vulnerability to flood Hazard, JOEG 74(3), 289-305, Pakistan.

Mustafa D (2002). power, and access to irrigation water and vulnerability to flood hazard, Environment and planning, Society and space 20(6), 737-752.

Niza C, Silva S, Lima ML (2008). Occupational accident experience association with worker's, Safety Science 46 (4), 959-971.

Norris C, Perry J, Simon P (1992). Association of project managers, project risk analysis and project management.

OSHC (2001 a). Survey on effectiveness of occupational safety and health training for construction workers in Hong Kong China.

OSHC (2001 b).Survey on safety culture , construction industry Hong Kong China.

Oztas A, Okmen O (2004). Risk analysis in fixed price design build construction project, JOBE 39, 229-237.

Perry JG (1986). Dealing with risks in contracts, Building technology and management, 23-26.

Pelling M (2003). Toward a political ecology of urban environment risk, and integrative approach to geography and environment, 73-79, New York.

Porter CE (1981). Risk allowance in construction, university of Manchester (UMIST).

Perry JG, Hayes RW (1985). Risk and its management in construction projects, proceedings of institution of civil engineers, Vol 78, 499-521.

Riggs JL, Brown SB, Trueblood RB (1994). Integration of technical, cost and schedule risks in project management, JOCOR 21(5), 521-533.

Raftery J (1994). Risk analysis in project management, 1st ed, E & FN Spon, UK.

Ribakoff S (1979). Construction contract arrangement, construction risks and liability sharing conference, American society of civil engineers, Arizona.

Royal Society (1992). Risk analysis perception and management, Report of a royal society study group, Londan.

Smith NJ (1999). Managing risk in construction project, Blackwell science Inc.

SEOAC (1995). Performance based seismic engineering of buildings, structural engineers association of California USA.

Tavares LV, Ferreira JAA, Coelho S (1998). On the optimal management of project risk, EJOR 107, 451-469.

Thomas AV, Kalidindi SN, Ganesh LS (2006). Modeling and assessment of critical risks in BOT road project, JOCME 24, 407-424.

Toakley AR, Ling SMC (1991). Risk management and the building procurement process, innovation and economics in building conference, 63-67, Australia.

UNDP, NCPDP (2008). Manual on hazard resistant construction for reducing vulnerability in building built without engineers, Gujarat India.

Uher TE, Toakley AR (1999). Risk management in the conceptual phase of a project, IJOPM 17(3), 161-9.

Vaughan EJ (1986). Fundamentals of risk and insurance, 4th ed New York.

Visscher H, Suddle S, Meijer F (2008). Quantitalive risk analysis as a supporting tool for safety protocols at mukti functional urban locations, construction innovation, IPM 8(4), 269-279.

Watts MJ (1983). Silent violence, food famine and peasantry in northern Nigeria, Berkeley.

Wirba EN, Tab JHM, Howes R (1996). Risk interdependencies and natural language computations, ECAM 3(4), 251-269.

Ward SC (1999). Assessing and managing important risks, IJOPM 17(6), 331-336.

Ward SC, Chapman CB (1991). On the allocation of risk in construction project, IJOPM 9(3), 140-7.

William CA, Heims RM (1989). Risk management and insurance, Mcgraw Hill, New York, USA.

YEM (2006).Turkish construction sector report building information center,150 pp.

Zhi H (1995). Risk management for overseas construction project, IJOPM 13(4), 231-237.

Zhang H (2007). A redefinition of the project risk process, IJOPM 25, 694-701.

Zeng J, An M, smith NJ (2007). Application of a fuzzy based decision making methodology to construction project risk assessment, IJOPM 25, 589-600.

Zayed T, Amer M, Pan J (2008). Assessing risk and uncertainty inherent in Chinese highway project using AHP, IJOPM 26, 408-419.