International Journal of Industrial Engineering & Production Research

December 2015, Volume 26, Number 4
pp.229 -241

pISSN: 2008-4889

http://IJIEPR.iust.ac.ir/

Conceptual Model Development using Latin Hypercube Sampling for OHS Integration into Project Risk Evaluation

Yahia Zare Mehrjerdi, Ehsan Haqiqat

Department of Industrial Engineering, Yazd University, Yazd, Iran Yazm2000@yahoo.com
Department of Industrial Engineering, Yazd University, Yazd, Iran Ehsan.haqigat@gmail.com

KEYWORDS

Occupational Health and Safety (OHS),
Project Management,
Latin Hypercube Sampling (LHS),
Risk Assessment,
Construction.

ABSTRACT

Project management in construction industry, in many cases, is imperfect with respect to the integration of Occupational Health and Safety (OHS) risks. This imperfection exhibits itself as complications affecting the riskiness of industrial procedures and is illustrated usually by poor awareness of OHS within project teams. Difficulties on OHS regularly came about in the construction industry. The integration of OHS risk is not systematic in construction areas in spite of progressing laws and management systems. As project safety and risk evaluation in construction industry is an important issue, thus, the way of doing evaluation and liability estimation is necessary. In this paper, we propose a new systematic approach based upon Latin Hypercube Sampling (LHS) for integrating occupational health and safety into project risk evaluation. This approach tries to identify and evaluate reinforcement effects in a systematic approach for integrating OHS risks into project risk assessment. Furthermore, the proposed method allows evaluating and comparing OHS risks before and after the mitigation plan. A case study is used to prove the workability, credibility of the risk evaluation approach and uncomplicated integration of OHS risks at a construction project. This approach enables continual revaluation of criteria over the direction of the project or when new information is obtained. This model enables the decision makers such as project managers to integrate OHS risks toward schedule plan and compare them before and after the mitigation plan. The mentioned model is found to be useful for predicting OHS risks in construction industries and thus avoiding accidents over the path of the project.

1. Introduction[1]

Liao and Perng (2008) and Niza et al. (2008) have discussed on the subject matter of construction work and high-risk occupational area in modern society. That was resulted in by the combination of many causes such as high-risk characteristic of construction work and poor knowledge of construction workmen. Cooke (1997) and Gam bates, et al. (2008) have mentioned the most efficient method to enhance safety performance is the prevention of accidents and decreasing uncertainty before its occurrence. Therefore,

* Corresponding author: *Yahia Zare Mehrjerdi*
Email: *Yazm2000@yahoo.com*

Langford et al. (2000) and Jung et al. (2008) have pointed that safety risk analysis is a based upon when safety management is built and risk evaluation becomes an essential task which forms a part of safety management systems.

Aksorn and Hadikusumo (2008), Aneziris, et al. (2008) and Visscher (2008) are suggestig to improve safety performance and safety professionals where they are the key for carrying out the site assessments. Thus, safety professionals' understandings and conceptions of safety risks will influence the quality and credibility of risk assessment (Fung, et al., 2010). Elimination of occupational risks leads to the success of projects (Fung, et al., 2010, Baril-Gingras, 2006). Some also used linear assignment for ranking the risks that is a deterministic approach (Sayadi and et al. (2011), Arish and et al. (2009). Others have used system dynamic approach for quantitative risk assessment (Nasirzadeh, et al., 2013) and FMEA approach and system dynamics for new product development (Zare Mehrjerdi and Dehghanibaghi, 2012). The purpose of this article is to present a new systematic approach for the evaluation and comparison of OHS risks before and after mitigation actions. In this regard, a new procedure for integrating occupational health and safety into project risk evaluation based upon Latin Hypercube Sampling is proposed. Hence, the proposed approach is based upon known techniques and tools as such as Latin Hypercube Sampling instead of Monte Carlo analysis, expert judgment, and the analysis of accidents and incidents.

This paper is organized as follows: section 2 discusses the risk and risk management where it gives its importance to the approach proposed, The Latin Hypercube Sampling is outlined in Section 3. Section 4 presents the methodology including the conceptual model of the proposed systematic approach. A case study is presented in section 5. Comparing plan distribution is the topic of section 6. Finally, author's conclusion and directions for future research is provided in Section 7.

2.Risk and Risk Management

Kendrick (2003) indicated that uncertainty can be explained as the occurrence that its likelihood of the event sets between 0 and 1. As mentioned in PMBOK®Guide (2008a) risk appears because of uncertainty. Uncertainty can be delineated by probability distributions. Beta or triangle distributions are regularly used for modeling uncertainty. Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and monitoring and controlling a project (PMBOK®Guide 2008a)[2]. Liu and Guo (2009) explained that the key step and basis of risk management process is risk identification and its extended challenges (Hagigi and Sivakumar 2009). OHSAS 18001 (2007) has stressed that by lowering risk probability or its severity, we can reduce the risks. Risk is clarified as the impact of uncertainty on the achievement of targets (ISO31000 2009). It is defined also as an innate in the occupations of man and all companies (Badri, Gbodossou and Nadeau 2012). Risk is a combination of the probability and the consequences of the occurrence of a specified dangerous event (OHSAS 18001, 2007). "OHS Risk'' is the significance of a hazard, in terms of the probability, and severity of an injury or illness occurring as a result of the hazard. In chapter 3 of the construction extension to the PMBOK®Guide (2008b), PMI® gave an overview of the project safety management processes. This procedure includes ''all activities of the project sponsor/owner and the performing organization which determine safety policies, objectives, and, responsibilities so the project is planned and executed in a manner that prevents accidents, which cause, or have the potential to cause, personal injury, fatalities, or property damage''. Term of safety management has been defined in PMI® by both health management and safety management. All aspects of project management interact with project safety management (Construction Extension to the PMBOK ®Guide 2008b).To manage and identify OHS risk associated with a project, an organization requires involvement and participation of each person who has a role in the project such as specialists in risk analysis, stakeholders, end users, experts, customers, risk management team, project team members, and the project manager (Hare and Cameron 2006). Qualitative assessment remains essential in prioritizing OHS risk (e.g. collecting data, modeling techniques and expert opinion). Qualitative assessment is often supplemented by a quantitative review to the extent possible. Following risk assessment, the process is completed by adopting a risk control action plan

---

[2]Project Management Body of Knowledge: a reference work on project management,
edited by the Project Management Institute (PMI®).

integrated into the project management process as an indicator measuring the effectiveness of the approach (PMBOK®Guide 2008a). In project management, according to Aubert and Bernard (2004) risk is defined as the combination of the probability of occurrence and the impact of an event. The equation as it was suggested by Aubert and Bernard (2004) for calculating and prioritizing risks at the end of the evaluation phase is:

Risk (i) = Probability Undesirable event (i) × Impact Undesirable event (i)

3.Latin Hypercube Sampling Theory

Latin Hypercube Sampling (LHS) is a statistical approach for originating a sample of credible aggregations of parameter values from a multi dimensional distribution. The method was first described by McKay, et al (1979). It was further developed by Iman et al. (1981). When trying a function of N variables the range of each variable is divided into M equally probable intervals. M sample spots are then placed to satisfy the Latin hypercube requirements; note that this forces the number of divisions, M, to be equal for each variable. Furthermore, note that this sampling plan does not require more samples for more variables; independence is one of the main utilities of this sampling plan. Another benefit is that random samples can be taken one at a time, remembering which samples were taken so far. Maximum number of combinations for a Latin Hypercube of M divisions and N variables (dimensions) can be calculated with the following formula as proposed by Iman et al. (1981):

$$\left(\prod_{n=0}^{M-1}(M-n)\right)^{N-1} = (M!)^{N-1}$$

3-1. Latin Hypercube Sampling vs Monte Carlo Simulation

Statisticians have developed different methods to sample from distributions. If we could do an infinite number of iterations in our simulation, these approaches would produce equal results. Nevertheless, since we use a finite number of iterations, sampling methods do not produce equivalent results. A sampling method is considered more effective than another if it approximates a distribution with less iteration (Kaut and Wieland, 2001). There are two popular sampling methods of Monte Carlo Simulation and Latin Hypercube Sampling. Sampling is the procedure by which values are randomly drawn from the chosen distribution. As mentioned by Kaut and Wieland (2001) Monte Carlo simulation draws samples from the full range of the distribution on each draw. It is a completely random sampling technique. Most observations drawn are closer to the mean and create clustering.

The tails (areas of high uncertainty) are generally underrepresented in the sampling, whereas in Latin Hypercube, samples from all parts of the distribution, lessening clustering. It is not entirely random (is a stratified sampling method). Latin Hypercube divides a distribution into intervals of equal probability and randomly draws from each interval and ensures that all portions of the distribution are sampled including the tails (areas of high uncertainty). Owen (1997) have proven that the variance of the number of the points (n(t)) of Latin hypercube sample, V_{LHS}, is related to the variance of the points of Monte Carlo sample, V_{MC}, by

$$V_{LHS} \leq \frac{n(t)}{n(t)-1} V_{MC} \text{ if } n(t)>1$$

Hence, Latin Hypercube Sampling is more efficient than Monte Carlo sampling because it requires less iteration. The master key to Latin Hypercube Sampling is stratification of the input probability distributions. Stratification divides the cumulative curve into identical intervals on the cumulative probability scale (0 to 1.0). The sample is then randomly taken from the stratification of the input distribution. Sampling is forced to represent values in each interval, and thus is forced to recreate the input probability distribution. As a more effective sampling method, Latin Hypercube offers great benefits in terms of increased sampling effectiveness and faster run-times (because of fewer iterations). These profits are especially noticeable in a personal computer based simulation environment such as Pert master software. When running a simulation, it is important that all areas of the input distribution get sampled, especially the low probability (high uncertainty) areas. If not, uncertainty will seem less than it actually is. As mentioned by Iman, R. L. (2008) Latin Hypercube aids the analysis of situations where low probability outcomes are represented in input probability distributions

This property of Latin Hypercube sampling allows having better and more accurate evaluation of OHS risks. Stratification of the input probability distributions enables the evaluation of conditions where probability results are low.

4. Methodology

This paper proposes a conceptual model for integrating occupational health and safety into project risk evaluation based upon Latin Hypercube Sampling (LHS). We have considered a model of risk composed of three elements detailed below and the conventional steps of risk management. The proposed approach is divided into three phases of (1) risk identification; (2) risk evaluation and (3) mitigation actions. Our analysis is based upon a model of risk composed of three principal elements: the risk factors, the undesired occurrence (event), and the impacts of undesired occurrences. The proposed conceptual model allows the decision makers such as project manager to compare the impacts of mitigation actions before and after mitigations. In order to control OHS risks, all of these elements must be identified and different causal links likely to appear in an area of study must be cleared up as well as their procedures and the conditions that trigger them. It should be noted that the project surroundings is made up of controllable variables such as the efficacy of health and safety measures. Aubert and Bernard (2004) presented a similar approach without specifying the impact of an undesirable event. The causality links are identified by the evaluators and determine how the potential impact of a risk will be evaluated. Each link (i) between a factor, an event and an impact thus defines a possible route of concretization of a risk as an event having a negative impact.

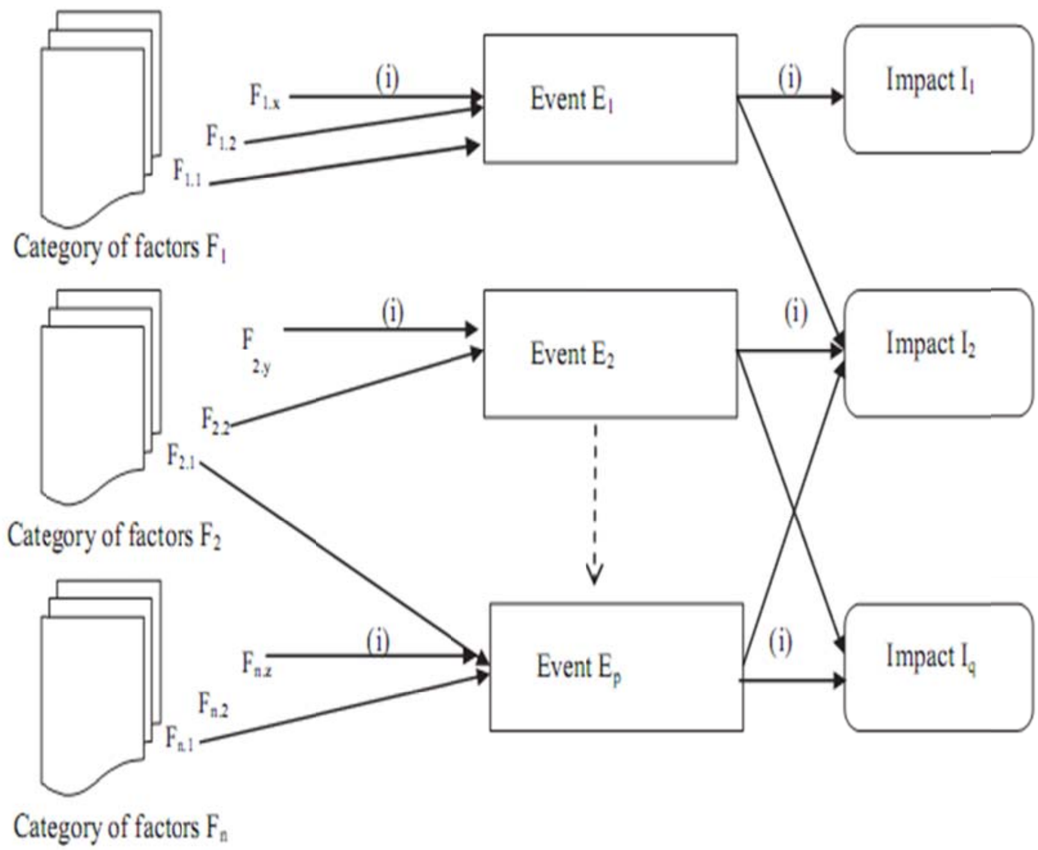

Fig.1. The links in a risk factors approach to risk analysis; example inspired from Aubert and Bernard (2004).

Badri et al(2012) proposed a conceptual model for integrating occupational health and safety into project risk evaluation based upon multi-criteria comparison (AHP). As mentioned in Forman and Selly (2002) AHP is not a magic formula or model that finds the right answer. Rather, it is a process that helps decision-makers to find the best answer. This evaluation was limited to the causal links that they identified in the first phase of the proposed approach without evaluating reinforcement effects between risk factors. Their research didn't have comparison of risk factors in an attempt to identify and evaluate reinforcement effects. In the following subsections of the paper, in the structure of a case study we describe and analyze in more details the 3 phases of the proposed approach used to manage OHS risks.

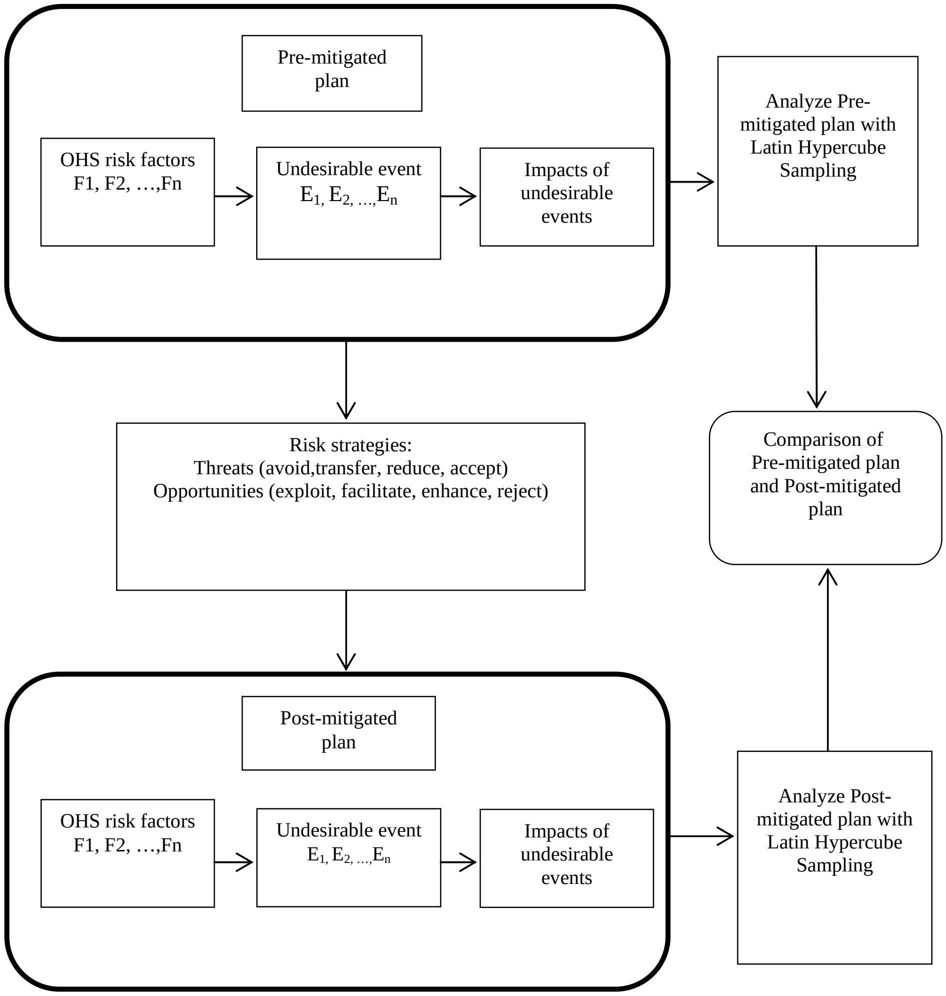

Fig. 2.Conceptual model for modeling of risk

5. Case Study

This study tries to avoid and mitigate the effects of OHS delay factors which might harm the completion of project on time. This project has been implemented in Iran. In this study, OHS integration was limited to the tasks handled by the Health and Safety department that manages and promotes worker health and safety. This case study is about the installation of Void glasses on a geometrical structure. In this project as mentioned above 3 phases of project risk management (risk identification, risk assessment, mitigation actions) which are illustrated bellow has been implemented.

In the structure of a case study, the proposed approach, conceptual model for integrating occupational health and safety into project risk evaluation based upon Latin Hypercube Sampling (LHS) was described and analyzed in 3 phases. In this project, we analyze the impact of OHS delay factors which can delay the project completion time. With the aim of project manager and the experts of Health and Safety department OHS risks were identified and controlled. Also risk evaluation and compering of pre and post-mitigation plans are conducted by Pert master software.

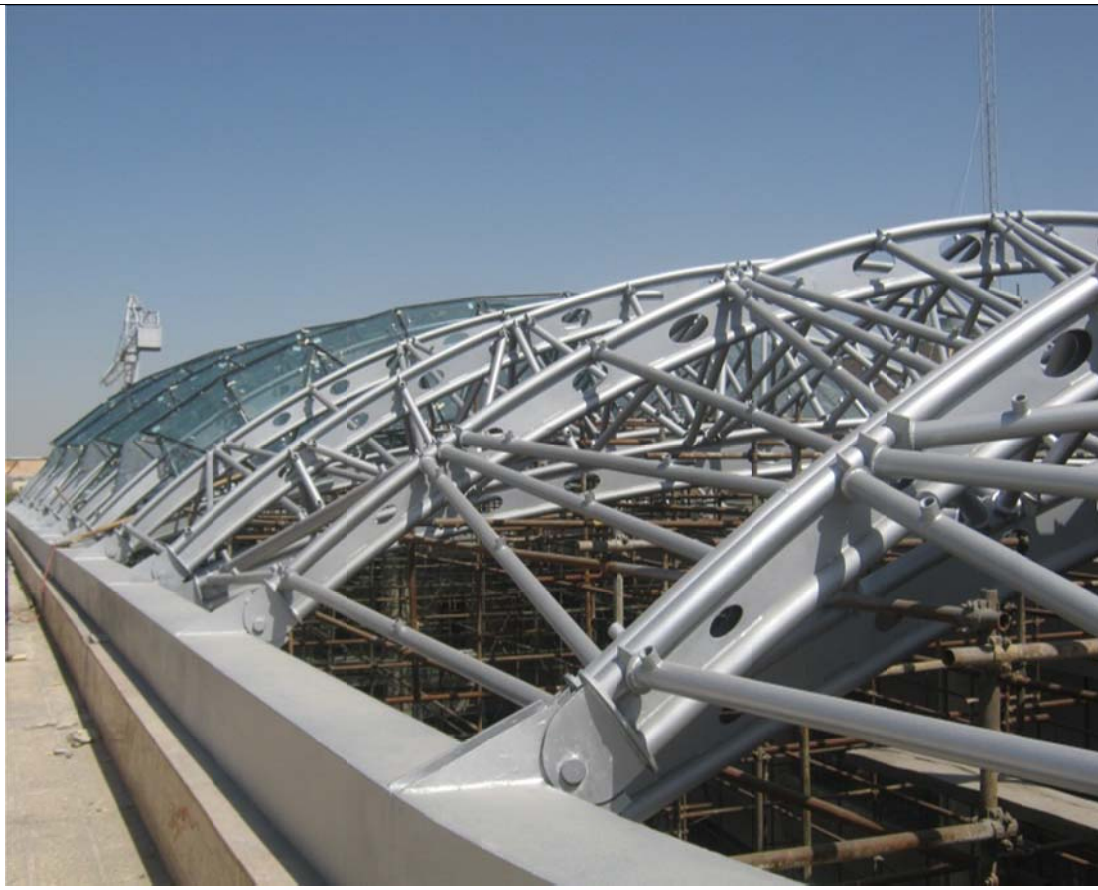

Fig.3. Case study: Installation Void Glasses on a Geometrical Structure

5-1. Phase 1: Risk Rdentification

Risk identification necessarily involves in the identification of the elements of the risks. The risk model includes three elements: (1) risk factors, (2) undesirable events and (3) the impact of undesirable events (Aubert and Bernard 2004, Badri, A.; Nadeau, S.; Gbodossou, A. 2012). To identify these mentioned items the team used organized systematic method of risk analysis. Fig. shows causal links, in which each arrow represents possible OHS risks related to the project.

5-2. Phase 2: Risk Evaluation

In this research, the Pertmaster software is introduced. It is similar to the most planning software as it uses Latin Hypercube Sampling (LHS) for simulating project time/cost and develops more realistic project completion time. This project planning software uses LHS analysis for schedule risk analysis capability. It can produce a histogram, probability density function and cumulative probability curve (primavera systems, 2004). Risk analysis using Pert Master Software allows a project manager to analyze a Critical Path Method (CPM) project schedule using probability distributions of the task durations. To run risk analysis in Pert Master, firstly it is necessary to set up a CPM schedule, which includes entering tasks and milestones and adding logic to define task relationships. Secondly, the risk duration distribution on each task is set up, which means that each task is assigned minimum, most likely, and maximum durations. The task relationships and OHS risks are added to the related tasks. In Pert Master software we use risk register to:

- Define risks (threat and opportunity) including risk owner, causes, effects, status, probability and cost, time and custom impacts and fields.
- Track any detailed actions used to mitigate the probability and impact of risks using a mitigation plan.
- Map risks to tasks and Work Breakdown Structures (WBS) items.

- Define the impact a risk has on each task or WBS item it is mapped to.
- Quantify the schedule, cost, performance and environment impact caused by the risks on the project.

Compare Pre-Mitigation and Post-Mitigation scenarios.

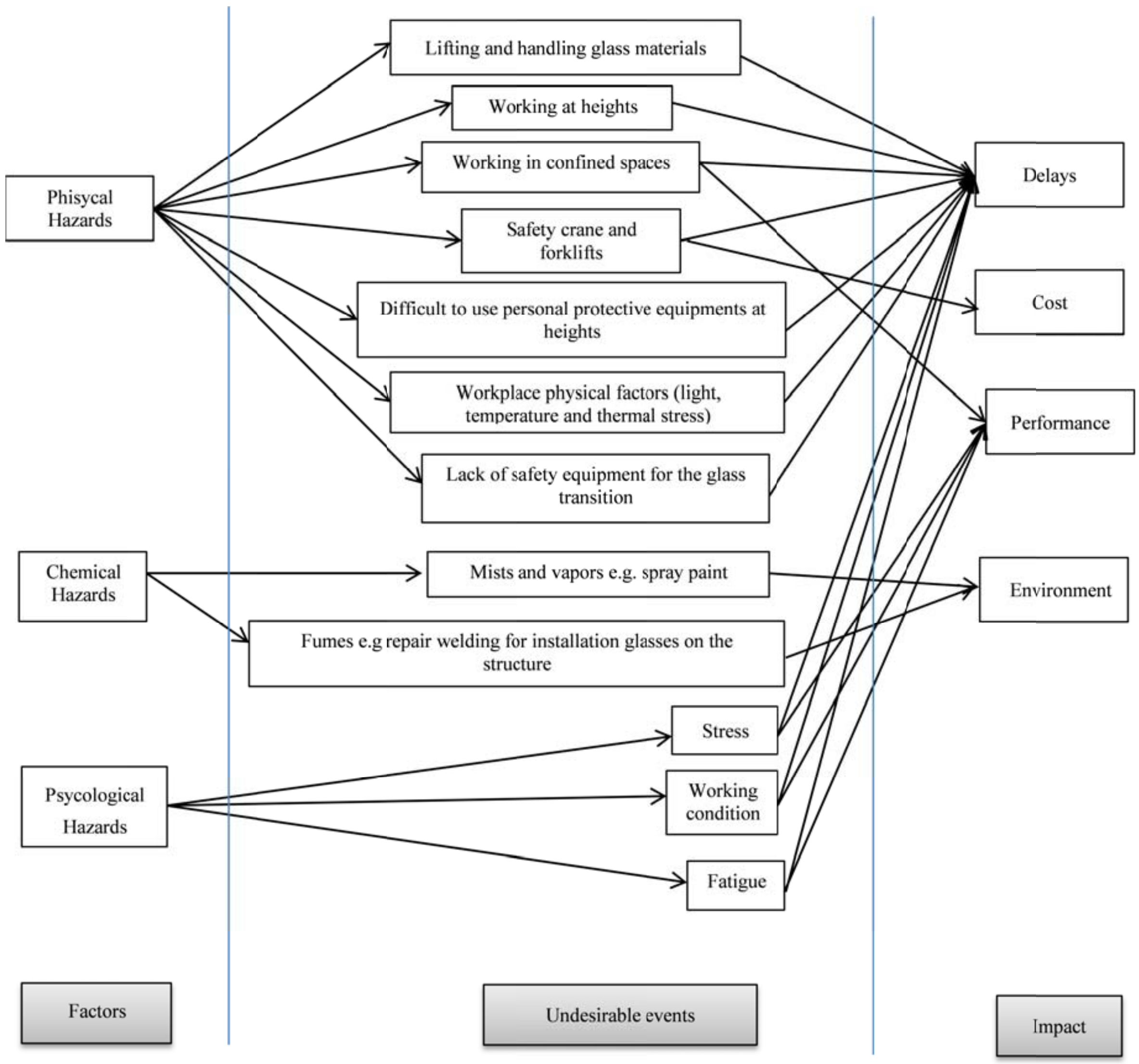

Fig.4. Case study: Links Between Undesirable Events, Their Risk Factors and Their Impact.

In our research, we used triangle distributions for risk analysis according to the expert's view. The most utilizable likelihood distributions described in the project management literature for modeling uncertainty are Beta and Triangle (Hayse 2010). Triangle distributions can be represented by three approximations of optimistic, pessimistic, and most likely values. Van Dorp and Duffey (1999) stated that the choice of Beta or Triangle distribution to model activity duration has a somewhat small effect on simulation results for total project duration. When a risk plan is built, the mitigation actions are added as new tasks to the built risk plan. After mapping the risks to the tasks in the project, the pre-mitigated and post-mitigated risk plans can be built. Building a risk plan creates a new schedule that contains the cost and schedule impacts. The pre-mitigated model is built using the probabilities and impacts associated with the pre-mitigated mappings while the post-mitigated model is built using the probabilities and impacts associated with the post-mitigated mappings. Table 1 shows the pre-mitigated and post-mitigated plans.

Tab 1: Case study: mitigation plan (Pre-mitigation plan, Response, Post-mitigation plan)

Risk			Pre-mitigation						Response	Post-mitigation					
ID	Type	Title	Probability	Schedule	Cost	Performance	Environment	Score	Type	Probability	Schedule	Cost	Performance	Environment	Score
001	Threat	Lifting and handling glass materials	H	H	N	N	N	28	Reduce	L	L	N	N	N	3
002	Threat	Working at heights	H	VH	N	N	N	56	Reduce	M	M	N	N	N	10
003	Threat	Working in confined spaces	H	L	L	L	N	7	Avoid	N	N	N	N	N	0
004	Threat	Safety crane and forklifts	M	H	VH	N	N	40	Reduce	L	H	VH	N	N	24
005	Threat	Difficult to use personal protective equipments at heights	M	L	N	N	N	5	Accept	M	L	N	N	N	5
006	Threat	Workplace physical factors (light, temperature and thermal stress)	M	L	N	N	N	5	Accept	M	L	N	N	N	5
007	Threat	Lack of safety equipment for the glass transition	M	M	N	N	N	10	Reduce	L	M	N	N	N	6
009	Threat	Mists and vapors e.g. spray paint	L	N	N	N	M	6	Accept	L	N	N	N	M	6
010	Threat	Fumes e.g. repair welding for installation glasses on the structure	VL	N	N	N	M	2	Accept	VL	N	N	N	M	2
011	Threat	Stress	H	M	N	M	N	14	Reduce	L	M	N	M	N	6
012	Threat	Working conditions	H	N	N	H	N	28	Reduce	L	N	N	H	N	12
013	Threat	Fatigue	H	M	N	H	N	28	Avoid	N	N	N	N	N	0

The overall impact of a risk is set to the highest of all impacts. Each risk impact is given a numeric value: Negligible=0, VL=1, L=2, M=3, H=4, VH=5. The highest of all the impacts of these is used to determine the overall impact. In this case study, a risk register has 4 impact types and 5 impact values (VL, L, M, H and VH). For instance, if a risk is assessed as follows: Cost impact = H, Schedule impact = N, Performance impact = N, Environmental impact = N, Numerical impact = 4 then, the overall impact is set to H. The overall impact is then combined with the probability to select the risk score from the probability and impact scoring grid (figure 5). If the Probability of the risk is above H then the risk score would be 24 (figure 5). In the score column, the red squares are the sign of being more risky while the yellow ones are less risky and the green ones are acceptable.

	Impacts				
	Very Low	Low	Medium	High	Very High
Very High %	6	12	18	36	72
High %	4	7	14	28	56
Medium %	3	5	10	20	40
Low %	2	3	6	12	24
Very Low %	1	1	2	4	8

Fig.5. Case study: risk matrix

5-3. Phase 3: Mitigation Actions

A hazard is a situation, a condition or a thing that may be dangerous to the safety or health of the workers. There are many ways to control worker's exposure to hazards (occupational health and safty-tool kit for small business 2011). Delay of progress still happens in projects during construction process. Chris (1988) mentioned that over 80% of projects exceed their scheduled time even with the employment of software methods. When delay occurs, contractors can implement mitigation actions to minimize the effects of the delay factor. For reducing identified risks some actions in administrative and engineering controls and personal protective equipment (PPE) are implemented. The plans which are helped to control OHS risks listed in a breakdown structure. Fig. 6 represents the nine mitigation actions being proposed to control OHS risks in this case study..

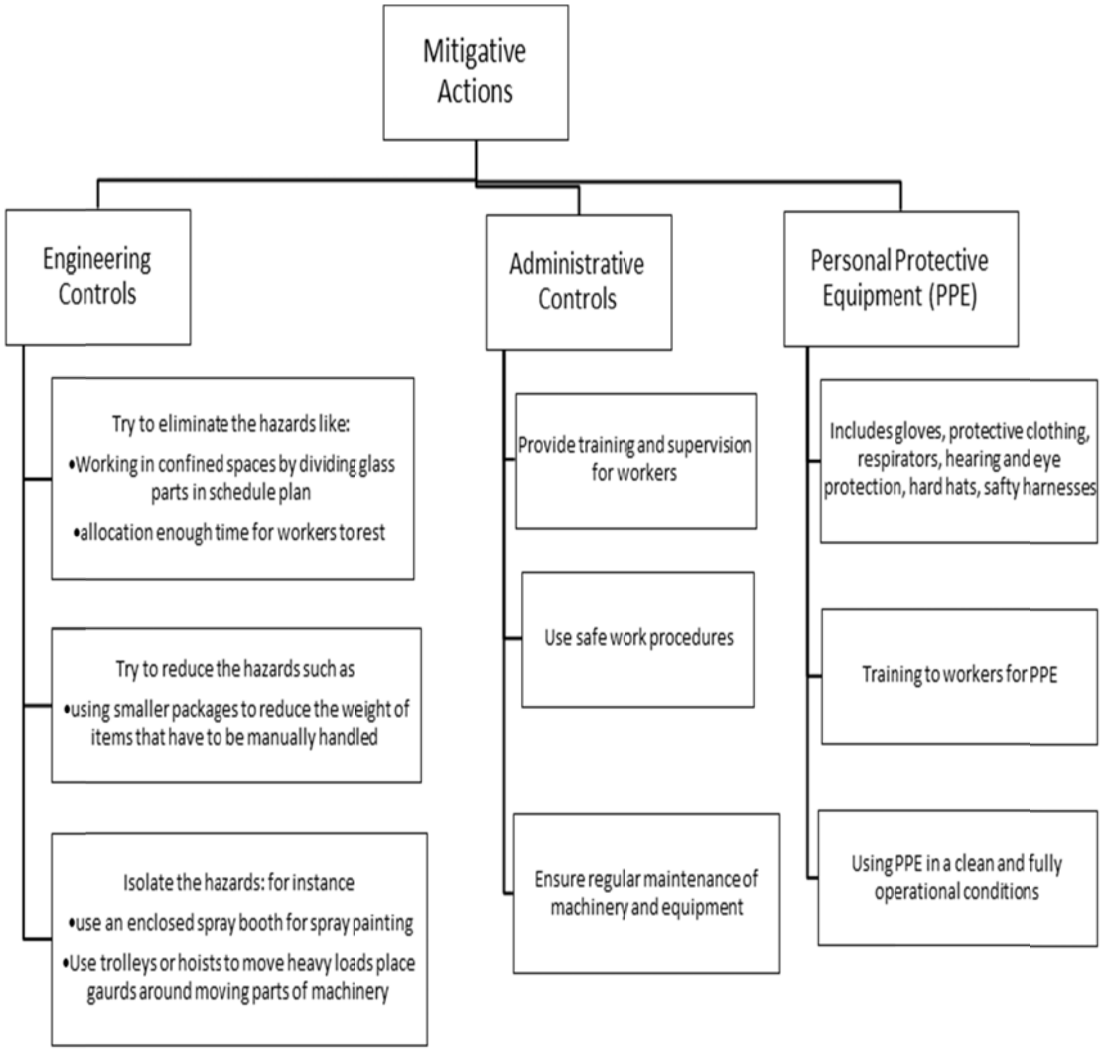

Fig.6. Case Study: Mitigation Actions

6.Comparing Plan Distributions

The data of case study has been analyzed where the sample in figure 7 shows three s-curves representing the plan without OHS risks (pink curve), pre-mitigation model with OHS risks before mitigative actions (blue curve) and post-mitigation model with OHS risks, when mitigative actions has been implemented in the case study (green curve). As mentioned before, this paper is about the application of LHS sampling and creates awareness for dealing with OHS risks which can delay the project completion time. We use Latin Hypercube Sampling Instead of Monte Carlo for the evaluation of the data of the case study. Each diagram is obtained based upon the LHS technique. The gap between the three curves can be interpreted as being an estimate of the schedule benefit that is expected to be gained from the mitigation at the P80. In this case study, we could reduce the time of project for 40 days with the implementation of the mitigative actions which mentioned in section 5.3. Fig.7 indicates that if we didn't consider OHS risks in this project at a confidence level of 80 % the project delays 56 days but after implementing mitigative actions this delay time reduces to 16 days and a gap between these two times (40 days) indicates that our mitigative actions were beneficial for this case study. The standard deviation of each plan also has shown in Figure 7. In this study, we just analyze the impact of OHS delay factors which can delay the project completion time.

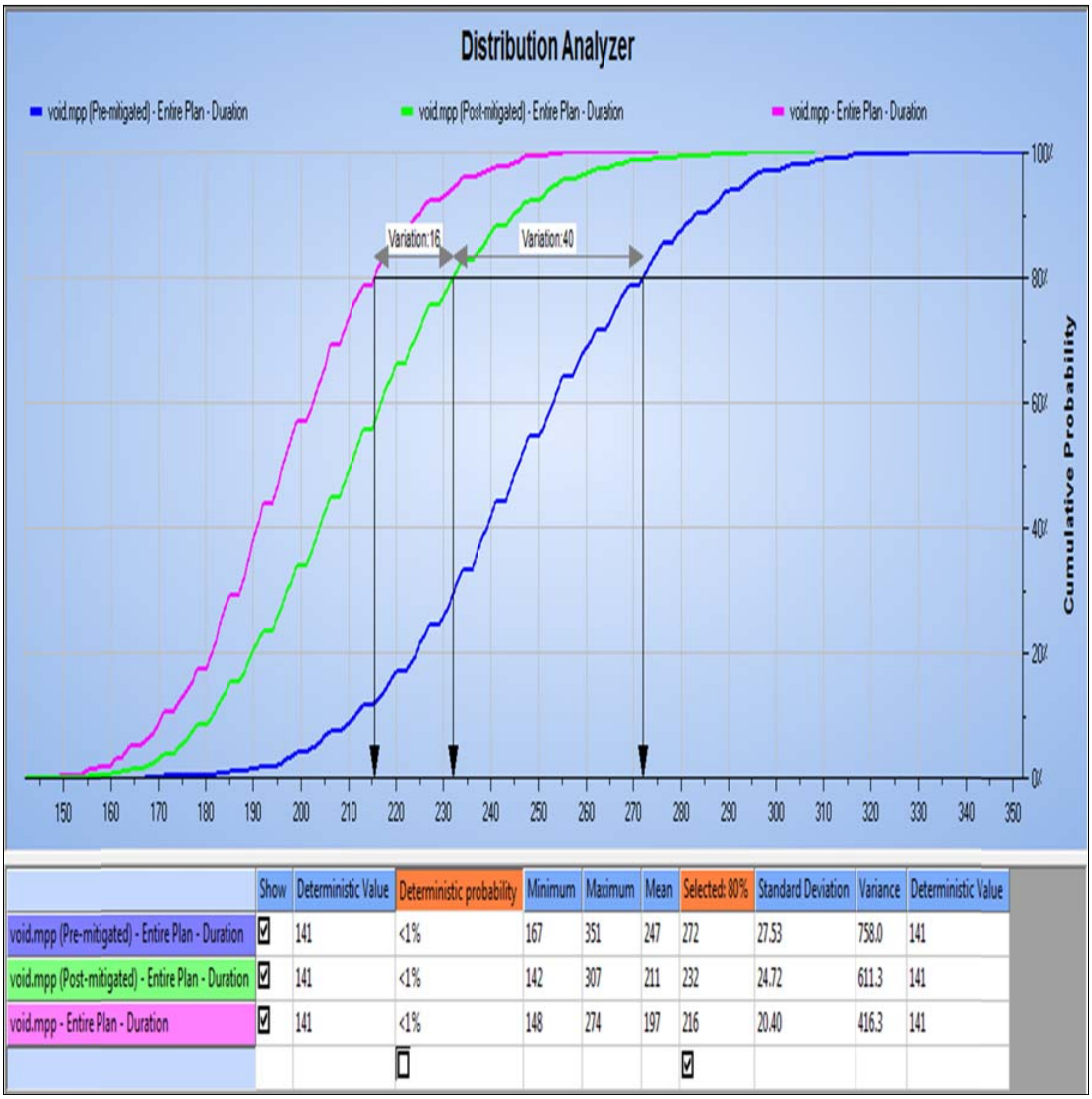

Fig.7. three s-curves from different plans show the effect of mitigation on the project uncertainty with the 80% highlighted.

7. Conclusion and Further work

The feasibility study focused on technical, economical and environmental aspects and did not integrate OHS with the conventional risks. This research tried to create awareness for dealing with the OHS risks which can delay the project completion time and calls for applying risk management for construction projects. The mentioned model is found to be beneficial for predicting OHS risks in construction activities and thus preventing accidents over the course of the project. This model allows the decision makers such as project managers to integrate OHS risks toward schedule plan and compare them before and after mitigative actions. The research can be extended subsequently for evaluating the effects of delay on the cost and the quality of the work. Also in the case study the application of LHS instead of Monte Carlo method is considered and it allowed having better and more accurate evaluation of the OHS risks**.**

References

[1] Aksorn, T., and B.H.W. Hadikusumo. "Critical success Critical success factors influencing safety program performance in Thai construction projects." Safety Science 46 (4), (2008): 709–727.

[2] Aneziris, O.N., et al. "Quantified risk assessment for fall from height." Safety Science 46 (2), (2008): 198–220.

[3] Aubert, B., and J.G. Bernard. Mesure intégrée du risque dans les organisations. 1st. Montréal: Les Presses de l'université de Montréal, (2004).

[4] Arish, M., Shirazi, A., Esfahani, S.M.M. " Case-Based Decision Support Model for Risk Responses Planning." International Journal of Industrial Engineering & Production Research. Autumn (2009);20(3);1-14.

[5] Badri, A., A. Gbodossou, and S. Nadeau. "Occupational health and safety risks: Towards the integration into project management." Safety Science 50, (2012): 190–198.

[6] Badri, A.; Nadeau, S.; Gbodossou, A. "Proposal of a risk-factor-based analytical approach for integrating occupational health and safety into project risk evaluation." Accident Analysis and Prevention 48, (2012): 223– 234.

[7] Baril-Gingras, G., Bellemare, M., Brun, J.-P. "The contribution of qualitative analyses of occupational health and safety interventions: an example through a study of external advisory interventions." Safety Science 44, (2006): 851–874.

[8] Chris, W. "Risk-based scheduling and analysis, software development manager at Lexis_Nexis." PM network magazine, (1988): 29-33.

[9] Construction Extension to the PMBOK®Guide. Pennsylvania: Project Management Institute, Inc, (2008)b.

[10] Cooke, R.M. "Uncertainty modelling: examples and issues." Safety Science 26 (1–2), (1997): 49–60.

[11] Forman, E.H., and M.A. Selly. Decision by Objectives. How to Convince Others that You Are Right,. 2nd. Edited by Co. Pte. Ltd. Singapore: World Scientific Publishing, (2002).

[12] Fung, I. W. H., V. W. Y. Tam, T. Y. Lo, and L. L. H. Lu. "Developing a Risk Assessment Model for construction safety." International Journal of Project Management 28, (2010): 593–600.

[13] Gambatese, J.A., M. Behm, and S. Rajendran. "Design’s role in construction accident causality and prevention: perspectives from an expect panel." Safety Science 46 (4), (2008): 675–691.

[14] Glenn Kautt, CFP, and Fred Wieland, Ph.D. "Modeling the Future: The Full Monte, the Latin Hypercube and Other Curiosities." FPA Journal, (2001).

[15] Hagigi, M., and K. Sivakumar. "Managing diverse risks: an integrative framework." Journal of International Management 15, (2009): 286–295.

[16] Hare, B., and I., Duff, A.R. Cameron. "Exploring the integration of health and safety with pre-construction planning." Engineering Construction and Architectural Management 13, (2006) : 438–450.

[17] Hayse, J. Using Monte Carlo Analysis in. Environmental Assessment Division, Argonne National Laboratory, (2010).

[18] Iman, R.L., J.C. Helton, and J.E. and Campbell. "An approach to sensitivity analysis of computer models, Part 1. Introduction, input variable selection and preliminary variable assessment." Journal of Quality Technology 13 (3), (1981): 174–183.

[19] Iman, R. L. Latin Hypercube Sampling. Encyclopedia of Quantitative Risk Analysis and Assessment, (2008).

[20] ISO31000. Risk Management and Guidelines. first. Geneva: International Organization for Standardization, (2009).

[21] Jung, Y., S. Kang, Y.S. Kim, and C. Park. "Assessment of safety performance information systems for general contractors." Safety Science 46 (4), (2008): 661–674.

[22] Kendrick. "Identifying and Managing Project Risk." Amacom Books, (2003).

[23] Langford, D., S. Rowlinson, and E. Sawacha. "Safety behaviour and safety management: its influence on the attitudes of workers in the UK construction industry." Engineering, Construction and Architectural Management 7 (2), (2000): 133–140.

[24] Liao, C.W., and Y.H. Perng. "Data mining for occupational injuries in the Taiwan construction industry." Safety Science 46 (7), (2008): 1091–1102.

[25] Liu, Z., and C. Guo. "Study on the risks management of construction supply chain." In: EEE/INFORMS International Conference on Service Operations, Logistics and Informatics (SOLI). (2009). 629–632.

[26] McKay, M.D., R.J. Beckman, and W.J. Conover. "A Comparison of Three Methods for Selecting Values of Input Variables in the Analysis of Output from a Computer Code." Technometrics (American Statistical Association) 21 (2), (1979): 239–245.

[27] Niza, C., S. Silva, and M.L. Lima. "Occupational accident experience.association with workers’ accident explanation and definition." Safety Science 46 (4), (2008): 959–971.

[28] "occupational health and safty-tool kit for small business." www.worksafe.alberta.ca. (2011).

[29] Owen, A. B. "Monte Carlo variance of scrambled equidistribution quadrature." SIAM J. Numer. Anal., 34, (1997), 1884–1910.

[30] PMBOK®Guide. A Guide to the Project Management Body of Knowledge. fourth. Pennsylvania: Project Management Institute, Inc., (2008)a.

[31] Project Management Institute, Construction Extension to the PMBOK..Guide, third ed. Pennsylvania. Project Management Institute, Inc., (2008) b.

[32] Sayadi A.R.,Hayati M.,Azar A. Assessment and ranking of risks in tunneling projects using linear assignment technique.International Journal of Industrial Engineering & Production Research. Spring (2011); 22(1) ; 27-38.

[33] van Dorp, J.R., and M.R. Duffey. "Statistical dependence in risk analysis for project networks using Monte Carlo methods." International Journal of Production Economics 58, no. 1 (1999): 17-29.

[34] Visscher, H., Suddle, S., Meijer, F. "Quantitative risk analysis as a supporting tool for safety protocols at multi-functional urban locations." Construction Innovation: Information, Process, Management 8 (4), (2008): 269–279.

[35] Nasirzadeh, F., M. Khanzadi & M. Rezaie, System Dynamics Approach for Quantitative Risk Allocation, International Journal of Industrial Engineering & Production Research, (2013), Volume 24, Number 3, pp. 237-246.

[36] Zare Mehrjerdi, Y. & M. Dehghanbaghi, A Dynamic Risk Analysis on New Product Development Process, International Journal of Industrial Engineering & Production Research, March (2013), Volume 24, pp. 15-33.