STATE OF ART REVIEW OF HAZARDS & RISK ASSOCIATED
WITH VIADUCT WORK AND SUGGESTION TO IMPROVE
SAFETY

Bikarama Prasad Yadav¹*, Dr.N.A.Siddiqui², Dr Ashutosh Gautam³

Address for Correspondence
¹² University of Petroleum & Energy Studies, Dehradun, Uttarakhand, 248007
³ India Glycols Ltd Kashipur, Uttarakhhand India

ABSTRACT
Most Indian metro cities are facing the problem of traffic congestion, arising from indiscriminate use of personal vehicles, due to lack of an effective transport system to meet the demands of increasing population. An effective public transport system can not only ease the traffic flow but also improve the air quality of a region by taking personal vehicles off the road in large numbers. Providing an effective rail or road transport system requires construction of viaducts for safe and congestion free movement of traffic. Viaducts also facilitate connecting existing network over otherwise difficult terrain and optimized use of available land. Construction of rail and road network requires working in hazardous environment. Rail and road construction work at ground level is hazardous but this hazard increases manifold for work above ground level. As per estimates given by Occupational Safety Administration (OSHA), UK more than 10% of the workers involved in ground level is hazardous but this hazard increases manifold for work above ground level. Providing an effective rail or road transport system requires construction of viaducts for safe and congestion free movement of traffic. Viaducts also facilitate connecting existing network over otherwise difficult terrain and optimized use of available land. Construction of rail and road network requires working in hazardous environment. Rail and road construction work at ground level is hazardous but this hazard increases manifold for work above ground level. As per estimates given by Occupational Safety Administration (OSHA), UK more than 10% of the workers involved in viaduct construction meet accidents ranging from minor injuries to fatality. Therefore, the importance of reviewing the existing safety measures and suggestions to improve the existing safety record cannot be undermined. This paper reviews the existing safety practices and standards followed by viaduct construction industries. The causes of high accident rate are identified and suggestions are given to improve the safety of workers involved in viaduct construction, thereby, drastically bringing down the number of injuries.

KEYWORDS: Hazardous environment, construction Safety, Viaduct hazards, Risk in construction etc.

INTRODUCTION
Expanding existing network of rail and road via viaducts is being used to provide for smooth movement of public, private and good carriers. The viaduct concept was started in 18th century and improvements were done during late 19th to 20th century thereby popularizing this concept in urban infrastructure. In ancient times, the same concept was in used while crossing over river or canal by putting wooden plank but in 21st century drastic changes came and use of viaduct based on modern concept was promoted. The majority of work carried in viaduct work involves working at height where life of working personnel remains in danger and majority of accidents are due to fall during work at height. There are numerous hazard associated with performing viaduct work and even in 21st century we have failed to control the accidents in viaduct work. Compared to other construction works accidents leading to injury and even death happen more frequently in viaduct because of the nature of work. From inception of construction project till it is finished, inherent hazard and underlying hazard are considerable. As per bureau of labour statistics (BLS) 150,000 workers are injured every year and majority of workers are injured due to fall, while injury due to contact with the equipment was also identified as a major for work at height accidents. One out of every ten workers gets injured in a year (OSHA, Year) and they have also identified fall hazards as the main reason behind majority of accidents at construction site. There are various activities in construction which keep changing all of sudden or on routine basis which makes the work place unstable in nature and due to which special attention is required round the clock. Hazard identification and assessment is the technique use by site execution personnel to designer analyzing the consequences before execution of a job. There are two steps involved in the identification of risk in construction through interviewing the personnel involved from design to execution stage. The first stage is knowledge acquisition and the second stage is participation of core design team (Chapman 2001). Limited research has been done to minimize and control the risk due to inherent hazard associated with construction work. Although, from time to time, concerns regarding safety in construction industry have been raising but still it remains the most hazardous industry. In Spain 30% of all the industrial accidents were reported in the construction industry between 2000 to 2006 mainly (Gangolells, Casals et al. 2010). The goal of proactive risk assessment is to minimize the risk during construction without compromising quality and safety at work place and avoiding a project from missing the set deadline.

SAFETY CULTURE IN CONSTRUCTION INDUSTRY
Improving behavioral based safety (BBS) is the most effective way by which risk is can be effectively managed. It is the most effective tool which has been implemented since 1980 in Europe and North America and today it is the most popular tool worldwide (Li, Lu. et al. 2015). Improved risk management is seen by applying BBS concept. A large number of illiterate migrated workers are involve in construction industry thereby bringing instability and increasing inherent risk but this can be controlled by applying or implementing proactive behavioral based safety approach. Risk management is total human control system which is applicable since initiation of projects till its completion. BBS can change the mind set of personnel and management towards safety and likewise towards audit, identification of hazard and risk assessment and its control measures. BBS helps to minimize and control risk with participation from all level of management. Even though safety aspects in construction get finalized even before mobilization of workmen, equipment but its implementation is rarely realized(Behm 2005). Behm (2005) revealed that 40% of fatalities in construction happen due to ill approach of designer, architect, & structural engineers. Identification of hazard during design and planning stage in construction industry is done
In this situation it is difficult to quantify management. Since majority of assumptions, and advice the safety behavior which meets accidents and its unstable work nature. It is difficult to assess on the hazard vulnerability of construction project researchers in this filed. These limitations are based certain limitation which has been raised construction and traditional approach of used in various forms.

**MINIMIZATION IN CONSTRUCTION**

**BACK GROUND ON HAZARD AND RISK**

exact data of body parameters linguistic terms above study, author has used calculated as using sum of product methods. hierarchy process.

measured using fuzzy reasoning and fuzzy analytic methods assessing the failure concept. Further, likelihood of structural accidents was analyzed by using fuzzy sets. (Blockley 1980) has mentioned various methods assessing the failure of structure and structural safety measures. (Faber and Stewart 2003) addresses the issues connected with risk acceptance criteria, hazard avoidance and estimation of human life and endeavors to give proposals to the judicious treatment of these viewpoints. He has also highlighted the problematic areas and the requirements for further training, examination and spread are pushed. (An, Lin et al. 2006) In the system, fuzzy reasoning approach is adopted to calculate the risk level of all different hazards and its failure frequency, its consequence and probability. (An, Lin et al. 2006) Statistics shows the number of accidents includes not only the workers but also from non-employee side, public etc. Authors describes the dangerous nature of construction industry mainly railways where he identified the need of increasing awareness to bring proactive safety management system. He observed that causes of accidents are fundamental milestone to control accidents can be achieved by risk analysis. In last few years risk analysis plays central role identifying the hazards e.g. Derailment hazard, Collision Hazards, Fire Hazards, Electrocution hazards, fall hazards, train strike, slip trip etc.

**ACCIDENT PREVENTION THROUGH DESIGN CONSIDERATIONS:**

Design considerations are the most important factor that has the potential to minimize and control construction accidents. Aires, Gámez et al. (2010) effect of hazard and its consequences because of involvement of high level of uncertainty, limited ability of humans which believed in holistic approach. Considering by above statements, it is clear that risk analysis methods in the construction business is uncontrolled with deficient information and/or uncertain, not well characterized, and inadequate data, especially in the outline stage, for which traditional or conventional methodologies don't give sufficient answers. A step ahead fuzzy techniques characterize methods of subjective analysis or assessments of all inborn uncleanness and also for human creativity, intuition which is main component of risk analysis methods (Pinto, Nunes et al. 2010).

Fuzzy linguistic parameters were in used to deal with uncertain and inadequate data (Gürcanli and Müngen 2009). He has considered the cost of health care, trains, machines upgradation and various tools used in construction. He derived the parameters of accident and likelihood for different types of construction and based on the activity. The data was collected by past accidents records and government data logged by governmental agencies. This approach may be used in various fields but it has specifically used for construction industries. (Berih, Patnaik et al. 2012) has given characterization and expectation model in view of registering strategy for the surveying the chief to investigate the word related wounds and making arrangements for budgetary costs to enhance safety performances in Indian construction industries. (Blockley 1975) He has considered probability of basic mishaps in basic introducing so as to design fuzzy ideas. He has likewise dissected the accident evaluation system for underground construction utilizing a model in fuzzy concept. Further, likelihood of structural accidents was analyzed by using fuzzy sets. (Blockley 1980) has mentioned various methods assessing the failure of structure and structural safety measures. (Faber and Stewart 2003) addresses the issues connected with risk acceptance criteria, hazard avoidance and estimation of human life and endeavors to give proposals to the judicious treatment of these viewpoints. He has also highlighted the problematic areas and the requirements for further training, examination and spread are pushed. (An, Lin et al. 2006) In the system, fuzzy reasoning approach is adopted to calculate the risk level of all different hazards and its failure frequency, its consequence and probability. (An, Lin et al. 2006) Statistics shows the number of accidents includes not only the workers but also from non-employee side, public etc. Authors describes the dangerous nature of construction industry mainly railways where he identified the need of increasing awareness to bring proactive safety management system. He observed that causes of accidents are fundamental milestone to control accidents can be achieved by risk analysis. In last few years risk analysis plays central role identifying the hazards e.g. Derailment hazard, Collision Hazards, Fire Hazards, Electrocution hazards, fall hazards, train strike, slip trip etc.

**BACK GROUND ON HAZARD AND RISK MINIMIZATION IN CONSTRUCTION**

Identification of hazard and its analysis in construction are often a traditional methods normally used in various forms. Due intrinsic uncertainty of construction and traditional approach of identification of hazard and risk assessment, there are certain limitation which has been raised by various researchers in this filed. These limitations are based on the hazard vulnerability of construction project and its unstable work nature. It is difficult to assess and advice the safety behavior which meets accidents due to involvement of operation procedure, human error and decision taken by designer and management. Since majority of assumptions, opinions are involved then risk assessment process should be more strict and reviewed by safety experts. In this situation it is difficult to quantify the adverse casually. Even though there are consensuses noted while considering inherent hazard and risk which are present in construction industries but these are generally overlooked by the architects, designer or planner. Risk in construction projects are uncertain and it effect at least one of the objective of the project e.g. cost, scope, schedule etc. (Rezakhani 2012). To avoid such risk identification of hazard and effective risk management is necessary. Therefore, assessment of risk, which may effects its scope or work or objective of projects, is required by the construction companies. Managing risk at project sites can benefit to the project manager not only in the safety related incidents but also in many financial issues and also increase the confidence in achieving project objectives (Rezakhani 2012). As per international labour organization (ILO) about 60000 fatal accidents or almost 30-40% of total accidents occurred in construction globally and 7% -10% of global workforce works in construction industry (Lew and Lentz 2010). Many initiatives and many control measures have been suggested to address these problems in the construction industry. Different organizations are actively addressing the hazards in construction globally and workers engaged in construction industry are better trained and aware than before.

Investigation of work based accidents highlights the poor performances of involved working personal as well as that of contractor. Achieving the objective zero accidents is not possible unless owner, designer and other parties shoulder the well-defined responsibilities. Individual worker, supervisor, manager, designer or consultant cannot enforce zero tolerance for accidents or reduce the accident in significant way. Change in the trends and level of safe execution of construction projects can be achieved only when proactive involvement can be seen from all - workers to owner.

A number of risk assessment methodologies are available to assess the site conditions and help minimize the identified risks. (Haight 2001).

The risk corresponding to body parts wise was measured using fuzzy reasoning and fuzzy analytic hierarchy process. The overall risk of project was calculated as using sum of product methods. In the above study, author has used fuzzy numbers and linguistic terms for input value of each input parameters because of unavailability of precise and exact data of body part wise injury.
analyzed accidents data from 10 countries and found that more than 10% reduction in work place accidents was noticed when safety design considerations were in place. Design safety must be considered during the design phase, before execution of construction work approval of work procedure, as indicated in design is necessary. Workforce engaged in construction is neither consistent nor they are permanent; therefore establishing workforce competency is a ever present problem for employer. Statistics show that implementation of safety design considerations result in reduction in accidents (Lew and Lentz 2010). Decrease in the number of accidents and injuries in construction through implementation of safety design considerations will not only save lives but also improves the work quality and life. It also results in reduction in number of accidents claims and other financial expenditure for employers or contractors (Ku, Pollalalis et al. 2008). Role of designer, extent of distribution of accountability, allocation of responsibility during construction based on technical capability of architect & engineers has shown significant reduction in accident rates in building projects. Implementing the concept of safe design and 3D models enhances the feasibility of executing the project on time. UK (Hecker, Gambatese et al. 2004) mandated prevention through design in construction along with other European nations in 1995. Builders, construction companies and consultants were persuaded to implement safety design in construction which resulted in noticeable improvement in safety performance. Many design professionals raised the concern over implementation of prevention through design as it may result in framing of harsh and impractical regulations against designers in case of any construction injury. Hecker, Gambatese et al. (2004) have shown that designers lack safety design knowledge. Construction project allotted through bidding process constraints the constructor in implementing design safety considerations during execution of the project. Gambatese, Behm et al. (2005) have developed an outline for the implementation of safety design considerations, implementation of which resulted in considerable enhanced safety, wellbeing and health of construction workers. Gambatese, Behm et al. (2005) are of the view that designing of safety is quite possible and can have positive impact on safety of construction workers, safe execution, cost effectiveness at end and on time delivery of the project. Gambatese (1998) argue that role of designer in construction safety is encompasses construction safety design. A number of cases have been brought to the court where designer mistakes and their ill approach resulted in accidents. It has been seen (Gambatese 1998) that unless safety is incorporated through contractual binding on designer during bid-build process, they do not bother much in incorporating safety features in the structure thereby enhancing construction workers safety. Role of contractor in ensuring safety during construction exercise is well defined and the role or participation of designer in enhancing construction safety must be increased. Increased participation of designer in ensuring construction safety will improve the implementation of the concept of inherent safety in construction projects. Design engineers must be held accountable and liable for safety hazards arising from design even if no legal bindings are stated. Once the concept of design safety is implemented, decrease in number of accidents, injuries and associated cost would reduce. According to Hinze and Wiegand (1992) designer plays an important role in development of a project and same time he/she play an important role in implementing safety in design. Traditionally construction worker safety has been regarded as the sole responsibility of the construction contractor. Only one third of contractor, companies or designer follow the design content helpful for workers safety (Hinze and Wiegand 1992). Some of the impractical aspects of prevention through design have resulted in legal cases against contractors and have discouraged the design contractors. Torgabeh and Hosseiniyan (2012) gave the design and planning concept of construction safety design. They through the implementation of design safety were able to reduce the number of accidents for workers engaged in construction. There have been a number of legal cases where the construction safety was compromised because of the lack of knowledge legal standards by designer or it was found that the information provided by the contractor was inadequate. Generally it is found the lack of safety data hampers hazard identification and incorporation of safety features into design. Contractors engaged in design built projects have been seen to go for cost cutting at the expense of worker safety. Gambatese, Behm et al. (2008) studied relationship between design and construction site safety. It was found that there is a definite link between design decision and construction safety as they directly influence accident causation. Occupational diseases are not the part of design resulting in injuries and accidents. Smallwood (2008) highlighted the inclusion design and construction safety issues in project specific Quality Health Safety and Environment (QHSE) plan. Pressure of cost cutting from the contractor influences the engineering designer resulting in compromised HSE requirements thereby diverts from holistic approach in implementation of health safety issues in construction. Smallwood (1996) studied data more than 75 contracting company and found that 50% of companies identified the design as an aspect or factor, which if not done properly negatively effects the health and safety of construction workers. He also revealed that almost 90% of contractors suggested that safety of the construction can be improved through design and along with it; architects and engineers should learn construction safety as part of their curriculum during colleges. Behm (2005) studied 230 fatality cases in US between 1990 to 2003. Out of the 230 cases only 224 cases were used for the study as for the other 6 cases sufficient information was not available. Review was done to access whether any design is linked to the incidents. Based on the assessed data and review Behm (2005) observed, 42% of accidents were having design content issues for which more than 40 suggestion were given to improve the workers design safety. Gambatese and Hinze (1999) reviewed many design firms and constructing company regarding advice and implementation of safety in design. They found the lack of skills in designers to implement safety features in order to avoid or to reduce the safety risk or lack of confidence in implementing the safety in design.
Based on reviews, suggestions were given to develop some methodical approach to implementation and adding safety in design considerations. As per Mroszczyk (2006) majority of construction accidents happens during the initial phase of work when project gets allocated. Mroszczyk (2006) has suggested that including the safety design consideration since its beginning would help decrease the number of accidents. Zhou, Whyte et al. (2012) used digital data in implementing safety in construction. Virtual Reality, CAD and building information modelling, sensing warning technology are helpful to develop tools for hazard identification and safe project delivery.

CONCLUSION:
A state-of-the-art literature review revealed the fact that majority of accidents happened in construction industry during the initiation phase due to ill approach of designer, architect and engineers. Although only 7-10 % global workforce works in construction industry more than 30-40 % of global industrial accidents are from construction industry. Analysis of a number of accidents indicates that holistic approach of hazard identification and risk assessment, which is largely ignored by the construction designer, helps improve the on time project delivery, mobility of workforce. Active engagement of concerned and competent person and implementation of legislation strictly would also help improve the safety in construction industry. Significant improvements were noticed in accident prevention when enforcement had been seen on standard and other legislation.

Although construction safety design protocols have been set quite long ago in construction, but lack of proactive implementation results in areas specific accidents. Even as various tools have being developed for risk management, implementation of these risk management tools adapter for site specific needs is required. Allocation of hazard in any activity and evaluating its risk value is not a solution until consideration includes well construction safety design and planning strategy. Many initiatives taken by experts, to reduce accidents during initial stages of construction have resulted in decrease in number of accidents. To further improve the safety in construction, various tools have been made. One such tool is based on fuzzy logics which has the capability to take into consideration uncertain and inadequate data.

REFERENCES: