

# Visualization Technology Aided for Construction Safety Management

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**Abstract** - Construction safety management has been a popular issue in research and practice in the last few decades due to high accident and death rates in the construction industry. The variability and complexity of construction sites makes safety management more difficult to implement than in other industries. As a promising technology, visualization has been extensively explored to aid safety management in construction industry. This paper provides a comprehensive review to analyze research and development and application methods to the use of visualization technology in safety management and suggests possible future research directions to extend its application. Survey has been conducted among various construction sites about worksite safety management practices using job safety analysis worksheet based on that risky jobs and Job Hazard Area (JHA) have been identified. Fall protection, BIM architectural and structural model, scaffolding layout and phasing animation (visualization) for a sample plan have been developed which would enable to attain zero accident worksite. It is found that visualization technology can improve safety management by aiding safety training, Job Hazard Area (JHA) identification and on-site safety monitoring and warnings to a greater extent.

**Key Words:** Visualization, Construction safety management, Job Hazard Area (JHA), Building Information Modelling (BIM), Augmented Reality (AR).

## 1. INTRODUCTION

Construction work has become one of the most hazardous industrial activities in the country. The rate of injury in the construction activity is more than any other industry. Next to agriculture industry, construction industry holds the second position in India. Although significant improvements have been taken place in construction technologies and processes in recent decades, the safety record in the construction industry continues to be one of the poorest. Every day lot of individuals plummet victim to injury, impair and unchanging loss caused by accidents on construction sites.

The prevention of construction accidents usually involves predicting the future accidents and their nature under given circumstances. The making of such predictions is based on knowledge about past accident reports. In the construction industry, the major causes of accidents are related to its unique nature, difficult worksite conditions, human behaviour and poor safety management which result in unsafe work methods and procedures.

Due to the fact that accident rates in construction are high when compared to other industries, the project and construction managers need to be fully prepared to deal with accidents when they occur and should undertake proper investigations and report procedures afterwards. Accident statistics represent not only terrible human tragedies but also substantial economic loss. This is because accident cause damage to plant and equipment and the loss of productive work time until the normal site working rhythm and morale are restored. Accidents can also reduce the work rate by causing work disruption.

### 1.1. Objective of the project

- To measure the factors related to safety of labors and site environment.
- To aid JHA identification and management during the preconstruction process.
- To aid on-site safety monitoring on workers and construction equipment during the construction process.

### 1.2. Scope of the project

- To make the environment safe by JHA identification and management.
- To make the job safe by adopting safety policy to the fullest range by both large and small construction firms as well as by making owner, consultant, contractor and stakeholder more responsible in pre-construction safety planning.
- To make workers safety conscious by instructing them, the importance of construction safety and negative impacts of lack of construction safety towards their lives and wellbeing.
- To attain zero accident work places with stronger commitment and concerted effort on behalf of owners, designers and contractors alike.

### 1.3. Need for project

Safety is the control of the identified dangers in order to achieve an acceptable risk. Safety at work is very important for every employee in the industry because all employees want to work in a safe and secure atmosphere. Health and safety are the key factors for all industries to promote the well-being of workers and employers. It is a duty and moral

responsibility of the company to take care of employee protection.

## 2. DEFINITIONS

**Safety:** A state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community. It is an essential resource for everyday life, needed by individuals and communities to realize their aspirations.

**Construction safety management:** A systematic way of identifying hazards and managing risks relating the construction workplace.

**Visualization:** The act or process of interpreting in visual terms or of putting into visible form.

**Building Information Modelling (BIM):** It is an intelligent 3D model-based process for creating and managing information on a construction project across the project lifecycle. One of the most important outputs of this process is the building information model, the digital description of all aspects of the built asset. This model is based on information that was compiled together and updated in key phases of a project. Actions can be optimized for those who interact with the building by creating a digital building information model, resulting in a greater value for the entire life of the asset.

**Augmented Reality (AR):** A technological innovation that incorporates virtual elements into real surroundings. In construction, augmented reality makes it possible to combine virtual architectural designs with the physical reality of a job site. This amazing technology increases accuracy and efficiency by reducing errors related to managing time, money and resources.

## 3. LITERATURE REVIEW

**Bambang Endroyo et al (2017),** studied the model of the maturity of pre-construction safety planning and stated that every individual personnel such as owner, consultant, contractor and stakeholder should be more responsible in pre-construction safety planning. Maturity Index of Pre-construction Safety Planning (MIPSAP) is a model for evaluating a maturity of pre-construction safety planning which is carried out by owner, consultant, contractor and stakeholder during pre-construction stage. The building projects with low MIPSAP score (very not mature and not mature) should be re-planned to achieve high MIPSAP score (mature and very mature) before starting the project to the construction stage.

**Chandan Mehra et al (2016),** studied the importance of safety in Indian construction and stated that there is an essential for any construction project to have certain safety

guidelines and procedures to be followed for site activities and to create awareness among the workers, site supervisor and engineers. The best way to protect workers against hazards is to control problems at the source. Workers must have PPE (Personal Protective Equipment) that fits properly. Poorly fitted PPE may cause additional hazards. The economic cost is not the only basis on which a contractor should consider construction safety. The reasons for considering safety are humanitarian concerns, economic reasons, laws and regulations and organizational image.

**Devdatt P Purohit et al (2018),** examines the hazard identification and risk assessment in construction industry and stated that hazards must be identified first and then the risk should be evaluated and determined to be tolerated or not to manage risk. The hazards and risk should be identified by analyzing each steps involved in various activities in the construction and suggestions should be given in order to eliminate or reduce the risk assessment. A collective term Hazard Identification and Risk Analysis (HIRA) encompasses all the activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public or the environment are consistently controlled within the organizations risk tolerance level.

**Dheeraj Benny et al (2017),** studied the construction safety management and accident control measures and stated that the major issues on safety should be erased completely at the planning stage itself. Early planning of construction processes should be promoted in order to improve safety at the worksite. Proper remedies and measures should be taken in every construction site to prevent any chance of occurrence of any kind of accidents. Implementation of safety measures is more important than safety planning and training. The implementation of proper health and safety criteria can improve the sustainable value of projects.

**Hongling Guo et al (2017),** studied the Visualization technology - based construction safety management and concluded that the safety related problems in construction industry such as Insufficient safety training, Incomplete safety planning and Invalid safety monitoring can be solved with the help of visualization technology, which not only makes information digital and visual but also depicts the construction environment and processes comprehensively and accurately. The main contributions of visualization technology to safety management are improving the safety training of workers, aiding Job Hazard Area (JHA) identification and management and aiding on-site safety monitoring.

**Hongmin LI and Jianjun LIU (2018),** investigated the Construction Site Safety Management Research Based on BIM Technology and stated that BIM technology detects design conflicts during the design phase of complex structures and improve design quality and also detects space

conflicts. It prevents and eliminates many security issues from the source of the design. The virtual construction digital model produced by the BIM system automatically analyzes the structural space shapes of each floor, actively searches for holes that need to take safety measures, proposes safety warnings and automatically arranges safety protection railings to mark locations. It also aids for identification of hazard factors, division of hazardous areas, management of construction space conflicts, establishment and implementation of safety measures, real-time safety monitoring, and safety evaluation and digital security training based on BIM.

**S. Kanchana et al (2015)**, investigated the labor safety at construction sites and stated that preventing labor accidents, occupational illness, and injuries should be a primary concern of all the employers and employees. The current status of safety at workplace should be examined and safe working environment for the employees of construction companies should be created. Information pertaining to the number of accidents taking place in small and large construction sites, cause for the accidents and type of injuries suffered by the workers should be collected and examined, appropriate preventive measure should be taken.

**Kyungki Kim and Yong Cho (2015)**, studied BIM-Based Planning of Temporary Structures for Construction Safety and concluded that Created set of algorithms analyze geometric conditions in BIM, generate required temporary stair towers and analyze their impact on safety. Optimized locations and shapes of temporary stair towers and associated potential safety hazards can be identified and visualized in BIM and schedule. By incorporating more types of temporary structures, safety and productivity of a construction project can be improved by assisting construction planners to make optimal decisions related to temporary structures.

**Seyed Meysam Khoshnava et al (2012)**, studied the Application of BIM in Construction Safety and stated that the BIM concept determines virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, improve safety, work out problems, and simulate and analyze potential impacts. BIM-based site plan can be used to produce illustrative representations of the site and safety arrangements and the views can be used for orientation of site workers, task guidance and instructions, for informing about risks and for discussions with the client concerning site arrangement, enclosure and temporary roads and walkways.

#### 4. RESEARCH METHODOLOGY

The following methodology has been adopted to analyze the Job Hazard Area (JHA) and implementing the works related to construction safety management with the aid of visualization technologies.

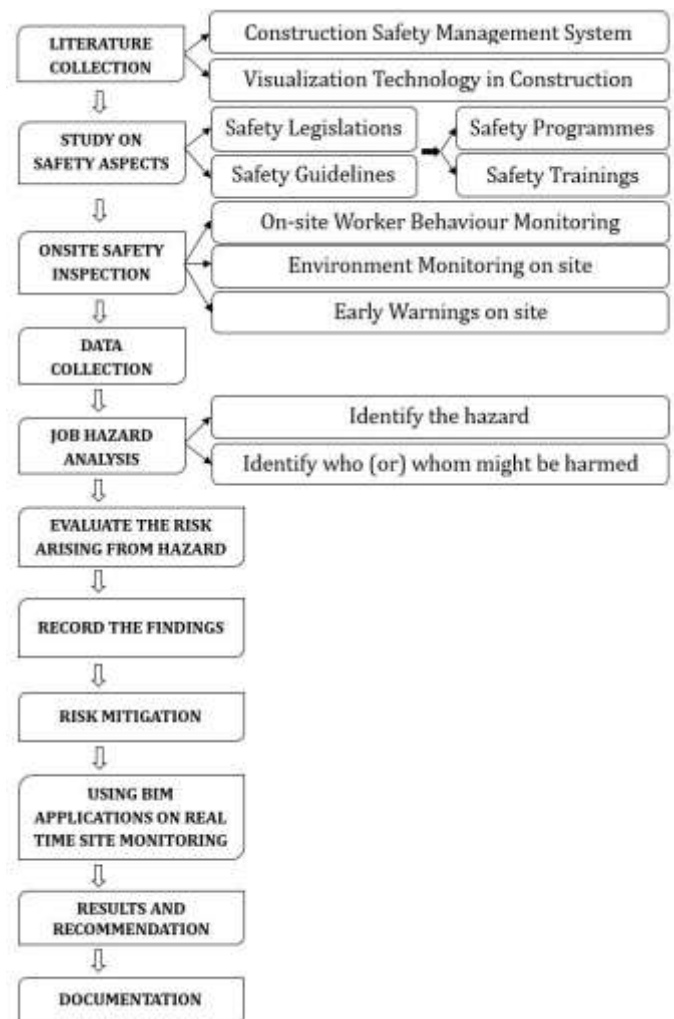


Fig -1: Methodology adopted

#### 5. DATA COLLECTION

Survey has been conducted among various construction sites about worksite safety management practices and also survey among labor about worksite safety condition using job safety analysis worksheet.

Title of Operation:		Building:
Position/Title (person who does job):		Section:
Department:		
S.NO.	POTENTIAL HAZARD	PROCEDURE TO BE FOLLOWED
Prepared by:		Date:
Approved by:		Date:

Fig -2: Job safety analysis worksheet



## 6. DATA ANALYSIS

Risky jobs and Job Hazard Area (JHA) have been found based on accident types and rate of accidents happened at construction sites through survey conducted regarding safety.

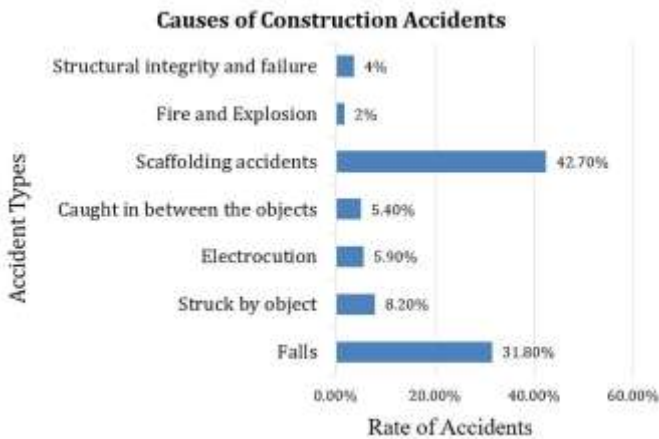


Fig -3: Causes of accidents

## 7. Risk Mitigation Using Software

Sample project (School Building) has been taken and made the floor plans using AutoCAD. Fall protection, BIM architectural and structural model, scaffolding layout and phasing animation (visualization) for a sample plan have been developed to make zero accident worksite.

Mitigation for the risk of falls ie., Fall protection has been provided to the taken sample project using AutoCAD.



Fig -4: Falling accident prevention

A 3D architectural model using Revit software has been prepared. By visualizing this Job Hazard Areas (JHA) can be

found and few causes of construction accidents can be controlled.

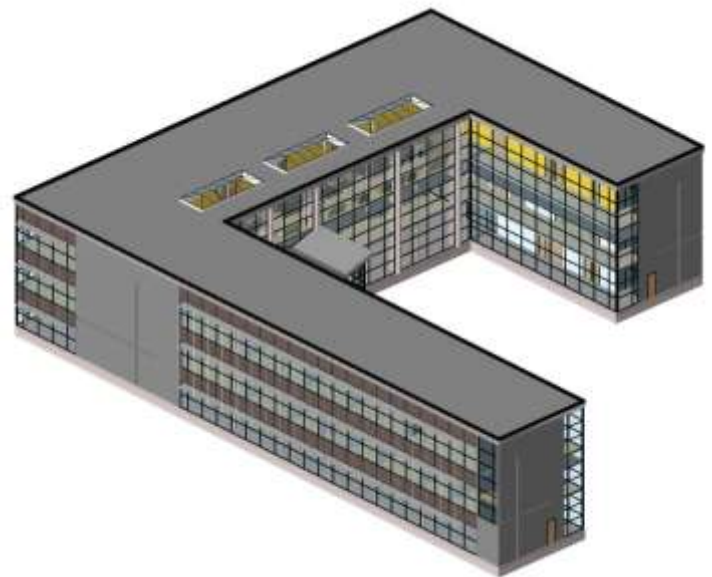


Fig -5: BIM architectural model

A 3D structural model using Revit software has been prepared. By visualizing this, structural integrity and failure can be controlled through proper design of joints with more care.

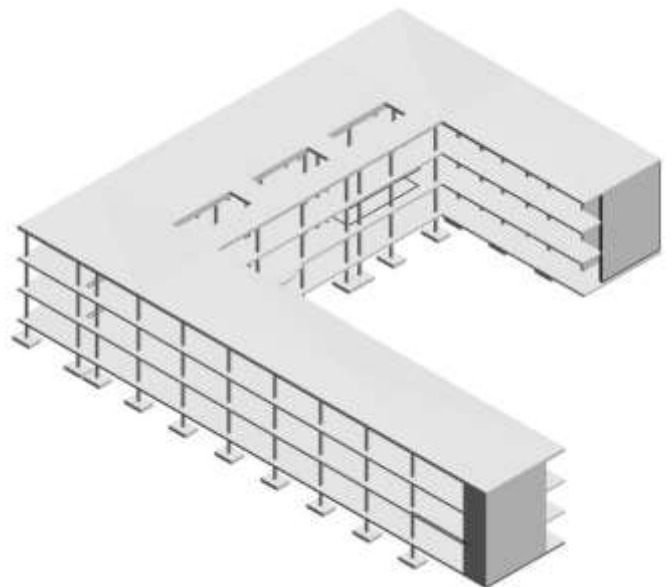


Fig -6: BIM structural model

Augmented Reality (AR) animation has been created through AUGIN mobile application. This technology is the Augmented Reality for Architecture, Engineering and Construction. It allows to mix virtual elements with the real world. In this project AUGIN is used for visualization of 3D architectural model. By visualizing this phasing animation, Job Hazard

Areas (JHA) can be found and few causes of construction accidents can be controlled.

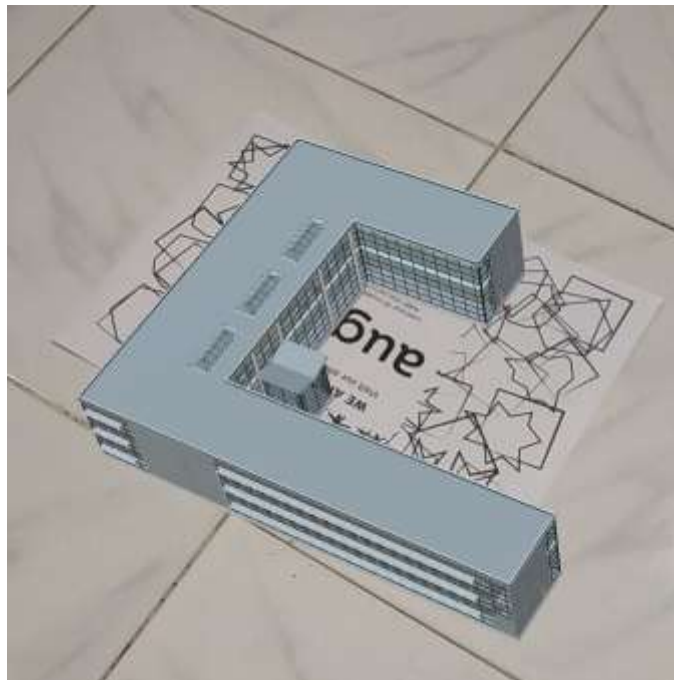


Fig -7: 3D architectural model (phasing animation)

In this project AUGIN is also used for visualization of 3D structural model. By visualizing this phasing animation, structural integrity and failure can be controlled



Fig -8: 3D structural model (phasing animation)

At the construction site, scaffolding systems are major temporary structures that offer the work teams an adequate work area to support the activities. Therefore, effective planning and design of scaffolding systems is considered critical to improve overall design performance.

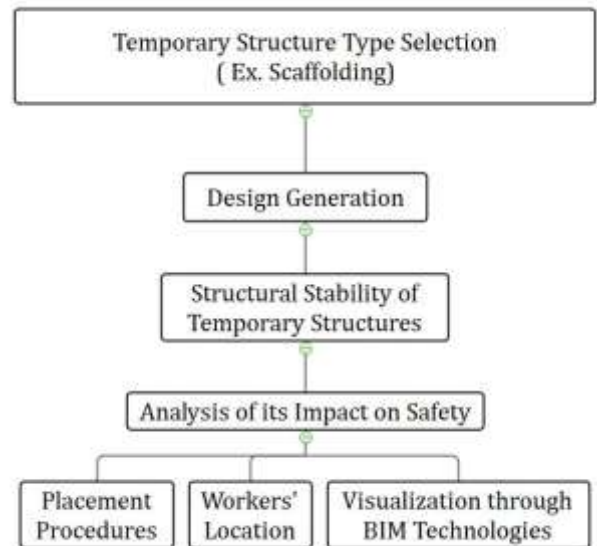


Fig -8: Safety management on temporary structures

Construction scheduling has been done using Primavera for the sample project (School Building) taken. Proper planning and scheduling are required to ensure that a construction project is completed on time and within budget. By creating a schedule, it is possible to have complete control over all project activities and can plan business operations down to the lowest level.



Fig -9: Construction scheduling for sample project taken

## 8. RESULT & DISCUSSION

Visualization technology has been used to identify and manage JHAs involving major types of accidents, for example falling from height, structural collapse and spatial collisions. Hence, safe environment will be created and safe job will be given to all the employees by identifying and managing the Job Hazard Area (JHA) as well as by improving safety trainings and regular construction safety monitoring with the aid of visualization technology. This also will lead to attain zero accident worksite.

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