

# A STUDY ON CONSTRUCTION SAFETY ISSUES AND DEVELOPMENT OF A GENERAL SOLUTION FRAMEWORK

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**Abstract:** - Safety in an inevitable factor to be considered in construction industry. Absence of safety measures can cause accidents in construction sites leading to injuries or even fatality. On the other hand, modern technologies have the potential to improve construction safety. In this context, the Objective of this study is to identify the construction safety issues and develop technical solutions for that. For the purpose, (1) extensive literatures survey was conducted to get insight into the problem and (2) questionnaire survey in construction sites was conducted to establish the major safety issues. Based on these studies solution concepts based on radio frequency identification (RFID) was proposed. Personal Protection Unit (PPU) checking system and a proximity alert system were developed using RFID and tested. Also a Building Information Modeling (BIM) based fall protection plan and a proactive safety plan to be submitted to authorities was developed.

**Keywords:-** Safety, Personal Protection Unit(PPU), Proximity Alert System, Fall Protection Plan, Questionnaire, Proactive safety plan, General Solution Framework

## 1. INTRODUCTION

Safety can be defined as the absence of danger at sites or eliminating the situations which will be fatal. Thousands of construction workers are injured or killed in construction accidents each year. Construction companies provide safety equipments and training, but unfortunately accidents still happen. When a construction site accident occurs, the owners, architects, designers and manufacturers of equipment are held responsible for inadequate safety provisions. Use of modern technologies may be used in construction sites. Construction companies are slow in adapting automated technologies that have proven to work in other industries. Radio Frequency identification is a technology which can revolutionize safety prevention. Once tested successfully in the construction environment, these emerging technologies could be adapted.

Building Information Modelling (BIM) is gaining importance in the construction industry. If we have information we can model it. These technologies are handy in the planning stages. Fall protection plans can be developed using BIM. This will give an idea to the safety officer in advance where to provide the necessary fall prevention measures like hand rails, nets etc.

## 2. OBJECTIVE SCOPE AND METHODOLOGY

### Objective

The objective of this project is to study construction safety issues and to develop a general solution framework.

- To identify the safety issues by conducting a questionnaire survey.
- To develop technical solutions and safety plans.

### Scope

The scope of the project is limited to

- i. Development of technical solutions for
  - a. Fall related accidents,

- b. Accidents related to moving equipment's,
  - c. Accidents due to careless behaviour of workers
- ii. Development of a proactive safety plan

### Methodology

The initial phase of the project consists of a questionnaire survey. This is to analyse the conditions in the site and find out the safety issues. Questionnaires are given to various reputed firms in Ernakulam .Information obtained from questionnaire was analysed to identify the safety issues.

Technical solutions include development of a Personal Protective Equipment checking system, a proximity Alert System and fall protection plans. Personal Protective Equipment checking system and proximity Alert System based of RFID were developed in Matlab environment.

A 3D Model based fall protection plan was developed. 3D model of a building was prepared in Revit. The fall prone zones were identified in the 3D model and safety rails were provided.

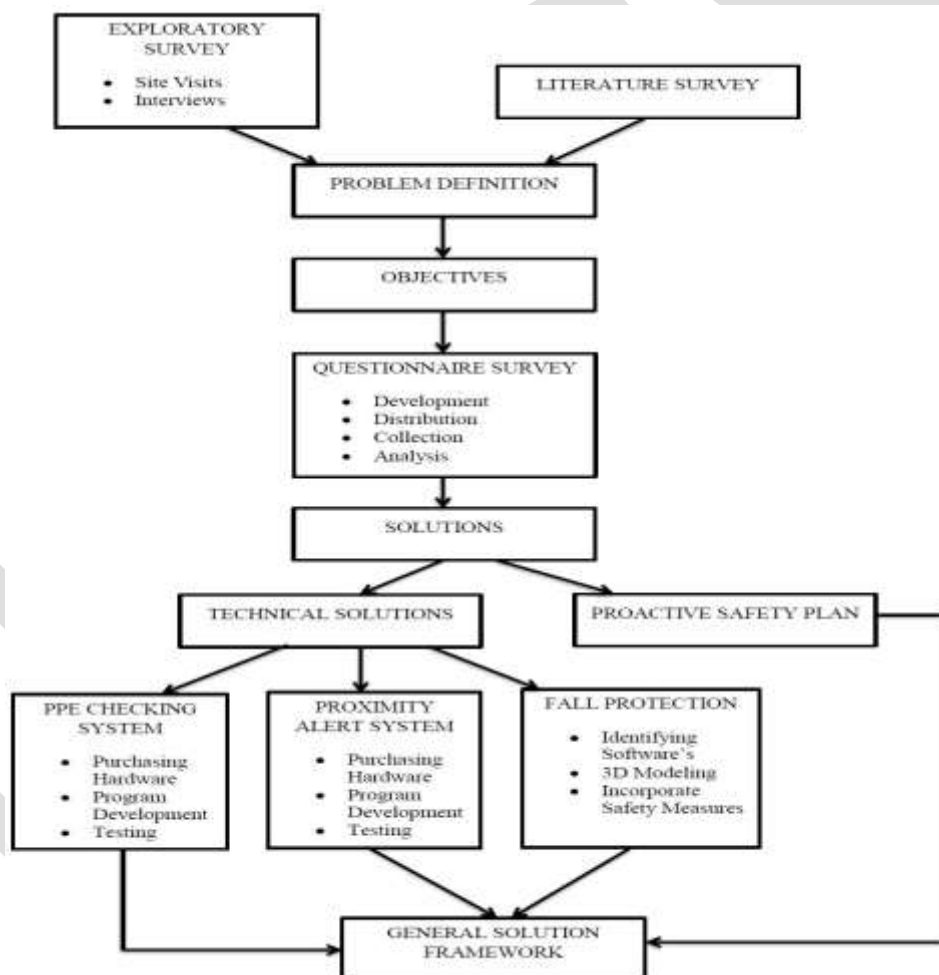


Fig 1:Methodology

### 3. QUESTIONNAIRE ANALYSIS

To understand the various safety issues in construction sites and to find remedies a questionnaire survey was conducted. Questionnaires were distributed to various design, contracting and other firms. The collected questionnaires were analysed to get an idea about safety issues and the possible remedies in the opinion of experts. Questionnaire consisted of 2 parts. ‘A’ part containing multiple choice questions (10 questions A1 A2...A10). ‘B’ part consists of scale based questions (12 questions B1, B2...B12). The number of respondents was 35.

Some of the conclusions from multiple choice questions of questionnaires are as follows:

- Accidents on construction sites are due to Lack of safety knowledge as shown in Fig 2.
- The major reasons of accidents on sites are that the workers are short of Safety training as shown in Fig 3.
- The most common type of accident in construction sites are fall related accidents as shown in Fig 4

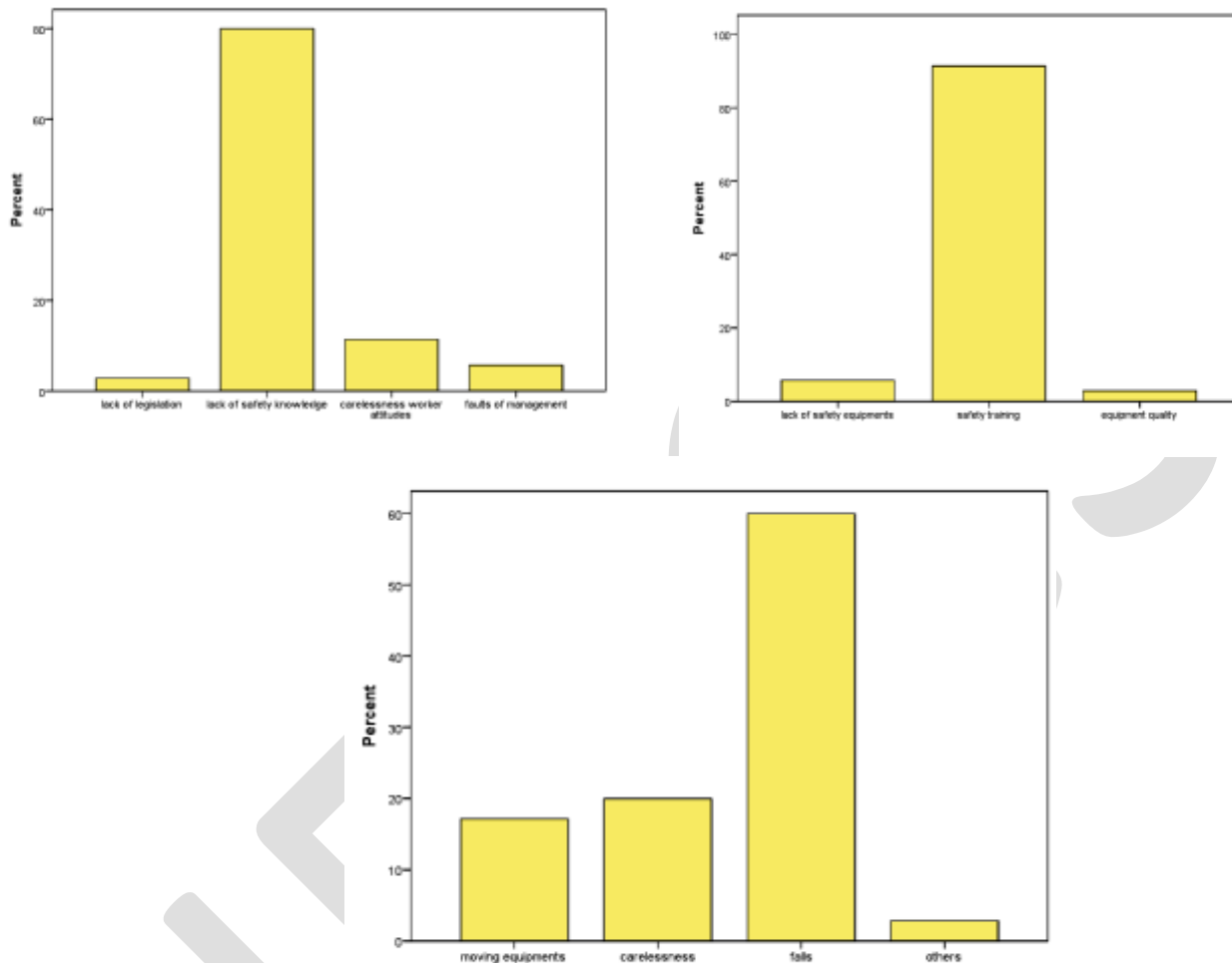


Fig 4: Major types of accidents in sites

The bar charts give the percentage distribution of votes for different questions.

When developing a questionnaire, items or questions are generated that require the respondent to respond to a series of questions or statements. Participant responses are then converted into numerical form and statistically analyzed. Likert scale was used for the analysis. The frequency index (FI) was calculated (Table 1).

$$FI = \frac{\text{Sum of weights} \times 100}{(\text{Highest Weight} \times \text{Number of Questionnaires})}$$

The conclusions obtained from the scale based questions are as follows:

- Accidents in sites are due to lack of safety knowledge.
- Engineers must have knowledge of current safety regulations, rules, and standards and update this knowledge.
- Construction professionals should form an alliance to share experience and set code practice to promote and assure safety in sites.
- The government should set up a construction safety council with members from constructional professionals to study strategy and establish common safety working practices in the construction industry.

Table 1: Frequency Index

Scale	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Total	Frequency Index	Rank
	1	2	3	4	5			
Weight	5	4	3	2	1			
B1	18	16	1	-	-	157	89.7	5
B2	7	27	1	-	-	146	83.4	8
B3	30	5	-	-	-	170	97.1	1
B4	1	27	5	-	2	130	74.2	12
B5	9	14	9	2	1	133	76.0	11
B6	27	8	-	-	-	167	95.4	2
B7	16	18	1	-	-	155	88.6	6
B8	15	18	2	-	-	153	87.4	7
B9	26	9	-	-	-	166	94.5	3
B10	7	20	8	-	-	139	79.4	10
B11	18	17	-	-	-	158	90.3	4
B12	9	18	8	-	-	141	80.6	9

#### 4. TECHNICAL SOLUTIONS

The construction process is associated with accidents. Sometimes this may be fatal. Measures should be taken to guarantee a safe working environment for the workers. Modern technologies may be useful in ensuring safety. Technical solutions were developed for the following safety issues

- Fall Related
- Equipment Related and
- Carelessness of workers

##### Personal Protective Equipment checking system

In order to ensure that the workers use all personal protective equipment's (PPE) a program was developed. It is based on radio frequency identification. RFID cards are attached to all the PPE's. The workers are asked to move through an RFID gate. It is provided with RFID antennas. As they pass the gate the details of the RFID cards attached to their PPE's will be retrieved by the antennas. The PPE details of employees are stored in a database. The program compares the card details provided by antenna with the workers PPE details in the database. If the workers carries all the PPE required for his safety he will be allowed to work else alert will be given.

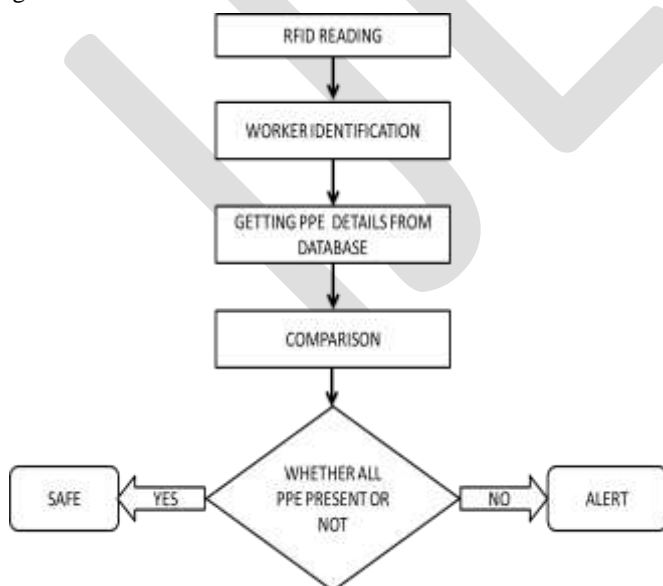


Fig 5: PPE checking system



Fig 6: Prototype-RFID Reader and Cards

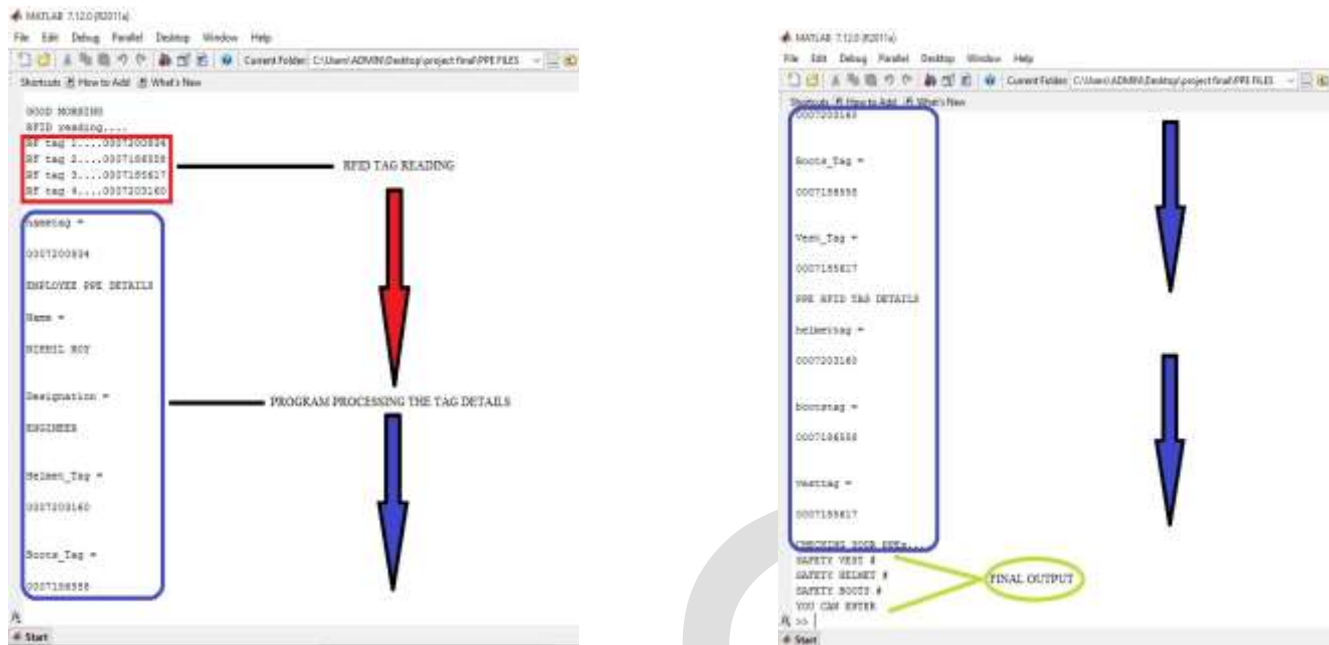


Fig 7: Working of PPE checking system

### Proximity Alert System

To prevent equipment related safety issues like run over by trucks, a proximity alert system was developed. This is also based on RFID. A single or a group of Radio frequency antennas are provided on the equipment. The works and others vehicles carry RFID tags. The antennas continuously scan for RF tags in its range. Once the antennas detect a tag alert will be given.

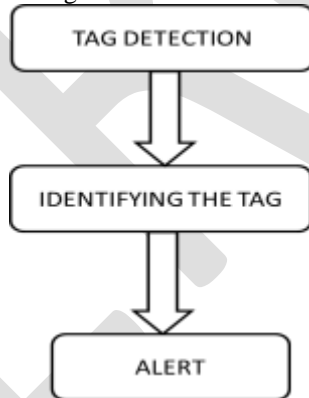


Fig 8: Proximity Alert System



Fig 9: Program Scanning for RFID Tags



Fig 10: Program detecting a Tag

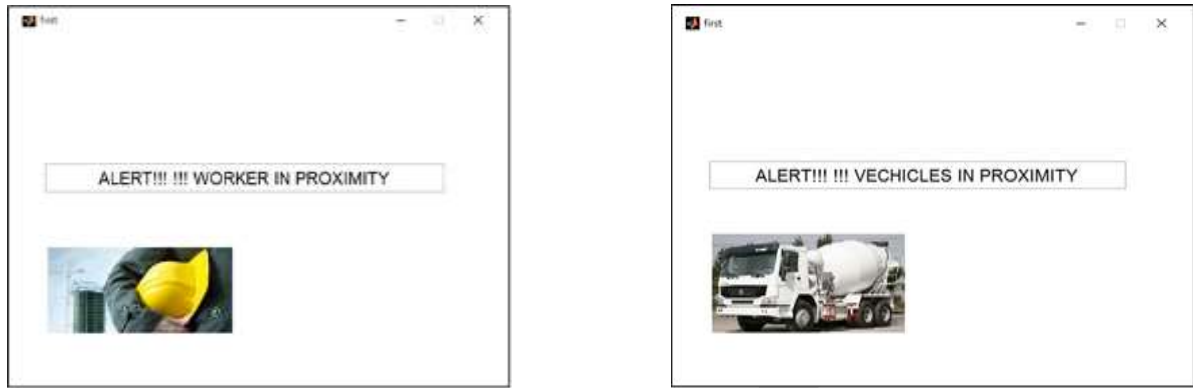


Fig 11: Output of Program

### Fall Protection Plan

Falls from building is a common site accident. Reasons may be careless worker attitude, alcohol consumption or lack of safety equipments. 3D model based fall protection plan which are developed during the planning stage of the project can prevent accidents. They can give a better idea to the safety officer on where to provide safety rails and nets. Such plans can be linked with the schedule. A 3D BIM based fall protection plan was developed. It was linked with construction schedule and a simulation video was developed.

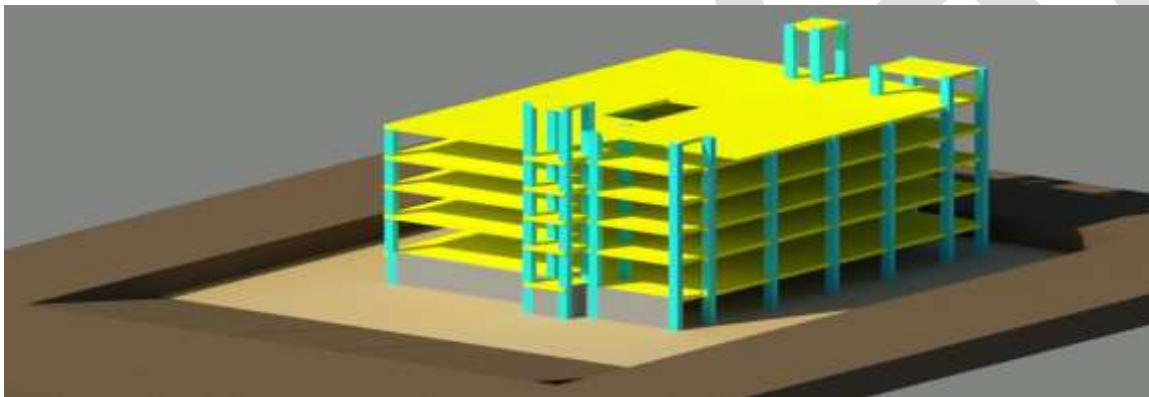


Fig 12: 3D model of building without fall protection

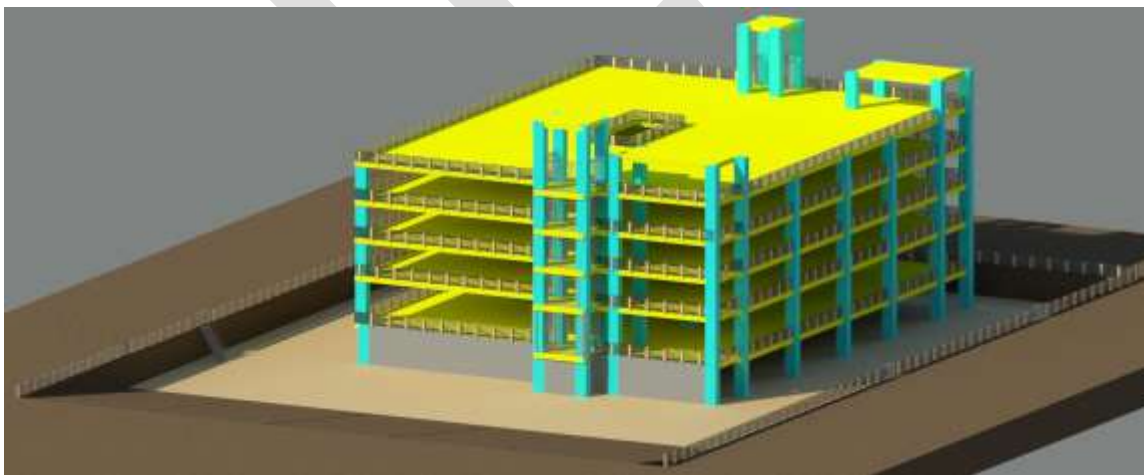


Fig 13: 3D model of building with fall protection

## Proactive Safety Plan

A proactive safety plan was developed. It contains details about possible safety issues, remedies, medical help details, safety officer details etc. This plan can help in accident prevention during construction phase.

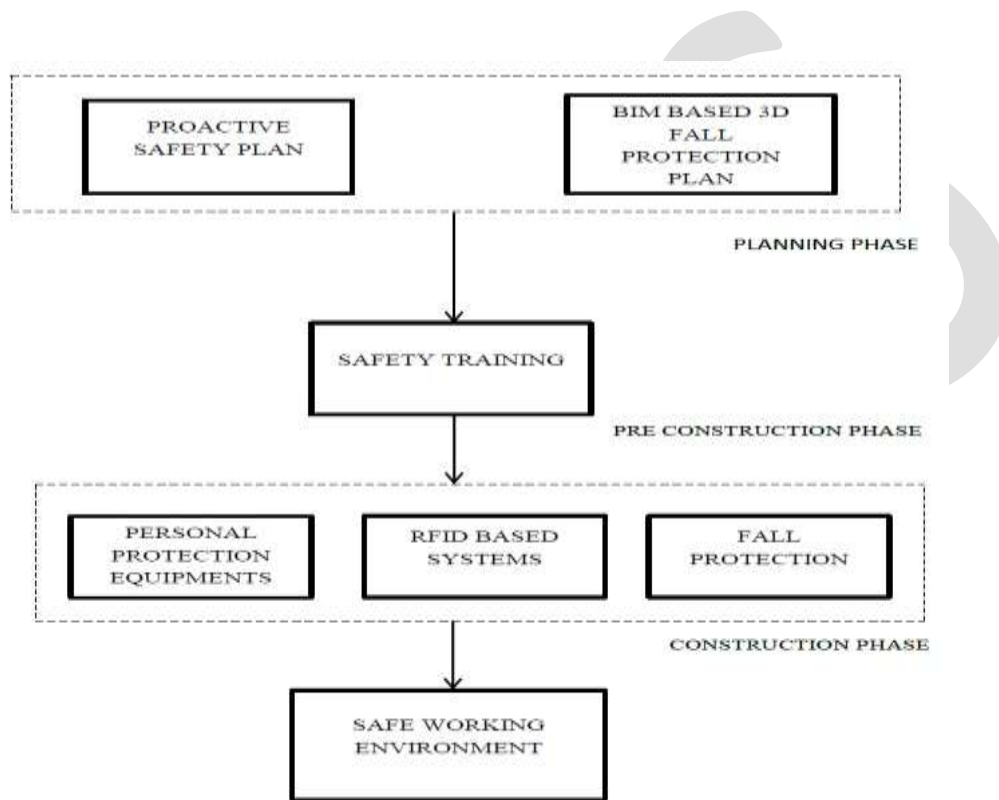


Fig 14: General Solution Framework

## 5. CONCLUSION

The safety issues in construction sites were studied and steps to prevent accidents were identified. Lack of safety Knowledge and safety training are the major reasons for accidents. The management, safety officers and workers should join hands and work towards the goal of ensuring 100% safety in sites. It is recommended that the workers get proper safety training and personal protection equipments. The proposed radio frequency identification based personal protection equipment checking and proximity alert systems were tested successfully. If implemented the proposed RFID based systems can prevent accidents in sites. It is recommended that importance is given to safety in the planning stage itself. If implemented the proposed fall protection plan and proactive safety plan can prevent fall related and other accidents.

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