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Safety Analysis of High Rise Buildings

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Abstract

In the construction sector, safety and accidents are important factors that have a big impact on the well-being of workers, project schedules, and project overall expenses. In addition to being required by law, putting safety first in construction is a wise strategic move with broad ramifications. The comparative safety study of high-rise structures presented in this work focuses on assessing how safety precautions, construction costs, and project schedules interact. The study creates a baseline for safety benchmarks by first looking at current safety norms and laws that apply to high-rise buildings. It then looks at how different safety features and precautions affect project durations and construction costs. The comparison is made between projects that follow safety protocol and projects without safety implications and their impact on time and cost of the overall project cost using MS Project.

Keywords: Safety analysis, accidents, MS project, safety and accidents, project overall expenses

INTRODUCTION

The construction industry, particularly in the realm of high-rise buildings, is characterized by the intricate interplay of various factors, among which safety, cost, and time stand as fundamental pillars. Achieving a delicate equilibrium between these elements is crucial for the success of any construction project. Safety considerations, while paramount for the well-being of occupants and the longevity of the structure, often introduce complexities that can impact both the financial outlay and project schedule. Historically, safety has been viewed as a non-negotiable aspect of construction, with stringent regulations and standards in place to mitigate risks and ensure the welfare of workers and future occupants. However, as the demand for innovative, taller structures rises in urban landscapes, so does the need for a nuanced understanding of how safety considerations influence the twin imperatives of cost and time in construction projects. Through the examination of case studies, real-world examples, and innovative practices, this paper aims to identify strategies that optimize safety without unduly burdening project costs or extending timelines. By the end, stakeholders will have gained a comprehensive understanding of the intricate relationships between safety, cost, and time, enabling them to navigate the challenges of high-rise construction with a strategic and informed perspective.

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MOTIVATION

Safety implementation in construction industry is neglected and looked at as an additional protocol to be followed; although it is given a minimal importance it makes a major impact on the efficiency of the project. This papers proves the and evaluates the impact of implementation of safety in construction site.

The objective of the research focuses on analyzing accidents and their impact on project time and cost through case studies, interviews, and questionnaires. Data is gathered from experienced engineers and from other experts of this industry and compared using MS project software. The results reveal the importance of safety protocols in implementing safety measures in projects.

LITERATUREREVIEW

envisioned BIM as a repository of building information, transforming collaboration and communication among project teams [1]. BIM integration with project scheduling, highlighting its role in construction planning accuracy, visualization, conflict identification, resource allocation, and project delays [2]. explored BIM's sustainable aspects, highlighting its ability to quantify environmental impacts and aiding eco- friendly materials and construction practices [3]. Study BIM's 3D visualization capabilities in safety, identifying and mitigating hazards, improving planning, reducing incidents, and promoting a safety-centric approach for safer working conditions and reduced liability [4]. analyses an academic building's energy performance as a case study to reduce energy usage. It is said that energy consumption may be reduced by using trimming techniques early in the design phase and the best optimization variables. The use of virtual technology early in the design process may greatly cut energy usage and help develop appropriate energy patterns [5]. The most promising possibilities of using BIM in improving both constructability review and safety planning processes, and to clarify the relationship of constructability and safety [6]. The research addressing the use of BIM to improve construction safety. The results provided a comprehensive research synthesis and analysis, augmenting knowledge on the role of BIM in construction safety. The study output can be considered a reference framework to enhance construction workers' safety by means of new technologies, which can play a fundamental role for developing "Safety 4.0" in the construction industry [7].

Literature Gap

Although there are numerous researches on safety implementation and its impact on efficiency of a project, there is only a handful showing the numerical impact. This research is on actual valuation of the impact and arriving at a numerical result exposing the importance of implementing safety protocol [8-11].

Theoretical Framework

Several important ideas and interconnected elements can be used to organize a conceptual structure for safety precautions and accidents in the construction industry, taking into account their effects on time and cost. An environment that prioritizes safety is fostered by a positive safety culture, and thus increases adherence to safety procedures. Thus, there is a lower chance of mishaps, which minimizes downtime and related time and expense overruns. Timeliness, accident prevention, and disruption avoidance are all facilitated by proactive hazard identification and risk management. This reduces the need for expensive corrective actions and associated legal ramifications. By enhancing monitoring and response times, safety technology implementation can lessen the severity and frequency of incidents. This proactive strategy reduces long-term expenses related to accidents, improves project efficiency, and minimizes downtime. By improving safety practices and procedures through learning from events, similar mishaps can be avoided in the future. This iterative process of improvement lowers the frequency of accidents and their related effects on project schedules, which results in long-term cost savings. As a result, it highlights how closely related safety, time, and money are in the construction sector. In order to optimize construction projects in terms of both time efficiency and cost effectiveness, it emphasizes the significance of taking a proactive approach to safety and incorporating it into the organizational culture, procedures, and technologies.

Research Methodology

The initial research is done through the data accumulation of various accidents and the impact of the accident occurrence on the time and cost of the entire project. The data is accumulated through research on case studies and examples. Also, the general interview method is used to obtain valuable information from the experience of the experts in the field. A questionnaire form is circulated among the experienced engineers and field engineers to obtain information about their experience with accidents on site and

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the impact on cost and project delays. Subsequently, all the obtained data is used on an existing project schedule; the accidents are assumed to occur at each stage of the project, and their corresponding cost impact is evaluated. For this evaluation, MS Project software is used for comparison. Ultimately, the result of the evaluated data is obtained, revealing the actual importance of the implementation of safety protocols in a project.

Questionnaire Survey

A questionnaire survey has been conducted to better understand the financial impact of accident occurrences on construction sites. The pattern of the questionnaire is described below:

- Section 1: General Information
- Section 2: Accident Information
- Section 3: Cost Expenditure
- Section 4: Preventive measures
- Section 5: Lessons learned
- Section 6: Additional Comments

This questionnaire was distributed to the project manager, site supervisor, safety officer, and construction manager.

Data Collection

The data of cost of equipment used for safety is retrieved by doing market research, many of the local vendors and online prices are compared and the selling price of the products is collected.

Experimental Work Project specifications

A Residential complex is chosen in this work which consists of 2 basement, ground floor and 7upper floors. This residential tower is taken for analysis. The selected structure has a 1008 Sqm area i.e., 28m X 36m. A typical floor consists of 4 numbers of 2BHK and2 numbers of 3BHK. Estimation of cost and quantities are done based on the obtained data from the company using MS Project with a time deadline of 490days.

Determining Dependencies and Allocating Resources

After sequencing the activities, specific activities are linked so as to facilitate the commencing of the later activities based on start to start, finish to start, finish to finish and start to finish**.** The estimated resources are then allocated to each activity according to the requirements Table 1-3.

Table 1. Safety equipment details.

Safety Equipment	Hypothetical Cost (INR)	Suggested Price Source
Hard Hat	500 - 800	Local Safety Equipment Suppliers, E-commerce Websites
Safety Goggles	150 - 300	Local Hardware Stores, Online Market Places
Ear Plugs	50 - 100	Industrial Suppliers, Safety Equipment Retailers
High Visibility Vest	300 - 500	Work wear Stores, Safety Equipment Distributors
Respirator Mask	200 - 400	Medical Supplies Stores, Safety Equipment Retailers
Safety Gloves	100 - 250	Industrial Supplies Shops, Safety Equipment Suppliers
Safety Harness	1000 - 1500	Safety Equipment Retailers, Construction Suppliers
Safety Shoes	800 - 1200	Shoe Stores, Work wear Retailers
Fall Arrest System	2000 - 3000	Safety Equipment Distributors, Construction Suppliers
Fire Extinguisher	1000 - 1500	Fire Safety Equipment Suppliers, Online Retailers

Table 2. Features of the selected project.

Salient Features of the Project	
Project name	Willow Tree
Project type	Residential Project
Client	Prestige
Type of Contract	Item rate contract
Project Location	3HG5+WWJ, Vidyaranyapura Main Road, Vidyaranyapura, Bengaluru, Karnataka560097
Project Start Date	May2023
Project Finish Date	Sep 2025
Project Specifications	Single tower with Basement + 7Floors

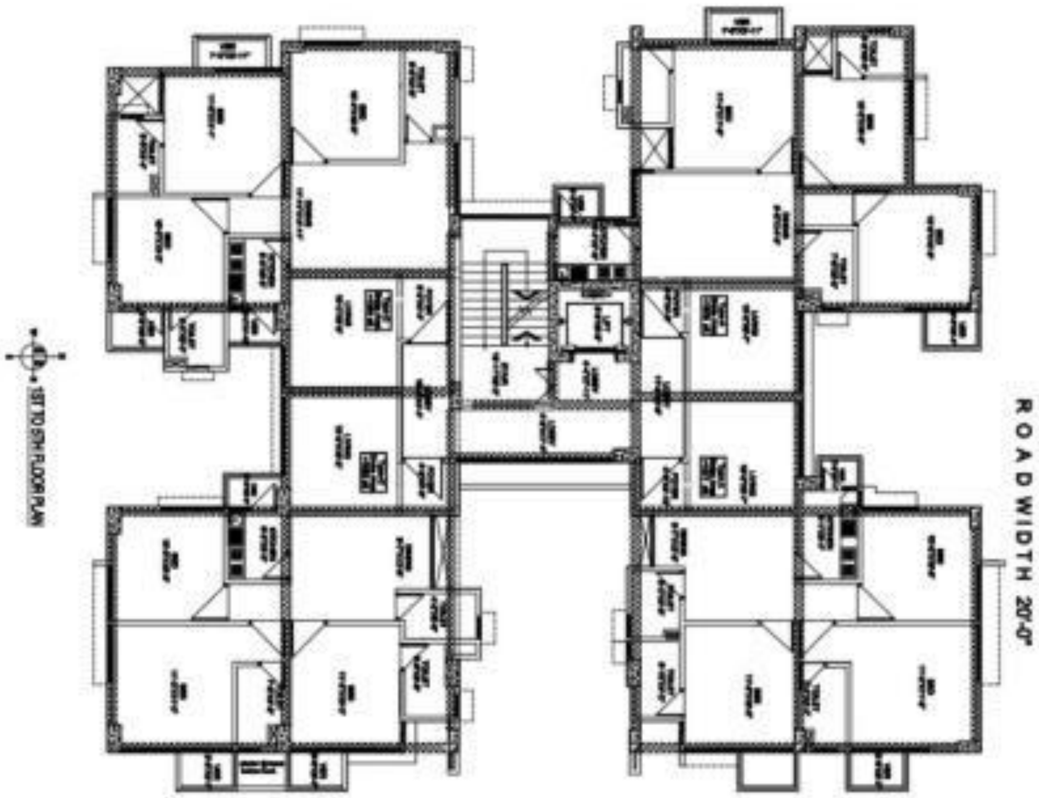

Figure 1. General Floor 2D plan of the building.

After allocating the resources, the software gives an overall cost estimate. The costs are allocated to each resource including the labor charge. These rates were obtained from the planning manager. Results of planning and scheduling for general project obtained from Bill of Quantities are, The project duration was estimated to be 483days and the cost of the project from foundation to finishing including labor charges was estimated to be Rs. 50,852,840.

Planning and Scheduling

The project duration was estimated to be 490 days, and the cost of the project from foundation to finishing, including labor charges, was estimated to be Rs. 53,983,850 when the planning and scheduling are done in accordance with the safety approach. But the project duration increased to 550 days, and the cost of the project from foundation to finishing, including labor charges, became Rs. 58,524,240.02, when the planning and scheduling were done without the safety approach. Table 3 shows the comparison of the cost and time of all three schedules.

Table 3 Table determining dependencies.

Task Name	Duration	Start	Finish	Predecessors
1st Floor	*20 days*	*Sat 21-03-23*	*Mon 13-04-23*	
Column Erection	10 days	Sat 21-03-23	Wed 01-04-23	31FS+2 days
Slab Shuttering	12 days	Wed 25-03-23	Tue 07-04-23	33SS+3 days
Reinforcement works	12 days	Fri 27-03-23	Thu 09-04-23	34SS+2 days
Services/MEP work	3 days	Thu 09-04-23	Sat 11-04-23	35FF+2 days
Concreting	3 days	Fri 10-04-23	Mon 13-04-23	36SS+1 day
Block Works	12 days	Fri 14-08-24	Thu 27-08-24	62
Door Frame	10 days	Sat 15-08-24	Wed 26-08-24	172SS+1 day
Window Frame	10 days	Sat 15-08-24	Wed 26-08-24	172SS+1 day
Electrical Conduits	7 days	Thu 03-09-24	Thu 10-09-24	172FS+5 days
Cement plastering (Kitchen and Bathroom)	3 days	Mon 14-09-24	Wed 16-09-24	175FS+2 days
Plumbing	12 days	Fri 25-09-24	Thu 08-10-24	176FS+7 days
Ceiling Putty	4 days	Thu 17-09-24	Mon 21-09-24	176
GVP	9 days	Tue 22-09-24	Thu 01-10-24	178
Waterproofing for bathroom and Balcony	6 days	Fri 02-10-24	Thu 08-10-24	179
Tile laying (Kitchen and	7 days	Mon 23-08-24	Mon 30-08-25	185SS+1 day
bathroom)				
Fire and Safety	12 days	Thu 24-09-24	Wed 07-10-25	179SS+2 days
Putty for walls	4 days	Thu 24-09-24	Mon 28-09-25	179SS+2 days
Painting	10 days	Fri 25-09-24	Tue 06-10-25	183SS+1 day
Floor Tiles	8 days	Sat 21-08-24	Mon 30-08-25	169FS+10 days
Doors and Windows installation	2 days	Tue 31-08-24	Wed 01-09-25	185
Plumbing Fittings	3 days	Tue 31-08-24	Thu 02-09-25	186FF+1 day

Accident schedule

The study and relevant research was done to accumulate data with respect to accidents occurring in the construction site. The data collected was revlant to activities of the general scdgule of the existing project. The data optioned was incorporated into the project schedule including the cost expense (Figure 5) caused due to the particular accident occurrence and the time delay due to the same. Also notes are added in the schedule to show the cause of the accident depending on the nature of accident occurred (Figure 6).

Safety schedule

The project schedule is updated with safety precautions and respective safety requirements for efficiently performing each activity of the project. The data collected for safety cost is done by detailed market research and the quantity of equipment required is estimated based on nature of work in the activity. The schedule is updated with the data. The time and cost of the overall project is presented.

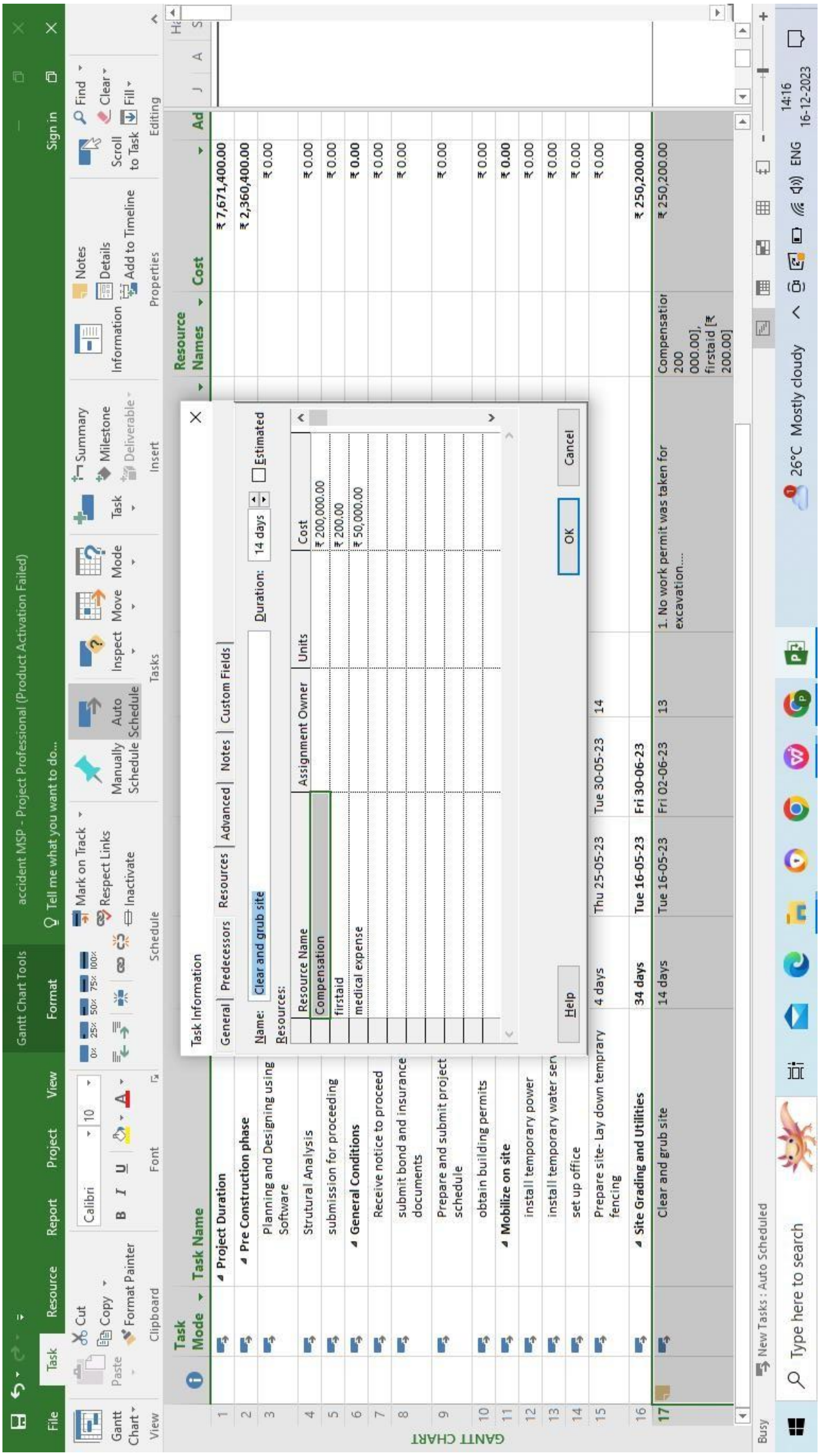

Figure 5. Expense breakup caused due to accident.

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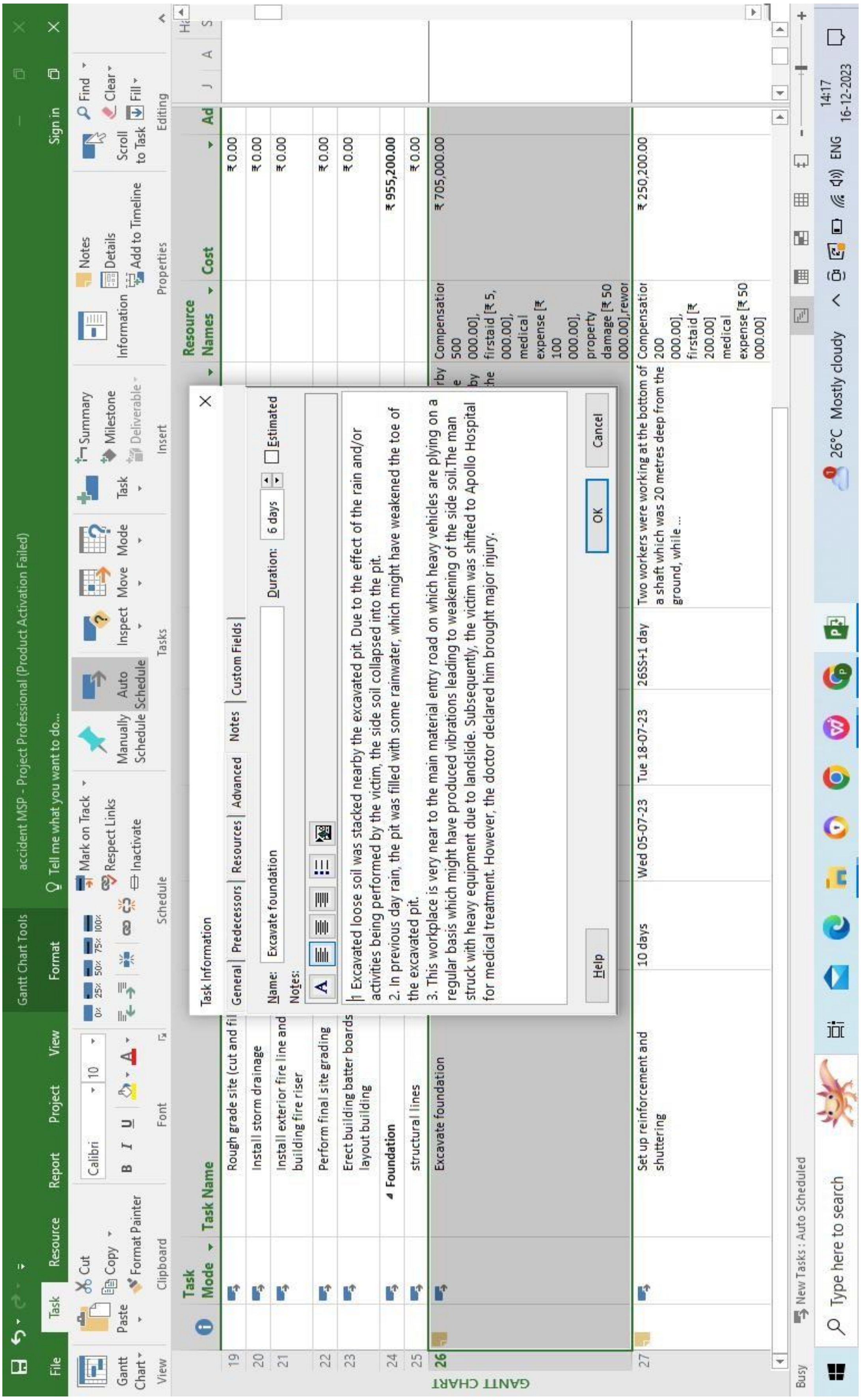

Figure 6. Notes showing the nature of accident.

Figure 7. Resource sheet of safety schedule.

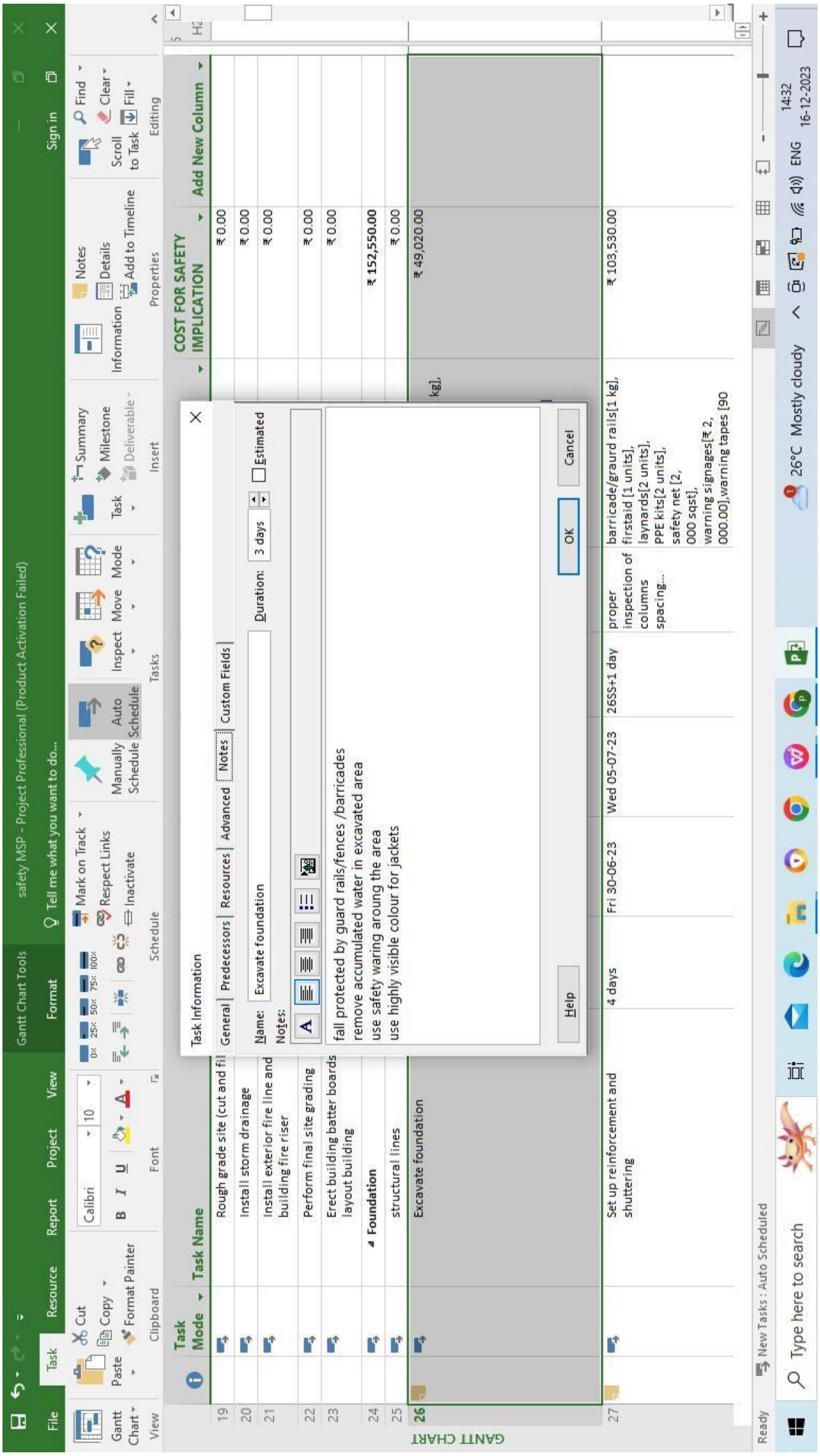

Figure 8. Safety precautions for an activity.

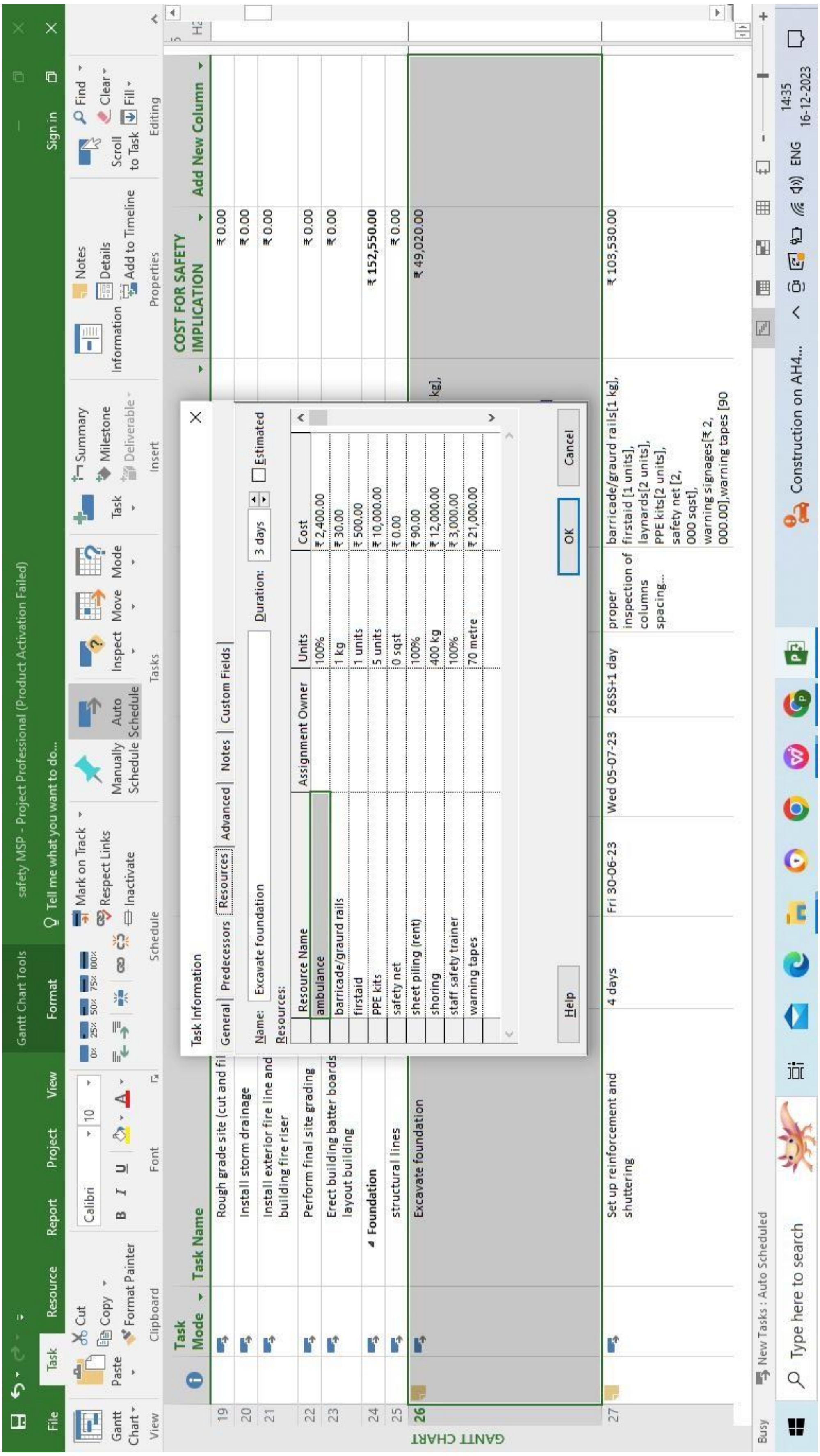

Figure 9. Resources required for precautionary measures.

Table 4. Comparison of all schedules.

Schedule Type	Cost	Time
General Schedule	Rs. 50,852,840.00	483 days
Safety Schedule	Rs. 53,983,850.00 (+31,31,010)	490 days(+7 days)
Accident Schedule	Rs. 58,524,240.02 (+76,71,400)	550 days (+67 days)

Graphical Representation

Figure 10. Shows the comparisons of all the schedules showing their respective overall cost, the graph shows the cost of project is majorly increased due to negligence in safety implementation. Figure 11, the graph shows the overall time needed for completion of the project. The overall time of project is increased due to occurrence of accidents and lost man hours which can be otherwise reduced if safety protocol is followed.

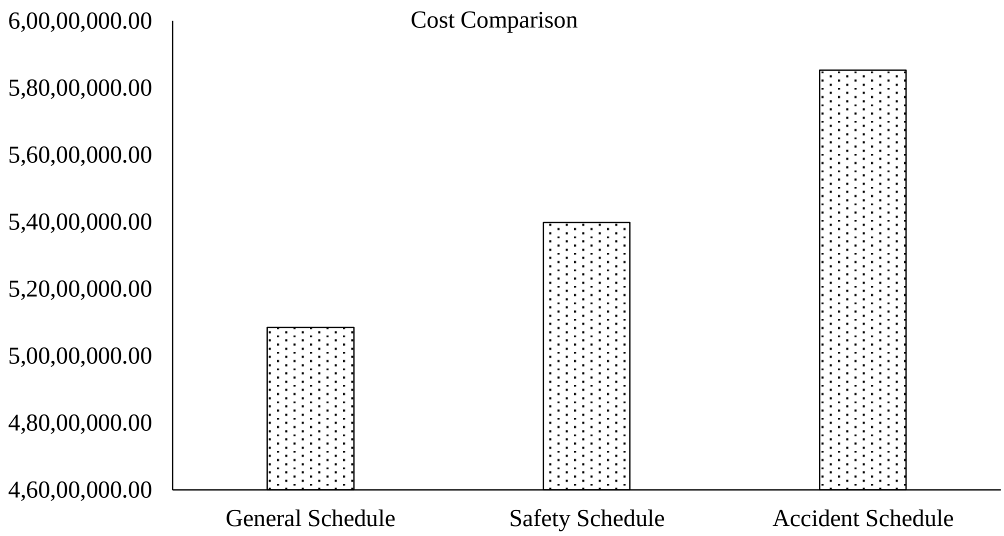

Figure 10. Comparison of Cost.

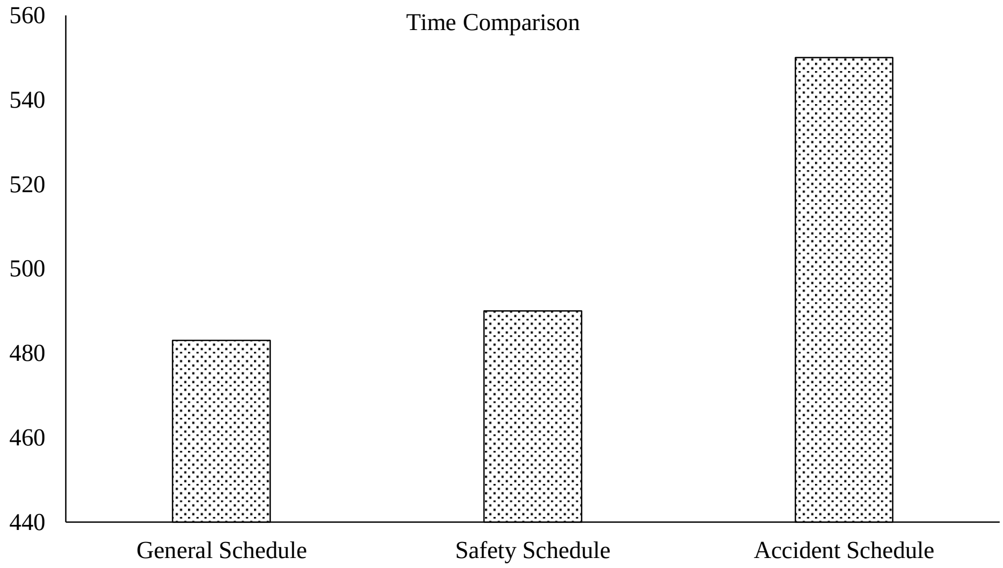

Figure 11. Comparison of Time.

RESULTS AND DISCUSSIONS

The graphs precisely show adoption of safety practices impacts the project time and cost in a positive way. It also proves project efficiency is improved due to minimization in major accidents and project delays. The research is limited to theoretical evaluation based purely on assumptions of accidents and its impact on time and cost. This result obtained by evaluating limited data.

Valuation of all the Results

The projects comparisons with general project schedule respectively, shows that the increment in time and cost of overall project is considerably minimal w.r.t safety schedule and majorly impacted in accident schedule. The evaluated date is shown in the table below. This positive result of the safety schedule is due to implementation of safety protocols reduces the cost expenditure that would have otherwise been caused by accident occurrence, the expense of precautionary measure is considerably low to cost of accident. Also the time is majorly saved by safety implications Table 1.

Table 5. Valuation of all the results.

	Cost	**Time**
Safety Schedule	6.15 %	7 days
Accident Occurring Schedule	15 %	67 days

CONCLUSIONS

In conclusion, this paper has laid the groundwork for a holistic understanding of safety's impact on high-rise construction projects. Through a theoretical framework grounded in diverse perspectives and the practical application of MS Project software, we've unveiled the intricate relationships between safety considerations, project management principles, and technological tools. As the construction industry advances, integrating safety seamlessly into the project life cycle emerges not only as a regulatory necessity but as a strategic imperative for fostering resilience, mitigating risks, and ensuring the success of high-rise endeavour. This research provides a stepping stone for future endeavour, urging stakeholders to embrace a unified approach that harmonies safety, technology, and construction excellence in the dynamic landscape of high-rise buildings.

The research can be further improvised by using the evaluated result and improvising with inclusion of advanced software like BIM. To arrive at a more precise and realistic result. By devolving a 4D-CAD model of the same project, it is possible to show how advanced technologies can be used to enhance safety of the construction site which completes the motivation of this research.

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