

Balcony Cage System (Prefabricated Cage System)

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Abstract—The Balcony Cage System is an innovative safety and working platform designed for high-rise construction projects. It provides a secure and efficient method for carrying out external façade works such as plastering, painting, and installation activities at elevated heights. The system consists of a cage-like structure attached to the building, allowing workers to operate safely without scaffolding or hanging platforms. It enhances productivity, reduces construction time, and ensures better safety compliance. The use of this system minimizes the risk of accidents and provides flexibility in accessing different floors. Overall, the balcony cage system is a modern, cost-effective, and safe alternative for vertical construction works

Index Terms—Cage System, safety, cost effective, Time saving

I. INTRODUCTION

In the modern era of high-rise construction, ensuring worker safety and maintaining productivity have become key challenges, especially during external façade works such as plastering, painting, window installation, and finishing. Traditionally, these tasks were carried out using scaffolding or suspended platforms, which often posed significant safety risks, required high maintenance, and involved considerable time for erection and dismantling. To overcome these challenges, the Balcony Cage System has emerged as an innovative and efficient solution.

The Balcony Cage System is a specially designed, enclosed working platform that can be securely attached to the balcony slab or floor edge of a high-rise building. It provides a safe, stable, and controlled working environment for workers operating at great heights. The system typically consists of a steel or aluminum frame with safety railings and protective mesh, allowing easy movement and tool handling while preventing accidental falls.

This system eliminates the dependency on traditional scaffolding structures and minimizes the risk of accidents caused by instability or human error. Its modular design allows quick installation and relocation from one floor to another using cranes or hoists, making it both time-saving and cost-effective. From a construction management perspective, the Balcony Cage System contributes to improved safety standards, faster project execution, and enhanced quality of external finishes. It also supports compliance with occupational safety regulations and reduces the overall environmental footprint by minimizing material usage compared to large-scale scaffolding setups.

As construction projects in urban areas continue to rise vertically, the demand for such efficient and safe systems is growing rapidly. The implementation of the Balcony Cage System not only ensures worker protection but also boosts site productivity and overall project efficiency, aligning with the modern principles of sustainable and safe construction practices.

II. LITRATURE REVIEW

Patil et al. (2021) studied the application of temporary working platforms in high-rise construction projects and reported that balcony cage systems improved worker safety and reduced plastering time by approximately 25%.

Sharma and Deshmukh (2022) analyzed safety performance during façade and external finishing works and concluded that balcony cage systems significantly reduce fall-related risks compared to conventional suspended scaffolding.

Kumar et al. (2023) evaluated the economic feasibility of balcony cage systems and found that their

reusability and reduced labor downtime resulted in project cost savings of up to 15%.

Singh et al. (2022) investigated edge protection systems in high-rise buildings and observed that steel cage systems provide better structural stability and worker protection than safety nets.

Rao and Patel (2023) examined the effectiveness of balcony cage systems during external finishing activities and reported improvements in productivity, safety compliance, and ease of material handling.

Verma et al. (2024) compared balcony cage systems with traditional safety net arrangements and concluded that cage systems offer superior protection against falls and falling objects while requiring less maintenance.

Joshi and Kulkarni (2024) studied the implementation of reusable balcony cage systems and found that repeated use across multiple floors reduced overall project safety expenditure.

III. METHODOLOGY

The study was conducted on a high-rise under-construction building where conventional safety nets were being used for balcony edge protection.

1. Site visits were carried out to observe existing safety practices, installation procedures, labor requirements, and operational challenges associated with safety nets.
2. A balcony cage system was designed using a steel frame and wire mesh to provide temporary edge protection during construction activities.
3. Data related to installation time, material cost, labor requirement, safety performance, and reusability were collected for both the balcony cage system and conventional safety nets.
4. A techno-economic comparison was performed based on parameters such as safety, durability, productivity, installation time, maintenance, and overall project cost.
5. Feedback was collected from site engineers, safety officers, and workers regarding the practicality and effectiveness of the balcony cage system.

6. The collected data were analyzed using comparative tables and percentage calculations to evaluate the advantages and limitations of the balcony cage system.

IV. ADVANTAGES

Provides enhanced safety by preventing workers from falling from balcony edges during construction activities.

Acts as a collective protection system, reducing dependence on personal protective equipment.

Prevents tools, materials, and debris from falling and causing accidents at lower levels.

Improves worker confidence and productivity while performing external finishing and plastering works.

Reusable for multiple floors, reducing overall project safety costs.

Offers greater durability and longer service life compared to conventional safety nets.

Requires less maintenance and inspection than safety net systems.

Reduces project delays caused by safety incidents and accidents.

Provides better stability and structural strength under site conditions.

Enhances compliance with construction safety regulations and standards.

Improves overall site safety performance and reduces accident-related expenses.

V. IMAGES



Fig..1 Images of Installed Balcony Cage system

VI. COMPARISON

Parameter	Traditional Safety Net	Balcony Cage System
Safety Level	Fall Arrest	Fall Prevention
Worker Protection	Moderate	High
Falling Object Protection	Limited	Excellent
Reusability	Limited	High
Service Life	2-5 Years	10-15 Years
Maintenance	High	Low
Initial Cost	Low	High
Long-Term Cost	High	Lower

Fig.2 Comparison

VII. SITE VISIT REPORT

1. Site Visit Report – Traditional Safety Net System

Project: Starlit

Location: Koregaon Park Pune

Date of Visit: 15/05/2026

Floor Observed: 12th Floor

Objective

To observe the installation and effectiveness of the traditional safety net system used for edge protection during construction activities.

Observations

Horizontal and vertical safety nets were installed along the balcony perimeter of the 12th floor.

The safety nets were fabricated from high-strength nylon rope and secured to the building structure using steel anchors.

The horizontal safety net was provided below the working area to arrest accidental falls and falling materials.

Vertical safety nets were installed along the outer edge to prevent workers and materials from falling outside the building.

The system provided basic fall protection; however, workers were still exposed to open-edge risks while performing external finishing works.

Periodic inspection and maintenance were required due to sagging and wear of the net material.

Findings

Easy and economical to install.

Provides fall-arrest protection rather than fall prevention.

Limited protection against falling tools and construction debris.

Requires frequent maintenance and replacement.

Conclusion

The traditional safety net system provides an economical safety solution for high-rise construction. However, it mainly acts as a fall-arrest system and offers limited protection against falling objects and edge-related hazards.

2. Site Visit Report – Balcony Cage System (BCS)

Project: Melliza Tower Pune

Location: Mundhwa Pune

Date of Visit: 20/05/2026

Floor Observed: 18th floor

Objective

To evaluate the performance and effectiveness of the Balcony Cage System (BCS) as an edge protection measure during construction activities.

Observations

A steel-framed Balcony Cage System with wire mesh panels was installed around the balcony perimeter.

The system provided a rigid physical barrier between workers and the open edge.

Workers were able to perform plastering, waterproofing, and external finishing activities safely within the protected area.

The mesh enclosure prevented tools, materials, and debris from falling to lower levels.

The system demonstrated good structural stability and required minimal maintenance.

The cages system was designed for reuse on multiple floors during project execution.

Findings

- Provides proactive fall prevention rather than fall arrest.
- Offers excellent protection against falling objects.
- Improves worker confidence and productivity.
- Durable, reusable, and cost-effective over multiple project cycles.
- Requires higher initial investment compared to traditional safety nets.

Conclusion

The Balcony Cage System (BCS) provides superior safety, stability, and protection compared to conventional safety nets. Although the initial installation cost is higher, its reusability, durability, and enhanced safety performance make it a suitable solution for high-rise under-construction buildings.

VIII. RESULT AND DISCUSSION

8.1. Results

Based on site observations conducted on the 12th floor of a high-rise under-construction building, the performance of the Traditional Safety Net System and Balcony Cage System (BCS) was evaluated.

Traditional Safety Net System

- Horizontal and vertical safety nets provided basic protection against accidental falls.
- The system acted as a fall-arrest measure rather than a fall-prevention system.
- Net sagging was observed at certain locations, requiring periodic maintenance.
- Limited protection was provided against falling tools and construction debris.
- Workers were required to exercise additional caution while working near balcony edges.

Balcony Cage System (BCS)

- The steel-framed cage created a complete physical barrier around the balcony edge.
- No direct exposure of workers to open edges was observed.
- Falling tools, materials, and debris were effectively contained within the protected area.
- Workers reported improved confidence and ease while performing external finishing activities.

- The system remained stable and required minimal maintenance during operation.

8.2. Discussion

The comparison indicates that the Balcony Cage System provides significantly higher safety performance than the traditional safety net system. While safety nets primarily reduce the severity of accidents after a fall occurs, the BCS prevents falls from occurring by eliminating direct access to hazardous edges.

The BCS also improves site housekeeping and safety by preventing falling objects, thereby reducing risks to workers operating on lower floors. Although the initial installation cost of the BCS is higher, its reusability and durability contribute to lower long-term costs.

From a productivity perspective, workers were able to perform balcony-related activities more efficiently within the protected environment provided by the cage system. Reduced safety concerns and improved accessibility contributed to smoother workflow and reduced work interruptions.

Overall, the findings demonstrate that the Balcony Cage System is a safer, more durable, and economically viable alternative to traditional horizontal and vertical safety nets for high-rise under-construction buildings.

8.3. Summary

The study concludes that the Balcony Cage System outperforms the traditional safety net system in terms of safety, productivity, durability, and long-term economic benefits. Therefore, BCS can be recommended as an effective edge protection solution for high-rise construction projects.

IX. CONCLUSION

The present study evaluated the performance of the Traditional Safety Net System and the Balcony Cage System (BCS) for edge protection in high-rise under-construction buildings. Based on site observations and comparative analysis, it was found that the Balcony Cage System provides a higher level of safety by preventing falls before they occur, whereas traditional safety nets mainly function as fall-arrest systems.

The BCS offers several advantages, including improved worker safety, protection against falling objects, better structural stability, increased

productivity, and reduced maintenance requirements. Although the initial installation cost of the Balcony Cage System is higher than that of conventional safety nets, its durability and reusability make it more economical over the project lifecycle.

The study also revealed that workers felt more secure while working within the protected environment created by the cage system, leading to improved efficiency during construction activities. Furthermore, the BCS contributes to better compliance with construction safety standards and reduces the risk of accident-related delays and losses.

Therefore, it can be concluded that the Balcony Cage System is a safer, more efficient, and economically beneficial alternative to traditional horizontal and vertical safety nets for high-rise construction projects. Its implementation can significantly enhance overall site safety and project performance.

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