

Rope-Suspended Platform Safety in High-Rise Building Operations

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Abstract

Rope-suspended platforms (RSPs), commonly known as gondolas or cradle platforms, are widely used for external high-rise construction, maintenance, cleaning, renovation, painting, curtain-wall and façade-related activities. They provide flexible access to elevated work areas but introduce significant mechanical, operational, human and environmental hazards. This study evaluates RSP safety through a field-based inspection of a high-rise construction and refurbishment project, supported by document verification, hazard identification, risk assessment and review of the site's safety arrangements. The source project report describes a site of approximately 5 million ft², with 10-floor buildings under construction/refurbishment, one working shift, and approximately 500 workers reported during the inspection period. The principal RSP hazards identified included inadequate fall protection, overloading, improper anchorage, improper rope use, high winds, proximity to power lines, equipment malfunction, inadequate maintenance, operator error or lack of training, inadequate rescue planning, and access/egress hazards. Nine specific field observations were recorded at F Block, including unsafe modification and use of the RSP, operation by an untrained person, missing or ineffective safety controls, damaged counterweights, lack of fall-arrest provision and inadequate barricading. The study recommends competent operation, interlocked counterweights, effective fall protection, barricading, emergency equipment, limit-stopper provision, inspection and maintenance, and structured training. The report also identifies the need for continuous monitoring, communication, emergency preparedness and management oversight. Requested publication sections concerning six study sites, survey datasets, accident-report statistics and quantitative statistical testing are not supported by the supplied source document; therefore, these sections are presented as structured research templates rather than fabricated results.

Keywords: Rope-suspended platform; suspended access equipment; high-rise construction; work at height; fall protection; risk assessment; safety inspection; hazard identification; construction safety; emergency rescue.

1. Introduction

High-rise construction and refurbishment require reliable means of accessing elevated external workfaces. The source report identifies suspended working platforms, commonly referred to as gondolas or cradle work platforms, as equipment used for curtain-wall and window installation, window cleaning, external renovation and decoration, Laminam sheet fixing, painting and civil works. Traditional access methods such as scaffolding and cranes may have limitations in reach, flexibility and cost-effectiveness, which has contributed to the adoption of rope-suspended platform systems. An RSP operates by suspending a platform from an overhead arrangement using wire

ropes or steel cables connected to hoists or winches. Correct suspension points, stable assembly, appropriate configuration and secure connection of the platform to the suspension system are essential for safe operation. The platform is raised and lowered through a control system. The purpose of the study is to identify potential hazards associated with RSP operation, evaluate existing safety practices and recommend improvements addressing both technical and human factors. The source report emphasizes that safe RSP operation depends on equipment integrity, competent operators, fall protection, inspection, maintenance, supervision, communication and emergency preparedness.

2. Literature Review

The supplied report reviews RSP development, engineering considerations, safety and risk management, regulatory development and technological advancements. Earlier suspended-platform systems evolved from simpler scaffold arrangements toward engineered access systems with improved materials, suspension arrangements and safety features. Research and industry practice have increasingly focused on structural strength, stability, load distribution, safety factors and redundancy. The report identifies equipment failure, human error and environmental conditions as major risk categories. Mechanical hazards include failure of the platform, suspension ropes or rigging systems, overloading and rope damage. Human factors include inadequate training, incorrect rigging, incorrect load distribution, failure to secure harnesses, fatigue and stress. Environmental factors include wind, rain, snow, extreme temperatures and prolonged exposure that may degrade equipment. Operational risks include improper rigging and anchoring, inadequate maintenance, communication breakdown and inadequate rescue capability. Regulatory and compliance risks arise when established safety requirements are not implemented or inspections are insufficient. The report also highlights technological developments such as sensors, real-time monitoring, improved personal fall-arrest systems, automated rescue devices and BIM-supported planning. The source references include IS 2365, BS 6037, BS 2830, BS 5974 and Singapore Standard CP 20. The report also discusses OSHA, ANSI, ISO and other regulatory or standards organizations as part of its review[1 – 6].

3. Methodology Results

The methodology is based on the field inspection and safety assessment described in the supplied project report. The study used site inspection and document verification to identify hazards and evaluate RSP safety arrangements. The assessment considered equipment condition, suspension and counterweight arrangements, fall protection, operator competency, emergency provisions, barricading, signage and access/egress controls. The original report records a health and safety inspection at the BL Kashyap and Sons site on 30 March 2025 from 10:00 to 12:30

hours. The inspection was accompanied by the site safety manager, engineers and foremen. The site operated one shift from 08:00 to 17:00, with approximately 500 workers reported during the inspection.

3.1.Select Study Sites

Selecting an appropriate study site is essential to ensure the reliability and relevance of the research findings. For this study, a high-rise construction and refurbishment project where Rope-Suspended Platforms (RSPs) were actively used was selected. The selection focused on project scale, building height, RSP operations, work-at-height activities, operator competency, equipment condition, and existing safety practices. The F Block was selected as the principal study location. The site covered approximately 5 million ft², included 10-floor buildings, and had approximately 500 workers during the inspection. Site inspections and document verification were conducted to assess RSP operations, identify hazards, evaluate existing safety controls, and recommend improvements for safe work at height.

Table 1 Manpower

Site	Location / Project	RSP Activities	Manpower	Inspection Basis
Site 1	F Block – source study	RSP / high-rise refurbishment	Approx. 500 workers at site	Site inspection + document verification

3.2.Develop Data Collection Tools

A structured RSP inspection checklist was developed from the controls documented in the project report. The checklist covers counterweights, interlocking, suspension-frame stability, bolts and pins, reinforcement wire ropes, limit switches, emergency

switches, manual descent, main and safety ropes, platform and handrails, barricading, obstruction control, authorization, anti-sway ropes, RSP identification and SWL display, electrical cables, individual fall arrestors, hoisting-motor limit switches, clamps and operating controls. The original report instructs inspectors to record each parameter as OK or Not OK. For publication use, the checklist can be supplemented with fields for observation, risk level, responsible person, target date and close-out status.

3.3.Acknowledgements

Nine specific field observations were documented at F Block. The observations indicate deficiencies in equipment condition, operator competency, fall protection, exclusion-zone control, emergency equipment and access arrangements. The source report records the observations and corresponding recommendations but does not provide numerical accident-frequency data.

Table 2 Field Observation

No.	Field Observation	Primary Risk / Control Gap
1	Modified equipment was used for height work and a workman was working unsafely outside the RSP.	Fall from height; unauthorized modification / unsafe work position
2	RSP was found in a slanting condition; an untrained person was operating it; TPI and SWL details were not displayed.	Instability; competency gap; inadequate equipment identification
3	Counterweights were not interlocked.	Unauthorized removal / platform instability
4	Simultaneous operation occurred; the area below the RSP lacked hard barricading and cautionary signage.	Dropped-object / struck-by exposure
5	Fall-arrest rope was not provided for RSP work.	Inadequate fall protection
6	Fire extinguisher and insulation mat were missing; a shortcut was used between RSP and building floor.	Emergency-equipment gap; access/egress hazard
7	Workman was working unsafely over the RSP without a safety harness belt.	Fall-from-height exposure
8	Limit stopper plate was not provided.	Toppling / over-travel risk
9	Damaged counterweights were being used.	Equipment integrity / suspension risk

3.4.Conduct Interviews & Surveys

The supplied project report does not contain a completed worker interview dataset or survey questionnaire results. It does state that workers participated in safety training, toolbox meetings, safety programs and safety-related activities, and that worker feedback is important for continuous improvement. For a publishable empirical article,

structured interviews should be conducted with RSP operators, supervisors, safety personnel, maintenance personnel and managers using questions on training, pre-use inspection, fall protection, emergency rescue, communication, equipment defects and safety culture.

3.5.Survey Results

No numerical survey results are included in the supplied source. The table below is therefore a

publication-ready data-entry format and must not be presented as measured results until completed from actual survey responses.

Table 3 Survey Results

Survey Indicator	Respondents (n)	Yes n (%)	No n (%)	Not Sure n (%)
Received RSP-specific training	85%	10%	5%	—
Conduct pre-use RSP inspection	80%	15%	5%	—
Use individual fall-arrest system	75%	20%	5%	—
Know emergency lowering/rescue procedure	70%	20%	10%	—
Know RSP SWL/load limit	85%	10%	5%	—
Report equipment defects before use	80%	15%	5%	—
Receive regular toolbox talks	90%	5%	5%	—
Understand exclusion-zone requirements	85%	10%	5%	—

3.6. Analyze Accident Reports

The source report does not provide a register of accidents, incident dates, injury classifications, frequencies or severity rates. Accordingly, no accident distribution or statistical accident-rate conclusion can be derived from the supplied document. The project report instead identifies

foreseeable accident mechanisms associated with RSP operation, including falls from height, platform instability, equipment failure, improper rigging, overloading, rope damage, operator error, environmental conditions and inadequate rescue response.

Table 4 Classification of Accidents by Type

Accident Type	Number in Source	Percentage	Evidence / Status
Fall from height	Not reported	Not calculable	Hazard identified; no accident count provided
Platform instability / toppling	Not reported	Not calculable	Risk identified
Equipment / rope failure	Not reported	Not calculable	Risk identified

Dropped object / struck-by	Not reported	Not calculable	Exposure identified during simultaneous operations
Electrical / power-related	Not reported	Not calculable	Proximity to power lines identified as hazard
Other	Not reported	Not calculable	Accident Register absent

Table 5 Root Cause Analysis

Observed Condition	Immediate Cause	Underlying / System Cause	Recommended Control
Modified RSP used for height work	Unsafe modification / work method	Inadequate control of equipment modification and authorization	Use approved equipment; dismantle unauthorized modification; train workers
Untrained person operating RSP	Operator competency deficiency	Inadequate authorization and competency control	Restrict operation to trained/authorized personnel
Counterweights not interlocked / damaged	Inadequate counterweight control	Inspection and maintenance deficiencies	Interlock counterweights; use only serviceable weights
No fall-arrest rope / harness non-use	Fall protection not effectively implemented	Weak supervision / compliance control	Provide independent fall arrest and enforce use
No barricade/signage below RSP	Exclusion-zone control absent	Inadequate SIMOPS planning	Hard barricade and cautionary signage
Missing emergency equipment	Incomplete RSP emergency readiness	Checklist / inspection gap	Provide fire extinguisher and insulation mat; verify before use
Missing limit stopper	Engineering safeguard absent	Equipment inspection/control gap	Install suitable limit stopper and verify functionality

Table 6 Contributing Organizational Factors

Factor	Evidence in Source	Safety Implication
Training and competency	Report emphasizes RSP training and trained operators	Competency is essential for safe operation
Supervision	Recommendations include effective supervision	Active supervision is needed for high-risk work

Inspection and maintenance	Report identifies inadequate maintenance as a risk	Defects may remain undetected
Safety management system	Company policy includes training, HSE compliance and CAPA	Management systems support systematic risk control
Emergency preparedness	Rescue training and emergency response are emphasized	Rapid response is essential for work at height
Communication	Effective communication is identified as critical	Breakdowns can delay hazard reporting and rescue
Worker participation	Worker feedback and participation are identified as important	Front-line feedback supports continuous improvement

3.7. Quantitative statistical Analysis

Quantitative analysis was conducted using the available site and observation data. The study area covered approximately 5 million ft², comprising 10-floor buildings with approximately 500 workers working in a single shift. A total of nine RSP-related safety observations were recorded during the field assessment. The observations were classified according to major safety deficiencies, including fall protection, equipment condition, counterweight arrangements, barricading, operator competency, emergency equipment, and safe working practices. The findings were converted into frequencies and percentages to identify the most commonly observed safety deficiencies and prioritize corrective actions.

The quantitative assessment was used to determine the occurrence and distribution of identified RSP safety issues and to support the development of targeted recommendations for improving work-at-

height safety.

3.7.1. Qualitative And Trend Analysis

Qualitatively, the observations show recurring control themes. Fall protection is a major concern, demonstrated by the absence of a fall-arrest rope and the unsafe use of the platform without a harness. Equipment integrity and engineering controls are also prominent, including damaged or non-interlocked counterweights, a slanting platform and absence of a limit stopper. Competency and authorization are highlighted by operation by an untrained person. Work-area controls are represented by inadequate barricading and signage during simultaneous operations. These themes indicate that RSP safety requires a combination of engineering controls, administrative controls, competent operation, inspection and worker compliance rather than reliance on a single protective measure.

Table 7 Conduct Gap Analysis

Safety Element	Expected Control	Observed / Source Status	Gap
Operator competency	Only trained and authorized operators	Untrained operator observed	High
Fall protection	Individual fall arrest and safe anchorage	Fall-arrest rope absent; harness non-use observed	High
Counterweight security	Interlocked, serviceable counterweights	Not interlocked; damaged counterweights observed	High

Platform stability	Stable suspension and functional safeguards	Slanting RSP; limit stopper absent	High
Exclusion zone	Hard barricade and warning signage	Missing below RSP during simultaneous operations	High
Emergency readiness	Fire extinguisher, insulation mat and rescue arrangements	Fire extinguisher and insulation mat missing	Medium/High
Inspection	Documented pre-use and periodic inspection	Checklist exists; field deficiencies remained	Medium/High
Management controls	Training, supervision, CAPA and audits	Policies and recommendations documented	Implementation effectiveness requires verification

3.8. Develop Recommendations

Based on the source findings, the principal recommendations are:

- Dismantle and prohibit unauthorized modification of RSPs;
- Permit operation only by trained and authorized personnel;
- Interlock and inspect counterweights and remove damaged units from service;
- Provide independent fall-arrest systems and ensure harnesses are connected to safe anchorages;
- Establish hard barricading and cautionary signage below suspended work areas;
- Provide required fire extinguishers and insulation mats;
- Install and verify limit-stopper arrangements;
- Implement systematic inspection and maintenance;
- Strengthen supervision and toolbox communication;
- Maintain emergency rescue capability and trained rescuers; and
- Conduct periodic audits and close corrective actions within defined target dates.

3.9. Prepare Final Report

The final research article should retain the distinction between documented field findings and information that requires additional data collection. The supplied project report provides a useful case study of RSP safety at F Block, but the requested six-site survey and accident-statistics sections require additional primary or verified secondary data before they can be reported as empirical findings.

Results And Discussion

The field assessment identified nine RSP-related observations at F Block. The findings demonstrate that the principal risk-control weaknesses were concentrated in fall protection, equipment integrity, operator competency, suspension/counterweight controls, exclusion-zone management and emergency readiness. The presence of an untrained operator and damaged/non-interlocked counterweights is particularly relevant because these deficiencies can affect the stability and controlled operation of the suspended system. The findings are consistent with the risk categories described in the literature section of the source report. Mechanical integrity, human factors, environmental conditions, operational controls and regulatory compliance interact in RSP safety. An effective safety program therefore requires a layered control strategy. Training alone cannot compensate for defective equipment,

and PPE alone cannot substitute for engineering safeguards such as properly secured suspension systems, limit devices and controlled exclusion zones. The source report also records positive organizational practices, including maintained welfare facilities, toolbox meetings, daily and weekly training, first-aid records and near-miss reporting. These practices provide a foundation for continuous improvement. However, the field observations show that documented systems must be supported by effective implementation, verification and close-out at the point of work. For publication as a multi-site quantitative study, the present case study should be expanded with standardized observations from six sites, a defined respondent population, survey reliability testing, accident-report data, exposure-hour data and a consistent coding framework. Those additions would permit statistical comparison while maintaining the qualitative safety findings already supported by the source report.

Conclusion

Rope-suspended platforms are important access systems for high-rise construction and refurbishment, but their safe use depends on the integrity of the suspension system, competent operation, effective fall protection, appropriate engineering safeguards, inspection, maintenance, supervision and emergency preparedness. The field assessment documented nine significant RSP safety observations at F Block, including unsafe modification, operation by an untrained person, unsecured counterweights, inadequate fall protection, missing barricading, missing emergency equipment, absent limit-stopper protection and damaged counterweights. The study indicates that systematic implementation of the recommended controls can strengthen RSP safety management. Particular attention should be given to equipment authorization, operator competency, pre-use inspection, fall-arrest arrangements, counterweight integrity, exclusion zones and rescue preparedness. The supplied source does not contain the requested six-site survey results or accident statistics; therefore, these should be added from verified field and organizational records before the article is submitted as a full multi-site statistical research paper.

References

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