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# Operational and Mechanical Risk Management in Automotive Showroom Facilities

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## Abstract

Automotive showroom facilities are commonly operated as commercial retail environments despite involving several operational and mechanical conditions associated with light industrial facilities. The presence of heavy vehicle loading, confined vehicle movement, hydraulic lifting systems, and flammable detailing chemicals introduces risks that are often insufficiently addressed through conventional commercial safety practices. This study investigates operational and mechanical risks in small-to-medium automotive showroom facilities located in the Pune metropolitan region. Risk identification was conducted through structured facility walkthroughs and zone-based observation across six dealership sites. A 5×5 Risk Matrix and an adapted Failure Mode and Effects Analysis (FMEA) framework were used to prioritise identified hazards. SolidWorks-based layout modelling was additionally employed to evaluate showroom floor slab loading under different vehicle display configurations. The analysis identified floor slab overloading from clustered SUV displays, vehicle-pedestrian interaction during manoeuvring operations, solvent vapour accumulation in detailing bays, and hydraulic ramp failure modes as major operational concerns. The findings indicate that relatively practical engineering controls, including layout optimisation, pedestrian segregation, preventive inspection practices, and controlled chemical storage, can significantly improve operational safety within dealership environments. The study highlights the need for structured facility-level risk management approaches in automotive showroom operations and demonstrates the applicability of engineering risk assessment methods within this sector.

**Keywords**: Automotive showroom safety, Facility risk management, FMEA, Structural loading, Hydraulic ramp safety, Chemical hazard management, Risk assessment.

## 1. Introduction

A fully loaded Mahindra XUV700 weighs approximately 2,185 kg at kerb weight. A Toyota Fortuner weighs around 2,270 kg, while a Mercedes-Benz GLS 450 can exceed 2,485 kg. These are not abstract numbers. When multiple heavy SUVs are positioned together on a showroom floor designed primarily for standard commercial occupancy loading under IS 456:2000 [1], the actual imposed loading may exceed the intended design assumptions of the slab. In many dealership facilities, neither showroom managers nor architects formally evaluate this risk during routine operations.

The automotive retail sector in India has expanded rapidly over the past decade, particularly in urban regions such as Pune, Mumbai, Bengaluru, and Hyderabad. Pune alone hosts a large number of passenger vehicle dealerships ranging from premium OEM-backed facilities to compact single-brand outlets operating from commercial ground-floor spaces. While the size and layout of these facilities vary considerably, most operate without a structured facility-level risk management framework.

Unlike manufacturing plants, automotive showrooms are generally classified as commercial spaces rather than industrial facilities. As a result, several operational hazards associated with vehicle movement, floor loading, chemical storage, and service transition activities remain insufficiently addressed under conventional commercial occupancy standards [2]. Detailing bays routinely use flammable solvents, aerosol coatings, and cleaning compounds governed under hazardous material handling provisions [3], while service transition areas involve vehicle lifting systems, inspection pits, and hydraulic equipment.

This paper does not focus on vehicle safety in road environments. Instead, it examines operational and mechanical risks within automotive showroom facilities themselves, including structural loading, pedestrian-vehicle interaction, hazardous chemical storage, and service-area failure modes. The study applies a structured risk assessment methodology using a 5×5 Risk Matrix and an adapted Failure Mode and Effects Analysis (FMEA) framework based on established risk management principles [4][5].

The objective of this work is to identify the principal operational and mechanical risks present in small-to-medium automotive showroom facilities and propose practical engineering controls that can improve safety, reliability, and facility risk management practices.

## 2. Problem Statement

Manufacturing facilities in India generally operate under established safety and operational standards through frameworks such as the Factories Act, 1948, the National Building Code (NBC) 2016, and various Bureau of Indian Standards (BIS) safety guidelines [2]. Automotive manufacturing plants, in particular, follow strict OEM-mandated protocols related to floor load capacity, hazardous material storage, pedestrian movement, fire safety, and equipment inspection.

Automotive dealerships, however, occupy a unique middle ground between commercial retail spaces and light industrial facilities. Although these facilities regularly accommodate vehicles weighing over 2 tonnes, detailing chemicals, hydraulic lifting systems, and confined vehicle movement corridors, there is currently no dedicated mandatory risk-management framework specifically designed for automotive showroom operations in India.

As a result, many small-to-medium dealership facilities rely primarily on informal operational practices rather than structured engineering controls. Common examples include verbal instructions during vehicle movement, temporary storage arrangements for flammable detailing chemicals, and the absence of periodic structural inspections for showroom floor slabs. In several facilities, customer movement areas and vehicle manoeuvring paths overlap directly, increasing the possibility of collision-related incidents.

The lack of documented facility-level risk assessment creates uncertainty regarding the structural, operational, and safety performance of these environments. Risks associated with floor slab overloading, solvent vapour accumulation, hydraulic ramp failure, and pedestrian exposure are often managed reactively rather than through preventive engineering analysis.

Accordingly, this study seeks to address the following research question:

*"What are the major operational and mechanical risks present in small-to-medium automotive showroom facilities, how significant are these risks, and what practical engineering controls can be implemented to reduce them effectively?"*

## 3. Literature Review

ISO 31000:2018 provides a widely accepted framework for organisational risk management by establishing principles, processes, and guidelines applicable across different sectors and operational environments [4]. The framework offers a systematic approach for identifying, evaluating, and controlling risks. However, ISO 31000 is intentionally generic in nature and does not specifically address mechanical, structural, or operational hazards associated with automotive showroom facilities.

For process-level hazard identification, Failure Mode and Effects Analysis (FMEA) remains one of the most widely adopted engineering risk assessment tools. Originally developed for aerospace and defence applications under MIL-P-1629 standards [5], FMEA has since been adapted for manufacturing systems, maintenance operations, facility management, and industrial process safety. The methodology is particularly useful for analysing operational failure modes, evaluating their effects, and prioritising corrective actions using Severity, Occurrence, and Detectability parameters.

Structural safety considerations relevant to showroom facilities are governed primarily through IS 456:2000, which defines design and loading requirements for reinforced concrete structures [1]. Commercial floor slabs are generally designed based on standard occupancy load assumptions; however, concentrated vehicle loading generated by modern SUVs and premium vehicles may create localised stresses significantly higher than conventional commercial loading expectations. Recent increases in average passenger vehicle weight have further intensified this concern in dealership facilities.

Chemical handling and storage practices within detailing and service zones introduce additional operational risks. Products such as thinners, aerosol coatings, solvent-based cleaners, and polishing compounds are classified as flammable materials under hazardous substance handling regulations [3]. International safety standards such as OSHA Process Safety Management guidelines and NFPA 30 also provide reference frameworks for storage and handling of combustible liquids in enclosed operational spaces [6][7].

Previous studies related to automotive facility safety remain comparatively limited. Gupta and Rao [8] investigated fire hazards in automotive workshop facilities and observed inadequate storage practices for flammable compounds in a majority of surveyed locations. Malhotra et al. [9] examined structural loading concerns associated with heavier vehicle categories in commercial facilities across Indian urban regions. However, existing literature addressing integrated operational, structural, and mechanical risk management specifically within automotive showroom facilities remains sparse.

The present study attempts to bridge this gap by combining facility observation, structural loading assessment, risk matrix evaluation, and FMEA-based analysis within the context of automotive showroom operations.

# 4. Methodology

## 4.1. Study Sites and Observation Protocol

Six automotive showroom facilities located within the Pune metropolitan region were selected for observational assessment between January and March 2024. Selection criteria included:

a) Single-storey ground-floor facility configuration,

b) Sales floor area ranging from approximately 400 m² to 1,200 m², and

c) The presence of at least one detailing or Pre-Delivery Inspection (PDI) bay integrated within the facility.

The selected facilities included three passenger vehicle dealerships, one used-vehicle outlet, and two multi-brand service and display centres. None of the observed facilities maintained a documented facility-level operational risk management plan, and no recent structural load assessment records were available during the study period.

Structured walkthrough inspections were conducted using a zone-based observation checklist developed specifically for this work. For systematic risk identification, each showroom was divided into four operational zones:

- Public vehicle display floor.
- Vehicle entry and manoeuvring corridor.
- Detailing and PDI bay.
- Service transition and inspection area.

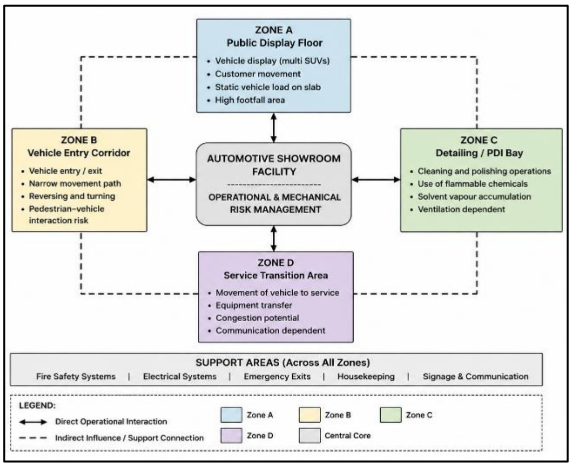


***Figure 1:*** *Block diagram of operational zones and risk interaction pathways considered for facility-level risk assessment in automotive showroom environments.*

Each zone was evaluated against predefined hazard categories including structural loading, pedestrian-vehicle interaction, hazardous chemical handling, ignition sources, ventilation adequacy, and emergency access obstruction.

## 4.2. Risk Matrix Construction

A 5×5 Risk Matrix approach was adopted to prioritise identified hazards based on Likelihood and Impact ratings [4]. Likelihood was classified on a scale from 1 to 5, where 1 represented “Rare” occurrence and 5 represented “Almost Certain” occurrence. Impact severity was similarly rated from 1 (“Negligible”) to 5 (“Catastrophic”).

The final Risk Score was calculated using:

$$L \times I = Risk\ Score$$

where:

$$L = Likelihood\ rating$$
$$I = Impact\ rating$$

The resulting scores were grouped into the following categories:

- $Low\ Risk$: $1 - 4$
- $Low - Medium\ Risk$: $5 - 8$
- $Medium\ Risk$: $9 - 12$
- $High\ Risk$: $13 - 19$
- $Critical\ Risk$: $20 - 25$

***Table 1:*** *5×5 Risk Matrix Used for Hazard Prioritisation*

| Likelihood \ Impact | 1 Negligible | 2 Minor | 3 Moderate | 4 Major | 5 Catastrophic |
|---|---|---|---|---|---|
| 5 Almost Certain | 5 | 10 | 15 | 20 | 25 |
| 4 Likely | 4 | 8 | 12 | 16 | 20 |
| 3 Possible | 3 | 6 | 9 | 12 | 15 |
| 2 Unlikely | 2 | 4 | 6 | 8 | 10 |
| 1 Rare | 1 | 2 | 3 | 4 | 5 |

***Risk Classification:*** *Low (1–4), Low-Medium (5–8), Medium (9–12), High (13–19), Critical (20–25).*

Impact evaluation considered three primary consequence dimensions:

- Personnel injury or fatality.
- Structural or equipment damage.
- Regulatory or operational impact.

The highest observed consequence category was used as the final Impact rating for each identified hazard.

## 4.3. SolidWorks Layout Modelling

To evaluate structural loading conditions, one representative showroom facility (Site 3) was modelled using SolidWorks 2023 simulation tools. The selected facility consisted of an approximately 780 m² premium-segment showroom located in Pune.

The floor slab was modelled as a reinforced concrete plate element using material properties corresponding to M25-grade concrete as specified in IS 456:2000 [1]. Vehicle loads were applied as distributed pressure loads over tyre contact patch regions based on measured tyre dimensions from the heaviest display vehicle observed during the study.

The analysis compared the existing vehicle display arrangement against modified layout configurations generated by altering inter-vehicle spacing and cluster orientation. The purpose of the simulation was not to perform full structural certification, but rather to evaluate how showroom layout planning influences peak slab stress distribution and localised loading intensity. The simulation results presented in this study are intended for comparative risk assessment purposes only and should not be interpreted as certified structural design validation or replacement for a professional structural audit.

## 4.4. FMEA Application

A facility-oriented Failure Mode and Effects Analysis (FMEA) framework was adapted for showroom risk assessment [5]. In this approach, each operational zone was treated as a functional process area, while activities such as vehicle movement, chemical handling, customer circulation, and hydraulic lifting operations were considered operational functions.

Potential failure modes were identified for each activity and evaluated using three parameters:

- $Severity\ (S)$
- $Occurrence\ (O)$
- $Detectability\ (D)$

Each parameter was rated on a scale of 1–10, and the Risk Priority Number (RPN) was calculated using:

$$RPN = S \times O \times D$$

The FMEA results were subsequently compared with the 5×5 Risk Matrix rankings to ensure consistency in hazard prioritisation and recommended control measures.

 

## 5. Risk Identification

### 5.1. Zone A: Public Display Floor – Static Load Distribution

The most significant structural risk identified during the study was floor slab overloading caused by the clustering of heavy SUV vehicles within the showroom display area. Over the last decade, average passenger vehicle weight has increased considerably due to the growing market preference for SUVs and premium utility vehicles. Across the six observed facilities, the average displayed vehicle weight was estimated at approximately 1,847 kg, considerably higher than typical showroom loading conditions considered in older commercial floor designs.

The primary concern is not the load from an individual vehicle, but the combined static loading effect created when multiple heavy vehicles are positioned within a limited floor area. In premium segment showrooms, vehicles are often grouped closely together for visual presentation, resulting in concentrated loading conditions over specific slab regions.

A representative vehicle cluster consisting of three large SUVs positioned within an approximately 6 m × 5 m display region generated an estimated combined static load exceeding 6,500 kg. The corresponding distributed loading intensity was significantly higher than the standard commercial occupancy loading values commonly adopted for showroom floor slabs under IS 456:2000 provisions [1].

To evaluate this condition, the floor layout of Site 3 was analysed using SolidWorks Simulation. The baseline showroom arrangement produced elevated principal stress concentrations within slab regions located beneath the vehicle cluster. Alternative layout configurations were then evaluated by increasing inter-vehicle spacing and modifying cluster orientation relative to the primary beam direction. The revised arrangement demonstrated a measurable reduction in peak stress concentration levels, indicating that showroom layout planning can significantly influence structural loading behaviour.

Figure 2 presents a simplified conceptual representation of the comparative slab-loading assessment performed during the study. The illustration highlights the concentration of localised stress regions generated beneath clustered heavy SUV display configurations. The analysis further indicated that increased inter-vehicle spacing and improved layout distribution can contribute to reduction of peak localised slab stress concentrations within showroom floor regions.

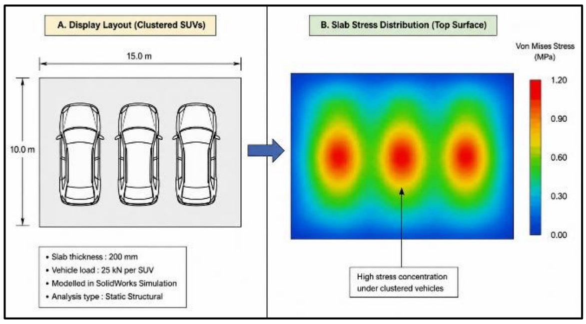


***Figure 2:** Schematic representation of showroom floor slab loading and indicative stress distribution under clustered SUV display conditions using SolidWorks-based simulation analysis.*

Although the present analysis does not replace a formal structural audit, the results indicate that dealership facilities displaying heavy SUV clusters should periodically evaluate slab loading conditions, especially in older commercial buildings not originally designed for concentrated automotive loading.

$$\textbf{\textit{Risk Score}}: Likelihood = 4, Impact = 5$$

$$\textbf{\textit{Final Risk Rating}}: 20\ (Critical)$$

### 5.2. Zone B: Vehicle Entry and Manoeuvring Corridor - Kinetic Risk

The movement of vehicles within confined showroom spaces creates a significant operational safety risk, particularly in areas where customer movement overlaps with vehicle entry or repositioning paths. Although showroom vehicles generally move at low speeds, the combination of high vehicle mass, restricted manoeuvring space, and pedestrian presence increases the severity of potential collision incidents.

During the observational study, five out of the six facilities did not maintain any physical separation between customer circulation areas and vehicle movement corridors. In several locations, vehicles entering or exiting the showroom shared the same pathway routinely used by customers, sales personnel, and support staff.

The risk becomes more critical during reversing operations associated with vehicle repositioning, delivery handovers, or movement between the showroom and service areas. Large SUVs and premium vehicles often have restricted rearward visibility despite the presence of parking sensors and camera systems. In enclosed indoor environments, sensor warning sounds may be partially masked by ambient noise levels, increasing the possibility of driver blind spots during low-speed manoeuvring.

Measurements taken during the walkthrough inspections indicated that several vehicle movement corridors provided limited lateral clearance relative to vehicle width. In some facilities, the available side clearance between the moving vehicle and adjacent pedestrian zones was observed to be less than standard recommended operational spacing for safe vehicle circulation [10].

None of the surveyed facilities maintained a formal pedestrian exclusion protocol during vehicle movement activities. Existing safety practices were generally informal and dependent on verbal communication between staff members.

Recommended engineering controls include:

- Designated pedestrians walk lanes.
- Physical bollards or movement barriers.
- Low-speed movement protocols.
- Vehicle spotter assistance during reversing operations.
- Floor markings and warning signage in transition areas.

The findings indicate that kinetic interaction between vehicles and pedestrians represents one of the most immediate operational risks within showroom environments.

$$\textbf{Risk Score}: Likelihood = 4, Impact = 4$$

$$\textbf{Final Risk Rating}: 16\ (High)$$

### 5.3. Zone C: Detailing and PDI Bay - Hazardous Chemical Storage

Among all operational zones evaluated during the study, the detailing and Pre-Delivery Inspection (PDI) bay presented the highest chemical and fire-related risk potential. These areas routinely handle flammable cleaning agents, polishing compounds, aerosol coatings, paint correction chemicals, and solvent-based products used during vehicle preparation activities.

Commonly observed materials included cellulose thinners, isopropyl alcohol-based cleaners, tyre dressing sprays, silicone compounds, and aerosol protectants. Several of these substances are classified as flammable materials under hazardous chemical handling regulations and require controlled storage conditions [3].

During facility inspections, multiple sites were observed storing detailing chemicals on open shelving units positioned close to electrical equipment and steam-cleaning systems. In certain cases, chemical containers were placed without secondary containment measures, increasing spill and vapour accumulation risks.

Particular concern was associated with vapour accumulation inside enclosed detailing bays. Solvent vapours generated from thinner-based compounds are heavier than air and may accumulate near floor level under insufficient ventilation conditions. In facilities lacking forced exhaust ventilation, the probability of vapour concentration approaching combustible limits increases significantly during continuous detailing operations or accidental spills.

Fire protection arrangements also varied across the observed facilities. While some sites maintained basic extinguisher access, several lacked appropriate fire suppression equipment specifically intended for flammable liquid hazards. In a few cases, only $CO_2$ extinguishers were available despite the presence of combustible chemical storage.

Additional risks identified within detailing and PDI zones included:

- Inadequate ventilation systems.
- Absence of Material Safety Data Sheet (MSDS) displays.
- Improper segregation of flammable compounds.
- Lack of spill-control measures.
- Limited personnel awareness regarding chemical handling procedures.

Recommended control measures include:

- Installation of forced exhaust ventilation systems.
- Segregated flammable chemical storage

cabinets.
- Secondary spill containment arrangements.
- ABC or foam-type fire extinguishers.
- Mandatory MSDS display and staff safety training.
- Restricted ignition sources within detailing areas.

The analysis indicates that detailing and PDI zones require substantially stronger chemical hazard management practices than those currently observed in most small-to-medium dealership facilities.

$$\boldsymbol{Risk\ Score}: Likelihood\ =\ 3, Impact\ =\ 5$$

$$\boldsymbol{Final\ Risk\ Rating}: 15\ (High)$$

### 5.4. Zone D: Service Transition Area - Hydraulic Ramp and Pit Risks

The service transition zone forms the operational connection between the showroom floor and the workshop or inspection area. In several of the facilities studied, this zone included hydraulic lifting systems, inspection pits, or vehicle ramps used during pre-delivery inspection (PDI), underbody checks, and vehicle servicing operations.

Hydraulic lifting systems introduce both mechanical and operational risks if periodic inspection and maintenance procedures are not followed consistently. The most common failure concern observed during the study was gradual hydraulic seal degradation, which can result in slow uncontrolled lowering of the vehicle platform under load conditions. Although gradual descent may initially appear minor, it can eventually create severe safety hazards for personnel working beneath or around the lifted vehicle.

A second and more critical failure mode involves sudden hydraulic line rupture or locking mechanism failure, potentially causing rapid platform descent. Safety standards such as IS 7155 specify inspection, maintenance, and load-testing requirements for vehicle lifting equipment [11]. However, none of the facilities using hydraulic ramps were able to provide recent documented inspection or load-testing records during the study period.

Inspection pits also presented notable fall-related hazards. One facility operated an open inspection pit without adequate edge marking, protective barriers, or visual warning indicators near the vehicle entry side. Poor floor contrast and limited physical protection significantly increased the possibility of accidental slips or falls during vehicle movement or workshop activity.

Additional operational concerns observed in service transition areas included:

- Inadequate floor markings around lifting equipment.
- Absence of emergency shut-off procedures.
- Oil leakage near hydraulic systems creating slip hazards.
- Lack of designated pedestrian-safe movement zones.
- Inconsistent maintenance documentation for lifting equipment.

Recommended engineering controls include:

- Periodic hydraulic ramp inspection and certified load testing.
- Installation of redundant mechanical locking systems.
- High-visibility pit-edge markings and protective barriers.
- Preventive maintenance schedules for lifting equipment.
- Controlled access protocols during lifting operations.
- Improved housekeeping and spill-management practices.

The findings indicate that service transition zones represent a combined mechanical and personnel safety risk area requiring regular inspection and stricter operational controls.

$$\boldsymbol{Risk\ Score}: Likelihood\ =\ 3, Impact\ =\ 4$$

$$\boldsymbol{Final\ Risk\ Rating}: 12\ (Medium - High)$$

## 6. Risk Register Summary

Table 2 summarises the major operational and mechanical risks identified during the study, along with their corresponding risk ratings and recommended engineering control measures. The prioritisation was based on the 5×5 Risk Matrix evaluation discussed in the methodology section.

 

***Table 2:*** *Showroom Facility Risk Register — Priority Rankings and Recommended Controls*

| Risk Description | Likelihood (L) | Impact (I) | Risk Score (L × I) | Risk Level | Recommended Control Measures |
|---|---|---|---|---|---|
| **Floor slab overload due to clustered SUV display** | 4 | 5 | 20 | Critical | Redistribution of vehicle layout and structural audit as per IS 456 |
| **Solvent vapour accumulation in detailing bay** | 3 | 5 | 15 | High | Forced exhaust ventilation and controlled chemical storage |
| **Vehicle-pedestrian collision risk on showroom floor** | 4 | 4 | 16 | High | Designated walk lanes, movement barriers, and spotter protocol |
| **Hydraulic ramp failure in service transition area** | 3 | 4 | 12 | Medium-High | Periodic inspection, load testing, and redundant locking systems |
| **Battery acid spill in EV handling/storage zone** | 2 | 4 | 8 | Low-Medium | Spill containment systems, PPE station, and neutralisation kits |
| **Fire hazard from detailing chemical storage** | 2 | 5 | 10 | Medium | Segregated flammable storage and suitable fire extinguishers |
| **Slip and fall risk on polished showroom flooring** | 4 | 3 | 12 | Medium-High | Anti-slip coating and wet-floor safety protocol |
| **Overhead clearance strike during tall vehicle entry** | 3 | 3 | 9 | Medium | Height clearance indicators and sensor-assisted warning systems |

***Scores Calculation:*** *As L × I per the 5×5 Risk Matrix. Controls represent minimum recommended interventions pending full FMEA completion.*

The risk register indicates that floor slab overloading, pedestrian-vehicle interaction, and detailing-bay chemical hazards represent the highest-priority operational concerns within the observed facilities. Several of these risks can be significantly reduced through relatively practical engineering interventions, improved facility planning, and periodic inspection practices.

The findings also demonstrate the importance of applying structured facility-level risk assessment methods within automotive dealership environments, particularly as vehicle dimensions, operational density, and service complexity continue to increase.

## 7. Discussion

The findings of this study indicate that automotive showroom facilities should no longer be viewed purely as commercial retail environments. Although customer interaction remains the primary operational function of these facilities, the presence of heavy vehicles, hydraulic equipment, flammable chemicals, confined manoeuvring corridors, and service-transition activities introduces several engineering and operational risks more commonly associated with light industrial environments.

One of the most important observations from the study is the increasing mismatch between modern vehicle characteristics and older commercial showroom infrastructure. The growing market preference for large SUVs and premium vehicles has significantly increased average vehicle loading conditions, while many dealership buildings continue operating under conventional commercial occupancy assumptions. The SolidWorks-based layout analysis demonstrated that vehicle positioning and display planning can substantially influence localised slab stress distribution, suggesting that layout optimisation may serve as a practical risk-reduction measure in existing facilities.

The study also highlights the importance of movement management within confined showroom environments. Vehicle-pedestrian interaction risks were observed in nearly all surveyed facilities due to the absence of clearly segregated movement zones. In practice, low vehicle speed often creates a false sense of safety; however, confined geometry and restricted visibility during reversing operations increase the probability of collision-related incidents.

Chemical handling risks within detailing and PDI zones were similarly underestimated across multiple facilities. The storage of flammable solvents and aerosol-based compounds in enclosed areas without dedicated ventilation or spill-control arrangements creates conditions that may contribute to fire hazards and vapour accumulation. These findings are consistent with previous observations reported in automotive workshop safety studies [8].

The adapted FMEA framework and 5×5 Risk Matrix used in this work proved effective in prioritising facility-level operational hazards. While the study does not aim to replace formal structural or industrial safety audits, it demonstrates that relatively simple engineering controls, such as improved layout planning, pedestrian segregation, preventive inspection schedules, and controlled chemical storage, can significantly improve operational safety within dealership environments. The broader implication of this study is that automotive showroom facilities represent a hybrid operational environment requiring more structured engineering risk management practices than those currently adopted in many small-to-medium dealerships.

## 8. Limitations of the Study

The present study was conducted using observational assessment, facility walkthroughs, and simplified engineering analysis within a limited number of automotive showroom facilities located in the Pune metropolitan region. As a result, several limitations should be considered while interpreting the findings.

The study included six dealership facilities representing small-to-medium showroom environments. Although the selected sites provided practical insight into common operational risks, the sample size remains limited relative to the broader automotive dealership sector across India. Variations in building age, structural design, operational practices, and OEM-specific facility standards may influence risk conditions in other locations.

The structural loading analysis performed using SolidWorks Simulation was intended primarily as a comparative decision-support exercise rather than a complete structural certification study. Access to original structural drawings, reinforcement detailing, slab thickness verification, and site-specific material testing data was not available during the analysis. Consequently, the simulation results should be interpreted as indicative rather than definitive structural assessments.

Similarly, the operational risk evaluation relied on observational inspection and qualitative scoring methods using the 5×5 Risk Matrix and FMEA framework. Although these methods are widely accepted for engineering risk prioritisation, certain scoring parameters such as likelihood and detectability involve a degree of professional judgement.

The study also did not include long-term monitoring of facility incidents, environmental exposure measurements, or detailed experimental testing of chemical vapour concentration levels, hydraulic equipment behaviour, or floor slab response under dynamic loading conditions.

Despite these limitations, the study provides a practical framework for identifying and prioritising operational and mechanical risks within automotive showroom facilities and establishes a foundation for future research in this area.

## 9. Future Scope

Future research in automotive showroom facility risk management can be expanded in several technical and operational directions. As dealership infrastructure continues to evolve with increasing vehicle size, electric vehicle adoption, and integrated service operations, the need for structured engineering-based safety assessment will become more significant.

One important area for future work is the development of detailed structural assessment models for showroom facilities handling high-density SUV and electric vehicle display configurations. More advanced finite element analysis, combined with actual structural drawings and material inspection data, could provide more accurate evaluation of slab loading behaviour under concentrated vehicle loads.

The increasing adoption of electric vehicles also introduces new operational considerations related to battery handling, charging infrastructure, thermal runaway risk, and emergency response planning. Future studies may focus specifically on EV storage zones, charging bay safety systems, lithium-ion battery spill management, and ventilation requirements within enclosed showroom environments.

Additional research may also examine:

- Real-time vehicle movement monitoring systems within dealership facilities.
- Sensor-assisted pedestrian safety systems for confined manoeuvring zones.
- Automated ventilation and vapour detection systems in detailing bays.
- Digital risk-monitoring frameworks using IoT-based facility sensors.
- Integration of AI-assisted predictive maintenance systems for hydraulic lifting equipment.

Future studies involving a larger number of dealership facilities across different cities and operational categories may also help establish standardised facility risk benchmarks for the automotive retail sector. The findings of the present work suggest that automotive showrooms should increasingly be treated as hybrid commercial-engineering environments requiring dedicated operational safety standards and structured facility-level risk management practices.

# 10. Conclusion

Automotive showroom facilities are commonly treated as commercial retail spaces; however, the operational conditions observed during this study indicate that they also possess several characteristics of light industrial environments. The presence of heavy vehicle loading, confined vehicle movement zones, hydraulic lifting systems, and hazardous chemical storage introduces operational and mechanical risks that are often insufficiently addressed through conventional commercial safety practices.

The study identified floor slab overloading, vehicle-pedestrian interaction, solvent vapour accumulation, and hydraulic ramp failure as some of the most significant risks within small-to-medium dealership facilities. The application of a 5×5 Risk Matrix and an adapted FMEA framework allowed these hazards to be systematically prioritised based on likelihood and impact severity.

The SolidWorks-based layout assessment further demonstrated that showroom floor planning and vehicle arrangement can meaningfully influence localised structural loading behaviour. Similarly, the study showed that several operational hazards may be reduced through relatively practical engineering interventions, including improved vehicle circulation management, preventive equipment inspection, controlled chemical storage, enhanced ventilation systems, and structured safety protocols. Although the present work is limited in scale, the findings highlight the need for more formalised facility-level risk management practices within the automotive dealership sector. As vehicle dimensions, operational complexity, and customer footfall continue to increase, dealership facilities will require greater integration of engineering safety principles into routine operational planning.

The study concludes that structured operational risk assessment methods can provide a practical foundation for improving safety, reliability, and facility management standards within automotive showroom environments.

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