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A Comparative Study of Active and Passive Fire Safety Systems in Residential and Industrial Buildings of Jammu and Kashmir

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Abstract: ***Fire accidents are a frequent and serious problem in Jammu and Kashmir, often resulting in loss of life and property. This study compares how well active and passive fire safety systems work in both homes and industrial buildings across the region. Data was collected using surveys (127 participants), site visits, and interviews with people involved in fire safety.The findings show that passive fire safety systems (like fire doors and escape paths) are not commonly used in many residential areas. Industrial buildings follow safety rules better due to strict checks by authorities. However, active systems (like alarms and fire extinguishers) are often not well-maintained in both sectors.This paper recommends combining both types of systems and improving awareness to make fire safety more effective and reduce risks in future.***
Keywords: Active fire safety, Passive fire protection, Fire risk, Residential buildings, Industrial safety, Jammu and Kashmir, Fire prevention

I. INTRODUCTION

Fire safety is very important, especially in a place like Jammu and Kashmir, where old buildings, crowded areas, and lack of awareness increase the chance of fire accidents.[1] Over the years, many homes and factories in the region have suffered heavy damage due to fire, mainly because fire safety systems were missing or not working properly.There are two main types of fire safety systems,Active and Passive fire protection systems [2].Active fire safety systems include tools that need to work when a fire happens like fire alarms, smoke detectors, sprinklers, and fire extinguishers [3]. They help control or stop the fire as soon as it is detected.Passive fire protection systems are built into the structure of the building, like fire-resistant walls, fire doors, safe exits, and sections designed to stop fire from spreading [4]. They don't need human or automatic action to work they simply slow down the fire and help people escape safely.

Even though there are national fire safety rules like the National Building Code (NBC) 2016, and the Fire & Emergency Services Department in Jammu and Kashmir has its own regulations, these are not properly followed, especially in residential areas [5,6]. Old houses and apartments often lack basic safety features. Even where systems exist, they are rarely checked or maintained. Industrial buildings follow rules a little better due to regular inspections, but smaller units still have many issues [8].While many researchers have talked about fire safety, very few have compared how active and passive systems actually perform in real situations especially in a place like Jammu and Kashmir with its unique challenges [9]. This study fills that gap by checking where these systems are used, how well they work, and what's missing in both homes and industries.

This research mainly incorporates active and passive fire safety systems used in residential and industrial areas. How do their condition and performance compare in real use and what common problems are found, and how can thembe fixed to improve safety. To answer these, we used surveys, on-site checks, and interviews. The results aim to help building owners, fire safety engineers, government officials, and the general public understand how fire safety can be improved in the region.

II. RESEARCH METHODOLOGY

This study used a mixed-methods approach, which means it combined both numbers (quantitative data) and real-life observations (qualitative data). The goal was to assess how well active and passive fire safety systems are working in residential and industrial buildings in Jammu and Kashmir (Srinagar, Jammu, Badi-Brahmna, Pulwama, and Kathua). The methods used were designed to reflect the actual ground situation, focusing on the availability of systems, how well they work, and whether they follow fire safety rules.

A. Data Collection Methods

We used three main ways to collect data:

1) Structured Surveys

We collected 127 responses from people such as house owners, industry managers, and local residents. The survey included questions about:

- What types of fire safety systems they have
- How often these systems are checked or repaired
- How aware they are about emergency procedures
- What they think about fire safety risks in their area

2) Field Inspections

We visited 26 residential buildings and 18 industrial units to physically inspect their fire safety systems. We checked:

- Active systems: Fire extinguishers, smoke detectors, alarms, and sprinkler systems whether they were available and working
- Passive systems: Fire doors, emergency exits, smoke barriers, and fire-resistant construction materials

3) Stakeholder Interviews

We spoke to Safety officers, engineers, safety consultants, and local disaster management staff. These interviews helped us understand:

- Why some rules are not followed
- How often equipment is maintained
- Whether people are trained in fire safety or not

B. Tools and Instruments Used

1) Survey forms (both online through Google Forms and printed copies)
2) A fire safety inspection checklist made using NBC 2016 guidelines and IS codes
3) Photographs taken at the sites

III. DATA ANALYSIS AND RESULTS

This part of the study explains the results we got from surveys, on-site visits, and interviews (Table 1 and Table 2). It compares how well active and passive fire safety systems are installed and used in residential and industrial buildings across Jammu and Kashmir. The findings show that many buildings especially houses and old residential areas have serious gaps in fire safety. These gaps include poor system coverage, lack of maintenance, and very low public awareness.

Figure 1: On-site industrial visits and community fire safety awareness sessions.

1) Distribution of Fire Safety Systems

Table 1: Availability of Active Fire Safety Systems

Fire Safety Equipment	Residential (%)	Industrial (%)
Fire Extinguishers	12%	80%
Smoke Detectors	5%	65%
Fire Alarm Systems	7%	58%
Automatic Sprinklers	8%	40%

Interpretation:
Industrial buildings are much better equipped with active fire safety tools like extinguishers and alarms. Most residential buildings either don't have these systems or have out-dated equipment that doesn't work properly.

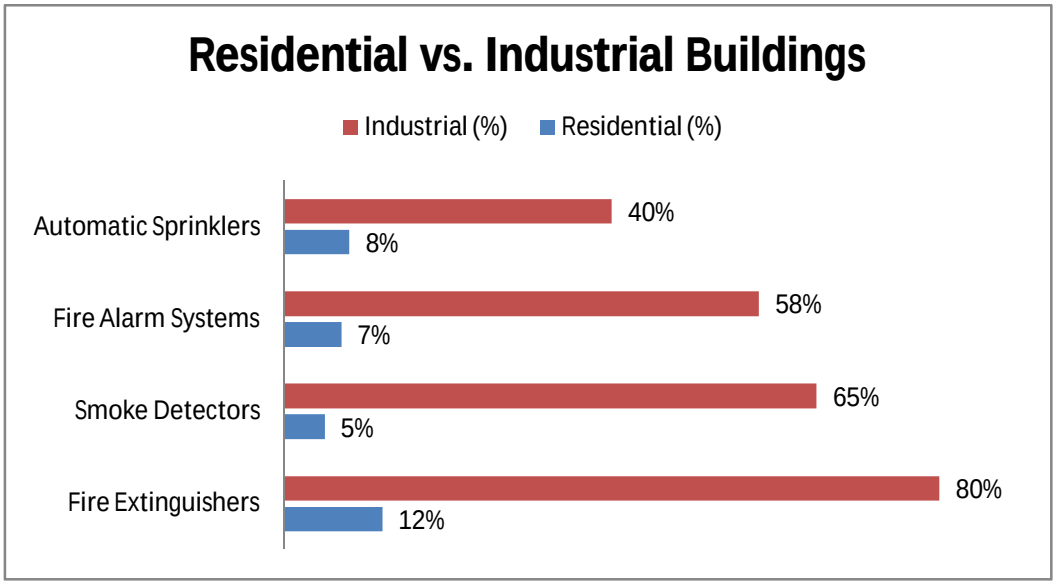

Figure 2: Active Fire Safety in Residential vs. Industrial Buildings

2) Passive Safety Infrastructure

Table 2: Availability of Passive Fire Safety Measures

Passive Feature	Residential (%)	Industrial (%)
Fire Doors	10%	50%
Emergency Exits	15%	60%
Smoke Barriers	5%	45%
Fire-Resistant Materials	8%	55%

Interpretation:
Passive fire safety features are more commonly found in industrial buildings. However, many of them are not maintained properly. In contrast, most residential buildings especially older ones don't have fire exits, fire-resistant materials, or any kind of smoke barriers.

3) Maintenance and Functionality

Through field visits and interviews, it was observed that even where fire safety systems exist, they are often not taken care of. In low-income housing areas and small businesses, fire extinguishers were found expired or kept in locked rooms, making them useless in emergencies (Table 3).

Table 3: Fire Safety Equipment Maintenance

Category	Regularly Maintained (%)	Not Maintained / Expired (%)
Residential	22%	78%
Industrial	65%	35%

Interpretation:
Most industrial units maintain their systems better due to rules and inspections. But in residential areas, especially older houses, maintenance is very poor.

4) Training and Awareness Levels

The survey also asked people if they had attended any fire drills or training programs. The results were disappointing. Only 20% of industrial workers and 8% of residents had any fire safety training or knew how to act during a fire emergency,rest 72% had no idea about basic fire response or emergency evacuation procedures. (Figure 3).

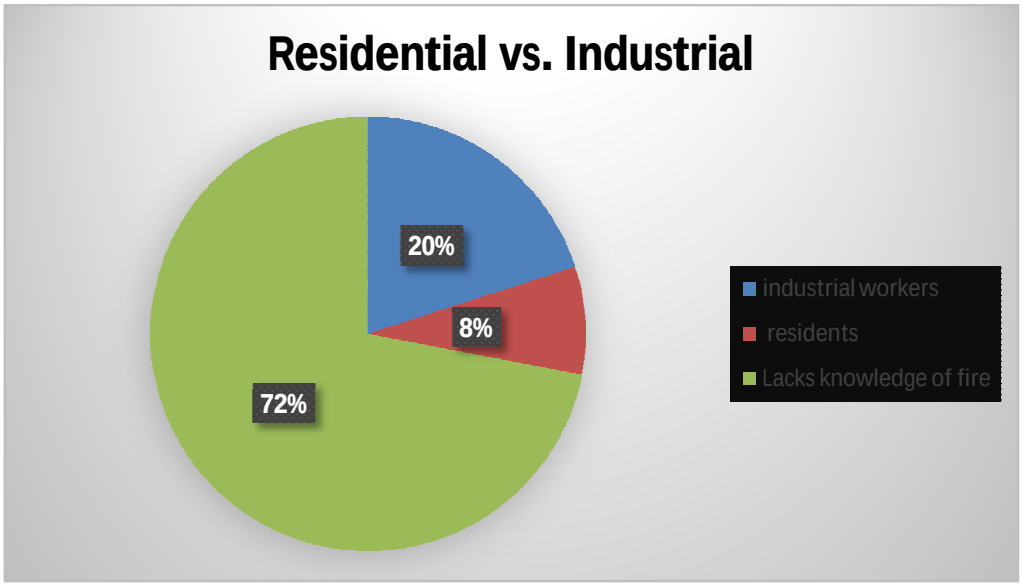

Figure3: Fire Safety Training in Residential vs. Industrial Respondents

Interpretation:
There is a major gap in awareness and training. Most people, especially in residential areas, are not prepared for fire emergencies and do not know how to use fire safety tools.

IV. DISCUSSION

This paper presents a reflective analysis of the key findings from the study, linking them with broader fire safety frameworks and the unique geographical and socio-economic realities of Jammu and Kashmir [11]. The aim is to interpret the data and insights collected in relation to the core research objectives was to assess the effectiveness of active and passive fire and life safety measures and to develop localized strategies for improving fire safety preparedness.By combining data from surveys, interviews, and direct field observations, the study draws a detailed picture of recurring vulnerabilities and possible interventions across residential and industrial sectors of the region.

1) Fire Safety Awareness and Infrastructure Gaps

One of the most evident and concerning findings of this study is the widespread lack of fire safety preparedness in residential areas. More than 80% of the homes surveyed had no fire extinguishers installed (Table 1), and a large portion of residents lacked even basic awareness of how to respond during a fire. This reflects a broader pattern seen in many under-resourced regions, where fire safety often takes a back seat due to low awareness, insufficient enforcement, and financial constraints.In contrast, industrial units especially those located in parts of Jammu showed somewhat better preparedness, likely because they are subject to regulatory checks (Table 1)[12]. However, this does not mean they are adequately prepared.

During site visits and interviews, several issues came to light: maintenance of fire equipment was irregular, fire drills were rarely conducted, and staff awareness was limited beyond designated safety officers [13].Multiple fire officials emphasized that simply installing fire safety systems is not enough. Equipment was often found to be non-functional, out-dated, or installed without proper planning [14]. Training, regular audits, and practical mock drills were identified as crucial yet missing components in most settings.

2) Trends in Fire Incidents and Regional Disparities

The analysis of fire incident records between 2018 and 2023 revealed some critical trends. Unsurprisingly, urban areas like Srinagar and Jammu witnessed the highest number of reported fire incidents [15]. However, the extent of damage and casualties tended to be more severe in rural and hard-to-reach areas. This is largely due to slower emergency response times and lack of fire infrastructure [16].

Srinagar alone accounted for hundreds of incidents in one year, mostly concentrated in densely packed neighbourhoods with narrow lanes and aging wooden structures. These patterns highlight that it's not just the number of fire incidents that matters but also where they happen[17]. Older city layouts with no fire lanes and hillside settlements with steep terrain are far more vulnerable. The design and planning of many towns and villages have inadvertently created high-risk zones for fire emergencies [18].

3) Systemic and Institutional Shortcomings

Beyond individual behaviour or building-level preparedness, this research also identified deeper systemic challenges that impact fire safety across the region. A major issue is the lack of consistent fire safety enforcement [19]. Despite national guidelines such as the NBC 2016, many buildings especially in residential areas lack compliance due to poor oversight, lack of inspections, or informal construction practices [20].Moreover, in some areas, expired equipment and the absence of fire exits were observed during inspections. These problems point to a lack of coordinated governance and weak administrative monitoring [21]. Unless fire services and local bodies work together consistently, the implementation of even the well-designed policies will remain patchy [22].

V. CONCLUSION AND RECOMMENDATIONS

Fire safety continues to be an overlooked yet vital component of infrastructure planning and risk mitigation, particularly in the context of Jammu and Kashmir. This research has comprehensively assessed the effectiveness and implementation gaps of active and passive fire and life safety measures across both industrial and residential sectors of the Union Territory. The findings reveal a stark disparity: while industrial facilities generally maintain higher levels of compliance, driven in part by regulatory oversight and institutional policies, residential buildings lag significantly behind in both system installation and maintenance.

The study identified that over 70% of surveyed residential properties lacked any functional fire safety system. Where systems were present, especially in non-industrial structures, maintenance was often absent, with expired extinguishers and non-functional alarms being common. Moreover, a lack of public awareness compounds the vulnerability, with only a fraction of the population particularly in high-density residential areas having received basic fire safety training.The gap between policy formulation and implementation is particularly evident in the frequent bypassing of fire safety regulations, especially in the urban housing sector, where Fire Safety No Objection Certificates (NOCs) are often issued without proper inspection.

To address these issues, the study proposes a set of context-specific and actionable recommendations. These include mandatory fire safety installations in all residential structures, bi-annual maintenance audits by the Fire and Emergency Services, community-driven fire safety awareness campaigns, and the digitization of compliance monitoring. Furthermore, policy reforms such as stricter enforcement of the National Building Code and linking fire safety compliance to property approvals can help bridge the enforcement gap.This research contributes a practical and regionally relevant framework that can be adopted by policymakers, urban planners, local bodies, and community organizations to enhance fire safety outcomes. The emphasis on both infrastructure-based (passive and active systems) and community-based (training and awareness) measures ensures that fire risk reduction strategies are not only technically sound but also socially inclusive.

Based on the findings, several key steps are recommended to improve fire safety in Jammu and Kashmir. Firstly, basic fire safety systems such as extinguishers, alarms, and emergency exits should be made legally mandatory in all residential buildings, including existing ones, with strict enforcement by local authorities. Secondly, biannual inspections by Fire & Emergency Services should be conducted, and results made public to ensure accountability. Thirdly, public awareness must be increased through door-to-door campaigns and regular fire drills organized by resident welfare associations. Additionally, urban development laws must be updated to ensure strict implementation of NBC fire safety codes, with penalties for violators and proper verification of Fire NOCs linked to property services.

The use of technology is also crucial; a digital dashboard should be created to track inspections, safety system status, and emergency readiness. Lastly, financial incentives such as subsidies or tax discounts should be offered to households and small businesses that install certified fire safety equipment, encouraging wider adoption and compliance.By implementing the proposed interventions, Jammu and Kashmir can make meaningful progress toward a more fire-resilient future safeguarding life, property, and environmental integrity across both industrial and residential landscapes.

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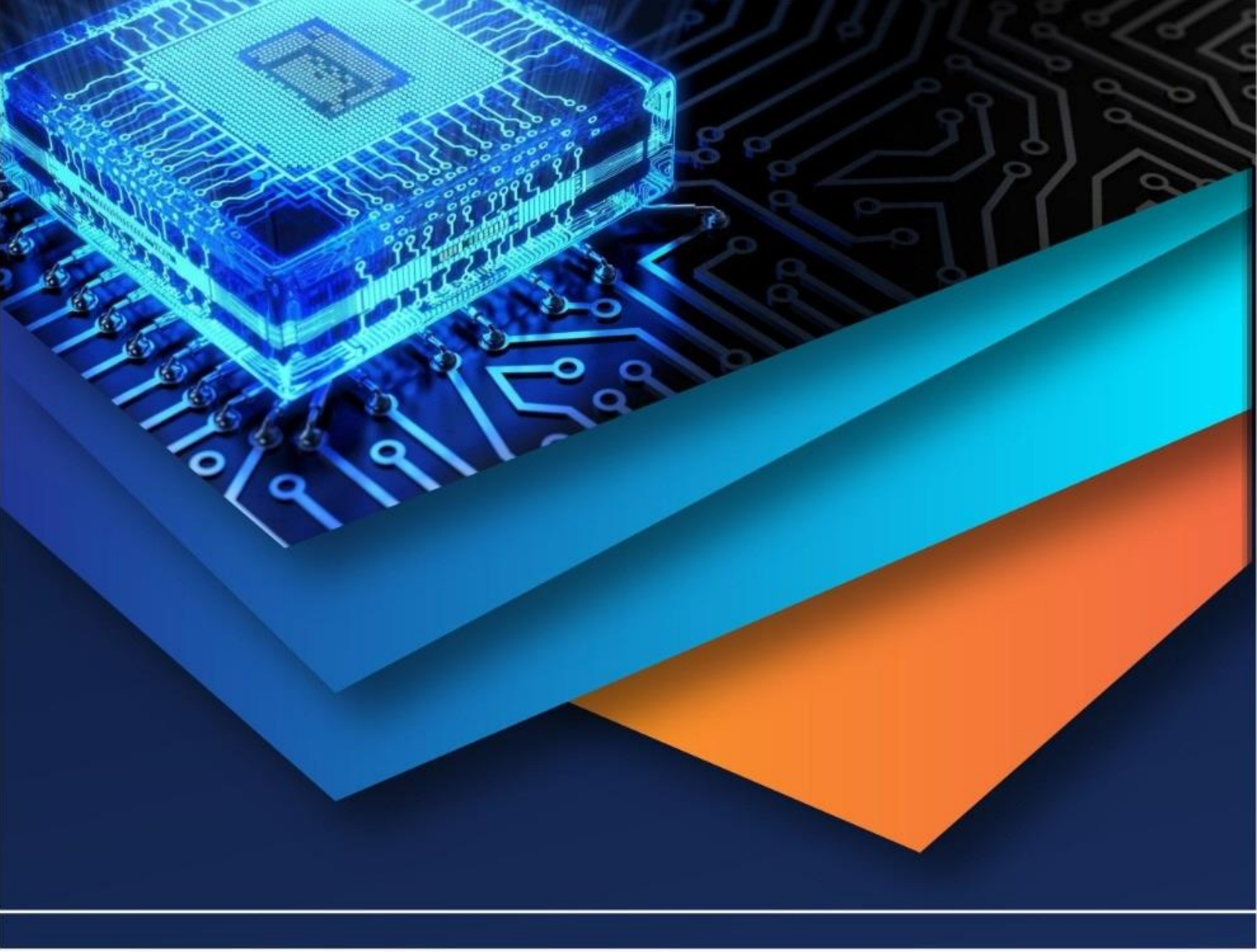

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