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Root Cause Analysis- Technical Report

Engineering Applications & Study Skills (ACMA 4039)

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1. Executive Summary (abstract)

This Root Cause Analysis (RCA) of the Cube fire in Bolton identifies the incident as a systemic failure of material choice, regulatory oversight, and risk management rather than an isolated accident. The immediate ignition source was a discarded cigarette on a balcony, but the rapid escalation was driven by combustible external wall systems (HPL cladding and timber/composite balcony decking) that permitted vertical and lateral fire spread.

The RCA, structured in line with PAS 9980 (BSI, 2010) methodology, highlights critical risk factors, such as the vulnerability of external wall systems, inadequate cavity barriers, and resident behaviours interacting with combustible balcony design. Severity and occurrence ratings were high, while detection controls such as Building Control sign off proved insufficient, resulting in elevated Risk Priority Numbers (RPNs). Internal compartmentation performed effectively, and the Greater Manchester Fire and Rescue Service's immediate evacuation strategy ensured all residents were safely evacuated, proving strong emergency response capability.

Key recommendations include the replacement of combustible materials with non-combustible alternatives, façade redesign to limit fire spread, stricter enforcement of smoking bans, and ongoing rehearsal of evacuation protocols. The findings emphasise that reliance on evacuation alone is unsustainable; prevention through safer construction and regulatory reform is essential.

In conclusion, the Cube fire illustrates how minor ignition events can escalate into major incidents when systemic vulnerabilities exist. The RCA demonstrates the importance of PAS 9980 (BSI, 2010) aligned assessments in identifying and mitigating risks in external wall systems, ensuring that lessons learned translate into safer buildings across the sector.

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3. Introduction

Root Cause Analysis (RCA) and Fire Risk Appraisal of External Walls (FRAEW) are closely related within fire safety management. RCA provides a systematic methodology for identifying the underlying causes of fire incidents, enabling the development of targeted corrective actions to prevent recurrence and enhance overall safety performance.

FRAEW is a structured, risk-based evaluation of a building's external wall construction, designed to determine the likelihood of fire spread across or within these elements. This process is critical for establishing whether remediation or mitigation measures are necessary, particularly where combustible materials, poor workmanship, or inadequate fire-stopping compromise compliance and occupant safety.

The importance of these assessments was tragically underscored by the Grenfell Tower fire in 2017 (Journalism, 2019), where combustible cladding and insulation materials contributed to rapid vertical fire spread, resulting in catastrophic loss of life and prompting a comprehensive review of building safety regulations. A FRAEW conducted under the principles later formalized in PAS 9980:2022 would likely have identified these hazards and recommended proportionate remediation measures (BSI, 2022).

The Grenfell Tower fire highlighted the critical importance of fire safety in buildings, leading to stricter building regulations. External Wall Systems (EWS), while providing insulation and weather protection, can pose significant fire hazards if combustible materials are used. Key safety measures include:

Collectively, RCA and FRAEW form a robust framework for safeguarding multi-occupied residential buildings. By identifying latent fire hazards and recommending proportionate interventions, these processes not only support regulatory compliance but also contribute to creating safer living environments.

3.1.Importance

The implementation of comprehensive and proportionate risk assessments forms a cornerstone of effective risk management within the workplace. Employers are legally obligated to undertake and support documented assessments where five or more individuals are employed, as required by the Management of Health and Safety at Work Regulations (GOV, 1999) and reinforced by the Building Regulations 2010 (GOV, 2010) for fire safety compliance. This structured process enables the identification of hazards, evaluation of associated risks, and the application of measures to eliminate, mitigate, or adequately control threats to health, safety, and overall well-being.

The British Safety Council (British Safety Council, n.d.) states the following as the main purposes of a risk assessment as:

- *To identify health and safety hazards and evaluate the risks presented within the workplace*
- *To evaluate the effectiveness and suitability of existing control measures*
- *To ensure additional controls (including procedural) are implemented wherever the remaining risk is considered to be anything other than low.*
- *To prioritise further resources if needed to ensure the above.*

4. Literature Review

4.1. Overview

Risk mitigation represents an initiative-taking strategy aimed at minimizing potential hazards before they escalate into critical issues. In the context of building façades, risks may arise from inadequate design, material degradation, fire hazards, and environmental exposure. Effective mitigation requires a systematic approach that integrates advanced diagnostic technologies, comprehensive inspections, and adherence to evolving regulatory frameworks.

Key Risk Factors:

- **Material Deterioration:** Prolonged exposure to adverse weather conditions, pollutants, and ultraviolet radiation can accelerate façade degradation over time.
- **Fire Safety Compliance:** The presence of non-compliant cladding materials and external wall systems introduces significant fire hazards, needing rigorous assessment and remediation.
- **Structural Weaknesses:** Deficiencies in installation practices, maintenance protocols, or design integrity can compromise the structural and fire safety performance of façades.
- **Regulatory Non-Compliance:** Continuous updates to building safety legislation, including the Building Safety Act 2022 (UK Government, 2022) and PAS 9980:2022 (BSI, 2022), require property owners and duty holders to adopt an initiative-taking stance toward compliance.

A systematic failure analysis process is essential for determining the root causes of structural or material deficiencies. Understanding these causal factors enables stakeholders to implement corrective measures that prevent recurrence, thereby ensuring long-term safety, resilience, and regulatory conformity. Through this integrated approach, building owners, developers, and property managers can address latent hazards effectively while supporting compliance with statutory obligations.

4.2. Scenario RCA

On November 15, 2019, a fire occurred at The Cube, student accommodation in Bolton, Greater Manchester. Rapid and unexpected fire spread was clear from the outset, severely affecting the building which featured a High Pressure Laminate (HPL) external wall cladding system. Investigators later concluded that a discarded cigarette was the most likely ignition source. Despite life being evidently at risk from the very intense and unpredictable fire, no serious injuries were reported, and all 217 residents were safely evacuated. The incident caused significant disruption to students at the University of Bolton, resulting in the loss of coursework, personal belongings, and essential documents. For international students, the destruction of passports and visa papers added further hardship to an already distressing situation.

The rapid fire spread at The Cube in Bolton was primarily attributed to the use of high-pressure laminate (HPL) cladding combined with timber framing. These materials are highly combustible and, when installed without adequate fire-stopping measures, create a pathway for flames to propagate quickly across external walls. The absence of cavity barriers and insufficient compartmentation further worsened the situation, allowing fire to bypass intended containment zones.

The event raised serious concerns about regulatory oversight and compliance with the Regulatory Reform (Fire Safety) Order 2005 (GOV, 2005). It exposed gaps in enforcement and highlighted the need for clearer guidance on assessing external wall systems. A Fire Risk Appraisal of External Walls (FRAEW) conducted under PAS 9980:2022 (BSI, 2010) would likely have found these hazards and recommended remediation measures such as replacing combustible cladding and installing cavity barriers, significantly reducing the risk of rapid fire spread.

While this example involves a student accommodation building, the principles apply directly to manufacturing facilities:

- Many industrial buildings use similar cladding systems for cost and insulation.
- Manufacturing sites often have higher ignition risks (e.g., welding, flammable materials).
- PAS 9980 offers a structured way to assess and mitigate these risks before incidents occur.

5. Root Cause Analysis

5.1. Methodology

RCAs are a systematic process to identify and eliminate risks, reducing the probability of future risks through mitigation measures, therefore improving efficiency, quality, and most importantly; safety.

They are utilised by:

1. Defining the problem.
 - a. Describing the issue; and
 - b. Consequences of failure, including the severity, potential reasons why, and the Occurrence
2. Collecting data.
 - a. Current controls, including detection, and risk priority number
3. Identifying possible causes.
4. Analysing those causes.
5. Implementing corrective actions.
 - a. Recommended action, including responsibility, and target dates.
6. Monitoring.

5.2. Results

The RCA demonstrates that the incident was not simply the result of a single ignition source, but rather the outcome of multiple interacting failures within the building's design, material selection, and regulatory oversight. While the immediate cause was traced to a discarded cigarette igniting combustible balcony decking, the RCA highlights that the true root causes lay in the external wall system and the broader regulatory environment that permitted combustible materials to be used in high-risk settings.

The analysis shows that combustible cladding and balcony materials created a façade highly vulnerable to rapid fire spread, with flames propagating vertically and laterally across the building. This vulnerability was compounded by design features such as recessed façades and inadequate cavity barriers, which allowed falling debris to ignite secondary fires. Although internal compartmentation performed as intended, preventing fire penetration into flats, the external fire dynamics overwhelmed initial containment efforts.

From a PAS 9980 (BSI, 2010) perspective, the RCA underscores that the risk rating for the external wall system was critically high, with severity and occurrence scores reflecting both the combustible nature of the materials and the likelihood of ignition from everyday resident behaviour. Detection controls, such as Building Control sign-off, proved insufficient, resulting in high Risk Priority Numbers (RPNs) across key categories. The RCA therefore identifies systemic issues: outdated regulatory compliance frameworks, inadequate enforcement of non-combustible material standards, and insufficient behavioural controls for residents.

6. Conclusion

In conclusion, extensive research and RCA results highlight that the Cube fire was a systemic failure of material choice and regulatory oversight, rather than an isolated accident. This case illustrates how RCA can expose the deeper structural and policy weaknesses that transform minor ignition events into major incidents. It provides a clear example of why PAS 9980 (BSI, 2010) methodologies are critical in assessing external wall systems, prioritising risk reduction, and ensuring that lessons learned translate into safer buildings across the sector.

7. References

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Appendix A – Root Cause Analysis

Process / Function	Identified Issue	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	O c c	Current Controls	D e t	R P N	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
											Actions Taken	S e v	O c c	D e t	R P N
External Wall System	HPL cladding with timber/composite balcony decking	risk to life, structural integrity/ damage, loss of property	10	combustible HPL cladding, and timber decking balconies failed under fire exposure	9	evacuation strategy in place, building control sign off	3	270	full removal, and replace combustible materials with non combustible alternatives	building owner and fire safety consultant	cladding remediation and balconies removed	3	2	8	48
Balcony Configuration	cigarette discarded on balcony, ignited decking	localised fire escalation into facade	8	smoking on balconies permitted, with combustible surfaces	7	resident handbook discourages smoking	4	224	enforce smoking ban on balconies and install fire safe bins	property management	Smoking policy updated and adequate disposals installed	3	2	8	48
Regulatory Compliance	use of materials that failed under fire conditions	systematic risk across similar buildings	10	building regulations permitted combustible materials	9	Building Control sign off	2	180	review and update fire safety compliance	fire safety lead	PAS 9980 reviews initiated	4	3	7	84
Emergency Response	fire spread overwhelmed initial containment	potential for delayed evacuation	9	rapid external fire growth due to falling debris	6	GMFRS evacuation protocol	9	486	maintain and rehearse evacuation plans	GMFRS and building management	evacuation successful, with zero casualties	2	2	9	36
Compartmentation	internal compartments held integrity	fire contained externally	5	no breach observed	2	regular inspections	9	90	maintain and inspect compartmentation	building management	integrity maintained	2	2	9	36

Figure 1. Dowling, E. Root Cause Analysis snapshot based on the Cube, Bolton, fire.

Appendix B – Personal Development Plan

Name: Emiah Dowling

Degree: BEng Mechanical Engineering (Degree Apprenticeship)

Previous Qualifications: A level (L3 Pearson Engineering, B Mathematics, C Design Technology)

Previous Experience: 9 months Apprentice Fire Engineer

Long Term Goals (5 to 10 years)				
Develop expertise in Fire Engineering, progressing from academic studies to professional, with the goal of achieving a Chartered Engineer status, within a professional institution such as IMechE.				
Short Term Goals (0 to 5 years)				
Develop skills, knowledge, and competencies needed to achieve a First Class Honours in Mechanical Engineering BSc, by consistently performing at the highest academic level across all modules.				
Goal	Objective	Resources Required	Measurement	Target Date
Strengthen Mathematical and Scientific foundations for mechanical systems.	Develop and practice problem solving in thermodynamics, fluid mechanics, and materials science using English Language resources; rather than as taught in Welsh.	- Attend study sessions. - Use English Language textbooks.	Improved performance in core modules, and confidence in technical vocabulary.	End of Level 4.
Develop professional capability in engineering risk management.	Apply Root Cause Analysis (RCA) to mechanical failure scenarios and safety assessments.	- Completion of Study Skills module. - RCA case studies. Feedback.	Submission of <u>ACMA 4039</u> Technical Report.	End of Level 4.
Improve technical communication and report writing skills.	Develop clear, structured reports and RCA documentation.	- Study Skills module guidance. - Utilise examples of technical writing. Feedback.	Submission of assessed reports, utilising peer reviewing methods.	End of Study Skills module.
Take ownership of academic and personal development.	Manage deadlines, and communication with tutors, support available, and employee.	- Utilise planning methods. - Access to student support services such as reviews with Apprentice Liaison Officer.	Consistent attendance and timely submissions.	Immediate and ongoing.

Figure 2, Dowling, E. Personal Development Plan snapshot.