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## CHALLENGES AND OPPORTUNITIES FOR AUTOMATING PHYSICAL COMPLIANCE ON CONSTRUCTION SITES

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### Aim

To review the literature on the challenges of physical compliance on construction sites and evaluate the opportunities in digital technologies, process improvements and behavioural changes to improve the compliance process.

### Objectives

- Appraise the contemporary challenges and failures within the construction compliance process, drawing from a review of scholarly literature and industry reports.
- Review and categorize the issues encountered in construction compliance, classifying them according to the dimensions of process, human behaviour, and digital technology.
- Identify and analyse the barriers and obstacles in improving physical compliance in terms of process, behaviour, and technology in construction projects.
- Discuss the emerging research trends and forthcoming areas of investigation pertaining to the automation of physical compliance within the construction industry.

## Introduction

The construction project lifecycle includes several compliance requirements that need to be checked at multiple levels and at different phases of the project.

In the construction phase, a project must adhere to extensive regulations encompassing various aspects of the building process, including insurance, building codes, worker agreements, union requirements, safety codes, and more [1].

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The paper addresses the challenges of construction compliance by undertaking a literature review on the compliance failures and breaks it down into three categories or dimensions – process, behaviour and technology.

The study tries to answer the question *‘Can the integration of digitalization, behavioural changes, and process improvement offer a viable solution to address non-compliance issues in the construction industry?’*

### Non-compliance: a Global Perspective

- Poor quality in 80% of building projects - 50% increase in building costs [2].
- Manual inspection process inefficiencies – 66% cost overruns; 53% schedule delays [3].
- Effective quality management can save £12 billion annually in UK [4].
- In the US, cost of rework - 6% to 12% of the total construction cost [5].

### Non-compliance: an Irish Perspective

- Local authorities only required to carry out inspections for 12% to 15% of new buildings [6]
- Inspection rate - abysmally low [7].
- 150 out of 300 vacant properties under Dáil's - fire hazards; €100 million to rectify (2015) [8].
- 23 local authorities found over 90% of inspected dwellings - non-compliant with the Standards' Regulations. [7]

## Compliance Failures & Challenges Grenfell Tower Fire

- Use of polyethylene material of the Aluminium Composite Materials (ACM) panels in external cladding.
- Absence of a comprehensive sprinkler system and effective fire-resistant compartmentation.
- Inadequacies in the fire protection systems; exposed gas pipe installations.
- No "wet riser"



Fig 1: Grenfell Tower Fire

## Compliance Failures & Challenges Priory Hall Scandal

- Lack of compliance with building regulations and safety standards [9].
- Fire hazards and numerous building defects.
- Flooding of the underground car park shortly after completion - inadequate waterproofing measures.
- Unauthorized room constructions without proper planning permissions [10].



Fig 2: Priory Hall



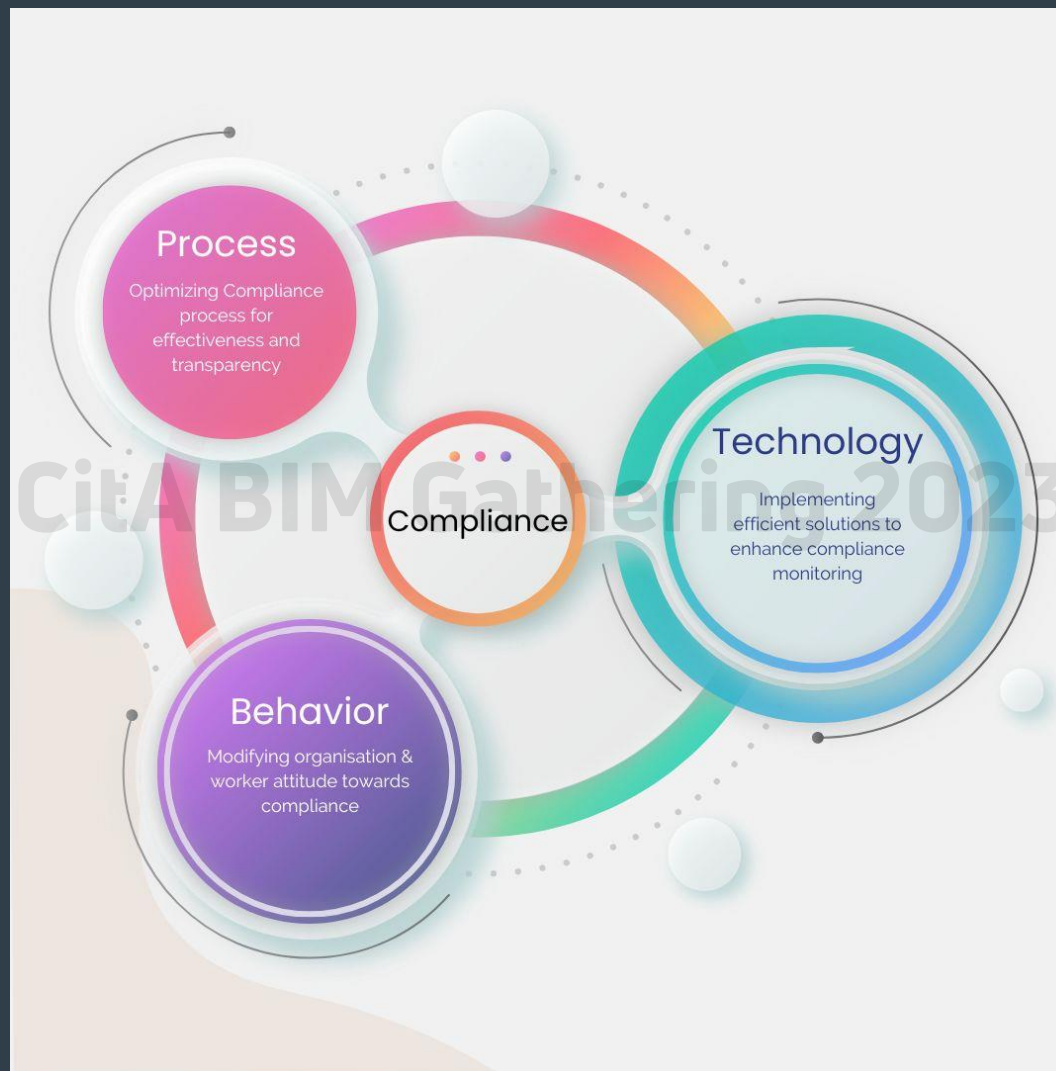


Fig 3: Dimensions of Construction Compliance

## Methodology

From an initial survey of journal papers written about construction compliance, it was noted that compliance challenges can be broken down into three primary categories – process, behaviour, and technology.

**Technology Dimension** - 'Automation', 'artificial intelligence', 'robotic', 'sensors' were used along with 'construction compliance'. *Rejected* 'Automated construction compliance'

**Process Dimension** - Building Control (Amendment) Regulations, Code of Practice and other associated reports ([6], [11], [12]).

**Behaviour Dimension** - 'Compliance behaviour', 'worker behaviour' and 'behaviour practices at construction sites.' Additionally, compliance behaviour in different industries and as a sociological theme was searched.

### Compliance Issues: A Categorical Analysis Compliance Process

Self-Regulation – a problem before BCAR [11].

2014 - Move Away – BCAR [11], Code of Practice [6], etc.

Issues still persist:

- Weakly defined compliance process; lack of clarity in compliance tasks and sequence of activities [3].
- Level of education and training of the inspector [15].
- Data collection and analysis systems; inspector’s experience [16].
- Fragmentation of data [16].
- Regulatory regime - dispersed across multiple authorities; heavily skewed towards the inspectors/certifiers[12].



Fig 4: Issues with current compliance regime in Ireland

## Compliance Issues: A Categorical Analysis Compliance Behaviour

Construction Compliance behaviour - rarely reviewed research area.

Non-compliant behaviour is not just an incentivisation problem [17]

Individual behaviour is guided by multiple aspects including information availability, compliance capacity and willingness, and even peer effect.

Organisational attitudes – Ethical Climate Theory [18] – **Caring, Law & Code, Instrumental**

*“The consensus of organization members on ethical issues to support their ethical judgments and actions.”*

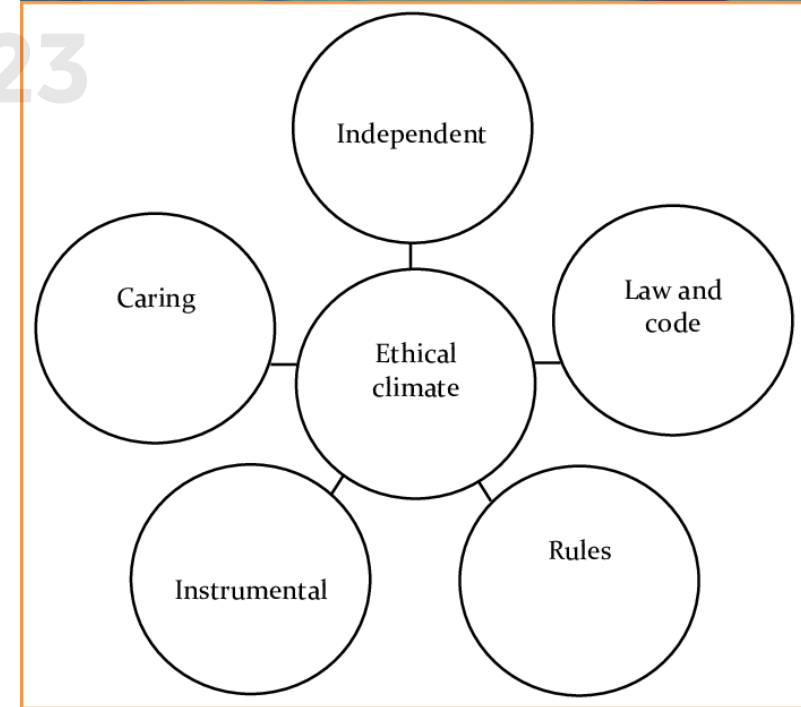


Fig 5: Ethical Climate Theory

### Compliance Issues: A Categorical Analysis Compliance Technology

4 categories based on the type of work done by the technologies: *data collection, information retrieval, progress estimation, visualization* [3].

Research in technologies include:

- Robots with 360 view capture [3]
- Basic video calls for site inspection [20]
- Integration of VR with GPS and IOT sensors [21]

Automated Compliance Inspection Workflow mapping [3], [23].

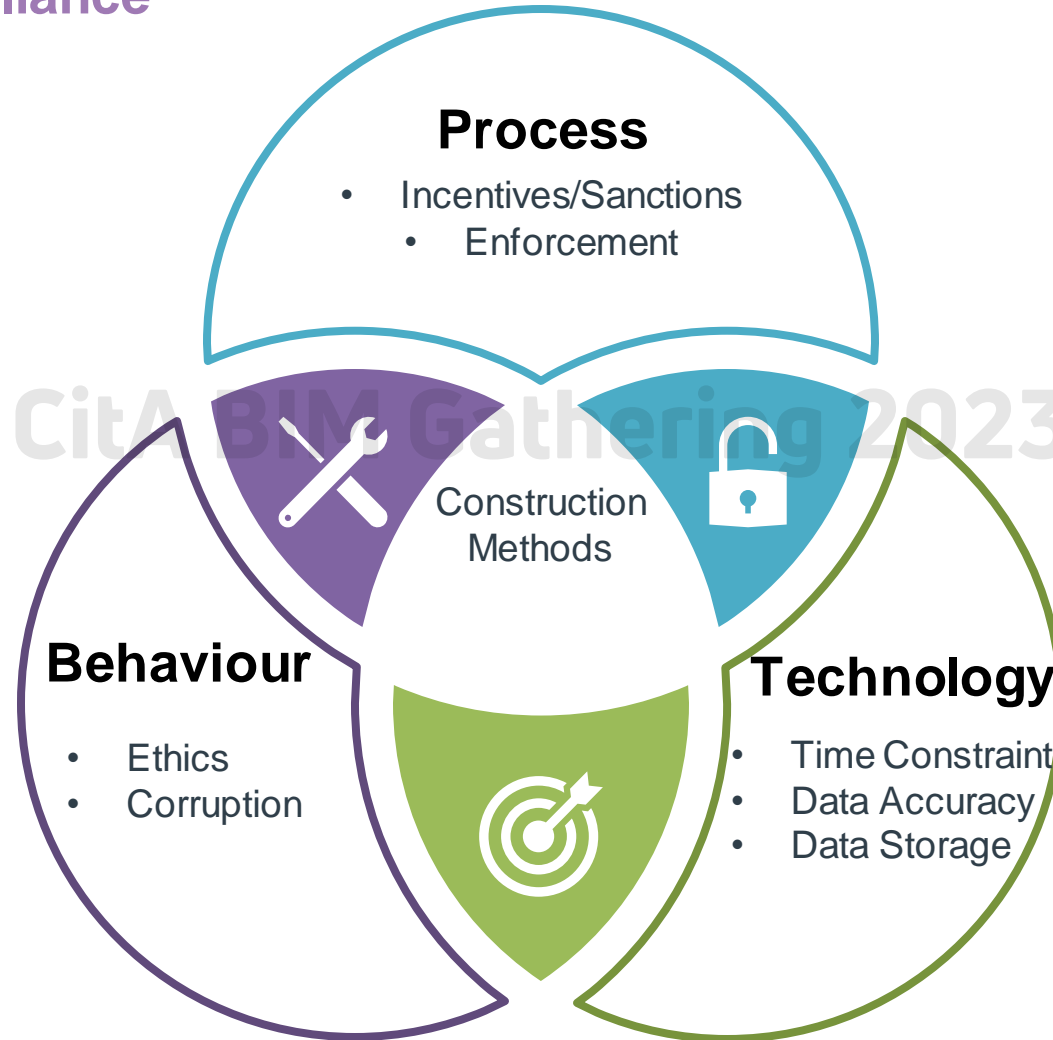



Fig 6: Technology used in Construction Compliance (clockwise)—View Capture, IOT Sensors, AR/VR, 360 view analysis

## Barriers to Efficient Compliance


**Process-Behaviour**

- Willingness



**Process-Technology** 

- Education
- Data Collection
- Resource Constraint

**Behaviour-Technology** 

- Capacity

Fig 7: Categorisation of Compliance Barriers

## Emerging Research Trends/Future Areas of Investigation

Pillar	Future Research Focus/Trends
Process	Research on robust systems, protocols, and workflows at ground levels to guide construction activities.
	Advantages and disadvantages of independent third-party compliance authority and minimising conflicts of interest among parties.
	Research on more advanced digital platforms for streamlined documentation and permit acquisition.
	Potential of blockchain technology for secure and transparent record-keeping of compliance-related activities.
Behaviour	Development of comprehensive compliance training programs for all construction personnel.
	Research on the value of reward-based system to recognize and incentivize compliant behaviour.
	Requirement of industry-wide codes of ethics to guide ethical behaviour and decision-making.
Technology	Research on breakdown of individual construction activity and relevant technology that can check its compliance
	Utilization of BIM as a gateway to check compliant data and store reports
	Research on machine learning algorithms to analyse compliance patterns and predict potential violations.
	Utilization of virtual reality (VR) and augmented reality (AR) for immersive compliance training experiences.

## Conclusion

The construction industry continues to face significant challenges in achieving compliance, leading to substantial risks, cost overruns, and compromised safety.

Understanding compliance challenges and barriers through the framework of the three pillars—*process, behaviour, and technology*—provides a comprehensive perspective.

There also exists a research gap in comprehensively understanding the barriers to automating compliance checks at sites. The discussion on digitalisation cannot be removed from the aspects of process and behaviour. By addressing these pillars conjunctively, including **enhancing procedural frameworks**, **promoting responsible behaviour**, and **leveraging technological advancements**, stakeholders can lay the foundation for making a positive impact on compliance in construction.

Further research needs to be done by carrying out surveys and interviews about the specific challenges to compliance and creating a comprehensive framework to address them. Further, digital technologies for compliance needs to be tested in simulated environments along with necessary process improvements and behaviour changes to effect change.



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A nighttime photograph of a stone bridge with multiple arches spanning a river. In the background, a large, illuminated church with a dome and two towers is visible. The scene is reflected in the calm water of the river. The sky is dark with some light clouds.

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