An Early-Intervention Framework for Controlling Cost, Schedule and Rework in Building Projects

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***Abstract*—Design changes are a persistent feature of building projects and can generate cascading effects across cost, schedule, procurement, coordination, quality and rework. Existing research has extensively examined the causes and consequences of design changes, while recent studies have increasingly explored quantitative and digital approaches for assessing their impacts.**

However, a practical need remains for a structured decision process that can be applied when a change is first proposed, before its effects propagate into construction activities.

This study develops a Design Change Early-Intervention Framework for the design–construction interface. A structured literature synthesis was undertaken using peer-reviewed research on design change, rework, change management, BIM-enabled change assessment, schedule impact and proactive risk management. The literature was thematically organized around five decision requirements: change identification, affected-scope mapping, impact assessment, decision authorization, and controlled implementation.

The resulting framework introduces seven change-management gates through which each proposed design change is screened for its cause, affected disciplines, cost exposure, schedule exposure, procurement consequences, quality implications and rework potential. The framework emphasizes multidisciplinary review before site implementation and establishes a feedback mechanism through which completed changes contribute to project learning. The study contributes a practical conceptual model linking architectural decision-making with construction project control. Future empirical research should validate the framework using project records and measurable indicators such as change-cycle time, rework hours, cost variance, schedule variance and RFI frequency.

***Index Terms*—Design change; Construction management; Change risk; Rework; Design–construction interface; Project control.**

I. INTRODUCTION

Building projects are delivered through a sequence of interdependent decisions rather than through isolated design and construction activities. Architectural requirements are translated into drawings, specifications, quantities and construction information, which are subsequently coordinated with structural, mechanical, electrical, plumbing, fire and specialist systems. Once construction begins, changes to any of these information streams can affect work already completed or activities that depend on the revised information. The management of change is therefore a central construction-management issue rather than merely an administrative task.

Design changes may be initiated by clients, designers, contractors, regulators, site conditions or other project circumstances. Earlier research has consistently associated design changes with rework, cost impacts and schedule disruption, while communication and coordination have been identified as important mechanisms for reducing their consequences [1], [2]. A recent systematic review has further demonstrated that design-change risk remains a multidimensional problem involving client requirements, organizational issues, resource constraints, construction factors, technical deficiencies, technology, sustainability and regulatory influences [3].

The practical difficulty is not simply that changes occur. The more consequential issue is the time between recognizing a proposed change and understanding its downstream consequences. A change to an architectural partition, for example, may affect doors, finishes, electrical points, HVAC distribution, fire systems, quantities, procurement and the sequence of trades. If the change is assessed only

within the discipline that originated it, secondary impacts may remain invisible until construction.

Recent research demonstrates the importance of earlier assessment. Quantitative research has examined the schedule consequences of design changes during finishing works [4], while BIM-based studies have investigated integrated change management and prediction of cost and schedule implications [5], [6]. These developments indicate a transition from reactive change administration toward proactive change decision-making.

However, advanced digital approaches may require project data, software integration and specialist skills that are not available on every building project. There is therefore value in a management framework that can be implemented conceptually even where advanced analytics are not yet available.

This study addresses that need by developing an early-intervention framework at the design–construction interface. The objective is not to eliminate legitimate design changes, but to ensure that their consequences are identified before approval and controlled before implementation.

II. RESEARCH AIM, OBJECTIVES AND QUESTIONS

2.1 Research Aim

The aim of this study is to develop an early-intervention framework for managing design changes at the design–construction interface and controlling their potential effects on cost, schedule and rework in building projects.

2.2 Research Objectives

The objectives are:

1. To synthesize current knowledge on design-change causes, impacts and management practices in building projects.
2. To identify the information required to assess a proposed design change before construction implementation.
3. To map design changes to their potential cost, schedule, procurement, quality and rework consequences.
4. To develop a stage-gated framework for multidisciplinary change assessment and authorization.
5. To identify how BIM and related digital tools can support, but not replace, construction-management decision-making.

2.3 Research Questions

RQ1: What project information is required to assess a design change before it is implemented?

RQ2: How can the potential cost, schedule, procurement, quality and rework impacts of a design change be evaluated at the design–construction interface?

RQ3: How can a stage-gated intervention process reduce uncontrolled propagation of design changes?

RQ4: How can BIM and digital information management support the proposed process?

III. LITERATURE REVIEW

3.1 Design Changes as a Project-Control Problem

Design change is not inherently negative. Changes may improve functionality, respond to regulations, correct errors, accommodate site discoveries, improve constructability or satisfy legitimate client requirements.

The project-control problem arises when changes are introduced without sufficient assessment of their effects. Aslam et al. examined design changes and their relationship with construction cost, while Yap et al. investigated design changes and collaborative management mechanisms [1], [2].

The literature indicates that a change should therefore be treated as a project event requiring structured assessment rather than simply as a revised drawing.

3.2 Design Change, Rework and Project Performance

Rework represents one of the major pathways through which design changes affect project performance. When construction work has already been completed, a design revision may require demolition, modification or repetition.

Even when physical rework is avoided, a change can generate indirect work including:

- Drawing revisions;
- Additional approvals;
- Procurement changes;
- Rescheduling;
- Additional coordination;

- Revised quantities;
- Additional inspections; and
- Contractual administration.

Research on rework has identified design-related factors among important contributors to project-performance problems [7], while earlier research has established the relationship between project characteristics and rework cost [10].

Therefore, design-change assessment should consider both direct change cost and secondary rework exposure.

3.3 Proactive Change Management

Proactive change management seeks to evaluate the probability and consequences of a change before it becomes a disruptive event.

Abad et al. proposed a proactive change-management approach using risk assessment and fuzzy fault-tree analysis [8]. Motawa et al. developed an integrated change-management system emphasizing structured information and change tracking [9].

These studies indicate that change management can move beyond simple approval tracking toward explicit risk assessment.

3.4 BIM and Design-Change Assessment

Building Information Modelling provides a digital representation through which affected components and relationships can be examined.

Recent research has investigated integrated 4D design-change management, linking change information with construction progress [5]. Other research has explored BIM and machine learning for predicting cost and schedule implications of design changes [6].

The potential advantages include:

- Visualization of affected elements;
- Clash and interface identification;
- Quantity extraction;
- Schedule linkage;
- Improved communication;
- Change traceability; and
- Historical data development.

However, BIM does not itself make the management decision. The quality of the decision remains dependent on the quality of information, responsibilities and governance.

IV. RESEARCH GAP

Recent literature has substantially improved understanding of the causes and consequences of design changes.

A 2026 systematic review identified multiple categories of design-change risk [3]. Quantitative research has investigated schedule effects [4], while BIM research has addressed change tracking and prediction [5], [6].

Therefore, the research gap addressed in this study is not simply the identification of design-change causes. Instead, the gap lies at the decision interface between design and construction:

How can information about a proposed design change be systematically converted into an early project-control decision before the change propagates into construction?

The proposed study addresses this gap through a structured early-intervention framework.

V. METHODOLOGY

5.1 Research Approach

The study adopts a structured literature-synthesis and conceptual framework-development approach.

The research does not claim a primary survey, experimental dataset or statistical validation. This is important because project-performance data should not be fabricated in the absence of verified project records.

5.2 Literature Identification

Literature was identified using research themes including:

- Design change in construction;
- Construction change management;
- Design-change risk;
- Construction rework;
- Cost impact;
- Schedule impact;
- Bim-based change management;
- Proactive change management; and
- Construction project control.

Priority was given to peer-reviewed research and recent publications, supported by established foundational studies.

5.3 Thematic Analysis

The literature was organized into five major themes:

1. Causes and triggers of change;
2. Propagation pathways;
3. Project impacts;
4. Existing control mechanisms; and
5. Digital support mechanisms.

These themes were then translated into management requirements for an early-intervention process.

5.4 Framework Development

The proposed framework was developed by mapping these requirements into seven management gates:
Change Capture → Scope Mapping → Impact Screening → Multidisciplinary Review → Decision & Authorization → Controlled Implementation → Closure & Learning

VI. RESULTS

6.1 Thematic Findings

Table I. Thematic findings and management implications.

Theme	Literature finding	Management implication
Change triggers	Client, design, technical, organizational, construction and regulatory factors repeatedly appear in research	Every change should be classified by cause
Propagation	A design decision can affect several disciplines and work packages	Cross-disciplinary assessment is necessary
Cost	Changes may affect quantities, labour, materials and procurement	Cost assessment should precede approval
Schedule	Late changes can interfere with ongoing activities	Programme impact must be assessed
Rework	Changes may require modification or removal of completed work	Existing work must be checked
Communication	Poor information flow can amplify change impacts	A controlled information trail is required
Digital support	BIM/4D/BIM-ML can improve impact visibility	Digital tools should support management decisions

VII. PROPOSED DESIGN CHANGE EARLY-INTERVENTION FRAMEWORK

The principal contribution of this study is the Design Change Early-Intervention Framework (DCEIF).
The framework contains seven gates.

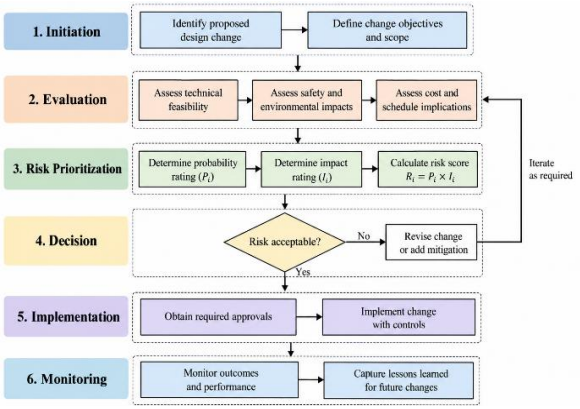

Fig. 1. Proposed framework for the evaluation and management of design changes in building projects.

Gate 1 — Change Capture

Every proposed change should first be formally captured.

Minimum information should include:

- Change description;
- Initiating party;
- Reason for change;
- Affected drawing/model;
- Required implementation date;
- Current construction status; and
- Urgency.

Gate 2 — Scope Mapping

The change should then be mapped across all potentially affected disciplines.

These may include:

- Architecture;
- Structural engineering;

- Electrical systems;
- Hvac;
- Plumbing;
- Fire protection;
- Vertical transportation;
- Specialist systems;
- Finishes;
- Procurement; and
- Construction sequencing.

Gate 3 — Impact Screening
The proposed change should be assessed against:
1. Cost;
2. Schedule;
3. Procurement;
4. Rework;
5. Quality;
6. Safety;
7. Coordination; and
8. Contractual implications.

Gate 4 — Multidisciplinary Review
The relevant project stakeholders should review the change.
Depending on the change, this may include:
- Architect;
- Structural consultant;
- Mep consultants;
- Bim coordinator;
- Contractor;
- Quantity surveyor/cost manager;
- Planning engineer;
- Procurement team; and
- Project manager.

Gate 5 — Decision and Authorization
The change should be categorized as:
- Approve
- Reject
- Defer
- Modify and reassess

No significant change should proceed to construction without the required authorization.

Gate 6 — Controlled Implementation
After approval:
- Drawings must be revised;
- Bim models should be updated where applicable;
- Specifications should be revised;
- Quantities should be updated;
- Programme impacts should be incorporated;
- Procurement changes should be communicated; and
- Site instructions should be formally issued.

Gate 7 — Closure and Learning
After implementation:
- Physical completion should be verified;
- Actual cost impact should be recorded;
- Actual schedule impact should be recorded;
- Rework should be documented;
- Approvals should be closed; and
- Lessons learned should be entered into the project change register.

This creates a feedback loop for future projects.

VIII. IMPACT ASSESSMENT MATRIX

Table II. Design change impact assessment matrix.

Impact dimension	Questions before approval	Evidence/ record
Cost	What quantities, rates, labour and procurement packages change?	Revised estimate
Schedule	Which activities move, stop or require additional work?	Updated programme
Procurement	Have materials already been ordered or fabricated?	Procurement status
Rework	What completed work must be removed or modified?	Site inspection
Quality	Do specifications, testing or approvals change?	Revised specification
Coordination	Which disciplines/interfaces are affected?	BIM/model coordination
Contract	Does the change affect scope or responsibility?	Change order

IX. CHANGE-RISK PRIORITIZATION

A qualitative risk score can be used as an initial screening mechanism:

$$Ri=Pi \times Ii \quad \{1\}$$

Risk Priority = Probability × Impact

where (Ri) is the risk priority score for change (i), (Pi) is the probability rating, and (Ii) is the impact rating. Both Probability & Impact may be rated from 1 to 5.

Table III. Proposed design change risk screening matrix.

Score	Risk level	Recommended action
1–4	Low	Routine discipline review
5–9	Moderate	Multidisciplinary review
10–16	High	Formal impact assessment
17–25	Critical	Senior approval and mitigation

This matrix is proposed as a management screening tool, not as a statistically validated predictive model.

X. REPRESENTATIVE HIGH-RISE BUILDING APPLICATION

To demonstrate the framework, a representative high-rise residential building is considered.

The building includes:

- Architectural systems;
- Structural systems;
- Electrical systems;
- HVAC;
- Plumbing;
- Fire protection; and
- Vertical transportation.

Assume that during the finishing stage, the client requests a revision to a typical apartment kitchen and utility layout.

At first sight, this appears to be an architectural change.

However, the framework identifies several secondary consequences.

Table IV. Illustrative application of the DCEIF.

Stage	Issue	Required action
Change capture	Client requests revised kitchen	Record formal change
Scope mapping	Walls, doors, finishes affected	Identify affected elements
Interface check	Electrical/plumbing points shift	Coordinate MEP
Schedule check	Finishing work already programmed	Assess programme impact
Procurement	Joinery/sanitary items may be ordered	Check procurement status
Rework	Blockwork/plaster may be complete	Assess demolition/rework
Decision	Cost and programme exposure identified	Management approval
Implementation	Approved revision issued	Update information
Closure	Work completed	Inspect and record actual impact

This example demonstrates that an apparently small architectural decision may propagate across multiple construction-management functions.

XI. DISCUSSION

The literature indicates that design changes are a longstanding construction-management problem, but the management challenge is evolving.

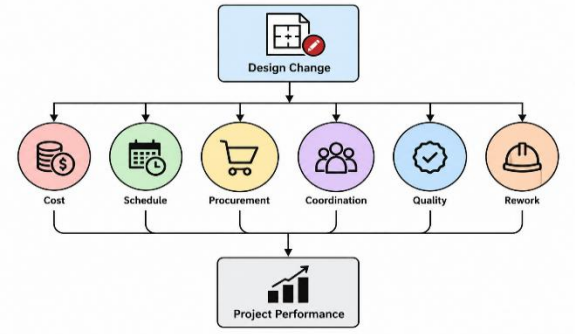

Fig. 2. Propagation of design change impacts on project performance.

Earlier research concentrated heavily on causes, cost and schedule impacts. More recent research increasingly examines:

- Proactive risk assessment;
- Bim-enabled change tracking;
- 4d schedule analysis;
- Predictive analytics; and
- Machine-learning-based impact prediction.

The proposed framework connects these strands by converting research findings into a practical decision sequence.

The first important principle is that a design change should be treated as a controlled project event, not simply as a revised drawing.

The second principle is that the originating discipline should not be the only discipline involved in assessing the change.
The third principle is that the project team should understand consequences before authorization, rather than discovering them after construction begins.
The fourth principle is that BIM should be treated as an enabling mechanism, rather than as a replacement for project governance.

XII. PRACTICAL IMPLICATIONS

For architects
Architects should consider downstream construction interfaces whenever issuing or revising design information.

For project managers
Project managers should require documented impact assessment before approving significant post-design changes.

For contractors
Contractors should link change requests with:
- Work packages;
- Site progress;
- Procurement;
- Subcontractor activities; and
- Construction sequence.

For cost managers
Cost teams should assess both:

Direct variation cost + secondary cost/rework exposure.
For BIM coordinators
BIM coordinators can help identify:
- Affected elements;
- Clashes;
- Interfaces;
- Quantities; and
- Schedule relationships.

For organizations
Organizations should retain completed change information as a knowledge base for future projects.

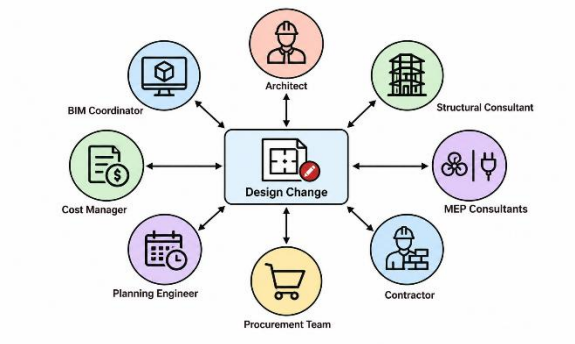

Fig. 3. Multidisciplinary review for design change assessment.

XIII. LIMITATIONS

This study is conceptual and literature-based.
It does not statistically validate the proposed framework or quantify its effect on project performance.
The high-rise building scenario is illustrative and is not presented as empirical evidence from a confidential project.

The qualitative risk matrix is a management-screening mechanism rather than a validated predictive model.
Future empirical research should test the framework using real project change registers from multiple building projects.

XIV. FUTURE RESEARCH

Future research can operationalize the framework using project databases containing:
- Change type;
- Initiating party;
- Discipline;
- Location;
- Timing;
- Cost impact;
- Schedule impact;
- Procurement status;
- Rework;
- Approval duration; and
- Final project outcome.

These variables could subsequently support statistical analysis or machine-learning models.

BIM-based implementation could connect change requests directly to:

- Model objects;
- Work packages;
- Schedule activities;
- Quantities; and
- Procurement records.

Longitudinal research could determine whether repeated use of the framework reduces:

- Change-cycle time;
- Rfi frequency;
- Rework hours;
- Cost variance; and
- Schedule variance.

XV. CONCLUSION

Design changes cannot be completely eliminated from building projects because requirements, regulations, site conditions, constructability considerations and stakeholder decisions continue to evolve.

The objective of construction management should therefore not be to eliminate every change, but to prevent uncontrolled propagation of change.

This study developed a Design Change Early-Intervention Framework for the design–construction interface.

The framework consists of seven gates:

1. Change Capture
2. Scope Mapping
3. Impact Screening
4. Multidisciplinary Review
5. Decision and Authorization
6. Controlled Implementation
7. Closure and Learning

The framework integrates cost, schedule, procurement, quality, rework, coordination and contractual considerations within a single decision process.

Its contribution is therefore not another classification of design-change causes. Instead, it translates existing research into a practical decision structure that can be applied by architects, consultants, contractors and project managers.

BIM and other digital tools can strengthen the framework by improving traceability and impact visibility. However, the central requirement remains disciplined project governance.

Empirical validation using real project data is recommended before claiming quantitative improvements in project performance.

ACKNOWLEDGMENT

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REFERENCES

[1] M. Aslam, E. Baffoe-Twum, and F. Saleem, “Design changes in construction projects—causes and impact on the cost,” Civil Engineering Journal, vol. 5, no. 7, pp. 1647–1655, Jul. 2019, doi: 10.28991/cej-2019-03091360.

[2] J. B. H. Yap, H. Abdul-Rahman, and C. Wang, “Collaborative model: Managing design changes with reusable project experiences through project learning and effective communication,” International Journal of Project Management, vol. 35, no. 7, pp. 1253–1271, Oct. 2017, doi: 10.1016/j.ijproman.2017.04.010.

[3] M. A. N. Ismail, C. K. I. Che Ibrahim, S. Belayutham, and A. H. Mohamad, “Contributing factors leading to design changes risk in civil engineering projects: A systematic review,” Engineering, Construction and Architectural Management, 2026, doi: 10.1108/ECAM-08-2025-1324.

[4] S. H. Kim and Y. S. Kim, “Quantitative analysis of schedule impact due to design changes in finishing construction work: A case study of office buildings,” KSCE Journal of Civil Engineering, vol. 30, no. 2, Art. no. 100362, Feb. 2026, doi: 10.1016/j.kscej.2025.100362.

[5] L. Wang, J. Lee, J. Nimawat, K. Han, and A. Gupta, “Integrated 4D design change management model for construction projects,” Journal of Construction Engineering and Management, vol. 150, no. 5, Art. no. 04024023, 2024, doi: 10.1061/JCEMD4.COENG-14246.

[6] B. S. Abdulfattah, H. A. Abdelsalam, M. Abdelsalam, M. Bolpagni, N. Thurairajah, L. Florez Perez, and T. E. Butt, “Predicting implications of design changes in BIM-based

construction projects through machine learning," Automation in Construction, vol. 155, Art. no. 105057, Nov. 2023, doi: 10.1016/j.autcon.2023.105057.

[7] A. M. Al-Janabi, M. S. Abdel-Monem, and K. M. El-Dash, "Factors causing rework and their impact on projects' performance in Egypt," Journal of Civil Engineering and Management, vol. 26, no. 7, pp. 666–689, 2020, doi: 10.3846/jcem.2020.12916.

[8] F. Abad, E. Eshtehardian, and K. Taghizade, "Framework for proactive change management: Assessing the risk of change in construction projects using fuzzy fault tree analysis," Journal of Architectural Engineering, vol. 25, no. 2, 2019, doi: 10.1061/(ASCE)AE.1943-5568.0000358.

[9] I. A. Motawa, C. J. Anumba, S. Lee, and F. Peña-Mora, "An integrated system for change management in construction," Automation in Construction, vol. 16, no. 3, pp. 368–377, May 2007, doi: 10.1016/j.autcon.2006.07.005.

[10] P. E. D. Love, "Influence of project type and procurement method on rework costs in building construction projects," Journal of Construction Engineering and Management, vol. 128, no. 1, pp. 18–29, Feb. 2002, doi: 10.1061/(ASCE)0733-9364(2002)128:1(18).

[11] J. B. H. Yap and M. Skitmore, "Investigating design changes in Malaysian building projects," Architectural Engineering and Design Management, vol. 14, no. 3, pp. 218–238, 2018, doi: 10.1080/17452007.2017.1384714.

[12] B.-G. Hwang, X. Zhao, and K. J. Goh, "Investigating the client-related rework in building projects: The case of Singapore," International Journal of Project Management, vol. 32, no. 4, pp. 698–708, 2014.

[13] O. S. Dosumu and C. O. Aigbavboa, "Impact of design errors on variation cost of selected building projects in Nigeria," Procedia Engineering, vol. 196, pp. 847–856, 2017, doi: 10.1016/j.proeng.2017.08.016.

[14] A. S.-T. Chang, "Reasons for cost and schedule increase for engineering design projects," Journal of Management in Engineering, vol. 18, no. 1, pp. 29–36, Jan. 2002, doi: 10.1061/(ASCE)0742-597X (2002)18:1(29).

[15] S. Han, P. E. D. Love, and F. Peña-Mora, "A system dynamics model for assessing the impacts of design errors in construction projects," Mathematical and Computer Modelling, vol. 57, nos. 9–10, pp. 2044–2053, May 2013, doi: 10.1016/j.mcm.2011.06.039.

EQUATION

$$R_i = P_i \times I_i \quad \{1\}$$

where (R_i) is the risk priority score, (P_i) is the probability rating, and (I_i) is the impact rating.

AUTHOR DECLARATION

Funding: No external funding was received for this study.

Conflict of Interest: The author declares no known conflict of interest.

Data Availability: This study does not use a primary empirical dataset. The analysis is based on published literature and an illustrative application developed for framework demonstration.

Ethical Considerations: The study does not involve human participants, personal data or confidential project records.

Generative AI Disclosure: Generative artificial intelligence tools were used for language drafting, formatting support and figure-development assistance. The author is responsible for verifying the literature, methodology, interpretation, originality and final submitted manuscript.