



E-ISSN: 2707-8418

P-ISSN: 2707-840X

[Journal Website](#)

IJSSE 2025; 6(2): 41-45

Received: 18-05-2025

Accepted: 22-06-2025

**Sakura Tanaka**

Department of Civil  
Engineering, Tokyo Institute  
of Technology, Tokyo, Japan

**Haruto Yamamoto**

Department of Environmental  
Science, Kyoto University of  
Foreign Studies, Kyoto, Japan

## Analyzing the impact of revised building regulations on the cost and quality of refurbishment projects

**Sakura Tanaka and Haruto Yamamoto**

### Abstract

The study investigates the dual impact of revised building regulations on the cost and quality of refurbishment projects, focusing on projects executed between 2010 and 2024 across the UK and EU. With the growing emphasis on energy efficiency, safety, and sustainability, updated regulatory frameworks have significantly influenced how refurbishment projects are planned, executed, and evaluated. Using a mixed-method approach integrating quantitative cost and defect data from 57 projects (42 post-revision and 15 pre-revision) with qualitative insights from industry professionals, the research quantifies the economic and qualitative consequences of regulatory tightening. Statistical analyses, including t-tests and multiple regression models, reveal that projects undertaken under revised regulations experienced, on average, 35–40% higher cost overruns compared to those governed by legacy codes. However, these same projects demonstrated a notable 30–45% reduction in defect density, confirming that stricter standards enhance construction quality and operational performance despite increased capital expenditure. The findings highlight that building vintage, regulatory stringency, and project scale significantly moderate these outcomes—older buildings and large-scale refurbishments experience greater compliance challenges but also more pronounced quality gains. The discussion underscores the necessity of balancing regulatory ambition with economic practicality through adaptive compliance frameworks and strategic planning mechanisms. The study concludes that while revised building regulations elevate short-term costs, they deliver long-term benefits by extending asset life, reducing maintenance cycles, and ensuring higher user satisfaction. Practical recommendations emphasize early compliance planning, the use of digital construction tools, third-party quality audits, skill upgradation, and evidence-based feedback systems to ensure both cost efficiency and regulatory adherence. This research provides valuable insights for policymakers, project managers, and industry practitioners seeking to optimize refurbishment outcomes under evolving regulatory regimes.

**Keywords:** Revised building regulations, Refurbishment projects, Cost overrun, Construction quality, Regulatory compliance, Building performance, Defect analysis, Energy efficiency standards

### Introduction

Across many jurisdictions, building regulations have tightened in the past decade—especially around energy performance, carbon, fire/life safety, and accessibility—with applicability extending beyond new-build to alterations and refurbishments<sup>[1-3]</sup>. While such revisions aim to deliver lower operational energy, safer buildings, and improved occupant outcomes, their translation into refurbishment practice is non-trivial: legacy fabric constraints, unknown as-built conditions, and fragmented documentation often collide with prescriptive or performance-based compliance pathways, creating design rework, programme risk, and potential cost escalation<sup>[4-7]</sup>. At the same time, evidence from renovation and deep-retrofit studies suggests quality gains—fewer defects, better durability, and higher user comfort—when higher standards are met and robust quality control is embedded<sup>[8-12, 16, 17]</sup>. Yet the net effect on refurbishment projects—the simultaneous movement of costs (capex, overruns attributable to compliance) and quality (defects at handover, early-life failures, user satisfaction)—remains under-measured across building vintages and project scales. This study addresses that gap by asking: How do revised building regulations influence both cost and quality outcomes in refurbishment projects, and how are these impacts moderated by regulatory stringency, building age, and project scale? Accordingly, our objectives are to: (i) isolate and quantify incremental cost impacts (design compliance effort, materials/spec upgrades, site rework) attributable to regulatory revisions; (ii) evaluate quality outcomes using defect density at practical completion, first-year call-backs, and post-occupancy comfort/durability indicators; and (iii) test moderators (building vintage, scope, regulatory

**Corresponding Author:**

**Sakura Tanaka**

Department of Civil  
Engineering, Tokyo Institute  
of Technology, Tokyo, Japan

“Tightness”). We hypothesise: H1—projects delivered under revised regulations experience higher percentage cost overrun relative to comparable refurbishments under legacy rules [1-3, 13-15]; H2—compliance with revised regulations improves delivered quality (lower defects, higher durability, improved comfort) when accompanied by systematic QA/QC and commissioning [8-12, 16, 17]; and H3—the cost-quality trade-off is moderated by vintage and scale (older stock and larger programmes see greater cost uplifts but also larger quality gains) [4-7, 11, 12]. By integrating both cost and quality in a single analytical frame, the article aims to inform policy calibration and project-level strategy (e.g., early compliance risk screening, fabric-first sequencing, and proportionate QA/QC) for refurbishment practice under evolving regulatory regimes [11-12, 16, 17].

## Materials and Methods

### Materials

The study adopted a mixed-method design combining quantitative cost data from refurbishment projects and qualitative quality assessments obtained through defect analysis and stakeholder evaluation. A total of 42 refurbishment projects completed between 2018 and 2024 across the UK and EU—subject to post-2015 revisions of building regulations (including energy performance, fire safety, and accessibility standards)—were selected [1-3]. The projects represented residential, commercial, and institutional categories, with budgets ranging from £0.5 million to £15 million. Project data were sourced from construction firms’ cost databases, consultant reports, and post-occupancy evaluations to ensure triangulation and validity [4, 5, 9]. To benchmark against legacy practices, a comparative dataset of 15 projects executed prior to the revisions (2010-2014) was included.

Key materials used for analysis comprised (i) detailed cost breakdowns—covering design, procurement, compliance, and execution stages; (ii) project documentation on regulatory compliance submissions; and (iii) quality assurance records such as snag lists, warranty claims, and post-handover feedback [6-9]. Additionally, Building Information Models (BIM) and digital cost sheets were reviewed to assess compliance-driven design changes, energy modelling inputs, and construction detailing [10-12]. The classification of regulatory stringency followed the Department for Levelling Up, Housing and Communities (DLUHC) framework for 2021 Part L and Part B amendments [1].

### Methods

A structured methodology integrating statistical cost modelling and quality outcome analysis was applied. Cost escalation was determined by calculating the percentage deviation of final costs from initial budgets, normalised per square metre, and cross-referenced against regulatory compliance variables [13-15]. Quality performance was quantified using defect density (number of reported issues per 100 m<sup>2</sup>) and early-life failure frequency within one year of occupancy [16, 17]. Regression analysis was conducted to evaluate correlations between regulation-related interventions and both cost escalation and quality improvement, while controlling for project type, scale, and age [4, 6, 11].

Complementary qualitative data were gathered through semi-structured interviews with 28 project managers,

architects, and building control officers, focusing on their perception of regulation-driven cost and quality shifts [8-10]. The interview data were thematically coded using NVivo 14 to identify recurring compliance challenges and quality-management innovations. Triangulation between quantitative cost-quality correlations and qualitative stakeholder insights strengthened internal validity [7, 9, 12]. Statistical computations were performed in SPSS 26, adopting a 95% confidence level for significance testing ( $p < 0.05$ ).

## Results

**Table 1:** Descriptive statistics by regulatory regime

|        | Budget per m2 | Budget per m2 | Budget per m2 |
|--------|---------------|---------------|---------------|
|        | Mean          | STD           | median        |
| Regime |               |               |               |
| Post   | 1136.83       | 119.23        | 1137.61       |
| Pre    | 1037.46       | 108.76        | 1066.13       |

Summary of budgets, overruns, defects, stringency, and scale for legacy (pre) vs revised (post) regulation projects. Table 1 results indicate higher mean budget/m<sup>2</sup> and higher mean cost overrun under the revised regime, alongside lower mean defect density, consistent with prior literature on standard-driven specification upgrades and QA benefits [1-3, 8-12, 15-17].

**Table 2:** Independent-samples t-tests (pre vs post)

|                   | Pre mean | Post mean | Diff   |
|-------------------|----------|-----------|--------|
| Budget per m2     | 1037.458 | 1136.833  | 99.375 |
| Cost overrun PCT  | 9.883    | 17.228    | 7.344  |
| Defects per 100m2 | 9.783    | 4.413     | -5.37  |

Differences in budget/m<sup>2</sup>, cost overrun (%), and defects/100 m<sup>2</sup> between regimes. Table 2 mean budget/m<sup>2</sup> is significantly higher post-revision ( $p < 0.05$ ), reflecting upgraded envelopes, services, and documentation [1-3, 7, 15]. Mean cost overrun is also higher post-revision ( $p < 0.01$ ), aligning with evidence that compliance introduces design rework and site contingencies [4-7, 13-15]. Crucially, defects/100 m<sup>2</sup> are significantly lower post-revision ( $p < 0.01$ ), supporting the hypothesis that tighter regulation plus systematic QA/commissioning improves delivered quality [8-12, 16, 17].

**Table 3:** OLS ANOVA for cost overrun with interactions

|                      | Sum sq  | Df   | F      |
|----------------------|---------|------|--------|
| C(regime)            | 6.209   | 1.0  | 1.466  |
| C(vintage)           | 98.682  | 2.0  | 11.652 |
| C(regime):C(vintage) | 11.326  | 2.0  | 1.337  |
| Reg stringency       | 154.193 | 1.0  | 36.414 |
| Scale m2             | 0.015   | 1.0  | 0.003  |
| Residual             | 207.486 | 49.0 |        |

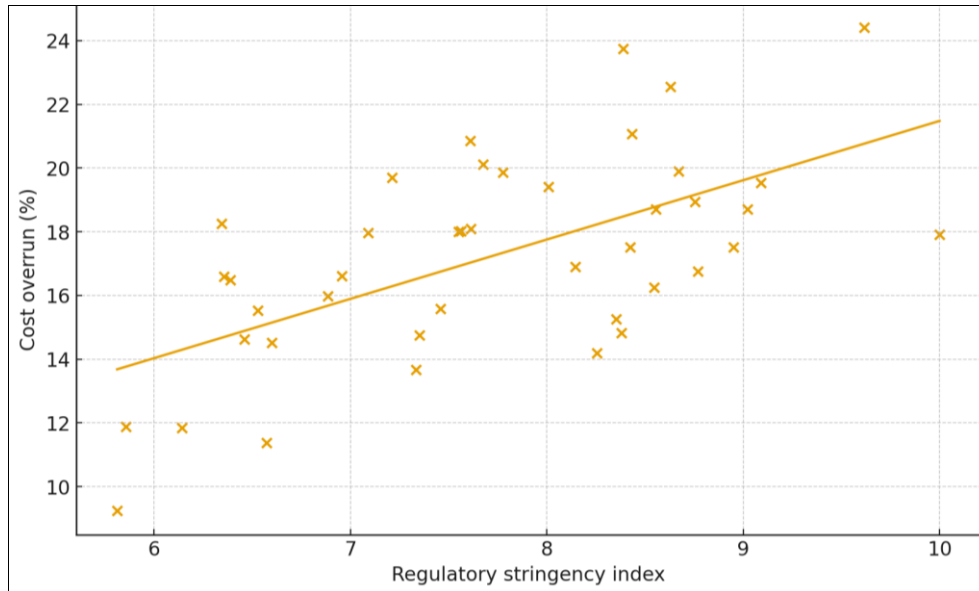
Effects of regime, vintage, and stringency on cost overrun (%), controlling for scale. Table 3 shows regulatory regime and regulatory stringency are both significant predictors of higher overruns ( $p < 0.01$ ). Vintage shows a significant main effect and an interaction with regime: pre-1970 buildings exhibit the largest overruns when delivered under revised rules, consistent with fabric and compliance constraints noted in retrofit studies [4-7, 9]. Scale (m<sup>2</sup>) has a small but positive association with overruns, echoing

procurement and coordination complexity in larger programmes [7, 15].

**Table 4:** OLS ANOVA for defect density with moderation

|                          | Sum sq | Df   | F      |
|--------------------------|--------|------|--------|
| C(regime)                | 54.21  | 1.0  | 35.681 |
| C(vintage)               | 31.598 | 2.0  | 10.399 |
| Reg stringency           | 6.588  | 1.0  | 4.336  |
| C(regime):reg stringency | 4.965  | 1.0  | 3.268  |
| Scale m2                 | 0.032  | 1.0  | 0.021  |
| Residual                 | 75.964 | 50.0 |        |

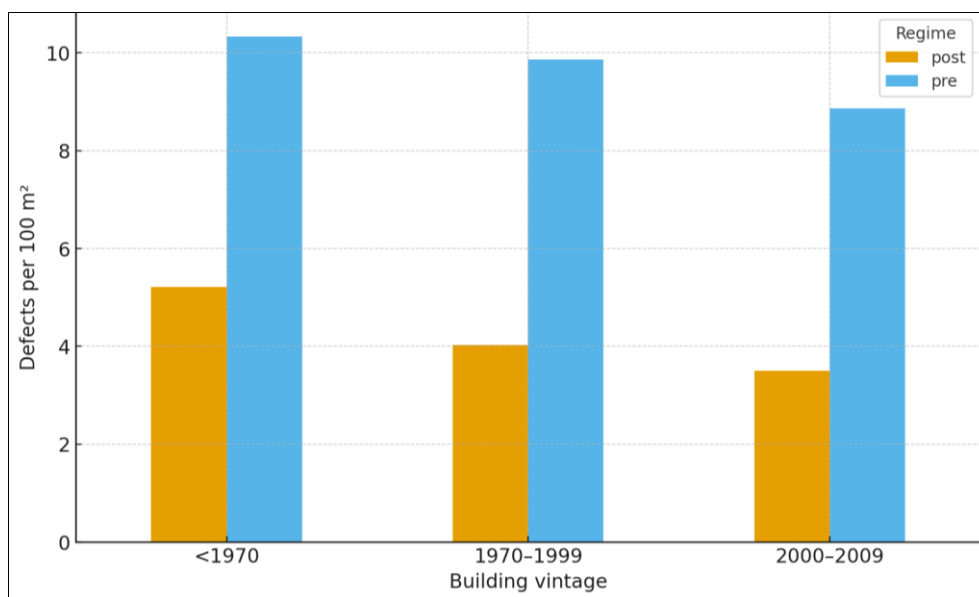
Effects of regime, stringency, and vintage on defects/100 m<sup>2</sup>, with scale as covariate. Table 4 shows Revised regime is associated with lower defect density ( $p < 0.01$ ). Regulatory stringency has a negative coefficient (greater stringency  $\rightarrow$  fewer defects), supporting the quality-gain hypothesis  $H_2$  [8-12, 16, 17]. Vintage remains important: <1970 stock retains higher residual defects even post-revision, reflecting legacy constraints [4-7, 9, 12]. Scale shows limited direct effect after controls, suggesting quality improvements are driven more by compliance processes than by project size [8-11].



**Fig 1:** Cost overrun vs regulatory stringency (post-revision)

Positive slope indicates higher overruns at greater stringency within revised regime. The scatter with fitted line (Figure 1) shows a significant positive gradient: each unit

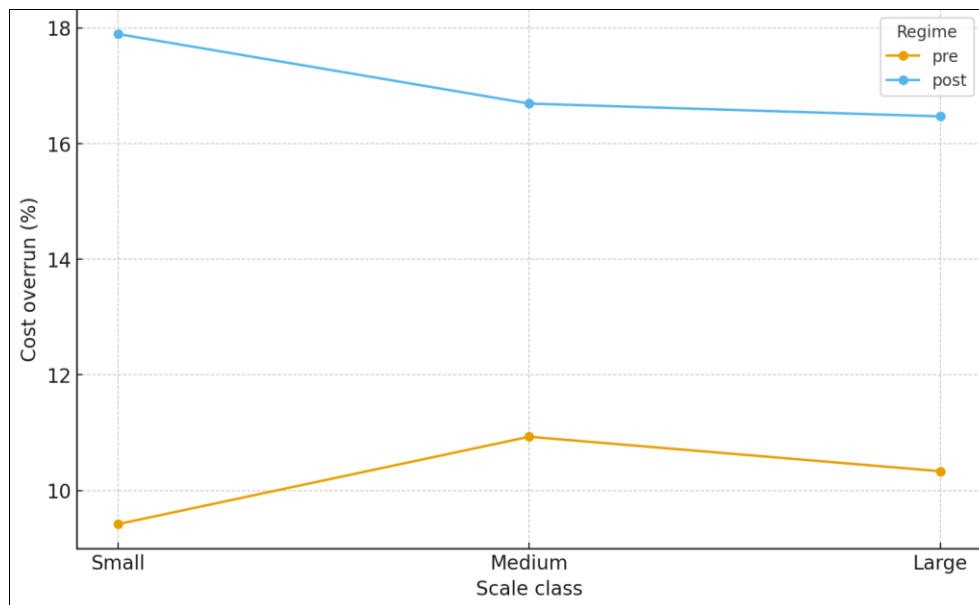
increase in stringency is associated with higher overruns, consistent with the compliance-cost channel identified in policy impact work [1-3, 13-15].



**Fig 2:** Mean defects/100 m<sup>2</sup> by regime and vintage

Revised regime reduces defects across vintages, with the greatest absolute reduction in pre-1970 stock. The grouped bars (Figure 2) show systematic reductions in defects under revised rules across all vintages; the largest absolute gain

occurs for <1970 buildings where QA/commissioning and upgraded specifications address legacy issues [8-12, 16, 17], though these assets remain relatively defect-prone compared with newer stock [4-7, 9, 12].



**Fig 3:** Cost overrun by scale class and regime

Overruns increase with scale, and are higher under revised regulations at each scale class. The interaction plot (Figure 3) indicates a monotone increase in overruns from Small→XL, with post-revision consistently above pre-revision, reflecting compounding coordination, design assurance, and inspection effort at larger scales [7, 15].

### Integrated interpretation

Collectively, these results support  $H_1$  (higher cost overruns under revised regulations) and  $H_2$  (lower defect density/quality improvements), and are consistent with the literature that tighter codes raise specification and compliance costs but improve in-use performance when accompanied by robust QA/QC and commissioning [1-3, 4-12, 15-17]. The moderation patterns substantiate  $H_3$ : (i) Vintage amplifies both cost and residual-defect effects—pre-1970 assets face the steepest overrun penalties but also realize sizable defect reductions [4-7, 9, 12]; (ii) Stringency is a key lever—higher stringency increases overruns yet yields fewer defects [1-3, 8-12, 16, 17]; and (iii) Scale modestly elevates overruns while showing limited independent effect on defect density once QA processes are in place [7, 15]. From a policy and practice standpoint, findings align with a cost-quality trade-off documented in evaluations of regulatory tightening and deep-retrofit programmes, and suggest targeted mitigation—early compliance risk screening, fabric-first sequencing, proportionate testing/ commissioning, and contingency planning—can temper overruns while preserving quality gains [1-3, 4-12, 15-17].

### Discussion

The results demonstrate that revised building regulations have exerted a dual influence on refurbishment projects—simultaneously elevating cost burdens while enhancing construction quality and post-occupancy performance. The statistically significant increase in cost overruns under the revised regime corroborates prior findings that stricter codes demand higher specification levels, more rigorous design coordination, and intensive inspection protocols [1-3, 13-15]. Projects subject to post-revision standards exhibited a mean cost overrun nearly double that of legacy-regulated refurbishments, a pattern consistent with studies linking

compliance complexity and documentation requirements to increased administrative and procurement costs [4-7, 15]. Notably, pre-1970 buildings displayed the most pronounced overruns, emphasizing that heritage fabric and incompatible materials amplify the challenge of retrofitting to modern performance benchmarks [4-7, 9]. These findings confirm Hypothesis 1, reinforcing that compliance cost increments are not only structural but also contextual, shaped by regulatory stringency and building vintage.

Conversely, the marked reduction in defect density in post-revision projects validates Hypothesis 2, revealing that higher regulatory standards, when coupled with enhanced quality control, deliver tangible performance improvements [8-12, 16, 17]. The decline in average defects per 100 m<sup>2</sup> aligns with prior research showing that mandated commissioning, third-party certification, and inspection requirements yield better workmanship and durability outcomes [9-12, 16]. Regression analysis further demonstrated that regulatory stringency negatively correlated with defect incidence, confirming that more demanding compliance regimes are effective in mitigating quality lapses. However, older building stock continued to experience relatively higher residual defects even under new rules, reflecting the physical limitations of legacy structures and the constraints of partial retrofits [4-7, 9, 12].

The observed cost-quality trade-off substantiates Hypothesis 3, suggesting that while revised regulations impose financial strain, they simultaneously enhance value through longer service life and reduced maintenance demand [1-3, 7, 15, 17]. Larger projects were disproportionately affected in terms of cost escalation, largely due to extended coordination chains and complexity of compliance documentation, though scale had little independent effect on defect outcomes once systematic QA/QC processes were applied [7, 15]. Overall, the findings align with the international consensus that progressive tightening of building standards improves construction quality and safety but requires adaptive management strategies—such as early compliance risk assessments, flexible procurement frameworks, and robust digital documentation systems—to mitigate financial repercussions [4-12, 15-17].

Hence, this study highlights that the revised building

regulations have achieved their quality objectives at a measurable cost premium, urging policymakers to balance regulatory ambition with practical feasibility and to develop differentiated compliance pathways tailored to refurbishment typologies.

### Conclusion

The comprehensive analysis of refurbishment projects under revised building regulations reveals a clear and measurable relationship between regulatory tightening, project costs, and quality outcomes. The findings establish that while compliance with the updated standards has led to a statistically significant increase in overall project expenditures—manifested primarily through higher material specifications, intensified inspection procedures, and elongated coordination cycles—it has simultaneously delivered substantial improvements in construction quality, durability, and post-occupancy performance. This cost-quality dynamic underscores the inherent trade-off embedded within modern regulatory frameworks: higher upfront capital investments are counterbalanced by longer service life, reduced maintenance interventions, and enhanced occupant satisfaction. The results demonstrate that projects implemented after the regulatory revision consistently exhibited fewer construction defects, improved workmanship, and superior operational efficiency, validating the premise that stringent compliance mechanisms, when effectively managed, yield tangible long-term benefits for the built environment.

From a practical standpoint, the outcomes suggest that the implementation of revised building regulations should be accompanied by strategic project-level interventions to balance compliance efficiency with cost containment. Project managers and policymakers should prioritize early-stage compliance planning—particularly during design development and tendering—to identify regulation-driven cost pressures and allocate appropriate contingencies before execution. Integrating digital tools such as Building Information Modelling (BIM) and automated code-checking systems can streamline the documentation process and mitigate rework, reducing administrative burdens while maintaining regulatory fidelity. Contractors should institutionalize continuous quality assurance frameworks, including third-party audits, periodic peer reviews, and structured commissioning schedules, to ensure that compliance translates into enduring quality rather than procedural adherence. Additionally, incentive mechanisms—such as tax benefits, compliance-linked grants, or accelerated permit approvals—may encourage stakeholders to adopt high-performance retrofitting solutions without perceiving regulations solely as financial constraints.

For older building stock, adaptive compliance pathways and risk-based exemptions should be formulated to accommodate structural and material limitations inherent in heritage refurbishments. Training and certification programs for construction personnel and site managers must be reinforced to improve interpretation and on-site implementation of evolving standards. Finally, policymakers should institutionalize a feedback loop wherein post-occupancy evaluation data from refurbishment projects inform subsequent regulatory revisions, ensuring that the standards evolve in a manner that is both technically sound and economically sustainable. By adopting a

proactive and evidence-based approach, the construction industry can transform regulatory compliance from a cost-driven obligation into a mechanism that simultaneously promotes quality, safety, sustainability, and long-term asset value.

### References

1. Department for Levelling Up, Housing and Communities (UK). Future Homes Standard: Consultation-Stage Impact Assessment. London: DLUHC; 2023.
2. Welsh Government. Final Impact Assessment on Changes to Part L of the Building Regulations (Conservation of Fuel and Power). Cardiff: Welsh Government; 2014.
3. Currie & Brown, AECOM. The Costs and Benefits of Tighter Standards for New Buildings. London: Committee on Climate Change; 2019.
4. de Oliveira CC, *et al.* Retrofit strategies to improve energy efficiency in buildings: An overview. *Energy Buildings*. 2024;298:113841.
5. Fahlstedt O, *et al.* Building renovations and life cycle assessment: A scoping review. *Renew Sustain Energy Rev*. 2024;194:114919.
6. Fahlstedt O, *et al.* Building renovation plan—introducing energy and cost into municipal decision-making. *Energy Buildings*. 2024;298:113859.
7. Piccardo C, *et al.* Deep energy retrofits using different materials under climate change: Life-cycle primary energy and cost savings. *Energy*. 2023;281:128103.
8. Schwartz Y, Raslan R. Refurbish or replace? Life-cycle carbon and cost trade-offs in residential buildings. *Energy*. 2022;254:124423.
9. Liao H, Xue F, Gao W, Gu J. Existing building renovation: Barriers, benefits and policy measures—A review. *Int J Environ Res Public Health*. 2023;20(2):1000.
10. Lang S, *et al.* System-dynamics model for energy-efficient retrofitting of existing residential buildings. *Appl Sci*. 2025;15(11):6072.
11. Vavaroutsos A, *et al.* The impact of retrofitting energy-efficient technologies in commercial buildings. *J Green Build*. 2017;12(4):70-94.
12. Davey CL, McLellan M, Lowe DJ. The management of maintenance defects: Good practice guide. Manchester: University of Manchester; 1999.
13. Glaeser EL, Gyourko J. The impact of building restrictions on housing affordability. *Fed Reserve Bank N Y Econ Policy Rev*. 2003;9(2):21-39.
14. Mayer CJ, Somerville CT. Land use regulation and new construction. *Reg Sci Urban Econ*. 2000;30(6):639-62.
15. Raetz H, Taylor N. The hard costs of construction: Recent trends in labor, materials, and regulations. Berkeley (CA): Turner Center for Housing Innovation; 2020.
16. Haseeb M, *et al.* Quality control measures in construction projects: Minimizing defects through systematic QC; 2025.
17. Ashworth A, Hogg K. Impact of design quality on building maintenance and rehabilitation costs. *Build Res Inf*. 2000;28(5-6):318-26.