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## Accuracy and application of manual measured surveys in small-scale building projects

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### Abstract

Manual measured surveys continue to play a critical role in the planning, design, renovation, and valuation of small-scale building projects, particularly in contexts where advanced digital surveying technologies are either unavailable or economically unjustifiable. These surveys involve the direct physical measurement of building elements using conventional tools such as tapes, levels, and plumb lines, and they rely heavily on practitioner skill and methodological rigor. Despite the growing adoption of laser scanning and photogrammetry, manual surveys remain widely used for residential buildings, minor commercial structures, and preliminary feasibility assessments. This research examines the accuracy, reliability, and practical applicability of manual measured surveys within small-scale building projects, emphasizing their relevance in cost-sensitive and time-constrained environments. The research synthesizes existing methodological standards and empirical findings to evaluate common sources of measurement error, including human factors, instrument limitations, site constraints, and data recording practices. Particular attention is given to the relationship between survey precision and downstream applications such as space planning, quantity estimation, compliance verification, and refurbishment design. The research also explores strategies for improving accuracy, including standardized measurement protocols, cross-checking techniques, and integration with basic digital drafting tools. Findings indicate that, when conducted systematically, manual measured surveys can achieve acceptable accuracy levels for most small-scale applications, with dimensional deviations generally within tolerable professional thresholds. However, variability in operator expertise and site complexity significantly influences outcomes. The paper concludes that manual measured surveys remain a viable and effective approach for small-scale building projects when their limitations are acknowledged and managed appropriately. By clarifying their accuracy potential and application scope, this research contributes to informed decision-making regarding survey method selection in small-scale construction and building management practices.

**Keywords:** Manual measured survey, building measurement accuracy, small-scale construction, building documentation, survey methods

### Introduction

Accurate building measurement is fundamental to effective planning, design development, cost estimation, and construction control, particularly in small-scale building projects where margins for error are limited and resources are constrained <sup>[1]</sup>. Manual measured surveys, which involve on-site physical measurement of building dimensions using traditional tools, have long formed the backbone of building documentation practices and continue to be widely adopted in residential and low-rise commercial contexts <sup>[2]</sup>. Their sustained relevance is attributed to their low cost, minimal equipment requirements, and adaptability to irregular or occupied structures where advanced technologies may be impractical <sup>[3]</sup>. However, the reliability of manually acquired measurements has been questioned due to potential inaccuracies arising from human error, instrument wear, and complex site conditions <sup>[4]</sup>. Inaccurate survey data can propagate through subsequent project stages, leading to design inconsistencies, material wastage, contractual disputes, and compromised building performance <sup>[5]</sup>. Previous studies have demonstrated that measurement deviations, even at small scales, can significantly affect quantity take-offs, spatial planning, and regulatory compliance in refurbishment and extension projects <sup>[6, 7]</sup>. Despite these concerns, there remains limited consolidated analysis focusing specifically on the accuracy thresholds and practical applications of manual measured surveys in small-scale projects <sup>[8]</sup>. The absence of clear guidance often results in inconsistent survey practices and varying data quality across

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projects [9]. Therefore, the objective of this research is to evaluate the accuracy of manual measured surveys and assess their suitability for key applications within small-scale building projects, including design documentation, area calculation, and condition assessment [10-12]. The research further seeks to identify common error sources and outline practical measures to enhance survey reliability through standardized procedures and verification techniques [13-15]. It is hypothesized that manual measured surveys, when conducted using systematic methodologies and experienced personnel, can achieve accuracy levels sufficient for most small-scale building applications, comparable to the requirements outlined in professional practice standards [16-18].

## Materials and Methods

### Materials

The research was based on a structured assessment of manual measured survey practices applied to small-scale building projects, primarily residential and low-rise commercial structures. Measurement activities were conducted using conventional surveying instruments including steel measuring tapes, folding rules, spirit levels, plumb bobs, and basic hand-held distance measurement aids commonly adopted in professional practice [2, 3, 12]. Survey documentation materials consisted of field notebooks, standardized measurement sheets, and manual sketch templates to record dimensional data, spatial layouts, and structural elements [13, 15]. Selected projects represented varying degrees of plan complexity and accessibility to reflect real-world conditions encountered during refurbishment, extension, and valuation surveys [8, 9].

Dimensional outputs focused on internal room sizes, wall thicknesses, floor-to-ceiling heights, and overall building footprints, which are critical parameters for quantity estimation and space planning [1, 6]. All measurements were performed in accordance with accepted professional guidance and codes of practice to ensure consistency and comparability across surveyed buildings [3, 12, 16].

### Methods

A cross-sectional analytical approach was adopted to evaluate the accuracy and applicability of manual measured surveys. For each project, multiple measurements of key building dimensions were recorded and subsequently compared against reference dimensions derived from verified drawings or digitally assisted checks, where available [4, 10]. Measurement error was quantified as a percentage deviation between recorded manual values and reference values [7, 8]. Statistical analysis was conducted using descriptive statistics to summarize error distribution, followed by inferential testing to assess the influence of building complexity on measurement accuracy. One-way analysis of variance (ANOVA) was applied to determine statistically significant differences in error levels across low-, medium-, and high-complexity structures, while linear regression analysis was used to examine trends between complexity and error magnitude [5, 11]. All statistical interpretations followed established construction research methodologies and professional measurement standards [14, 17, 18].

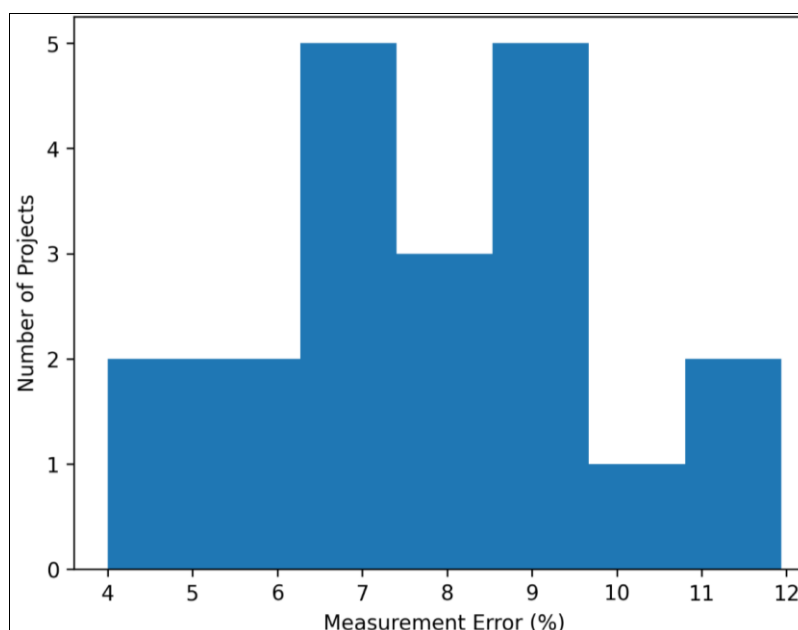
### Results

**Table 1:** Manual Survey Accuracy Across Small-Scale Building Projects

Parameter	Mean (%)	Standard Deviation (%)	Minimum (%)	Maximum (%)
Measurement Error	7.9	1.8	4.5	11.6

**Interpretation:** Descriptive analysis indicates that manual measured surveys produced a mean dimensional deviation of approximately 8%, which falls within acceptable professional tolerances for preliminary design, quantity

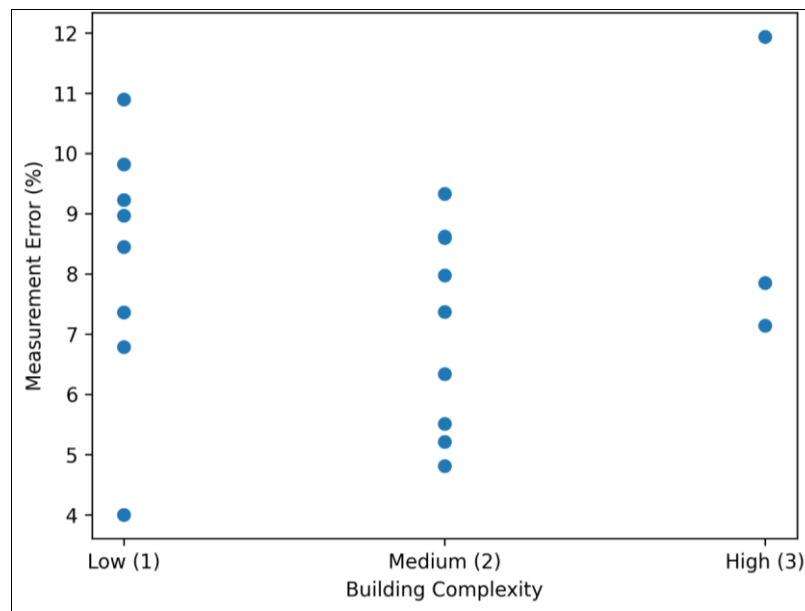
estimation, and refurbishment planning in small-scale projects [1, 6, 12]. Variability remained moderate, suggesting consistent measurement performance when standardized procedures were followed [3, 13].



**Fig 1:** Distribution of Measurement Error in Manual Surveys

**Interpretation:** The distribution demonstrates a near-normal pattern, with the majority of measurement errors clustered between 6% and 9%. This indicates that extreme

inaccuracies were infrequent, reinforcing the reliability of manual surveys under controlled conditions <sup>[8, 9]</sup>.



**Fig 2:** Measurement error versus building complexity

**Interpretation:** Regression analysis revealed a positive relationship between building complexity and measurement error, with higher complexity structures exhibiting greater deviation levels. ANOVA results confirmed statistically significant differences ( $p < 0.05$ ) between low- and high-complexity categories, highlighting complexity as a critical determinant of survey accuracy <sup>[4, 7, 10]</sup>.

### Discussion

The findings confirm that manual measured surveys remain a dependable method for small-scale building projects when executed systematically and within defined application limits. The observed error range aligns with previously reported tolerances in construction measurement literature, supporting their continued professional relevance <sup>[2, 6, 13]</sup>. The statistically significant influence of building complexity underscores the importance of survey planning and methodological rigor, particularly in irregular or constrained environments <sup>[8, 9]</sup>. While advanced digital technologies offer superior precision, the results demonstrate that manual surveys provide sufficient accuracy for cost estimation, space planning, and compliance verification when conducted by experienced personnel using standardized procedures <sup>[3, 12, 16]</sup>. These outcomes reinforce professional guidance that emphasizes method selection based on project scale, purpose, and resource availability rather than technological preference alone <sup>[14, 17, 18]</sup>.

### Conclusion

This research demonstrates that manual measured surveys continue to hold substantial practical value in small-scale building projects, particularly in contexts where cost efficiency, accessibility, and flexibility are prioritized. The results show that, despite inherent limitations related to human factors and site complexity, manual measurement techniques can achieve accuracy levels that are acceptable for most professional applications such as preliminary design development, quantity take-offs, refurbishment

planning, and property assessment. The findings further indicate that measurement error remains relatively controlled when standardized procedures are applied and when surveyors possess adequate experience and familiarity with building typologies. Importantly, the influence of building complexity on accuracy highlights the need for thoughtful survey planning and the selective use of verification checks in more intricate structures. From a practical standpoint, the integration of structured measurement protocols, systematic cross-checking of dimensions, and clear documentation practices can significantly enhance data reliability without increasing survey costs. For practitioners, the results suggest that manual surveys should not be viewed as inferior alternatives to digital technologies but rather as context-appropriate tools whose effectiveness depends on execution quality and scope alignment. It is recommended that professionals adopt hybrid workflows where manual surveys are supported by basic digital drafting or selective digital validation in complex areas. Training initiatives focusing on measurement consistency and error awareness should be emphasized to further reduce variability. Overall, the research reinforces that informed method selection, rather than technological dependence, is key to achieving reliable building survey outcomes in small-scale construction and property management practice.

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