

IDENTIFICATION OF DEFECTIVE CONSTRUCTION WORKS DURING BUILDING INSPECTIONS

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Meeting the quality requirements in construction works is critical for structural safety of the buildings, particularly in seismically active regions with old building stocks. Code compliance through strict inspections is essential not only for reliable structures, but also for prevention of cost and time overruns causing financial losses. In Turkey, building inspections are mandatory during the construction phase of the projects and building inspectors are responsible from the inspection of the construction works to ensure code compliance. Building inspectors are frequently subjected to different type of problems due several defects during inspections. This study aims to identify the frequently encountered defective construction works based on a quantitative study. A questionnaire was administered to 57 building inspectors by using 1-5 Likert scale to evaluate 20 critical construction work items. The results, which were ranked according to the Relative Importance Index (RII) showed that concrete works, reinforcement works, and HVAC are the top three works where problems were frequently observed during inspections. On the other hand, less problems were observed in painting, landscaping works and prefabricated construction works.

Keywords: Auditing, Relative importance index, Quality, Code compliance.

1 INTRODUCTION

Inspection of works in sites is one of the key activities in construction processes. Performance of these activities are required regularly to maintain the expected quality levels and to monitor the progress of the jobs according to the expectations stated in the contracts (Halder *et al.* 2023). Being vital for successful construction management practices and safe structural implementations, it is one of the vital activities that needs to be planned and supervised. Various parties work simultaneously to perform the activities on the construction sites, therefore all kinds of challenges, glitches or inaccuracies in the implementations have the potential to negatively impact the plans of multiple parties. Inspection activities are critical for all structures regardless from the type or location during construction phases everywhere. Nevertheless, particular focus is needed for the buildings located on seismically active regions. Code compliance through strict inspections is essential not only for construction of reliable structures, but also for prevention of cost and time overruns causing financial losses.

In Turkey, building inspections are mandatory during the construction phase of the projects and building inspectors are responsible from the inspection of the construction works to ensure code compliance. Building Inspection Law No. 4708 (2001) was enacted to regulate the methods

and basis of project and building inspections. Its major purposes are defined as ensuring the quality of all the construction works to maintain the life and property safety. Located on a very active seismic region, buildings constructed in Turkey are frequently subjected to earthquakes, which makes the inspection activities essential and critical. These activities are mostly posing challenges for the inspectors that are overseeing the compliance to codes, standards, regulations, and other contract associated requirements. This study aims to identify the frequently encountered defective construction works based on a quantitative investigation. Findings are expected to provide insights to develop strategies for the most challenging construction works during the inspection activities.

2 CONSTRUCTION WORKS AND INSPECTIONS

The construction projects involve numerous works, in which mostly the activities must be performed based on several codes, standards and contractual requirements. The performance and coordination of these works are provided by the associated parties on the construction site. An independent company is employed to inspect the performance of the works due to the mandatory Building Inspection Law No. 4708 (2001). The inspected works include but not limited to activities related to approval of plans and projects, preparation of permit files, placement of reinforcement bars, concrete pouring and placement, material tests, erection of walls, electrical and HVAC implementations, preparation of occupancy permit documents. The fundamental and/or special requirements are usually expressed in the contracts approved by the project parties or mandated by the codes, laws, regulations, or standards. The compliance of the works is inspected, approved, or revised after the inspectors' site visits and investigations. During these investigations, the inspectors report defects and request for rectifications. In this study, the most frequently encountered works are researched to draw attention to these particular works that might jeopardize the successful performance of project management, particularly affecting cost and schedule estimations in construction projects.

3 METHODOLOGY

This research followed four research steps as seen on Figure 1. First, a comprehensive literature review was conducted to identify work packages that might be related to defects during inspections.

In the next step, questionnaire survey was designed by means of 5-point Likert scale to collect data regarding the frequency of inspection defects for each work package.

Then, a questionnaire survey was distributed to building inspectors, who were randomly selected, through different ways, such as face to face, e-mail, telephone, social media. The questionnaire was distributed 57 participants with different levels of experience, from 20 different cities, mostly in Istanbul, working on building inspection firms. The average years of experience of participants was calculated as 8.61. The participants work with different roles, such as quality control engineers, owner representatives, technicians, chief inspectors, coordinators and architects in building inspection firms.

At the final step, the collected data were compiled and analyzed in SPSS v15.0 software for reliability analysis as well as Relative Importance Index (RII) analysis was employed to rank the work packages in terms of their frequency.

RII, which is a common and reliable method for ranking variables, is calculated by Eq. (1) Dixit *et al.* 2019, Boakye and Adanu 2022):

$$\text{Relative Importance Index (RII)} = (\sum \omega) / A * N \quad (1)$$

where ω is the weighting given to each factor by the respondent (ranging from 1 to 5 in this study), A is the highest weight (i.e., 5 in this study), and N is the total number of respondents (i.e., 57 in this study). The higher RII value the factors has, the more important it is compared to the other factors with lower RII values.

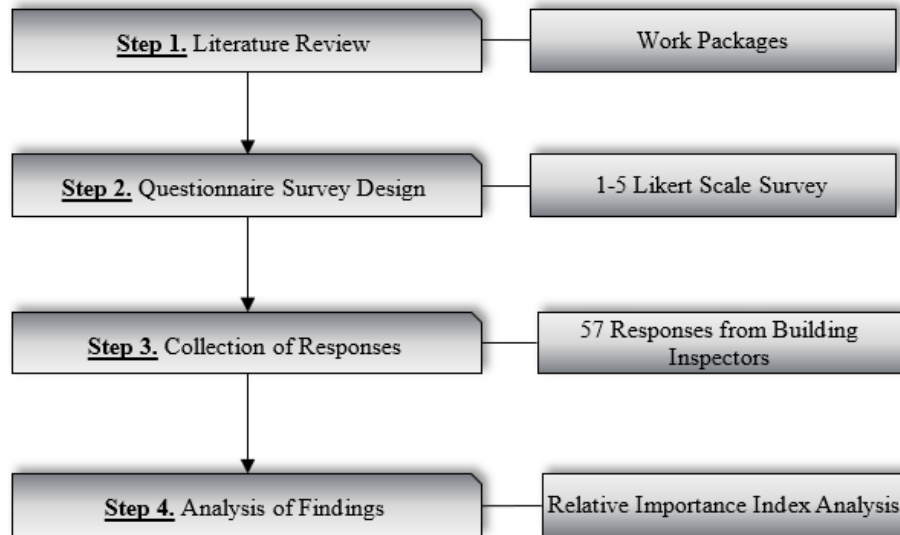


Figure 1. Research flow.

4 RESULTS

The internal consistency must be checked to verify the reliability of collected data to identify the construction tasks that are more prone to defective performance. For this purpose, the Cronbach's alpha ($C\alpha$) value was used to consistency of the entire dataset. This value should be at least 0.70 in order to be considered reliable, and values higher than 0.9 indicates excellent reliability (Gunduz and Elsherbeny 2020). The calculations revealed Cronbach's alpha value in this study to be 0.81, which is greater than 0.70 (Qu *et al.* 2009), the data was considered consistent and reliable. Considering the results of RII analysis, which can be seen on Table 1, rough construction works, such as concrete works, reinforcement works, roof works as well as Heat, Ventilation and Air Conditioning (HVAC) are the most prominent works where problems were frequently observed during inspections. On the other hand, it is noteworthy that the least problems were experienced in earthworks, which constitute the first stages of construction projects, such as excavation, filling, and ground improvement. Less problems were also observed in painting and landscaping which are the final stage of the construction works. Another highlight is that prefabricated works were the most unproblematic construction works.

5 DISCUSSIONS

The inspection of each work item is of great importance for ensuring quality in the whole project life cycle in the construction industry. Inspection of some particular work items are directly related to safety rather than the achievement of project objectives. Any defect in such works may cause deaths of thousands of people during an earthquake. Especially, rough construction works, such as reinforcement and concrete works, play crucial role on enabling earthquake resilience. On February 6, 2023, two devastating earthquakes, which have both more than 7.5 Mw

magnitude, occurred in Kahramanmaraş in Turkey, caused the death of more than 50,000 people (AFAD 2023). The impacts of such earthquakes, which also showed that quality problems in reinforcement and concrete works, such as lack of material (steel and concrete) quality, problems in on-site implementations, design problems in column and beams, brought about collapse of huge number of buildings (Şahin 2023). Unfortunately, the implications of the earthquakes also proved the reinforcement works (1st rank with RII= 0,655) and concrete works (3rd rank with RII=0, 597) as prominent defective construction works, which comply with the findings of the present study.

Table 1. RII analysis.

Rank	Work item	Mean	Std. Dev.	RII
1	Reinforcement works	3,22	1,13	0,655
2	HVAC	2,84	0,95	0,614
3	Concrete works	2,94	0,95	0,597
4	Roof works	2,71	1,04	0,579
5	Electrical installation works	2,59	1,09	0,572
6	Surveying	2,80	0,97	0,555
7	Elevator works	2,54	1,03	0,555
8	Stair works	2,43	1,16	0,548
9	Formwork	2,70	1,22	0,545
10	Insulation	2,54	1,16	0,541
11	Plastering	2,59	0,82	0,538
12	Masonry	2,59	1,01	0,534
13	Infrastructure	2,38	1,01	0,531
14	Exterior wall	2,42	0,98	0,521
15	Steel works	2,45	1,01	0,509
16	Excavation-Filling	2,47	0,94	0,493
17	Ground improvement	2,40	1,08	0,479
18	Landscape	2,14	1,12	0,459
19	Painting	2,03	1,01	0,431
20	Prefabricated construction works	1,92	0,96	0,425

HVAC works ranked on 2nd place with RII=0,614. This is also an expected finding, as several problems are observed in HVAC works due to lack of coordination between designers and practitioners, clashes, time-related problems and change orders during the construction phase (Çelik 2009).

On the other hand, the survey revealed that prefabricated construction works ranked in last place with RII=0,425. This can be explained by the strict and standard control of fabrication phase.

6 CONCLUSION

Building inspection processes play crucial role in success of construction projects in ensuring quality and avoiding time and cost overruns. It is also extremely important to be able to

determine the most defective construction works in order to tackle with potential challenges in different phases of the project. Thus, the current study utilized a survey based on a questionnaire administered to building inspectors to identify defective construction works. After statistical analysis, the study highlighted the riskiest construction works as concrete works, reinforcement works, and HVAC, in which several problems were observed during inspections. On the other hand, less problems were determined in painting, landscaping works and prefabricated construction works. Implications of this study may contribute to building inspection studies, which have an important place particularly in building safety. The study is also of great importance for taking various preventive measures regarding contracts, legislation, regulations, and laws for ensuring better building safety and earthquake resilient built environment. Follow-up studies involving field studies and qualitative surveys might be crucial for better understanding of building inspection processes.

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