Potential defects & failures in building industry

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Abstract. Padang is one of red zone area of earthquake disaster. Quality of building is of important aspect towards disaster resistant. This paper is to report findings of the survey on potential defects and failure modes in building industry in Padang City. The survey was conducted in 3 building projects. The research has uncovered technical defects and potential failures leading to vulnerability of structural deficiencies of buildings. Findings show that inappropriate procedures, defective selected materials and concrete structures of beam, column and foundation, defective design of electrical circuits are among those potential defects undermining the quality of buildings. These quality defects may lead to vulnerability of buildings under earthquake disasters.

1 Introduction

Padang City is classified as a medium to high earthquake prone area (KRB). Based on the Center for Volcanology and Geological Hazard Mitigation, the main epicenter of the earthquake was in the Mentawai islands and the coast of West Sumatra with an intensity of more than VIII MMI (Modified Mercally Intensity). Therefore, building quality is something that must be considered during the construction process, especially in Padang City.

Building construction is an important component in city development. It requires a focus on quality and safety. However, sometimes the building construction process is not free from potential defects and failures that can affect the quality and reliability of the building structure. This research aims to identify the types of defects and failures that are common in building construction in Padang City, find out the causes and ways to overcome them. Through an in-depth understanding of these issues, effective corrective and preventive measures can be taken.

1.1 Potential defects and failures

1.1.1 Identified defects

Identifying defects in buildings is an important step in maintaining building quality and sustainability. Defects can come from various aspects including: design, construction process, materials and maintenance [1]. Rapid urban growth and diverse environmental conditions such as in the Padang City area make it important to understand the most common types of defects and the factors that contribute to their occurrence.

1.1.2 Identified failures

An in-depth understanding of the types of failures common to buildings is essential to maintain their structural integrity and occupant safety. According to Regulation (PP) No. 22 of 2020 on the implementation of construction services, construction failure is a condition where the results of construction work do not comply, in part or in whole, with the work specifications agreed in the construction contract. Structural failures can arise due to various factors such as improper design, defective materials, and misuse of the building. Therefore, the importance of failure identification involves analyzing and recognizing problems that can result in a decrease in building quality and safety.

1.2 Contributing factors

Factors that influence the occurrence of defects and failures in building construction include:

1. Construction Factor

During the construction process, disputes often occur between the parties involved in the activity. This can disrupt the process of achieving project success in terms of time. Imperfections in construction work usually include several deficiencies in the implementation of the work both from the planning design, supervision and construction process. Buildings that fail during the construction process are said to be unable to meet consumer demand [2]. Construction work with technical defects can be interpreted as work that does not comply with the agreed contract provisions [3]. The quality of construction implementation is an important factor that can affect the likelihood of defects and failures. Errors in the placement of materials such as concrete,
steel, or other structural components can result in structural imperfections. In addition, a lack of understanding of the correct construction execution procedures, such as layout or fastening, can lead to imperfections in the building.

2. Material Factor
The selection of materials used must meet the expected requirements, the use of poor materials will cause poor construction quality. Buildings with defective materials can cause many construction defects in the structure [4].

3. Environmental Factors: Environmental conditions in Padang City, such as extreme weather and geological activity, have a potential impact on the construction of the building. Severe weather such as heavy rain or high humidity can accelerate corrosion or deterioration of materials. Geological activities such as earthquakes can cause structural damage or foundation failure if not properly anticipated.

2 Results and discussions
Initial identification by field survey, informant interviews, and documentation of defects and failures have been carried out sequentially. Implementing contractors and supervising consultants were interviewed as informants in 3 (three) different building construction projects, namely office building, library building, and laboratory building. The questions focused on the types, causes, impacts of defects, ways to overcome the defects that occurred, as well as the presence or absence of overall failure in each building project shown in Figure 1.

A descriptive qualitative method with a grounded theory approach was used to identify potential defects and failures. Grounded theory is an inductive method through a series of systematic procedures to construct data so that a theoretical formula is formed. Brief questions describing core categories are made to answer theoretical category questions [5]. This approach can directly organize and summarize data sets, and build original analysis from the data owned through communication with several sources [6]. Grounded theory focuses on formulating general theories about phenomena that are not adequately explained by existing theories alone [7]. Grounded theory analysis goes through 3 (three) stages, namely open coding (initial category formation from the information obtained), axial coding (collection of interconnected categories for concept formation), and selective coding (simplifying the variation of relationships between categories to produce specific themes). The results are shown in Table 1.

Table 1. Coding results of office building construction project.

<table>
<thead>
<tr>
<th>Category</th>
<th>Coding</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of defect</td>
<td>• Foundation planning error</td>
<td>Identification of types, causal factors, impacts and ways to resolve defects in the library building construction project.</td>
</tr>
<tr>
<td></td>
<td>• Wasp nest-shaped column bottom</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Beam and column joint deterioration</td>
<td></td>
</tr>
<tr>
<td>Causes of defects</td>
<td>• Lack of understanding of soil conditions, for foundations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uneven concreting resulting in air voids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Incomplete compaction of concrete joints due to improper mix or poor adhesives</td>
<td></td>
</tr>
<tr>
<td>Impact of defects</td>
<td>• Potential structural failure and damage and decreased building stability if foundation type is not replaced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Potentially less dense and consistent structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Potentially reduced bearing capacity or structural strength and uneven load distribution on the structure</td>
<td></td>
</tr>
<tr>
<td>How to overcome</td>
<td>• Repair of porous concrete and beam joint areas with adhesive coating and curing.</td>
<td></td>
</tr>
<tr>
<td>Failure</td>
<td>• No significant failure</td>
<td>Identify the failure of the library building construction project.</td>
</tr>
<tr>
<td>Type of defect</td>
<td>• Porous/cracked column surface</td>
<td></td>
</tr>
<tr>
<td>Causes of defects</td>
<td>• Less than perfect concrete compaction</td>
<td></td>
</tr>
<tr>
<td>Impact of defects</td>
<td>• Potential reduction in structural stability and performance</td>
<td>Identification of types, causal factors, impacts and ways to overcome defects in laboratory building construction projects.</td>
</tr>
<tr>
<td></td>
<td>• Potential to cause deformation of the column structure</td>
<td></td>
</tr>
<tr>
<td>How to overcome</td>
<td>• Inspection of the porous area of the column and repairing with adhesive material and curing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inspect and repair cracked concrete areas using appropriate binders under supervision.</td>
<td></td>
</tr>
</tbody>
</table>
2.1 Technical defects

Technical defects are problems associated with materials, or components that can affect the quality, structure and function of a building. The construction projects studied generally experienced defects during the construction process, such as porous beams and columns, deflection of beams. Porousing of beams and columns occurs due to improper use or mixture of materials. This factor causing concrete loss also occurred in a hotel construction project in Semarang City. In the construction project, concrete deterioration occurred in the process of mixing, dismantling formwork and compaction [8]. In addition, additional load and curing can also be the cause of concrete damage [9]. If these defects are not addressed quickly and appropriately, it will affect the quality of the structure in the long run. Beam deflection is caused by the mismatch of beam bearing capacity and low scaffolding strength. Structural instability and damage to structural elements can occur if these defects are not properly addressed. Therefore, the supervision of the contractor during the project is very important so that defects that appear can be resolved immediately.

2.2 Management defects

Defect management refers to issues related to planning, coordination, and supervision on construction projects. Generally, these defects result in work and cost inefficiencies and delays. In Building Construction in Padang City, good planning of the building structure is essential to ensure the robustness of the building. In the library building project, the 5 (five) meter thick soil layer hindered the initial work plan for the pile foundation. Therefore, the foundation type plan was changed to a concrete rib network construction type (KJRB). The KJRB foundation type is a refinement of the cobweb construction foundation (KSSL) which is applied to soils with low bearing capacity, has a hard soil layer and a solution for medium height buildings in earthquake areas [10,11]. Supervision and communication between contractors and workers in the field are needed to overcome this type of defect.

2.3 Human defects

Human defects are problems stemming from human negligence or actions that affect the quality, safety, and reliability of buildings. Human errors arise due to activities performed beyond their capabilities [12]. Building quality can decrease due to lack of skills, maintenance, knowledge of field operators, design quality, and project information [13]. In this study, the miscalculation of electric current power in the construction of office buildings resulted in the obstruction of project operations and construction. Therefore, an appropriate increase and adjustment of electrical power is carried out so that project operations can run well. In addition, work that was not in accordance with procedures, where ceramic work was carried out first before roofing work was carried out, resulted in damage to the tiles and granite installed due to falling light steel plates. This defect was addressed by repairing the broken tiles and providing additional protection to prevent further floor damage. Therefore, periodic and thorough evaluation, good coordination and material improvement are the main focus in addressing the defect issue and preventing future failures.

3 Proposed mitigation

To address defects and failures, a comprehensive approach is required:

1. Technical Defects: Ensure that quality materials are used and construction execution is carried out according to standards.
2. Defect Management: Regular project monitoring, strict schedule management, adjustment of planning as needed and good collaboration between stakeholders.
3. Human Defects: Skills training for the workforce, as well as improved supervision and communication between project teams.
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