CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

The Causal Factors of Building Construction Defects

Utami Dewi Arman[1*], Jihan Melasari[2], Afrilda Sari[3], Kharisma Permata Sari[4]
[1,2,3,4] Universitas Putra Indonesia YPTK, Indonesia
*Corresponding author e-mail: udewi2679@gmail.com

Received 21th Feb 2024; Revision 20th March 2024; Accepted 31th March 2024

ABSTRACT

Defects are something that must be identified in the implementation of quality management. Defects can potentially lead to construction failures and injury. This study aims to identify and analyse the causal factors of building construction defects based on the perspective's project stakeholders. This research is quantitative-descriptive research conducted through questionnaires distributed to the purposive respondents. Then, conduct statistical analysis and evaluate the causal factors of construction defect using Failure Mode and Effect Analysis (FMEA). Based on the results, the critical causal factors of building construction defects are lack of communication within the project environment with a value of 33.6; poor performance of the project management team with a value of 30.3; improper design and specification with a value of 27.88; lack of supervision in the site with the value of 24.60 and lack of competency of the construction labour with the value of 23.04. Project stakeholders are expected to pay more attention to critical causal factors as preventive measures to prevent structural failure and injury.

Keywords: *Causal Factor; Construction Defects; FMEA; Stakeholder; Building*

INTRODUCTION

There are many cases of structural failure to construction accidents that occur in West Sumatra Province such as the collapse of the Kelok Pinyaram Bridge in District 2 X 11 Kayu Tanam, Bukittinggi City, West Sumatra Province which occurred in December 2018 and the collapse of the Sikabu Bridge, in Padang Pariaman Regency occurred in June 2020. Then there were also cases of structural failures in the Bukit Manggis Solok Selatan Road Project executed in 2021 that suffered damage on the road section at KM 170 500 Bukit Manggis in South Solok Regency [5] and other cases of construction defects caused by selecting substandard material to DPR building in Padang city, where the type of landfill used was the inappropriate. The landfill used in this project should be grainy soil, but in fact, at the site was found the clay type, which in this case defect occurred. By highlighting cases due to construction defects and construction failures in West Sumatra Province recently, this study aims to identify and analyze the causals of construction defects based on the perspective of project stakeholders in West Sumatra Province.

Construction defects and failures are defined as a condition of deviation or imperfection of the building or construction work that is still within tolerance limits, meaning that they do not endanger the construction as a whole. Construction failure is a condition of deviation, errors, and damage to the outcomes of construction work that can result in the collapse of a building. Another definition of a defect in construction work is the activities that result in a reduction in

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

the value of construction. Construction defects can be caused by design errors, process defects, damaged materials, improper use or installation of materials, lack of adherence to blueprints by contractors, or a combination thereof [1]. Building defects can be caused by design errors, manufacturing process defects, defective materials, improper use or installation of materials, lack of compliance with the design or a combination thereof [16]. Construction defects are things that must be identified in the implementation of quality management. Construction defects can potentially result in the failures of building structures even construction accidents. Here are some causal factors for defects in construction or structures based on previous research listed in Table 1.

Table 1. Causal Factors of Construction Defects

Code	Causal Factors	References
CF1	Weather/climate factor	[18], [16]
CF2	Building location and environmental factors	[3] cited by [4], [16], [8]
CF3	Poor performance of the project management team	[11], [15], [13], [14]
CF4	Lack of supervision in the site	[4], [16], [9], [8]
CF5	Poor quality of construction materials	[11], [18], [4], [10], [16], [9], [8]
CF6	Improper design and specification	[15], [13], [3] in [4], [18], [4], [10], [16], [14], [2], [17], [12], [1], [9], [8]
CF7	Lack of safety control in construction process	[19]
CF8	Lack of skills and work experience/competency of the construction labour	[4], [14], [12], [9], [8]
CF9	Improper method of building maintenance	[18], [10], [16], [8]
CF10	Lack of communication in the project environment	[15], [12], [8]
CF11	Poor quality/condition of construction equipment	[11], [18], [12], [8]

METHOD

This study is a quantitative descriptive research that identifies and analyzes the causal factors of building construction defects. The research respondents involved Cipta Karya Agency (owner), contractors, and consultants located in West Sumatra Province. The research was initiated by determining the problem statement and research objectives based on preliminary observations of several cases of construction failure in West Sumatra Province. Furthermore, conduct a literature study and begin to compile instruments to collect primary and secondary data. The primary data collection instrument uses a questionnaire form that tests the validity and reliability of causal factors which are analysed using Failure Mode and Effect Analysis (FMEA). FMEA is a methodical process for determining the root cause of a problem [6]. FMEA is a causal analysis technique used to determine how an item, facility, or system can fail and the consequences of the failures [7]. Some of the phases that need to be considered when using FMEA are firstly identifying causal factors of construction defect from previous research, examining the occurence, severity and detection for building project, which further compiles a scale of occurrence, severity and detection. Furthermore, calculate the RPN of each causal factor and the average RPN. The critical causal factors values are the RPN values above

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

the average RPN. Causal factors that have higher critical RPN require control and mitigation efforts. The rating scale of severity, occurrence and detection can be shown in Table 2, Table 3 and Table 4. To calculate the RPN value, the formula used is,

Causal Priority Number (RPN) = S (severity) x O (occurance) x D (detection) (1)

Table 2. Rating Scale of Severity

Rating Scale	Description
1	Defects that can be ignored (negligible)
2	There is non-structural damage, for instance, fine plaster cracks, damp buildings (mild severity)
3	There is significant damage, for instance: cracks, tilted columns (moderate severity)
4	Significant structural damage requiring rework (high severity)
5	Potential for failure and construction accidents

Table 3. Rating Scale of Occurrence

Rating Scale	Description
1	Very rarely found more than10 years
2	Rarely found within 5-10 years
3	Occasionally found within 3-4 years
4	Frequently found less than 1 year

Table 4. Rating Scale of Detection

Rating Scale	Description
1	The causes of defect are very easy to detect and preventive measures can be taken quickly
2	The causes of defect are easy to detect and preventive measures can be taken
3	Slightly easy to detect and sometimes preventive measures can be taken
4	It is difficult to detect and methods of preventing defect are less effective
5	It is extremely difficult to detect and preventive measures are not effective

Then, to calculate the RPN of causal factors respectively and the average of RPN. The most critical causal factor is seen from value that exceed the average RPN displayed through the histogram chart which can be shown in figure 1. The average RPN can be formulated as follows,

$$Average\ RPN = \frac{\sum_{i=1}^{i} RPN_i}{\sum_{n=1}^{n} r_n} \quad (2)$$

RESULTS AND DISCUSSION

The processing of questionnaire data begins with identifying the characteristics of respondents in the study which determine the profile of respondents who provide their assessment and furthermore to analyze the causal factors of construction defects using FMEA. The respondents

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

of this study consisted of 30 people. In figure 1, it can be shown that respondents based on Cipta Karya agency are 8 people (26.67%), the contractors are 12 people (40%) and the consultants are 10 people (33.33%). Thus, the dominant respondent profile is the contractor. In figure 2, it can be shown that the work experience of respondents varies from 0-5 years as many as 4 people with a percentage of 13.33%, 5-10 years as many as 5 people with a percentage of 16.67%, and more than 10 years as many as 21 people with a percentage of 70%. Based on the experience of handling building construction projects, the most dominant respondent who filled of the questionnaires have more than 10 years of experience.

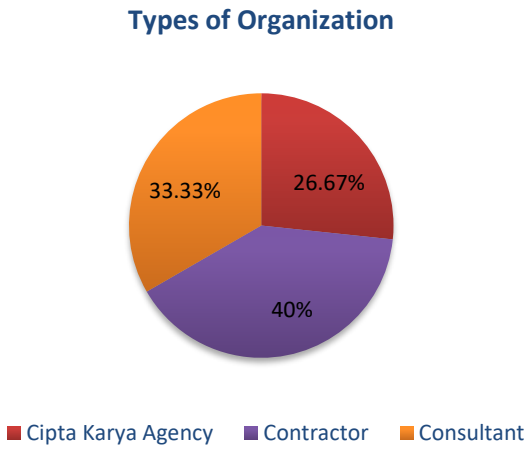

Figure 1. The number of respondents based on type of organization

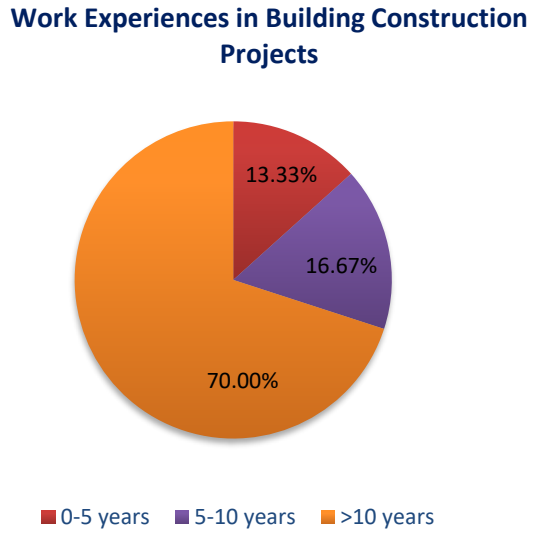

Figure 2. The number of respondents based on work experiences in building construction projects

The RPN Value Based on the Owner's Assessment

Based on the calculation, an average RPN value of 16.736 was obtained and critical causal factors that have RPN values more than the average RPN value based on the assessment of owner were lack of communication in the project environment (CF 10) with the highest with RPN value of 33.66, lack of supervision in the site (CF4) with RPN value of 23.51, lack of

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

skills and work experience/competency of the construction labour (CF8) with RPN value of 23.04, poor quality of construction material (CF5) with RPN value of 19.30, and poor performance of the project management team (CF3) with RPN value of 17.72. The results of the RPN calculation according to the perspective of the Cipta Karya agency as the owner of the public facilities construction project can be shown in Figure 3.

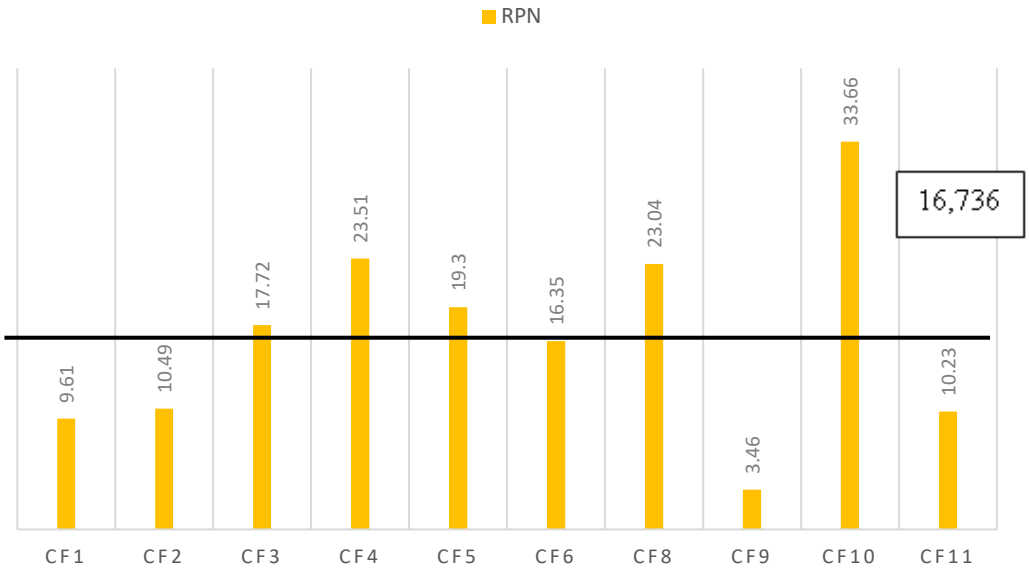

Figure 3. The calculation of RPN Based on the Owner's Perspective

The RPN Value Based on the Contractor's Assessment

Based on the calculation of the average RPN value, an average RPN value of 16.905 was obtained while critical causal factors that have RPN values more than the average RPN value based on the assessment of the contractor are the poor performance of the project management team (CF3) with RPN value of 30.30, improper design and specification (CF6) with RPN value of 27.88, lack of supervision in the site (CF4) with RPN value of 20.49, lack of skills and work experience/competency of the construction labour (CF8) with RPN value of 19.28, and lack of communication in the project environment (CF10) with RPN value of 18.75. The results of the RPN calculation according to the perspective of the contractor can be shown in Figure 4.

Figure 4. The calculation of RPN Based on the Contractor's Perspective

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

The RPN Value Based on the Consultant's Assesment

Based on the calculation of the average RPN value, an average RPN value of 15.975 was obtained while critical causal factors that have RPN values more than the average RPN value based on the assessment of the consultant are lack of supervision in the site (CF4) with RPN value of 24.60, lack of communication in the project environment (CF10) with RPN value of 22.92, lack of skills and work experience/competency of the construction labour (CF8) with RPN value of 22.22, the poor performance of the project management team (CF3) with RPN value of 19.43, poor quality of construction material (CF5) with RPN value of 19.41 and improper design and specification (CF6) with RPN value of 18.71. The results of the RPN calculation according to the perspective of the consultant can be shown in Figure 5.

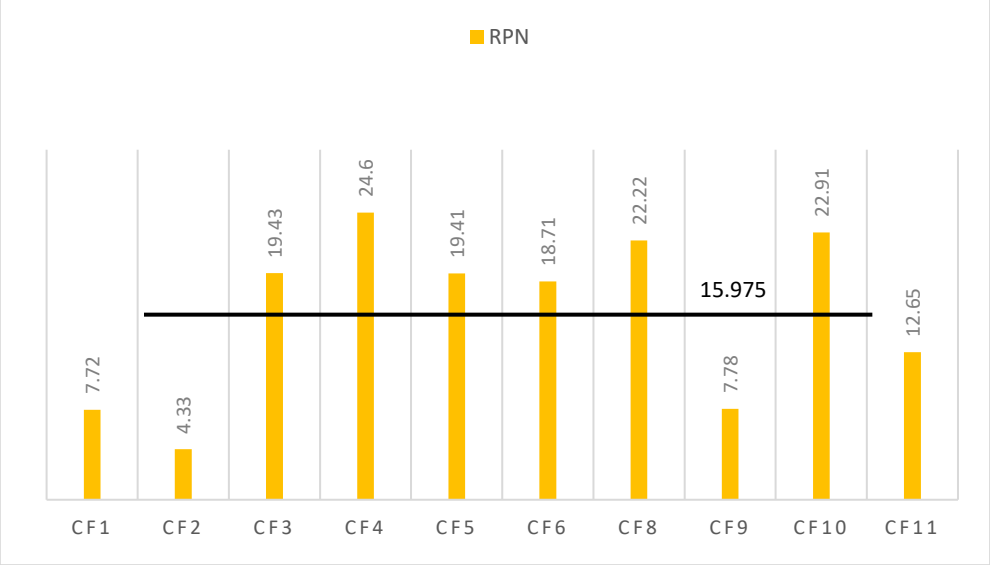

Figure 5. The calculation of RPN Based on the Consultant's Perspective

Discussion

The causal factors of construction defect that have the greatest critical RPN value and need to be considered to prevent deviation, structural failures, and even work accidents are lack of communication in the project environment, the poor performance of project management team, improper design and specifications, lack of supervision in the site, and lack of skills and work experiences or competency of the construction labour. Lack of communication is the greatest causal of construction defect according to the result. Effective communication within the project environment is one strategy for preventing defects and project failures. The most common forms of communication in construction projects occur between parties using interpersonal face-to-face communication such as meetings, communication through electronic media such as e-mail, instant messages, voice messages, and multimedia communications through internet. Construction projects develop a network of communication channels in which all project stakeholders, both internal and external, including the government, sponsors, financial institutions, insurance companies, material and equipment suppliers, owners, subcontractors, contractors, design consultants and supervisors, and workers have communication procedures both formal and informal. In addition, effective communication between workers on site is also important, so that no misunderstandings in receiving information and carrying out work instructions. The poor performance of the project management team was influenced by how leadership of the project manager in managing the project including the arrangement of procurement, schedule, material, cost estimation, cost control, accident causal identification and analysis as well project quality management.

Improper material and equipment also have the potential to cause defect and lead to structural failure, for instance, using quality of concrete that does not meet the requirements which the composition of the mixture of cement, sand and water is inappropriate or using dirty water can cause cracks in concrete slab. Poor site supervision during construction process also has the potential to cause defects in the building structure. For instance, lack of supervision in masonry work so that the plastering procedure is inappropriate, which cause cracks on the building walls, that means that defects are found after the masonry is finished. In addition, the competence of operators and workers is one factor contributing to causing defect. Lack of skills and experience affects the quality of the work they done. In this case, the importance of a certified labour and expected contractors perform regular training for their employees, especially related to work methods and construction safety programs.

CONCLUSION

Based on the collection and results of data analysis, it can be summarized that some findings are as follows :

1 Causal factors of construction defect based on the owner's assessment are lack of communication in the project environment, lack of supervision in the site, lack of skills and work experience/competency of the construction labour, poor material quality, and low performance of the project management team.
2 Causal factors of construction defect based on the contractor's assessment are low performance of project management team, improper design and specification, lack of skills and work experience/competency of the construction labour, lack of supervision in the site and lack of communication in the project environment.
3 Causal factors of construction defect based on the consultant's assessment are lack of supervision in the site, lack of communication in the project environment, lack of skills and work experience/competency of the construction labour, poor performance of project management team, poor quality of construction material and improper design and specifications.
4 Causal factors of construction defect based on project stakeholder’s assessment in West Sumatra Province, are lack of communication in the project environment, poor performance of the project management team, improper design and specifications, lack of supervision in the site, and lack of skills and work experience/competency of the construction labour.
5 Preventive measures that can be conducted by all stakeholders in building project to prevent structural defects are to improve communication between the project management team and workers or communication among workers in the site, to improve the performance of the project management team in terms of competency of workers and operatives and also project manager’s leadership, to improve quality of design which in design process need to involve owner that the consultant can accommodate client’s needs and requirements, to increase discipline and firmness in supervision in project and the importance of selecting and paying attention to the quality and characteristic of construction materials.

REFERENCE

[1] Meor Hasan, M. I., Abd Razak, N. N., Endut, I. R., Abu Samah, S. A., Mohd Ridzuan, A. R., & Saaidin, S. “Minimizing Defects in Building Construction Projects”. Jurnal Teknologi, 78(5-2), 2016. https://doi.org/10.11113/jt.v78.8494

[2] Jitendra Agarwal., Marco Haberland., Milan Holicky., Miroslav Sykora. "Robustness of Structures: Lessons from failures". Structural Engineering International: Journal of the International Association for Bridge and Structural Engineering (IABSE), Vol 22 No.1, pp 105-111, 2012. http://dx.doi.org/10.2749/101686612X13216060213635

[3] Akinpelu, J.A. "The need for a code of conduct, building regulations, and by-laws for the building industry in Nigeria". The Professional Builder, Nigeria Institute of Building, pp 11-14, 2002.

[4] Ayininuola, G.M. and Olalusi, O.O. "Assessment of Building Failures in Nigeria: Lagos and Ibadan Case Study". African Journal of Science and Technology (AJST) Science and Engineering Series Vol. 5, No. 1, pp. 73 – 78, 2004. https://doi.org/10.4314/ajst.v5i1.15321

[5] Arman, U.D., Jihan Melasari, & Septia Edrian Saputri. "Identifikasi Faktor-Faktor Penyebab Berkontribusi Terjadinya Kegagalan Konstruksi Jalan dengan Metode Fault Tree Analysis (FTA)". Civil Engineering Collaboration, 6(2), 53–63, 2021. https://doi.org/10.35134/jcivil.v6i2.33

[6] Mahdi Bahrami., Danial Hadizadeh Bazzaz., S. Mojtaba Sajjadi. "Innovation and Improvements In Project Implementation and Management; Using FMEA Technique". International Conference on Leadership, Technology and Innovation Management. Procedia - Social and Behavioral Sciences 41 (2012) 418–425, 2012. http://dx.doi.org/10.1016/j.sbspro.2012.04.050

[7] Sofian Bastuti. "Analisis Risiko Kecelakaan Kerja dengan Metode Failure Mode and Effect Analysis (FMEA) dan Fault Tree Analysis (FTA) Untuk Menurunkan Tingkat Risiko Kecelakaan Kerja (PT. Berkah Mirza Insani)". TEKNOLOGI Vol.2 Nomor 1, Maret 2019 hal 48-52, 2019.

[8] Manuel Buitrago.,Juan J Moragues.,Pedro A. Calderon., Jose M Adam. Handbook of material failure analysis with case studies from the construction industries (pp.157-170), 2018. Edition: 1st Chapter: 8. Publisher: Mathew Deans Editors: Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei. http://dx.doi.org/10.1016/B978-0-08-101928-3.00008-2

[9] Baba Shehu Waziri. "Design and construction defects influencing residential building maintenance in Nigeria". Jordan Journal of Civil Engineering Vol 10, No.3, pp 313-323, 2016. http://dx.doi.org/10.14525/JJCE.10.3.3605

[10] Wai Kiong Chong.,Sui Pheng Low. "Assessment of Defects at Construction and Occupancy Stages". Journal of Performance of Constructed Facilities Vol.19 No.4, pp 283-289, 2005. https://doi.org/10.1061/(ASCE)0887-3828(2005)19:4(283)

[11] Ziad A, Eldukair., Bilal M Ayyub. "Analysis of Recent US Structural and Construction Failures". Journal of Performance of Constructed Facilities, Vol. 5, No. 1, pp 57-73, 1991. https://doi.org/10.1061/(ASCE)0887-3828(1991)5:1(57)

[12] Monika Jingmond., Robert Agren. "Unraveling causes of defects in construction". Construction Innovation, Vol 15 No.2, pp 198-218, 2015. http://dx.doi.org/10.1108/CI-04-2014-0025

[13] P, E Josephson., Y. Hammarlund. "The Causes and Costs of Defects in Construction. A Study of Seven Building Projects". Automation in Construction, Vol 8 No.6, pp 681-687, 1999. https://doi.org/10.1016/S0926-5805%2898%2900114-9

[14] P,E,D, Love.,R, Lopez.,Y,M, Goh.,C,M, Tam. "What goes up, shouldn't come down: Learning from construction and engineering failures". Procedia Engineering, Vol 14, pp 844-850, 2011. https://doi.org/10.1016/j.proeng.2011.07.107

[15] Richard E, Millet. "Failures: How to Avoid Them". Journal of Management in Engineering. Vol.15 No.5,pp 32-36, 1999.

[16] N, Ahzahar., Nurulzatushima Abdulkarim., Siti Hafizan Hassan. "A study of contribution factors to building failures and defects in the construction industry". The 2nd International Building Control Conference 2011. Procedia Engineering 20 (2011) 249–255, 2011. http://dx.doi.org/10.1016/j.proeng.2011.11.162

[17] Nuria Forcada., Marcell Macarulla., Marta Gangolles., Miquel Casals. "Assessment of construction defects in residential buildings in Spain". Building Research & Information, 42:5, 629-640, 2014. http://dx.doi.org/10.1080/09613218.2014.922266

[18] Kumalasari Wardhana., Fabian C Hadipriono. "Study of Recent Building Failures in the United States". Journal of Performance of Constructed Facilities, 2003, Vol 17 (3), pp 151-158, 2003. https://doi.org/10.1061/(ASCE)0887-3828(2003)17:3(151)

[19] A.Kh. Baiburin. "Errors, Defects and Safety Control at Construction Stage". International Conference on Industrial Engineering, ICIE 2017. Procedia Engineering 206 (2017) 807–813, 2017. https://doi.org/10.1016/j.proeng.2017.10.555