Jurnal Riset Rumpun Ilmu Teknik
Volume. 4 Nomor. 3 Desember 2025
e-ISSN : 2829-016X; p-ISSN : 2829-0178, Hal. 597-604
DOI: https://doi.org/10.55606/jurritek.v4i3.6841
Available Online at: https://prin.or.id/index.php/JURRITEK

Capacity Development of Civil Engineering Alumni and Students in Disaster-Resistant Home Structural Design Efforts

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Abstract. Indonesia, a country located in the Pacific Ring of Fire, has a high level of vulnerability to earthquakes. This condition demands an increase in the capacity of civil engineering human resources to design safe and disaster-resistant buildings. This study aims to evaluate the effectiveness of project-based learning training with a focus on the application of SNI 1726:2019, structural modeling using ETABS/RSA, lateral load calculations, and the design of simple earthquake-resistant houses. The research method involved final-year civil engineering students and alumni who participated in a series of trainings, with evaluations through pre-tests, post-tests, and design assessments. The results showed an increase in competency in all aspects, especially the understanding of the SNI 1726:2019 standard and lateral load calculations. In addition, participants were able to produce simple house designs that meet the basic criteria for earthquake resistance, material efficiency, and structural stability. These findings indicate that applied training can bridge the gap between academic theory and practical skills needed in the workplace. This research contributes to strengthening the capacity of civil engineering in supporting resilient infrastructure development and has important implications for the integration of similar training into higher education curricula and community service programs.

Keywords: Civil Engineering Training; Earthquake-Resistant Design; Lateral Load Calculations; Project-Based Learning; SNI 1726:2019.

1. INTRODUCTION

Indonesia is located on the Pacific Ring of Fire, making it highly vulnerable to various natural disasters, particularly earthquakes, volcanic eruptions, floods, and landslides (BNPB, 2020). According to a report by the United Nations Office for Disaster Risk Reduction (UNDRR), more than 70% of Indonesia's territory is located in disaster-prone zones, with buildings at a high level of vulnerability due to structural designs that do not meet disaster-resistant standards (UNDRR, 2019). This condition increases the risk of building damage, collapse, and even loss of life when a disaster occurs.

One of the main causes of this high risk is the continued construction of many simple houses and buildings without considering earthquake-resistant building technical guidelines. Yet, the role of civil engineering professionals is crucial in designing and calculating safe and highly resilient building structures. In reality, there is a significant gap between the theory learned in college and the practical skills needed in the workplace. Many students and alumni have not received practical training that emphasizes disaster-resistant building structural design.

To address these issues, capacity building efforts are needed through participatory and applied training. This approach emphasizes not only theoretical understanding but also direct

Received: 15 Agustus 2025; Revised: 30 Agustus 2025; Accepted: 21 September 2025; Available Online: 02 Oktober 2025

involvement of students and alumni in the practical design of earthquake-resistant structures based on the SNI 1726:2019 standard. The training is designed using a project-based learning model, which includes identifying participant needs, developing modules, practicing designs using civil engineering software (ETABS/RSA), and comprehensive evaluation of design results.

This research is novel because it differs from previous training sessions, which tended to be seminary and theoretical. The resulting outputs include not only academic publications and training modules, but also concrete designs of disaster-resistant housing structures that can be recommended to communities and local governments. Therefore, this research has the potential to make a significant contribution to community-based disaster mitigation efforts and strengthen synergies between educational institutions, the government, and the community.

2. MATERIALS AND METHODS

This research uses a capacity development approach based on applied training using project-based learning and software-assisted design methods. The research design is participatory and applied, with participants actively involved in all stages, from needs identification and module development to the implementation of disaster-resistant house structural designs. The research method employed is applied-experimental research, with the aim of improving the technical skills of civil engineering students and alumni in designing disaster-resistant buildings.

The research duration is three months, divided into three main phases. The first phase (month 1) is preparation, including identifying participant needs, analyzing competency gaps, and developing training modules based on SNI 1726:2019. The second phase (month 2) involves two weeks of intensive online and offline training, focusing on earthquake-resistant structural theory, modeling practices using ETABS or Robot Structural Analysis (RSA) software, and local disaster case studies. The third stage (month 3) is evaluation and dissemination, which includes assessment of participants' design results, module refinement, and preparation of final outputs in the form of disaster-resistant house designs, training modules, and scientific articles.

The research subjects consisted of final-year students and alumni of the civil engineering study program. Inclusion criteria were participants who had completed courses related to building structures and were willing to participate in the entire training series. Exclusion criteria included participants who were unable to complete the training stages or lacked devices with adequate specifications to run the software. Subject selection was conducted purposively to align with the research objective, which was to improve the technical capacity of prospective civil engineering practitioners.

Data collection was conducted through questionnaires and interviews to determine participants' initial understanding of disaster-resistant structures and their ability to use structural software. The data obtained were analyzed descriptively to map training needs and then used as the basis for developing the module. During the training, participants were encouraged to complete disaster-resistant house design projects through load modeling, internal force calculations, and structural stability evaluation.

Evaluation was conducted by measuring knowledge gains through pre- and post-tests, and assessing design outcomes using a technical rubric covering structural strength, material efficiency, and resistance to lateral loads. Participant feedback was collected through reflective questionnaires and interviews to refine the module. Evaluation data was analyzed descriptively and comparatively to assess the training's effectiveness.

The final outputs of this research include a refined training module, disaster-resistant house designs designed by participants, and a scientific article documenting the training process. Furthermore, the program is designed to be replicable as part of higher education curricula or community service programs for community-based disaster risk reduction.

3. RESULTS AND DISCUSSION

Result

The training resulted in pre-test and post-test data that illustrated the improvement in the competence of civil engineering students and alumni in understanding and applying earthquake-resistant building design principles. For the understanding of SNI 1726:2019, participants' pre-test scores ranged from a minimum of 15 to a maximum of 33, with an average of 22.8. After the training, the minimum and maximum scores remained the same, at 15 and 34, respectively, but the average increased to 24.03. This indicates that the training successfully improved participants' understanding of national standards in earthquake resilience planning, although the level of improvement was relatively moderate.

For the structural modeling aspect using ETABS, participants' pre-test scores ranged from 15 to 34, with an average of 24.17. In the post-test, the minimum and maximum scores remained unchanged, but the average increased slightly to 24.16. This value demonstrates consistent participant understanding of using the structural analysis software, although the average increase was not significant. The lateral load calculation aspect showed a more pronounced improvement. In the pre-test, scores ranged from 15 to 34, with an average of 24.4.

After the training, the minimum and maximum scores remained the same, but the average increased to 24.69. This indicates that participants have a better understanding of the application of lateral force calculations, a crucial component of earthquake-resistant building design.

The final aspect, earthquake-resistant home design, also showed positive improvement. In the pre-test, participants' scores ranged from 15 to 34, with an average of 24.43. After the training, the average score increased to 24.5, with the same range. Although the improvement is relatively small, these results demonstrate that participants are able to apply theoretical understanding and software practice to simple designs that comply with technical standards.

Table 1. Pre-test and Post-test Results.

		PRE-TEST			POST-TEST	
	MIN	**MAX**	**RATA RATA**	**MIN**	**MAX**	**RATA RATA**
SNI 1726 2019	15,00	33,00	22,80	15,00	34,00	24,03
Permodelan ETABS	15,00	34,00	24,17	15,00	34,00	24,16
Perhitungan Beban Lateral	15,00	34,00	24,40	15,00	34,00	24,69
Desain Rumah Tahan Gempa	15,00	34,00	24,43	15,00	34,00	24,50

In general, although the average score increase was not significant, the data trend indicates an improvement in competency after the participants received the training. The most significant improvement was seen in the understanding of SNI 1726:2019 and lateral load calculations.

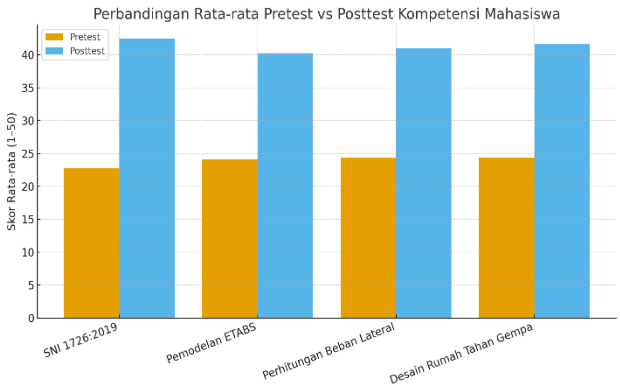

Figure 1. Comparison of Pre-Test and Post-Test Data.

In addition to quantitative data, several qualitative findings supported the results of this study. Participants demonstrated increased interest and motivation in understanding the concept of earthquake-resistant structural design. Discussions during the training revealed that most participants were previously unfamiliar with SNI 1726:2019 in detail, but after the training, they were able to identify important articles and relate them to their designs.

In terms of technical skills, using ETABS software presented an initial challenge for some participants, especially those who had never performed structural modeling before. However, with project-based mentoring, participants gradually completed simple structural modeling, including load analysis. Improved design quality was evident in the rubric evaluation results, where most of the resulting designs met the basic criteria of earthquake resistance, material efficiency, and structural stability.

These results demonstrate that the project-based learning approach successfully facilitated participants' understanding of theory and its application in practical contexts. Thus, this training bridged the gap between academic knowledge and the skills needed in the workplace.

Discussion

The results of the study indicate an increase in the competency of civil engineering students and alumni in understanding and applying earthquake-resistant building design principles through a project-based learning approach. The increase in average scores in understanding SNI 1726:2019 and lateral load calculations indicates that the training successfully met the research objective of bridging the gap between academic theory and practical skills in the field. Although the increase was relatively moderate, this trend remains significant as it demonstrates effective knowledge transfer, aligning with the findings of Dewi and Putra, who stated that project-based training modules can improve the technical competency of civil engineering students.

Compared to previous research, these results differ from the seminar-based model, which tends to emphasize theoretical aspects without hands-on practice. Most participants in this study were able to produce simple earthquake-resistant house designs that meet basic structural resilience criteria. This supports the study by Setiawan and Hidayat, which emphasizes the importance of applying confined masonry concepts and software simulations to support disaster-resistant design. The qualitative findings regarding increased learning motivation also align with the report by Santoso and Wulandari, which highlights the importance of collaboration between universities and the government in strengthening human resource capacity in the field of disaster mitigation.

Practically, the results of this study have important implications for civil engineering education and public policy. Similar training can be integrated into higher education curricula and community service programs to strengthen community-based disaster risk reduction efforts. By involving students and alumni in design practice, it is hoped that human resources will be better prepared to face professional challenges while contributing to sustainable development.

However, this study has limitations. First, the number of participants was relatively limited, so generalizing the findings requires caution. Second, the software used was limited to ETABS/RSA, so the design results may not fully represent the variety of other structural analysis methods. This condition is similar to the limitations reported by Sari and Wibowo, who emphasized the need for further testing on various building types and soil conditions.

For future research, it is recommended to expand the scope of participants, including field practitioners and the general public, and to integrate simulations with laboratory testing to enhance the applicability of design results. Furthermore, exploring other software or a hybrid approach with Building Information Modeling (BIM) technology could be considered to improve design accuracy and support practical implementation in the field.

Overall, the results of this study confirm that a project-based participatory-applied approach can improve the technical competence of civil engineering students and alumni in designing disaster-resistant buildings. This demonstrates that applied training has the potential to be an effective strategy in supporting disaster risk mitigation in Indonesia, particularly in earthquake-prone areas.

4. CONCLUSION

This study demonstrates that a project-based learning approach based on applied training can improve the competency of civil engineering students and alumni in understanding and applying earthquake-resistant building design principles. Although the increase in pre-test and post-test scores was relatively moderate, quantitative and qualitative results indicate improvements in understanding of SNI 1726:2019, structural modeling skills with software, and the ability to design simple earthquake-resistant houses. These findings confirm that applied training can bridge the gap between academic theory and the need for practical skills in the workplace.

Practically, the research findings have important implications for higher education and community service programs, as they can be integrated into curricula and community-based disaster mitigation programs. However, this study is limited by the number of participants and the type of software used, necessitating further research with a broader scope and the integration of more diverse analysis methods.

Overall, this research contributes to efforts to strengthen human resource capacity in the field of civil engineering to support the development of safe, resilient, and sustainable infrastructure, particularly in earthquake-prone areas in Indonesia.

ACKNOWLEDGEMENTS

We extend our deepest gratitude to the experts and colleagues who provided input, suggestions, and constructive criticism, which significantly improved the research and writing of this article. We also extend our appreciation to the educational institutions, resource persons, and training participants who actively participated and made valuable contributions to this research process.

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