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Research paper

Effectiveness of Earthquake-Resistant Housing Training in Enhancing Disaster Mitigation Understanding among Vocational School Teachers

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ABSTRACT

Background: Several studies indicate that teachers still have limited comprehension of reinforcement detailing, structural behaviour, and the application of SNI 1726:2019 and SNI 2847:2019. These limitations highlight the need for practical, hands-on training that strengthens both conceptual knowledge and technical construction skills, particularly for simple residential structures that frequently experience seismic damage.
Methods: This study employed a descriptive qualitative approach to analyse the implementation and results of socialization activities and training on earthquake-resistant housing for teachers in the construction and property engineering department at SMK Negeri 1 Padang. Data collection was conducted through direct conceptual socialization, documentation, and participant engagement notes. The training consisted of conceptual socialization, demonstrations of the use of structural teaching aids such as a type 36 house model and reinforcement assemblies, hands-on practice, and field simulations designed to connect theoretical concepts with real-world practice.
Results: The result of this study indicates that the practice-oriented training model is a valuable strategy to improve the competence and teaching skills of vocational teachers in earthquake-resistant housing construction and is proven to be effective in strengthening their contribution to disaster mitigation efforts.
Conclusion: The training activity significantly improved teachers' understanding of building structural components, reinforcement techniques, and basic load flow mechanisms in earthquake-resistant housing construction. Teachers' active involvement in concepts and enabling them to apply construction principles in accordance with SNI. The collaborative learning environment provided a platform for the exchange of experiences among teachers, and field simulations also strengthened the connection between theoretical understanding and field processes.

INTRODUCTION

Indonesia is recognized as one of the most seismically active countries in the world because it lies at the intersection of three major tectonic plates, namely the Indo-Australian, Eurasian, and Pacific plates. This geological condition places many areas, including West Sumatra, at high risk of earthquakes. Therefore, local communities are required to understand how to construct earthquake-resistant structures.

The Indonesian National Standards (SNI), particularly SNI 1726:2019 for seismic design and SNI 2847:2019 for structural concrete, serve as key technical references for earthquake-resistant housing construction. Despite the availability of these standards, many studies show that their application in the field is still far from optimal, especially for simple housing projects. Medriosa and Wau (2023) found that numerous buildings are constructed without proper structural analysis, with insufficient reinforcement detailing and weak attention to connection requirements. These conditions indicate a substantial gap between the technical provisions outlined in SNI and real practices in construction sites. In addition, Arifin and Andreas (2024) reported that community preparedness in Padang Barat is closely related to people's understanding of tsunami hazards and the effectiveness of mitigation programs delivered to them. From a global perspective, Galano and Calabrese (2023) also emphasized that non-engineered buildings in many developing countries remain highly susceptible to earthquake damage due to poor implementation of seismic technologies and building standards. This view is consistent with Chieffo et al. (2020), who underlined the importance of reliable seismic vulnerability assessment for estimating potential impacts on human safety, infrastructure, cultural heritage, and economic conditions. Moreover, international studies on seismic risk have increasingly focused on regional hazard characteristics, physical vulnerability, exposure levels, and socioeconomic aspects of urban areas (Altindal et al., 2021; Chieffo et al., 2024). Collectively, these findings highlight the urgent need to strengthen the implementation of seismic design standards in Indonesia to minimize the vulnerability of non-engineered residential buildings.

In vocational education settings, teachers at Vocational High Schools (SMK) hold a crucial role as instructors and as front-line agents of disaster mitigation, particularly in transferring technical knowledge of earthquake-resistant construction to students. However, reports from vocational education studies and community service activities reveal that teachers' comprehension of earthquake-resistant structures is still relatively limited, especially in technical areas such as reinforcement detailing, structural representation, and bar anchorage (Mahmud et al., 2023). This situation indicates the importance of enhancing teachers' capacity through training models that emphasize direct practice and real construction experience. Therefore, socialization and hands-on training on earthquake-resistant housing structures are considered a relevant strategy to address this competence gap. Practice-based training, such as using structural models, reinforcement simulations, and demonstrations of portable bar-bending tools, allows teachers to gain direct technical experience. Such efforts also align with national policies promoting disaster education in schools (BNPB, 2023).

Although previous studies have explored public understanding of earthquake-resistant construction, very few have specifically examined the improvement of SMK teachers' competencies through technical training based on SNI standards. Existing research generally

focuses on the evaluation of construction standard implementation but has not integrated practical training, technical teaching aids, and instructional media within the vocational education context. Therefore, this study offers novelty by developing a practice-based socialization and training model that can be directly applied in construction learning at SMK.

Based on these conditions, this study aims to develop and strengthen SMK teachers' professional competence in earthquake-resistant housing construction through practice-based training. Specifically, the objectives are to: (1) enhance teachers' conceptual and procedural competence in understanding earthquake-resistant house principles and structural behaviour; (2) improve teachers' practical skills in reinforcement detailing and earthquake-resistant construction techniques in accordance with SNI 1726:2019 and SNI 2847:2019; and (3) equip teachers with the ability to utilize instructional teaching aids**,** such as house models, reinforcement assemblies, and portable bar-bending tools, as effective media in vocational construction learning.

METHODS

Type of Research

This study employed a descriptive qualitative design to explore the implementation of the training program. This approach focused on describing the activity process, the level of participant engagement, and the outcomes achieved. Data were collected through direct observation, activity documentation, researcher field notes, and interactions with participants during training sessions.

Research Location and Time

This research was conducted at SMK Negeri 1 Padang, focusing on the construction and property engineering program as the primary research location. Socialization sessions, technical demonstrations, hands-on reinforcement practice, and field simulation activities were conducted during the period allocated for community service and training programs.

Research Variables

The primary variable explored in this research was teachers' level of understanding of earthquake-resistant housing construction. To make this variable measurable, it was defined through several operational indicators, which included:

1. Comprehension of the fundamental structural principles applied in earthquake-resistant buildings.
2. Knowledge of basic structural elements used in simple residential houses.
3. Proficiency in carrying out reinforcement work in accordance with SNI 2847:2019 and SNI 1726:2019.
4. Ability to recognize load paths and interpret structural behaviour under seismic forces.
5. Competence in utilizing instructional media, such as house models and reinforcement assemblies, during learning activities.

Research Subjects

Participants in this study consisted of teachers from the Construction and Property Engineering program at SMK Negeri 1 Padang. A total of fifteen vocational teachers participated in the training. They represented a wide range of teaching experience, from junior to senior staff, and were actively involved in construction-related subjects, including building structures, concrete work, and construction practices. These teachers were selected intentionally because

of their strategic position in delivering learning materials on earthquake-resistant construction and in raising awareness of disaster mitigation among vocational students.

Data Analysis Techniques

The collected data were examined using descriptive analysis by organizing and categorizing findings from observations and documentation. The analysis emphasized the interpretation of participant engagement, their level of understanding, and the overall results of the training program. No formal instruments, such as tests or questionnaires, were used, as the primary objective was to describe the actual conditions and effectiveness of the activities as they occurred in the field.

RESULTS AND DISCUSSION

The training program implemented at SMK Negeri 1 Padang reflects a practice-oriented learning model that contributes to improving vocational teachers' understanding of earthquake-resistant housing construction. The activity ran smoothly, encouraged active participation, and received positive feedback from teachers majoring in Construction and Property Engineering. Based on field observations, the high level of engagement among participants indicates that the practical approach applied throughout the program was effective in strengthening their understanding of earthquake-resistant construction concepts. The integration of interactive discussions, visual structure media, reinforcement assembly practices, and field simulations offered a rich and holistic learning experience for vocational teachers. These results support previous research showing that practice-based training plays a significant role in improving vocational competencies, particularly in engineering and construction fields that require procedural skills (Fjellström, 2014). Given that West Sumatra is located in an earthquake-prone area, improving teachers' understanding through this training is highly relevant and an important part of local disaster mitigation efforts.

1. **Implementation of Socialization**

   The socialization activity created an interactive and collaborative learning environment for teachers. During the session, participants actively engaged in group discussions, Q&A sessions, and real-life case analyses of building damage caused by earthquakes. As presented in Figure 1, the learning process was characterized by peer-to-peer interactions, where teachers shared practical experiences and structural perspectives with their colleagues. These peer-to-peer exchanges contributed to improving participants' conceptual understanding of earthquake-resistant construction. These results support the findings of Yani et al. (2022), who reported that collaborative learning in construction education improves analytical skills, deepens structural understanding, and encourages active engagement among students.

Figure 1. Socialization on Earthquake-Resistant Housing

2. Development and Use of Earthquake-Resistant Structural Teaching Aids

a. Type-36 House Model

The Type 36 house model serves as an effective learning medium because it displays the main structural components of a house completely and proportionally, from the foundation and tie beams (sloof) to the columns, beams, and roof system. As illustrated in Figure 2, the use of this physical model allows participants to better understand construction concepts through direct and concrete visualization. This finding is consistent with Afify et al. (2021), who reported that physical model-based learning activities can significantly improve spatial visualization skills and structural understanding when compared to conventional two-dimensional drawing approaches.

Figure 2. Type-36 House Model

b. Reinforcement Assembly Model

The socialization activities fostered an interactive learning environment where teachers actively engaged in discussions and problem-solving tasks related to the concept of earthquake-resistant housing. The spacing and dimensions of the reinforcement bars were regulated in accordance with SNI 2847:2019 and SNI 7396:2008 standards. As illustrated in Figure 3, hands-on practice using actual reinforcement materials helped participants better understand proper installation procedures and anchorage details. This observation aligns with Addis (2021), who stated that physical modeling allows students to more effectively internalize the structural relationships between building components.

Figure 3. Column and Tie-Beam Reinforcement Assembly

3. Development of a Portable Rebar Bender

The application of a portable rebar bender allowed teachers to take part in direct practice of bending reinforcement bars for columns and tie beams. As presented in Figure 4, the device enabled participants to carry out bending activities efficiently, even within limited working spaces. The use of this equipment is considered helpful in supporting teachers to demonstrate proper rebar bending procedures to their students in classroom and workshop settings. This approach is in line with the findings of Gunasagaran et al. (2021), who reported that incorporating real practice tools in civil engineering training can significantly improve learners' technical skills and professional preparedness.

Figure 4. Introduction of the Portable Rebar Bender

4. Field Simulation and Demonstration

Field simulations and technical demonstrations played a key role in connecting construction theory with real field experience. As illustrated in Figure 5, teachers participated enthusiastically in reinforcement practices and structural observations, which indicated that this approach was effective in strengthening their technical understanding. Through direct field activities, teachers were better equipped to convey earthquake-resistant housing principles to students in a more practical manner. These findings are consistent with Wibawanto et al. (2022), who reported that simulation-based learning in vocational education improves learning outcomes and technical skills. In addition, Chen (2019) highlighted that combining visual media with hands-on practice enhances concept retention and technical performance. Similar conclusions were also drawn by Santoso et al. (2022),

who emphasized that field-based technical training is highly effective in developing vocational skills and improving job readiness.

Figure 5. Demonstration of the Portable Rebar Bender

5. Evaluation and Feedback

The evaluation phase was carried out through open discussions, participants' reflections, and question-and-answer sessions conducted after all training activities had been completed. During these sessions, teachers shared their newly gained understanding, challenges faced during implementation and plans to integrate earthquake-resistant construction concepts into their classroom teaching. Although the evaluation was descriptive in nature, the results suggest that the practice-oriented learning approach contributed to improving teachers' instructional readiness. Moreover, this training model is considered applicable and easily adaptable in other vocational schools because it relies on simple, low-cost, and flexible instructional media.

The integration of physical models, procedural practice, and field simulations was found to be effective in strengthening participants' comprehension of construction concepts. Bodur et al. (2020) emphasized that physical modeling plays an important role in developing deeper structural and spatial thinking, which is essential in earthquake-resistant construction training. In a similar vein, Lee et al. (2022) demonstrated that combining simulation-based design activities with physical model representations can improve learning performance and deepen conceptual understanding in engineering and technology education.

The training outcomes further indicate that the improvement in teachers' understanding of earthquake-resistant housing construction was influenced not only by the instructional materials but also by the effective integration of hands-on practice, live demonstrations, and structural learning media. In technical education, practice-based approaches are widely recognized as being more effective than lecture-oriented methods, particularly when learners can observe and perform construction procedures step by step. This finding is consistent with Adami et al. (2021), who reported that demonstration- and simulation-based construction training significantly enhances technical knowledge, procedural competence, and safety behavior.

In addition, the availability of physical learning media, such as the Type-36 house model and rebar mock-ups, strongly supported participants' ability to understand the relationships among different structural elements. The use of scaled models enabled

teachers to visualize abstract concepts, including load paths, framing systems, and column reinforcement principles, more concretely. These observations are in line with Setyorini and Raharjo (2023), who found that physical models and structural representation media improve learners' comprehension of building component details and inter-element relationships.

The training also highlighted the importance of field simulations, particularly in earthquake-prone areas such as West Sumatra. Participants' understanding of retrofitting techniques and reinforcement assembly improved when they directly observed how structural components interact in real construction settings. From a disaster mitigation perspective, teachers' knowledge of simple earthquake-resistant housing design is crucial in vocational education. Fitria et al. (2024) showed that applying basic structural measures, such as column strengthening, beam–column joint reinforcement, and wall-tie systems, can significantly enhance the seismic resilience of non-engineered houses, thereby underscoring the value of such technical training for teachers.

Furthermore, the results of this training are consistent with broader studies emphasizing the need for instructional innovation in technical education. A systematic review by Man et al. (2024) on VR-based construction safety training concluded that realistic and interactive learning media are more effective in developing skill mastery than conventional approaches. This supports the relevance of demonstrative and interactive media applied in earthquake-resistant housing training.

Overall, the training program had a clear positive impact on improving vocational teachers' understanding of earthquake-resistant construction, both at the conceptual and procedural levels. The combination of observation, hands-on practice, field demonstrations, and collaborative learning formed a comprehensive and contextually relevant instructional model. Considering Indonesia's high seismic risk, similar training programs should be implemented on a continuous basis in vocational education to ensure that both teachers and students are technically prepared to meet industry needs and to contribute to disaster mitigation efforts.

LIMITATIONS OF THE STUDY

Although the training produced encouraging results, several limitations should be considered. First, the study did not use quantitative instruments, such as pre- and post-tests or standardized questionnaires, to objectively measure participants' learning gains. Second, the lack of a control group makes it difficult to determine whether the observed gains were solely the result of the training activities. Third, the relatively short duration of the program limited the evaluation of long-term knowledge retention and the continued application of skills in teaching practice. Fourth, the descriptive analysis was based largely on observation and documentation, which may involve a degree of subjectivity. Finally, participants' initial competency levels were not formally assessed, making it impossible to accurately estimate the extent of their learning progress.

These limitations suggest that, although the practice-oriented approach appears promising, future research should adopt a more rigorous design. The use of mixed methods extended training periods, comparison groups, and objective assessment tools is

recommended to provide stronger evidence regarding the effectiveness of similar training programs.

CONCLUSION

This study concludes that the socialization and training program on earthquake-resistant housing for teachers at SMK Negeri 1 Padang was effective in improving both their conceptual understanding and practical competence in applying earthquake-resistant construction principles. The combination of interactive discussions, structural visualization using teaching aids, reinforcement practice, and field demonstrations enabled participants to relate theoretical knowledge to real construction conditions. These learning activities directly fulfilled the research objectives, namely strengthening teachers' understanding of earthquake-resistant structures, enhancing their skills in reinforcement work in accordance with SNI standards, and introducing instructional media that support construction learning.

An important finding from this training is that teachers' technical competence develops more strongly when learning is supported by hands-on activities and collaborative interaction. The use of scaled house models, reinforcement assemblies, and portable bar-bending tools proved to be effective in improving structural comprehension as well as procedural accuracy. This confirms that practice-based learning represents a relevant and powerful approach for vocational education, particularly in the construction field.

In view of these positive results, further development of similar programs is strongly recommended. Future training initiatives could include more advanced materials, such as seismic detailing simulations, structural analysis workshops, and the integration of digital construction technologies. In addition, continuous professional development and follow-up evaluations are needed to maintain teachers' competencies and to strengthen the application of earthquake-resistant construction principles in vocational classrooms. Ultimately, such efforts are expected not only to enhance teaching quality but also to contribute to broader disaster mitigation capacity in earthquake-prone regions.

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DISCLOSURE STATEMENT

The authors declare that there are no potential conflicts of interest related to the conduct of this research, preparation of the manuscript, or publication of the results.

NOTES ON CONTRIBUTOR

Laras Oktavia Andreas is a faculty member in the Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang. Her academic interests cover construction materials, building technology, and vocational pedagogy. She has been involved in a number of studies related to practice-based learning, instructional models in construction education, and disaster-aware teaching approaches. In addition, she actively participates in community

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Fitra Rifwan serves as a lecturer in the Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang. His expertise lies in structural engineering, construction education, and earthquake-resistant housing systems. His recent work has focused on developing instructional media, vocational learning models, and promoting the implementation of SNI standards in building construction. He is also actively engaged in community service programs related to disaster mitigation and technical training for vocational school teachers.

Agri Americo Agamuddin is a lecturer at the Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang. His research interests include structural analysis, building design, earthquake-resistant construction, and the development of vocational education. He has contributed to various research and community service projects involving SNI-based construction training, structural visualization media, and capacity-building initiatives for vocational teachers in disaster-prone areas.

Fani Keprila Prima is a lecturer in the Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang, with a specialization in educational development for timber construction and roof-truss design. She is involved in research and community service activities focused on training vocational school teachers, particularly in safe and efficient timber construction techniques that support earthquake-resistant housing concepts. Her contribution enhances the relevance of the program to building characteristics commonly found in seismic regions.

Annisa Prita Melinda is a Ph.D. candidate at the Department of Architecture and Civil Engineering, Toyohashi University of Technology, Japan. Her research focuses on building structures, construction materials, and the quality of earthquake-resistant housing. She actively contributes as a resource person in research and community outreach programs related to earthquake-resistant structures. Her academic background and practical experience strengthen the effectiveness of training programs aimed at improving disaster mitigation awareness among vocational school teachers.

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