FACTORS AFFECTING BUILDING DAMAGE AND PEOPLE'S PREPAREDNESS FOR EARTHQUAKE IN CHIANG RAI

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Civil Engineering

Department of Civil Engineering
Faculty of Engineering
Chulalongkorn University

Academic Year 2017

ปัจจัยที่มีผลต่อความเสียหายอาคารและการเตรียมความพร้อมของประชาชน
สำหรับแผ่นดินไหวในจังหวัดเชียงราย

นายณรงค์เดช อินทรัตน์ชัยกิจ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรดุษฎีบัณฑิต
สาขาวิชาวิศวกรรมโยธา ภาควิชาวิศวกรรมโยธา
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ปีการศึกษา 2560

Thesis Title	FACTORS AFFECTING BUILDING DAMAGE AND PEOPLE'S PREPAREDNESS FOR EARTHQUAKE IN CHIANG RAI
By	Mr. Narongdej Intaratchaiyakit
Field of Study	Civil Engineering
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ในวันที่ 5 พฤษภาคม 2014 ประเทศไทยเกิดแผ่นดินไหวขนาด 6.3 ริกเตอร์ในเชียงราย แผ่นดินไหวครั้งนี้ได้รับการบันทึกว่าเกิดแผ่นดินไหวครั้งใหญ่ที่ประเทศไทยในอำเภอแม่ลาว แผ่นดินไหวครั้งนี้ทำให้เกิดความเสียหายต่ออาคารและการบาดเจ็บล้มตาย ในงานวิจัยนี้มีกลุ่มตัวอย่าง 277 คนที่อาศัยอยู่ในหมู่บ้านที่ 2 และ 7 ของตำบลดงมะดะ อำเภอแม่ลาว จังหวัดเชียงราย แบบสอบถามถูกใช้สัมภาษณ์กับกลุ่มตัวอย่าง และถูกนำมาวิเคราะห์ข้อมูลโดยใช้ Chi-square, Fisher’s exact test, a Mann-Whitney U test และ a Kruskal-Wallis test วัตถุประสงค์ของการศึกษาเพื่อตรวจสอบตัวแปรที่มีผลกระทบต่อระดับความเสียหายของโครงสร้าง การเตรียมความพร้อมเกี่ยวกับพฤติกรรมในช่วงระหว่างการเกิดแผ่นดินไหวในอนาคต การเตรียมความพร้อมแผ่นดินไหว การรับรู้ความเสี่ยงจากแผ่นดินไหว และชนิดกรอบความเสียหายของอาคารใดที่มีผลกระทบต่อการรับรู้ความเสี่ยงจากแผ่นดินไหว ผลการวิจัยจะพบว่า สถานที่ตั้งของอาคาร และชนิดอาคารมีผลกระทบต่อระดับความเสียหายของโครงสร้าง แต่ที่ปีที่สร้างไม่มีผลต่อระดับความเสียหายของโครงสร้าง การบาดเจ็บล้มตายและประสบการณ์แผ่นดินไหวในวันที่ 5 พฤษภาคม 2014 ไม่มีผลต่อการเตรียมความพร้อมสำหรับพฤติกรรมในช่วงระหว่างการเกิดแผ่นดินไหวในอนาคต แต่การจัดสัมมนาได้มีผลต่อการเตรียมความพร้อมสำหรับพฤติกรรมในช่วงระหว่างแผ่นดินไหวในอนาคต เพศ อายุระดับการศึกษา ความเป็นเจ้าของบ้าน และรายได้ผลต่อการเตรียมพร้อมแผ่นดินไหว อย่างไรก็ตามเวลาที่อาศัยอยู่ในบ้านปัจจุบันไม่มีผลต่อการเตรียมพร้อมแผ่นดินไหว เพศ อายุระดับการศึกษา ความเป็นเจ้าของบ้านรายได้และเวลาที่อาศัยอยู่ในบ้านปัจจุบันไม่มีผลต่อการรับรู้ความเสี่ยงจากแผ่นดินไหว กลุ่มตัวอย่างส่วนใหญ่มีพฤติกรรมในการรับรู้ถึงความเสี่ยงที่ดีแม้ว่าสถานะทางเศรษฐกิจและสังคมแตกต่างกันก็ตามเนื่องจากพวกเขาอยู่ใกล้กับศูนย์กลางแผ่นดินไหว ในขณะที่กลุ่มตัวอย่างส่วนใหญ่มีการเตรียมความพร้อมแผ่นดินไหวในระดับต่ำอาจเป็นเพราะฐานะทางเศรษฐกิจและสังคมของพวกเขาเกือบเป็นคนจน และหนึ่งในสามของผู้เข้าร่วมโครงการเป็นคนจน ดังนั้นกลุ่มตัวอย่างจึงขาดแคลนเงินสำหรับการเตรียมความพร้อมแผ่นดินไหว ประชาชนอาจจะเตรียมความพร้อมรับมือกับแผ่นดินไหวมากขึ้นเมื่อพวกเขารับรู้ข้อมูลแผ่นดินไหวด้วยกรอบที่เหมาะสม โดยรวมแล้วการให้การศึกษาด้วยสัมมนา การเตรียมความพร้อมแผ่นดินไหว และการเสริมสร้างความเข้มแข็งของอาคารด้วยข้อบังคับเกี่ยวกับแผ่นดินไหวอาจลดความเสี่ยงจากแผ่นดินไหวได้

ภาควิชา วิศวกรรมโยธา ลายมือชื่อนิสิต ....

สาขาวิชา วิศวกรรมโยธา ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

ปีการศึกษา 2560

5871426521 : MAJOR CIVIL ENGINEERING

KEYWORDS: STRUCTURAL DAMAGE LEVELS,,EARTHQUAKE PREPAREDNESS, SEISMIC RISK PERCEPTION, FRAMING

NARONGDEJ INTARATCHAIYAKIT: FACTORS AFFECTING BUILDING DAMAGE AND PEOPLE'S PREPAREDNESS FOR EARTHQUAKE IN CHIANG RAI. ADVISOR: ASSOC. PROF. DR.SUPOT TEACHAVORASINSKUN, D.Eng., 135 pp.

On May 5, 2014, an earthquake with a magnitude of 6.3 on the Richter scale occurred in Chiang Rai, Thailand. This earthquake was the strongest earthquake in Thailand at the Mae Lao District region. It also caused building damage and casualties. In this research, 277 participants living in village no.2 and village no.7 of Dong Mada, a sub-district at Mae Lao district in Chiang Rai, were selected. A questionnaire was used to interview these participants, and the data were analyzed by Chi-square, Fisher's exact test, a Mann-Whitney U test, and a Kruskal-Wallis test. The objective of this study was to examine factors that affected building damage, preparedness for behavior during future earthquakes, preparedness before and after earthquakes in the future, seismic risk perception; and what would be the framing type of building damage that affected seismic risk perception. The results indicated that the location of the buildings and building types affected structural damage levels while the year built did not affect structural damage levels. The casualties and earthquake experience of May 5, 2014 did not affect preparedness for behavior during future earthquakes. However, seminars did. Sex, age, education levels, house ownership, and income were associated with preparedness before and after earthquakes in the future. However, time living in the present house and villages were not associated with preparedness before and after earthquakes in the future. Sex, age, education levels, house ownership, income, and time living in the present house were not associated with seismic risk perception. Most participants behaved well on risk perception although most with low socio-economic status lived near the epicenter, and most participants behaved with low preparedness. It may be because most of their low socio-economic status, meaning one-third of the participants were poor; thus, they lacked money for earthquake preparedness. People may have more earthquake preparedness when they perceive earthquake data by the suitable framing. Overall, giving earthquake education through seminars, facilitating preparation for earthquakes, and strengthening buildings with seismic provisions are all factors likely to decrease earthquake risk.

Department:	Civil En□ineering	Student's Signature	....
Field of Study:	Civil Engineering	Advisor's Signature	....
Academic Year:	2017		

ACKNOWLEDGEMENTS

I would like to gratitude to my advisor, Assoc. Prof. Dr.Supot Teachavorasinskun for several advices, encouragement, and continuous advocate throughout this research. I would also like to express my deepest thankfulness to Assoc. Prof. Dr.Boonchai Ukritchon, Assoc. Prof. Dr.Tirawat Boonyatee, Dr.Tadashi Nakasu, Asst. Prof. Dr.Siam Yimsiri for their valuable advice, beneficial comments and to be committees of my dissertation defense. Their suggestions and comments help this research more successfully. Assoc. Prof. Dr.Boonchai Ukritchon also recommended English language. I thank Mr. Akevit Pichitsiri and others who helped me to collect data. Finally, I thank my family for advocate throughout my life.

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Abbreviations	Definition
TMD	Thai Meteorological Department
DMR	Department of Mineral Resources
DPT	Department of Public Works and Town
GERD	Geotechnical Engineering Research and Development center
DDPM	Department of Disaster Prevention and Mitigation
MOI	Ministry of Interior
NSO	National Statistical Office
BORA	The Bureau of Registration Administration
FEMA	Federal Emergency Management Agency

CHAPTER 1

INTRODUCTION

1.1 Theme and Background

In Thailand, earthquakes often occur in the western and northern areas due to active fault lines from China, Myanmar, as well as the northern and western Thailand. Active fault lines in Thailand constitute Mae Chan, Mae Ing, Mae Hong son, Mae Tha, Theon-Long-Phrae, Phayao, Pua fault line, and so on, as shown in Figure 1.1(TMD, 2014).

Figure 1.1 Map of active fault zones in Thailand. Adapted from Courtesy of Department of Mineral Resources, Ministry of Natural Resources and Environment (DMR, 2016)

Table 1.1 Selected historical earthquakes in Asia occurring from 1901 to 2007

Date	Country	Focal depth (km)	Magnitude	Total deaths
15/2/1901	China	0	6.5 Ms	-
19/9/1902	Australia	2	6.0 ML	2
4/1/1917	Taiwan (1916–17 Nantou earthquakes)	0	6.5 Ms	54
24/1/1917	China	0	6.5 Ms	-
2/12/1943	Taiwan	0	6.5 Ms	3
9/9/1969	Japan	7.5	6.0 Ms	1
28/4/1971	China	8	6.3 Ms	2
16/8/1973	China	6.4	6.4 Ms	1
21/7/1976	China	4.3	6.1 Mw	11
23/8/1976	China	7.9	6.4 Mw	41
6/11/1976	China	7.7	6.3 Mw	33
7/11/1976	Iran	6.5	6.0 Mw	17
1/1/1977	China	5.3	6.0 Mw	2
5/7/1983	Turkey (1983 Biga earthquake)	2.6	6.1 Mw	5
13/9/1984	Japan (1984 Otaki earthquake)	1.1	6.2 Mw	29
24/4/1985	Philippines	5.3	6.1 Mw	6
15/9/1985	Indonesia	4.2	6.3 Mw	10
23/4/1992	Burma	7.9	6.1 Mw	4
23/2/1994	Iran	7	6.1 Mw	6
3/2/2002	Turkey	5	6.5 Mw	44
22/2/2005	Iran (2005 Zarand earthquake)	7	6.4 Mw	-
31/3/2006	Iran (2006 Borujerd earthquake)	7	6.1 Mw	-
2/6/2007	China	5	6.1 Mw	-

Note. The data are adapted from “List of deadly earthquakes since 1900” (Wikipedia, 2016)

Table 1.1 displays characteristics of 24 selected earthquakes that occurred from 1901 to 2007. The number of deaths depended on earthquake magnitude at any countries and focal depths that were less than eight km. These earthquakes can be classified as shallow (up to 70 km below the surface).

Most of the subsoil in Chiang Rai, Chiang Mai, and Kanchanaburi was categorized as stiff soil; however, all sites in Bangkok were categorized as soft soil (Poovarodom, Warnitchai and Hansapinyo, 2010).

On May 5, 2014 at 18.08 p.m. according to Time in Thailand, an earthquake with a magnitude 6.3 on the Richter scale existed in Chiang Rai because of displacement of the Phayao fault that was energy fault. This earthquake was the biggest earthquake in Thailand at the latitude of 19.756 degrees N, the longitude of 99.687 degrees E. In the Mae Lao district area, hypocenter was at a depth of 7 km and had an intensity of VII, leading to much damage to homes, buildings, ancient buildings, roads, and other infrastructures in several communities including Chiang Mai, Chiang Rai, Phayao, Phrae, Nan, Lampang, and Kamphaeng Phet. TMD (2014) reported that on 12 May 2014, the disaster regions in Chiang Rai occurred seven districts whereas 50 sub-districts were damaged (Figure 1.2(a) – (d)) including 609 villages, 8,935 homes, over 100 injuries, and one-person death.

On May 5, 2014, an earthquake with a magnitude 6.3 on the Richter scale occurred in Chiang Rai. This earthquake was among the biggest earthquakes in Thailand of the magnitude that occurs once every 500 years, as can be seen in Table 1.2 (TMD, 2014; TMD, 2016). DPT (2014) reported that on May 5, 2014, an earthquake with a magnitude 6.3 on the Richter scale occurred in Chiang Rai. This earthquake caused significant building damage. The total private buildings damaged totaled

10,369. The number of severely damaged buildings was 475; the inhabitants could no longer use the buildings for living. A total of 2,180 private buildings were damaged but able to be repaired and could be used for partial living. A total of 7,714 private buildings were damaged but still suitable for residents to continue living there safely.

Table 1.2 Selected historical earthquakes in Thailand between 624 B.C. and 2007

Date	Epicenter	Magnitude /Intensity	Short description of Event
624 B.C.	Yonok	VI MM	The earthquake and thunder occurred in the morning
534	Yonok	VIII MM	Felt the earthquake in the morning, 4 pagodas broken
1482	Chiang Mai	VI MM	Felt the earthquake in the morning, a loud noise
1545	Chiang Mai	VII MM	The top of pagoda broke off (from 86 m remain 60 m high)
23 December 2006	Mae Rim district in Chiang Mai	3.6	Felt the earthquake at Mae-rim district
22 April 2007	Wiang Papao district in Chiang Rai	4.5	Felt the earthquake at Wiangpapao district in Chiang Rai and Phayao
1 July 2008	Phrao district in Chiang Mai	3.8	Felt the earthquake at Chiang-Mai
5 May 2014	Dong Mada sub-district of Mae Lao district in Chiang Rai	6.3	Many damaged roads, buildings, and households with one death near the epicenter
24 May 2014	Na Noi district in Nan	3.6	Felt the earthquake in Naiwaing sub-district, Muang Nan district in Nan
24 October 2014	Dok Kham Tai district in Phayao	3.6	Felt the earthquake at Dok Kham Tai district in Phayao
20 August 2015	Thong Phaphum sub-district, Sangkha Buri district in Kanchanaburi	4.5	Felt the earthquake at Sangkha Buri district in Kanchanaburi
6 January 2016	Mae Ho sub-district, Mae Sariang district in Mae Hong Son	3.5	Felt the earthquake at Mae Sariang district in Mae Hong Son

Note. The data are adapted from TMD (2016).

After May 5, 2014, it was found that several buildings were damaged in Chiang Rai in Mae Lao and Mae Suai districts more than others because they were near north segment of the Phayao fault line. Even though Phan District was far from the north segment of the Phayao fault line, much damage occurred because there was site amplification with considerable shear wave velocity at 30 m in depth from the ground surface. The Phan District soil is a clay with slight sand mix and had an amplification factor of about 1.64. Moreover, the Chiang Rai to Chiang Mai roadway at the 151-152 km milestone cracked about 100 m in length and settled more than 2 m in depth due to liquefaction when the earthquake struck at a local magnitude of M_L 5 earthquake and the ground acceleration was higher than 0.1g (Wiwekwin and Kosuwan, 2014).

(a) (b)

(c) (d)

Figure 1.2 Building damage

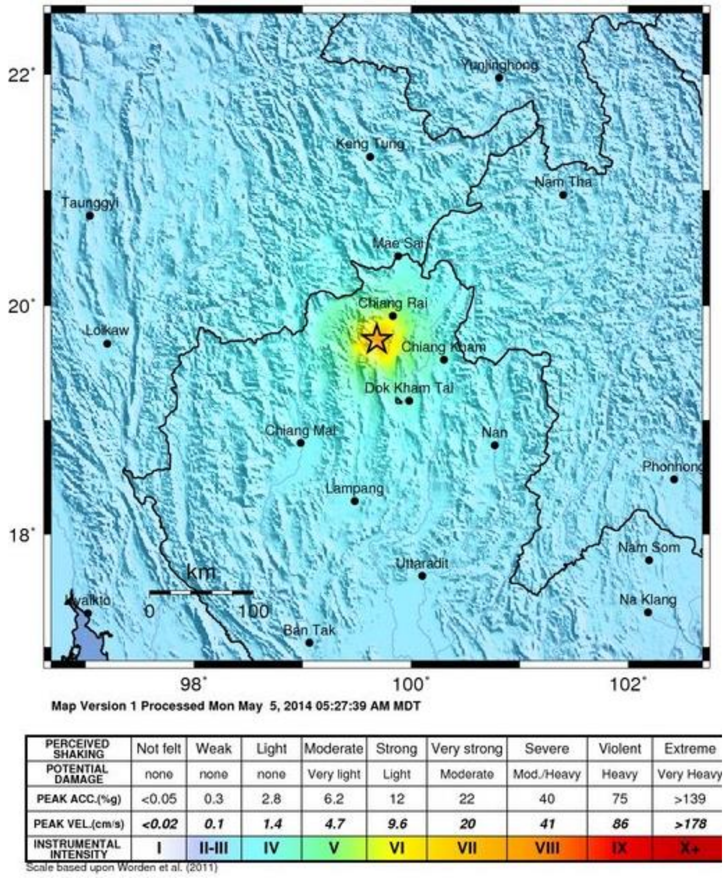


Figure 1.3 ShakeMap display of the site of intensity of VII indicated by the yellow star (USGS, 2014)

In Figure 1.3, ShakeMap display of the site of intensity around the hypocenter depends on the soil class and distance from the hypocenter in Chiang Rai, Thailand TMD (2014).

Ruangrassamee, Boonyatee, Chintanapakdee, Jankaew, Thanasisathit, Chandrangsu and Lukkunaprasit (2014) showed that in Chiang Rai in the Mae Lao and Phan districts, most buildings have not been designed for earthquake resistance. Thus, damage appeared on several buildings, bridges and other structures on September 11, 1994, in Phan district. Over 50 buildings consisting of schools and hospitals appeared to incur minor and moderate damage because of an earthquake. Short columns and reinforced concrete columns with unreinforced masonry infill walls were damaged due to shear cracks and flexural cracks in short columns. Concrete columns had few reinforcement bars which caused soft story problems in many of the local two-story residences. Thus, some residences collapsed and some did not.

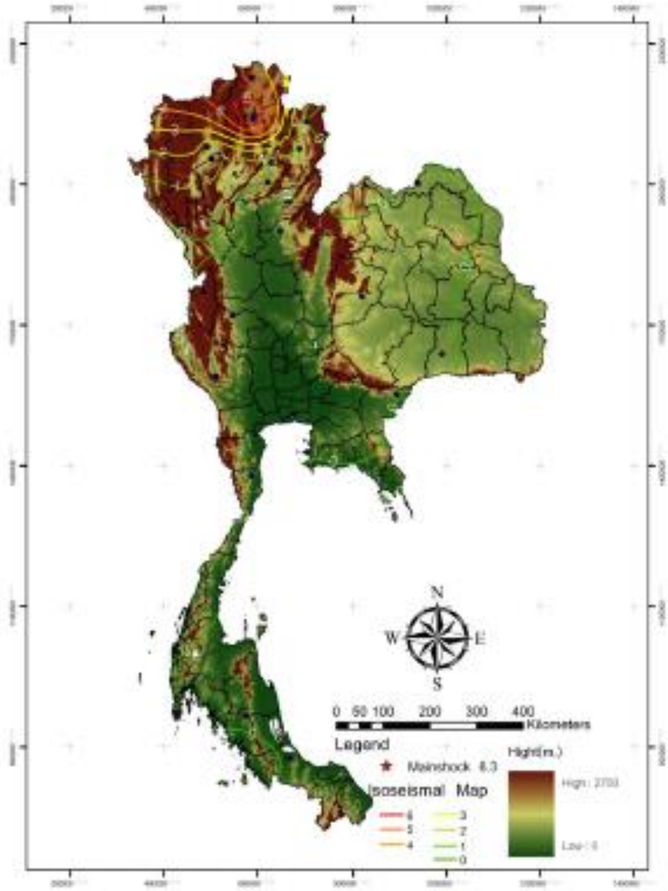
Ruangrassamee et al. (2014) surveyed buildings at Dong-Mada sub-district, Mae Lao District. It was found that for instance, flexural cracks of soft story columns that opened space without braced columns (Figure 1.4(a)), shear cracks of short column of reinforced concrete with unreinforced masonry infill wall (Figure 1.4(b)), and soft story with torsional irregularity collapsed (Figure 1.4(c)) appeared on building damage. Masonry walls comprised hollow cement blocks in buildings since these masonry walls were cheap. Nevertheless, no anchorage was between wall and column, thereby causing collapse of buildings comprising masonry walls. At 10 km from the epicenter, the maximum acceleration was forecasted about 0.2g - 0.3g from the attenuation relations of Sadigh's equation.

(a) (b) (c)

Figure 1.4 Building damage (Ruangrassamee et al., 2014)

The northern and western Thailand had both local magnitudes of M_L 5.5 - 6.5 earthquake and maximum ground acceleration of 0.2g, thereby causing increased excess pore water pressure that produced liquefaction in loose to medium dense sand at a depth of 2 - 8 m from the ground surface. This liquefaction was possible to damage to 2 - 3 story buildings in Chiang Mai and Chiang Rai (Teachavorasinskun, Pattararattanakul and Pongvithayapranu, 2009).

On May 24, 2011 at 13.35 (UTC), Tarlay had a magnitude M 6.8 earthquake at a latitude of 20.705 degrees N and a longitude of 99.949 degrees E causing many buildings and roads to incur damage causing one casualty in Northern Thailand. People that lived in buildings higher than 10 stories in Bangkok felt the shock. In addition, liquefaction and the large structural failure were found in Maesai district such as shear failure of columns due to short columns or load transfer from masonry walls (Ruangrassamee, Ornthammarath and Lukkunaprasit, 2012).



Perceived Shaking	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
Acc.(%g)	< 0.17	0.17 - 1.4	1.4 - 3.9	3.9 - 9.2	9.2 - 18.0	18.0 - 34.0	34.0 - 65.0	65.0 - 124.0	> 124.0

Figure 1.5 Map displaying site of PGA by Kringing Method (TMD, 2014)

As shown in Figure 1.5, the bulk of high PGA values are located in the North and Western zones of Thailand. If PGA has a high value, damage to buildings or construction could incur high loss.

TMD (2014) created an intensity map of the damage of the ground and buildings to be compared with the Modified Mercalli scale (generally defined as MM), which consisted of twelve levels defined by Roman numerals I-XII. Buildings near the hypocenter had enormous damage and some collapse, but others incurred only slight damage as a result of being well designed. Chiang Mai, Phayao, and Lampang had an intensity of IV, V, and VI level, respectively. Furthermore, liquefaction in Chiang Rai occurred at an intensity of VII and VIII levels.

On May 5, 2014, an earthquake with a magnitude of 6.3 on the Richter scale led to liquefaction in Chiang Rai as can be seen in Figure 1.6.

Figure 1.6 Liquefaction appearing in Mae Sai (GERD, 2014).

At PGA = 0.1g, liquefaction areas occurred in Chiang Rai and Chiang Mai. At PGA = 0.2g, liquefaction areas occurred partly in Northern provinces. At PGA = 0.3g, liquefaction areas mostly occurred in Chiang Rai and Chiang Mai. Civil engineering calculated structures on the ground and the foundation in the northern areas. One must consider partial liquefaction in particular in Chiang Rai, Chiang Mai and Nan for calculating or designing as well if the soil layers consist of loose to medium dense sand.

Because the earthquake caused peak ground acceleration at PGA = 0.1g, liquefaction occurred (Tanapalungkorn, 2014).

Palasri (2012) showed that a seismic hazard map in Thailand indicated peak horizontal accelerations having 10 % probability of exceedance in 50 years and 2 % probability of exceedance in 50 years. This was used for designing earthquake resistant structures. Peak horizontal accelerations were also presented in return period terms showing 10 % in 50 years or 475 years (about 500 years) and 2 % in 50 years or 2,475 years (about 2,500 years).

Construction was poor because seismic provisions were not effectively enforced and plane in evacuation was not efficient, thereby increasing the number of injuries and deaths (Paradise, 2005).

Ground shaking affected building damage. The building damage depended on the number of factors such as earthquake magnitude, a building location from an epicenter, focus depth, soil condition supporting a building, a construction method, and building materials (Andrews, 2016). Strength of shaking estimated by attenuation of ground motions rose when distance from the epicenter decreased (Dowrick, 2003)

Because buildings were quickly constructed and were not standard in their seismic provisions, a large number of people in city areas raised the risk for both injuries and deaths (Bendimerad, 2004).

Disaster risk reduction was related to the risk perception of individuals, households, and communities. Disaster risk reduction requiring preparedness and preventive measures was designed and achieved by government and donor agencies. In addition, disaster risk reduction activities could succeed when people understood risk perception, and both agencies and staff involved in the disaster risk reduction activities were able to plan disaster risk reduction activities (Ainuddin, Kumar Routray and Ainuddin, 2014).

People's seismic risk perception can be considered by probability of occurring earthquake, imminence, and severity (Paul and Bhuiyan, 2010).

Framing affected people's risk perception and risk preparedness (Cowan, McClure and Wilson, 2002; Hurnen and McClure, 1997; McClure and Sibley, 2011; Richard Eiser, Bostrom, Burton, Johnston, McClure, Paton, van der Pligt and White, 2012). Effective communication that was necessary to detect a suitable method was essential to understanding complicated risk frames which were difficult and uncertain (Slovic, 1986). People experienced main shocks causing them to be likely well prepared for aftershocks if they received the earthquake risk framing about aftershock warnings, and made them aware of what to do during the aftershocks (Mileti and Fitzpatrick, 1992). As for risk communication, people perceived greater risk when facing the risk framing with disaster pictures rather than with only pictures that did not reflect disasters (Keller, Siegrist and Gutscher, 2006). Thus, disaster risk messages transferred between agencies and people should obviously communicate the risk effectively. These messages should be easy to interpret and comprehend in order to successfully reduce disaster risk (Eriksen and Prior, 2013; Fischhoff and Downs, 1997; Richard Eiser et al., 2012). When presenting the same problem was conducted in different word, phrase, or sentence patterns, people's judgment was different (Henrich, McClure and Crozier, 2015; Linville, Fischer and Fischhoff, 1993; McClure and Sibley, 2011; McClure, White and Sibley, 2009; Smith and Petty, 1996; Tversky and Kahneman, 1981).

Henrich et al. (2015) reported that the effects of risk framing on earthquake risk perception had the most important effect on people's risk decisions and could be employed to communicate risk information effectively.

Thus, building and property damage including casualties can be reduced by disaster risk reduction activities.

1.2 Objectives

The objective of this study was to examine, firstly, variables (villages, year built, and building types) that influenced building damage; secondly, factors (seminars, casualties, and earthquake experience of May 5, 2014) that influenced people's earthquake preparedness for behavior during future earthquakes; thirdly, factors (sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure) that affected people's earthquake preparedness before and after earthquakes in the future; next, factors (sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure) that affected people's seismic risk perception; finally, what would be the framing type of building damage that affected people's seismic risk perception.

1.3 Scopes

Building samples were explored. These building samples, which consisted of wood structures and reinforced concrete buildings with unreinforced masonry infill walls, were one-story and two-story building types totaling 277 houses for the study in Dong Mada. Located in the northern Thailand, Dong Mada is a sub-district at Mae Lao District in Chiang Rai. Village no.2 (Rattan Creek Village) and village no.7 (Dong Mada Village) of a Dong Mada sub-district were opted for this study. A questionnaire was used to interview people about building damage, earthquake preparedness, seismic risk perception, and framing type of building damage.

1.4 Research methodology

Firstly, there was selecting the location of this study. Secondly, multistage sampling was used for selecting sample. Thirdly, minimum sample size was estimated by Yamane formula. Next, data were gathered about building damage, villages, year built, and building types; people's earthquake preparedness for behavior during future earthquakes, seminar, casualties, and earthquake experience of May 5, 2014; people's earthquake preparedness before and after earthquakes in the future, sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure; people's seismic risk perception, sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure; the framing type of building damage that affected people's seismic risk perception.

Then, Chi-square test and/or Fisher's exact test were used to determine the following relationship: Villages (Villages no. 2 and no. 7) versus structural damage levels; Year-built before as well as after 1997 versus structural damage levels; Building types (reinforced concrete with unreinforced masonry infill walls and wood buildings) versus structural damage levels; Preparedness for behavior during future earthquakes versus casualties, seminars, and earthquake experience of May 5, 2014. After that, A Mann-Whitney U test and/or a Kruskal-Wallis test were used to determine the following relationship: earthquake preparedness before and after earthquakes in the future versus sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure; seismic risk perception versus sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure; Finally, Chi-square test and/or Fisher's exact test were used to determine what would be the framing type of building damage that affected people's seismic risk perception.

1.5 Benefits

Anticipated benefits of this study consist of factors that influence building damage; factors that affect people's earthquake preparedness for behavior during future earthquakes; factors that affect people's earthquake preparedness before and after earthquakes in the future; factors that affect people's seismic risk perception; framing type that affects people's seismic risk perception; and overall, the results of the study may be used to enhance earthquake risk reduction.

CHAPTER 2
LITERATURE REVIEW

2.1 Natural disasters

Natural disasters occur around the world. Disaster is defined as an event which results from a community/society encountering severe effects and losses (UNISDR, 2009). Communities experience problems with their economy, society, and public services such as water, energy, sewage, and other health-related problems as a result of natural disasters (Noji, 1997).

Hazards can be classified into two types: natural and manmade hazards. Natural hazards are caused by geological, water & climatic, environmental, and biological hazards while manmade hazards are caused by chemical, industrial, and nuclear accidents as well as accident relating to hazards. Hazards can be seen in Table 2.1 (Vihar, 2006).

Major natural disasters are categorized into four hazard types: drought, floods, cyclones, and earthquakes (Burton, Kates and White, 1993). Solway (1999) reported the possible impact of natural hazards categorized into three types: 1) social and human effects, 2) physical effects, and 3) economic effects (see Table 2.2). Factors affect the possible impact of natural hazards such as location, topography, geology, and soil types.

Table 2.1 Several types of hazards (adapted from Vihar, 2006)

Types of hazards	Hazards		
Geological hazards	1. Earthquake 2. Tsunami	3. Volcanic eruption 4. Landslide	5. Dam burst 6. Mine fire
Water & climatic hazards	1. Tropical cyclone 2. Tornado and hurricane 3. Floods 4. Drought	5. Hailstorm 6. Cloudburst 7. Landslide 8. Heat & cold wave	9. Snow avalanche 10.Sea erosion
Environmental hazards	1. Environmental pollutions 2. Deforestation	3. Desertification 4. Pest infection	
Biological hazards	1. Human and animal epidemics 2. Pest attacks	3. Food poisoning 4.Weapons of mass destruction	
Chemical, industrial and nuclear accidents hazards	1. Chemical 2. Industrial	3. Oil spills / fires 4. Nuclear	
Accident hazards	1. Boat / road / train accidents / air crash rural / urban fires bomb /serial bomb blasts	3. Building collapse 4. Electric accidents 5. Festival related disasters	

Table 2.1 Several types of hazards (adapted from Vihar, 2006)

	2. Forest fires	6. Mine flooding

Table 2.2 Possible impact of natural hazards (adapted from Solway, 1999)

Effect	Social and human effects	Physical effects	Economic effects
Primary effects	- Injuries - Deaths - Loss of income or employment chances - Homelessness	- Ground deformation and loss of ground quality - Structural damage to buildings and infrastructure - Collapse of buildings and infrastructure - Non-structural damage, loss of ground quality for buildings and infrastructure	- Business interruption because of damage to buildings and infrastructures - Loss of productive workforce through injuries, deaths and relief efforts - Funds for response and relief
Secondary effects	- Disease or disability - Psychological impact of	- Progressive deterioration of damaged buildings	- Loss supported by insurance industry, weakening the

Table 2.2 Possible impact of natural hazards (adapted from Solway, 1999)

Effect	Social and human effects	Physical effects	Economic effects
	shock, injury, and bereavement - Loss of social unity - Unrest leading to government response that is perceived as being insufficient	and infrastructure due to lack of repair	insurance market and increasing premiums - Loss of markets and trade chances through business interruption in short term - Loss of confidence by investors, withdrawal of investment - Funds for repair

2.2 Hazard, Risk, Exposure and Vulnerability, and Building Vulnerability

Hazards are dangerous events resulting from actions of humans that are unnatural, leading to damage of property, the environment, the economy, and society at large (DDPM, 2013).

Hazards mean natural incidents that are probably influential to many locations, or in combination (e.g. earthquake faults, coastlines) at contrasting times (season, time). Hazards have several severity levels. Disaster risk is a function consisting of a natural hazard as well as the number of people that may be affected. Disaster risk depends on location and time exposure to hazardous incidents including vulnerability levels to particular hazards. Risk (R), hazard (H), and vulnerability (V) can be written as following an equation (Wisner, Blaikie, Cannon and Davis, 2003):

$$R = H * V \quad (1)$$

Risk is a probable hazard (Brehmer, 1987). It is also defined as the probability of the disaster event affecting a community in its economy, society, life, and property (DDPM, 2013). In addition, risk is possible to result in injuries and losses (Dowrick, 2003). Risk perception is defined as being able to predict the vulnerable incident that could lead to damage to the people (Brehmer, 1987).

Vulnerability means the probability of the destruction, damage, casualties, or loss (Wisner et al., 2003).

Earthquake hazards are natural events such as ground motion, ground shaking, and ground failure (Dowrick, 2003). Earthquake risks are expectations of losses in the economy, buildings, and lives (Fournier d'Albe, 1982; UNDRO, 1979).

Exposure and vulnerability affect risk. The exposure is that buildings, property, the environment, and people located in a disaster area. The vulnerability refers to the characteristics of a community that cannot handle hazards. For example, a weak building cannot resist hazards, and crowded people living in weak buildings in disaster areas face higher risk (DDPM, 2013). Vulnerability can also be classified into physical and socio-economic vulnerability. Physical vulnerability includes the location and strength of buildings to resist earthquakes. Socio-economic vulnerability such as poverty affected risk; for examples, the poor did not have enough money to construct stronger buildings; thus, they were unable to rebuild their houses (Vihar, 2006).

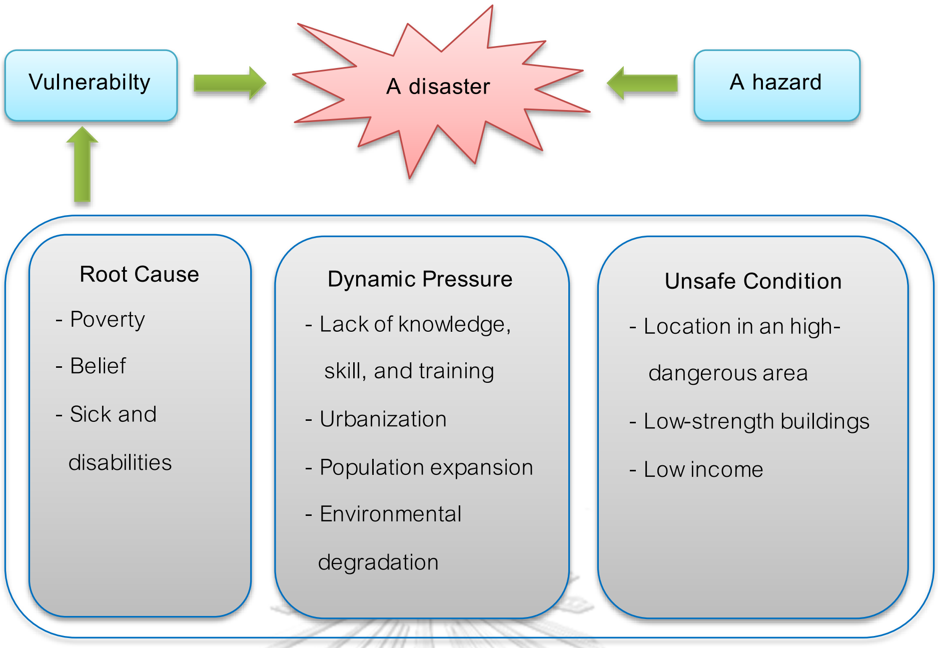


Figure 2.1 Combination of vulnerability and a hazard causing a disaster (adapted from DDPM, 2013; Montoya, 2002)

As can be seen in Figure 2.1, the combination of vulnerability and a hazard can cause a disaster. It is useful to determine risk reduction (DDPM, 2013; Montoya, 2002). Moreover, the interaction between vulnerability and a hazard leads to a disaster. Either vulnerability or a hazard alone is not a disaster; therefore, a disaster must comprise both vulnerability and a hazard. For example, the number of vulnerable people faces a hazard and the severity of damage, impeding their livelihood. Recovery in psychology to prey is conducted and the physical damage is replaced by physical resources (Wisner et al., 2003).

Wisner et al. (2003) showed that in comprehending risk of vulnerability of specific hazardous incidents, the Pressure and Release model (PAR model) as a basic instrument can be used to present what causes occurrence of disasters when there are natural hazards and vulnerable people.

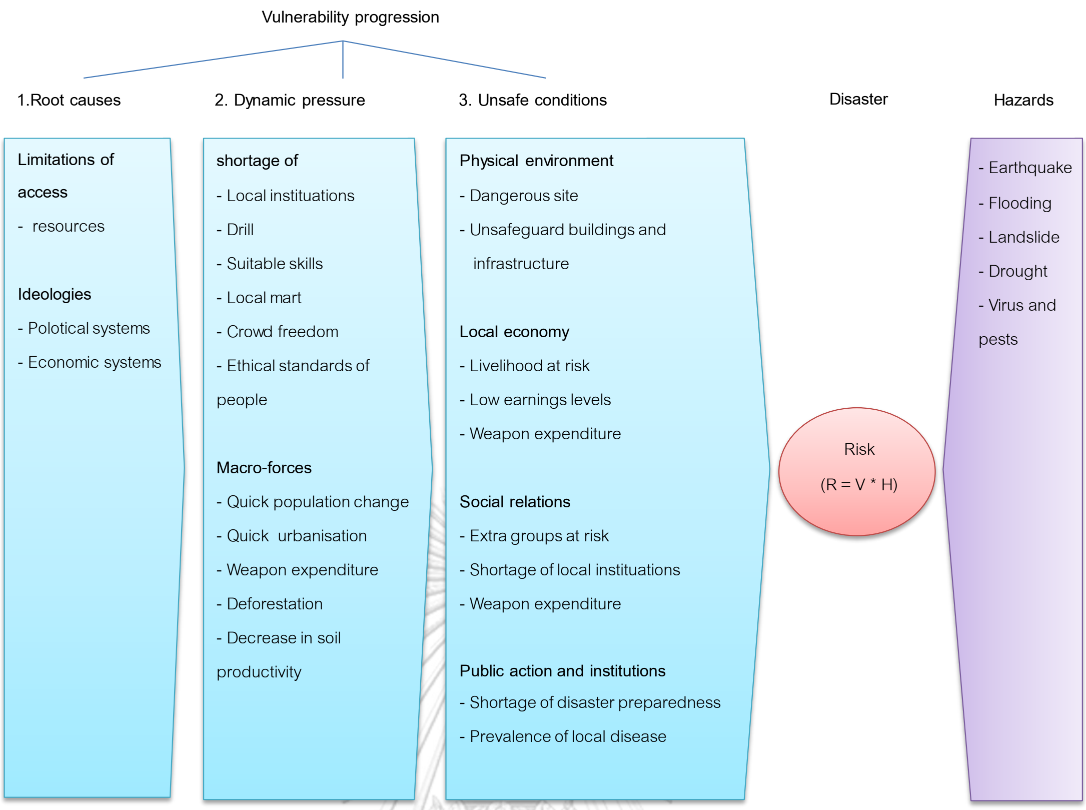


Figure 2.2 Pressure and Release model (PAR model): Vulnerability progression (adapted from Wisner et al., 2003).

Figure 2.2 shows the PAR model. The PAR model concept is that a disaster, which occurs slowly, consists of the vulnerability side and the hazard side. As to "pressure", pressure increases both the vulnerability side and hazard side, increasing the severity of the disaster. With regard to the "release" concept, when pressure is decreased, vulnerability reduces as well. The "release" concept also affects disaster reduction.

The primary root causes of increased vulnerability are the economy, demographics, and politics. These root causes influence judgment on allocation and distribution of resources to various groups of people. The root causes depend on the economy, demographic, politics, laws, the police and military, as well as administration. Root causes mirror the use of power in a society. People who have very low socio-economic status (e.g. homelessness) or live in high risk locations (e.g. steep, urban areas with high flood possibility) are likely to be neglected or given lesser importance from economic and political authorities, thus causing three sources of vulnerability. First, there are insecure and unpleasant to access to livelihood, causing higher vulnerability. Secondly, people do not receive adequate help from the government to mitigate hazards. Thirdly, people have a low socio-economic status and marginal politics, and they tend to lose confidence in themselves and their local knowledge. Even if they have confidence in their ability, they may lack important raw materials because they have low socio-economic status and marginal politics including low access to resources. The root causes are often changeable due to power conflicts, resources (financial, data), and identities. In contrast, disasters often result in the overthrow of elites and power change since people suffer from disasters.

Dynamic pressures are procedures for converting root cause effects to unsafe conditions, and then the relationship between unsafe conditions and hazards that people face are considered. Dynamic pressures are comprised of epidemic disease, quick urbanization, present wars, overseas debt, and building renovations.

Unsafe conditions include people's vulnerability presented in time and space linked to a hazard (trigger events). For instance, people live in hazardous areas and they have inadequate money to renovate buildings, building codes are not efficient and/or are not sufficiently enforced, people's livelihoods face dangerous events such as wildlife encroachment, prostitution is prevalent with risky diseases, sea fishing is conducted in small boats, etc. The majority of people are vulnerable since they have insufficient livelihoods, causing no flexibility to face shocks, and their socio-economic status is poor. The reason for being poor is the lack of equality in bargaining and politics affecting discrimination in the economy. People' vulnerability can be decreased by effectively coping with poverty in communities. People's vulnerability resulting from unsafe conditions meets a hazard (trigger event) leading to a disaster.

Root causes, dynamic pressures, and unsafe conditions depend on change. For example, rapid changes in new construction methods and materials occurred in Pakistan. This influenced communities that were slightly changeable for several years in unsafe conditions. For instance, dangerous buildings were constructed on steep hills causing many buildings to be at risk from landslides, while agriculture was conducted on flat land. Moreover, unsafe conditions consisted of decreased emphasis on building safety and a shortage of new construction methods for concrete buildings with seismic codes. However, some of these variables may have led to a shortage in the ability and materials to deal directly with dynamic pressures. Firstly, a shortage of wood for building construction occurred as a result of deforestation. Secondly, there was a shortage in the availability of carpenters and masons to construct buildings. Consequently, farmers and laborers both constructed and maintained buildings despite having little knowledge of construction methods.

Quick population growth is a dynamic pressure affecting vulnerable groups; for example, vulnerable groups suffer from drought. When both quick population growth and quick urbanization occur together, regions having few resources should improve agriculture quickly to obtain intensification of agriculture. Quick population growth will increase vulnerability. For instance, immigration occurs, causing settlement and livelihood changes. When people settle in at-risk areas, they are more likely to suffer from disasters than people settling in non-risk areas.

Natural hazards affect children and senior citizens because they are more vulnerable than adults (Ennew and Milne 1989; Hardoy and Satterthwaite 1989, as cited inWisner et al., 2003). Children and seniors in Japan, North America, and Europe are more at risk from disasters than adults because they move more slowly and they have weaker immune systems than adults. These younger and older groups are expected to incur more casualties. Vulnerability of senior citizens increases when social protection (e.g. health care, pensions) decreases (ICIHI, 1988; World Bank, 1994, as cited in

Wisner et al., 2003). In Bangladesh, access to land and ownership is not equal, thereby causing the poor to be powerless (Hartmann 1995; Boyce 1987, as cited in Wisner et al., 2003).

Increase in landless households, immigration from countryside to cities, and settling in dangerous areas comprise growing population pressure. When high inequality in access to land occurs, poor people will settle in dangerous areas (Wisner et al., 2003). A method for resolving this problem would reduce disaster vulnerability and wishes in big families such as intensive land reform, the empowered women, sufficient public service provisions (e.g. communication, education, and health). This approach has been attempted by China, Sri Lanka, and India for reducing population growth (Hartmann 1995: 289–304; Franke and Chasin 1989, as cited in Wisner et al., 2003).

Urbanization is important to growth in families having low incomes or living in squatter areas. Migrants from the countryside come to crowded cities receive land pressure from the urbanization process. These immigrants are at risk of facing natural hazards, starvation, and poor health (Richards and Thomson 1984; Pryer and Crook 1988; Cairncross et al.1990a; Wisner 1997, as cited in Wisner et al., 2003).

Hewitt reported that urbanization is associated with earthquake risks affecting building damage to multi story buildings and squatter areas containing weak home structures. Regions having a large number of older, deteriorated are riskier when moderate earthquakes occur, and people living in the slums face a greater risk of death.

2.3 Disaster Risk Reduction, Disaster Management, and Disaster Risk Management

Disaster risk reduction is a method of reducing the risk to lives and property and includes the management of city planning to better cope with disasters (DDPM, 2013). Disaster risk reduction can be done through preparedness and mitigation. Preparedness before disasters including the establishment of emergency plans, modern warning systems, and seminars are used to rescue people and plan for evacuation in order to reduce casualties and damage when disaster happens. The mitigation includes helping people to move away from hazardous regions and into strengthened buildings in order to reduce overall economic and social vulnerability as well as real damage when disasters happen (Vihar, 2006).

Earthquakes cause casualties and substantially damaged buildings. Thus, these problems should be eliminated by disaster management that constitutes mitigation, preparedness, response, and recovery (Federal Emergency Management Agency, National Emergency Training Centre et al., 1998 as cited in Montoya, 2002, pp.6-7). These are denoted as (Figure 2.3):

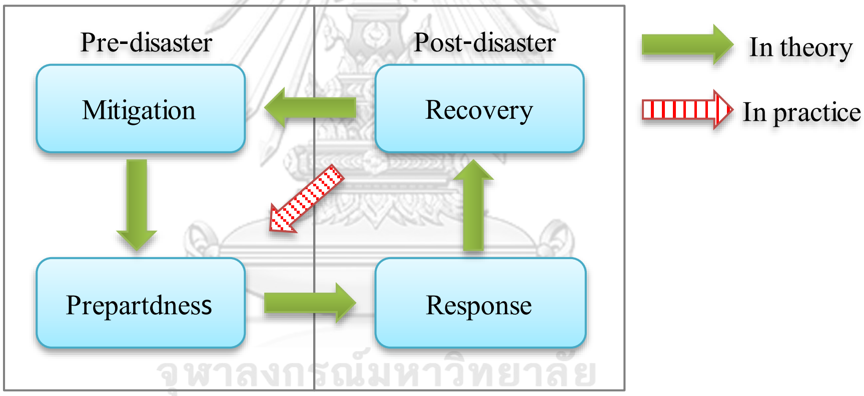


Figure 2.3 Disaster management (adapted from Montoya, 2002)

Montoya (2002) showed that:

1. Mitigation involves pre-disaster exercises and post-disaster drills in order to lessen feasible disasters in the future by utilizing land-use, regulatory enforcement, seismic building codes, and insurance.

2. Preparedness involves planning how to respond to disasters in the future by using tools, cooperative agreements with rules and responses from several organizations, public information and training for large numbers of people in risk areas.

3. Response is concerned with aiding to disaster prey and lessening secondary damage involving activities which happen during and instantly after a disaster. Response activities detect aid, extinguished, and evacuated prey as well as decreases secondary damage. People in disaster regions and local government officials help themselves for many hours or days before foreign resources can access the site.

4. Recovery is a part of destiny disaster management. This recovery turned for the better situations or even situations that became close common. Long-term recovery from disasters may take many years to cover disaster regions or fully rebuild in order to lessen disasters such as repair to infrastructure (roads, water, and power supplies), the distribution of medicines and clothing and shelter supply, the removal of debris, providing advice on psychology and offering job assistance as well as loans for small business.

As shown in Figure 2.3, in theory, disaster management consists of mitigation, preparedness, response, and recovery. Disaster management in practice is similar to disaster management in theory, but disaster management in practice tends to neglect mitigation.

Vihar (2006) showed that the three important activities in disaster risk management are pre-disaster activities, during-disaster activities, and post-disaster activities. First, pre-disaster activities consisting of mitigation and preparedness can reduce loss of life and property from possible hazards through such methods such as awareness campaign, strengthened buildings, and preparation in disaster management plans to households and communities. Next, during-disaster activities are called emergency response activities. People involved in during-disaster activities can learn how to react. Finally, post-disaster activities called recovery activities are aimed at the successful rehabilitation of damaged communities.

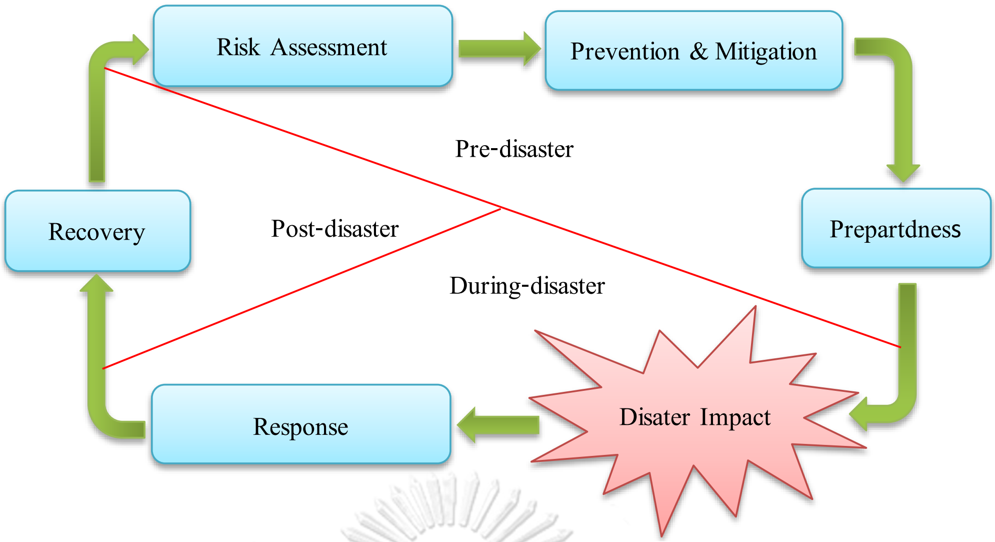


Figure 2.4 Disaster risk management (adapted from DDPM, 2013)

As shown in Figure 2.4, DDPM (2013) reported that disaster risk management is a method for handling risk factors in order to reduce the effects of disasters through three measures: pre-disaster activities, during-disaster activities, and post-disaster activities.

1. The first pre-disaster activities are prevention, mitigation and preparedness. Prevention and mitigation aim to eliminate or reduce disasters affecting people and communities through methods such as developing earthquake resistant buildings and passing legislation regulating construction requirements. Preparedness is defined as operations aim at fostering understanding among people of how to face a disaster such as developing warning systems, implementing evacuation plans, and distributing preparation kits.

2. The second during-disaster activities are based on response. Response is focused on rescue, kit distribution, and caring susceptible residents.

3. The third post-disaster activities are based on recovery. Recovery deals with the situation in the community after a disaster in order to foster recovery after an abnormal event by retrofitting buildings, managing reconstruction, and assisting residents with psychological and financial rehabilitation. Loss and damage should be evaluated for the recovery plan.

Effective disaster risk management requires risk assessment in the pre-disaster phase in order to reduce loss of life and property. The purpose of risk assessment is to understand the cause of the risk, to identify hazards, exposure, and vulnerability, to analyze possible hazardous events, to predict damage, to create hazard maps, to plan disaster risk management, and to detect weak points of strategies in order to improve them (DDPM, 2013).

Earthquake hazard assessment can make use of seismic hazard maps which must require several data such as peak ground acceleration (PGA), magnitude, site, focal depth, and attenuation equation (Damnernsawat, 2012).

For earthquakes, seismic hazard assessment is used to predict possible earthquakes with magnitude in the future from past earthquake statistics and present earthquake data. The objective of seismic hazard assessment is to identify earthquake locations, to find relationship between magnitude and frequencies causing earthquakes, to determine the attenuation of ground motion, and to identify percentage of probability of exceedance (Dowrick, 2003).

2.4 Building codes, Building damage, injuries and deaths

In 1997, based on the Building Control Act (MOI, 1979), Ministerial Regulation No. 49 announced a seismic provision in Thailand. This seismic provision was the first earthquake resistance design in seismic zone 2 for ten provinces in Thailand such as Kanchanaburi, Chiang Rai, Chiang Mai, Tak, Nan, Phayao, Phrae, Mae Hong Son, Lampang, and Lamphun (MOI, 1997). In 2007, since most soils of Bangkok and the suburbs around Bangkok is made up of clay that tends to be at risk from faraway earthquakes, expansion of the seismic provision in Thailand was deemed necessary to cover Bangkok and its suburbs (Seismic zone 1). Seismic zone 1 consisted of five provinces in Thailand including Bangkok, Nonthaburi, Pathum Thani, Samut Prakan, and Samut Sakhon. This zone comprised a soft soil area. Seismic zone 2 was the area near active fault lines. The Ministry of Interior (1997, 2007) mandated that private buildings having heights lower than 15 m were not legally obligated to follow a design for earthquake resistance. Using building law and seismic design did not cover many building types that were built before 1997 because it was limited to just a few building types (MOI, 2007).

Ground shaking affected building damage. The building damage depended on the number of factors such as earthquake magnitude, a building location from an epicenter, focus depth, soil condition supporting a building, a construction method, and building materials (Andrews, 2016). Strength of shaking estimated by attenuation of ground motions rose when distance from the epicenter decreased (Dowrick, 2003).

Residents in buildings built before the seismic provision may face hazards (Kiecolt and Nigg, 1982). Construction at that time was poor because seismic provisions were not strictly forced, and plans for evacuation were not effectively enforced either, thereby potentially increasing the number of injuries and deaths (Paradise, 2005).

More owners than contractors and construction companies mostly constructed the private buildings, many of which did not undergo strict enforcement of the seismic provisions; therefore, those buildings and residents are vulnerable to earthquakes. Moreover, many buildings were old and lacked maintenance, thereby causing building deterioration leading to vulnerability of buildings and residents as well (Uprety and Poudel, 2012).

When buildings were quickly constructed and were not standard in seismic provisions, a large number of people in city areas faced risk of both injuries and deaths. Furthermore, the buildings were probably more vulnerable since they were built before seismic codes and lacked of preparedness in organization. Communities lacked a protective culture from earthquakes. Risk on earthquake exposure was due to seismic-tectonic surroundings and building vulnerability (Bendimerad, 2004).

The greatest risk factors impacting risk of injury and death were the structural damage level and people's location during earthquakes (Ellidokuz, Ucku, Aydin and Ellidoku, 2005). These included environmental degradation, limited awareness about preparedness for earthquakes, and poor construction of buildings. In addition, low standards for construction methods along with poor materials and quickly constructed buildings such as those built with small or inadequate reinforcement in concrete buildings, a lack of the coerced seismic codes, low earthquake mitigation, preparedness, and locations in seismic zones (Halvorson and Hamilton, 2010). Building locations influenced higher than average the people's earthquake knowledge and high seismic risk perception (Tekeli-YeŞil, Dedeoğlu, Braun-Fahrlaender and Tanner, 2011).

Residence construction by the traditional method used wood and a mix of clay and stone to effectively resist earthquakes earthquake (Deken, 2007 as cited in Halvorson and Hamilton, 2010). The traditional structures were likely better than reinforced structures (Davis, 1984 as cited in Halvorson and Hamilton, 2010). Seismic design was not legally enforceable at that time to building heights that were lower than 15 m, thereby causing building damage. Wood buildings were less damaged than reinforced concrete buildings because they were lighter and more flexible (Soralump, Feungaugsorn, yangsanphu, Jinagoolwipat, Thongthamchart and Isaroranit, 2014).

In Thailand, the construction cost for earthquake resistant design increased about 12.22% and 14.07% for the 4-story of central and Northern provinces of conservative buildings of the Department of Public Works and Town & Country Planning, respectively, because of the increased reinforcements. Moreover, since the base shear of building was greater in the northern provinces than in the central provinces, the construction cost of building was higher in northern provinces than in the central provinces (Thongpanya, 2014).

2.5 Education, Socio-Economic Status, Experience, Hazard perception, and Preparedness

The higher wealth and education of people increased their inclination to evacuate from old to newer buildings. The condition of old buildings could represent the status of being poor (Armas and Avram, 2007; Rogers, 2003). Furthermore, the poor suffer more than the rich in hazard preparation due to their lack of money (McClure, Walkey and Allen, 1999). Furthermore, moderate and high socio-economic levels were more prepared than lower socio-economic levels (Tekeli-YeŞil, DedeoǦlu, Tanner, Braun-Fahrlaender and Obrist, 2010a). Higher income citizens was more prepared than those with lower income because they tended to have more materials that were essential for preparedness activities (Edwards, 1993).

Disaster education could improve disaster preparation (Lehman and Taylor, 1987). People with more education tended to be more prepared (Edwards, 1993). Development in earthquake preparedness depended on the education of school, family, and community including self-educated people, whereas earthquake experience did not result in an increase in earthquake perception (Rajib, Koichi Shiwaku Hirohide and Masami, 2004).

Moreover, higher perception of hazard awareness and increased number of activities could decrease damage when people obtained disaster education (Faupel and Styles, 1993). People with higher educational levels were more prepared, aware, and mitigating than lower with educational levels (Farley, Barlow, Finkelsteln and Rlley, 1993; Heller, Alexander, Gatz, Knight and Rose, 2005; Tekeli-YeŞil et al., 2010a). In addition, awareness was also affected by soil condition and distance from the house to the fault or seismic areas (Tekeli-YeŞil et al., 2010a).

Development of general education and earthquake education, especially in high seismic areas, could mitigate damage from earthquakes in the future. In addition, general education, seismic areas, and earthquake preparedness were related to behavior during earthquakes (Taghizadeh, Hosseini, Navidi, Mahaki, Ammari and Ardalan, 2012). Awareness could be improved by conducting public activities and earthquake preparedness subjects (Tekeli-YeŞil, DedeoĞlu, Braun-Fahrlaender and Tanner, 2010b; Tekeli-YeŞil et al., 2010a), and awareness of seismic risks could be improved by conducting many seminars (Paul and Bhuiyan, 2010). Seminars on earthquake preparedness in the future should be geared towards people having lower education and socio-economic levels (Tekeli-YeŞil et al., 2011). Anxiety levels of injuries and deaths could be managed by increasing preparedness activities (Showalter, 1993). Disaster risk might be decreased by conducting workshops that lead to improving public awareness and preparedness (Ainuddin et al., 2014).

Hazard experience affected people's risk perception (Lindell and Hwang, 2008). Furthermore, their risk perception depended on modern, frequency, and people's severe experience with hazards (Lindell and Perry, 2000); additionally, those with higher experience were likely to prepare for earthquakes than those with lower experience (Tekeli-YeŞil et al., 2010a). People did not experience severity in hazards, thereby assessing their impact that was lower than actual impact (Siegrist and Gutscher, 2008).

Hazard perception was related to the severity of their experience (Jackson, 1981); whereas it was not associated with severity of past experience (Lehman and Taylor, 1987). Preparedness was associated with severity of previous experience (Jackson, 1981); in contrast, it was not related to severity of prior experience (Lehman and Taylor, 1987; Rüstemli and Karanci, 1999). People had higher anxiety and more miserable effects from past earthquakes, thereby possibly arousing them to increase their preparedness (Heller et al., 2005).

Earthquake preparedness could reduce nervousness, muddle, and business interruption (Uprety and Poudel, 2012). Disaster preparedness was associated with cultural perception from exercise, experience, and education (Jung, 1959 as cited in Paradise, 2005, p.171). Preparedness that was affected by education levels and location could reduce earthquake risk (Paul and Bhuiyan, 2010). People that lived near the epicenter were more prepared for earthquakes than people that did not (Farley et al., 1993). However, people rejected disaster preparedness. This may be because they may underestimate the hazard risks. Therefore, they did not achieve protection against hazards (Slovic et al., 1974; Tversky and Kahneman, 1974 as cited in Edwards, 1993). Additionally, people neglected disaster preparedness because they thought that disasters would not affect them in spite of their hazard awareness (Burton & kates, 1964; Kunreuther et al., 1978 as cited in Edwards, 1993). Complex data about hazards were not beneficial since people underwent understanding problems with contents. When data were not proposed to people continuously, people may not have remembered the data (Waterstone, 1978 as cited in Edwards, 1993).

Earthquake preparedness was related to experience, property damage in the past, house ownership, marital status, time living in Dhaka City, age, numbers of floors, age, education, and income. However, earthquake preparedness was not related to soil zone, family size, intending for remaining in Dhaka, and gender (Paul and Bhuiyan, 2010). Media that was used to communicate risk between sender and receiver affected earthquake preparedness. Furthermore, the internet was used to distribute earthquake preparedness information (Tekeli-YeŞil et al., 2011).

Demographic variables were composed of home ownership, length of residence, gender, age, education level, marital status, and numbers of dependent children. Relations between demographic variables and earthquake preparedness were investigated by using a regression analysis. It was found that home ownership and length of residence were associated with earthquake preparedness while gender, age, education level, marital status, and numbers of dependent children were not associated with earthquake preparedness (Spittal, 2003).

2.6 The Mulilis-Lippa Earthquake Preparedness Scale (ML-EPS) and The Earthquake Readiness Scale (ERS)

The Mulilis-Lippa Earthquake Preparedness Scale (ML-EPS) was used to evaluate earthquake preparedness for people and small businesses. ML-EPS was comprised of 27 earthquake preparedness items (e.g. “Do you have a flashlight?”; “Do you have extra batteries for the flashlight?”. Each item or each question was answered by no (1 point), unsure (2 points), or yes (3 points). These 27 items were derived from many books and brochures. There were reliability coefficients (or internal) from 0.68 to 0.97 for these 27 items (Mulilis, Duval and Bovalino, 2000). Nevertheless, the ML-EPS had some items that were unnecessary for evaluating earthquake preparedness. In addition, the ML-EPS did not show how to interpret framework in order to analyze data and did not have standard score intervals in order to describe data. The ML-EPS also did not have questions about the prevention of building collapsing. This was limitation of the ML-EPS since a key point of earthquake preparedness was protection against deaths, and most deaths resulted from building collapse.

However, the Earthquake Readiness Scale (ERS), which is a new scale, was improved to evaluate earthquake preparedness. The ERS that was comprised of 23 earthquake preparedness items can be divided into two groups. The first group was the mitigation actions involving earthquake damage limitation (e.g. securing movable objects) which consisted of high-level activities. The second group was the planning actions involving survival facilitation (e.g. having important medicines and having a first aid kit), which consisted of low-level activities. Each item or each question was answered by “no” or “yes”. Scores on the ERS ranged from 0 to 23. The reliability for the ERS was about 0.85 for the residential survey sample and 0.87 for the exploratory sample. In order to compare with other research, scores should be transformed into score intervals. There were five intervals. First, scores between 0 and 4 represented people showing very poor preparedness. Second, scores between 5 and 8 represented people showing poor preparedness. Third, scores between 9 and 12 represented people showing moderate preparedness. Next, scores between 13 and 16 represented people showing effective preparedness. Finally, scores between 17 and 23 represented people showing very well preparedness. The one-factor model had one latent variable (earthquake preparation), while the two-factor model had two latent variables (survival facilitation and damage limitation). It was found that the one-factor model was more suitable than the two-factor model. Furthermore, prior the ERS questions, there was a question that asked, “Are you prepared for a big earthquake?” This question was rated on a scale of one (not at all prepared) to seven (very prepared). Participants who had greater scores had the higher preparedness. Demographic variables were gathered by asking ERS questions regarding gender, age, and home ownership. Age and home ownership were associated with earthquake preparedness (Spittal, Walkey, McClure, Siegert and Ballantyne, 2006). Length of residence and home ownership were associated with earthquake preparedness (Heller et al., 2005; Mulilis et al., 2000; Spittal, McClure, Siegert and Walkey, 2008), while gender, age, education were not associated with earthquake preparedness (Spittal et al., 2008).

2.7 Poverty

Poverty occurs in Thailand due to economic problems. This poverty causes hardship to daily life and impedes development in quality of life, including for the country as well (Saranjit, 2015). Poverty is defined as insufficient income, food, drinking water, sanitation, clothing, education, home, materials, culture in daily life, and so on (United Nations Development Programme, 1997; World Bank, 2007 as cited in Saranjit, 2015). Factors associated with poverty include unemployment, jobs with a daily wage, agriculture, and low education levels (Saatci and Akpinar, 2007). Poor people can be categorized by the poverty line (Ainuddin et al., 2014). The poverty line was based on the least Income or expenditure (World Bank, 2008 as cited in Saranjit, 2015). When people had income below poverty line, people are considered poor (Ainuddin et al., 2014; Goedhart, Halberstadt, Kapteyn and Praag, 1977). In Thailand, the poverty line for expenditure in Chiang Rai was 2,428 THB/Person/Month (NSO, 2016).

2.8 Seismic risk perception

Perception depends on previous experience and memory. Hazard perception, attitude, and preparedness could change when Individuals have disaster experience (Davis, 1989 as cited in Paul and Bhuiyan, 2010). Memory and experience are the same. The memory relied on age, disaster severity, and so on (Slovic, 1999 as cited in Paul and Bhuiyan, 2010).

People's seismic risk perception can be considered by probability of occurring earthquakes, imminence, and severity. Five questions were used to interview participants about seismic risk perception related to: severity of future earthquakes, fear of future earthquakes, future earthquakes affecting family, future earthquakes affecting property damage, future earthquakes affecting injuries and deaths. The data were analyzed by univariate analysis. As for seismic risk perception scores, the highest mean was "death and injuries", the second highest mean was "severity of future earthquakes", and the third highest mean was "fear of future earthquakes". Respondents had high seismic risk perception scores and greater than the mean because they had much earthquake knowledge that they received from news through print and electronic media (Mulilis and Duval, 1995 as cited in Paul and Bhuiyan, 2010).

Ainuddin et al. (2014) showed that earthquake risk perception was related to age, income, an education, and a house type. Age, income, education, and house type were analyzed by Chi square. Important variables affecting risk perception were the house type and education level when the data were analyzed using logistic regression.

Tekeli-YeŞil et al. (2011) showed that earthquake risk perception was related to sex, education levels, economic status, and house ownership.

Armas¸ (2006) showed that earthquake risk perception was related to sex, age, education, location, socio-economic status and so on.

Viscusi and Zeckhauser (2006) showed that men's environmental risk perception was lower than women's environmental risk perception.

2.9 Framing on risk perception

2.9.1Negative and Positive frames influencing risk perception

The uncertainty or risk of the product or behavioral frame was presented in a negative frame (loss frame) as more persuasive than a positive frame (gain frame)(Smith and Petty, 1996). For instance, for women having skin cancer detection behaviors with high involvement, negative frames made more effect than positive frames. Nevertheless, in men having skin cancer detection behaviors with low involvement, positive frames made more effect than negative frames (Rothman, Salovey, Antone, Keough and Martin, 1993). Another example, related to product, positive frames (e.g. 75% of lean) were more persuasive than negative frames (25% of fat) although both were identical (Levin, 1987).

McClure et al. (2009) reported that health and marketing frames were often conducted, leading to their study focusing on the effects of earthquake preparedness based on action frames and outcome frames. There was evidence to indicate that negative action frames (bad preparedness) with negative outcome frames (confronting risky events) were more influential to judging earthquake preparedness than others (negative action frames with positive outcome frames, positive action frames with positive outcome frames, and positive action frames with negative outcome frames). McClure and Sibley (2011) reported that negative action frames with negative outcome frames normally resulted in the largest earthquake preparedness effect for survival. Therefore, these frames are likely to increase earthquake preparedness.

2.9.2 Frequency and time frames influencing risk perception

As regards to low probability, a ratio of great numbers (10/100) had more effect than a ratio of small numbers (1/10) in people's judgment because people may focus on the numerator, but they neglected the denominator. Likewise, with regard to death by cancer, a ratio of great numbers (1,286/10,000) had more effect than a ratio of small numbers (24.14/100) in people's judgment, although in fact, 1,286/10,000 had less risky than 24.14/100. Thus, the ratio bias was influential to respond to people's risk judgment (Yamagishi, 1997). In contrast, in regards to high probability, a ratio of great numbers (90/100) had less effect than a ratio of small numbers (9/10) in people's judgment because it was obvious to communicate (Pacini and Epstein, 1999).

Construal Level Theory (CLT) demonstrated that people's different risk perception depended on temporal distance. This temporal distance was employed in terms of a temporal frame. For instance, a short time frame (e.g. a day frame), which consisted of being more concrete, specific, and comprehensive, was employed in close events, whereas a long time frame (e.g. a year frame), which was more abstract and common, was employed in far future events. People thought that the year frame (e.g. 36,500 dead population due to cancer per year were higher in risk than the day frame (e.g. 100 dead population is due to cancer per day) in people's judgment because of the ratio bias effect (Bonner and Newell, 2008). However, using a short time frame (e.g. a day frame) rather than a long time frame (e.g. a year frame) indicated concrete and proximity. It was also apparent that a short time frame (e.g. a day frame) could be more persuasive than a long time frame (e.g. a year frame) (Chandran and Menon, 2004). Moreover, with regard to the effects of drinking problems, short-time loss frames (e.g. days) were perceived at higher risk than a long-time frame (e.g., years) (Gerend and Cullen, 2008).

The population sample often used natural frequencies or absolute frequencies rather than probabilities. For example, if the probability was 80%, then it was substituted with "8/10". Participants perceived greater risk when facing the risk expressed for data in frequency formats rather than expressed as data in probability formats because it was simpler to communicate and understand the risk. Risk in frequency formats could be more accurate in computation than risk in probability formats (Hoffrage and Gigerenzer, 1998). Moreover, communication in frequency formats would lead to higher perceived risk compared with communication in probability formats (Slovic, Monahan and MacGregor, 2000). A time frame was influential to perceive risk (Linville et al., 1993; Shaklee and Fischhoff, 1990; Slovic, Fischhoff and Lichtenstein, 1978). Keller et al. (2006) showed that more people's flood risk perception was in a longer-time frame (30 years) than in a shorter-time frame (a year). More people's experiences putting on seat belts were in a group of expectation of lifetime drivers than those in a group of single trip drivers (Slovic et al., 1978). The end of the time window was viewed as the disaster possibility being existent (Doyle, Johnston, McClure and Paton, 2011; Doyle, McClure, Paton and Johnston, 2014); thus, the probability of earthquake preparedness may exist at the end of time window (McClure, H. Doyle and Velluppillai, 2015). However, regarding contraception, a shorter-time frame (one year) had more influential effect than longer-time frames (5 years, 10 years) (Shaklee and Fischhoff, 1990). Furthermore, the impacts of drinking problems were solved by effective communication. This communication was more effective in a short-time frame (e.g. days or hours) rather than in a long time frame (e.g. years). With regard to a short-term frame (e.g., days or hours) view of the impact of drinking problems, loss frames were more persuasive than gain frames (Gerend and Cullen, 2008).

2.9.3 Framing on earthquake risk perception

Henrich et al. (2015) examined the effects of risk framing on earthquake risk perception. The data were collected by randomly sending a questionnaire to participants. In the questionnaire, five frames constituted frequency frames (1600 deaths in 500 years in frame 1, 10% of chance of 1600 deaths in 50 years in frame 2, 3.2 deaths per year in frame 3) and probability frames (1.9 deaths per 100,000 people in frame 4, 19 deaths per million people in frame 5). Participants selected frame thought the worst risk. The data were analyzed by Chi square. The results showed that different frames influenced people's earthquake risk perception dissimilarly despite the identical earthquake risk. The researcher suggested that the frame had the most important effect on people's risk decision and could be employed to communicate risk information effectively.

2.10 Structural damage levels

Building damage depending on building types can be divided into five damage levels: no damage, slight damage, moderate damage, extensive damage, and complete damage, as detailed in Table 2.3 for reinforced concrete buildings with unreinforced masonry infill walls and as detailed in Table 2.4 for light wood (FEMA, 2003).

Table 2.3 Structural damage levels of reinforced concrete buildings with unreinforced masonry infill walls (FEMA, 2003)

Structural damage levels	Detail
No damage	No damage to buildings
Slight damage	Most infill walls show diagonal hairline cracks or sometimes horizontal cracks; cracks appear at interfaces between frame and infill walls.
Moderate damage	Big diagonal or horizontal cracks appear on most infill wall surfaces; crushing of brick around beam-column connections appears on some walls; concrete beams or columns may occur diagonal shear cracks.
Extensive damage	Big cracks appear on most infill walls; some bricks probably dislodge and fall; some infill walls probably bulge out-of-plane; partial or full fall of a few walls probably occurs; few concrete columns or beams are probable failure in shear resulting in partial collapse; permanent lateral deformation probably appears on structure.

Table 2.3 Structural damage levels of reinforced concrete buildings with unreinforced masonry infill walls (FEMA, 2003)

Complete damage	A combination of total failure of the infill walls and non ductile failure of the concrete beams and columns display to collapse structure about 15 % of total area of this building type being anticipated to be collapsed for low-rise.

Table 2.4 Structural damage levels of light wood frame (FEMA, 2003)

Structural damage levels	Detail
No damage	No damage to buildings
Slight damage	Small plaster or gypsum-board cracks at corners of door and window openings.
Moderate damage	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks appear across shear wall panels exhibited by small cracks in stucco and gypsum wall panels.
Extensive damage	Large diagonal cracks appear across shear wall panels, or large cracks appear at plywood joints; there is permanent lateral movement of floors and roof, partial collapse of “room-over-garage” or other “soft-story” configurations. Foundations cracks are small.
Complete damage	Structure may have large permanent lateral displacement, may collapse, or may be in imminent danger of collapse due to the failure of the lateral load resisting system; some structures may slip and fall off

Table 2.4 Structural damage levels of light wood frame (FEMA, 2003)

	the foundations; foundation cracks are large; about 3% of the total area of light wood frame is anticipated to be collapsed.

CHAPTER 3

METHODOLOGY

3.1 Study area

Figure 3.1 Regions of Thailand. From Six Regions of Amazing Thailand (Martin, 2018)

Thailand is divided into six geographical regions consisting of Northern Thailand, Northeastern Thailand, Western Thailand, Central Thailand, Eastern Thailand, and Southern Thailand (Martin, 2018). The northern and western regions in Thailand often occur several earthquakes because of active fault line from China, Myanmar, as well as the northern and western Thailand (TMD, 2014). In this study, Located in the northern Thailand, Dong Mada is a sub-district at Mae Lao district in Chiang Rai. Village no.2 (Rattan Creek Village) and village no.7 (Dong Mada Village) of a Dong Mada sub-district were opted for this study (Figure 3.2). They were near the epicenter at latitude 19.756 degrees N, longitude 99.687 degrees E on May 5, 2014 at 18.08 p.m. according to Thailand Time.

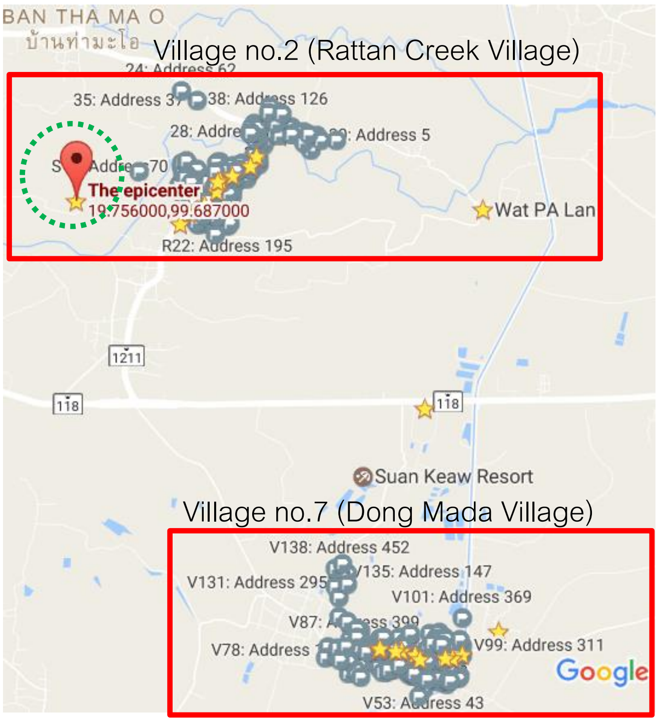


Figure 3.2 Site of interviewed participants and explored structures

3.2 Sampling and Data Collection

A total of 3,163 households were at Dong Mada sub-district (BORA, 2016). 256 households were minimum sample size estimated by margin of error *e* = 0.06 and 95% confidence level by using Yamane for known population equation as demonstrated below (Yamane, 1967).

$$n = \frac{N}{1 + Ne^2} \tag{3.1}$$

A margin of error could be present as several values indicated rounded figures such as 5%, 7%, 10% (Israel, 1992). In this study, if use of the margin of error was 0.05. The minimum sample size was about 355, but total households of village no. 2 and no. 7 were about 340 less than the minimum sample size. Furthermore, it was impossible to completely collect data on all households because some households had jobs outside the area. Thus, data were collected from about 277 households and use of the margin of error was 0.06 to obtain the minimum sample size.

There were two villages selected from Dong Mada sub-district consisting of village no.2 and no.7. At village no.2, data gathered were 136 families whereas data collected were 141 families at village no.7. Therefore, a questionnaire was distributed to 277 families, and 277 houses were used to examine structures as well. Building samples, which were comprised of wood buildings and reinforced concrete buildings with unreinforced masonry infill walls, were one-story and two-story.

Demographic characteristics such as sex and age were collected. Generally the oldest person was chosen from each household (ArmaŞ, Cretu and Ionescu, 2017). A total of 277 individuals of households in this study were interviewed by use of a questionnaire. For each household, a questionnaire was distributed from one participant matching demographic characteristics such as sex. Thus, each demographic characteristic (such as sex) from each household can be used to analyze individual differences in regard to earthquake preparedness before and after earthquakes in the future by the Mann-Whitney U test.

The questionnaire in this study was developed by author. This questionnaire was checked by an advisor. Moreover, the advisor piloted the questionnaire before surveying by interviewing some participants.

The questionnaire in this research consisted of questions about:

(1) Building damage items (e.g., cracks at concrete beams, columns, or walls) in order to assess structural damage levels by village, year built, and building types;

(2) People's preparedness for behavior during earthquakes in the future (e.g., staying away from cabinet and walls) with casualties, seminars, and earthquake experience on May 5, 2014. The preparedness for behavior during earthquakes in the future had five choices consisting of never, low, moderate, high, and very high;

(3) People's earthquake preparedness before and after earthquakes in the future was based on sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure. As to People's earthquake preparedness before and after earthquakes in the future, the Earthquake Readiness Scale (ERS) in this study was modified by deleting some items and adding some items in order to suitably use in Thailand society. For example, some items that were deleted included objects containing water were not above electrical equipment, heavy objects located on the floor, the chimney of the house being strengthened, etc. Some items that were added were having a blanket, having gloves, having a whistle, knowing the location of the circuit breaker, knowing the location of the water cut off as well as knowing how to turn it off, etc. Score intervals in this study for people's earthquake preparedness before and after earthquakes in the future can be divided into 5 intervals. Scores between 0 and 6 represented people being very poorly prepared. Scores between 7 and 12 represented people being poorly prepared. Scores between 13 and 18 represented people being moderately prepared. Scores between 19 and 24 represented people being adequately prepared. Scores between 25 and 31 represented people being very well prepared;

(4) Seismic risk perception was based on sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure. Score intervals in this study for seismic risk perception can be divided into 5

intervals. Based on this information, scores between 0 and 8 represented people behaving very poorly with seismic risk perception. Scores between 9 and 16 represented people behaving poorly with seismic risk perception. Scores between 17 and 24 represented people behaving moderately well with seismic risk perception. Scores between 25 and 32 represented people behaving well with seismic risk perception. Scores between 33 and 40 represented people behaving very well with seismic risk perception;

(5) Seismic risk perception of what would be the framing type of building damage.

As for framing types of private building damage, questionnaires based on the earthquake with a magnitude of 6.3 on the Richter scale that occurred in Chiang Rai of May 5, 2014 were distributed. Three frames constituted frequency frames (475 severely damaged buildings in 500 years in frame 1, 10% chance of 475 severely damaged buildings in 50 years in frame 2, 1 severely damaged building per year in frame 3). Participants chose the frame they thought the worst risk. The data were analyzed by Chi square.

3.3 Statistical analysis

Chi-square test and/or Fisher's exact test were used to determine: first, relationships between variables that influenced building damage in villages no.2 and no.7; and second, relationships between variables affected people’s preparedness about behavior during earthquakes in the future in villages no.2 and no.7. A Mann-Whitney U test and/or a Kruskal-Wallis test were used to determine the following relationship: third, relationships between variables affected people’s earthquake preparedness (earthquake preparedness actions composing preparedness actions before earthquakes and preparedness actions after earthquakes) in villages no.2 and no.7; forth, relationships between variables affected people’s seismic risk perception in villages no.2 and no.7. Chi-square test and/or Fisher's exact test were used to determine: fifth, what would be framing type of building damage that affects people's seismic risk perception.

Limitations of the statistics used in this study included:

Firstly, Chi square test and Fisher's exact test were employed in examining whether one categorical variable was related to another categorical variable. Limitations of the Chi square test are shown as follows: (1) expected frequencies in each cell of the table were more than 5 or Less than 20% of all cells that had expected frequencies of less than 5; (2) for the 2x2 table, Fisher's exact test rather than the Chi square test was used to analyze two categorical variables; (3) a big sample size was greater than 50 ($n > 50$).

However, Fisher's exact test was used to analyze the data as follows: (1) More than 20% of all cells had expected frequencies of less than 5; (2) there was a 2x2 table; (3) the sample size was small; (4) differences between numbers of rows and numbers of columns were large; for example, there were 20 rows and 2 columns; (5) most observed frequencies in many cells were zero.

Secondly, the Mann-Whitney U test and a Kruskal-Wallis test were non-parametric tests using both non-normal distribution data and normal distribution data. In these two tests, a dependent variable was quantitative, and an independent variable was categorical. The Mann-Whitney U test was employed in examining whether a mean rank of two groups differed significantly or two variables were related to each other. The Kruskal-Wallis test was employed in examining whether a mean rank of more than two groups differed significantly or a dependent variable was related to an independent variable.

3.4 Methodology

Firstly, a location was selected for this study. Secondly, multistage sampling used for selecting the sample for the five stages of this study. The first unit was the province. The second unit was the district. The third unit was the sub district. The fourth unit was the villages. The fifth unit was the households. This multistage sampling had higher error frequency than simple random sampling when the sample had the equal size, but the benefits of the multistage sampling were the effective cost and time. Thirdly, minimum sample size was estimated by Yamane formula. Next, data were gathered about building damage, villages, year built, and building types; people's earthquake preparedness for behavior during future earthquakes, seminar, casualties, and earthquake experience of May 5, 2014; people's earthquake preparedness before and after earthquakes in the future, sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure; people's seismic risk perception, sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure; the framing type of building damage that affected people's seismic risk perception.

Then, Chi-square test and/or Fisher's exact test were used to determine the following relationship: Villages (Villages no. 2 and no. 7) versus structural damage levels; Year-built before as well as after 1997 versus structural damage levels; Building types (reinforced concrete with unreinforced masonry infill walls and wood buildings) versus structural damage levels; Preparedness for behavior during future earthquakes versus casualties, seminars, and earthquake experience of May 5, 2014. After that, a Mann-Whitney U test and/or a Kruskal-Wallis test were used to determine the following relationship: earthquake preparedness before and after earthquakes in the future versus sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure; seismic risk perception versus sex, age, education levels, house ownership, time living in the present house, income, building types, villages, and expenditure; Finally, Chi-square test and/or Fisher's exact test were used to determine what would be the framing type of building damage that affects people's seismic risk perception.

Figure 3.3 presents a flow chart of the methodology utilized in this study.

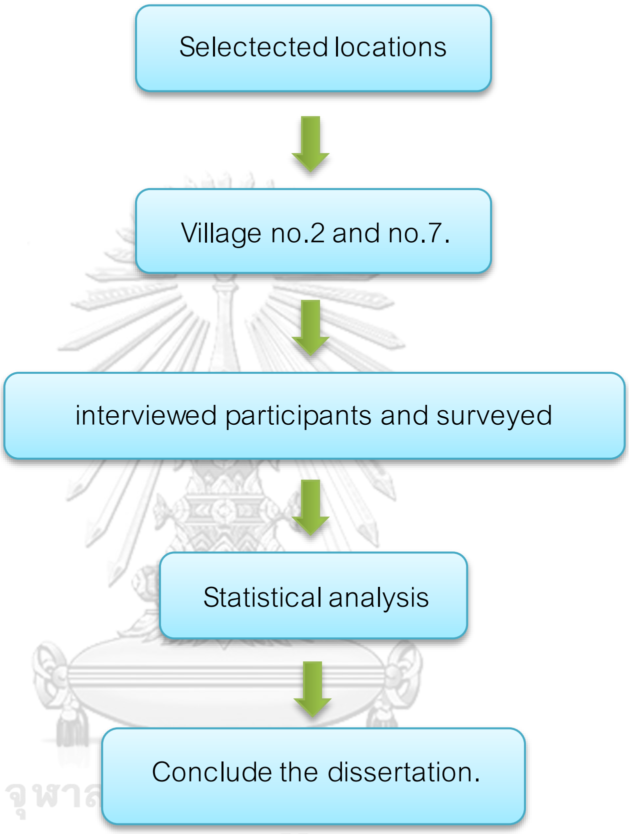


Figure 3.3 Flow chart of methodology utilized in this study

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Result of examining relationships between variables (villages, year built, and building types) and structural damage levels

4.1.1 Result from examining relationship between villages (no.2 and no.7) versus structural damage levels

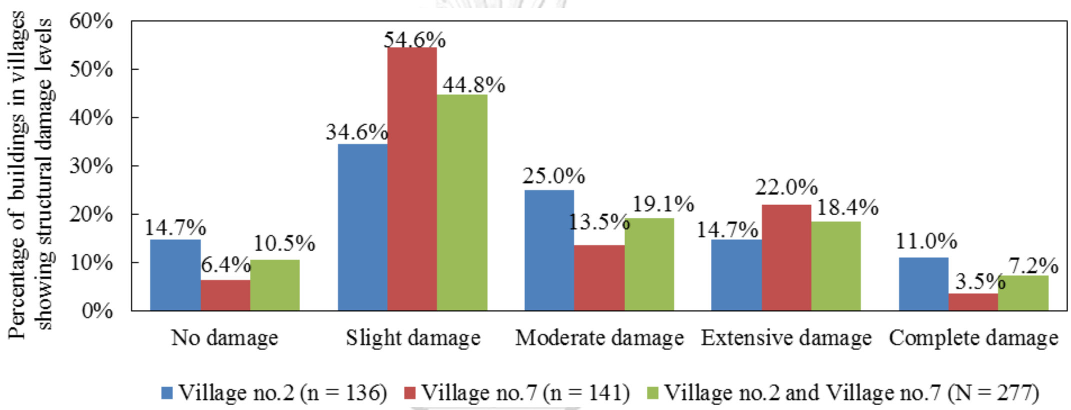


Figure 4.1 Structural damage levels by villages

Of 277 buildings, 49.1% were in village no. 2, and 50.9% were in village no. 7 as shown in Figure 4.1. There was slight damage to about 50% of the 277 buildings. Moderate damage was the second largest percentage of damaged buildings at about 19.1%. Similarly, the percentage of extensive damage was at 18.4%. Complete damage was the smallest percentage of damaged buildings at about 7.2%. Moreover, 11.0% of 136 buildings in village no. 2 were completely damaged which was greater than the 3.5% of 141 buildings in village no. 7. The slight damage level was the most damaged building in village no. 2 (34.6%) and village no. 7 (54.6%).

Relationship between villages and structural Damage levels is statistically significant ($\chi^2(4) = 22.966$, $p = 0.000 < \alpha = 0.050$). The contingency coefficient is 0.277. It seems that villages are related to structural damage levels. Based on this data, complete damage was higher in the buildings in village no. 2 than in the buildings of village no. 7 since village no. 2 is closer to the epicenter than village no. 7 (Figure 3.2 in chapter 3). This means that when a building location is close to the epicenter, it is likely to undergo more damage. This is consistent with the result obtained in a previous study (Andrews, 2016).

4.1.2 Result from examining the relationship between the year built before as well as after 1997 versus structural damage levels.

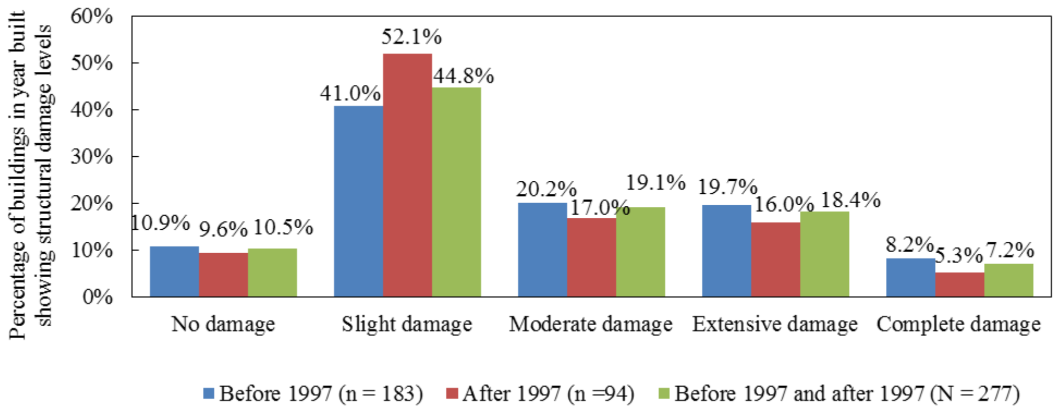


Figure 4.2 Structural damage levels by year built

Of 277 buildings, 66.1% were constructed before 1997, while 33.9% were constructed after 1997, as shown in Figure 4.2. There was slight damage at 41% of the 183 buildings constructed before 1997 and 52.1% of the 94 buildings constructed after 1997. There was moderate damage at 20.2% of the 183 buildings constructed before 1997 and at 17% of the 94 buildings constructed after 1997. Similarly, the percentage of extensive damage was at 19.7% of the 183 buildings constructed before 1997 and 16.0% of the 94 buildings constructed after 1997. The relationship between the year built and structural damage levels was not statistically significant ($\chi^2(4) = 3.341$, $p = 0.502 > \alpha = 0.050$). This indicates that the year built is not related to the structural damage levels. It can be concluded that not only construction before 1997 but also construction after 1997 incurred building damage at almost the same level because seismic codes were not enforced and covered to construct many buildings. For instance, inadequate reinforcement appeared in construction of reinforced concrete (RC) buildings with unreinforced masonry infill walls. This is similar to previous studies (Soralump et al., 2014).

4.1.3 The result from examining the relationship between building types (reinforced concrete with unreinforced masonry infill walls and wood buildings) versus structural damage levels

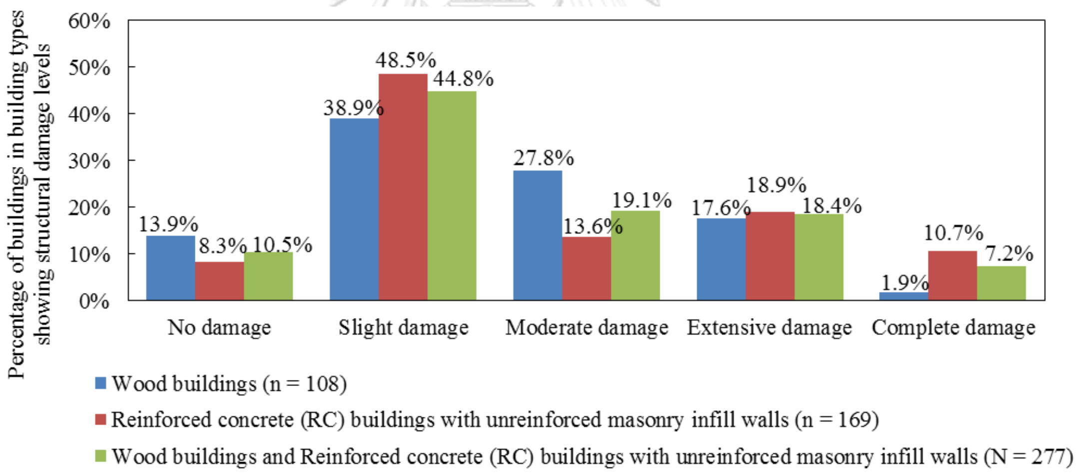


Figure 4.3 Structural damage levels by building types

Of 277 buildings, 39% are wood buildings and 61% are RC buildings with unreinforced masonry infill walls as shown in Figure 4.3. In regards to 169 RC buildings with unreinforced masonry infill walls, slight damage was the largest percentage of damaged buildings at 48.5%. Extensive damage was the second largest percentage of damaged buildings at 18.9%. Complete damage was the smallest percentage of damaged buildings at 10.7%. In terms of the 108 wood buildings, slight damage was the largest percentage of damaged buildings at 38.9%. Moderate damage was the second largest percentage of damaged buildings at 27.8%. Complete damage was the smallest percentage of damaged buildings at 1.9%. Relationship between the building types and structural damage levels is statistically significant ($\chi^2(4) = 17.386$, $p = 0.002 < \alpha = 0.050$). The contingency coefficient is 0.243. Based on this information, the building types are related to the structural damage levels. It could be inferred that the building types affect the structural damage levels. Based on this information at extensive and complete damage levels, wood buildings were less damaged than RC buildings with unreinforced masonry infill walls. This may be because they were lighter and more flexible. It could be inferred that the lower the RC buildings with unreinforced masonry infill walls, the lower the damage. This is similar to the result obtained in other studies (Soralump et al., 2014).

As for the structural damage levels versus the villages, year built, and building types, the most important factor affecting structural damage levels was the villages. The second most important factor affecting structural damage levels was the building types. Villages having a contingency coefficient of 0.277 were more influential to structural damage levels than building types having a contingency coefficient of 0.243 because of having higher contingency coefficient, while year built did not affect structural damage levels.

4.2 Result from investigating relationship between factors (casualties, seminar, and earthquake experience of May 5, 2014) and preparedness for behavior during future earthquakes.

4.2.1 Result from investigating the relationship between casualties versus preparedness about behavior during earthquakes in the future.

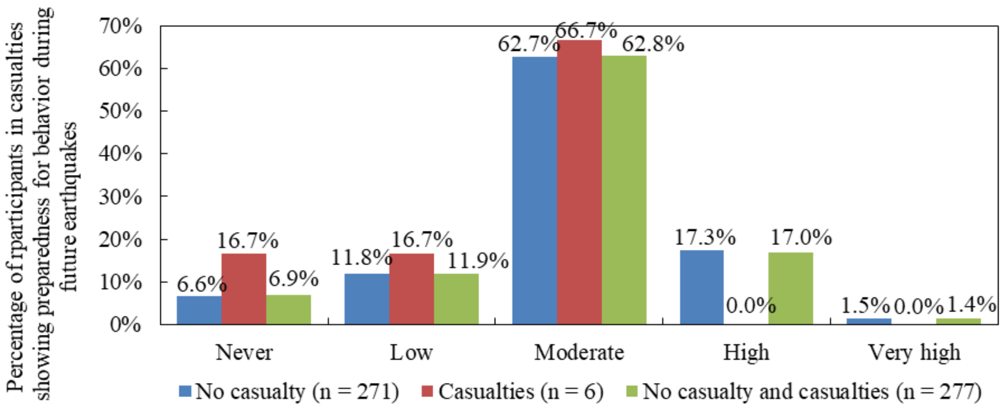


Figure 4.4 Preparedness for behavior during future earthquakes by casualties

Of 277 families, 97.8% did not suffer casualties while 2.2% consisted of six casualties that included one death and five injuries, as shown in Figure 4.4. The largest preparedness for behavior during future earthquakes was at a moderate level, participants involving casualties in their families were 66.7% while participants involving no casualties in their families were 62.7%. The relationship between casualties and preparedness for behavior during future earthquakes is not statistically significant (Fisher's exact test = 3.345, $p = 0.418 > \alpha = 0.050$). Based on this information, it can be concluded that casualties are not related to preparedness for behavior during future earthquakes. It could be concluded that casualties are not influential to preparedness for behavior during future earthquakes. This is in line with prior studies (Rüstemli and Karanci, 1999).

4.2.2 Result from investigating the relationship between seminars versus preparedness for behavior during future earthquakes

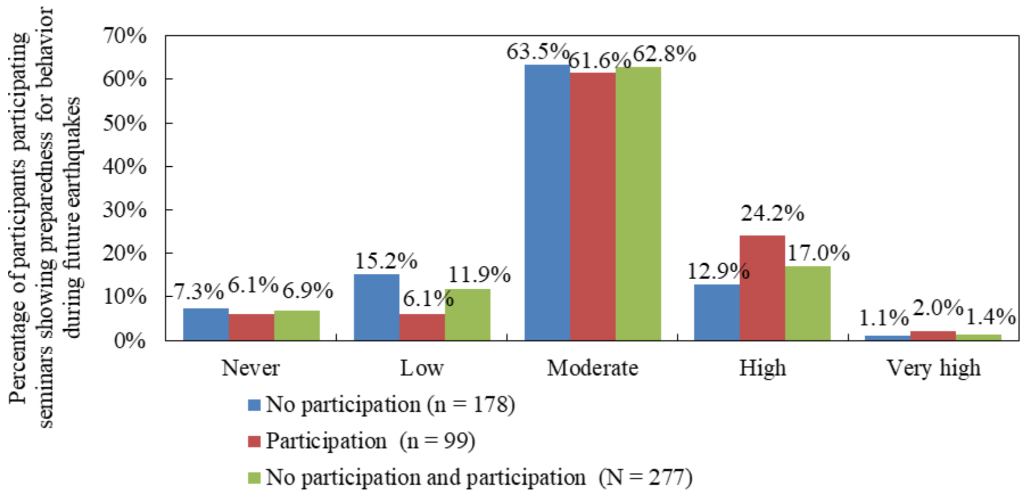


Figure 4.5 Preparedness for behavior during future earthquakes by seminars

35.7% of 277 participants took part in seminars whereas 64.3% did not, as shown in Figure 4.5. As to the most preparedness for behavior during future earthquakes, participants took part seminars at moderate level of 61.6%, while 63.5% did not. However, in regards to preparedness for behavior during future earthquakes, participants took part in seminars at a high level and a very high level, 24.2% and 2.0%, respectively. This is more than the participants that did not take part seminars, which were at 12.9% and 1.1%, respectively. The relationship between seminars and preparedness for behavior during earthquakes in the future is statistically significant ($\chi^2(4) = 9.768$, $p = 0.045 < \alpha = 0.050$). The contingency coefficient is 0.185. This signifies that seminars affect preparedness for proper behavior during earthquakes. This is similar to results obtained in other studies (Faupel and Styles, 1993; Hurnen and McClure, 1997; Lehman and Taylor, 1987; Paradise, 2005; Rajib et al., 2004).

4.2.3 Result from investigating the relationship between the earthquake experience of May 5, 2014 versus preparedness for behavior during future earthquakes.

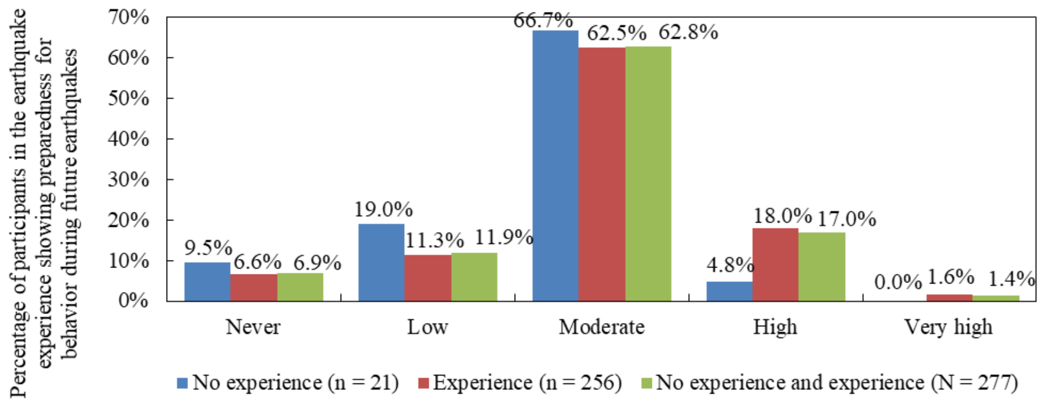


Figure 4.6 Preparedness for behavior during future earthquakes by earthquake experience of May 5, 2014

92.4% of 277 participants had earthquake experience, whereas 7.6% did not, as shown in Figure 4.6. As to most preparedness for behavior during earthquakes in the future, participants that had experience were at a moderate level of 62.5%, while participants that did not have experience made up 66.7%. The relationship between earthquake experience and preparedness for behavior during earthquakes in the future is not statistically significant (Fisher's exact test = 3.743, $p = 0.385 > \alpha = 0.050$). This indicates that earthquake experience was not related to preparedness for behavior during earthquakes. This may be because a number of casualties are small (only six casualties consisting one death and five injuries), and most structural damage levels are the slightly damaged in village no. 2 and village no. 7. This is in line with prior studies (Rüstemli and Karanci, 1999; Siegrist and Gutscher, 2008).

As for preparedness for behavior during future earthquakes versus casualties, seminars, and earthquake experience, the most important factor affecting preparedness for behavior during future earthquakes was seminars. The others did not affect preparedness for behavior during future earthquakes.

4.3 Earthquake preparedness in Chiang Rai

4.3.1Earthquake preparedness actions

Earthquake preparedness actions are composed of preparedness actions before earthquakes and preparedness actions after earthquakes. Preparedness actions before earthquakes consist of Items 1 – 25 in Table 4.1.and Table 4.2. Preparedness actions after earthquakes consist of Items 26 - 31 in Table 4.1.and Table 4.2.

Table 4.1 Item-to-Total Correlations and Cronbach's Alpha if item is deleted from conducting each of earthquake preparedness actions

Item	Detail	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	Have a first aid kit	0.538	0.790
2	Have food	0.582	0.788
3	Have drinking water	0.632	0.785
4	Have a torch	0.630	0.785
5	Have extra batteries for a torch	0.588	0.787
6	Have a map	0.357	0.801
7	Have a whistle	0.397	0.800
8	Have money	0.504	0.796
9	Have a deposit account	0.448	0.799
10	Have a blanket	0.644	0.787
11	Have gloves	0.493	0.796

Table 4.1 Item-to-Total Correlations and Cronbach's Alpha if item is deleted from conducting each of earthquake preparedness actions

12	Have protective mask	0.501	0.794
13	Have wet tissue	0.168	0.804
14	Have a fire extinguisher	0.398	0.800
15	Have a mobile phone	0.142	0.804
16	Know the location of the gas cut off and how to turn off it	0.120	0.804
17	Know the location of the circuit-breaker and how to turn off it	0.137	0.804
18	Know the location of the water cut off and how to turn off it	0.137	0.804
19	Have nostrums	0.220	0.804
20	Have plastic bags and tissue paper	0.056	0.811
21	Keep pesticides and flammable materials in locked cabinets including placing on bottom shelves	0.203	0.807
22	Have emergency phone numbers	0.341	0.798
23	Remove heavy furniture from sleeping regions	-0.057	0.816
24	Install heavy furniture to walls	0.039	0.807
25	Have a strengthening house to increase earthquake resistance	0.280	0.802
26	Plan how to behave after earthquakes	0.353	0.797
27	Know how to give first aid	0.331	0.799
28	Stay away from the earthquake regions	0.165	0.805
29	Examine for leaks of gas after earthquakes	0.370	0.797
30	Examine for electrical damage after earthquakes	0.409	0.794

Table 4.1 Item-to-Total Correlations and Cronbach's Alpha if item is deleted from conducting each of earthquake preparedness actions

31	Examine for water and sewage pipe damage after earthquakes	0.361	0.797

Cronbach's Alpha, which was used for reliability for this study, was calculated at 0.804 for 31 items by using data from Table 4.1. Table 4.1 displays both Corrected Item-Total Correlation and Cronbach's Alpha if Item deleted from conducting each earthquake preparedness actions (31 items).

Table 4.2 Percentage of participants (N=277) from villages no. 2 and no. 7 conducting each of earthquake preparedness actions

Item	Detail	Yes (%)
17	Know the location of the circuit-breaker and how to turn off it	99.28%
18	Know the location of the water cut off and the how to turn off it	99.28%
16	Know the location of the gas cut off and how to turn off it	98.19%
15	Have a mobile phone	94.95%
20	Have plastic bags and tissue paper	80.87%
23	Remove heavy furniture from sleeping regions	78.34%
19	Have nostrums	73.65%
27	Know how to give first aid after earthquakes	52.35%
30	Examine for electrical damage after earthquakes	51.99%
31	Examine for water and sewage pipe damage after earthquakes	50.54%
21	Keep pesticides and flammable materials in locked cabinets including placing on bottom shelves	49.10%
29	Examine for leaks of gas after earthquakes	45.85%
25	Strengthening the house to increase earthquake resistance	41.52%

Table 4.2 Percentage of participants (N=277) from villages no. 2 and no. 7 conducting each of earthquake preparedness actions

Item	Detail	Yes (%)
26	Plan how to behave after earthquakes	29.24%
22	Have emergency phone numbers	28.52%
4	Have a torch	14.44%
3	Have drinking water	13.72%
28	Stay away from the earthquake regions after earthquakes	13.72%
5	Have extra batteries for a torch	13.36%
2	Have food	13.00%
1	Have a first aid kit	11.19%
10	Have a blanket	9.39%
12	Have protective mask	5.42%
24	Install heavy furniture to walls	5.05%
11	Have gloves	4.33%
8	Have money	3.25%
7	Have a whistle	2.17%
9	Have a deposit account	2.17%
14	Have a fire extinguisher	1.81%
6	Have a map	1.44%
13	Have wet tissue	0.36%

As for preparedness actions before earthquakes consisting of Items 1 - 25 in Table 4.2, the percentage of the 277 participants on earthquake preparedness actions varied. For example, about 99% of the participants knew the location of the circuit breaker and water cut off as well as how to turn it off. About 98% of the participants knew the location of the gas cut off as well as how to turn it off. Nearly 95%

of the participants have a mobile phone. Plastic bags and tissue paper were at 80.87%. Removing heavy furniture from sleeping regions was at 78.34%. Nostrums were at 73.65%. A fire extinguisher was at 1.81%. Installing heavy furniture to walls was at 5.05%. Having a torch that participants prepared for earthquakes was at 14.44%. Drinking water that participants prepared for earthquakes was at 13.72%. Extra batteries for a torch that participants prepared for earthquakes were at 13.36%. Food that participants prepared for earthquakes was at 13.00%. Wet tissue that participants prepared for earthquakes was at 0.36%.

This indicates that most participants know the location of the circuit breaker, water cut off and gas cut off, and know how to turn them off because participants may use them regularly. Thus, they can remember the location of the circuit breaker, water cut off, and gas cut off as well as how to turn them off. Most participants remove heavy furniture from sleeping regions because heavy furniture may fall on participants when earthquakes occur. A few participants install heavy furniture to walls because they think that since big earthquakes have rarely occurred; thus, they thought that heavy furniture is unlikely to fall due to big-earthquake effects.

As for preparedness actions after earthquakes consisting of Items 26 – 31 in Table 4.2, knowing how to give first aid was the highest percentage of the participants at 52.35%. Next, the participants examined for electrical damage, water, and sewage pipe damage as well as leaks of gas at 51.99%, 50.54%, and 45.85%, respectively. Staying away from the earthquake regions after earthquakes was the smallest percentage coming in at only 13.72%.

This indicates that most participants know how to give first aid, examine for electrical damage, water and sewage pipe damage and gas leaks because these participants may have knowledge of earthquake effects after earthquakes. Most participants did not stay away from the earthquake regions after earthquakes because they feared that the property may be subject to burglary and/or temporary shelter was inadequate for the participants. Thus, most participants lived in front of their buildings. Moreover, a few participants had a fire extinguisher because most thought that a fire extinguisher was too expensive and it had just a short life. In addition, they thought that a big earthquake has rarely occurred; thus, they believed that fire did not always occur due to big-earthquake effects.

4.3.2 Earthquake preparedness scores

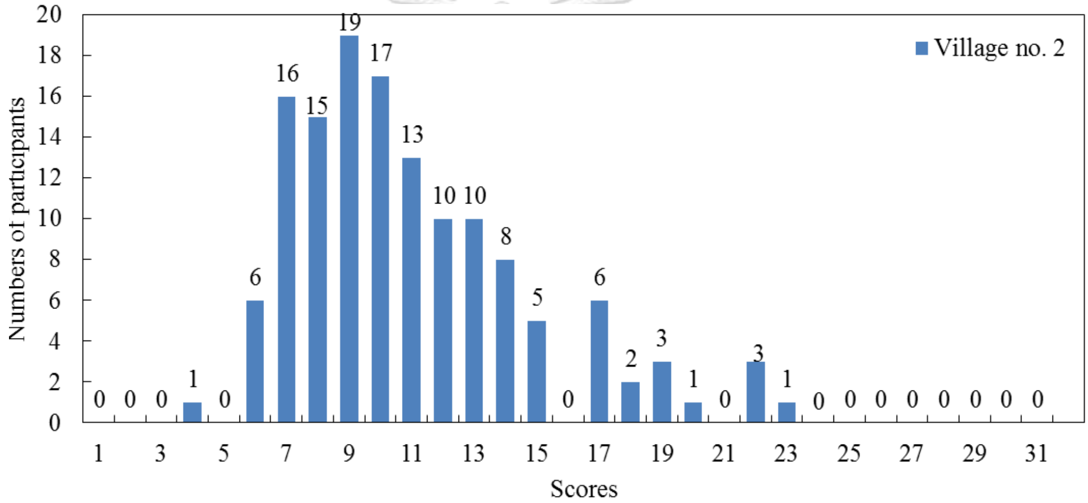


Figure 4.7 Earthquake preparedness scores of 136 participants in village no. 2

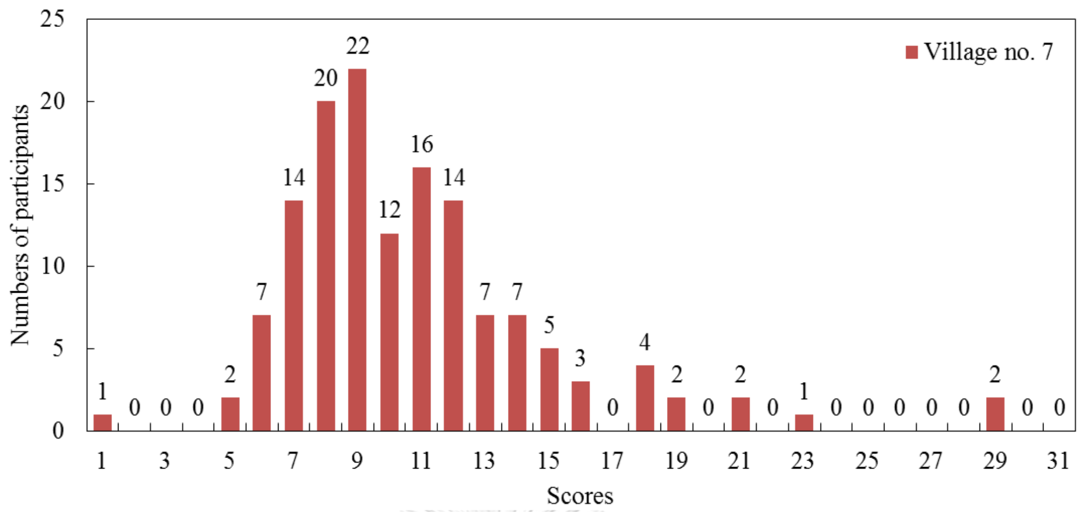


Figure 4.8 Earthquake preparedness scores of 141 participants in village no. 7

Figure 4.7 shows 136 participants in village no. 2 scoring on the earthquake preparedness scale ranging from 4 to 23. The mean was11.01; the median was 10; and the standard deviation was 3.83. The mean was greater than the median. Thus, data were skewed to the right. Higher scores showed higher earthquake preparedness. By contrast, lower scores showed lower earthquake preparedness. Of 136 participants, 45.59% had higher scores than the median, and 54.41% had lower scores than the median. It seems that most participants were slightly prepared for earthquakes because most participants had lower scores than the median and had scores that were less than half of the total score.

Figure 4.8 shows the 141 participants in village no. 7 scoring on the earthquake preparedness ranging from 1 to 29. The mean was10.77; the median was 10; and the standard deviation was 4.16. The mean was greater than the median. Thus, data were skewed to the right. Higher scores showed higher earthquake preparedness. By contrast, lower scores showed lower earthquake preparedness. Of the participants, 44.68% had higher scores than the mean score, and 55.32% had lower scores than the mean score. It seems that most participants were slightly prepared for earthquakes because most participants had lower scores than the median and had scores that were less than half of the total score.

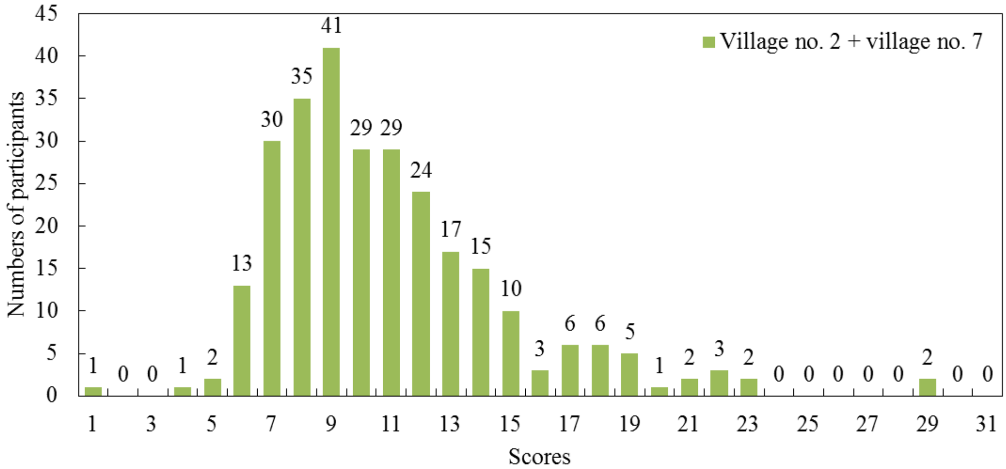


Figure 4.9 Earthquake preparedness scores of 277 participants from village no. 2 and village no. 7

Figure 4.9 shows 277 participants from village no. 2 and village no. 7 scoring on the earthquake preparedness scale ranging from 1 to 29. The mean was 10.88; the median was 10; and the standard deviation was 3.99. The mean was greater than the median. Thus, data were skewed to the right. Higher scores showed higher earthquake preparedness. By contrast, lower scores showed lower earthquake preparedness. Of the participants, 45.13% had higher scores than the median, and 54.87 % had lower scores than the median. It seems that most participants were slightly prepared for earthquakes because most participants had lower scores than the median and had scores that were less than half of the total score.

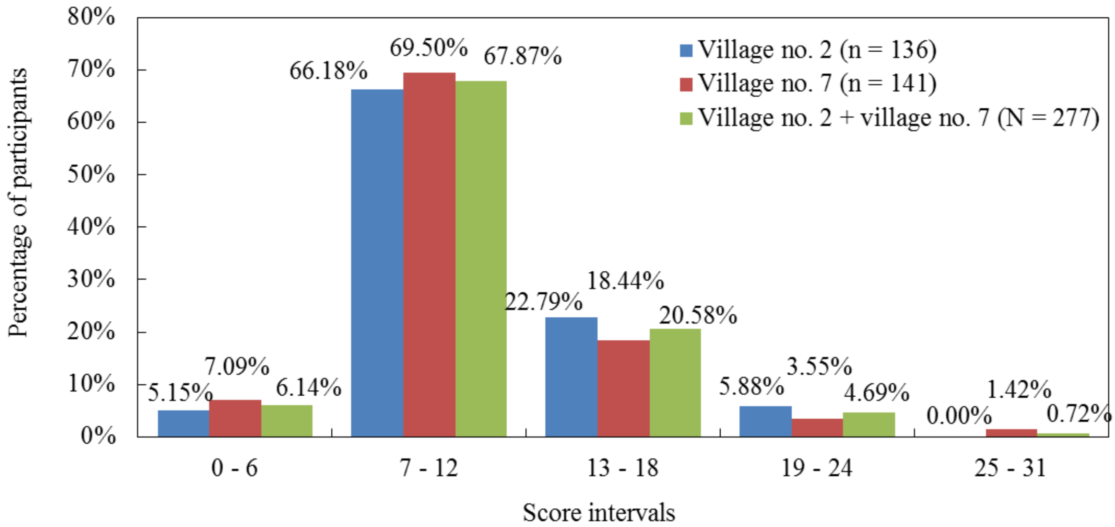


Figure 4.10 Percentage of earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 with score intervals

From Figure 4.7 - 4.9, it can be seen that scores are transformed into score intervals in order to make it easier for interpretation. This can also be seen in Figure 4.10. Score intervals in this study can be divided into 5 intervals. Based on this information, scores between 0 and 6 represented people behaving very poorly with earthquake preparedness. Scores between 7 and 12 represented people behaving poorly with earthquake preparedness. Scores between 13 and 18 represented people behaving moderately well with earthquake preparedness. Scores between 19 and 24 represented people behaving well with earthquake preparedness. Scores between 25 and 31 represented people behaving very well with earthquake preparedness.

In village no. 2 with 136 participants, the highest participant group (66.18%, n = 90) had scores ranging between 7 and 12. The second highest participant group (22.79%, n = 31) had scores ranging between 13 and 18. The smallest participant group (0.00%, n = 0) had scores ranging between 25 and 31.

In village no. 7 with 141 participants, the highest participant group (69.50%, n = 98) had scores ranging between 7 and 12. The second highest participant group (18.44%, n = 26) had scores ranging between 13 and 18. The smallest participant group (1.42%, n = 2) had scores ranging between 25 and 31.

In village no. 2 and village no. 7 with 277 participants, the highest participant group (67.87%, n = 188) had scores ranging between 7 and 12. The second highest participant group (20.58%, n = 57) had scores ranging between 13 and 18. The smallest participant group (0.72%, n = 2) had scores ranging between 25 and 31. It seems that most participants behave poorly with earthquake preparedness because most participants had scores ranging between 7 and 12 (people behaving poor with earthquake preparedness). They also had lower scores than those ranging between 13 and 18 (people behaving moderately well with earthquake preparedness).

4.3.3 Demographic variables and earthquake preparedness scores

Demographic variables in this study consisted of sex, age, education levels, house ownership, time living in the present house, and income.

Table 4.3 Demographic variables of participants in village no.2 and village no. 7

Variables		Frequency	Percent
Sex	Male	133	48
	Female	144	52
Age	1-40 years old	22	7.9
	41-60 years old	160	57.8
	More than 61 years old	95	34.3
Education levels	Illiterate	31	11.2
	Primary school	184	66.4
	High school	40	14.4
	Vocational school	10	3.6
	University	12	4.3
House ownership	No	43	15.5
	Yes	234	84.5
time living in the present house	Less than 1 year	4	1.4
	1 - 10 years	61	22
	More than 10 years	212	76.5
Income (THB/Person/Month)	Less than 2,428	73	26.4
	2,428 - 10,000	181	65.3
	10,001 - 15,000	10	3.6
	15,001 - 20,000	6	2.2
	More than 20,001	7	2.5
Expenditure (THB/Person/Month)	Less than 2,428	83	30
	2,428 - 10,000	177	63.9
	10,001 - 15,000	7	2.5
	15,001 - 20,000	5	1.8
	More than 20,001	5	1.8

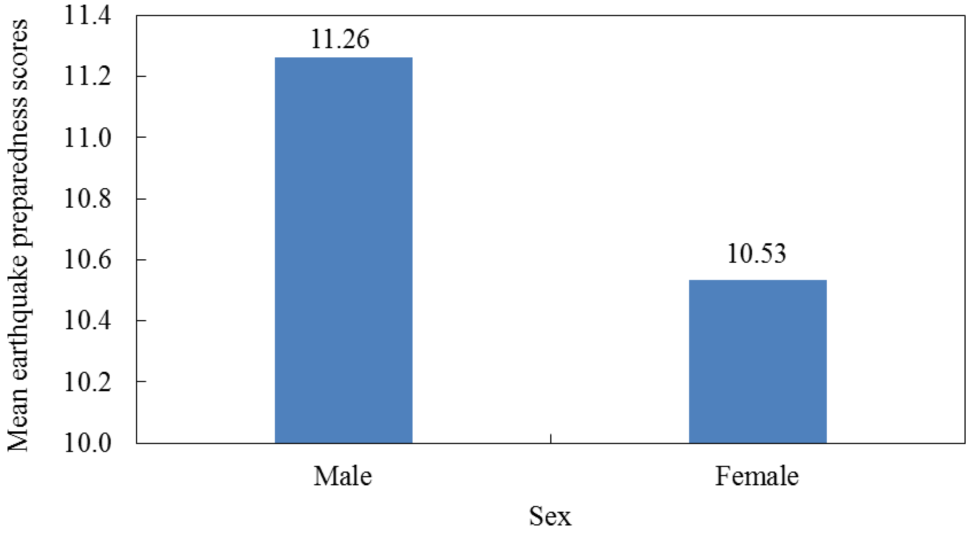


Figure 4.11 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by sex

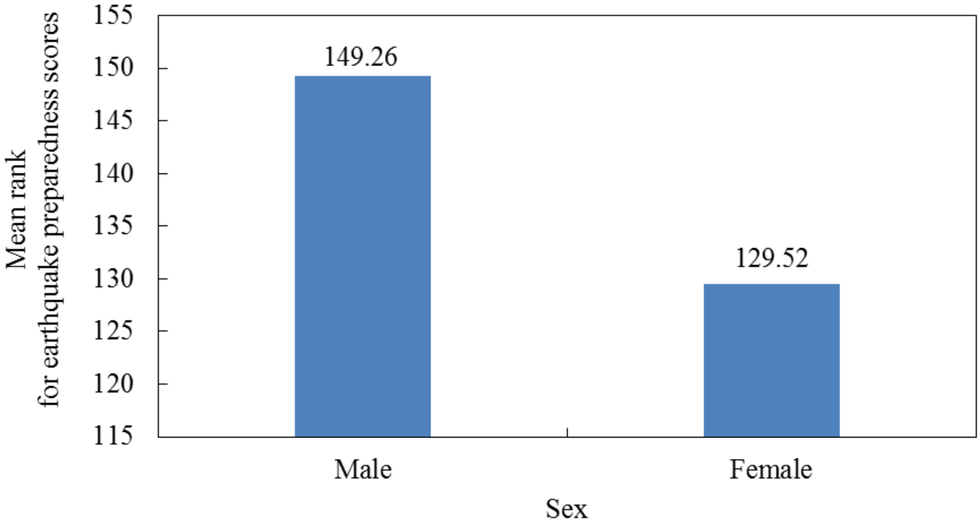


Figure 4.12 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by sex

As for earthquake preparedness scores by sex, males had an average of 11.26, whereas females had an average of 10.53; therefore, males had a higher mean than females (Figure 4.11).

According to the Mann-Whitney U test, there was statistically significant difference found (U = 8211.50, p = 0.040 < α = 0.050). In addition, males had an average rank of 149.26 (n = 133, median = 11.00) whereas females had an average rank of 129.52 (n = 144, median = 9.00); therefore, males had a higher mean rank than female (Figure 4.12), and the Eta was 0.091, showing a small relationship between sex and earthquake preparedness scores. It can be concluded that sex is associated with earthquake preparedness scores.

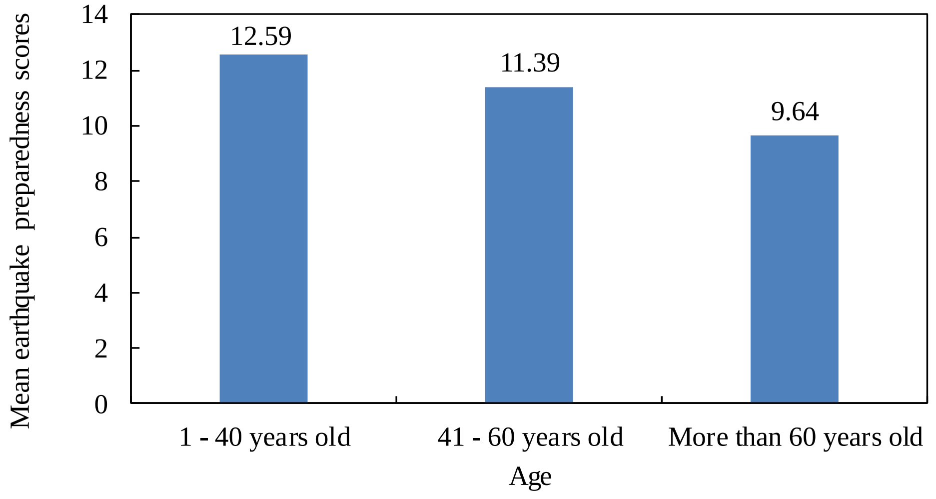


Figure 4.13 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by age

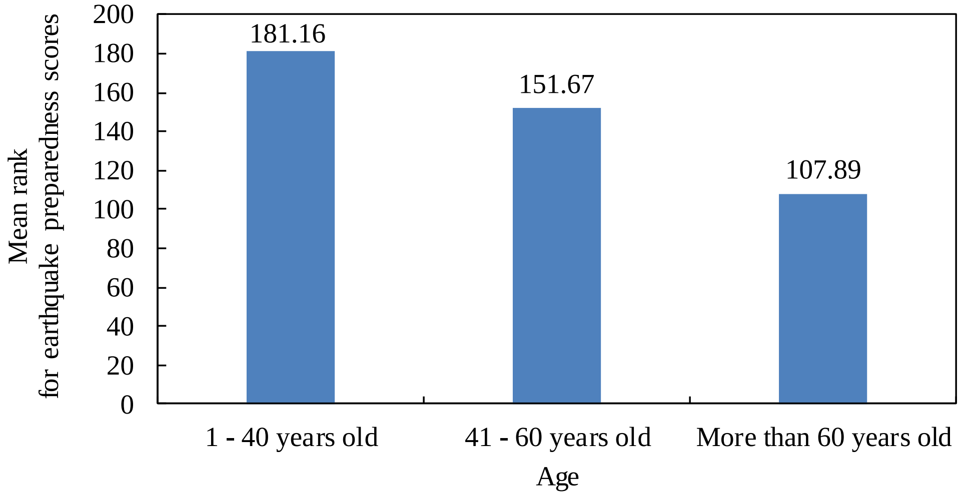


Figure 4.14 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by age

As for earthquake preparedness scores by age, the highest group was participants having an average of 12.59 for 1 – 40 years old; the second highest group was participants having an average of 11.39 for 41 – 60 years old; and the smallest group was participants having an average of 9.64 for more than 60 years old (Figure 4.13).

According to the Kruskal-Wallis test, there were statistically significant differences found among age groups on earthquake preparedness scores ($\chi^2(2)$ = 24.668, p = 0.000 < α = 0.050) with a mean rank of 181.16 (n = 22, median = 11.50) for 1 - 40 years old, a mean rank of 151.67 (n = 160, median = 11.00) for 41 – 60 years old, and a mean rank of 107.89 (n = 95, median = 9.00) for more than 60 years old; therefore, participants having a mean rank of 181.16 for 1 - 40 years old were higher than participants having a mean rank of 151.67 for 41 – 60 years and participants having a mean rank of 107.89 for more than 60 years old (Figure 4.14). The Eta was 0.239, showing a small relationship between age and earthquake preparedness scores.

As mentioned above, data were calculated by the Kruskal-Wallis test. There was a statistically significant difference between age groups on earthquake preparedness scores. Thus, pairwise comparisons will be computed by using the Bonferroni method to adjust significance values. The results of the tests indicated the following statistically significant differences:

(1) Between 1 – 40 years old group and more than 60 years old group on earthquake preparedness scores ($p = 0.000 < \alpha = 0.050$);

(2) Between 41 – 60 years old group and more than 60 years old group on earthquake preparedness scores ($p = 0.000 < \alpha = 0.050$);

It can be concluded that age is associated with earthquake preparedness scores.

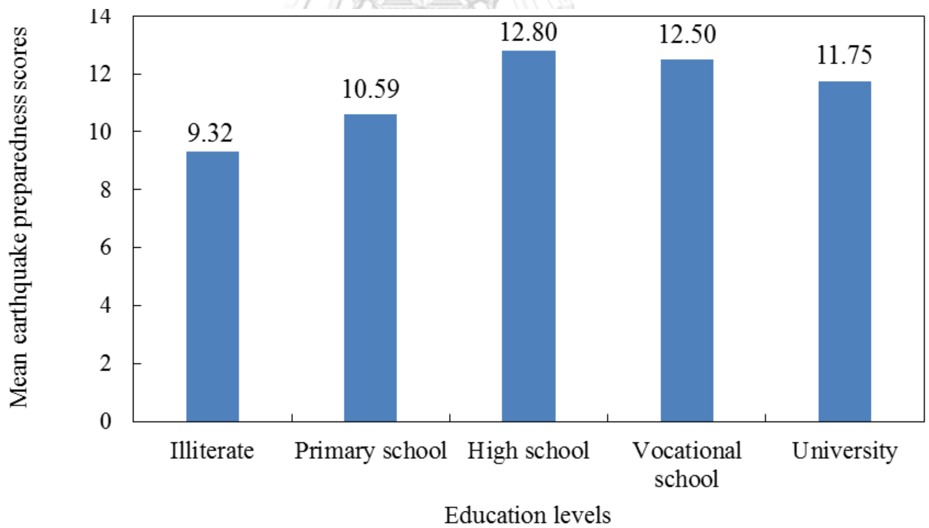


Figure 4.15 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by education levels

As for earthquake preparedness scores by education levels, the smallest group was participants having an average of 9.32 for being Illiterate; the second smallest group was participants having an average of 10.59 for completing primary school; the highest group was participants having an average of 12.80 for completing high school; the second highest group was participants having an average of 12.50 for completing vocational school; and participants had an average of 11.75 for completing university. Therefore, participants having an average of 12.80 for high school were higher than participants having an average of 12.50 for vocational school, participants having an average of 11.75 for university, participants having an average of 10.59 for primary school, participants having an average of 9.32 for being Illiterate (Figure 4.15).

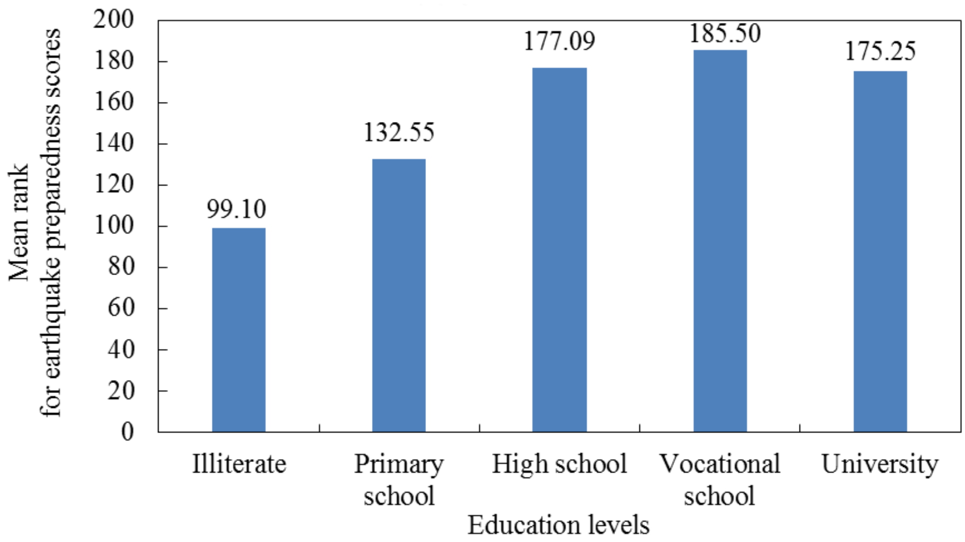


Figure 4.16 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by education levels

According to the Kruskal-Wallis test, there were statistically significant differences found among education level groups on earthquake preparedness scores ($\chi^2(4) = 23.994$, $p = 0.000 < \alpha = 0.050$) with a mean rank of 99.10 (n = 31, median = 9.00) for being illiterate, a mean rank of 132.55 (n = 184, median = 10.00) for completing primary school, a mean rank of 177.09 (n = 40, median = 12.00) for completing high school, a mean rank of 185.50 (n = 10, median = 12.50) for completing vocational school, and a mean rank of 175.25 (n = 12, median = 11.00) for completing university. Therefore, participants having a mean rank of 185.5 for completing vocational school were higher than participants having a mean rank of 177.09 for completing high school, participants having a mean rank of 175.25 for completing university, participants having a mean rank of 132.55 for completing primary school, and participants having a mean rank of 99.10 for being illiterate (Figure 4.16). The Eta was 0.249, showing a small relationship between education levels and earthquake preparedness scores.

As mentioned above, data were calculated by using the Kruskal-Wallis test. There was a statistical significance in the differences between education levels on earthquake preparedness scores. Thus, pairwise comparisons will be computed by using the Bonferroni method to adjust the significance values. The results of the tests indicated the following statistically significant differences:

(1) Between illiterate and university on earthquake preparedness scores ($p = 0.050 <= \alpha = 0.050$);

(2) Between illiterate and high school on earthquake preparedness scores ($p = 0.000 < \alpha = 0.050$);

(3) Between illiterate and vocational school on earthquake preparedness scores ($p = 0.029 < \alpha = 0.050$);

(4) Between primary school and high school on earthquake preparedness scores ($p = 0.014 < \alpha = 0.050$).

It can be concluded that education levels are associated with earthquake preparedness scores.

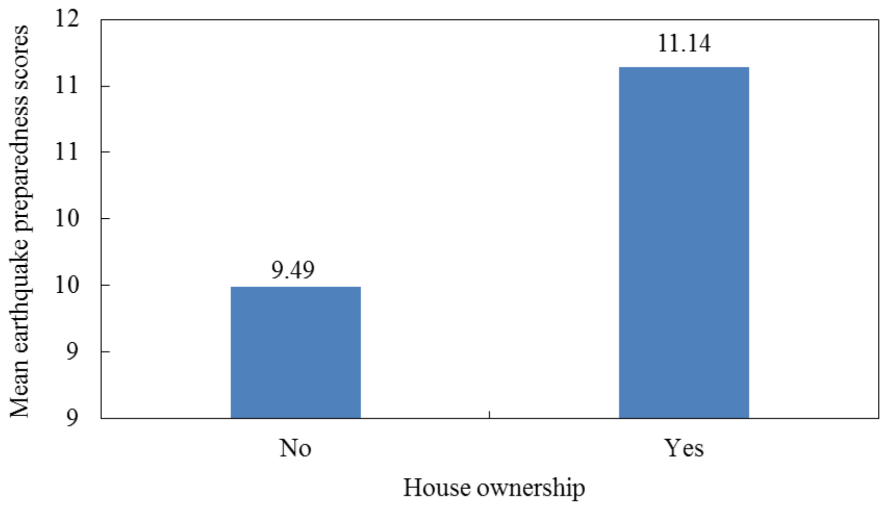


Figure 4.17 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by house ownership

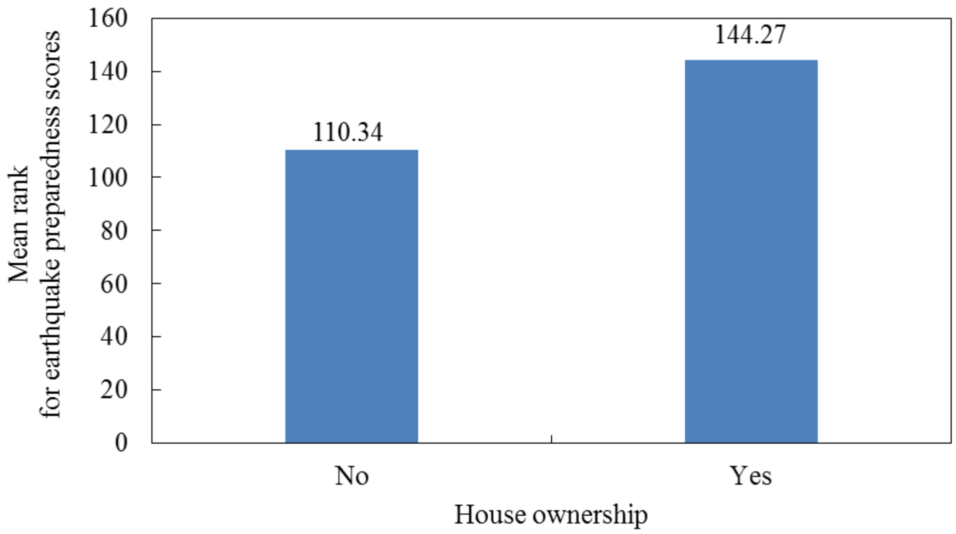


Figure 4.18 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by house ownership

As for earthquake preparedness scores by house ownership, house ownership had an average of 11.14, whereas non house ownership had an average of

9.49; therefore, house ownership had a higher mean than non house ownership (Figure 4.17).

According to the Mann-Whitney U test, it was found to be a statistically significant difference ($U = 3798.50$, $p = 0.010 < \alpha = 0.050$). As for earthquake preparedness scores, house ownership had an average rank of 144.27 (n = 234, median = 10.00) whereas non house ownership had an average rank of 110.34 (n = 43, median = 9.00); therefore, house ownership had a higher mean rank than non house ownership (Figure 4.18), and the Eta was 0.150, showing a small relationship between house ownership and earthquake preparedness scores. It can be concluded that house ownership is associated with earthquake preparedness scores.

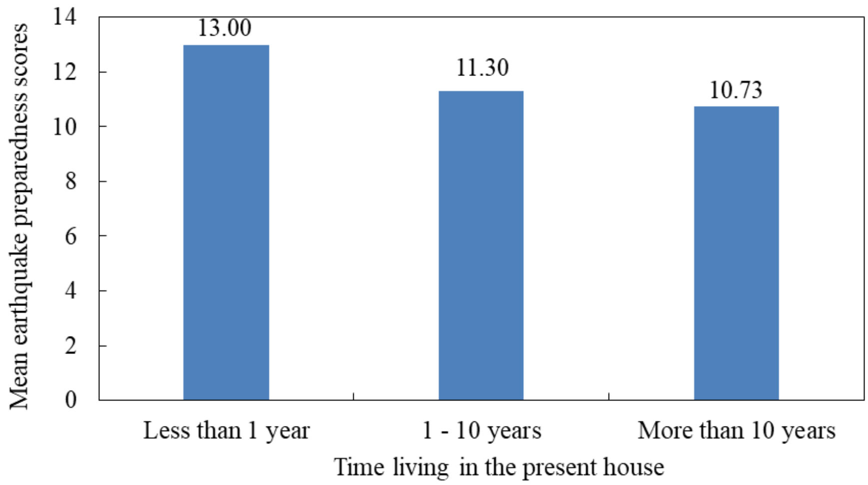


Figure 4.19 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by time living in the present house

As for earthquake preparedness scores, the highest group was participants having an average of 13.00 for time living in the present house less than 1 year; the second highest group was participants having an average of 11.30 for time living in the present house between 1 and 10 years; and the smallest group was participants having an average of 10.73 for time living in the present house more than 10 years. Therefore, participants having an average of 13.00 for time living in the present house less than 1 year were higher participants having an average of 11.30 for time living in the present house between 1 and 10 years and participants having an average of 10.73 for time living in the present house more than 10 years (Figure 4.19).

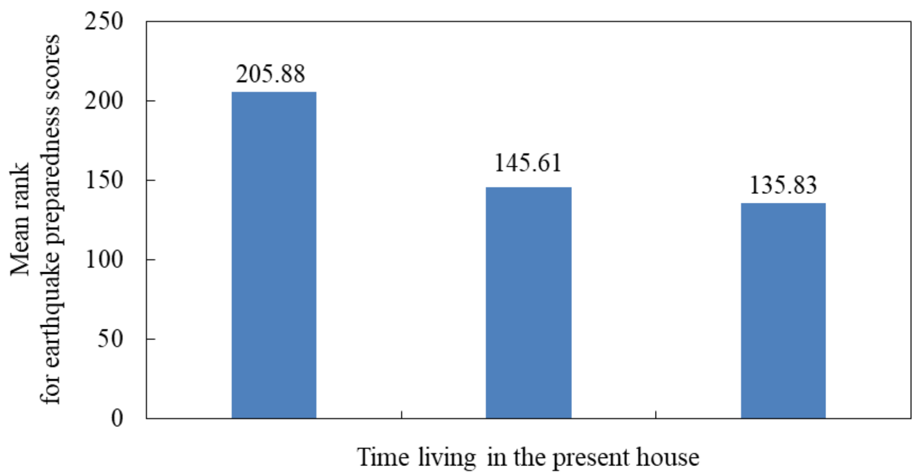


Figure 4.20 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by time living in the present house

According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among time living in the present house group on earthquake preparedness scores ($\chi^2(2) = 3.570$, $p = 0.168 > \alpha = 0.050$) with a mean rank of 205.88 (n = 4, median = 12.50) for time living in the present house less than 1 year, a mean rank of 145.61 (n = 61, median = 11.00) for time living in the present house between 1 and 10 years, a mean rank of 135.83 (n = 212, median = 10.00) for time living in the present house more than 10 years, that was, participants having a mean rank of 205.88 for time living in the present house less than 1 year were higher than participants having a mean rank of 145.61 for time living in the present house between 1 and 10 years and participants having a mean rank of 135.83 for time living in the present house more than 10 years (Figure 4.20). It can be concluded that time living in the present house is not associated with earthquake preparedness scores.

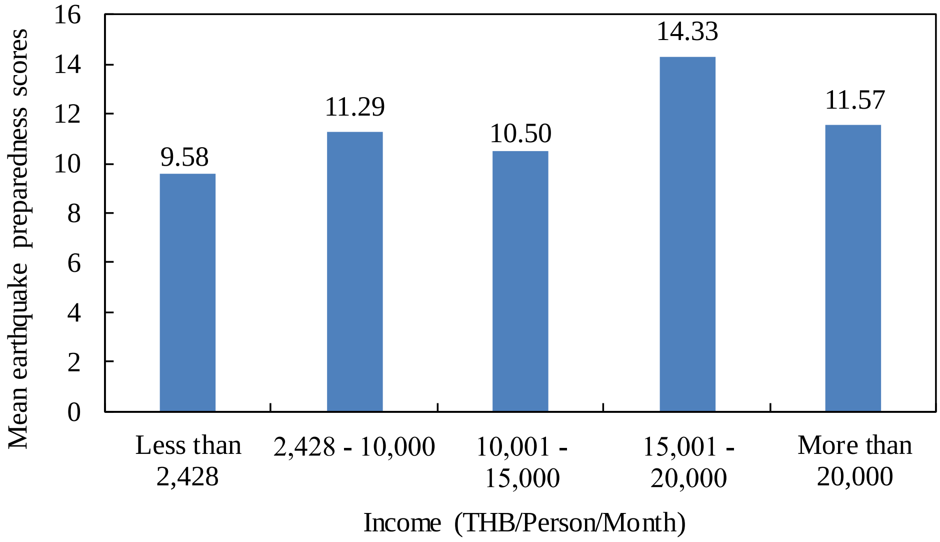


Figure 4.21 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by income

As for earthquake preparedness scores by income, participants had an average of 9.58 for income less than 2,428 THB/Person/Month; participants had an average of 11.29 for income between 2,428 and 10,000 THB/Person/Month; participants had an average of 10.50 for income between 10,001 and 15,000 THB/Person/Month; participants had an average of 14.33 for income between 15,001 and 20,000 THB/Person/Month; and participants had an average of 11.57 for income more than 20,000 THB/Person/Month. Therefore, participants having an average of 9.58 for income less than 2,428 THB/Person/Month were lower than participants having an average of 10.50 for income between 10,001 and 15,000 THB/Person/Month, participants having an average of 11.29 for income between 2,428 and 10,000 THB/Person/Month, participants having an average of 11.57 for income more than 20,000 THB/Person/Month, and participants having an average of 14.33 for income between 15,001 and 20,000 THB/Person/Month, respectively (Figure 4.21).

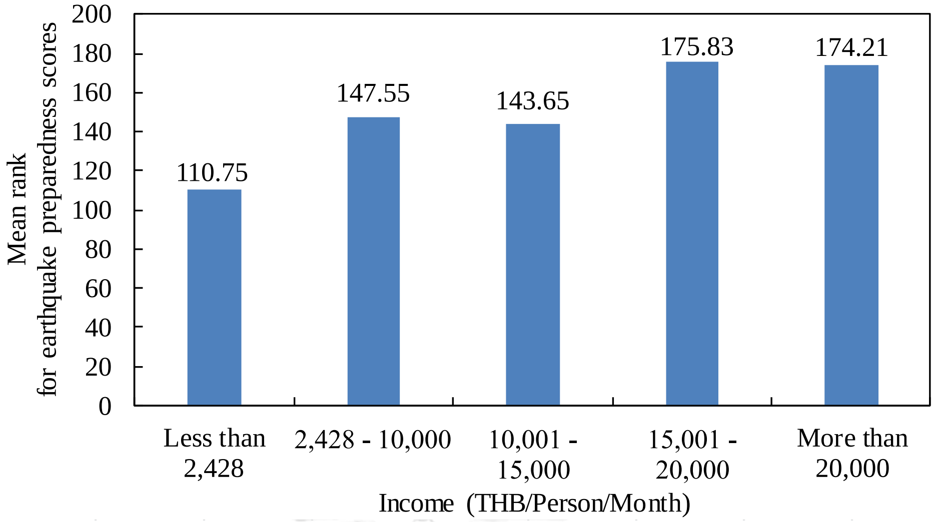


Figure 4.22 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by income

According to the Kruskal-Wallis test, it was found that there were statistically significant differences among income groups on earthquake preparedness scores ($\chi^2(4) = 13.934$, $p = 0.008 < \alpha = 0.050$) with a mean rank of 110.75 (n = 73, median = 9.00) for income less than 2,428 THB/Person/Month, a mean rank of 147.55 (n = 181, median = 10.00) for income between 2,428 and 10,000 THB/Person/Month, a mean rank of 143.65 (n = 10, median = 10.50) for income between 10,001 and 15,000 THB/Person/Month; a mean rank of 175.83 (n = 6, median = 14.00) for income between 15,001 and 20,000 THB/Person/Month; and a mean rank of 174.21 (n = 7, median = 11.00) for income more than 20,000 THB/Person/Month.

Therefore, participants having a mean rank of 110.75 for income less than 2,428 THB/Person/Month were less than participants having a mean rank of 143.65 for income between 10,001 and 15,000 THB/Person/Month, participants having a mean rank of 147.55 for income between 2,428 and 10,000 THB/Person/Month, participants having a mean rank of 174.21 for more than 20,000 THB/Person/Month, and participants having a mean rank of 175.83 for income between 15,001 and 20,000 THB/Person/Month, respectively (Figure 4.22). The Eta was 0.229, showing a little relationship between income and earthquake preparedness scores. It can be concluded that income is associated with earthquake preparedness scores.

As mentioned above, demographic variables and earthquake preparedness scores in this study found that sex, age, education levels, house ownership, and income are associated with earthquake preparedness scores. However, time living in the present house is not associated with earthquake preparedness scores.

4.3.4 Village and earthquake preparedness scores

As for earthquake preparedness scores by villages, participants in village no. 2 had an average of 11.01, whereas participants in village no. 7 had an average of 10.77; therefore, participants in village no. 2 had a higher mean than participants in village no. 7 (Figure 4.23).

According to the Mann-Whitney U test, it was found that there was not a statistically significant difference ($U = 9,134.00$, $p = 0.494 > \alpha = 0.050$). As for earthquake preparedness scores by village, the participant group in village no. 2 had an average rank of 142.34 (n = 136, median = 10.00) whereas a participant group in village no. 7 had an average rank of 135.78 (n = 141, median = 10.00); therefore, a participant group in village no. 2 had a higher mean rank than the participant group in village no. 7 (Figure 4.24). It can be concluded that villages are not associated with earthquake preparedness scores.

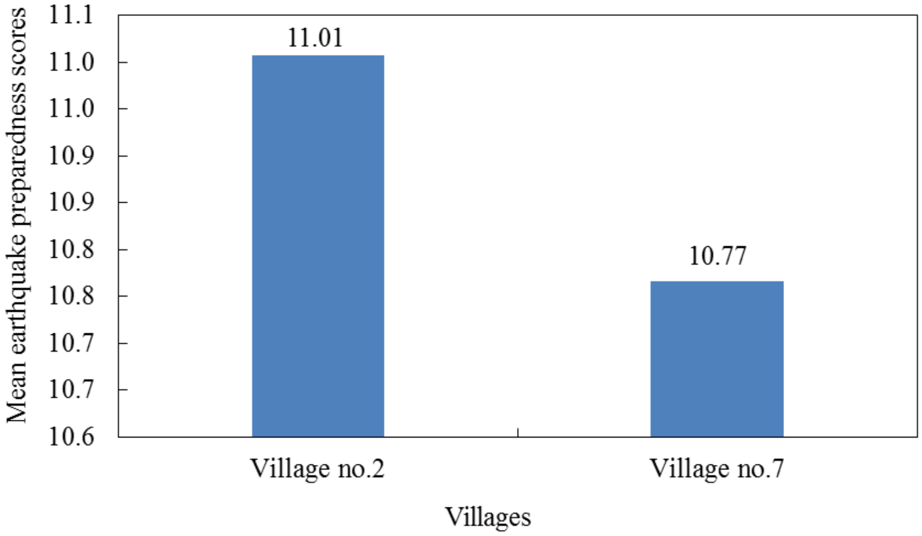


Figure 4.23 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by villages

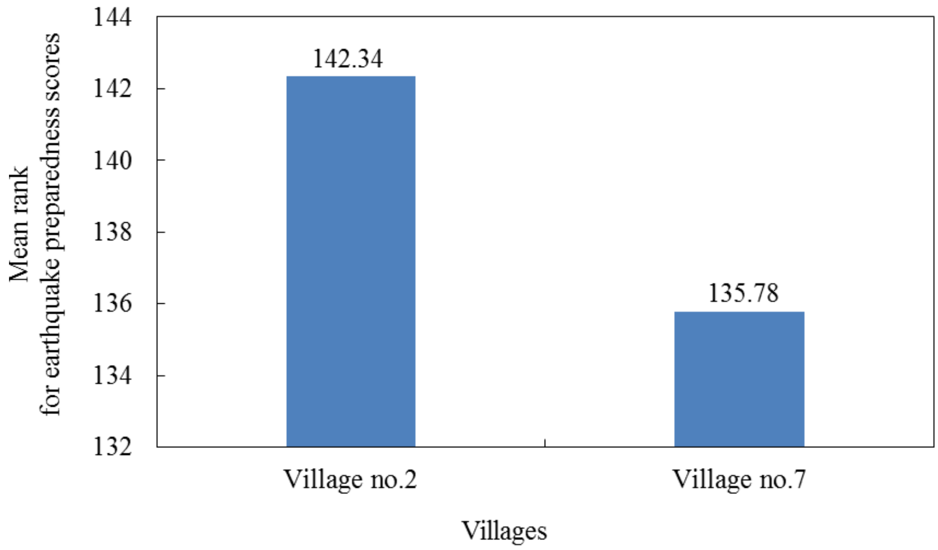


Figure 4.24 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by villages

As for earthquake preparedness before and after earthquakes in the future versus the factors (sex, age, education levels, house ownership, time living in the present house, income, villages, and expenditure), higher Eta showed higher a relationship between a variable and earthquake preparedness before and after earthquakes in the future. Thus, factors were listed in order of importance as follows: education levels, age, expenditure, income, house ownership, and sex, which had Eta of 0.249, 0.239, 0.236, 0.229, 0.15, and 0.091, respectively. Time living in the present house and the villages themselves did not affect earthquake preparedness before and after earthquakes in the future.

Males had a higher role than females because males had a higher mean rank than females for earthquake preparedness before and after earthquakes in the future. This may be because most males in Thai culture are considered to be the head of the household.

Limitations of this study in the demographic characteristics are shown as follows:

All ages were sampled in this study because perhaps the oldest person may not have been at home at the time of questioning. However, some research studies selected only the oldest person. This may have been because the oldest person may have better known how to be prepared such as knowing the location of the circuit breakers, water cut off and gas cut off, and know how to turn them off because those participants may use them regularly. Thus, they could remember the location of the circuit breaker, water cut off, and gas cut off as well as how to turn them off. Nevertheless, a child (such as age of ten years old) almost certainly had lower knowledge.

Age distribution in this study may not represent the total population of villages no. 2 and no. 7 because most respondents were of age 41 – 60 years old (57.8%) while the minority were older than 60 years old (34.3%). Moreover, most children, teenagers and some adults declined to answer the questions.

4.3.5 Poverty and earthquake preparedness scores

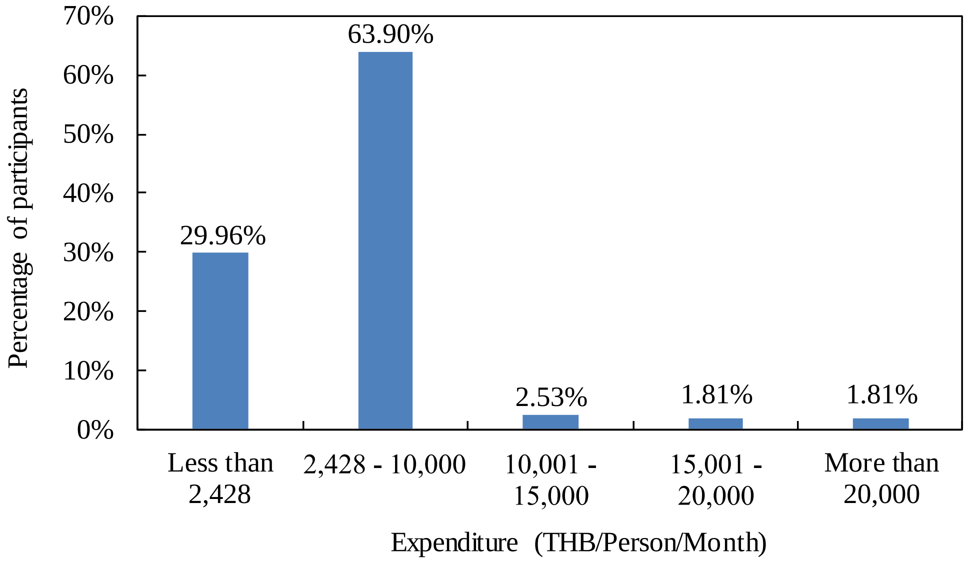


Figure 4.25 Expenditure of 277 participants in village no. 2 and village no. 7

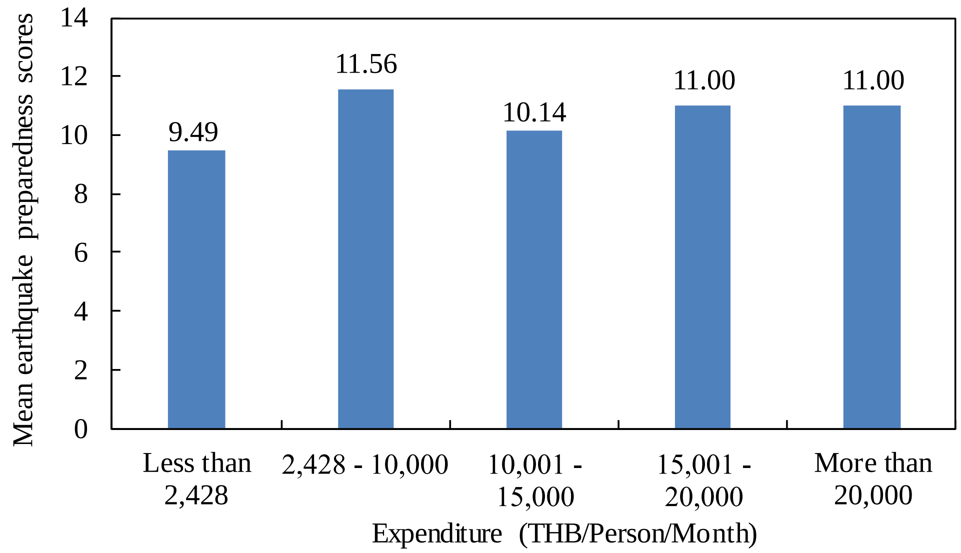


Figure 4.26 Mean earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by expenditure

In Thailand, the poverty line for expenditure in Chiang Rai was 2,428 THB/Person/Month (National Statistical Office, 2016). Of 277 participants, 29.96 % (n = 83) had less expenditure than 2,428 THB/Person/Month that was below the poverty line in Chiang Rai, meaning they were poor. 63.90% (n = 177) of 277 participants was the largest number of participants that spent between 2,428 and 10,000 THB/Person/Month (Figure 4.25).

As for earthquake preparedness scores by expenditure, participants had an average of 9.49 for expenditure less than 2,428 THB/Person/Month; participants had an average of 11.56 for expenditure between 2,428 and 10,000 THB/Person/Month; participants had an average of 10.14 for expenditure between 10,001 and 15,000 THB/Person/Month; participants had an average of 11.00 for expenditure between 15,001 and 20,000 THB/Person/Month as well as for expenditure more than 20,000 THB/Person/Month. Therefore, participants having an average of 9.49 for expenditure were less than 2,428 THB/Person/Month lower than participants having an average of 10.14 expenditure between 10,001 and 15,000 THB/Person/Month; participants having an average of 11.00 for expenditure between 15,001 and 20,000 THB/Person/Month as well as for expenditure more than 20,000 THB/Person/Month; and participants having an average of 11.56 for expenditure between 2,428 and 10,000 THB/Person/Month (Figure 4.26).

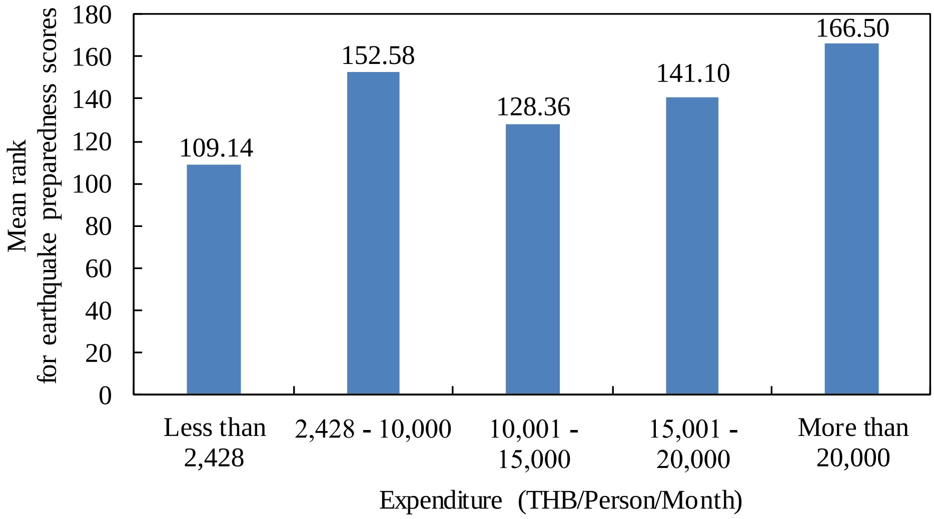


Figure 4.27 Mean rank for earthquake preparedness scores of 277 participants in village no. 2 and village no. 7 by expenditure

According to the Kruskal-Wallis test, there were statistically significant differences found among expenditure groups on earthquake preparedness scores ($\chi^2(4) = 17.511$, $p = 0.002 < \alpha = 0.050$) with a mean rank of 109.14 (n = 83, median = 9.00) for expenditure less than 2,428 THB/Person/Month, a mean rank of 152.58 (n = 177, median = 11.00) for expenditure between 2,428 and 10,000 THB/Person/Month, a mean rank of 128.36 (n = 7, median = 10.00) for expenditure between 10,001 and 15,000 THB/Person/Month; a mean rank of 141.10 (n = 5, median = 10.00) for expenditure between 15,001 and 20,000 THB/Person/Month; and a mean rank of 166.50 (n = 5, median = 11.00) for expenditure more than 20,000 THB/Person/Month. Therefore, participants having a mean rank of 109.14 for expenditure less than 2,428 THB were lower than participants having a mean rank of 128.36 for expenditure between 10,001 and 15,000 THB/Person/Month; participants having a mean rank of 141.10 for expenditure between 15,001 and 20,000 THB/Person/Month; participants having a mean rank of 152.58 for expenditure between 2,428 and 10,000 THB/Person/Month; participants having a mean rank of 166.50 for expenditure more than 20,000 (Figure

4.27). The Eta was 0.236, showing a small relationship between expenditure and earthquake preparedness scores.

From Figure 4.25 - 4.27, it can be concluded that of 277 participants, 29.96 % (n = 83) had expenditure less than 2,428 THB/Person/Month that are below poverty line in Chiang Rai, meaning they are poor. Poor people have the lowest mean earthquake preparedness scores at 9.49 and the lowest mean rank for earthquake preparedness scores at 109.14 among expenditure as follows: less than 2,428 THB/Person/Month, between 2,428 and 10,000 THB/Person/Month, between 10,001 and 15,000 THB, between 15,001 and 20,000 THB/Person/Month, and more than 20,000 THB/Person/Month. It can be concluded that expenditure is associated with earthquake preparedness scores.

4.4 Seismic risk perception in Chiang Rai

4.4.1 Seismic risk perception scores

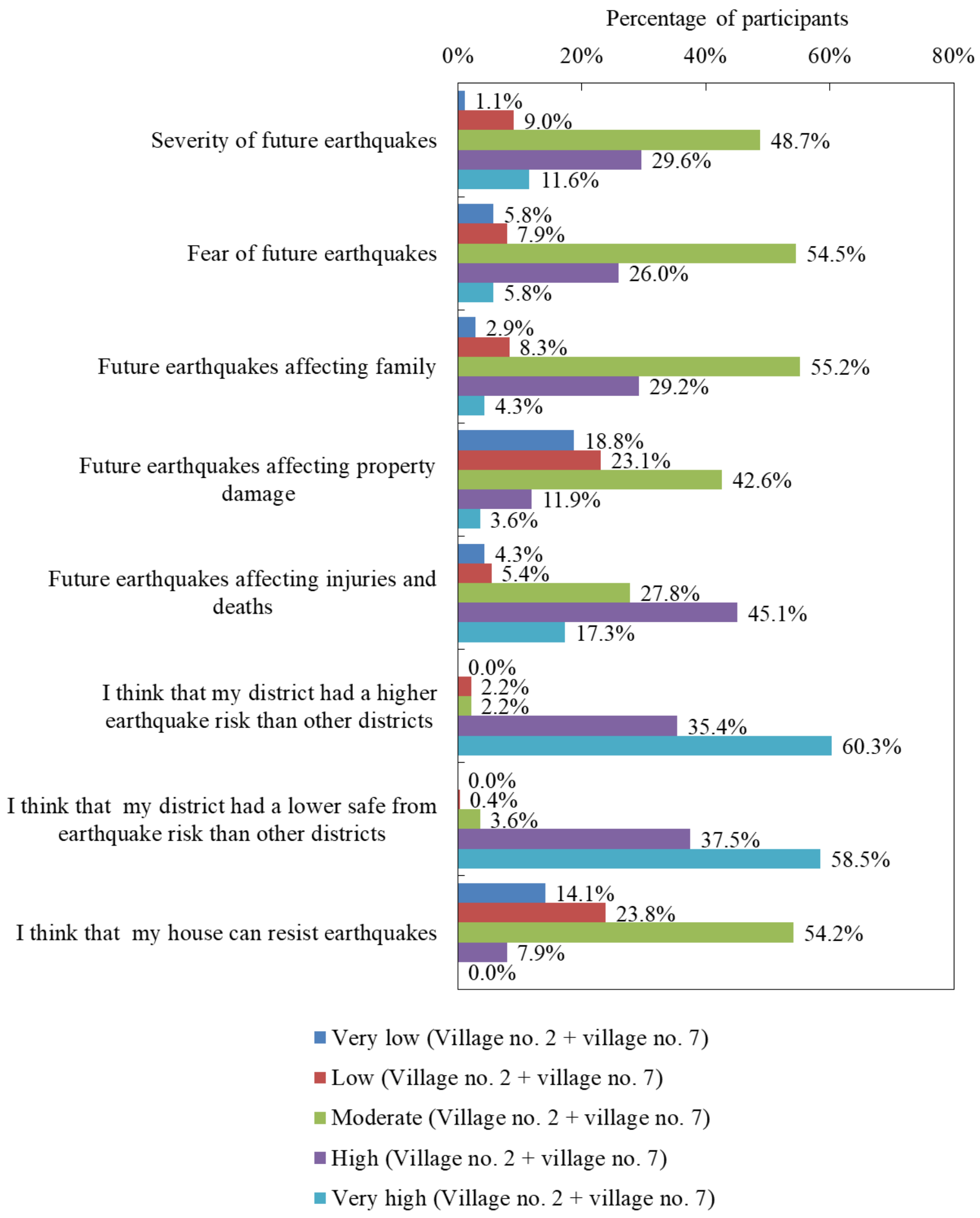


Figure 4.28 Seismic risk perception of 277 participants in village no. 2 and village no. 7

Figure 4.28 shows eight statements about seismic risk perception. These statements were rated on a scale of one to five, with one being very low, two being low, three being moderate, four being high, and five being very high.

As to severity of future earthquake statements, 41.16% (n = 114) of 277 participants expected the severity of future earthquakes at high and very high levels because most participants thought that they lived in a seismic area, but they did not know the frequency or the level of the severity of future earthquakes. 10.11% (n = 28) of all participants expected the severity of future earthquakes at very low and low levels because these participants thought that the earthquakes in the past already occurred severely on May 5, 2014, causing participants to think that future earthquakes would not occur with severity. In addition, some participants thought that a majority of earthquakes in Thailand had occurred at 3 – 4 magnitude on the Richter scale, causing participants to think that future earthquakes would not occur in severity (Figure 4.28).

As to the fear of future earthquakes statement, 31.77% (n = 88) of the 277 participants felt fear of future earthquakes at high and very high levels since their buildings were significantly damaged, or this may be because 25.63% (n = 71) of their 277 buildings were extensively and completely damaged (Figure 4.1 – 4.3). 13.72% (n = 38) of all participants felt fear of future earthquakes at very low and low levels since their buildings were not damaged and were only slightly damaged, or this may be because 55.23% (n = 153) of their 277 buildings were not damaged and were only slightly damaged (Figure 4.1 – 4.3).

As to the future earthquakes affecting family statement, 33.57% (n = 93) of the participants thought that future earthquakes would affect their families at high and very high levels since their buildings were significantly damaged, or 25.63% (n = 71) of their 277 buildings were extensively and completely damaged (Figure 4.1 – 4.3). Moreover, more than 50% or 66.06% (n = 183) of 277 buildings have been constructed without seismic codes. Furthermore, most buildings were repaired without seismic codes, and some buildings were not repaired, causing participants to think that if some strong earthquakes would occur in the future, their buildings are likely to see significant damage to their buildings. This caused people to think that future earthquakes highly affected family. For example, if buildings were highly damaged, people used a large budget for repairing buildings. In another example, people did not repair buildings due to lack of money, causing them to fear building collapse when strong earthquakes occur in the future. 11.19% (n = 31) of all participants thought future earthquakes would affect their family at low and very low levels since their buildings were not damaged and were only slightly damaged, or 55.23% (n = 153) of their 277 buildings were not damaged and only slightly damaged (Figure 4.1 - 4.3). This caused people to think that future earthquakes would affect their families at very low and low levels. For example, if buildings were slightly damaged, people did not repair buildings, or people used a small budget for repairing buildings.

As to future earthquakes affecting property damage, 15.52% (n = 43) of 277 participants thought that future earthquakes would affect property damage at high and very high levels since most of their buildings were constructed without site engineering. This indicates that most of their buildings were constructed before 1997 and without a seismic code at 66.06% (n = 183) of 277 buildings (Figure 4.2). In addition, seismic codes were neither enforced nor covered to construct many buildings. Thus, although buildings were constructed after 1997, many buildings were constructed without a seismic code. 41.88% (n = 116) of all participants thought future earthquakes would slightly cause property damage since most of their buildings were not damaged and only slightly damaged, or 55.23% (n = 153) of their 277 buildings were not damaged and only slightly damaged due to the biggest earthquake in Thailand on May 5, 2014 (Figure 4.1 - 4.3). This caused people to think that future earthquakes would affect property damage at very low and low levels.

As to future earthquakes affecting injuries and deaths, 62.45 % (n = 173) of 277 participants thought that future earthquakes would affect injuries and deaths at high and very high levels because if an earthquake occurs at night and walls fall on people, then it is highly possible to that the number of deaths will occur. 9.75% (n = 27) of all participants thought future earthquakes would affect injuries and deaths at very low and low levels since they thought that their buildings could resist earthquakes.

In regards to the statement, "I think that my district has a higher earthquake risk than other districts", 95.67 % (n = 265) of 277 participants thought that their district had a higher earthquake risk than other districts at high and very high levels because they knew they live in the highest seismic area in Thailand. 2.17% (n = 6) of all participants agreed with the statement at very low and low levels. This may be because they may not follow earthquake information from media or neighbor.

In regards to the statement, "I think that my district has a lower safe from earthquake risk than other districts", 96.03% (n = 266) of 277 participants agreed at high and very high levels because they knew they live in the highest seismic area in Thailand by following earthquake information from media and/or neighbor. 0.36% (n = 1) of all participants agreed with the statement at very low and low levels. This may be because they did not follow earthquake information from media and/or neighbor.

In regards to the statement, "I think that my house can resist earthquakes", 7.94% (n = 22) of 277 participants thought that their houses could resist earthquakes at high and very high levels because most of their houses were constructed with seismic codes and site engineers. 37.91% (n = 105) of all participants thought their houses could resist earthquakes at very low and low levels because most of their houses were constructed without seismic codes and site engineers.

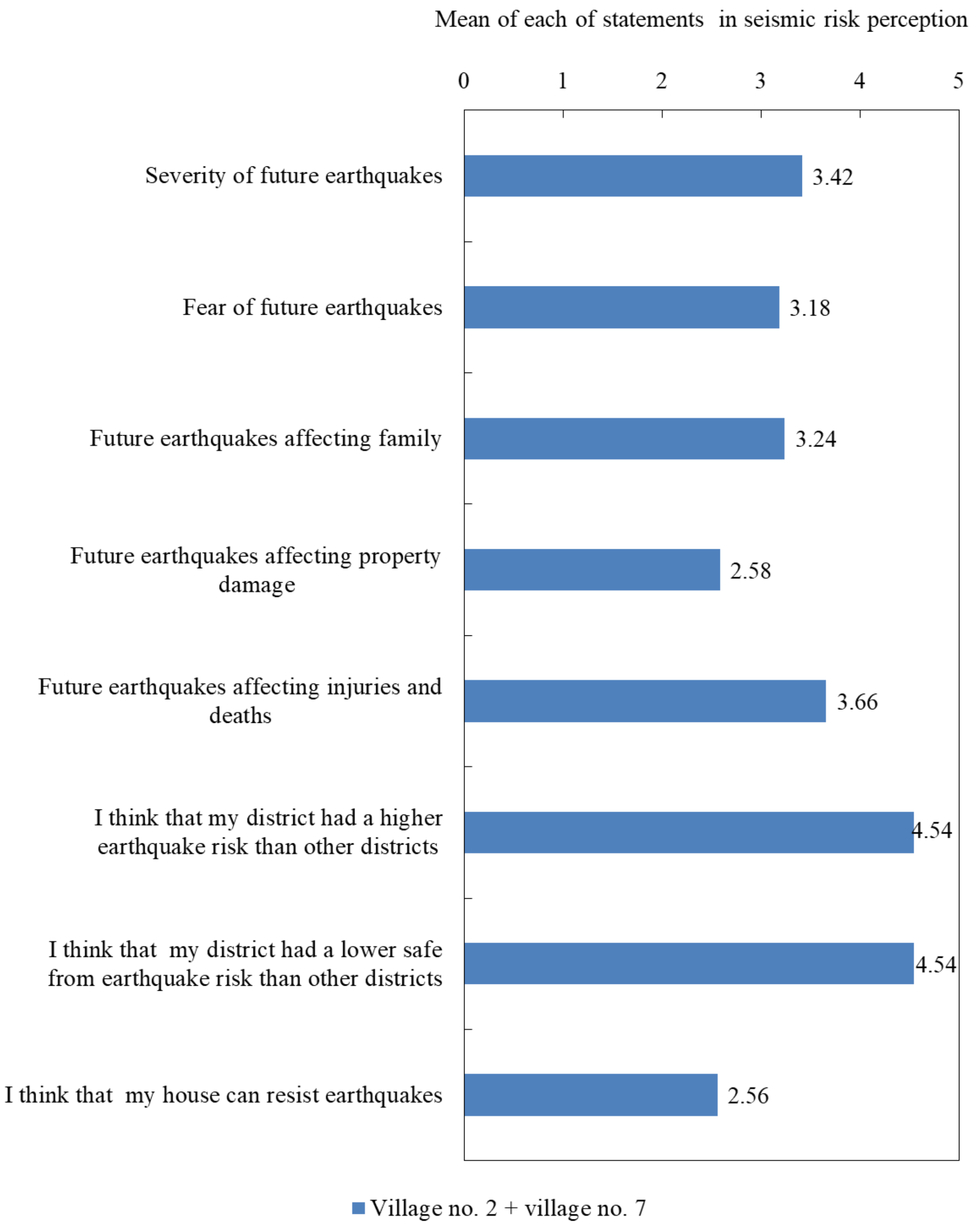


Figure 4.29 Mean of each statement in seismic risk perception of 277 participants in village no. 2 and village no. 7

The mean of each statement can be calculated from Figure 4.28, as shown in Figure 4.29. As for the mean of each statement in seismic risk perception (Figure 4.29), the highest mean group was, “I think that my district has a higher earthquake risk than other districts” and “I think that my district has a lower safe from earthquake risk than other districts”, at 4.54 (median = 5.00). The second highest mean group was “future earthquakes affecting injuries and deaths”, at 3.66 (median = 4.00). The second smallest mean group was “future earthquakes affecting property damage”, at 2.58 (median = 3.00). The smallest mean group was “I think that my house can resist earthquakes”, at 2.56 (median = 3.00).

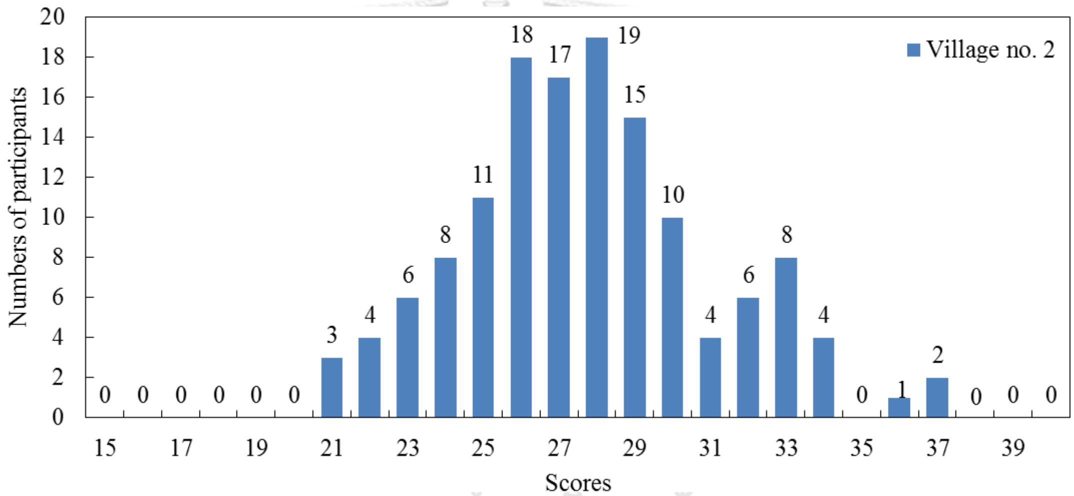


Figure 4.30 Seismic risk perception scores of 136 participants in village no. 2

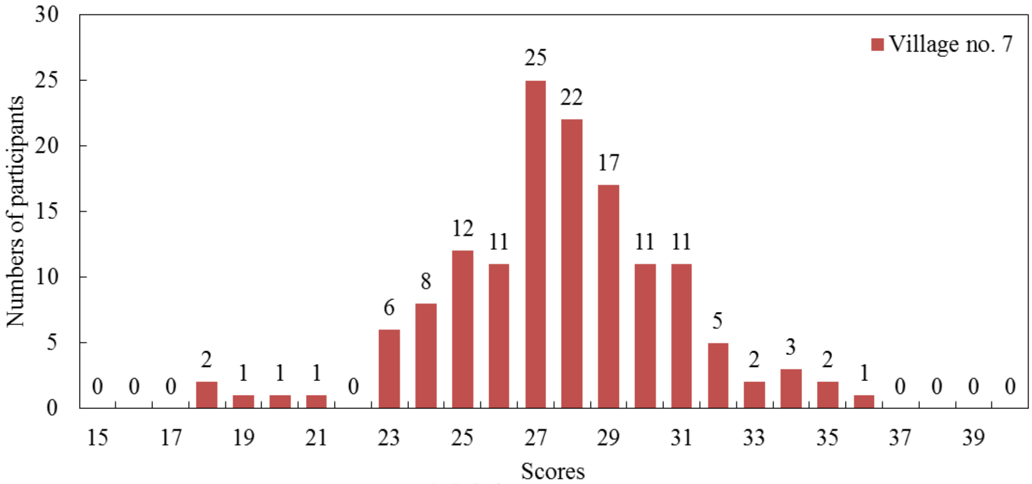


Figure 4.31 Seismic risk perception scores of 141 participants in village no. 7

Figure 4.30 shows 136 participants in village no. 2 scoring on the seismic risk perception ranging from 21 to 37. The mean was 27.76; the median was 28; the mode was 28; and the standard deviation was 3.34. The mean was less than the median Thus, data were skewed to the left. Higher scores showed higher seismic risk perception scores. By contrast, lower scores showed lower seismic risk perception scores. Of 136 participants, 36.76% had higher scores than the median, and 63.24% had lower scores than the median. It seems that most participants have seismic risk perception because most participants had lower scores than the median.

Figure 4.31 shows 141 participants in village no. 7 scoring on the seismic risk perception ranging from 18 to 36. The mean was 27.67; the median was 28; the mode was 27; and the standard deviation was 3.15. The mean was less than the median. Thus, data were skewed to the left. Higher scores showed higher seismic risk perception scores. By contrast, lower scores showed lower seismic risk perception scores. Of 141 participants, 36.88% had higher scores than the median, and 63.12% had lower scores than the median. It seems that most participants have seismic risk perception because most participants had lower scores than the median.

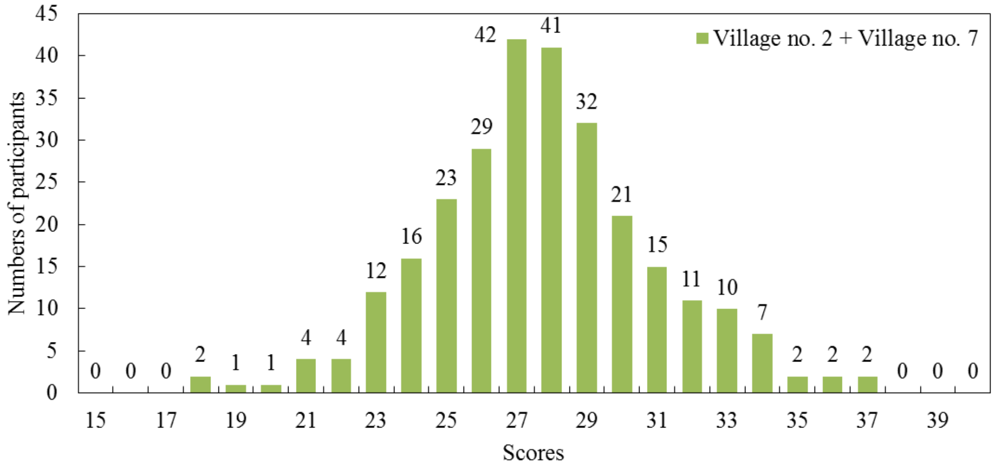


Figure 4.32 Seismic risk perception scores of 277 participants from village no. 2 and village no. 7

Figure 4.32 shows 277 participants from village no. 2 and village no. 7 scoring on the seismic risk perception ranging from 18 to 37. The mean was 27.71; the median was 28.00; and the standard deviation was 3.24. The mean was lower than the median. Thus, data were skewed to the left. Higher scores showed higher seismic risk perception. By contrast, lower scores showed lower seismic risk perception. Of 277 participants, 36.82% had higher scores than the median, and 63.18 % had lower scores than the median.

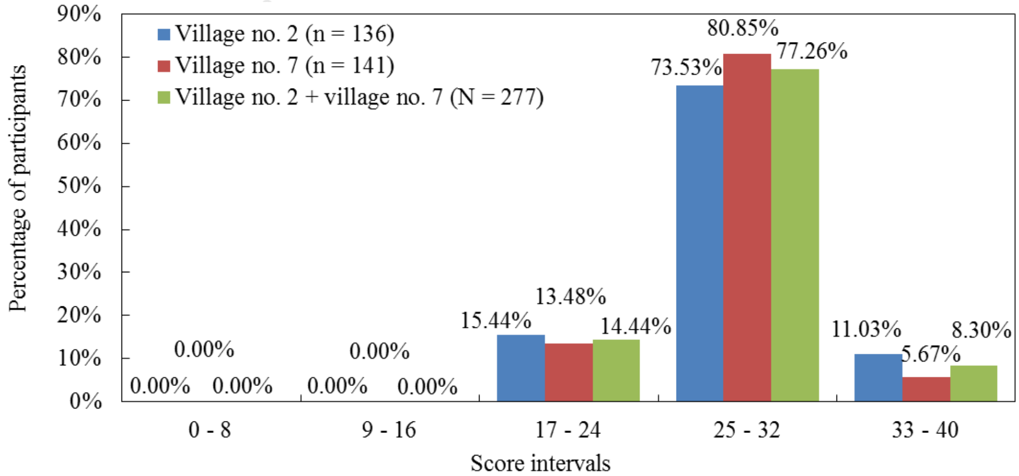


Figure 4.33 Percentage of seismic risk perception scores of 277 participants in village no. 2 and village no. 7 with score intervals

As shown in Figure 4.30 - 4.32, scores were transformed into score intervals in order to make it easier for interpretation as can be seen in Figure 4.33. Score intervals in this study can be divided into 5 intervals. Based on this information, scores between 0 and 8 represented people behaving very poorly with seismic risk perception. Scores between 9 and 16 represented people behaving poorly with seismic risk perception. Scores between 17 and 24 represented people behaving moderately well with seismic risk perception. Scores between 25 and 32 represented people behaving well with seismic risk perception. Scores between 33 and 40 represented people behaving very well with seismic risk perception.

In village no. 2 with 136 participants, the highest participant group (75.53%, n = 100) had scores ranging between 25 and 32. The second highest participant group (15.44%, n = 21) had scores ranging between 17 and 24. The smallest participant group (0.00%, n = 0) had scores ranging between 0 and 8 as well as between 9 and 16.

In village no. 7 with 141 participants, the highest participant group (80.85%, n = 114) had scores ranging between 25 and 32. The second highest participant group (13.48%, n = 19) had scores ranging between 17 and 24. The smallest participant group (0.00%, n = 0) had scores ranging between 0 and 8 as well as between 9 and 16.

In village no. 2 and village no. 7 with 277 participants, the highest participant group (77.26%, n = 214) had scores ranging between 25 and 32. The second highest participant group (14.44%, n = 40) had scores ranging between 17 and 24. The smallest participant group (0.00%, n = 0) had scores ranging between 0 and 8 as well as between 9 and 16. It seems that most participants behaved well with seismic risk perception because most participants had scores ranging between 25 and 32.

4.4.2 Demographic variables including building types and seismic risk perception scores

Demographic variables in this study consisted of sex, age, education levels, house ownership, time living in the present house, and income

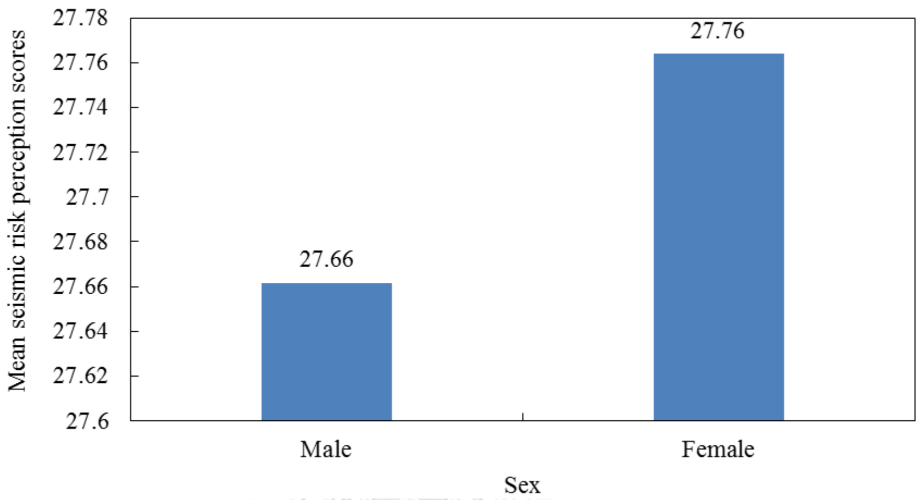


Figure 4.34 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by sex

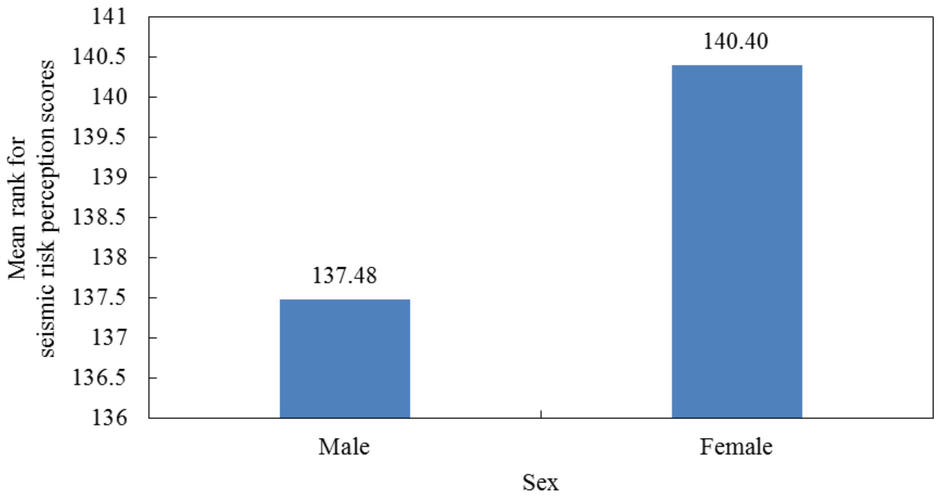


Figure 4.35 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by sex

As for seismic risk perception scores by sex, males had an average of 27.66, whereas females had an average of 27.76; therefore, males had lower mean than females (Figure 4.34). In addition, male had an average rank of 137.48 (n = 133, median = 28.00) whereas females had as an average rank of 140.40 (n = 144, median = 28.00) (Figure 4.35). According to the Mann-Whitney U test, it was found that there was not a statistically significant difference (U = 9374.50, p = 0.761 > α = 0.050) even though males had lower mean rank than females. It can be concluded that sex is not associated with seismic risk perception scores.

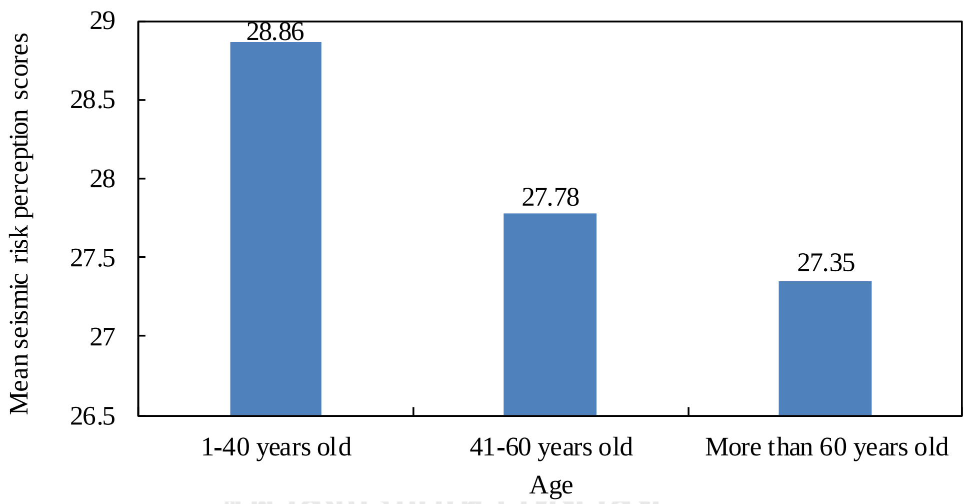


Figure 4.36 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by age

As for seismic risk perception scores by age, the highest group was participants having an average of 28.86 for 1 – 40 years old; the second highest group was participants having an average of 27.78 for 41 – 60 years old; and the smallest group was participants having an average of 27.35 for more than 60 years old (Figure 4.36).

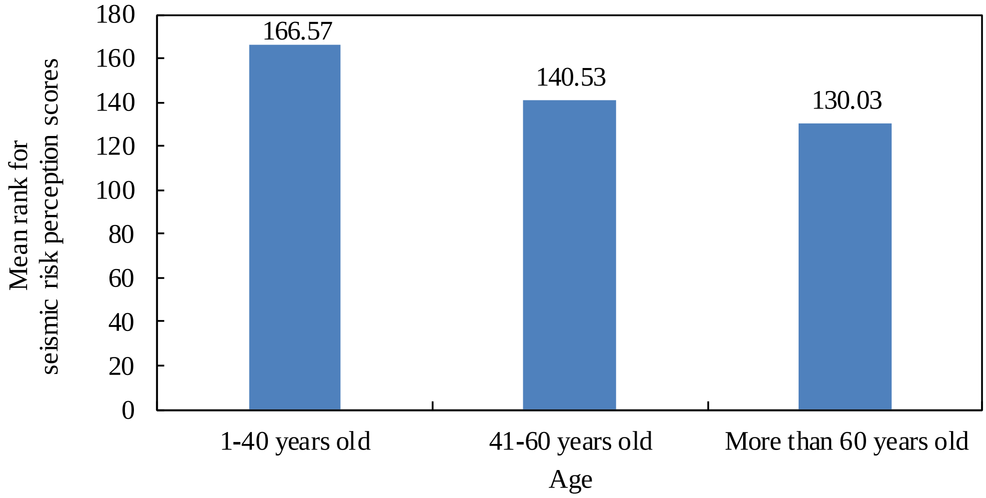


Figure 4.37 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by age

Figure 4.37 shows a mean rank of 166.57 (n = 22, median = 28.50) for 1 - 40 years old, a mean rank of 140.53 (n = 160, median = 28.00) for 41 – 60 years old, and a mean rank of 130.03 (n = 95, median = 27.00) for more than 60 years old. According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among age groups on seismic risk perception scores ($\chi^2(2)$ = 3.898, p = 0.142 > α = 0.050) even though participants having a mean rank of 166.57 for 1 - 40 years old were higher than participants having a mean rank of 140.53 for 41 – 60 years and participants having a mean rank of 130.03 for more than 60 years old. It can be concluded that age is not associated with seismic risk perception scores.

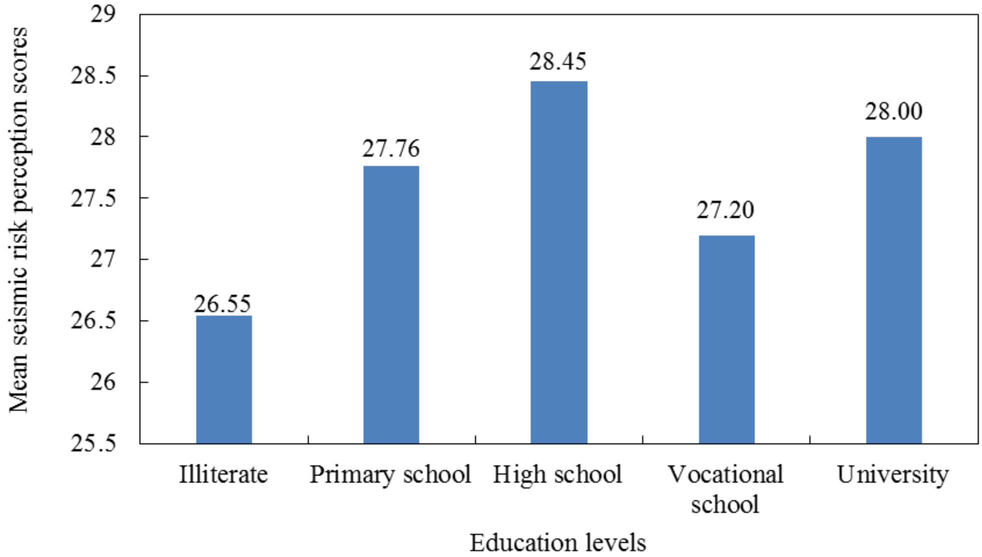


Figure 4.38 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by education levels

As for seismic risk perception scores by education levels, the smallest group was participants having an average of 26.55 for being illiterate; the second smallest group was participants having an average of 27.20 for completing vocational school; the highest group was participants having an average of 28.45 for completing high school; the second highest group participants having an average of 28.00 for completing university; and the third highest group participants had average of 27.76 for completing primary school. Therefore, participants having an average of 28.45 for completing high school were higher than participants having an average of 28.00 for completing university, participants had an average of 27.76 for completing primary school, participants having an average of 27.20 for completing vocational school, and participants having an average of 26.55 for being illiterate (Figure 4.38).

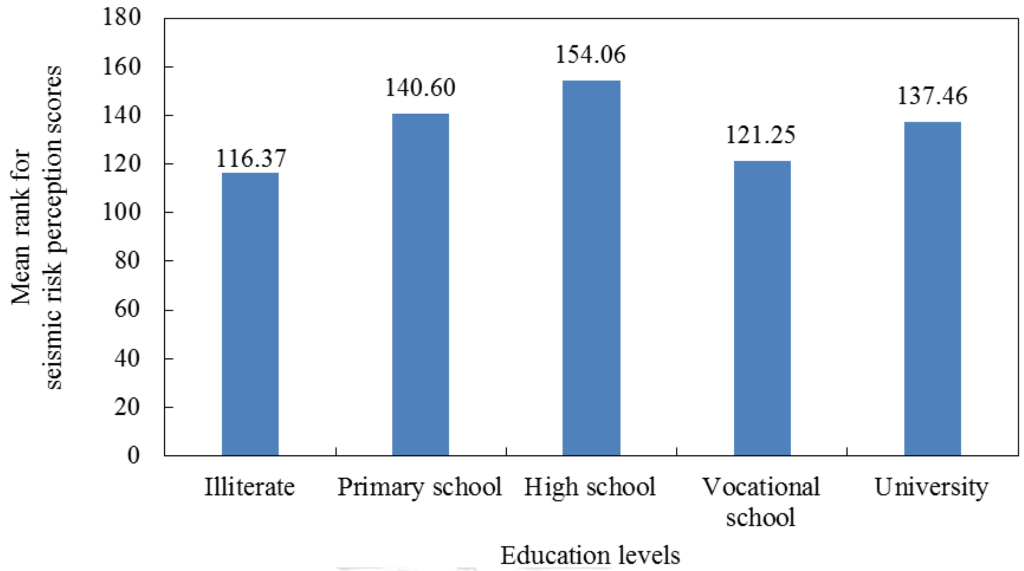


Figure 4.39 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by education levels

Figure 4.39 shows a mean rank of 116.37 (n = 31, median = 27.00) for being illiterate, a mean rank of 140.60 (n = 184, median = 28.00) for completing primary school, a mean rank of 154.06 (n = 40, median = 28.00) for completing high school, a mean rank of 121.25 (n = 10, median = 27.50) for completing vocational school, and a mean rank of 137.46 (n = 12, median = 27.50) for completing university. Therefore, participants having a mean rank of 154.06 for completing high school were higher than participants having a mean rank of 140.60 for completing primary school, participants having a mean rank of 137.46 for completing university, participants having a mean rank of 121.25 for completing vocational school, and participants having a mean rank of 116.37 for being illiterate. According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among education level groups on seismic risk perception scores ($\chi^2(4) = 4.507$, $p = 0.342 > \alpha = 0.050$). It can be concluded that education levels are not associated with seismic risk perception scores.

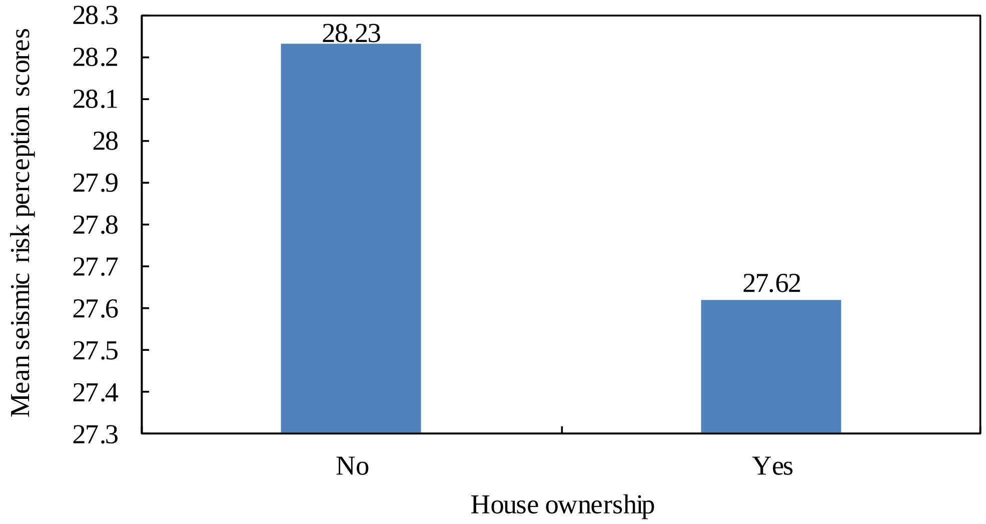


Figure 4.40 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by house ownership

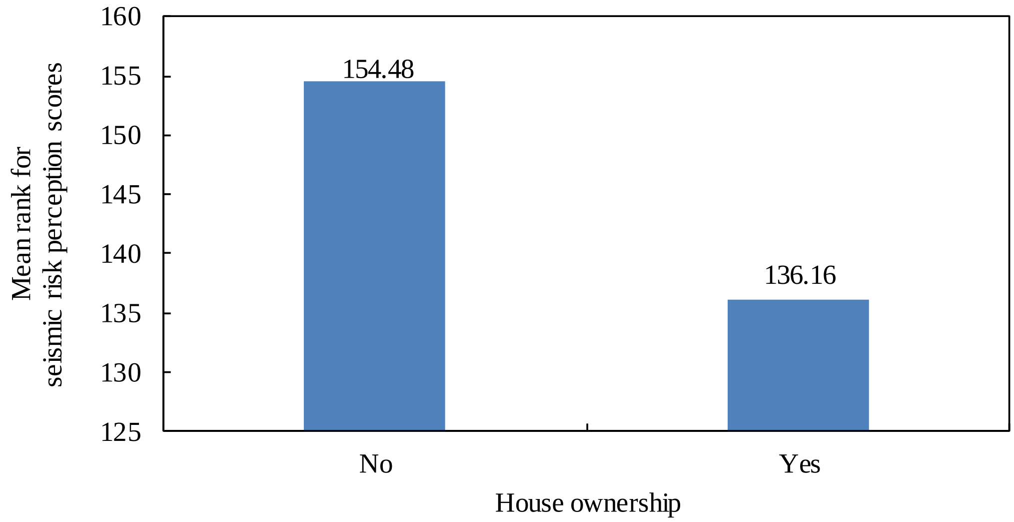


Figure 4.41 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by house ownership

As for seismic risk perception scores by house ownership, house ownership had an average of 27.62, whereas non house ownership had an average of 28.23; therefore, ownership had a lower mean than non house ownership (Figure 4.40).

In addition, house ownership had an average rank of 136.16 (n = 234, median = 27.50) whereas non house ownership had an average rank of 154.48 (n = 43, median = 28.00) (Figure 4.41), According to the Mann-Whitney U test, it was found that there was not a statistically significant difference (U = 4365.50, p = 0.166 > α = 0.050) even though house ownership had lower mean rank than non house ownership. It can be concluded that house ownership is not associated with seismic risk perception scores.

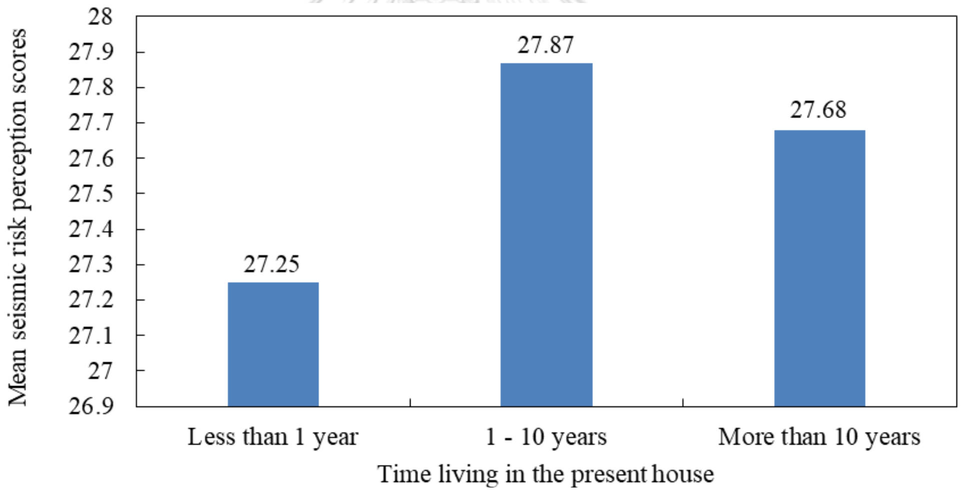


Figure 4.42 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by time living in the present house

As for seismic risk perception scores by time living in the present house, the largest group was participants having an average of 27.87 for time living in a present house between 1 and 10 years; the second highest group was participants having an average of 27.68 for time living in the present house more than 10 years; and the smallest group was participants having an average of 27.25 for time living in the present house less than 1 year. Therefore, participants having an average of 27.87 for time living in the present house between 1 and 10 year were higher participants having an average of 27.68 for time living in the present house more than 10 years; and participants having an average of 27.25 for time living in the present house less than 1 year (Figure 4.42).

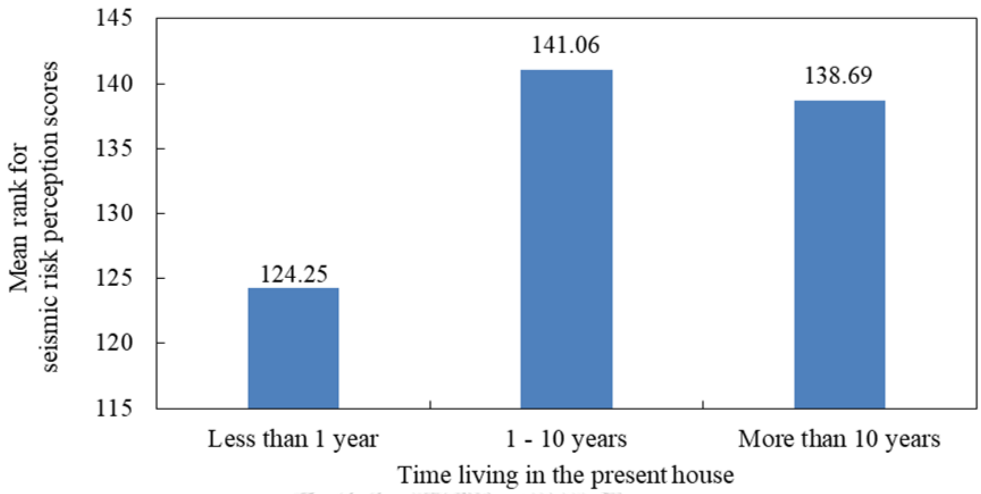


Figure 4.43 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by time living in the present house

Figure 4.43 shows a mean rank of 124.25 (n = 4, median = 27.00) for time living in the present house for less than 1 year, a mean rank of 141.06 (n = 61, median = 28.00) for time living in the present house between 1 and 10 years, a mean rank of 138.69 (n = 212, median = 28.00) for time living in the present house more than 10 years. That was, participants having a mean rank of 141.06 for time living in the present house between 1 and 10 years were higher than participants having a mean rank of 138.69 for time living in the present house more than 10 years, and participants having a mean rank of 124.25 for time living in the present house less than 1 year. According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among time living in present house groups on earthquake preparedness scores ($\chi^2(2) = 0.181$, $p = 0.913 > \alpha = 0.050$)

It can be concluded that time living in the present house is not associated with seismic risk perception scores.

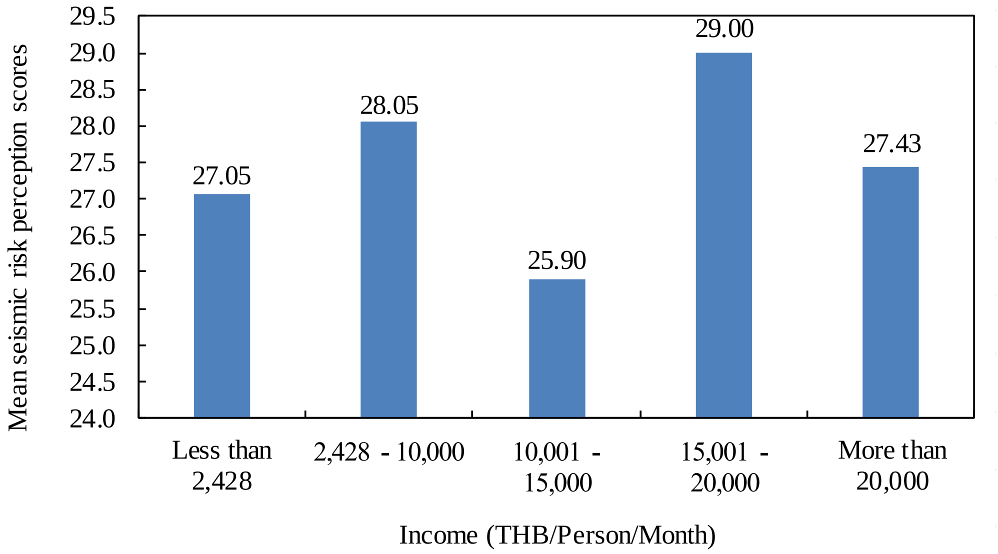


Figure 4.44 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by income

As for seismic risk perception scores by income, participants had an average of 27.05 for income less than 2,428 THB/Person/Month; participants had an average of 28.05 for income between 2,428 and 10,000 THB/Person/Month; participants had an average of 25.90 for income between 10,001 and 15,000 THB/Person/Month; participants had an average of 29.00 for income between 15,001 and 20,000 THB/Person/Month; and participants had an average of 27.43 for income more than 20,000 THB/Person/Month. Therefore, participants having an average of 25.90 for income between 10,001 and 15,000 THB/Person/Month were lower than participants having an average of 27.05 for income less than 2,428 THB/Person/Month, participants having an average of 27.43 for income more than 20,000 THB/Person/Month, participants having an average of 28.05 for income between 2,428 and 10,000 THB/Person/Month, and participants having an average of 29.00 for income between 15,001 and 20,000 THB/Person/Month, respectively (Figure 4.44).

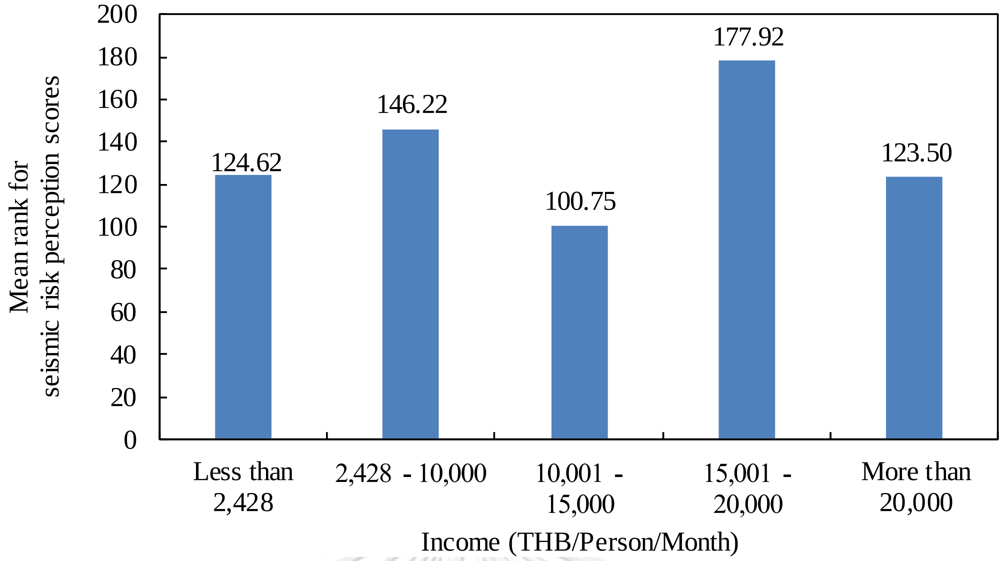


Figure 4.45 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by income

Figure 4.45 shows a mean rank of 124.62 (n = 73, median = 27.00) for income less than 2,428 THB/Person/Month, a mean rank of 146.22 (n = 181, median = 28.00) for income between 2,428 and 10,000 THB/Person/Month, a mean rank of 100.75 (n = 10, median = 26.50) for income between 10,001 and 15,000 THB/Person/Month; a mean rank of 177.92 (n = 6, median = 29.00) for income between 15,001 and 20,000 THB/Person/Month, and a mean rank of 123.50 (n = 7, median = 25.00) for more than 20,000 THB/Person/Month. Therefore, participants having a mean rank of 100.75 for income between 10,001 and 15,000 THB/Person/Month were less than participants having a mean rank of 123.50 for income more than 20,000 THB/Person/Month, participants having a mean rank of 124.62 for income less than 2,428 THB/Person/Month, participants having a mean rank of 146.22 for income between 2,428 and 10,000 THB/Person/Month, participants having a mean rank of 177.92 for income between 15,001 and 20,000 THB/Person/Month, respectively. According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among income groups on earthquake preparedness scores ($\chi^2(4) = 7.870$, $p = 0.096 >$

α = 0.050). It can be concluded that income is not associated with seismic risk perception scores.

As mentioned above, demographic variables and earthquake preparedness scores in this study indicate that sex, age, education levels, house ownership, income, and time living in the present house are not associated with seismic risk perception scores.

4.4.3 Building types and seismic risk perception scores

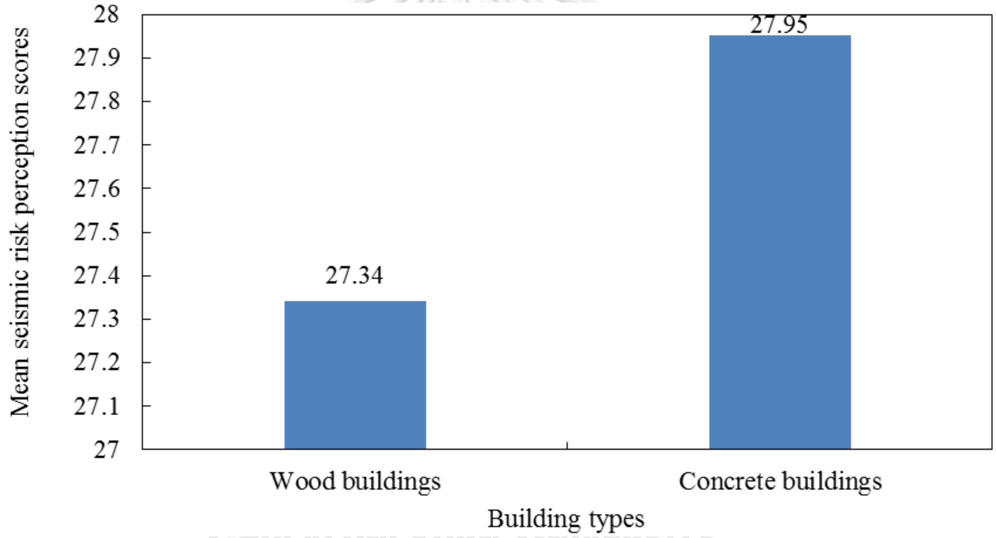


Figure 4.46 Mean seismic risk perception scores of 277 participants in village no. and village no. 7 by building types

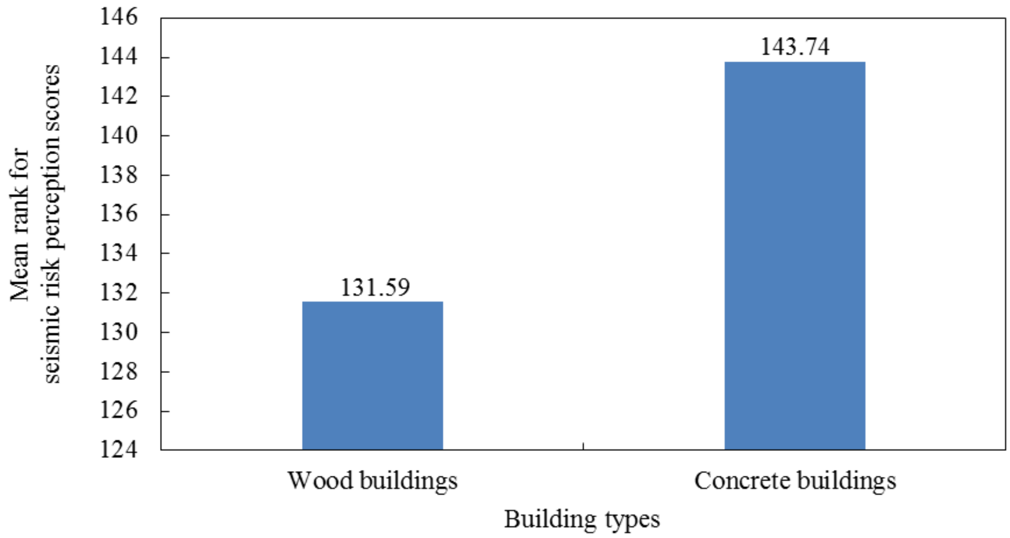


Figure 4.47 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by building types

As for seismic risk perception scores by building types, wood buildings had an average of 27.34, whereas concrete buildings had an average of 27.95; therefore, wood buildings had a lower mean than concrete buildings (Figure 4.46).

In addition, wood buildings had an average rank of 131.59 (n = 108, median = 27.00) whereas concrete buildings had an average rank of 143.74 (n = 169, median = 28.00) (Figure 4.47). According to the Mann-Whitney U test, it was found that there was not a statistically significant difference (U = 8,325.5, $p = 0.216 > \alpha = 0.050$) even though wood buildings had lower mean rank than concrete buildings. It can be concluded that building types are not associated with seismic risk perception scores.

4.4.4 Villages and seismic risk perception scores

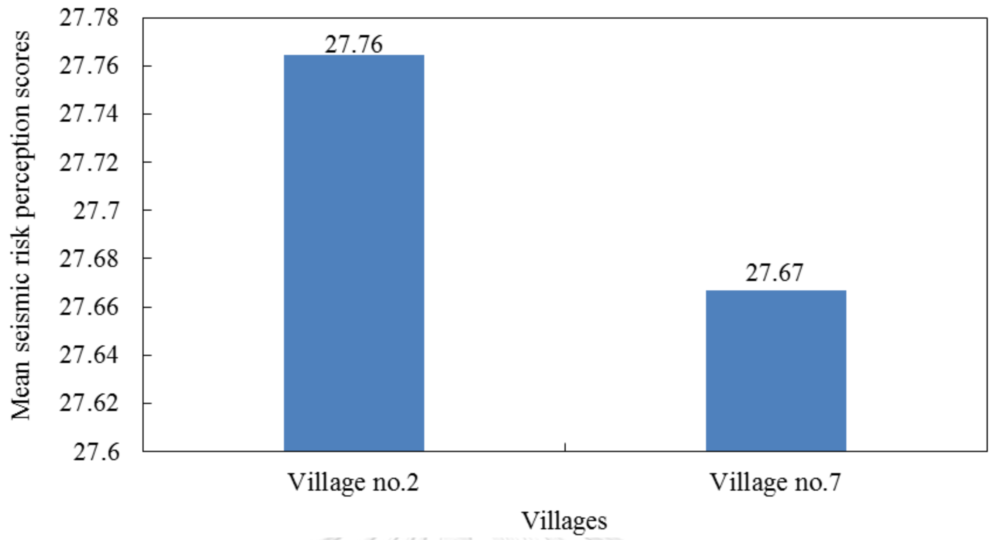


Figure 4.48 Mean seismic risk perception scores of 277 participants in village no. and village no. 7 by villages

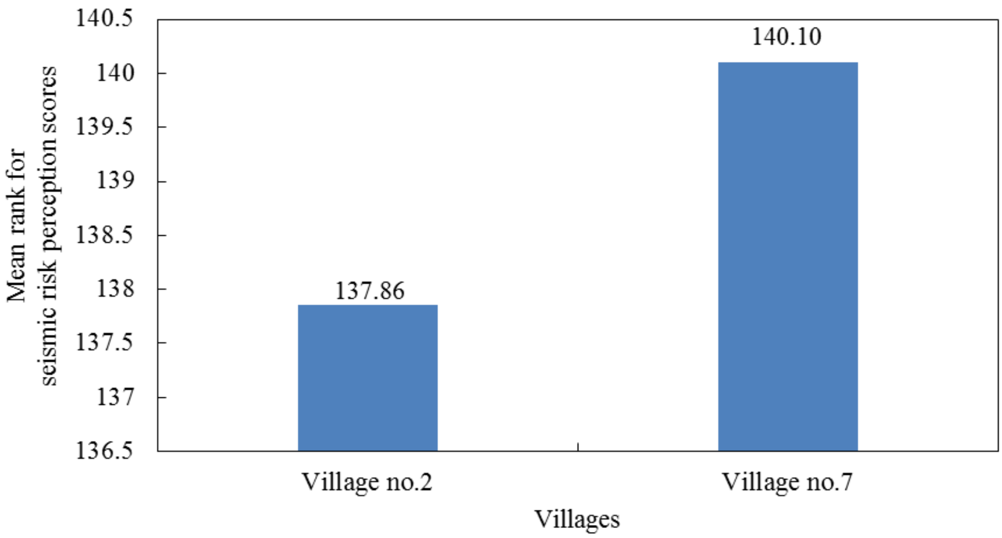


Figure 4.49 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by villages

As for seismic risk perception scores by villages, participants in village no. 2 had an average of 27.76, whereas participants in village no. 7 had an average of 27.67; therefore, participants in village no. 2 had higher mean than participants in village no. 7 (Figure 4.48). In addition, a participant group in village no. 2 had an average rank of 137.86 (n = 136, median = 28.00) whereas a participant group in village no. 7 had an average rank of 140.10 (n = 141, median = 28.00) (Figure 4.49). According to the Mann-Whitney U test, it was found that there was not a statistically significant difference (U = 9,433.00, p = 0.815 > α = 0.050) even though a participant group in village no. 2 had a lower mean rank than a participant group in village no. 7. It can be concluded that villages are not associated with seismic risk perception scores.

4.4.5 Poverty and seismic risk perception scores

Of 277 participants, 29.96 % (n = 83) had expenditure less than 2,428 THB/Person/Month that was below poverty line in Chiang Rai, meaning they were poor. 63.90% (n = 177) of 277 participants was the largest group of participants that spent between 2,428 and 10,000 THB/Person/Month (Figure 4.25).

As for seismic risk perception scores by expenditure, participants had an average of 27.12 for expenditure less than 2,428 THB/person/month; participants had an average of 28.09 for expenditure between 2,428 and 10,000 THB/person/month; participants had an average of 25.00 for expenditure between 10,001 and 15,000 THB/person/month; participants had an average of 28.60 for expenditure between 15,001 and 20,000 THB/person/month; participants had an average of 27.20 for expenditure more than 20,000 THB/person/month. Therefore, participants having an average of 25.00 for between 10,001 and 15,000 THB/Person/Month were lower than participants having an average of 27.12 for expenditure less than 2,428 THB/person/month; participants having an average of 27.20 for expenditure more than 20,000 THB/person/month; participants having an average of 28.09 for expenditure between 2,428 and 10,000 THB/person/month; and participants having an average of 28.60 for expenditure between 15,001 and 20,000 THB/Person/Month (Figure 4.50).

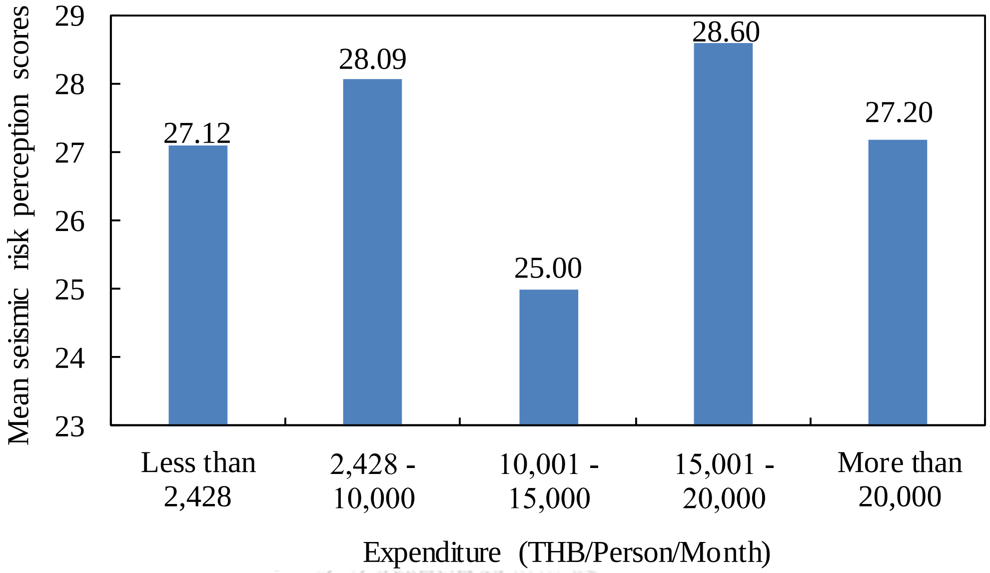


Figure 4.50 Mean seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by expenditure

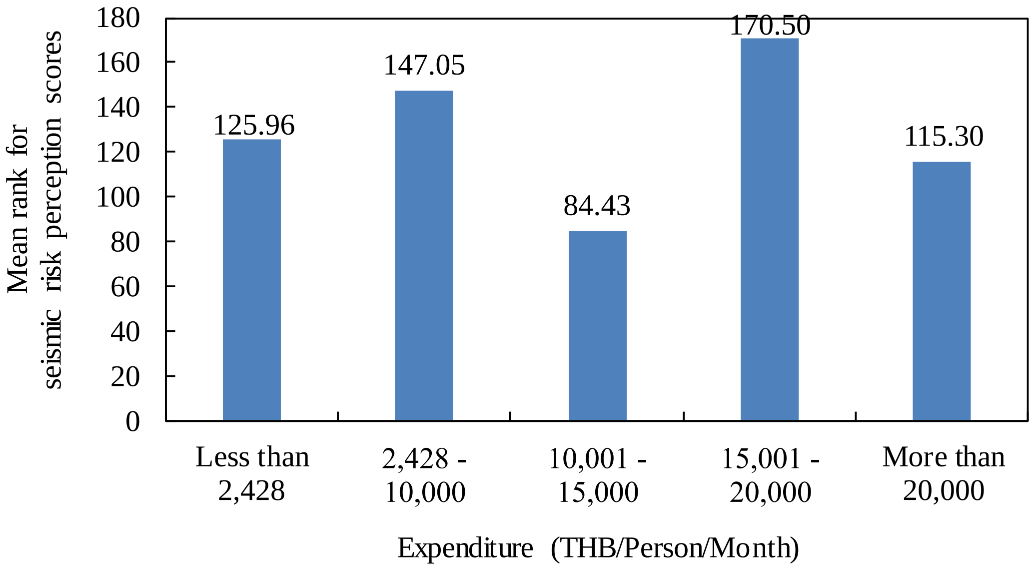


Figure 4.51 Mean rank for seismic risk perception scores of 277 participants in village no. 2 and village no. 7 by expenditure

Figure 4.51 shows a mean rank of 125.96 (n = 83, median = 27.00) for expenditure less than 2,428 THB/Person/Month, a mean rank of 147.05 (n = 177, median = 28.00) for expenditure between 2,428 and 10,000 THB/Person/Month, a mean rank of 84.43 (n = 7, median = 25.00) for expenditure between 10,001 and 15,000 THB/Person/Month; a mean rank of 170.50 (n = 5, median = 29.00) for expenditure between 15,001 and 20,000 THB/Person/Month; and a mean rank of 115.30 (n = 5, median = 25.00) for expenditure more than 20,000 THB/Person/Month. According to the Kruskal-Wallis test, it was found that there were not statistically significant differences among expenditure groups on seismic risk perception scores by expenditure ($\chi^2(4) = 7.870$, $p = 0.074 > \alpha = 0.050$).

It can be concluded that expenditure is not associated with seismic risk perception scores.

4.5 Framing type of building damage affecting people's seismic risk perception

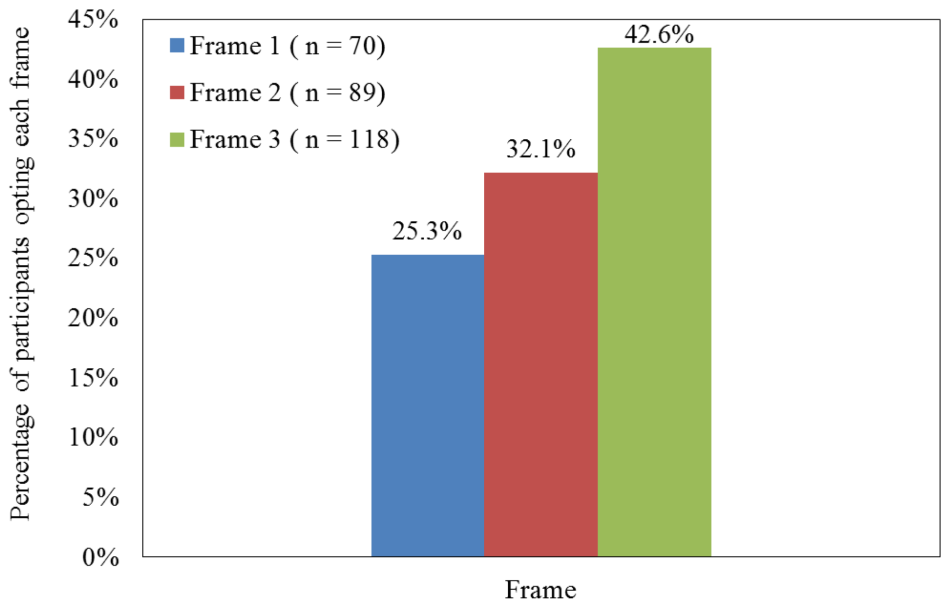


Figure 4.52 Percentage of participants opting Frame 1, Frame 2, and Frame 3

Each of 277 respondents selected the highest risk frame in their opinion. The percentage of participants selected each frame as can be seen in Figure 4.52.

Figure 4.52 shows the following three frames:

1. 25.3% (n = 70) of 277 participants opted for Frame 1 (475 severely-damaged private buildings existing once every 500 years).

2. 32.1% (n = 89) of 277 participants opted for Frame 2 (475 severely-damaged private buildings existing 10% chance in 50 years).

3. 42.6% (n = 118) of 277 participants opted for Frame 3 (one severely-damaged private building per year).

It can be seen that Frame 3 had the highest percentage of frames. Frame 2 was the second highest percentage of frames, and Frame 1 was the smallest percentage of frames. The data were analyzed by chi-square. It was found that there was a statistical significance ($\chi^2(2) = 12.657$, $p < 0.05$). The result showed that different frames were influential to differently perceived earthquake risk even if the frames were similar. These findings may infer that earthquake risk can be described by using frame in a crucial way. Frame 3 chosen by participants represents the highest risk among Frame 1, Frame 2, and Frame 3 since they thought that it is likely to be Frame 3. The average risk of severely-damaged private buildings per year was the one existing closely to the future, causing people to view with the highest perception among Frame 1, Frame 2, and Frame 3. Therefore, the importance of time frames can be used to describe earthquake risk.

In this study, a 50-year time frame and a 500-year time frame were judged as out of a lifetime, and the judged risk probability is greater at the end of the time frame than the others. However, people's earthquake risk perception was greater in a year's time frame than both a 50-year time frame and a 500-year time frame. This is consistent with the results found in other studies (Chandran & Menon 2004; Gerend & Cullen 2008; Shaklee & Fischhoff 1990).

With limited framing types of building damage covered in this study, the return period in this study was 10% in 50 years or around 500 years for three frames. It shows that within 500 years, the big earthquake existed. On the basis of severely-damaged private building frequencies within a time frame, there were three frames. Agencies or governments should choose Frame 3 in order to communicate in seismic risk regions because Frame 3 was chosen by participants as the highest risk among Frame 1, Frame 2, and Frame 3.

CHAPTER 5
CONCLUSIONS

The study can be concluded as follows:

(1) Result from examining relationship between variables (village, year built, and building types) and structural damage levels

Distance between the epicenter and the location of the building was associated with structural damage levels, while the year built was not associated with structural damage levels. There were causes of structural damage levels. For example, first, buildings tended to be more completely damaged near the epicenter than far from the epicenter since the epicenter location had the higher strength of the tremors than other locations further from the epicenter. Second, the seismic codes were both not enforced and did not cover the construction of many buildings. For instance, inadequate reinforcement appeared in construction of reinforced concrete (RC) buildings with unreinforced masonry infill walls. As a result, the earthquake resistance of the buildings was inadequate. Third, at extensive and complete damage levels, wood buildings were less damaged than RC buildings with unreinforced masonry infill walls because they were lighter and more flexible.

Reduction in building damage can be conducted as follows: Retrofitting buildings and/or new construction must strictly follow seismic codes; for example, RC buildings with unreinforced masonry infill walls must have sufficient reinforcement and high-quality materials in order to enhance earthquake resistance; a site engineer must control the construction by following seismic codes and construct precisely thereon; proper funds or low interest loans advocated by government should be given to people so they may construct new buildings and/or retrofit buildings for earthquake resistance in the present and future; and people in seismic risk zones should resettle. Nevertheless, in new buildings that are built, more wood buildings than RC buildings with unreinforced masonry infill walls should be constructed due to their lighter weight and flexibility.

(2) The result from investigating the relationships between factors (seminars, casualties, and earthquake experience of May 5, 2014) and preparedness for behavior during earthquakes in the future:

Casualties and earthquake experience from May 5, 2014 did not affect preparedness for behavior during earthquakes in the future because of the few casualties (one death and five injuries). In contrast, seminars affected preparedness for behavior during earthquakes in the future since seminars may develop how to behave during earthquakes in the future. Seminar programs may reduce injuries and deaths in seismic risk zones and increase preparation and awareness for earthquake risk reduction. In another method, people in seismic risk zones could resettle to external seismic zones far from the epicenter.

From (1) and (2), overall, giving earthquake education by seminars, preparation for earthquakes, and strengthening buildings with the seismic provisions is likely to decrease earthquake risk.

(3) Earthquake preparedness in Chiang Rai

Sex, age, education levels, house ownership, and income were associated with earthquake preparedness. However, time living in the present house and villages of residency are not associated with earthquake preparedness.

As for earthquake preparedness scores with score intervals, it seems that 67.87% of 277 participants behaved with bad preparedness or low preparedness because most participants had scores ranging between 7 and 12 from full scores that were 31.

As for earthquake preparedness scores by expenditure, about 30 % of 277 participants had a mean rank of 109.14 and would be considered poor since their expenditure that was less than 2,428 THB was below poverty line in Chiang Rai, while others were not poor because their expenditure was higher than 2,428 THB/person/month. Furthermore, 63.9 % of 277 participants were the largest participant group having a mean rank of 152.58 for expenditure between 2,428 and 10,000 THB/person/month. Expenditure between 2,428 and 10,000 THB/Person/Month group shows that they were not poor, but they were nearly poor since this group was above expenditure less than 2,428 THB/Person/Month group slightly.

Overall, most participants show low preparedness since the majorities are of low socio-economic status.

(4) Seismic risk perception in Chiang Rai

Sex, age, education levels, house ownership, income, and time living in the present house were not associated with seismic risk perception.

As for seismic risk perception scores with score intervals, it seems that 77.26% of 277 participants were the bulk of participants behaving well with seismic risk perception because most participants had scores ranging between 25 and 32 from full scores that were 40.

As for seismic risk perception scores by expenditure, about 30 % of 277 participants had a mean rank are considered to be poor since their expenditure that was less than 2,428 THB which was below the poverty line in Chiang Rai, while the others were not poor because their expenditure was higher than 2,428 THB/person/month. Furthermore, 63.9 % of 277 participants were most participant group having a mean rank of 147.05 for expenditure between 2,428 and 10,000 THB/person/month, Expenditure between 2,428 and 10,000 THB/Person/Month group indicates that they are not poor, but they are nearly poor since this group is above expenditure only by 2,428 THB/Person/Month group slightly.

Seismic risk perception in this study was gauged with eight statements, which were general statements as follows; "I think that my district has a lower safe from earthquake risk than other districts", "I think that my district has a higher earthquake risk than other districts", and "Future earthquakes affecting injuries and deaths" because these three statements that people judged had a higher mean than other statements. Thus, these three statements were commonly suitable statements to communicate seismic risk perception.

Overall, most participants behaved well with seismic risk perception although most of them had nearly poor socio-economic status.

From (3) and (4), overall, most participants behaved well with seismic risk perception although most of them had low socio-economic status. It may because they lived near the epicenter, while most participants behaved with low preparedness. This may be because 63.9 % of all participants were considered nearly poor, and one-third of all participants were poor; thus, they lack money for earthquake preparedness. It can be concluded that socio-economic status affects earthquake preparedness but does not affect seismic risk perception. People's earthquake risk judgment depends on types of statements. Agencies or governments could effectively communicate suitable statements to the population in earthquake areas.

(5) People's earthquake risk judgment depends on framing. Agencies or governments could effectively communicate by framing to the population in earthquake areas for earthquake preparedness in the future. A one year time frame would lead to higher perceived earthquake risk compared with a 50-year or 500-year time frame because an earthquake takes place once every year on average and is in life expectancy.

From (5), overall, people may have more earthquake preparedness when they perceive earthquake data by the suitable framing (e.g. a short time frame).

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APPENDIX

The questionnaire was used to interview participants and survey structures at village no. 2 and no. 7 of Dong Mada that is a sub-district at Mae Lao district in Chiang Rai

Table A1 Demographic and socio-economic data

Address no. ____________________ 1. Sex ☐ Male ☐ Female
2. Age (years) ☐ 1 - 40 ☐ 41 - 60 ☐ More than 61
3. Education level ☐ Illiterate ☐ Primary school ☐ High school ☐ Vocational school ☐ University
4. House ownership ☐ No ☐ Yes
5. Time living in a present house ☐ Less than 1 years ☐ 1 - 10 years old ☐ More than10 years
6. Income (THB/Person/Month) ☐ Less than 2,428 ☐ 2,428 - 10,000 ☐ 10,001 - 15,000 ☐ 15,001 - 20,000 ☐ More than 20,000

7. Expenditure (THB/Person/Month) ☐ Less than 2,428 ☐ 2,428 - 10,000 ☐ 10,001 - 15,000 ☐ 15,001 - 20,000 ☐ More than 20,000

Table A2 Building data

1. Village	☐ no.2 ☐ no.7 ☐ no.___
2. Year built	☐ before 1997 ☐ after 1997
3. Building types	☐ Wood ☐ Reinforced concrete with unreinforced masonry infill walls ☐ ______________________________
4. Structural damage levels ☐ No damage ☐ Slight damage ☐ Moderate damage ☐ Extensive damage ☐ Complete damage	

Table A3 variable data (seminars, casualties, and experience earthquake on May 5, 2014) and preparedness about behavior during earthquake in the future

1. Preparedness about behavior during future earthquakes ☐ Never ☐ Low ☐ Moderate ☐ High ☐ Very high			
2. Casualties	Injuries	☐ No: 0	☐ Yes: ______
	Deaths	☐ No: 0	☐ Yes: ______
3. Seminar	☐ No participation	☐ Participation	

4. Experience Earthquake on May 5, 2014

☐ No ☐ Yes

Table A5 Seismic risk perception

1. Seismic risk perception

1.1 severity of future earthquakes

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.2 fear of future earthquakes

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.3 future earthquakes affecting family

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.4 future earthquakes affecting property damage

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.5 future earthquakes affecting injuries and deaths

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.6 I think that my district had a higher earthquake risk than other districts

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.7 I think that my district had a lower safe from earthquake risk than other districts

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

1.8 I think that my house can resist earthquakes

☐ Very low ☐ Low ☐ Moderate ☐ High ☐ Very high

Because ______________________________

Table A6 Earthquake preparedness before and after earthquakes in the future

1. Earthquake preparedness before earthquakes in the future consisting of items 1-25 (Please select by ticking either No or Yes for earthquake preparedness)

1 Have a first aid kit	☐ No	☐ Yes
2 Have a food	☐ No	☐ Yes
3 Have drinking water	☐ No	☐ Yes
4 Have a torch	☐ No	☐ Yes
5 Have extra batteries for a torch	☐ No	☐ Yes
6 Have a map	☐ No	☐ Yes
7 Have a whistle	☐ No	☐ Yes
8 Have money	☐ No	☐ Yes
9 Have a deposit account	☐ No	☐ Yes
10 Have a blanket	☐ No	☐ Yes

11 Have gloves ☐ No ☐ Yes

12 Have protective mask ☐ No ☐ Yes

13 Have wet tissue ☐ No ☐ Yes

14 Have a fire extinguisher at house ☐ No ☐ Yes

15 Have a mobile phone ☐ No ☐ Yes

16 Know the location of the gas cut off and how to turn off it

☐ No ☐ Yes

17 Know the location of the circuit-breaker and how to turn off it

☐ No ☐ Yes

18 Know the location of the water cut off and how to turn off it

☐ No ☐ Yes

19 Have nostrums ☐ No ☐ Yes

20 Have plastic bags and tissue paper

☐ No ☐ Yes

21 Keep pesticides and flammable materials in locked cabinets including placing on bottom shelves ☐ No ☐ Yes

22 Have emergency phone numbers ☐ No ☐ Yes

23 Remove heavy furniture from sleeping regions

☐ No ☐ Yes

24 Install heavy furniture to walls ☐ No ☐ Yes

25. Strengthening the house to increase earthquake resistance

☐ No ☐ Yes

2. Earthquake preparedness after earthquakes in the future consisting of items 26 - 31 (Please select by ticking either No or Yes for earthquake preparedness)

26 Plan how to behave after earthquakes

☐ No ☐ Yes

27 Know how to first aid

☐ No ☐ Yes

28 Stay away from the earthquake regions

☐ No ☐ Yes

29 Examine for leaks of gas after earthquakes

☐ No ☐ Yes

30 Examine for electrical damage after earthquakes

☐ No ☐ Yes

31 Examine for water and sewage pipe damage after earthquakes

☐ No ☐ Yes

Table A7 Framing type of building damage affecting people's seismic risk perception

1. I think that my one choice selected has the most critical risk from an earthquake

☐ An earthquake happening once within 500 years on average caused 475 severe-damage private buildings

☐ There was 10% chance in 50 years that 475 severe-damage private buildings occurred

☐ The average risk of severe-damage private buildings per year was one

VITA

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