

Post Earthquake Structural House Strengthening Using Appropriate Strategies; A Study of Sai Khao, Amphoe Phan at Chiang Rai

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Abstract— Post earthquake aids in Thailand, especially in countryside areas, may not be suitable for house structure strengthening by providing budget, construction material, and labor, including correct knowledge of structural housing engineering to resist earthquakes. Thus, the working system plan and standard has been designed to adapt to the local strategy for appropriate coping with insufficient funding situation and improper understanding of the problems for residents in Sai Khao, Amphoe Phan, Chiang Rai. The researchers selected this area because they have experienced and suffered from earthquakes, and they can set a precedence for other risk areas. There are 13 participants in Sai Khao willing to apply this strategy from agreement in the local conference. The information was collected on November 2016, and it has influenced the inclusion into the local policy in 2017 by using assisted factors and criteria. From the result, most houses in this area are non-engineered structures due to their low income affecting their housing budget and utilization of materials under the standards. Moreover, post-disaster aid from May 2012 only helped to recover the appearance of the buildings, with no focus on structural reinforcement; the divided budget was inadequate to strengthen their houses. Practical application of this strategy can increase the efficiency of local aid and help set an example on proper disaster management for other risk areas in the future.

Index Terms—House Strengthening, Post Earthquake Strategies, Local Policy, Reinforce Structural House

I. INTRODUCTION

[1]. For the last decade, disasters around the world have a noticeable impact on both developed and developing countries in different ways. It is also notable that more than 90% of all disasters are related to the climate, almost half of insurance damage are caused by geological disasters, especially by the major earthquakes. Between 1980 and 2011, it is estimated that there were more than 2.3 million people killed by disasters. 48%

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of these deaths were from low-income countries, which suffered from only 6% of total occurrences of disasters. On the other hand, high-income countries suffered less deaths but was hit significantly harder by the economic damage. For example, the 2010 Haiti earthquake caused around 230,000 deaths and \$7.8 million in damage, while the 2011 Japan earthquake caused 20,000 deaths and \$210 million in damage. However, the global occurrences of disasters have shown that they can also leave an impact on developed countries. Even though the numbers of deaths and injuries are lower than developing countries, the economic damage can be disastrous.

Thailand, like other countries, faces the risk of occurring disasters. According to the information from Thai Meteorological Department, there have been several types of disasters that happened since the past to the present, such as tropical cyclones, rainstorms, thunderstorms, storm surges, landslides, floods, draught, wildfires and smoke, earthquakes, and tsunami. These occurs in different regions of the country during different months. For earthquakes, there are risk on all months, and the areas of risk are in the Northern and Western regions. Because various disasters occurs in every region of Thailand, the citizens should be prepared to deal with the possible disasters in their area, and help take part in reducing the impact of such risk for themselves and the community. Earthquake disaster is an unpredictable natural hazard and have increased for the last 40 to 50 years. Moreover, [2]. the earthquake is the highest of human loss.



Fig 1. Surveying the damaged houses



Fig 2. Non-Structural Houses

On May 5, 2012, an earthquake of 6.3 M magnitude and the epicenter was around Sai Khao of Amphoe Phan at Chiang Rai which 7 km depth because of the strike-slip fault called Phra Yao fault. The local people experienced aftershock more than 700 times and spread to Amphoe Mae Suai, Amphoe Mae Lao including Amphoe Mueang Chiang Rai. Therefore, this earthquake is the most extreme earthquake in 50 to 100 years in Thailand and has damaged to non-engineered building more than 10,000 houses and severe cases over 400 houses.



Fig 3. Repairing Houses

At present, most of houses have repaired but still be weak and able to fail as Fig 3 in case the earthquake occur again. The public sectors and government like the Community Organizations Development Institute (CODI) rescued them to recover the construction by budget and volunteer. In the other hand, this supporting was just make them to be the same but does not be better efficiency. Otherwise, some of process and budget were not enough to build for higher resistant and safety. In the developed country as Japan, they have a policy and law for reconstruction of people house to be stronger. Therefore, we should adapted and apply the suitable strategy to risk area of earthquake in Thailand especially at Sai Khao, Amphoe Phan at Chiang Rai for local development and structural house safety. Adaptation and designing the policy including strategy can be a standard and adequate system which aid the community with both satisfaction.

II. LITERATURE REVIEW

A. Strategy

[3]. Strategies to increase social resilience can describes by reinforcement of building and infrastructure, risk communication, community development, development of a business continuity plan (BCP), economic growth and land-use changes. There are just the basic strategies for establishing a resilient society post-disaster. The International Strategy for Disaster Reduction recommends the strengthening of a range of actions such as legislation, covering land use regulation, building codes and links to environmental protection. The ISDR. also suggests the adoption of comprehensive urban development strategies and land use plans with local governments playing a role with regard to components such as building standards, land and property markets, land and housing taxation, planning processes and infrastructure construction and management. The suitable strategy will be the base to develop the local community that depends on the culture and society in each area. Thus, the standard should be appropriate and clear to understand in terms of villagers 'perspectives.

B. Damage and Recovery

An illustration of the damage caused by this earthquake can describe a society as a five-storied pagoda [4]. consists of natural environment at the first storey. It is assumed that second storey is social schemes, culture and conventions, such as the administrative system or local community systems. It is then assumed that the third storey consists of infrastructures. Building environment and land use are assumed to be the fourth storey. Finally, our daily life is found at the top of the pagoda, as this shared "communal life" builds upon all four of the previous stories as Fig 4.

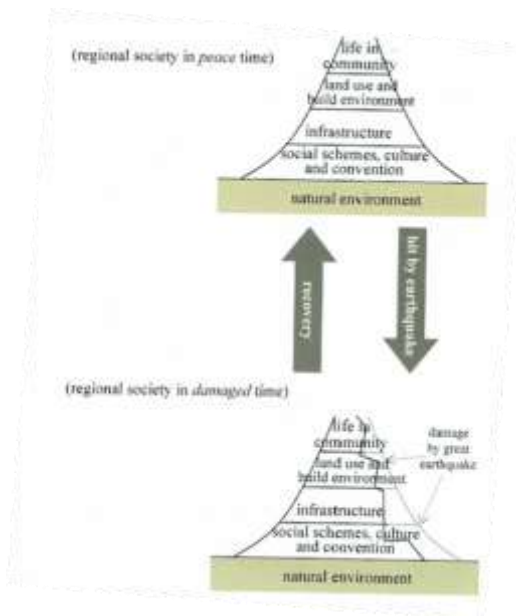


Fig 4. Damage of the recovery from earthquake using the model of a five-storied pagoda

C. Assisted Factors

When the building was failed or damaged, they must need to consider by interview for the satisfaction. The construction detail is as significant as the house’s owner mind about safety after repairing. In addition, there are many factors that affects to the helpful aids decision for example revenue of family’s members, damages of a house, structural house, poverty recording, financial availability, effective cost and house prize. And we can collect this information from surveying with the local leader of Tamboon Sai Kaow.

D. Non-Engineered Housing

[5]. Building that are constructed using traditional and indigenous techniques, without any or little involvement of qualified architects and engineers, can be considered as non-engineered buildings.

Most of the damaged houses caused by non-engineered because the villagers have a low income, so they build their houses by limited budget and unknown about correct resistant houses which can fail if the earthquake happen again as Fig 2.

III. METHODOLOGY

The team divided the procedure to be 2 parts which are Surveying for making the strategies and Operating to utilize them in this area by procedures as following;



Fig 5. The first Procedure for Survey

The period of surveying is between November 1 – 6, 2017 that was a few years after the 6.3 magnitude occurred. Therefore, the information of this time should be no bias. In the addition, November 2, 2017 at 3.16 am, the local people have experienced the earthquake again with 3.6 M and the epicenter is Amphoe Mae Suai where not far from the target area.

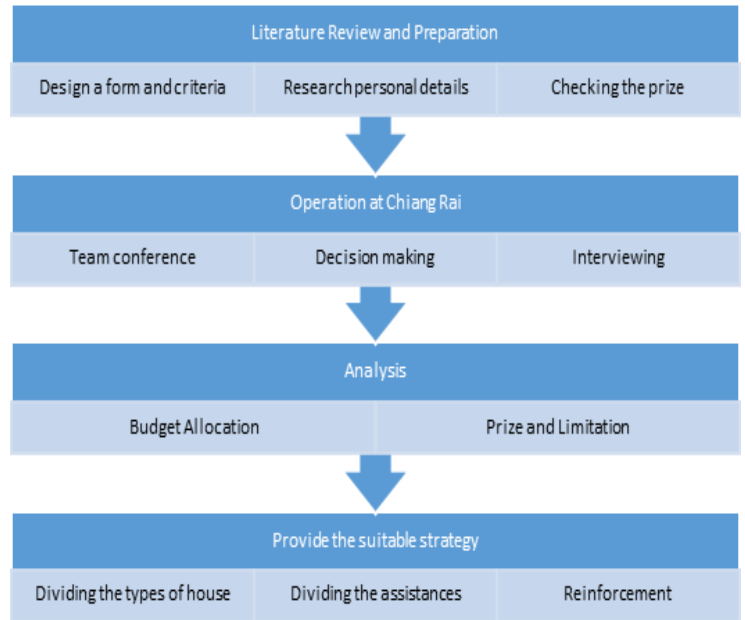


Fig 6. The second procedure for Strategy Utilization

For proper organization, we created the system work of this program to utilize with them. The systems consists of Details, Recruitment, The Selecting Criteria, Inspection, Aids, Contract, Operation or Application, Monitoring and Assessment.

A. Details

Post Earthquake Repairing and Strengthening Aid Project is for citizens in Tamboon Sai Khao, Amphoe Phan, Chiang Rai at first and has the purpose to increase the capability of self-protection of both lives and assets in the event of another earthquake. They need the cooperating from local sector, volunteers, education institutions, and the house’s owner. In term of the restriction, the project cannot fund the full cost of repairing for every household, and the repair is not done with beauty in mind, as it is only intended to reinforce the structural integrity and make the house safe to live in. The budget for the aid depends on the prior structure, the amount of damage, and the decision from the educational committee and local sector’s leader.

B. Recruitment

Public Relation about the project aid of team was expanded by the local representatives. The villagers can participate this project by notifying at the Sai Khao department for more information about criteria or correct detail. After checking, the participant property and details, they can also follow up at the Sai Khao Department. Both pass and no-pass participants can get the educational information about reinforcement of their houses even they did not receive the funding from the local sector or receive for some funding which the final decision of the committee have decided.

C. The Selecting Criteria

The participants are the residents who live in Tamboon Sai Kaow and live in the risk or suffered zone in Chiang Rai. They mostly live in the house after earthquake. If no aid from the private sector or local sector, they will be considered at first. In case got some aid from local sector, may be considered by Sai

Khao comitee. Moreover, they have to be good behavior in community and country. The name is on the poverty recording will be also considered at first. The decision of the local leader and committee under the assisted factors.

D. Inspection

The committee will defined the old house's cost by using standard costs of construction 2016 from Thai Appraisal Foundation and the approximate cost of repairing and reinforcement by Damage Checking, Repairing and Reinforcement and Estimating.

The damage checking will be concentrated on column, base, beam, joint, floor, wall, ceiling and roof including mirror and window. The providing budget will support only column, beam, wall and ceiling and roof because they have to be stronger to withstand the earthquake for human safety.

The methods of repair [6]. are applied to columns, beams, walls, ceilings, and roofs, depending on the severity of the faults by following;

1. Cover the crack with non-shrink concrete, cement grout, or shotcrete
2. Cover the crack with epoxy resin
3. Reinforce with reinforcing steel in the structure
4. Reinforce with other structural member as permanent support
5. Support the structure with structural steel, cut out the damaged area, reinforce with steel, and pour concrete again
6. Demolish and rebuild

The estimating of construction materials and labor, we utilized the latest version of local average material including the Comptroller General's Department. The approximately cost supposed to relate with the reinforcement under the damage which we can calculate from the interview form.

E. Aids

In term of typing, we help by budget for the construction, including worker wages and building materials used for the repair. This depends on the evaluation of the severity of the damage and the methods used for the repair. The next is material support that may be supplied from sponsors from private organizations, which will reduce the budget cost. As a Labor besides from hiring workers, there are charities with volunteers to help with building and repairing, which will reduce the budget cost. The last one is the engineering repair guidelines that the committee will give information on repairing methods for the participants who couldn't afford to repair at the moment, be it because the lack of fund or not meeting the requirements.

The Limitation of the prize has adapted from Thai Natural Disaster Law which be able to support not over 100,000 baht and consider by real damage and repairing including reinforcements. The rest of over fiscal, the house's owner have to pay by themselves. As a results of Amphoe Mae Lao [7] at Chiangrai ; The average of strengthening cost is around 19,000 baht (range of 10,001 – 30,000 baht). Tthe raw data can conclude that the mostly house prize is around 100,000 baht.

From the consideration, most of house prize range under 100,000 baht have a repairing cost between 30-50 %, and the house prize range more than 100,000 baht have the less repairing cost which is only 5 – 15 % or depend on the individual damage. In term of some aid participants, the committee will consider the repairing cost under the most

effective; the house prize which is lower than 100,000 baht, the repairing should be around 10 % or not over 15 % maximum by the local decision; the house prize which is higher than 100,000 baht, the repairing should be less than 40 % or not over 60 % mostly agreement in conference of local sector and team. The calculated prize base on local construction which is lower than in the city around 30 % and will be considered only the structural part of the house.

F. Contract

After the decision of committee, the participant who be selected will be notified and they supposed to have the willingness to reinforce their house. In term of documents, the agreements of funding source and the participants need to make a contract to prevent the trouble when they repair or reinforce the owner's house

G. Operation or Application

When the reinforcement start to work, it needs the cooperation from several; Sai Khao Department, the local Leaders, Modchanaphai Foundation, the participants in local area, sponsors in term of some material, volunteers and Educational team (Coordinator, Engineer, Architecture and Professor). From this step, this paper is not including.

H. Monitoring and Assessment

After operated, it is necessary to make a report for assessment for example the engineering structural house, satisfaction, suggestion etc. This step can be a suggestion for future projects. Over all, the strategy can be motivate to other area for development and reducing unfair helping system in Thailand.



Fig 7. The committee conference and surveying

IV. RESULTS

This system work and strategies already have utilized at Tamboon Sai Kaow, Chiang Rai which risk and affected the earthquake disaster and appeared the results as;

There have 13 participants to attend this program. Most of them are in poverty record and unable to support the structural reinforcement by their finance. Four of them need to rebuild all of construction because their houses are non-engineered construction and can be damaged severely that will affect to the residents in the house. Moreover, 12 of 13 houses were built

under 100,000 baht and use very light weight materials that may not withstand the great earthquake or extreme storm. The repairing and reinforcement comparing to limitation of standard, they are under the criteria that we have design in the system work. In addition, the houses are lower the standard in term of material and engineered structure. Some participants have received the primary aid by budget and some material but it is not enough to reinforce their house.

Over all, the local sector has accepted this system work and push forward to operate in other area in Chiang Rai also. They are progressing to help their people for reinforcement and adding more engineered construction knowledge.

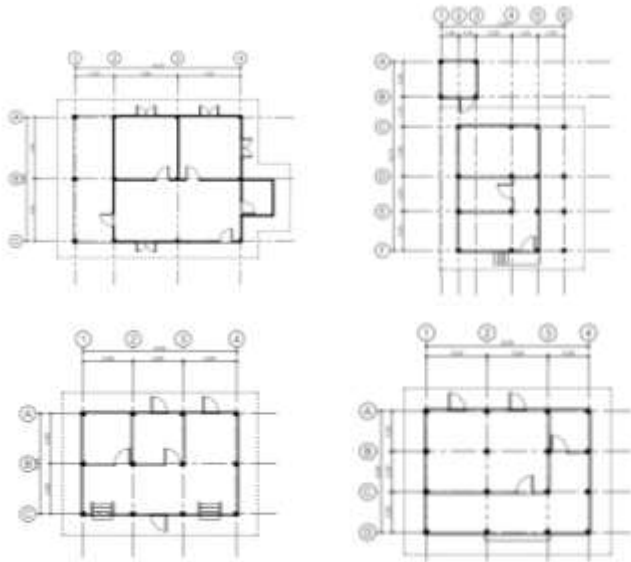


Fig 10. Some of the sketch up of participants houses

V. CONCLUSION

This paper have an objective to strengthen the structural house for better safety more than just repairing but the efficiency still be the same and suggest the appropriate strategy which can realize in the local area especially for Thai society including assist the low revenue people for better structural house and understanding about suitable construction of their house. After the studies, the program supposed to be forward to assessment and monitoring. The goal of this strategy is apply to the risk area of disaster like earthquake especially in developing countries. Actually, the strategy should be design depend on its area so this working can be adapted follow the situation.

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