PROCEEDING

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LANDSLIDES AND SLOPE STABILITY

Advancement of Research, Practice and Integrated Solutions on Landslides

Bali, Indonesia 27-30th September 2015

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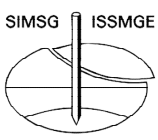

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PREFACE

Landslides have become a major threat and disasters at large scale residence area in urban as well as suburban area or villages. Our profession has important roles in public safety against landslides and man made slope failures and the potential of shaping the future of landslides risk management. The theme of the conference "ADVANCEMENT OF RESEARCH, PRACTICE, AND INTEGRATED SOLUTION ON LANDSLIDE" reflect the effort to synergize the academic research and findings and practical experience in facing climate change and human interference on the nature.

Engineering Geologists, Civil Engineers and Environmental Engineers and other professionals are concerned with the problems of debris flow, landslides and rockslides which may be caused by natural disasters, river erosion, climate change, human errors and geo-environtmental problems. Eventhough we have gained experience, knowledge and advanced technology, there are still numbers of deadly events that recently occured at many places in Indonesia such as in Padang Pariaman in Sumatera 2009 (more than 600 fatalities), South Cianjur 2009 (54 fatalities) and recently at one particular district area of Banjarnegara, Central Java with 351 fatalities (Legetang/Kepakisan, 16 April 1955), 90 fatalities (Sijeruk, 4 January 2006) and 108 fatalities (Jemblung, 12 December 2014) and also in many other countries as well.

Landslides Risk Reduction is hence very important steps in every country. They require multi hazard approach including institutional capacities such as policy, legislation, education and training, community awareness etc as an essential condition for its effectiveness. Many universities, research institutions, landslides centers and geological or geotechnical consultants have gained experience and knowledge which are of valuable importance. Case histories of landslides contribute to the state of the art for research and practice on landslides and rock slides. It is with the objectives of sharing knowledge, the conference has been aimed for the goals. Hence the conference is very important event for exchange of ideas and experience and for contribution among many countries all over the world.

We would like to extend my appreciation to all of you who have been travelling from far distance and specially to the Keynote Speakers and authors who made their efforts to share their knowledge and experience to the audience. This conference cannot be successful without the support of the department, the faculty of engineering, specially the dean Dr. Adhijoso Tjondro, Rector of Parahyangan Catholic University Dr. Mangadar Situmorang, and Director of LIPI Geoteknologi Dr. Haryadi Permana for their encouragement. Last but not least, to all members f the committee for their endless hard work and dedication, I have to acknowledge that they are the people behind the scene, for without them, this event will not come to reality.

Finally to all participants, I wish you find this conference useful and beneficial to you, and your institution.

Organizing Committee
International Conference on Landslides and Slope Stability
(SLOPE 2015)

Prof. Paulus P. Rahardjo, Ph.D.
Chairman

Dr. Adrin Tohari
Co-Chairman

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OVERVIEW OF LANDSLIDE EXPERIENCE IN WEST SUMATRA IN 2012-2014

A. Hakam [1], B. Istijono [1] and Sarbaini [2]

ABSTRACT: The West Sumatra is a province that stretching from the west coast to the hills in the middle of the Sumatra Island. Many landslides in West Sumatra frequently occur in areas along the mountain chain during last three years in this province. The diversities of physiographic and geologic conditions as well as surface vegetation lead to the landslide in the West Sumatra. In addition, the landslide occurrences are also influenced by the weather and local climate. The reduction of the strength of the soils due to the rain is the main factor causes landslides. In landslide remedial work, the budget and available technology as well as local resources capability are restrictions that necessary to be considered. This paper describes a review of the landslide in West Sumatra and treatment measures for the last 3 years (2012 to 2014). This study is very important to improve and to develop the efforts to reduce the landslide risk and treatment in the future.

Keywords: landslides, ground condition, remedial action

INTRODUCTION

The West Sumatra Province is geographically located in the west-central side of the Sumatra Island (Figure 1). In the middle of this province there are many hills that laid from the north to the south as part of the Bukit Barisan hill. The Bukit Barisan hill is also geologically formed due to the existence of the Semangko fault which divides the Sumatra Island into two parts, east and west. In addition, along the Semangko fault there are some active and non-active volcanoes which create a mountain area.

The formation of soil deposit of the West Sumatra province in general is dominated by the volcano activity along Semangko fault. The area around the Semangko fault is known as volcanic area. The lowest area of the volcanic area, the ground is dominated by sediment material that likely originated from the volcanic area. The physiographic of the West Sumatra province then can be divided into three groups that are volcanic area, hill area and flat area (Figure 2). These physiographic conditions form slopes with different types of soil, in where it will be shown that the landslide in the West Sumatra generally occurs.

In the last 3 years, it has been carried out the Landslide Reports in the West Sumatra by the Government Body. This paper shows a review of that landslide record that occurred in the West Sumatra in 2012 to 2014. This review is related to the incident location, type and geological condition of landslide, time of occurrence and remedial action that has been done.

Figure 1. Map of the West Sumatra province

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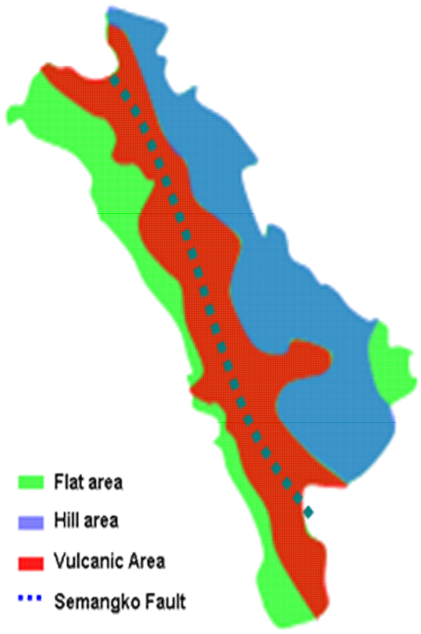

Figure 2. Physiographic map of West Sumatra (adapted from Sandy, 1985).

LANDSLIDE OUTLINE

Theories to analyze the stability of the slope have been written in many textbooks in many languages (example: Huang, 1983 and Hakam, 2010). Those references have been elaborating type of sliding, factors cause sliding, slope stability analysis theories also the methods for designing the retaining structures. Here, landslide types and factors cause the sliding of slopes are written briefly in the following sections.

Slopes can be failure in term of sliding (general landslide), flow of soil (debris flow) and rock debris (rock fall). There is also a slow movement of slope that known as creep. A creep generally does not cause a collapse in slope but result in displacement that may lead cracks and damage to the facilities there on. The illustrations of those types of landslide are shown in Figure 3.

In general, the factors that cause a landslide can be divided into two groups: internal and external factors. Both factors theoretically cause of decreasing the strength of soil or increasing the force thus reducing the safety factor of the slope. External factors are all of the disturbance from the outside of the slope, either made by natural or human. The examples of the external factor which can reduce the slope safety are vibrations from human activities, earthquakes, additional loads, the removal of retaining forces on the down of the slope and also the loss of slope covering. The internal factors are changing in the moisture content of the soil, increasing the soil mass due to water intrusion, the absence of cemented material in soil mass, increasing the water table, heaving - shrinking of the soil mass, sudden reduce of water table and liquefaction.

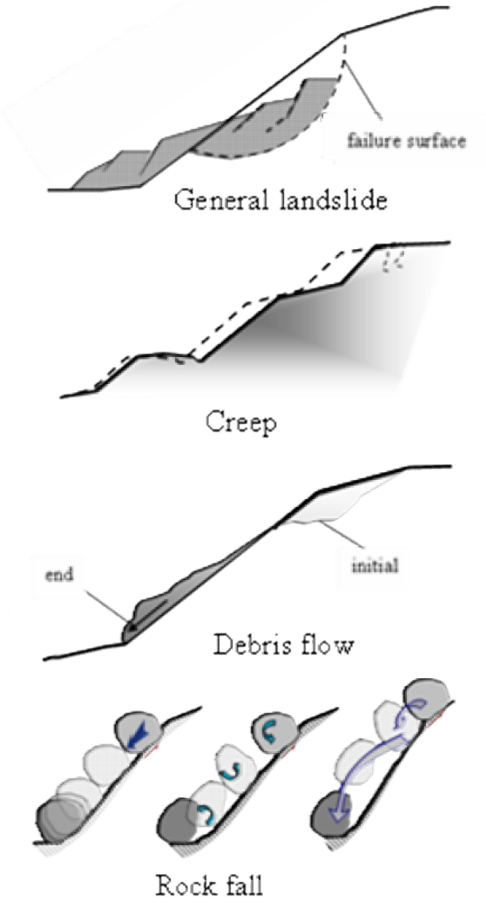

Figure 3. Illustration of sliding types

Further, common things that need to be considered in the dealing with landslide are topography, geology, water in the soil, climate and weather, vibration, history and time. These things directly or indirectly may trigger the slope stability.

LANDSLIDE IN WEST SUMATRA

Since there are many landslides in west Sumatra region, Division of Geology of Energy and Mineral Resources Department of West Sumatra province published annual reports of landslide. These good records of landslide are started in 2012. The summary of landslide records for last 3 years then are shown in the Table 1 – Table 3. The types of recorded landslides in the West Sumatra are any mass soil movements including general type of sliding, debris flows, creep and rock fall.

The landslides that are reported in here are the ground movement in which resulting in damage to

public and private facilities as well as fatalities. Many landslides in small scale that did not result in loss or casualties also occurred in the West Sumatra but not recorded in this reports. In 2012, the landslides have taken 11 lives in six locations. In 2013 only one event of landslide but took 20 lives at Maninjau Lake in Agam District. In 2014 there were four locations of landslide which resulted in the fatality of 7 lives.

Table 1. Landslides in 2012

No	Name	Type	Fatality	Trigger	Action
1	Tanah Datar	Debris flow	1	Heavy rain fault steep land no vegetation	Retaining wall Planting
2	Pasaman	Debris flow	1 (3 injd.)	heavy rain no vegetation	River Normalization Retaining wall Planting
3	Pariaman	Falling	1	Heavy rain Erotion on toe	Evacuation Drainage
4	Solok	General Landslide		Fault Wrong in land use Water Infiltration	Re-planting Relocation Cutting slope
5	Padang	Debris flow		Heavy rain Illegal logging	Retaining wall Relocation Re-planting
6	Padang	General Landslide	4	Heavy rain Farming field	Relocation Educating
7	Solok Selatan	Debris flow	1	Heavy rain	Re-planting Relocation
8	Tanah Datar	Debris flow	-	Heavy rain Steep Farming field Weathering rock	Gabion
9	Solok Selatan	General Landslide	3	Heavy rain Erosion on slope	Cutting slope Re-planting Relocation

In Table 4 is shown the time of the occurrence of landslides over 3 years. It can be seen that landslides occurred mostly in the early months and the end months of the years. In those months that are recognized as rainy season in the West Sumatra. It is very rarely landslides happened in March to June where the rain is also rare. There is also generally heavy rain felt at the time prior to the occurrence of landslides. Thus it is needed good preparation of equipments, funding and human resources to deal with landslides especially in the rainy season. Although there is only one incident of landslide triggered by an earthquake, it must receive special attention. Many landslides also happened during Sumatra earthquake in 2009.

In three years of the records, landslide locations in West Sumatra mostly occurred in volcanic area and some of the locations are in the hill area as shown in Figure 4 and Figure 5. The geology of these locations is made of relatively unstable young rocks. Geotechnical studies on some locations of slope indicate the behavior of clay against water affected the landslides. The reduction of the soil shear strength caused by the increase of the water content affected the slope stability and lead to the landslides. An assessment for the landslide in Maninjau-Agam showed that the saturation in soil mass can reduce the soil cohesion by 75% (Hakam et al, 2013).

Table 2. Landslide in 2013

No	Name	Type	Fatality	Trigger	Action
1	Agam	General sliding	20	Heavy rain	Replanting
2	Pesisir Selatan	Debris flow	-	Dike Failure Heavy rain Steep slope	Re-planting Gabion Slope cutting
3	Agam	General landslide	-	Steep slope Heavy rain	Retaining wall Re-planting Slope cutting
4	Pasaman	General landslide	-	Earthquake	Re-planting
5	Solok	Debris flow	-	Heavy rain Erotion	Re-planting
6	Solok	Creep	-	Fault Saturation in soil Heaving in soil	Planting Relocation
7	Payakumbuh	Debris flow	-	Heavy rain Fault Construction failure Logging	Slope cutting Planting
		General landslide			
8	Pantai cermin	General landslide	-	Heavy rain Fault	Re-planting Re-construction
		Debris flow		Heaving in soil Construction failure	Retaining wall
9	Maninjau	Debris flow	-	Heavy rain Dam failure	Rebuild dam Re-planting Gabion in river
10	Malalak	General landslide	-	Fault Heavy rain Wrong slope design	Redesign of slope Retaining wall
11	Solok Selatan	General landslide	-	Heavy rain Steep slope Logging	Cutting slope Re-planting
12	Tanah Datar	General landslide	-	Heavy rain Steep slope	Retaining wall Plugging crack

The understanding of the factors that cause of landslide is very useful to determine the corrective and preventive actions in the future. The rain is certainly very difficult to be controlled, but the water which triggers the occurrence of landslides can be controlled well.

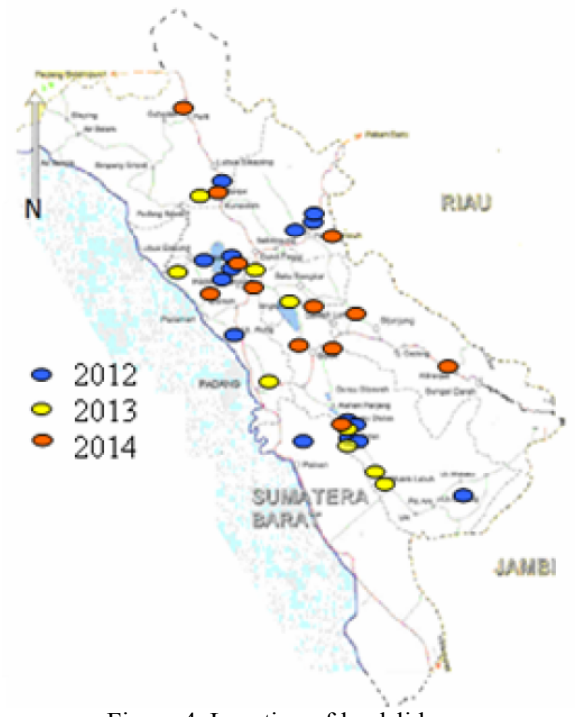

Figure 4. Location of landslides

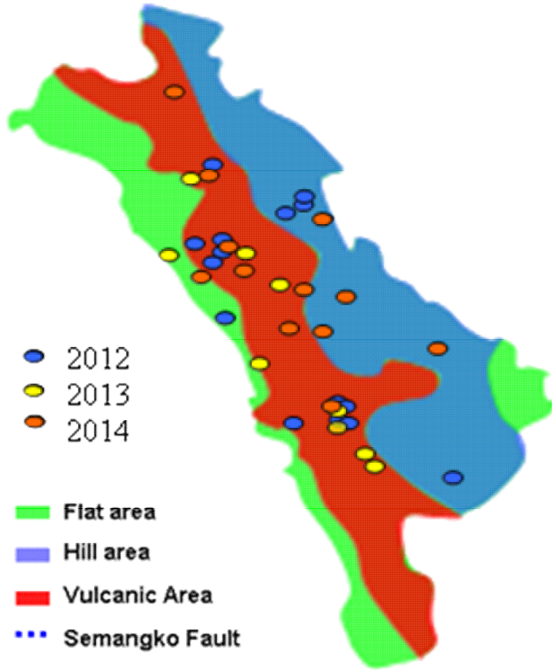

Figure 5. Distribution of landslides

Table 3. Lanslides in 2014

No	Name	Type	Fatality	Trigger	Action
1	Sawahlunto	General landslide	-	Heavy rain Steep slope Heavy rain Housing on top	Cutting slope
2	Pariaman	General landslide	1	Heavy rain Lack of vegetation Construction fault	Cutting slope Planting
3	Solok Selatan	Debris flow	-	Heavy rain Lack of vegetation Logging	Retaining wall Re-planting
4	Pasaman	Debris flow	3	Heavy rain Steep slope Human activity	Re-planting
5	Tanah Datar	General landslide	-	Steep slope Lack of vegetation	Re-planting
6	Agam	General landslide	-	Steep slope High water content	Cutting slope Planting
7	Tanah Datar	General landslide	-	Steep slope Lack of vegetation	Cutting slope Planting
8	Pasaman Barat	Debris flow	-	Heavy rain Steep slope Human activity Lack of vegetation	Re-planting Education
9	Pasaman	Debris flow	-	Heavy rain Weak soil	Gabion
10	Solok	Debris flow	-	Heavy rain Steep slope Non-cohesive soil Logging	Cutting slope Re-planting Education
11	Solok	Debris flow	-	Heavy rain Weak soil Erosion prone soil	Re-planting
12	Solok Selatan	General landslide	-	Heavy rain Steep slope Wrong slope const.	Cutting slope Planting
13	Pasaman	Debris flow	1	Heavy rain Steep slope Logging	Re-planting Gabion

Table 4. Occurrence time of landslide

Tahun	1	2	3	4	5	6	7	8	9	10	11	12
2012			■			■	■	■	■		■	■
2013		■					■	■	■	■	■	■
2014	■		■		■				■	■	■	

Note: ■ rain prior to ■ earthquake accur

Remedial actions to solve the landslide in West Sumatra are conducted generally in terms of replanting trees. The main reason to do this action is because the landslides occurred along the open locations at the hill and mountain areas. But at certain locations, the landslides also occurred at the roadsides. In these cases the restorations are done by constructing retaining walls. For landslide which occurred along the rivers, the gabions are chosen. The remedial action to prevent water intrusion in to the soil mass by controlling the water above the slope is rarely done.

The conventional reparation of landslides in the West Sumatra is caused by the lack of technology as well as limited budget. That is combined by the lack of knowledge of slope stability and stabilization of authorized bodies which deal with

landslides. The improvement of human capacity must be done, especially in terms of prevention tasks of landslides. In additional, the enough budgets and the appropriate technology to prevent landslides must be considered better.

Investigations on landslide in sliding prone locations should be done so that appropriate solutions associate with landslide can be made up. An example of an investigation on the slope stability and its solution for Maninjau sliding in Agam has been conducted in 2013 (Figure 6). The investigation procedure is started by a field survey and laboratory tests of soil samples then followed by stability analysis and delivering a recommended solution. On the laboratory investigation the undisturbed and saturated soils are tested and those data are used for the analysis. The slope protection by re-plantation deep-strong root vegetations was then recommended.

Figure 6. Maninjau – Agam Linslide 9n 2013 (Hakam et al, 2013)

CONCLUSIONS

Landslides in the West Sumatra generally occurred mostly in the highlands (hills and mountains) that have relatively steep slope and the disadvantage geotechnical conditions. The landslides that occurred from 2012 to 2014 have caused damage to infrastructures and fatalities. The cut of vegetations that covering slope surface and the change of land use have triggered landslides. Some landslides were also caused by inaccuracy of the artificial slopes design. Although in 2012 to 2014 there is only one landslide caused by an earthquake, it is important to notice that an earthquake can trigger landslides such that happened during the Sumatra Earthquake in 2009.

Mainly the landslides occurred during or after heavy rain. Along a year, landslides occurred in the rainy season i.e. in January, February and July to December. It is necessary to have a good preparation for the emergency response of landslides in those wet months.

Remedial actions for landslides in the West Sumatra are mainly associated with the availability of budget and technology. The plantation is more popular solution compared to preventive treatment such as surface water control. For a better solution in future it is necessary to develop understanding and to increase the human capacity related to the slope stability and protection.

ACKNOWLEDGEMENTS

We would like to thank the Ministry of Energy and Mineral Resources (ESDM) of West Sumatra province for providing the Report of Landslide in West Sumatra in which information and data in this paper are obtained.

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