CHAPTER I

INTRODUCTION

1.1 Background

Indonesia has major impacts of landslides impacting safety, infrastructure, property and environment of society. In these past few years, countless landslides have been destructing Indonesia and causing so much harm. In 2014, a landslide struck Banjarnegara, Central Java, Indonesia, killed at least 18 people and more than 90 were missing. Hundreds of houses had been destroyed by the landslide with more than 400 residents moved to temporary shelters (BBC, 2014). Another deadly landslide in 2016, also buried dozens of people in Banaran village, Ponorogo district, East Jaya. The landslide was 800 meters long with debris up to 20 meters (66 feet) had overturned vehicles, destroyed and buried buildings (DW, 2016).

According to the National Disaster Management Agency, the main challenge in most natural disaster including landslides is the access to the disaster zone is very limited. It tends to cause the mobility of the rescue teams gets hindered. Limited information on hazards map about which area has greater risk due to natural disaster is caused by the nescience of techniques to investigate and mostly are only based on personal judgment and observations to collect the data (JICA, 2015).

Finite element method (FEM) is a powerful yet effective tool for studying the onset of incipient landslide failures, (Ugai and Leshchinsky, 1995; Khosravi and Khabbazian, 2012; Zhou et al., 2013; Hung et al., 2017, 2018) including the initiation time, and the propagated runout behaviour. The FEM has advantages over the traditional limit equilibrium method (LEM) (Bishop, 1955; Duncan, 1996; Spencer, 1967; Mendjel and Messast, 2012; Liu et al., 2015; Yuan et al., 2018; Javankhoshdel et al., 2016; Chen et al., 2018). However, traditional Lagrangian FEM may be limited to model large deformation material behaviour (Chen and Lee, 2000; Crosta et al., 2006) and the obtained results may experience numerical convergence difficulty and not reliable (Chen et al., 2018). To solve the complex large deformation problems, coupling both Lagrangian and Eulerian approach may have better accuracy and feasible results.

Coupled Eulerian-Lagrangian (CEL) finite element modelling, has been used in several studies for investigating slope stability, seismic-induced rockslide and governing factor of safety (FOS). Those studies addressed that CEL finite element method produces better agreement and reliable results (Shirole et al., 2017).

1.2 Problem Formulation

Soil finite element modelling may suffer severe material deformation, and numerical issues may occur due to excessive mesh distortion. Lagrangian finite element approach is not suitable for cases where excessive element distortion is expected as it simply implements less computational by having no interface-tracking techniques and letting the particles attached with the material. In such cases, the Eulerian meshing approach is more suitable. The study of coupled Eulerian-Lagrangian (CEL) technique and its application is very limited in Indonesia. In this study, CEL finite element technique is introduced through the investigation of sliding mass behaviour on Aso-Bridge slope. The CEL method selectively meshes the analysis components accordingly to the components/bodies undergoing large deformations using Eulerian technique while the remaining using the conventional Lagrangian technique to simulate at the same time.

1.3 Purpose of the Study

The purpose of this study is to investigate the kinematic behaviour of sliding mass on Aso-Bridge slope using Coupled Eulerian-Lagrangian (CEL) finite element technique. The features of this study are the pre-failure mechanism (initial condition) and post-failure runout behaviour.

1.4 Problem Limitations

In this particular study, problem constraints are appointed as follows:

1. Simulation is using the Aso-Bridge landslide case – slope failure.
2. Commercial finite element software, ABAQUS, is used in this study.
3. The simulation can only be investigated in three-dimensional (3D) (Eulerian modelling).
4. The analysis is employed with elastoplastic geomaterial constitutive model in explicit algorithm integration.

5. Numerical properties of geomaterial used in the simulation are Mohr-Coulomb constitutive model with unit weight, $\gamma = 20$ kN/m^3; Young's modulus, E = 75E6 kN/m^2; Poisson's ratio, $\upsilon = 0.27$; cohesion, c = 80 kN/m^2; friction angle, $\phi = 35^o$ for the sliding mass and the slope except the cohesion, c = 95 kN/m^2.
6. The simulation was run with a dynamic explicit step with, t = 38 s input time, period time of the sliding mass reaching the riverbank started from the initial time $t_o = 0$s.

1.5 Research Benefit

This study is expected to be able to provide implementation reference of Coupled Eulerian-Lagrangian (CEL) finite element method to investigate other geotechnical structures. Material meshing integration in CEL technique has a significant influence on material deformations and the convergence of the numerical results.

1.6 The Originality of the Final Project

Hung et al. (2018) did a numerical investigation of failure and runout behaviour combining finite and discrete element methods on Aso-Bridge Landslide. The analyses were considering both horizontal seismic accelerations (HSA) and vertical seismic acceleration (VSA) to explore the salient features of the pre-failure mechanism and post-failure kinematic process of the coseismic landslide associated with the initiation time and kinematic runout behaviour. Although the coseismic process results have a satisfactory agreement with the event, it is suggested to describe kinematic runout behaviour using the material point method to enable large displacement for Lagrangian particles.

Shirole et al (2017) did a simulation on a large-scale seismic-induced rockslide in a continuum-based model. The study discovered that traditional Lagrangian finite element formulation is incapable to simulate the rockslide large deformation correctly. They then computed the problem using CEL FEM to solve the problem. The governed results had a fair agreement between those from CEL based model and those from the conventional continuum-based model.

Chen et al. (2018) proposed Coupled Eulerian-Lagrangian (CEL) finite element method to analyze slope stability. The study found that the factor of safety (FOS) value of the slope is underestimated by the traditional Lagrangian FEM based method as the extreme geometry of the slope amplifies the nonlinearity and causes early termination of finite element modelling. The results showed that the proposed method can obtain reliable results for both local failure and global failure of slope.

Numerous studies to investigate geotechnical structures using finite element analysis (FEA) have been performed since the past decades. However, Coupled Eulerian-Lagrangian (CEL) studies on geotechnical structures are still limited. There has not been any CEL study investigating sliding mass kinematic behaviour of Aso-Bridge slope, especially in

Indonesia. The author believes that this final project research is original and is not plagiarism from numerous studies in the past.

1.7 Final Project Conducting Location

The pre-failure and post-failure data were governed from Aso-Bridge landslide case. Coupled Eulerian-Lagrangian (CEL) simulation was conducted at Smart-Geo (SGE) Laboratory of National Cheng Kung University, Tainan, Taiwan.