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LIQUEFACTION SYSTEM DESIGN USING HYDRAULIC MECHANISM

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Abstract

Liquefaction is a natural disaster that cannot be predicted. Therefore a simulation tool is needed to determine the characteristics of the disaster, so that it can be reduced. This simulation tool moves on the x-axis and y-axis with the drive system using a hydraulic system. The purpose of this research is to measure the vibration parameters that arise in the liquefaction machine. In addition, to analyze the vibration system that arises in the liquefaction machine on the x-axis and y-axis. And the analysis method used is experiment. This mechanism is designed in 2 levels using 6 rollers on each floor. The speed and acceleration of the drive mechanism are able to describe the true state of liquefaction.

Keywords: Natural disasters, Liquefaction tools, hydraulic systems

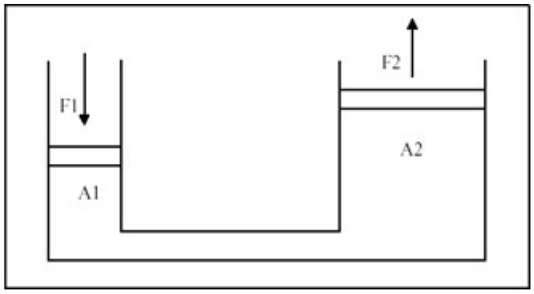
INTRODUCTION

Earthquakes are natural phenomena that cannot be prevented. Earthquake waves cause ground shaking under certain conditions, one of which can cause liquefaction (Oliver, 2019). Liquefaction is a phenomenon of loss of soil shear strength in a water-saturated layer due to an earthquake, causing the soil to collapse and behave like a liquid. Liquefaction generally occurs in water-saturated non-cohesive (granular) soils that receive cyclic loads in the form of earthquakes. (Mase et al., 2017). One of the liquefaction events that occurred in Indonesia was the result of the May 27, 2006 earthquake in the Special Region of Yogyakarta. The 2006 liquefaction was characterized by several phenomena, including the discovery of lateral spread and sand boils. (Mase et al., 2016) Then the earthquake shook the island of Lombok, West Nusa Tenggara (NTB) on July 29, 2018 with a scale of 6.4 M followed by aftershocks up to 133 times with a scale of 7 M, then there was another earthquake shock in Palu, Central Sulawesi on September 28, 2018 which reached 7.4 M so that it destroyed buildings in Palu, Donggala, Sigi and Balaroa. even the impact of the earthquake was felt as far as Bali and its surroundings. The natural disaster that occurred this time was a very special event because the earthquake was also followed by a tsunami and liquefaction (land movement) so that the death toll reached 2,256 and 1,309 were missing according to BNPB data (21/10/2018). In addition, buildings and infrastructure that were destroyed or damaged by the disaster included 68,451 houses, 327 houses of worship, 265 schools, 78 offices, 362 shops, 168 damaged/cracked roads, and 7 destroyed bridges (Hutabarat & Tampubolon, 2019). This event left deep sorrow not only for the people of Indonesia but also for the world. Earthquakes followed by liquefaction are not a common occurrence, either in Indonesia or elsewhere in the world.

LITERATURE REVIEW

a. Hydraulic system

A hydraulic system is a power transmission system that uses a liquid fluid. Mineral oil is a commonly used fluid. The basic principle of a hydraulic system is to exploit the property that liquids do not have a fixed shape but adapt to the shape of their container. Liquids are incompressible. Therefore, the pressure they receive is transmitted evenly in all directions . (RIZAL, 2010)



$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \text{..... (2.1)}$$

$$\frac{F_1}{F_2} = \frac{A_1}{A_2} \quad \text{..... (2.2)}$$

Sehingga diperoleh : $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ ..... (2.3)

b. Definition of Liquefaction

Earthquakes are unpreventable natural phenomena. Seismic waves cause ground shaking under certain conditions, one of which can lead to liquefaction. Liquefaction occurs when saturated, non-cohesive soil that has lost its shear strength is subjected to cyclic (regularly repeated) earthquake-induced shaking, causing pore water pressure to increase to near or exceed the vertical stress.

reviewing several serious damages or total damage to buildings due to soil cracking due to the liquefaction process, light damage occurs when the soil shifts as far as 50-100 mm, damage that requires light repairs or moderate damage occurs due to soil shifts as far as 120-600 mm, and heavy damage with soil shifts as far as more than 760 mm. Changes in soil properties from solid properties to liquid properties that occur in water-saturated soil are caused by an increase in pore water pressure and a reduction in effective soil stress and at the same time also reducing the shear strength of the soil in question. If this happens and the soil loses its shear strength, liquefaction will occur. (Oliver, 2019)

c. Understanding vibration

Have you ever played on a swing or seen someone swinging? In these games, we move back and forth up and down or up and down. Or when a drummer hits a drum, it will appear that the drum skin moves back and forth up and down. An object experiencing vibration always has a stable equilibrium position. If the object is moved away from this position and released, a force or torque will be generated to pull the object back to its equilibrium position. However, by the time the object reaches its equilibrium position, it has acquired kinetic energy so it goes beyond that position, stops somewhere on the other side, and then returns to its equilibrium position. From this simple illustration, we can define vibration as a back and forth motion around an equilibrium point/position. There are several terms that we will use in discussing all kinds of oscillatory motion, namely amplitude, period, frequency, and angular frequency. The amplitude of vibration, usually symbolized by the letter A, is the maximum displacement from the equilibrium point. The vibration period, which is usually symbolized by the letter T, is the time required for one vibration/one cycle (Sutisna, 2014).

METHOD

This research will comprehensively measure and analyze aspects to measure the vibration parameters that arise. This study employed a mixed methods approach. Quantitative methods were used to mathematically calculate and measure the vibration parameters generated in the liquefaction machine using hydraulic mechanisms on the x- and y-axes, thus achieving earthquake-like criteria.

Tools, PPE, and Materials

1. Tool

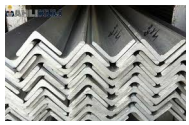
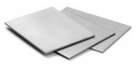
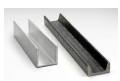
No.	Tool Name	Picture	Utility
1.	Welding machine 160 A		To connect the components of the shake table (iron)

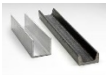
2.	Drilling machine		To make a hole in the shake table tool
3.	Hand grinder		Cutting iron and smoothing welds
4.	Bench grinder		Cutting iron
5.	Angle ruler		Creating precision objects during the joining process
6.	PC		Program Design & Development

2. PPE

No.	Tool Name	Picture	Utility
7.	Gloves		To protect hands during drilling and grinding processes.
8.	Welding Goggles		To protect the eyes during the welding process
9.	Welding gloves		To protect hands during the welding process
10.	Wearpack		To protect yourself from welding spatter

3. Material

No.	Material Name	Picture	Utility
1.	4x50 mm strip iron		Become the iron base of the base frame
2.	40x4 angle iron		Become the iron base of the base frame
3.	10 Wheels		As a load-bearing tool
4.	Hydraulic machine		As a shake table tool driver
5.	10 mm iron plate		As a wheel base
6.	5/8 `` solid iron		As a wheel base
7.	UNP 80 Iron		For rail frame

8.	UNP 65 Iron		For rail frame
9.	2x8 strip iron		As a base frame for iron plates
10.	Electrode		As an iron connecting material
11.	Grinding wheel		as a cutting and smoothing tool for cutting iron
12.	Drill bit		To drill holes in iron with a certain diameter according to the diameter of the drill bit
13.	Bolts and nuts		Binder
14.	bearing		As a damper and load support on the wheel

RESULTS AND DISCUSSION

The tool was made independently. It started with the design using Fusion 360 software. The resulting Fusion 360 image measures 1200 x 1200 mm x 400 mm. It uses a hydraulic machine with a 3-phase motor as its driving force to pump fluid in the form of oil that will be transferred to the hydraulic arm. The hydraulic arm itself consists of two arms, each positioned in the x- and y-axis directions.

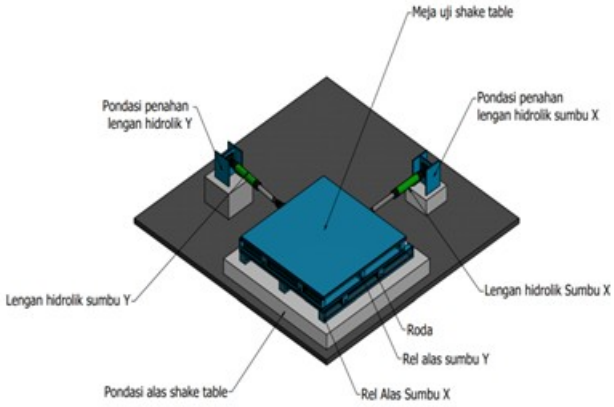


Figure 3.1 Shake table tool components (drawing by inventor 2015)

These tools consist of several components , namely:

1. The Y-axis hydraulic arm support foundation functions to withstand the thrust caused by the hydraulic arm on the Y-axis.
2. The x-axis hydraulic arm support foundation functions to withstand the thrust caused by the hydraulic arm on the x-axis.
3. The y-axis hydraulic arm serves to push the shake table in the y direction.
4. The x-axis hydraulic arm serves to push the shake table in the x direction.
5. The y-axis base rail functions as a base/track for the wheels in the y-axis direction.
6. The x-axis base rail functions as a base/track for the wheels towards the x-axis.
7. The wheel functions to support the given load.

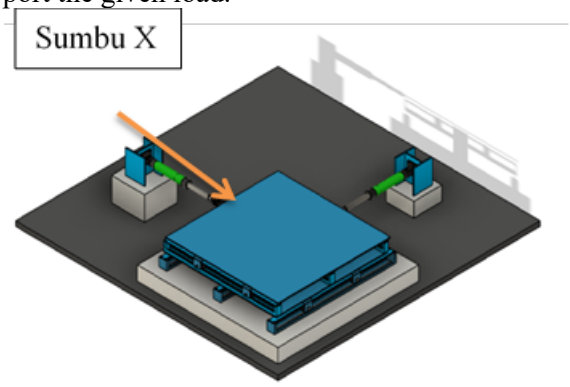


Figure 3.2 X-axis motion (drawing by inventor 2015)

The shake table moves in the x-axis due to the thrust provided by the hydraulic arm. The hydraulic arm moves due to Pascal's law, which essentially states that in a closed vessel with several identical holes at one end, force will be emitted in all directions with the same pressure and flow rate. To prevent the thrust provided by the hydraulic arm from being too great, wheels are used.

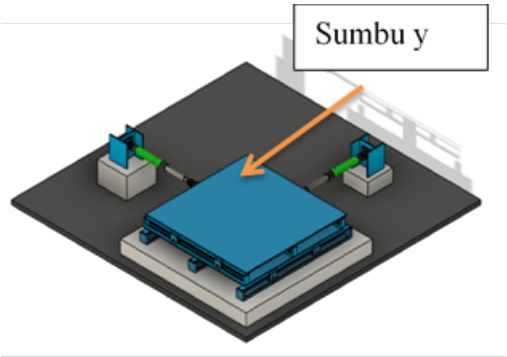


Figure 3.3 Y-axis motion (drawing by inventor 2015)

The shake table moves in the y-axis due to the thrust provided by the hydraulic arm. The hydraulic arm moves due to Pascal's law, which essentially states that in a closed vessel with several identical holes at one end, force will be emitted in all directions with the same pressure and flow rate. To prevent the thrust provided by the hydraulic arm from being too great, wheels are used.

CONCLUSION

1. The results of this shake table design are used to simulate earthquake and liquefaction movements.
2. The earthquake or liquefaction movement model is movement on the x-axis and y-axis simultaneously.
3. The size of this shake table is 1200 mm x 1200 mm x 500 mm
4. The drive system uses a hydraulic drive mechanism

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