

## SURAT - TUGAS

Nomor: 171-D/866/FT-UNTAR/II/2021

Dekan Fakultas Teknik Universitas Tarumanagara, dengan ini menugaskan kepada Saudara:

**Alfred Jonathan Susilo, ST., M.Eng., Ph.D.**

Untuk melaksanakan **Mempresentasikan Hasil Penelitian** dengan data sebagai berikut:

Judul Makalah : **Analysis of Some Failure Reduction on Primary Pile in The Secant Pile System**  
Nama Seminar : The 3 rd Tarumanagara International Conference on the Applications of Technology and Engineering (TICATE) 2020  
Penyelenggara : Universitas Tarumanagara  
Peran : Pemakalah (Presenter)  
Waktu Pelaksanaan : 03 - 04 Agustus 2020

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11 Februari 2021

Dekan



**Harto Tanujaya, S.T., M.T., Ph.D.**

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*Paper Title :*

Analysis of Some Failure Reduction on Primary Pile in The Secant Pile System

August 3<sup>rd</sup> - 4<sup>th</sup>, 2020 | Universitas Tarumanagara, Jakarta

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## Preface

On behalf of the organizing committee of the 3<sup>rd</sup> TICATE 2020, I would like to welcome all delegates to attend this international conference with great pleasure. In the concern of COVID-19 pandemic, this international conference is being held virtually from August 3<sup>rd</sup> – 4<sup>th</sup>, 2020 from Campus I of Universitas Tarumanagara at Jl. Letjen S. Parman No. 1, Jakarta 11440, Indonesia. The 3<sup>rd</sup> TICATE 2020 is organized by Universitas Tarumanagara and technically sponsored by IOP Publishing. The reason why this conference was changed to virtual format is that due to COVID-19 Pandemic, there are travel restrictions and social distancing ruled by almost all governments in the world, including Indonesian government. We still hold partially the physical presentations regarding the healthy protocols suggested by World Health Organization.

Instead of being postponed, we still hold this international conference virtually using Zoom Meeting because this conference is a forum for engineers, academics, practitioners, and students to exchange their experiences and knowledge. Many innovations and developments are being created from the last event to this one. These need to be shared among stake holders in the field of engineering and technology. Therefore, there is an urgent need to publish the newest results of researches in the conference proceedings.

The 3<sup>rd</sup> TICATE 2020 has attracted many academicians, scientists, engineers, postgraduates and other professionals from many countries. This conference accepted 217 papers from 5 different countries, those are Australia, Taiwan, India, Malaysia, and Indonesia. The aim of the conference is to promote exchange of ideas among engineers, researchers, and scientists active in the related areas of technology and engineering.

Our special thank goes to our Rector, Prof. Dr. Ir. Agustinus Purna Irawan, who has initiate this international conference, to our Plenary Speakers, Prof. Ir. Dr. Lee Sze Wei from Tunku Abdul Rahman University College, Malaysia, and Prof. Dr. Ir. Tresna P. Soemardi, S.E., M.S. from Universitas Indonesia, Indonesia, and to our Invited Speakers, Dr. Ayub Ahmed Janvekar from VIT University, Chennai, India and Prof. Ir. Dr. Mohd Zulkifli Abdullah from Universiti Sains Malaysia, Malaysia. Each keynote speaker will be given 30 minutes to hold his presentation and followed by 15 minutes Q&A session. At the parallel sessions, each presenter is given 15 minutes to present his/her work followed by 10 minutes Q&A session about the related topic. The parallel sessions are opened to all participants. The participants, including presenters at the parallel sessions, are attending this virtual international conference from Indonesia (Jakarta, Bandung, Medan, Yogyakarta, Aceh, Depok, Surabaya, etc.), Kuala Lumpur, Pulau Pinang (Malaysia), Australia, Taiwan, and India.

The virtual format of the 3<sup>rd</sup> TICATE 2020 still provides very satisfying overall technical quality of the conference, e.g. in presenting the articles. Because we used Zoom Meeting as the platform and a good internet connection to hold this virtual conference, the conference can be attended by about 500 participants from 5 countries without any problem.

We would like also to thank our partner international and national Universities in contributing and participating in this international conference. To all individuals and organizations such as the members of international editorial board, the conference organizers, the reviewers and the authors, for their contribution in making the 3<sup>rd</sup> TICATE 2020 as a successful international conference and a memorable gathering event. I am also grateful for the support of publication service of IOP Publishing.



We hope that the conference could present you wonderful memories to bring home in addition to new insights and friendship congregated during the event. We truly value your participation and support for the conference. We hope that you will gather many experiences and benefits from this event.

Dr. Hugeng, S.T., M.T. (SMIEEE)

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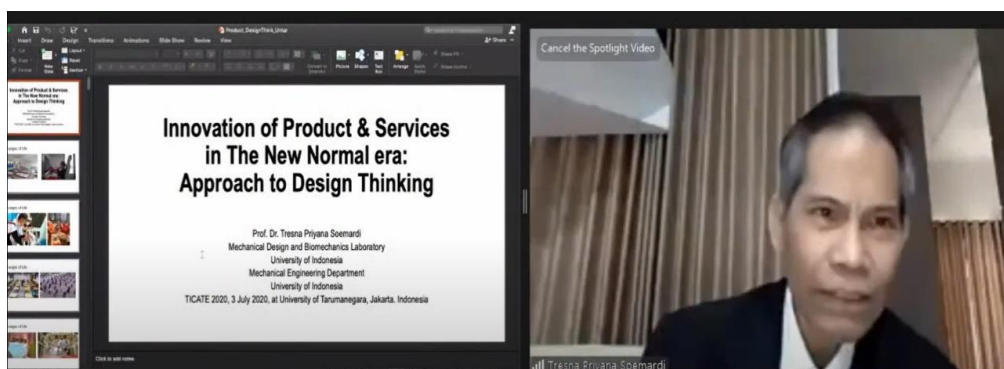
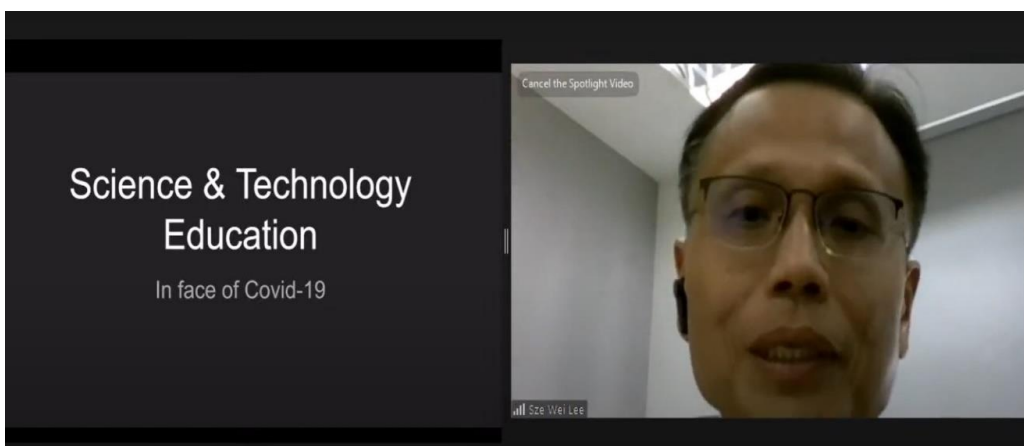
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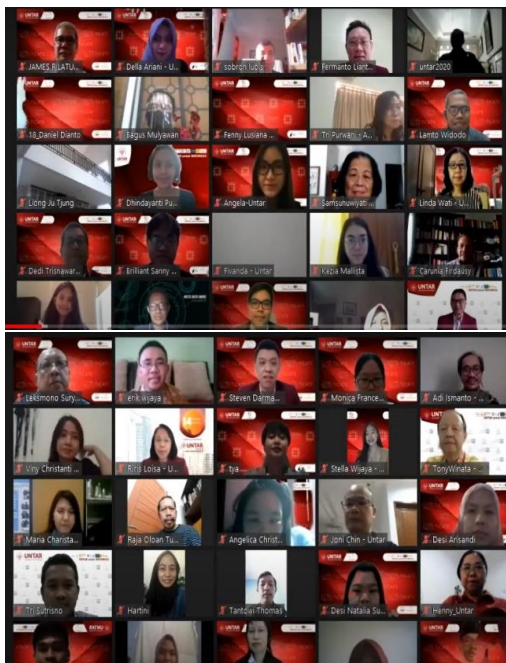
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## Analysis of Some Failure Reduction on Primary Pile in The Secant Pile System

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**Abstract.** Retaining wall is a very important structure in the basement construction process. The planning of the retaining wall, whether in the design or in the processing step should be precise, otherwise, it can be disastrous. In the construction process, problems sometimes happen when the excavation process is going on. Therefore, the role of retaining wall is crucial. If the retaining wall doesn't function well, the soil around the excavation site will shift and move and it can cause a rift or even more fatal failures to the structure. The analysis on this study is the failure analysis on retaining wall type secant pile. This analysis will be focusing on the failure that happen on primary pile. The analysis is done by reducing the strength of the primary pile based on the potential failure that might happen. This aims to test the deformation on the secant pile system, if there's a failure on the primary pile. It will be done in two different types of soil, clay and sand.

### 1. Introduction

One of the civil engineering projects is the construction of high rise buildings. It will be used for shops, offices, apartments and others. In urban areas that have limited land, buildings are built vertically because it can't be built sideways. Vertical building construction is an effort to optimize the land that is densely populated and getting expensive every year. Vertical building construction can be done vertically up or vertically down to the underground.

Underground building construction is usually used for basement. Basement can be used for various purposes, such as utility rooms, warehouses, and parking lots. The planning of basement itself must have the right design and the step of construction must be precise so it didn't cause failure in the building and surrounding buildings. In the construction of a basement, retaining walls are needed. Retaining wall is needed in order to hold the soil during the basement excavation process. In densely populated city centers, the number of excavations increases every year [1]. Structures in the immediate vicinity of excavations, dense traffic scenario, presence of underground obstructions and utilities have made excavations a difficult task to execute [2].

Therefore, one of the important thing in the construction of a basement is the need for a solid retaining wall structure so that the stability of the soil around the basement is maintained and does not cause movement or deformation in the surrounding buildings that can cause cracks, damage or collapse in the building. In the implementation, damage or failure in the structure of the retaining wall may occur. Failure can occur due to errors in the wall design or in the construction process.

This study will analyze the failure of the retaining wall structure, especially retaining wall type secant pile. Secant pile consists of two different pile characteristics, first is primary pile that contain



bentonite cement and the second is secondary pile, which is a pile made of reinforced concrete. In this study, only the failure on primary pile will be analyzed because bentonite cement require special works compared to reinforced concrete.

## 2. Method and Materials

### 2.1. Sample preparation

The sample consists of two different types of soil, sand and clay. The data that used in this analysis are boring log and laboratory result. If the laboratory result is incomplete, then the correlation of soil data is used to get the desired soil parameter. The soil parameter that used are cohesion ( $c$ ), angle of friction ( $\phi$ ), and unit weight ( $\gamma'$ ).

Here are the soil data and parameters that will be used in the calculation:

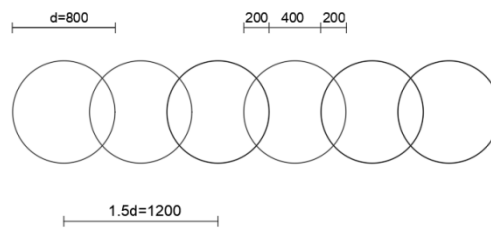
**Table 1.** Clay data and parameter

<i>Depth (m)</i>	<i>High (m)</i>	N-SPT	$c$ (kN/m <sup>2</sup> )	$\phi$ (°)	$\gamma'$ (kN/m <sup>3</sup> )	
0	4	4	7	19	27.5	16
4	5.5	1.5	64	194	27.5	20
5.5	7	1.5	19	70	27.5	18
7	10	3	57	194	27.5	20
10	13	3	28	108	27.5	20
13	16	3	4	18	27.5	14
16	22	6	11	40	27.5	17
22	23.5	1.5	22	82	27.5	19

**Table 2.** Sand data and parameter

<i>Depth (m)</i>	<i>High (m)</i>	N-SPT	$c$ (kN/m <sup>2</sup> )	$\phi$ (°)	$\gamma'$ (kN/m <sup>3</sup> )	
0	3.5	3.5	2	0	26	13
3.5	6	2.5	57	0	35	23
6	8	2	38	0	34	17
8	9.5	1.5	28	0	18	16
9.5	12.5	3	42	0	36	18
12.5	14	1.5	60	0	35	23
14	17	3	45	0	37	19
17	20	3	60	0	35	23

The secant pile wall is used for three story basement, with a 3.2 meter height for each story, so the total height of the retaining wall is 9.6 m and 10 m wide. The diameter of the secondary pile is 0.8 m and the primary pile is 0.4 m. The distance between each secondary pile is 1.2 m. The ground water level is at 0.0 m. The depth of secant pile is calculated until it reaches the hard soil. For clay, the depth of secant pile is 23.5 m and 20 m for sand.



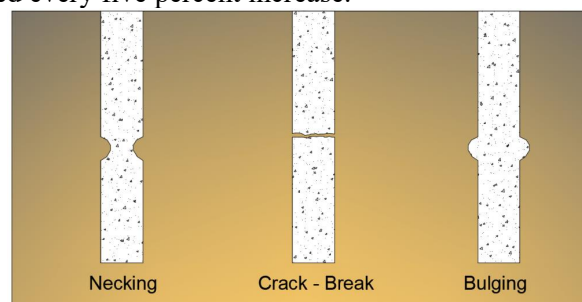
**Figure 1.** Secant pile information

## 2.2. Method

This analysis is done by analysis is done by reducing the strength of the primary pile based on the potential failure that might happen. There are some potential failure that might happen as:

- |  |          |
|--|----------|
| 1. Crack and void                        | : 5-10%  |
| 2. Necking dan bulging                   | : 10-15% |
| 3. Inclusion of foreign material         | : 20-25% |
| 4. Imperfect overlap between the pile    | : 30-35% |
| 5. Casting error of the bentonite cement | : 40-45% |

This percentage of reduction is based on the failed area on the pile from the whole pile. The percentage will be calculated every five percent increase.



**Figure 2.** Integrity Problems on Concrete Piles

(<https://www.fprimec.com/6-integrity-problems-of-concrete-piles/>)

This analysis started with the calculation of active and passive earth pressure, based on the Rankine Theory [3]. These are the formula for active and passive earth pressure:

$$K_a = \tan^2 \left( 45 - \frac{\phi}{2} \right) = \frac{1 - \sin \phi}{1 + \sin \phi} \quad (1)$$

$$K_p = \tan^2 \left( 45 + \frac{\phi}{2} \right) = \frac{1 + \sin \phi}{1 - \sin \phi} \quad (2)$$

After the earth pressure was calculated, the soil pressure should be calculated as well. There are two different formula for the soil pressure. For non-cohesive soil, at the depth of H, pressure P stated in:

$$P = \frac{1}{2} \times \gamma_s \times H^2 \times K \quad (3)$$

As for cohesive soil, P stated in:

$$P = \frac{1}{2} \times \gamma_s \times H^2 \times K + 2c \times H \times \sqrt{K} \quad (4)$$

All overall stability failure modes must be thoroughly checked on the retaining wall, such as:

1. Check for overturning :  $SF = \frac{\sum Mb}{\sum Mo}$  (5)

Where:

$\sum Mb$  = sum of the moments of forces tending to overturn

$\sum Mo$  = sum of the moments of forces tending to resist overturning

$$2. \quad \text{Check for sliding : } SF = \frac{\sum Vb}{\sum Vo} \quad (6)$$

Where:

$\sum Vb$  = sum of the horizontal resisting force

$\sum Vo$  = sum of the horizontal driving forces

The safety factor for overturning and sliding on clay is 2 and 1.5 for sand [4].

$$3. \quad \text{Check for bearing capacity failure : } SF = \frac{qu}{\sigma} \geq 3 \quad (7)$$

Where:

$$qu = c \cdot Nc \cdot Fcd \cdot Fci + q \cdot Nq \cdot Fqd \cdot Fqi + \frac{1}{2} \gamma b \cdot N\gamma \cdot F\gamma d \cdot F\gamma i \quad (8)$$

$$\sigma = \frac{V}{b} \left(1 \pm \frac{6e}{b}\right) \quad (9)$$

$$e = \frac{b}{2} - \left(\frac{\sum Mb - \sum Mo}{V}\right) \quad (10)$$

$$Fcd = 1 + 0.4 \left(\frac{D}{b}\right) \quad (11)$$

$$Fqd = 1 + 2 \tan \phi (1 - \sin \phi)^2 \left(\frac{D}{b}\right) \quad (12)$$

$$F\gamma d = 1 \quad (13)$$

$$Fci, Fqi = \left(1 - \frac{\psi}{90}\right)^2 \quad (14)$$

$$F\gamma i = \left(1 - \frac{\psi}{\phi}\right)^2 \quad (15)$$

$$\psi = \tan^{-1} \left(\frac{Pa}{V}\right) \quad (16)$$

Permitted Deflection:

This deflection on the secant pile will be compared with permission limit tolerance based on SNI 8460:2017 [5]. The maximum deflection that permitted is 0.5%H, where H is the depth of the retaining wall. The deflection is calculated with reducing the moment of inertia of the primary pile.

**Table 3.** Inertia Reduction

Percentage (%)	Inertia (m <sup>4</sup> )
0	0.010053
5	0.009550
10	0.009048
15	0.008545
20	0.008042
25	0.007540
30	0.007037
35	0.006535
40	0.006032
45	0.005529

### 3. Results

#### 3.1. The result on clay

The results of the stability check on the retaining wall as follows:

SF overturning	= 2.88	> 2 (OK)
SF sliding	= 0.74	< 2 (Not OK)
SF bearing capacity	= 0.005	< 3 (Not OK)

**Table 4.** Deflection Results on Clay

Percentage (%)	Deflection (cm)		Total (cm)	Permitted Deflection (cm)	Check
	Soil	Water			
0	4.36	4.15	8.51	11.75	OK
5	4.37	4.16	8.53	11.75	OK
10	4.39	4.17	8.56	11.75	OK
15	4.40	4.19	8.58	11.75	OK
20	4.41	4.20	8.61	11.75	OK
25	4.42	4.21	8.63	11.75	OK
30	4.43	4.22	8.66	11.75	OK
35	4.45	4.23	8.68	11.75	OK
40	4.46	4.24	8.70	11.75	OK
45	4.47	4.26	8.73	11.75	OK

### 3.2. The result on sand

The results of the stability check on the retaining wall as follows:

SF overturning	= 7.90	> 1,5 (Ok)
SF sliding	= 1.41	< 1.5 (Not OK)
SF bearing capacity	= 0.0001	< 3 (Not OK)

**Table 5.** Deflection Results on Sand

Percentage (%)	Deflection (cm)		Total (cm)	Permitted Deflection (%)	Check
	Soil	Water			
0	18.73	2.27	21.00	10	Not OK
5	18.79	2.27	21.06	10	Not OK
10	18.84	2.28	21.12	10	Not OK
15	18.89	2.28	21.18	10	Not OK
20	18.94	2.29	21.24	10	Not OK
25	19.00	2.30	21.30	10	Not OK
30	19.05	2.30	21.36	10	Not OK
35	19.11	2.31	21.42	10	Not OK
40	19.16	2.32	21.48	10	Not OK
45	19.21	2.32	21.54	10	Not OK

## 4. Conclusion

The check of retaining wall stability shows that both on clay and sand, the secant pile wall is safe against overturning but it can't resist the sliding and bearing capacity of the soil behind the wall. Furthermore, on sand, the deflection did not fulfill the permitted deflection so any failure should not happen on the pile. Otherwise, on clay, the deflection did fulfill the permitted deflection on those five failure that had been mention before ao the failure may occur on the pile. It can be strengthened in several ways, such as grouting to fill cavities on walls and the use of ring beam or anchor reinforcement.



## 5. References

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