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RESEARCH ARTICLE

Safety Factor Analysis on the Stability of the Retaining Wall Structure in Cimahi City, Indonesia

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Abstract

Retaining wall is a construction built to hold the ground on the slopes. Retaining wall can be said to be safe if its safety factors have been taken into account.In this study will be calculated the security factor based on SNI 8640:2017 on the location to be built retaining wall located in the area of Cimahi City, West Java using the help of software with two-dimensional finite element method.Based on the soil type map, the majority of the Cimahi City area consist of Tuffaceous Clay and Sandy Clay soils, which are alluvial fan deposits of volcanic origin, with soil thickness ranging from 1 m to 5 m. Retaining wall structures using cyclopean concrete appear to be slimmer compared to those using stone masonry. The use of dolken wood piles as additional reinforcement in locations using cyclopean concrete can strengthen the structure on the sliding plane, thus preventing overturning. Based on the modeling, the use of this structure resulted in a safety factor value greater than 1.5, with a displacement of 20 cm.

Keywords: Cimahi, Retaining Wall, Safety Factor

1. Introduction

Retaining wall is a construction built to hold the ground on the slopes. The construction of the land wall should be based on the calculation of stability and safety factors, as it can result in fatal consequences related to deaths and loss of property if there is a mistake in the construction of retaining wall. Retaining wall can be said to be safe if its safety factors have been taken into account. The calculation on the stability of retaining wall is one of the important aspects because it can affect the wall itself (Putri, 2017).

In addition to the calculation of the dimensions used, when designing the soil wall, it is necessary to take into account the loads that work on the ground wall itself, for example the weight of the ground itself and other additional loads. To calculate these loads there are binding rules as described in SNI 1727:2013.

Fig. 1. Research location of Center Cimahi District

In this study will be calculated the security factor based on SNI 8640:2017 on the location to be built retaining wall located in the area of Cimahi City, West Java using the help of software with two-dimensional finite element method. This analysis is done to obtain SF values on condition after reinforcement. The location of the work to be carried out is in Cimahi City with the following details.

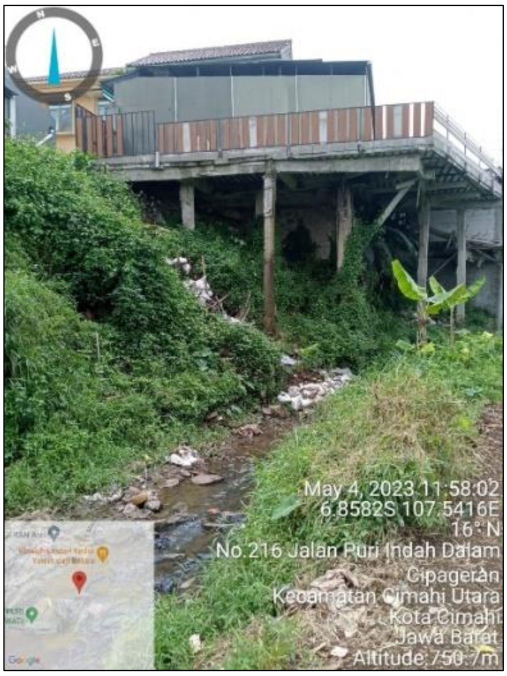

Fig. 2. Research location of North Cimahi District

Fig. 3. Research location of South Cimahi District

2. Literature review

2.1 Soil

The soil is formed by the melting of rocks that are mixed with the remains of organic material of organisms (plants or animals) that live inside or on it. In addition to the soil there are other components, air and water (Bintoro et al., 2017). In addition to the mixing of mineral and organic materials, in the process of soil formation formed also layers of the soil or horizons (Arifin et al., 2018).

2.2 Retaining wall

Retaining wall is a building that serves to stabilize certain soil conditions that are generally mounted on unstable cliff areas. The type of construction of the ground wall can be a pair of stones with a mortar, an empty pair of rocks, concrete, wood, and so on (Dinas PUPR Kota Tasikmalaya, 2020).

According to (Tanjung & Afrisa, 2016), retaining wall is a construction that serves as a free ground or natural soil and prevents land collapse in slopes or sloping areas whose strength is not guaranteed by the slope itself. Restrained soil gives an active impetus to the wall structure and makes the structure roll or shift. Retaining walls also serve to support the soil and prevent leakage from either rainwater loads, soil weight, or the loads that work on it.

2.3 Cyclopean concrete

Cyclopean concrete is the same as concrete in general, the difference is that cyclone cement is the aggregate size of which is used relatively large. The used aggregates usually have a size of up to 20 cm, but it is better to use larger aggregate than in general, this does not exceed 20% of the total (Leany, 2019).

2.4 Stone masonry

A retaining wall made of stone masonry is a type of retaining wall constructed using broken stones and cement mortar. This type of retaining wall utilizes the weight of the wall itself to withstand shifting and overturning caused by the pressure of the soil behind it (Bintang & Ardelia, 2017).

2.5 Dolken wood piles

Generally speaking, a pile is a reinforcement that is considered to be a group of rigid cap poles on the ground that receive a horizontal style. The horizontal style is a sliding tension that occurs along the sliding fields (Mochtar, 2000 in Sahara, 2017). A dolken wood is a wood cluster derived from a dark tree that has an average height of 12 m and then is vertically pushed into the soil and aims to increase the land sliding retention.

2.6 Two-dimensional finite element method software

The analysis of this study was carried out using a software of two-dimensional element methods that can analyse geotechnical problems in civil engineering planning and aims to analyse deformation, stability, slope safety factors, groundwater flows and so on in geotechnical engineering. This program is designed to perform geometry making that will be analysed (Sahara, 2017).

2.7 Safety factor

The safety factor is a factor that indicates the level of ability of a material to accept a load, both pressure and pull. This factor is related to the ratio of the allowable stress with the maximum stress generated (Mulyatno et al., 2014).

3. Research method

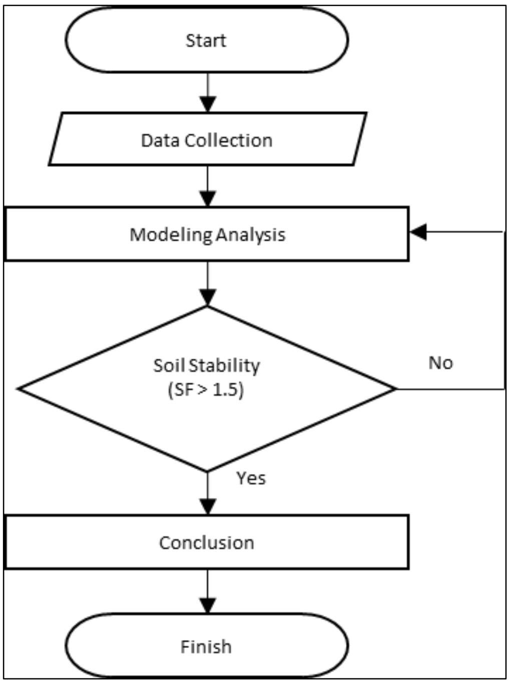

Fig. 4. Research flowchart

The concept of this research is to get an idea of the conditions at the research site. There are several processes in dealing with this, the first step is to collect data consisting of soil type maps and sondir data, and then the data is processed into analysis. If the soil stability of the analysis results is ≠ or ≤ 1.5, then it is necessary to re-analyses until obtaining SF value ≥ 1.5. After the results of analysis are obtained then draft conclusions and recommendations.

4. Analysis results

4.1 Soil data

According to the Groundwater and Environmental Geology Center of Bandung in 1996, the types of soil found in Cimahi City are highly diverse, including andesite rock, clay and sandy clay, sandstone, conglomerate and tuffaceous sandstone, tuffaceous clay, and silty clay.

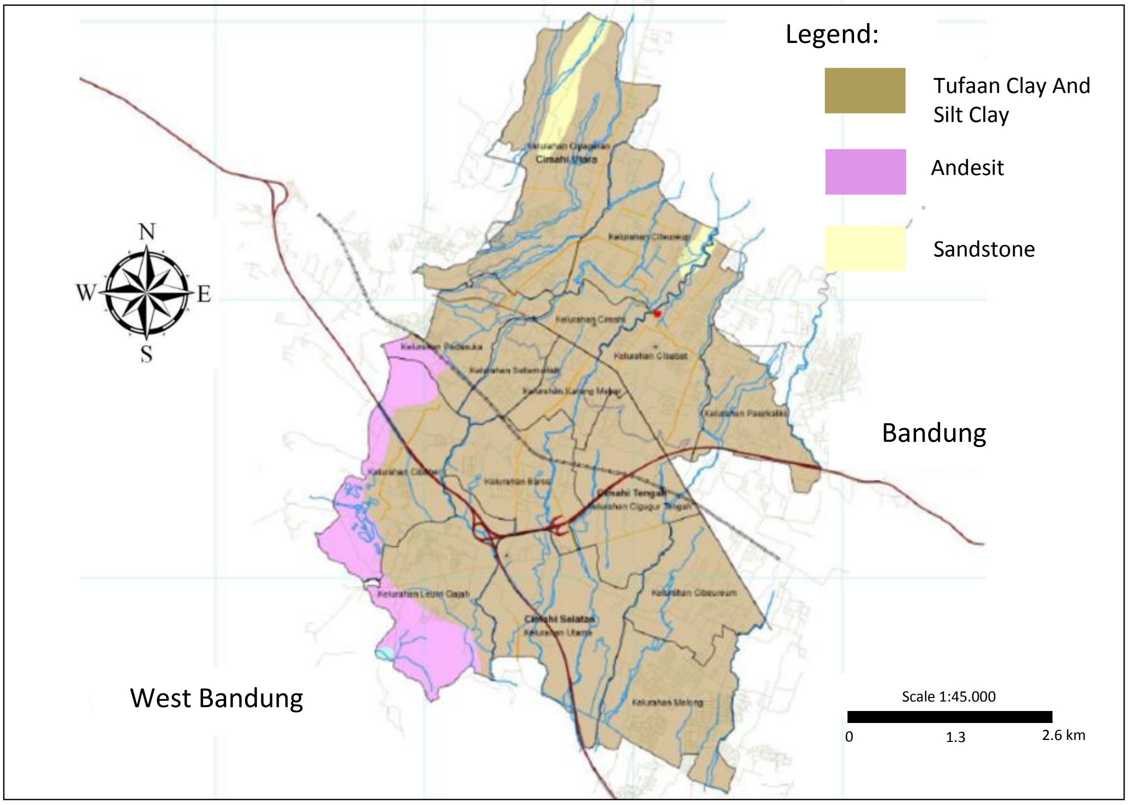

Fig. 5. Soil type map of Cimahi City (Fansuri, 2017)

The following are the cone penetration test data obtained from the research site.

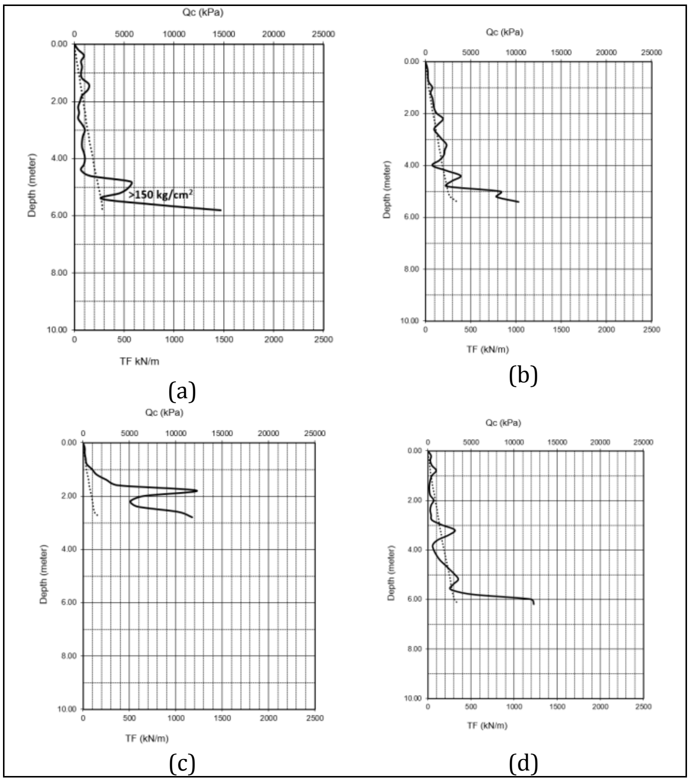

Fig. 6. (a), (b), (c), and (d) Results of the cone penetrations test data

The assumption of the soil parameters entered in the modeling is as follows.

Tabel 1. Soil parameters (Bowles, 1997; Robertson, 2010; Schmertmann, 1970; Srihandayani, 2017; Terzaghi et al., 1984)

Soil Type	Soil Parameters	Value	Unit
Clays	*γunsat*	16.0	kN/m^3
	γsat	18.0	kN/m^3
	Permeability	0.009	m/day
	Modulus Young (E)	2000	kN/m^2
	Poisson's Ratio (v)	0.20	-
	Cohesion (c)	20.5	kN/m^2
	Shear Angle (Ø)	20.0	°
Silty Clays	*γunsat*	18.0	kN/m^3
	γsat	18.0	kN/m^3
	Permeability	0.009	m/day
	Modulus Young (E)	3000	kN/m^2
	Poisson's Ratio (v)	0.2	-
	Cohesion (c)	16.0	kN/m^2
	Shear Angle (Ø)	14.0	°
Sandy Silts	*γunsat*	19.5	kN/m^3
	γsat	21.0	kN/m^3
	Permeability	0.09	m/day
	Modulus Young (E)	3000	kN/m^2
	Poisson's Ratio (v)	0.2	-
	Cohesion (c)	24.0	kN/m^2
	Shear Angle (Ø)	22.0	°
Silty Sands	*γunsat*	19.0	kN/m^3
	γsat	21.5	kN/m^3
	Permeability	90.0	m/day
	Modulus Young (E)	21000	kN/m^2
	Poisson's Ratio (v)	0.25	-
	Cohesion (c)	29.0	kN/m^2
	Shear Angle (Ø)	26.0	°
Sands	*γunsat*	21.0	kN/m^3
	γsat	22.0	kN/m^3
	Permeability	90.0	m/day
	Modulus Young (E)	45000	kN/m^2
	Poisson's Ratio (v)	0.25	-
	Cohesion (c)	30.0	kN/m^2
	Shear Angle (Ø)	35.0	°

4.2 Specifications of reinforcement materials

The following are the specifications of the material used.

Tabel 2. Cyclopean concrete material (Hariyadi & Abdurrozak, 2018)

Parameters	Value	Unit
Material Model	Linear Elastic	-
γ_{unsat}	24	kN/m^3
E_{ref}	19500000	kN/m^2
v (nu)	0.150	-

Tabel 3. Stone masonry material (Annisa & Abdurrozak, 2018)

Parameters	Value	Unit
Material Model	Linear Elastic	-
γ_{unsat}	22	kN/m^3
E_{ref}	619900	kN/m^2
v (nu)	0.150	-

Tabel 4. Dolken wood piles (Gasruddin, n.d.)

Parameters	Value	Unit
Material Model	Elastic	-
EA	1000000	kN
$L_{spacing}$	1	m

4.3 RW 09 Cipageran, North Cimahi District

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.66 > 1.50 with the maximum global shift that occurred was 0.049 m or 4.9 cm, so it can be said that this structure is safe (Badan Standardisasi Nasional, 2017).

On the structure a house load of 40 kN/m² (Badan Standardisasi Nasional, 2013) and a 1 m long dolken wood pile was installed in the foundation to strengthen the structure of retaining wall.

The soil condition on each modeling was made with the worst assumptions, so the resulting SF was assessed far safer than the actual conditions at the site of the study.

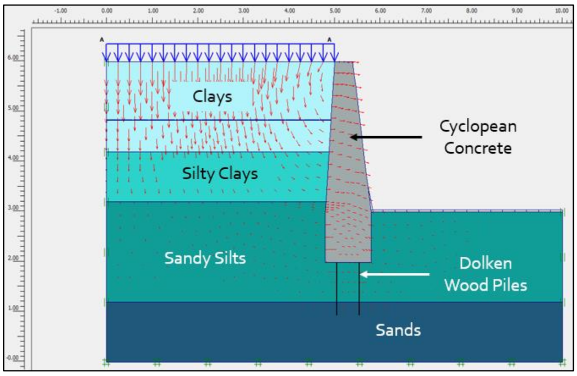

Fig. 7. The modeling results of the retaining wall at location RW 09 Cipageran

4.4 RW 26 Cipageran, North Cimahi District

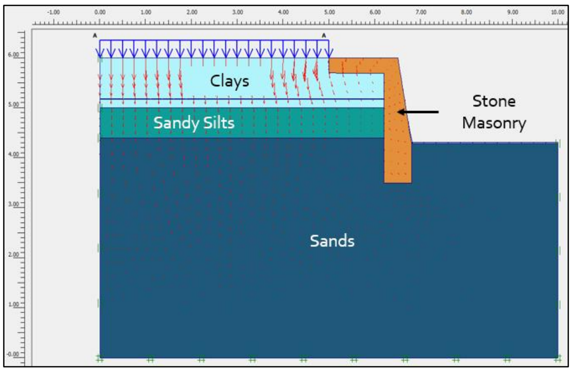

Fig. 8. The modeling results of the retaining wall at location 1 RW 26 Cipageran

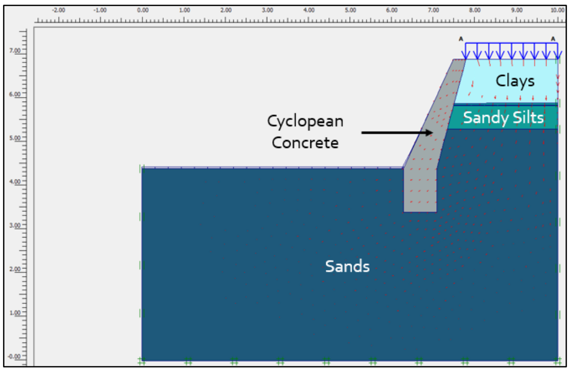

Fig. 9. The modeling results of the retaining wall at location 2 RW 26 Cipageran

Based on the modeling results it was found that reinforcements with the retaining wall plan yielded SF values at location 1 = 3.20 > 1.5 and location 2 = 1.91 > 1.5, so it can be said that the structure is safe. The structure used at location 2 is planned with cyclone concrete material, so it can be slimmer.

In both locations, a home load of 40 kN/m² is included.

4.5 RW 13 Pasirkaliki, North Cimahi District

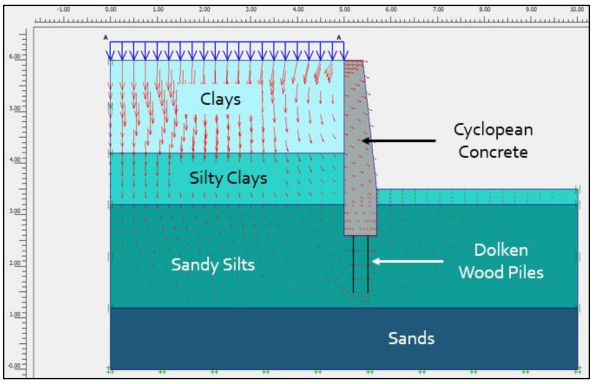

Fig. 10. The modeling results of the retaining wall at location RW 13 Pasirkaliki

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.76 > 1.50 with the maximum global shift that occurred was 5.7 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.6 RW 06 Central Cigugur, Central Cimahi District

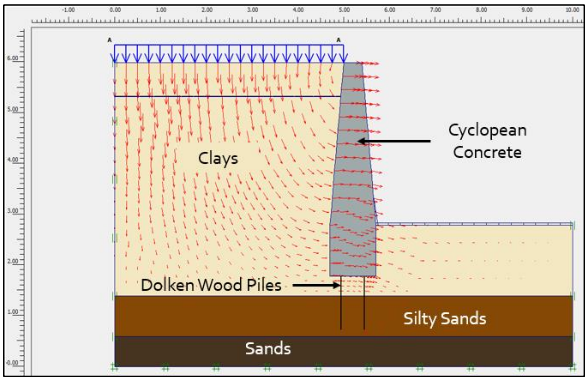

Fig. 11. The modeling results of the retaining wall at location RW 06 Central Cigugur

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.54 > 1.50 with the maximum global shift that occurred was 8.7 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.7 RW 09 Central Cigugur, Central Cimahi District

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.94 > 1.50 with the maximum global shift that occurred was 10 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

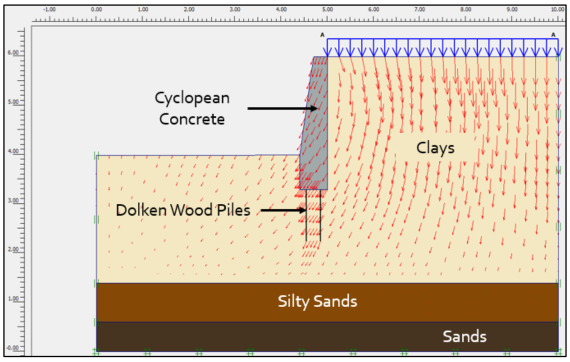

Fig. 12. The modeling results of the retaining wall at location 1, RW 09 Central Cigugur

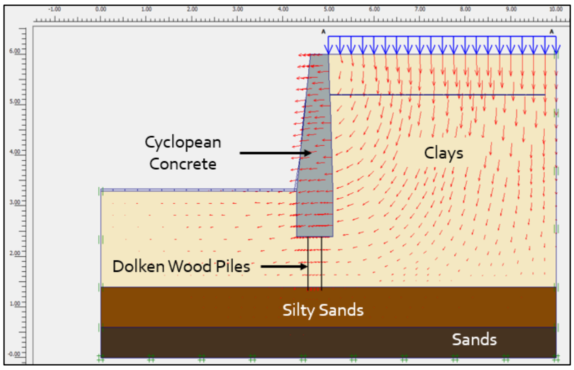

Fig. 13. The modeling results of the retaining wall at location 2, RW 09 Central Cigugur

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.62 > 1.50 with the maximum global shift that occurred was 8.6 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

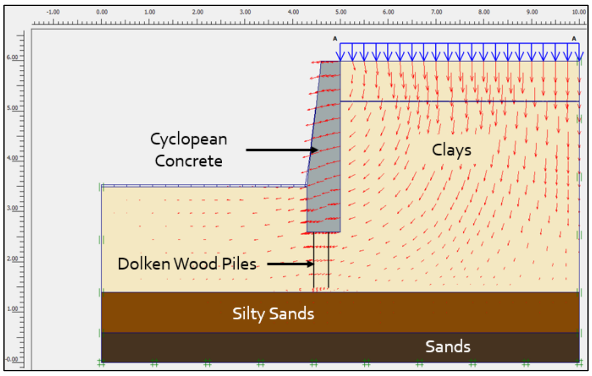

Fig. 14. The modeling results of the retaining wall at location 3, RW 09 Central Cigugur

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.71 > 1.50 with the maximum global shift that occurred was 8.6 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.8 RW 21 Baros, Central Cimahi District

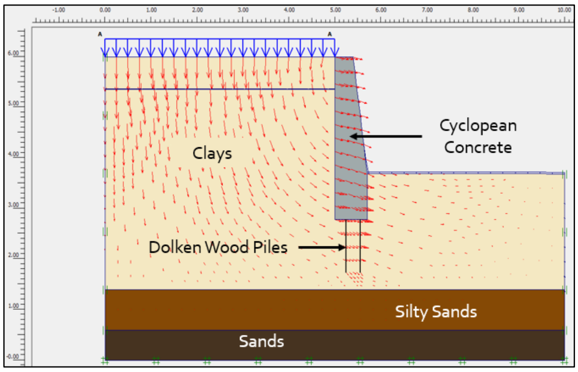

Fig. 15. The modeling results of the retaining wall at location RW 21 Baros

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.72 > 1.50 with the maximum global shift that occurred was 8.6 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.9 RW 10 Melong, South Cimahi District

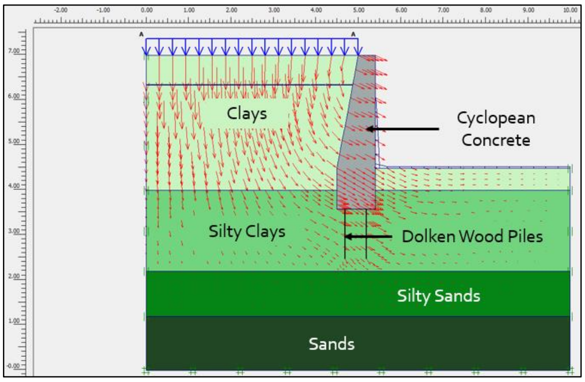

Fig. 16. The modeling results of the retaining wall at location RW 10 Melong

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.59 > 1.50 with the maximum global shift that occurred was 8 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.10 RW 07 Utama, South Cimahi District

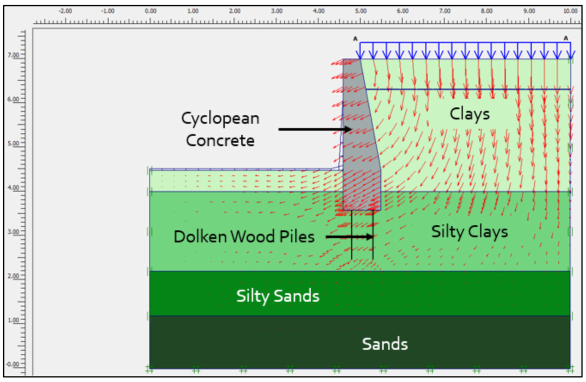

Fig. 17. The modeling results of the retaining wall at location RW 07 Utama

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.59 > 1.50 with the maximum global shift that occurred was 8 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

4.11 RW 05 Leuwigajah, South Cimahi District

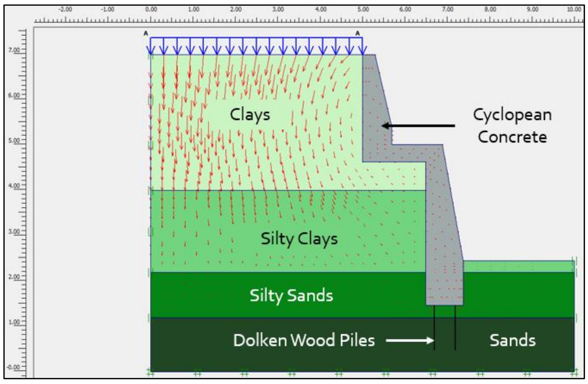

Fig. 18. The modeling results of the retaining wall at location RW 05 Leuwigajah

Based on the results of the modeling, it was found that the soil reinforcement with the retaining wall plan produced SF 1.66 > 1.50 with the maximum global shift that occurred was 10 cm, so it can be said that this structure is safe. On the structure a house load of 40 kN/m² was inserted and a 1 m long dolken wood pile was installed on a foundation to strengthen the structure of retaining wall.

5. Conclusion

The conclusions drawn from the analysis of this research are as follows:

a. Based on the soil type map, the majority of the Cimahi City area consist of Tuffaceous Clay and Sandy Clay soils, which are alluvial fan deposits of volcanic origin, with soil thickness ranging from 1 m to 5 m.
b. The modeling results indicate that the wall structure, constructed with cyclopean concrete, has a safety factor value greater than 1.5, with a displacement of 20 cm.
c. All soil conditions in each modeling are assumed to be in their worst condition, so the resulting SF values are much safer than the actual condition at each research location.
d. Retaining wall structures using cyclopean concrete appear to be slimmer compared to those using stone masonry.
e. The use of dolken wood piles as additional reinforcement in locations using cyclopean concrete can strengthen the structure on the sliding plane, thus preventing overturning.
f. In the design of the retaining wall, it is necessary to place pipelines into the body of the wall at a specific distance. These pipelines will function as water outlets, effectively mitigating the water pressure exerted on the structure.

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