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Original Article

Solution Buildings and Infrastructure Prevented Slides on Expansive Soils of Simple Method Load-Channeled and Naturally

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Abstract *- The research location was in Tangkil village, Citeureup, Indonesia, with fertile soil, narrow land, contoured land with 11 buildings, and some infrastructure. Objective: The infrastructure and buildings built in a narrow area that meets engineering standards and adjusted design life. Even though the building was built in expansive soil and easy landslide, ground and surface water flew through the subdrainage, and the soil was retained with retaining wall structures and counterfort. Observations at the project site, secondary data in the form of geology, hydrogeology, and soil tests topography. The novelty was that the building and infrastructure were successful, and no more repairs existed. The cost of the structure being built was cheap because the water pressure channeled horizontally through PVC AW pipes to o burden the structure. The little residual force accepted the structure so that the building and infrastructure did not crack and tilt. The solution must be easily understood by field engineers. The retaining wall was placed under the stairs of the building, so I did not see it. The solution applied to all countries where fertile soils and existing land contours had to be preserved for natural balance and environment friendly.*

Keywords *- Expansive soil, Sliding, Sub drainage, Retain soil fertility, Retained contour land, No shear collapse occurs.*

1. Introduction

Koesoemadinata (1963) and [1] Bemmelen (1949) had almost the same assumptions about tectonic events that occurred in the Bogor Zone [2] (ESDM, 2011). Two tectonic periods occurred in the Bogor zone, i.e., the Intra Miocene tectonic period and the Plio-Plistocene tectonic period. As for the Bogor-Jakarta area, Sukardi (1982) distinguished it into Tertiary Tectonic and Quarter Tectonic (Neotectonic). In the Plio-Plistocene Tectonic Period, there was also a process of folding and enlargement caused by Northward-facing forces. The force was caused by subsidence in the Northern Bandung Zone, then created strong pressure in the Bogor Zone and formed a folded structure, and the fault rose to the North. Furthermore, Sukardi (1986) explained that perhaps this Plio-Plistocene tectonic movement was one of the reasons why the Northern region was not exposed to (unaffected) Tertiary rocks. This was due to the existence of transverse fractures that more or less lead North-Northwest to South-Southeast.

Table 1. Clay minerals relation with sentul area activity (Skempton, 1953)

No	Sample	IP	% Clay	Activity	Clay Mineral
1	TS.1	43,55	37	1,177027	Illite
2	TS.2	41,39	44	0,9406818	Kaolinite
3	TS.3	14,95	4	3,7375	Ca – Montmorillonite
4	TS.4	35,32	29	1,217931	Illite
5	TS.5	55,14	59	0,9345763	Illite
6	TS.6	52	53	0,9811321	Illite
7	TS.7	35,39	43	0,8230233	Kaolinite
8	TS.8	60,81	48	1,266875	Illite

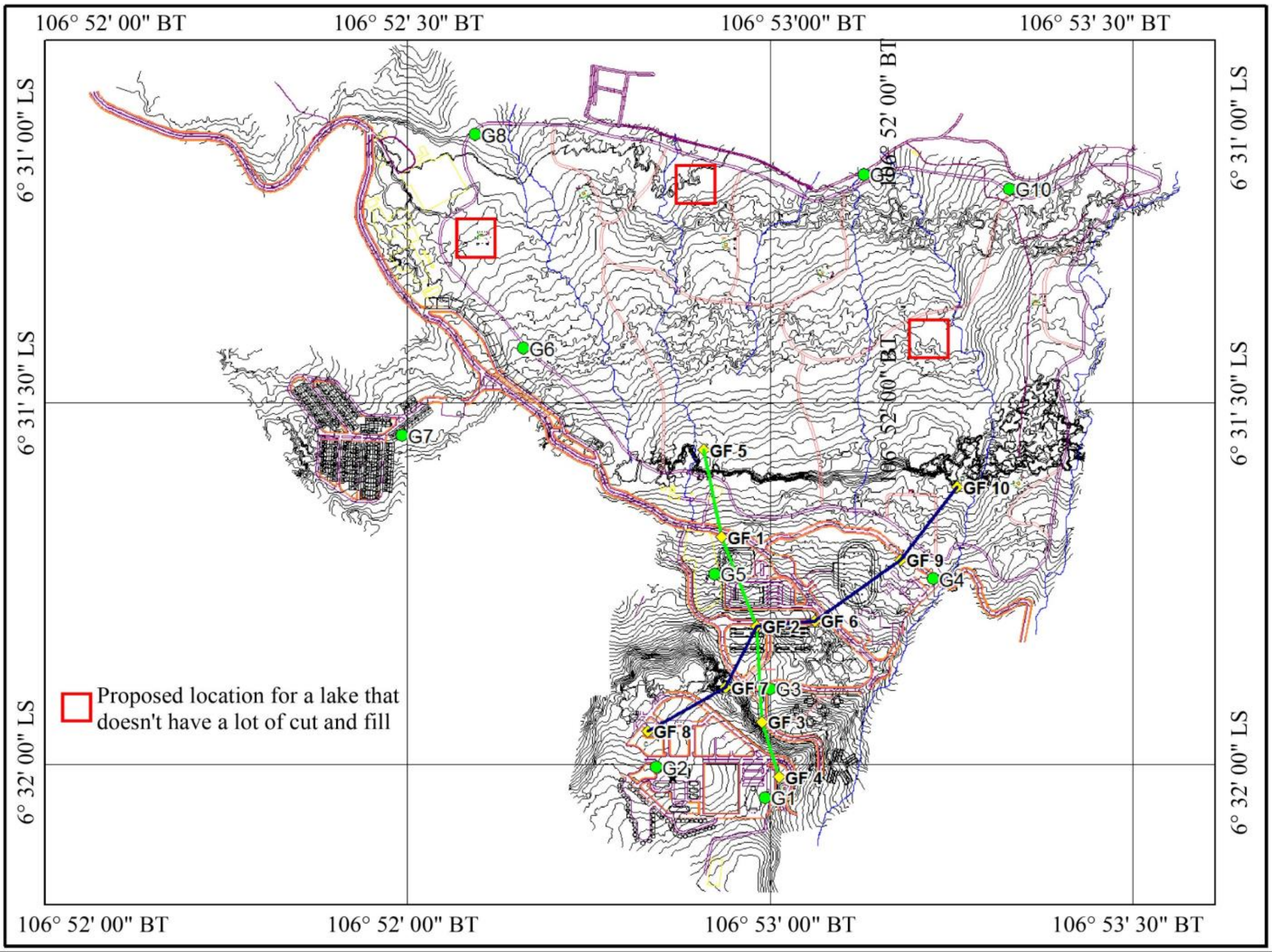


Fig. 1 Location TS1 until TS8

Excess water is a disaster for buildings on expansive soil; sub-drainages are installed under houses, roads, and solutions to overcome excess water. The potential sliding should be prevented from high to low contours, maintain the terraced and absorb water. Driscoll, R. (1983) [3].

The building does not move in the area of sliding potential by creating retaining walls that provide strength. The lower and upper structures calculated the workload. The structure does not withstand all forces, but the surface water distributed channeled does not compress the structure, so it is cheap and has a long life. Bo Chen, et. al. (2020) [4].

Expansive soil solutions were suitable for community settlement conditions; as far as possible, the steady natural environmental conditions used local materials for ease of construction.

Planted trees should have roots preventing landslides and absorbing water, such as mahogany trees for highland locations and some land vertical drains to collect surface water to absorb groundwater.

Solving cases, of course, had financial and non-financial effects, utilizing useful local materials at an optimal cost. Provide achieved safety solutions forever. Expansive soil has the potential to shrink and expand because the water content was content changed. The upper structure settlement was not uniform. Chen, F.H. (1988) [5].

H2O ions structurally bind the expansion soil of the montmorillonite mineral, and it is very easy to infiltrate, so the montmorillonite mineral is very unstable under stagnant conditions Liu et al. (2014),[6]; water easily seeps into the cracks of the dry layer so that the minerals shrink.

The 3 components of soil consist of solid materials, water, and air [7] Al-Rawas, A.A. et al. (2016). Soil technical properties are affected by water and air. The soil is said to be saturated if the voids are filled with water and the water content is zero when the soil is dry.

Expansive soil characteristics are different from other soil types, namely:

1. Clay changes in volume; the mineral content of clay is usually montmorillonite or vermiculite, where acyl and kaolinite expand into very fine particles.
2. In soil Chemistry, increasing the concentration and valence of cations can inhibit soil development.
3. With a high plasticity index, plasticity, and the liquid limit of the soil, the swelling potential is greater.
4. In infrastructure or building structure solutions, clay tends not to be cheap compared to other soil structures.
5. The high dry density possessed by the dry weight of the soil indicates a small particle distance, meaning large repulsive forces and high expansion potential.

Changes in relatively low water content must be retained so that the nature of the expansion of the soil in the dry season changes to the rainy season, and there is no significant change in volume. Or by changing the properties of the clay. Based on some references that are,

1. Holtz and Gibbs (1956)[8] classified the degree of shrinkage based on plasticity index, colloid content, and shrinkage limit.
2. Chen (1965)[5], refers to the Fluid Limit. Classifying the degree of land development. Chen (1988) refers to the Plasticity Index class as satisfying the degree of swelling of the soil.
3. Raman (1967) [9] classification of expansive soil refers to the shrinkage and plasticity index, a classification of the degree of soil development.

Table 2. below, three expert statements indicate Plastic Index > 32, Holtz and Gibbs (1956): Shrinkage limits, Roman (1967), different shrinkage index. The colloid content was proposed by Holtz and Gibbs (1956), 2 greatly different experts between Holtz and Gibbs (1956)>30 Chen>10 (1965), for very high expansive soils.

This study encourages reducing the amount of cement used in soil stabilization. The cementation formation, such as Calcium Aluminum Hydrate (CAH) in the good treatment samples of the triaxial test results, was observed, and newly formed compounds were cleaner and more sustainable environment for using RT (Recycle Tile). AL-Bared, M.A.M, *et. al.* (2019). [10]

The peak value of shear strength increases and decreases when the suction exceeds a specific value of the corresponding peak shear strength. Bo. C, *et. al.* (2020). [4]

Comparing the unsaturated soils from several real cases, the shear strength theory validated the accuracy and rationality of this model. The five parameters (for the effective stress model) or six parameters (for the shell casing model) are these formulae have the convenience and flexibility, the MC strength parameter of the saturated soil, and the installation parameters of SWCU Genuchten van UKSW DengD *et al.* (2020). [11]

The difference between the pseudo-dynamic and the pseudo-static approaches was drawn from the conservative method, but it still gives a fairly precise result as the pseudo-dynamic approach. The soil structure is small if the seismic wavelength value is high or large. Huang, Q. *et. al.* (2020). [12]

The suction valve in the CWCC (constant water content triaxial compression) test because the cavitation phenomenon does not limit SSM (The Suction stress-SWRC Method). The application of SSM is expected to reduce the time required and the projected costs with additional equipment, such as a pore water meter, in the CWCC test. Kim B-S, *et. al.* (2019). [13]

The experimental data is to predict vertical degression (sp), horizontal deformation (hdp), and slope (tp) of the reinforced square sand footing at each applied load where the dependent variables are predicted to decrease (sp), horizontal deformation (hdp) and slope (tp), respectively. Kaur, A. and Kumar, A. (2016) [14]

The sand layer interface and the angle of internal friction increase with increasing relative density and decrease with increasing oil content. The oil properties (particularly viscosity) play a major role in the interface frictional behavior. The SS interface of shear strength is always higher than the soil-material interface. Although the friction angle of sand contaminated with viscous liquid has decreased dramatically, it is compensated by the adhesion and cohesion formed between the soil grains and the construction material. Mohammadi, A, *et. al.* (2020). [15]

Table 2. Plasticity and shrinkage index underlying the expansive soil classification index

Data based on index tests								
CC *1	PI*1	PI *2 (1988)	PI*3	SI(%)*3	SL *1	PE*1	PE *2	DOE
>28	>35	>35	>32	>40	<11	>30		Very.High
20-31	25-41	20-55	23-32	30-40	7-12	20-30		High
13-23	15-28	10-35	12-23	15-30	10-16	10-20		Medium
<15	<18	0-15	<12	<15	>15	<10	<1	Low

Description: a. SL = shrinkage Limit. b. SI = Shrinkage Index. c. PI = Plasticity Index.

d. DOE = Degree of Expansion. e. CC = Colloid Content (% minus 0.0001 mm)

The larger S1 structure illustrations with greater sway and less sliding response due to the SSSI effect, while the increased shear response and structural stiffness due to shock and decrease in the moment-to-shear ratio (M/HL) of the S2 structure tend to slide more than the reference test. NgoV-L, *et. al.* (2019) [16]

A significant change in volume with increasing water content during the rainy period so that the shallow avalanche of the original slope surface is not saturated and will show changes. The characteristics of the suction matrix and shear strength, including the change in stress distribution with depth and time. Q, *et. al.* (2019). [17]

The sample with three ordinary sand columns (OSC) of the final bearing capacity was finally about 11% greater than the sample with OSC. The effect of the number of horizontal reinforcement layers, the length of the vertical package, and the number of sand columns were investigated, and the increased economy and bearing capacity.

In addition, the comparison of the reinforcement modes of the four horizontal layers of the geotextile achieves similar performance to high column wrap geotextile to the 50% from the point of view of increasing strength, while the geotextile required to wrap one column is approximately 2.5 times of the required geotextile for four layers (Shamsi, M. *et al.* 2019). . [18]

The decrease in efficiency of the grouting process until the completion of grouting will continue to decrease as time goes by. The three-dimensional predictive model of the proposed dynamic relationship with the grouting tie complements the grouting's compaction radius, which can more accurately evaluate the effectiveness and efficiency. (Xu, X-H, *et. al.* 2020). [19]

1.1. Objective

To build infrastructure and buildings on a narrow area, expansive soil must be careful, and the existing horizontal forces must be partially removed at all times so that each building and infrastructure does not collapse or break down.

The solution must be cheap and easy to construct, and groundwater must be channeled, maintaining the contours of the soil.

Overcoming a large area in the project must be practical, not theoretical, easy to digest by executors and project supervisors, easy to implement, and quick to install.

This work provides a solutions project work so that all parties can accept it and does not cause landslides, cracking, or damage; it is easy to implement quickly and has been tested since 2012, and all buildings and infrastructure are made without any indication of possible failure building.

2. Material and Method

Case study methodology survey results were to overcome cracks, sloping buildings, and infrastructure over ground that was easy to slide with direct surveys and provided solutions based on primary and secondary data, with the philosophy of horizontal forces at all times pressing the building must be partially distributed.

The residual load accepted structure concrete so that the structure concrete did not have to have large dimensions and its service life could be longer. Observation of primary land data in the field was:

1. Color of soil, properties of soil,
2. Surface water from the hill is very heavy, the direction of the water flow, the water discharge is large,
3. The behavior of soil is easy to slide, ground cracks thoroughly in hot the season,
4. A stone with a diameter of 3 m was only embedded and shifted 2 m in just one night,
5. The difference in the contours of the hills and lowlands with a large surface water content is the main effect of shear,

Secondary data:

1. Data from the geology survey team,
2. Hydrogeology, rock data, soil history of geology, the survey team,
3. Soil investigation, Result of laboratory and site land,
4. Precipitation and hydrology analysis from hydrologists,
5. Topography survey,
6. Indonesian Concrete Standard, Indonesian Load Standard, Indonesian Earthquake Standard.

Note: Vertical force of building load according to Indonesia Standard Code.

3. Result

Soil fertility and groundwater had to be retained as a source of life. The buildings and infrastructure were successfully constructed and operated, with no repeat construction or repair, so all the first was constructed and operated with no problem. The author analyzes the philosophy that the load was not all restrained but partially distributed through high-quality horizontal pipes and flexible, the remaining forces restrained so that the structure became inexpensive. It hoped that the structure was not long fatigued. The pipes were not easily broken if the earthquake shook, and if broken, still available holed former pipe covered geotextile so surface water flow. The results of the above-mentioned slope stability analysis showed that generally, the Northern area composed of clay from the Jatiluhur formation expands at an angle of 21° if a safety grade of 1.75 is used. The area had a slope, and the stability was below the allowable safety grade (Table 1). Clays with a thickness of 5 m generally had a safety grade of < 1.75, only at locations TS. 8 above the safety level of 1.75 on the condition that the area must have good drainage so that the clay can be dry. Security grade > 1.75 could be achieved at locations TS. 6 and TS. 8, with the thickness of the clay layer only 4m.

4. Discussion

To build infrastructure and buildings in a narrow area, one had to be careful so that the construction of infrastructure and buildings did not affect each other and cause damage Nelson J.D, Miller D 1992 [20]. Expansive soil used for the multi-storying of more than 2 floors should use a deep foundation. However, horizontally, the force is retained with a retaining wall and counterfort while building with a maximum of two floors and infrastructure used circle concrete pipes is put foundation position then took soil in the circle pipe concrete pushed downed then installed a reinforced bar and pour concrete. So, the original soil did not change its position, so it did not have landslides.

Soil classified as unstable can damage buildings and building infrastructure. A very high rate of expansion and shrinkage of the soil became very dangerous; the soil stabilization method was one of the efforts to obtain soil properties that meet engineering requirements. The expansive soil at Tangkil Village, according to Table 3 below. Longer slope gradient conditions than the undersized thickness may be considered that the slope of the slope is unlimited. Based on the above, in analyzing the stability of the slopes is used the method proposed by Duncan *et. al.* (1987)[21]. Data from undisturbed samples were obtained from the field (Figure 2) and used the slope of 21° according to slope measurement, and it was assumed that clay thickness of 5 m and 4 m.

Table. 3 The classification of expansive soil - Location in the Tangkil villages Kec. Citeureup. Sentul is based on the Atterberg Limit Test

No	Depth	Atterberg Limit Test			Degree of Expansive according to:			
DB	Sample	LL	PL	PI	Holtz & Gibbs	Chen	Chen	Raman
	(m)	(%)	(%)	(%)	(1956)	(1965)	(1988)	(1967)
1	1.50 - 2.00	73.70	47.08	26.62	High	Very High	High	Very High
	11.50 - 12.00	62.50	42.53	19.97	High	Very High	Medium	Medium
	13.50 - 14.00	63.40	37.71	25.69	High	Very High	High	Very High
2	1.50 - 2.00	76.10	40.32	35.78	Very High	Very High	Very High	Very High
	5.50 – 6.00	74.50	37.03	37.47	Very High	Very High	Very High	Very High
3	1.50 – 2.00	70.00	38.16	31.84	High	Very High	High	High
	7.50 – 8.00	73.00	34.77	38.23	Very High	Very High	Very High	Very High
	9.50 – 10.00	80.20	37.09	43.11	Very High	Very High	Very High	Very High

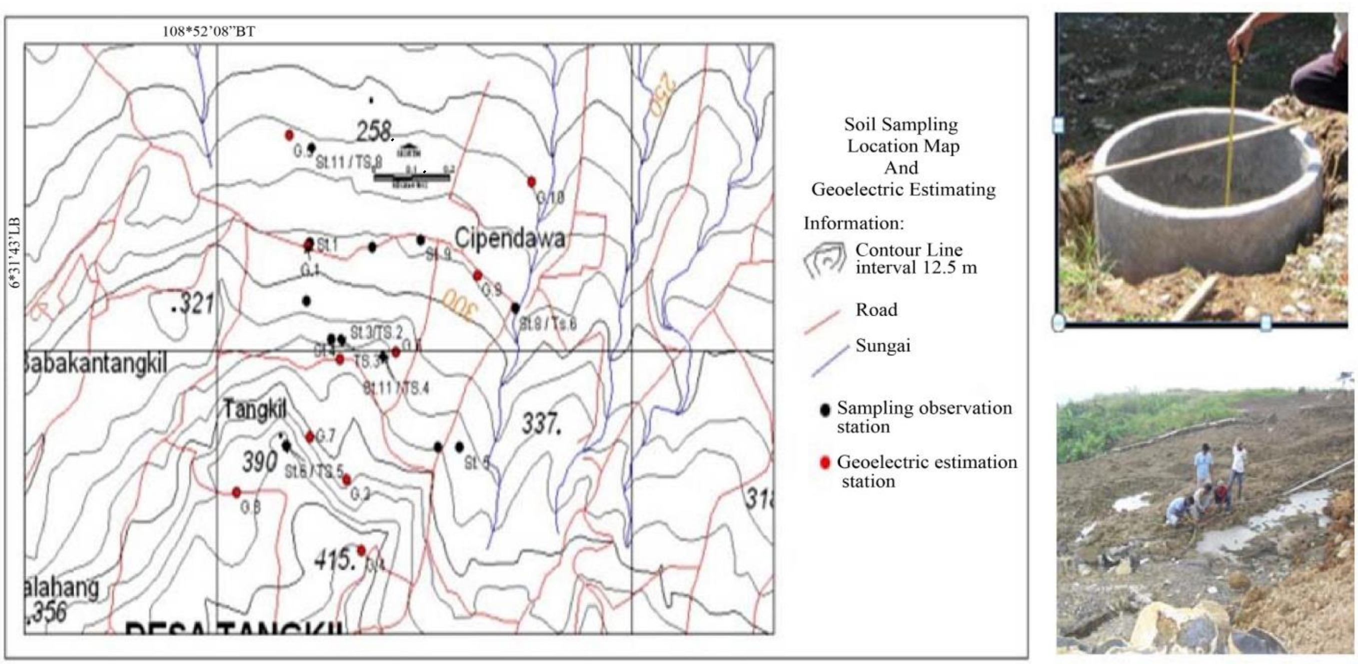


Fig. 2 Land location sampling map and existing soil with well foundation solutions to overcome sliding

The stability of slopes for areas in the Southern area dominated by old volcanic rocks riding on top of clay of Jatiluhur Formation have rock layers slope of N45º E/14º (Measurement at)

$$FS_2 = \frac{\sum \{[cb + (W - ub) \tan \Phi] \, 1/M(\theta)\}}{\sum W \sin\theta} \quad (1) \ \&$$

$$M(\theta) = \cos\theta \left(1 + \frac{\tan \tan\Phi}{FS_1}\right) \quad (2)$$

W = weight
θ = slope of the land
Φ = soil shear angle
cb = soil cohesion value
ub = pore pressure

The calculation of the slope stability can be given the following suggestions:

1. In the Jatiluhur Formation, clay with a position of rock layers parallel to the slope of the ground surface is unsafe for building construction, especially during the rainy season. This is because the calculations generally have a security grade of < 1.75 and a clay layer thickness of> 5 m.
2. On the second terrace or Southern of the Observation Station 4 Cliffs, it is quite safe because it has a security grade of 1.74 and a field of soil layer opposite the slope of the surface.
3. In the Southernmost slope, it is quite safe when the slope angle is supposed to have a slope 25°.
4. Behind the slopes at Observation Station 4, it is quite safe to build the building construction with a border on the sidewalk side of more than 5 m.
5. On the Southernmost slope up to a height of 30 m, passing through the Cliffs to a slope 25°. infrastructure construction.
6. Building construction can be built at the top of the hill; it only needs to be made a border from the Cliffs.
7. In the East, the spread of clay extends to the East side (Observation Station 5); no landslides have occurred at the small tilt of the slope.
8. Lightweight/1st1st-floor construction can be built on the North side by fixing the foundation and spreading out limestone mixed with original soil stirred with a backhoe and was an overlay. Heavy buildings or more than one floor are likely to collapse because it is prone to landslides and damage due to the very expansive nature of clay.

Three types of technical stabilization properties are physical stabilization, chemical stabilization, and mechanical stabilization (Ingles and Metcalf, 1972) [22] with a tilt of 45-50°, limited cost, and narrow land. There is almost no suitable land in the countryside, so the structure of buildings and infrastructure is easy to move and landslides because the soil is very fertile. It is necessary to provide the right solution, namely:

1. Narrow land contours on site 11 of office buildings, classrooms and houses, garages and ceremonial courts, tennis courts, lake utilization contours, site plan symmetry, the effect of active earth pressure and water pressure must be partially channeled so that the force received by the structure is reduced due to water pressure distributed partially through the drainage. Buildings must be isolated from water pressure and active soil pressure.
2. The natural balance is retained with natural conditions or contours that do not change; the distance and height of the land contour are relatively small, so the active force is small.
3. Surface water or groundwater is channeled through sub-drains created at the bottom of infrastructure and housing so as not to compress the structure and not damage the structure.
   Energy loss due to sub-drain is: L.v2 / (D.2g) (3)
   L = length of sub-drain
   D = sub-drain diameter,
   V = flow velocity,
   g = gravity
4. The structure must be stable, rigid, and strong if it experiences together with a decrease or deflection of the building so that it does not tilt or bend by using strong structural material, long life, and a friendly environment.
5. Equipment and tools are easy to use, but they canprevent landslides capability.
6. Two-floor buildings, garages, or one-floor buildings use circular pipe concrete. Others use piles, but points hit chunks of stone at some piling, which must be replaced with round pipe concrete.

Narrow/limited land is used in institutions such as Figure 5; hilly lowlands with many buildings and infrastructure must be careful, especially on land prone to landslides.

Energy loss greatly reduces the horizontal force that presses on the building, so the quality must be good in the sub-drain; attention to pipe thickness and pipe elasticity must be analyzed so that surface water steadily flows properly during high rainfall and earthquakes.

Technical Considerations, including:

1. Chemicals should not be used due to no environmentally friendly, expensive considerations and the reinforcement of retaining walls that receive active soil pressure.
   The circular pipe concrete foundation also supports the load on it.
   The capacity carrying shallow drilled foundation = A.σ + A skin (4)
   Shallow drill foundation bearing capacity is influenced by end bearing and skin friction, depending on the diameter of the concrete circle pipe and its depth.
2. Equipment mobilization is carried out to minimize costs and for beauty, comfort, and work speed.

3. Subdrains use easy materials, namely concrete circular pipes or PVC pipes, so buildings or infrastructure are not pushed by water mixed with soil.
4. Soil subsidence together is an upper and lower unitary structure.

   EI / L = stiffness (5)

   I = moment of inertia

   E = Modulus of Elasticity

   L = span of the structure

   So that the soil subsidence is not different, the upper and lower structures are combined so that the stiffness is large.
5. To use soil retaining walls installed counterfort to overcome the horizontal forces that must be retained. In principle, The horizontal force of active soil pressure, groundwater pressure, and surface water is due to the differences between the front and the rear of the building.
6. The equipment used was on existing land; the land was very steep, so it should be trimmed a bit for the tool holder /sit.
7. The use of appropriate structures strength to retain the permanent load but had to be easy to construct.

The analysis must meet the 7 (seven) provisions above and keep the contours stable. Infrastructure and buildings installed sub-drainage so that water did not push the building.

High-quality Poly Vinyl Chloride Channel was not easy to break and easy to replace if the broken or available horizontal hole pipe for surface water flow.

Shallow drill, beam tied. Floor slabs become a unified structure so that it is not easily damaged. The lower part of the lowest contour is given a concrete counterpart to hold the horizontal force. Strengthening structures are provided at the bottom of the road.

This applies to all countries where the soil was prone to landslides and the site contours from hills to lowlands or midlands.

a. Existing Land **b. Survey by Author** **c. Crack 10 cm after clearing**

Fig. 3 Survey of existing land and crack soil

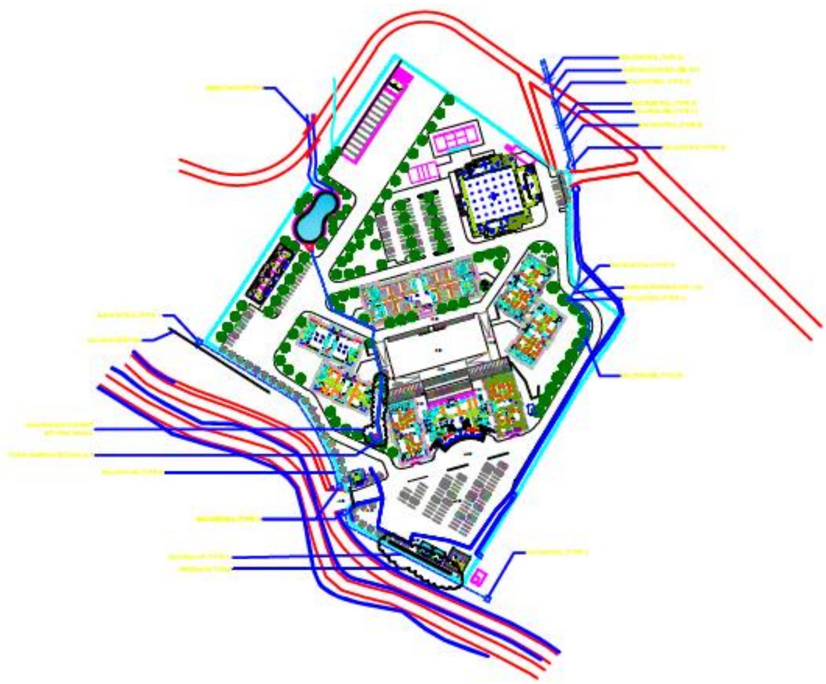


Fig. 4 Site Plan of government institution consists of 11 building offices, class

The project solution must be easy to understand and easy to construct so that all parties can construct it properly. Seven solutions:

1. All buildings and infrastructure were partially the same in one location closely; it is necessary to determine the front point and position of the equipment, which must be a small space for maneuvering to help cut and fill with minimal volume.
2. The water content of the soil must be retained so that it does not spread; it is necessary to install sub-drains on buildings and infrastructure. It is easy to get PVC pipe or concrete pipe. Water discharge pressure:

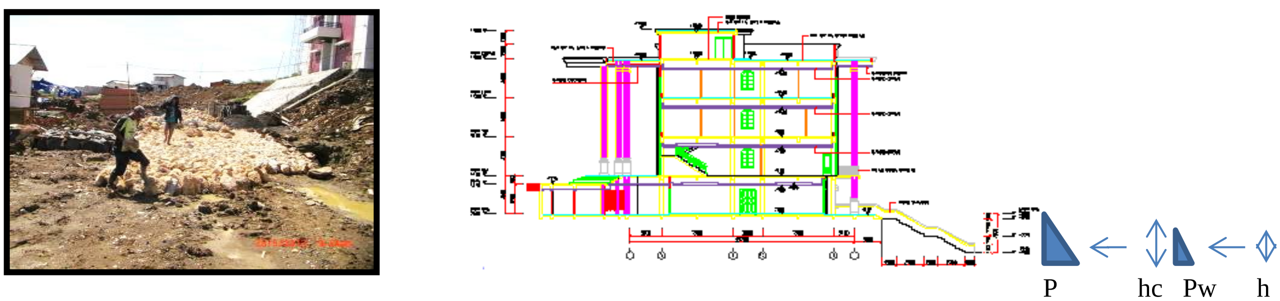
$$Q = VA \tag{6}$$

$$\text{or pressure } \gamma_{water}.\ H \tag{7}$$

This formula determines the diameter and length of the sub-drain that will be distributed under buildings and infrastructure.

The soil level had to flow water to sub-drainage under the building. The surface water at the slope level land must be able to flow in the sub-drainage to reduce fatigue in the building structure. Reduces fatigue and effectiveness cost building.

3. Without the use of chemicals and lime because of the large location, that requires high cost and damages the fertility environment.
4. The foundation adapts to the applied load; heavy loads were used by drill piles or piling foundations, while for light load used, well piles were united to the beams and floor slabs, i.e. two-floor and one-floor buildings, housing, garages, and roads.
5. The contour has retained no changing, so active soil pressure was relatively small, in addition to the cost of low-cut fill. Surface water was collected in the lake to be used for watering plants, cleaning cars, and daily cleaning. In engineering philosophy, the function of the lake was to dampen the strength of the flow so the current did not flow everywhere and collect in a location where its level was much lower.
6. Piling equipment did not use the elementation of a hammer, but the pressure jack to penetrate the stone, then piling goes into 12 m depth soil. The side of the piling is given well drill piling so that the piling does not tilt due to horizontal forces.
7. Horizontal forces had to be retained with counterforts and retaining walls by utilizing stairs and floor plate unity with tie beams and pile caps



a. Retaining wall implementation **b. Water force calculation, soil pressure**

Fig. 5 Counterfort, retaining wall by utilizing stairs and floor plate unity with tie beam and pile cap

Horizontal force due to active soil pressure and water pressure. [Fang H, Y (2013)] [23]

$$Ka = \tan^2 (45 - Ø) \tag{8}$$
$$P = 1/2 \times Ka \times \gamma \times (h_c)^2 \tag{9}$$
$$Pw = \gamma_w h^2/2 \tag{10}$$
$$P\ total = P + Pw \tag{11}$$

P = active force
Ka = coefficient of active soil pressure
Ø = internal friction angle of soil shear resistance angle
γ = weight of soil volume
H = height in general = hydraulic head
hc = the vertical distance from the ground surface, cohesive soil to zero stress point
γ_w = unit weight of water

Active earth pressure and water pressure must be analyzed carefully to not damage the building. Surface water and groundwater must be calculated even though it was channeled so that the building was expected to be strong and have a service life as planned. It had to be careful in building infrastructure, and buildings with each other in a narrow area can cause damage. The solution must not be expensive, easy to build, the contours of the land are fixed, and groundwater must be channeled. The good quality of channeled, for example, PVC AW, and it used flexible joints so its dynamic movement did not break; the software can be used analyzed to calculate soil retaining structures and water pressure, for example, plaxis. This application includes the type of soil according to its soil laboratory value and the water level.

Further research needs to be carried out on expansive soils with contour soils (hills to lowlands). Every building and infrastructure will be built must maintain the existing conditions so that there is no new balance that can lead to disaster.

5. Conclusion

The novelty was that the buildings and infrastructure did not crack or tilt with the solution; the water pressure had been channeled horizontally, collecting at the pool so that the surface water pressure at the building was close to zero. The building and infrastructure only received the residual force. The cost of the engineering structure was not expensive because the building and infrastructure contour land was retained, and the building structure only retained soil active pressure without water pressure. Besides that, the foundation, tie beam, and floor were unified to add strength and stiffness.

Through in-depth, measurable, detailed analysis, the results of hydrogeology, geology, and soil investigations were required for design. The lower and upper structures were calculated as the riel strength unity. The building had an isolated retaining wall using stone or concrete with counterforts in the shear potential area so that it did not fail and the building structure could withstand horizontal forces. The available horizontal hole former pipe flows surface water if the pipe breaks impact earthquake accident shock and its hope service life and infrastructure will long.

The solution applied to all countries, the fertile soil but easy landslides construction and easy understanding for field engineers landslides Continuous horizontal force, which can cause damage and destruction of the structure of buildings, became a solution focus. The contour difference causes the building to slide easily; added water pressure surface and groundwater from the hills plus rainwater with an average annual rainfall of 1534 mm more easily landslides.

This prevention was analyzed by the author so that the building was not damaged (cracked, tilted, and collapsed) practically and easily applied. The solution should be easy to build, cheap, and take care of soil contour, groundwater, and surface water had to be channeled and collected pool. The balance of nature is retained by taking care of the natural terracing, which adds to the overall beauty of the area.

In addition, it was also necessary to analyze the community environment and the natural environment. My manuscript hopes to be published as a sample academic; young engineers gave solutions with attention to balancing natural and environment-friendly but according to engineering standards. Although the soil structure was different, it was the balance of natural and environmental friendliness that had to always be applied.

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