Journal of Engineering and Social Sciences (JESS)

STABILITY ANALYSIS OF FLOOD CONTROL PARAPET WALL IN LAMONGAN RIVER, KEDANYANG VILLAGE, GRESIK DISTRICT

[1] Anggie Ariani, [2]Yayu Sriwahyuni Hamzah

[1,2]University of Sunan Giri Surabaya

ABSTRACT

Floods are natural disasters that occur due to continuous rainfall which can cause significant damage to communities, especially communities in downstream areas. To overcome the problem of flooding, embankments need to be built to prevent river overflows so as not to damage the property of the surrounding community.

This research focuses on analyzing the stability of embankments in Kedanyang Village, Kebomas District, Gresik Regency, which considers differences in foundation designs from previous projects. Quantitative research methods are used to test the resistance of parapet walls to rolling loads and vertical loads. The results show that the parapet wall is stable against overturning loads with a value of 181,420.8 kg, smaller than the pile bearing capacity of 267,976 kg, and stable against vertical loads with a pile bearing capacity of 130,720 kg, which can withstand a parapet wall load of 55,680 kg .

Keywords: Embankment Stability, Rolling Load, Vertical Load

Introduction

A flood is a natural disaster that occurs when an area or dry land becomes submerged in water. A flood can also be defined as water from a river or sea overflowing in large quantities onto land. The cause of flooding can occur due to increased rainfall in the area, obstruction of water flow elsewhere, overflow of rivers, lakes, and oceans. Floods are very dangerous because they can cause natural damage, loss of life, and loss of property.

Kali lamong watershed or Lamong river is administratively located in Surabaya City, Gresik Regency, Lamongan Regency, Mojokerto Regency, and Jombang Regency. Geographically, it is located between 112□ 07' 30“ to 112° 40‘ 21” East Longitude and 7° 11' 18“ to 7° 21′ 20” South Latitude. The river empties into Lamong Bay, which is also part of the Bengawan Solo river basin unit where water resources management is carried out by the Bengawan Solo River Basin Center. In the downstream part, the Kali Lamong watershed is a relatively flat area located between urban villages and rain-fed rice fields with ponds.

Kali Lamong is categorized as an intermittent river where in the rainy season (November - April) the flow discharge is quite large, while in the dry season (May - October) the base flow of the river downstream is almost nonexistent or zero. This river almost every year in the rainy season causes flooding which results in a lot of damage and losses that have an impact on the loss of property of the surrounding community, mostly in the form of ponds. For example, on February 10 - February 13, 2023 the southern region of Gresik experienced flooding due to the overflow of the lamong river which made four sub-districts affected by flooding, namely, Balongpanggang, Benjeng, Cerme, and Kedamean sub-districts. From the data of the Regional Disaster Management Agency (BPBD) of the Gresik Regency Government, there were 4,283 flooded houses from 26 villages, and 1,140 hectares of rice fields, 105 ponds were flooded. (Source taken from radargresik.jawapos)

To overcome the above problems, it is necessary to build embankments to prevent flooding due to the overflow of the Lamong River during the rainy season. With the embankment, the runoff from the river will be retained and the possibility of flooding will be smaller. In the embankment construction project, it is necessary to check the stability of the embankment that will support the embankment. The stability of the embankment can be seen from the resistance of the embankment to overturning loads and vertical loads that generally occur on concrete embankments. With the embankment, the runoff from the river will be retained and the possibility of flooding will be smaller.

In this case, stability analysis is important to ensure that the embankment can function properly to protect the area around the embankment from flooding which can result in loss of property of the community around the embankment, especially in Kedanyang Village, Kebomas District, Gresik Regency. Determination of the location of the embankment stabilization research in Kedanyang village with the consideration that there are differences in the embankment foundation design with the previous project. So it is considered necessary to conduct research at that location. Based on the above background, the researcher formulates the problem that concerns the researcher, namely how is the resistance of the parapet wall to overturning loads and to vertical loads.

Research Methods

This research uses a quantitative method with random sampling based on area (Cluster Random Sampling). Cluster sampling means taking soil samples for light sondir and boring data at three different points in the embankment area. Then tested in the laboratory. Sampling with light sondir (Cone Penetration Test/CPT) refers to the standard SNI 2827: 2008 “How to Test Field Penetration with Sondir Tools”. The lightweight cone tool used was a Dutch Cone Penetrometer with a capacity of 250 kg/cm^2 using the Biconus Patent from Delft. Tests were conducted at every 20 cm interval, with a crank rotation speed of 10 to 20 mm/s. The coordinates of the sondir testing points can be seen in the following figure and table:

Tabel 1. CPT Point Coordinates

Point	UTM Coordinates	
	(Easting)	(Northing)
S – 1	677374.00	9203611.00
S – 2	677419.00	9203636.00
S – 3	677569.00	9203591.00

Figure 1: Location of CPT Points

Sampling by boring in the field was carried out in reference to ASTMk D-1586-84; "Standard Method for Penetration Test and Split Barrel Sampling lof Soil". Drilling was carried out by taking undisturbed samples and conducting SPT every 2 meter interval (the first SPT was carried out at a depth of - 2.00 meters from the original ground level). SPT implementation was stopped after the price of SPT > 60 for 3 consecutive times as high as 45 cm up to a minimum thickness of 6 meters or adjusted according to demand.

Tabel 2. SPT Point Coordinates

Point	UTM Coordinates	
	(Easting)	(Northing)
BH - 1	677374.00	9203611.00
BH - 2	677419.00	9203636.00
BH - 3	677569.00	9203591.00

Figure 2: Location of SPT Points

For technical data analysis, it starts with finding the weight of the parapet wall construction, by finding the weight of each m3 of concrete with a length of 3 meters. Then then calculate the total weight of the parapet wall load by means of:

Foundation load weight + Parapet Wall load weight + Flood water load

After knowing the total weight of the parapet wall, then calculate the overturning moment on the parapet. Assuming maximum flood water with an elevation of + 5.30 m. Reference point o roll at the starting point of the foundation on the riverbank. With a longitudinal distance of piles = 3 meters. The equation of the tumbling load is:

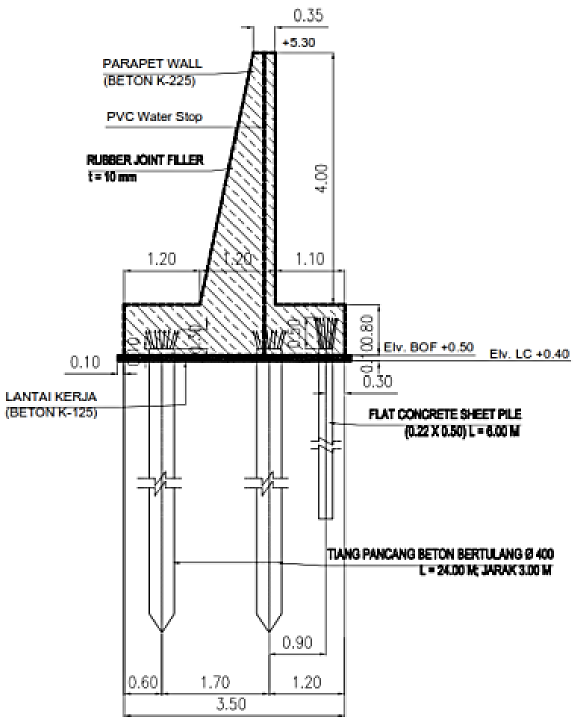
Rolling Moment = P1 x Distance + P2 x Distance
P1 = Weight of parapet wall load
P2 = Maximum flood weight with (t = 4.8 m)
Then calculate the bearing capacity of the pile on each of the three sondir results. Then calculate the bearing capacity of piles with booring based on the results of the Standard Penetration Test (SPT) using the method of Luciano Decourt (1982, 1996).

$$QL = Qp + Qs = [\ \alpha \times Np \times K \times Ap\ ] + [\ \beta \times (\ N3/3 + 1\ ) \times A3\ ]$$

Qp = bearing capacity of point bearing element
Qs = bearing capacity of skin friction element
Np = average price of SPT around 4B above and below the foundation base (B = diameter of foundation pile)
Ns = average price of SPT along the immersed pile
Ap = Cross-sectional area of the pile base (m2)
As = pile blanket area = π . B . D (m2)
A = base coefficient
= 1.00 for driven pile (piles)
= 0.85 for bored pile (in clay type soil)
= 0.60 for bored pile (in intermediate soil)
= 0.50 for bored pile (in sands soil)
β = shaft coefficient
= 1.00 for driven pile
= 0.80 for bored pile (in clay soil)
= 0.65 for bored pile (in sands)
= 0.50 for bored pile (in sands)
K = soil characteristic coefficient (12 t/m2 for clay, 20 t/m2 for clayey silt, 25 t/m2 for sandy silt, 40 t/m2 for sand)

Results and Discussion

In planning the dimensions of the parapet wall, the parapet wall plate foundation has a width of 3.5 m, a height of 0.80 m with a segmental 12.00 m. The parapet wall body has dimensions of 0.35 m top width, bottom width = 1.20 m with height = 4.00 m. The spun pile has a dimension of ø 40 cm with a depth of 24 m with a distance of 3.00 m lengthwise and 1.70 m transversely. Furthermore, the flat concrete sheet pile has a height of 0.22 m, a width of 0.50 m and a length of 6.00 m.



Based on the results of boring sondir measurements in the field, the following data were obtained:

Table 3. Sondir data S - 1

Depth (m)	QC (kg/cm²)	Qf + QC	QF	HP	JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.00	19	30	11	22	1264
22.20	18	27	9	18	1282
22.40	20	32	12	24	1306
22.60	21	33	12	24	1330
22.80	20	31	11	22	1352
23.00	21	33	12	24	1376
23.20	22	34	12	24	1400
23.40	22	35	13	26	1426
23.60	21	34	13	26	1452
23.80	23	36	13	26	1478
24.00	22	34	12	24	1502

24.20	23	37	14	28	1530
24.40	22	35	13	26	1556
24.60	21	33	12	24	1580
24.80	19	31	12	24	1604
25.00	21	32	11	22	1626

Effective depth of Spun Pile = -23.60
Cn value at -23.60 m
3 x D = 3 x 0.4 m = 1.2
Cn -22.40 m = 20.00 Kg/cm^2
Cn -24.80 m = 19.00 Kg/cm^2
Correction of Cn -23.60
value = (Cn - 22.40 + Cn - 24.80)/2
= (20+19)/2 = 19.50
Corrected value of Cn -23.60 = 19.50
JHP -23,60 = 1452 kg/cm

Table 4. Sondir data S - 2

Depth (m)	QC (kg/cm^2)				JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.20	20	31	11	22	1132
22.40	19	28	9	18	1150
22.60	21	33	12	24	1174
22.80	20	31	11	22	1196
23.00	22	34	12	24	1220
23.20	21	32	11	22	1242
23.40	22	35	13	26	1268
23.60	19	27	8	16	1284
23.80	21	33	12	24	1308
24.00	22	34	12	24	1332
24.20	22	35	13	26	1358
24.40	24	36	12	24	1382
24.60	23	35	12	24	1406
24.80	24	37	13	26	1432
25.00	22	35	13	26	1458

Effective depth of Spun Pile = -23.60
Cn value at -23.60 m
3 x D = 3 x 0.4 m = 1.2
Cn -22.40 m = 19.00 Kg/cm²
Cn -24.80 m = 24.00 Kg/cm²
Correction of Cn -23.60
value = (Cn - 22.40 + Cn - 24.80)/2 = (19+24)/2 = 21.50
Corrected value of Cn -23.60 = 19.50
JHP -23,60 = 1284 kg/cm

Table 5. Sondir data S - 3

Depth (m)	QC (kg/cm²)				JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.00	19	32	13	26	1102
22.20	21	35	14	28	1130
22.40	21	34	13	26	1156
22.60	20	33	13	26	1182
22.80	20	34	14	28	1210
23.00	21	35	14	28	1238
23.20	19	31	12	24	1262
23.40	20	33	13	26	1288
23.60	21	34	13	26	1314
23.80	22	36	14	28	1342
24.00	23	36	13	26	1368
24.20	22	35	13	26	1394
24.40	22	34	12	24	1418
24.60	23	36	13	26	1444
24.80	23	37	14	28	1472
25.00	21	35	14	28	1500

Effective depth of Spun Pile = -23.60
Cn value at -23.60 m
3 x D = 3 x 0.4 m = 1.2
Cn -22.40 m = 21.00 Kg/cm²
Cn -24.80 m = 23.00 Kg/cm²
Correction of Cn -23.60

value = (Cn - 22.40 + Cn - 24.80)/2 = (21+23)/2 = 22.00
Corrected value of Cn -23.60 = 19.50
JHP -23.60 = 1314 kg/cm
Calculation of load weight is calculated per segmental length of 3 meters to represent the parapet wall stability test.

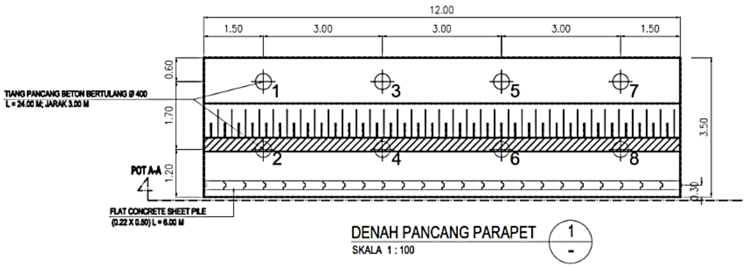


Figure 4. Plan of Parapet Piling

Parapet wall plate foundation (PL):
PL = l x t x Segment length x Specific gravity of reinforced concrete
= 3.5 x 0.8 x 3 x 2,400
= 20.160
Parapet wall weight (BL):
L = (a+b)/2 x t
BL = Trapezoidal Area x Segment length x specific gravity of concrete
=((0,35+1,2)/2 x 4) x 3 x 2,400
= (0.775 x 4) x 3 x 2,400
= 3.1 x 3 x 2,400
= 22.320

Flood weight (BA):
BA = Segment length x embankment height x specific gravity of water
BA = 3 x 4 x 1.1 x 1000 kg
= 13.200

After calculating the foundation and parapet wall and the weight of flood water. Produce the total weight of the parapet wall load, namely:
= PL + BL + BA
= 20,160 + 22,320 + 13,200 = 55,680 kg

To find out whether the parapet wall design is safe with a sponge pile foundation depth of 24 m. Then the calculation of parapet wall resistance to overturning loads is carried out. Assuming at the time of maximum flood water with a flood elevation of +5.30 m. The reference point for overturning is at the starting point of the foundation at the riverbank. Flat Concrete Pile is ignored to resist overturning load.
Action of overturning load from parapet wall (P1) and maximum flood water (P2).

P1 Parapet wall load weight = 55,680 kg
P2 Maximum flood water weight (t = 4.8 m) = 4.8/2 x 4.8 x 3 x 1000
= 34,560 kg
Rolling moment = P1 x 1.75 m + P2 x 2.43 m
= 55,680 x 1.75 + 34,560 x 2.43
= 181,420.8 kg/m

Calculation of bearing capacity of piles
Spun pile foundation system to obtain the optimum bearing capacity of the pile, utilizing the soil adhesion that occurs at the time of piling is included in the calculation of the bearing capacity of the pile. (assumed notation of pile bearing capacity is DTP)
For the calculation of Safety Factor (SF):
SF value for Conus / SPT = 2
SF value for adhesion = 2.5
Results of investigation of bearing capacity and soil adhesion at the project site

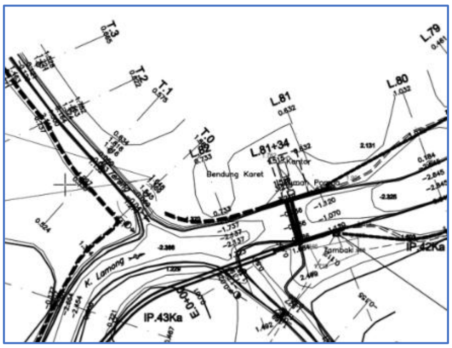


Figure 5. Embankment Project Location

DTP= (Area of TP x Cn)/(SF Conus)
= (Perimeter of TP x JHP)/(SF Adhesion)
At point S 1:
(Area of TP x Cn)/(SF Conus) = (1,256 x 19.50)/2 = 12,246
(TP Perimeter x JHP)/(SF Adhesion) = (126 x 1.452)/2.5 = 73.181
S 1 DTP = 12.246 + 73.181 = 85.427
At point S 2:
(Area of TP x Cn)/(SF Conus) = (1,256 x 21.50)/2 = 13,502
(Perimeter of TP x JHP)/(SF Adhesion) = (126 x 19.50)/2.5 = 54.482
S 2 DTP = 13.502 + 54.482 = 67.984
At point S 3:
(Area of TP x Cn)/(SF Conus) = (1,256 x 22.00)/2 = 12,816
(Perimeter of TP x JHP)/(SF Adhesion) = (126 x 19.50)/2.5 = 66,226
S 2 DTP = 12.816 + 66.226 = 79.042

Taken as a reference for the calculation of the pile bearing capacity of the S2 evaluation results (the smallest value), the total pile bearing capacity (DTP) = 67,984 kg.
Evaluation of vertical load and overturning load of parapet construction as follows: (Review of TP segmental calculation per 3 meters).
From the calculation of the bearing capacity of the pile it can be concluded that the bearing capacity of the pile obtained from S2 with the result of 67,984 x 2 piles) = 135,968 able to withstand the weight of the parapet load of 55,680 kg. In the overturning load with the result of 181,420.8. With the bearing capacity of rolling piles calculated by the formula:

DTP x SP 1 + DTP x SP 2
= 67,984 x 1.20 + 67,984 x 2.90
= 278.734,40

Conclusion
For the calculation of stability against overturning loads with Parapet Wall segments per unit, length = 12 meters and width = 3.5 meters, with parapet wall body height = 4 meters, and Spun Pile depth plan of 24 meters. It can be said to be stable / safe with the value of the overturning load obtained, which is 181,420.8 smaller than the bearing capacity of the pile with a value of 267,976. And from the calculation of stability to vertical loads, the pile bearing capacity value of 130,720 kg can withstand a parapet wall load of 55,680 kg.

References

Zaina, K.N.F(2018). Stabilitas tanggul. Retrived from https://id.scribd.com/document/395601077/Stabilitas-Tanggul

Permatasari Azizah, (2015) Studi Perencanaan Tanggul dan Dinding Penahan untuk Pengendalian Banjir di Sungai Cileungsi Kabupaten Bogor Jawa Barat. Retrived from https://repository.ub.ac.id/id/eprint/143573/

Robydiansyah, (2012) Kajian ulang stabilitas geser dan guling parafet di Sungai Grindulu Kabupaten Pacitan. Retrived from http://eprints.uny.ac.id/1971/1/KAJIAN%20ULANG%20STABILITAS%20GESER%20DAN%20GULING%20PARAFET%20DI%20SUNGAI%20G.pdf

Dhian D. Prayuda, Moh. Agus Wahyudin (2017) Stabilitas lereng tanggul Sungai Cimanuk Kabupaten Indramayu. Retrived from https://rekayasainfrastruktur.unwir.ac.id/index.php/jri/article/download/98/90/169

Bella Th. Tambing, Alva N, Sarajar, Jack H. Ticoh. (2023) Analisis Stabilitas tanggul timbunan tanah (Studi kasus: Tanggul pengaman Danau Tondano) Retrived from https://ejournal.unsrat.ac.id/v3/index.php/tekno

Sella Monica (2022) Analisis stabilitas tanggul dalam pekerjaan reklamasi di Tanjung Benoa. Retrived from https://tekniklepaspantai.itb.ac.id/wpcontent/uploads/sites/441/2022/03/15511015-Sella-Monica.pdf

Febby Sekar Dwi Lestari, Andre Primantyo Hendrawan, Tri Budi Prayogo (2022) Evaluasi dimensi dan stabilitas tanggul Kali Lamong di Kabupaten Gresik Jawa Timur. Retrived from Journal homepage: https://jtresda.ub.ac.id/

WH Setiawan (2019) Analisis stabilitas eksternal dinding penahan tanah tipe kantilever. Retrived from https://dspace.uii.ac.id/bitstream/handle/123456789/13996/05.3%20bab%203.pdf?sequence=7&isAllowed=y