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Abutment Stability Analysis of Earthquake Load At Wawolatoma Bridge Latoma Sub-District Konawe Regency

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ABSTRACT

In this increasingly modern era, human needs are also growing. These need to be supported by adequate transportation infrastructure and can help. The stability against shear was obtained by the value of Rh = 235.20 kN and the importance of active earth pressure (Pa) = 96.08 kN so that the safety factor against shear was obtained from the division between the Rh value divided by the Pa value, a matter of 2.45 was brought. Why, Thishere this value more significant than the safety factor from shear, which is 1.? it can be concluded that stability against shear can be safe. Strength against overturning is obtained by comparing the moment of resistance of the structure as a support with the moment of turning that causes overturning (Mgl). With a value of Mw = 414.038 kN/m and agl = 179.36 kN/m, ana Fg an anna luan of 2.31 isobtainedwhichhch is where this value is greater than the safety factor for overturning, which is 1.5. From the calculation results, the ultimate bearing capacity value for the foundation on the surface (qu) is 292.76 kN/m, two, and the soil pressure to the bottom is evenly distributed (q'). Of 78.54 kN/m^2.

Keywords: *Abutments, Earth Pressure, Moments*

Introduction

Bridges are one of the strategic transportation infrastructures for traffic movement. The bridge is a general term for construction as a transportation route across rivers, lakes, swamps, or other obstacles [1][2]. The bridge itself is divided into two parts, namely the superstructure of the bridge and the understructure of the bridge, where the bridge has several components, such as abutments, foundations, and pillars for bridges that have long spans. Where these needs need to be supported [1]

with the existence of adequate transportation infrastructure and can keep it. However, several states often need to be addressed in transportation infrastructure. Some of these obstacles are caused by geographical conditions in Indonesia, more precisely in Latthe oma Sub-District, Konawe Regency, such as the existence of a right that cuts off the transportation infrastructure[3]. As a result of these constraints, a bridge is needed to connect the disconnected parts of the transportation infrastructure. The purpose of this study was to determine the stability of the Wawolatoma bridge abutments against overturning and shearing, as well as the carrying capacity of the soil. The research location is in the village of Wowalatoma, Latoma Sub-District, Konawe Regency.

Figure 1 Research Location

Research Methods

The methodology of this research is to use an analysis of the Stability of the Abutment and earthquake loads so that it has a slight chance of collapsing but can experience significant damage and disruption to services due to the earthquake with a probability of exceeding 7% in 75 years (SNI 03-2833-2016). According to Hardiyatmo C.H. (2017), analysis of abutment stability in terms of the safety factor against sliding and overturning must be sufficient. For the safety factor against shifting of the abutment base, the minimum is taken as 1.5 Bowles (1997). Lateral earth pressure caused by the piled-up soil behind the abutment tends to topple the abutment by rotation at the fore toe of the abutment plate[4]–[11]. This overturning moment is countered by the moment due to the abutment's weight and the moment due to the importance of the soil. The earthquake load is taken as the horizontal force, which is determined based on the multiplication of the elastic response coefficient (Csm) with the equivalent structural weight, which is then modified by the response modification factor (R) with the following formulation[12][13]:

$$E_Q = \frac{C_{sm}}{R} \times W_t \quad (1)$$

Where:
E_Q : static horizontal seismic force (kN)
C_{sm} : response elastic coefficient
R : response modification factor
W_t : the total weight of the structure consisting of the appropriate dead load and live load (kN)

The elastic response coefficient Csm is obtained from the bedrock acceleration maps and acceleration spectra according to the earthquake area and the design earthquake return period. The acceleration coefficient obtained based on the earthquake map is multiplied by an amplification factor according to the soil conditions to a depth of 30 m under the bridge structure[14]–[20].

Table 1. Earthquake zone

Koefisien percepatan (*SD1*)	**Zona gempa**
$SD1 \leq 0{,}15$	1
$0{,}15 < SD1 \leq 0{,}30$	2
$0{,}30 < SD1 \leq 0{,}50$	3
$SD1 > 0{,}50$	4

Spectral response is a value that describes the maximum response of a single-degree-of-freedom system at various natural frequencies (natural periods) damped due to a ground shake.

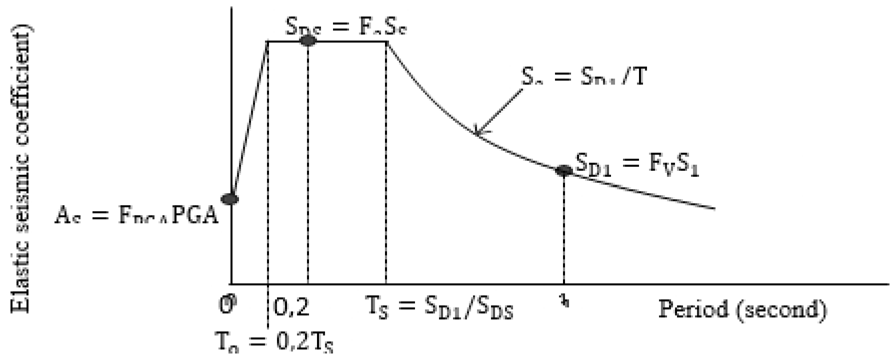

Figure 2. The typical shape of the spectral response at ground level

Results and Discussion

Structure and Material Data
Table 2 shows the structural specifications and types of materials found on the bridge

Table 2 structural specifications and types of materials found on the bridge

Dimension Description	**Notation**	**Dimensions**	**Unit**
The total span length of the bridge	Lt	30	m
The total width of the bridge	B	6.5	m
Specific Gravity			**kN/m^3**
Reinforced Concrete Weight		W_c	25
Unreinforced Concrete Weight		W'_c	24
Vehicle Board Floor Weight		W_r	11.03
The specific gravity of Water		W_w	9.8

Table 3 shows the dimensions of the substructure

Table 3 dimensions of the bottom structure

Part Weight Parameters			
	b(m)	h (m)	Shape
1	0.25	0.5	1
2	0.45	0.7	1
3	0.65	0.5	1
4	0.65	0.4	0.5
5	0.8	0.9	1
6	0.3	0.6	1
7	0.3	0.3	0.5
8	0.8	3.1	1
9	1.6	0.4	0.5
10	1.6	0.6	1
11	0.8	1	1
12	1.6	0.4	0.5
13	1.6	0.6	1
14	2	0.5	1
15	1.8	1.2	1
16	1.8	0.4	1
17	0.65	0.4	0.5
18	2.45	2.7	1
19	0.85	0.8	0.5
20	1.6	0.4	1
21	1.6	0.4	0.5

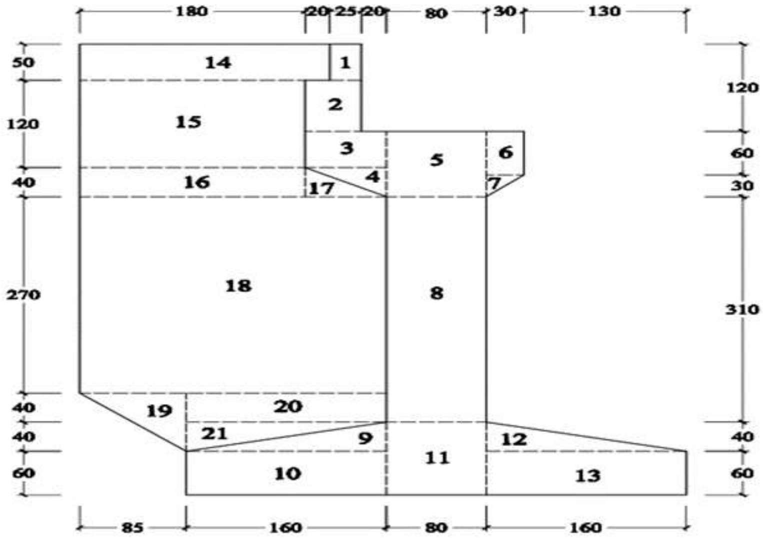

Figure 3 Model of the bottom structure

Earthquake Load (TEQ)

In SNI 1725:2016, for bridge loading on single-span bridges, it is not necessary to analyze earthquake loads on abutments[21]–[23]. But to add safety, the earthquake load is still calculated by assuming that the earthquake force that occurs cannot be less than or equal to the peak ground acceleration (As) multiplied by the total weight of the structure shown in Figure 4.

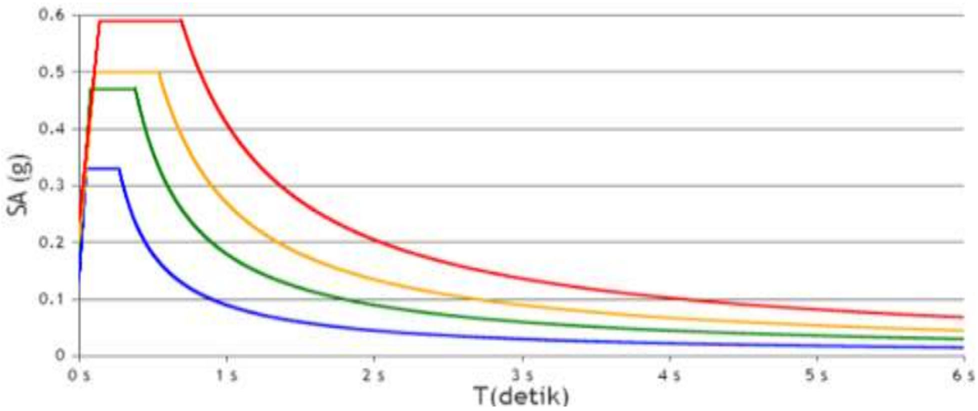

Figure 4. Spectral response design for the Wowalatoma Bridge location

Figure 5 shows the Response Spectrum of the Location of the Wawolatoma Bridge

Kelas	T0 (detik)	Ts (detik)	Sds (g)	Sd1 (g)
Tanah Keras (SB)	0,05	0,27	0,33	0,09
Tanah Keras, Batuan Lunak (SC)	0,08	0,38	0,47	0,18
Tanah Sedang (SD)	0,11	0,54	0,50	0,27
Tanah Lunak (SE)	0,14	0,69	0,59	0,41
Koordinat :				
Lintang	: -3.716.417.677.165.220			
Bujur	: 1.216.768.706.602.850			
PGA (g)	: 0,2605			
FPGA	: 1,7			
SS (g)	: 0,5490			
S1 (g)	: 0,1767			
As (g)	: 0,44			
TL (detik)	: 6			

Figure 5 Response Spectrum of the Location of the Wawolatoma Bridge

1. Vertical earthquake load
The value of the vertical earthquake load is obtained from 10% of the total additional dead weight and self-dead weight of the superstructure. Then the vertical earthquake load is.
vertical Earthquake Load,
PEQ = 10% x (PMS + PMA)
PEQ = 309.57 kN
the eccentricity of breast wall to pile cap, e = 0.5 m. So.
Moment
Mx = PEQ x e
Mx = 154.79 kN/m

2. Lateral earthquake loads
With the condition that the span in this case study is a single span type, the lateral earthquake force is obtained as follows.
PEQ lateral seismic force,
PEQ = As x (PMS + PMA)
PEQ = 2781.788kN
moment arm, YEQ
YEQ = h5 + h8 + h11
YEQ = 5 m
Moment, Muy
Muy = PEQ * YEQ
Muy = 13908.94kN/m
Horizontal force, Huy,
Huy = PEQ
Huy = 2781.788 kN

3. Longitudinal earthquake loads
With the condition that the span in this case study is a single span type, the lateral earthquake force is obtained as follows.
PEQ lateral seismic force,
PEQ = As x (PMS + PMA)
PEQ = 2781.788 kN
moment arm, YEQ
YEQ = h5 + h8 + h11
YEQ = 5 m
Moment, Muy
Muy = PEQ * YEQ
Muy = 13908.94 kN/m
Horizontal force, Huy,
Huy = PEQ
Huy = 2781.788 kN

Load Recap

After calculating the self-loading of the structure, both the upper and lower frames, as well as additional dead loads and live loads such as lane loads, all these loads are then inputted into the recap table, as seen in figure 6 below.

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Berat Bagian	Notasi	Berat (kN)
Beban Mati		
Berat mati sendiri	PMS	
Berat sendiri struktur atas	PMS	2631,00
Berat sendiri struktur bawah	PMS	3185,81
Berat mati tambahan	PMA	464,74
Total Beban Mati		6281,56
Beban Hidup		
Beban lajur "D"	PTD	3190
Beban Pejalan kaki	PTP	290,1
Beban rem	TTB	500
Total Beban Hidup		3980
Beban Aksi Lingkungan		
Beban Gempa	TEQ	
Beban gempa vertikal	EQV	309,57
Beban gempa lateral	PEQ	2781,788
Beban gempa longitudinal	PEQ	2781,788

Figure 6 load recap

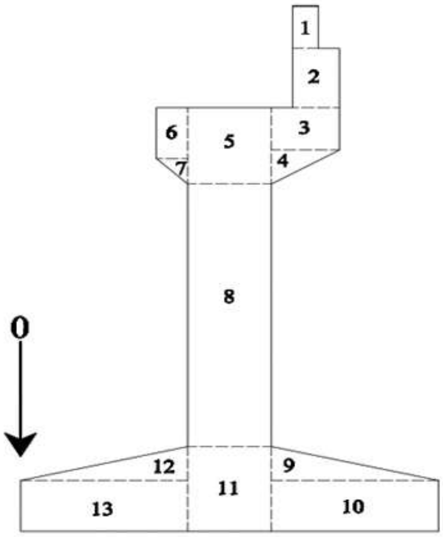

Figure 7. The eccentricity of the soil load

Total weight, W = 1248.00 kN
Total moment, Mw = 2691.25 kN/m
Is known:
Abutment Height, H = 6.2 m
Total Weight of Abutments, W = 1248.00kN
Soil Specific Gravity, GS = 2.68
The density of Water, γw = 9.81
Soil Pore Number, e = 0.43
Berat Volume Tanah, γ
$\gamma = (GS \times \gamma w)/(1 + e)$
$\gamma = 18,38517483$

Active earth pressure, Ka
The Ka value is taken from the Rankine coefficient table using the following values.
φ = angle of friction in the soil = 30°
ß = angle of inclination of the ground = 0°
Then the coefficient of active earth pressure (Ka) is obtained from Rankine's theory
Ka = 0.3333

Total active earth pressure, Pa
After obtaining the value of Ka, then the total active pressure (Pa) is calculated.
$Pa = 0.5 \times H^2 \times \gamma \times Ka$
Pa = 117.78 kN

Ground pressure
xe = 1/3 x H
xe = 2.07m

Moment Causes Overturn
Mgl = Pa x xe
Mgl = 243.40 kN/m

W	= total weight of abutments (kN)	= 1248.00kN
φ	= angle of friction in the soil	= 30°
δb	= 1/3 x 30°	= 10°
f	= tan δb	=1.225

Conclusion

The stability against shear is obtained by the value of Rh = 235.20 kN and the importance of active earth pressure (Pa) = 96.08 kN so that the safety factor against shear is obtained from the division between the Rh divided by the Pa value. The deal is 2.45, which is where this value is greater than the safety factor from shear, which is 1.5, so it can be concluded that stability against shear can be said to be safe.

Stability against overturning is obtained by comparing the moment of resistance of the structure as support (Mw) with the overturning moment or the moment that causes overturning (Mgl). With a value of Mw = 414.038 kN/m and Mgl = 179.36 kN/m, an Fgl value of 2.31 is obtained, which is where this value is greater than the safety factor for overturning, namely 1.5. So it is found that the abutment is safe or stable against overturning.

From the calculation results, the ultimate bearing capacity value for the foundation on the surface (qu) is 292.76 kN/m2, and the soil pressure to the bottom is evenly distributed (q') at 78.54 kN/m2. With a safety factor for collapse due to bearing capacity of 3 with a comparison between the qu and q' values of 3.73, where this value is greater than the safety factor against collapse, it is concluded that the abutment can withstand or be stable against the collapse factor write down the conclusions of your paper and further research suggestions in the form of narratives and not in bullet or numeral form.

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