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ANALYSIS OF PILAR AND ABUTMENT FOUNDATIONS ON THE BATU RASANG-MAMBULU VILLAGE BRIDGE PROJECT TAMBELENGAN DISTRICT SAMPANG REGENCY

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ABSTRACT

In building a bridge, careful and careful planning is needed and controlled. Because good planning will significantly support the implementation of safe and strong bridge construction, and the results are as desired. For this reason, we need technical plans, such as load calculation and management project management. This specialised plan must be carried out carefully and thoroughly and fulfil a strong and safe bridge; it can also carry it out as efficiently as possible in terms of cost and time. From this research on the bridge project in Batu Rasang Village - Mambulu, Tambelengan District, Sampang Regency, the results of the analysis of the design of the abutment and pillar structure calculations, the condition can support the bridge after knowing the outcome of abutment and pillar planning on the bridge (Q total > W/M) of 1042.31 > 7.14. Furthermore, on the subgrade characteristics from sondir test results with the results of existing calculations for determining the carrying capacity, the abutment and pillar construction can be stable because they can withstand the loads above them (P pile < P permit) of 27.54 < 28.43.

Keywords: *Strous Foundation; Abutment Foundation; Pillar Foundation; Batu Rasang–Mambulu Village Bridge.*

1. Introduction

Currently, Indonesia is carrying out development in all fields, especially in the transportation sector which is a supporter of other sectors. In this case, land transportation is growing and advancing rapidly. As a developing country, of course, Indonesia will always follow technological developments in the field of land transportation, for example implementing policies in improving land transportation facilities, as well as increasing new transportation. Apart from being the demands of the times that must be followed to keep pace with technological advances that continue to develop and to provide better services for users of land transportation services, it also aims to complement existing land transportation facilities to suit progress in the economic and social fields.

Therefore, considering the importance of land transportation which plays a role in crossing routes from one village to another, the Government of the Transportation Service and the Public Works Office of Bina Marga of Sampang Regency worked together to build a Bridge Project in Batu Rasang-Mambulu Village in Tambelengan District. With these facilities and infrastructure, it is hoped that it will make it easier for the surrounding community to increase human resources and work productivity, so that the Department of Transportation and the Department of Public Works of Highways of Sampang Regency can actually carry out their duties and functions as expected.

The village bridge project that connects Batu Rasang Village to Mambulu Village, which is located in Tambelengan District, Sampang Regency, is classified as not traffic-heavy, because this

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bridge has just been built along the village road. The plan from the Sampang Regency Government is that with the construction of this bridge, the road in that location, which was originally a village axis road, will be used as a district axis road which will later function to connect land transportation.

However, the construction of a bridge must be considered carefully, so that the bridge can provide benefits as expected, without compromising the safety element of road users and the bridge itself. This is because the bridge plays an important role in people's lives, especially as a land transportation link from Batu Rasang Village to Mambulu Village.

In the process of building a bridge, careful and careful planning is needed and controlled. Because good planning will greatly support the implementation of a safe and strong bridge construction, and the results are as desired. For this reason, technical plans are needed, such as the calculation of the load and the management of the project management. This technical planning must be carried out carefully and thoroughly in addition to fulfilling a strong and safe bridge, it can also be carried out as efficiently as possible in terms of cost and time. In this study, not all work items were calculated due to limited time, so the preparation only took some work related to the construction of the Batu Rasang Village Bridge - Mambulu, Tambelengan District, Sampang Regency, such as foundation work.

2. Material and Methods

Broadly speaking, the bridge construction consists of two main components, namely the super structure/upper structure and the sub structure. The superstructure is the part of the bridge that receives the load directly from the people and vehicles that pass through it. The superstructure consists of the main components, namely the bridge floor, main frame, transverse girder, longitudinal girder, diaphragm, mooring, and anchorage. In addition, there are also supporting components in the superstructure, namely connection equipment, ralling, bridge fences, drainage, lighting, parapets, and guardrails. The substructure is the part of the bridge that receives the load from the superstructure plus the soil pressure and impact forces from the crossing under the bridge. The sub-structure includes the bridge pillar (pier), the bridge base (abutment), and the foundation.

2.1. Definition of Methodology

In conducting research, a methodological approach is needed. Methodology is a pattern of thought for the preparation of studies. The purpose of the methodology is to provide logical direction, and the results achieved can be divided equally.

To conduct a research, what is needed is to plan and think carefully and consider rational things, in order to obtain the desired results and be responsible, it is necessary to prepare the steps in conducting a research. The system in collecting data from a study The process of collecting data for an analysis study of pillars and abutments on a bridge project is basically not a random research but uses a procedure with sequential steps and is related to each other in the hope of getting the required data in the research. This needs to be considered so that the data collected can be processed effectively and efficiently so that it can be used optimally.

2.2. Research Sites

This research was conducted in Batu Rasang-Mambulu Village, Tambelengan District, Sampang Regency with the aim of the bridge playing an important role in people's lives, especially as a land transportation link from Batu Rasang Village to Mambulu Village.

2.3. Construction Execution

1. Implementation of strous foundation
2. Implementation of abutment foundation
3. Implementation of pillar foundation

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2.4. Data Processing

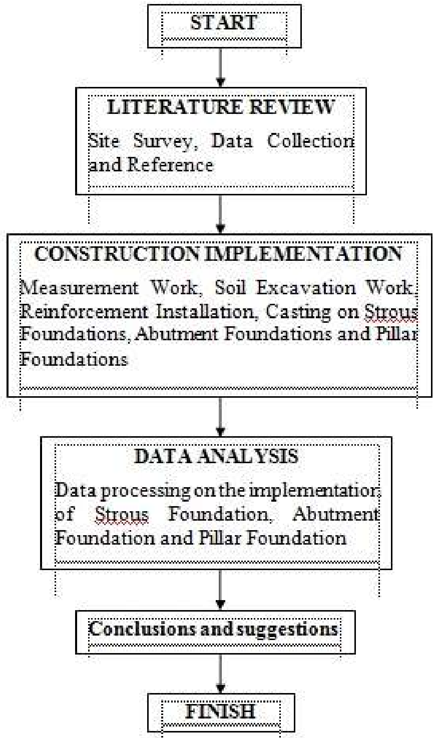

Figure 1. Research Flowchart

3. Result and Discussion

3.1. Definition of Bridge

Bridges are important infrastructure in the road network system [10]. Bridges are important structures in road infrastructure that function to connect a road segment that is cut off due to an obstacle. The obstacles are usually rivers, ravines, valleys, and lakes. Bridges are often a critical component in road infrastructure because they determine the maximum load that the road segment can pass [4].

Bridges are built to cross pedestrians, vehicles or trains over obstacles. Bridges are also part of land transportation infrastructure which is very vital in the flow of travel [8]. Bridge construction planning must be considered as effective and efficient as possible, so that bridge construction can meet the requirements of safety and comfort for bridge users. Therefore, it is necessary to master bridge technology both in terms of planning, equipment and materials [3].

3.2. General Description of Foundation

The foundation is a construction of the base or the lowest part of a building whose purpose is to carry the load on it to be transmitted evenly to the soil layer. The foundation can also be interpreted as an intermediary structure, which has the function of continuing the load of the building on it (including its own weight), to the soil on which the foundation stands, without causing soil damage or without causing a decrease in the building beyond its tolerance limit [13].

The foundation is a very important job in a civil engineering work, because it is this foundation that carries and holds a load that works on it, namely the top construction load [9]. The foundation serves to transmit the load that comes from the load of the building itself or external loads acting on the building to the surrounding soil. The load from the building structure is distributed through the column with the allowable stress intensity according to the bearing capacity of the soil [1].

The foundation is an important part of a civil building, the foundation as the basic load-bearing base of a construction. Roads, buildings, bridges, dams, and other civil structures without a strong foundation will inevitably fail. In application in the field, it often overrides the proper foundation bearing capacity analysis [11].

1. **Shallow Foundation**
   Shallow foundation criteria are determined by the ratio of the ratio between the width of the foundation (B) and the depth of the foundation (D). where for shallow foundations, it is determined when the depth of the foundation divided by the width is less than or equal to one or D/B≤1, as shown in the figure below.

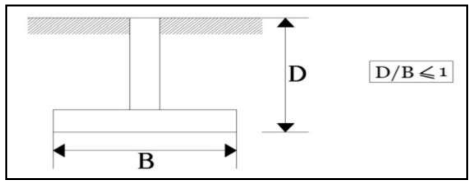

Figure 2. Shallow Foundation

2. **Deep Foundation**
   The criteria for deep foundations are determined by the ratio of the ratio between the width of the foundation (B) and the depth of the foundation (D). where for deep foundations it is determined when the depth of the foundation divided by the width is greater than or equal to four or D/B≥4, as shown in the figure below.

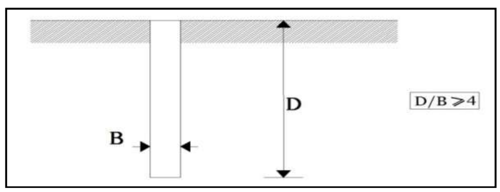

Figure 3. Deep Foundation

3.3. Strous Foundation

The strous foundation is foundation work by means of the soil being drilled manually or the driver of the drill bit is human power. A strous foundation is a deep foundation made by digging a hole and then adding the concrete mix. In the implementation in the field, the base of the well foundation is widened to minimize the stress that occurs in the supporting layer so that a greater carrying capacity is obtained [2].

The strous foundation belongs to the category of shallow foundations, but is used for loads that are not too heavy, for example for houses or buildings with short spans between columns. The workings of this foundation installation is drilling the soil with a diameter according to the calculation of the foundation diameter structure, then the casing from the PVC pipe casted with samba is used and the casing is removed [5].

3.4. Abutment Foundation

The abutment or the head of the bridge is the part of the building at the ends of the bridge, in addition to being a support for the superstructure, it also functions as a soil retainer. Bridge abutment foundations generally use well foundations that have been described on medium foundations, sometimes also using pile foundations which have also been described in deep foundations [12].

The abutment is the sub-structure of the bridge which is located on the two end supports of the bridge pillars, which function as load bearings that occur on the upper structure of the bridge, including the wind load of the floor plate or the force that occurs by downward vertical loads [7]. Due to the location of the abutment at the end of the bridge, this abutment also functions as a soil retainer. Generally, abutments are equipped with wing constructions that function to hold the ground in a direction perpendicular to the bridge axis [12].

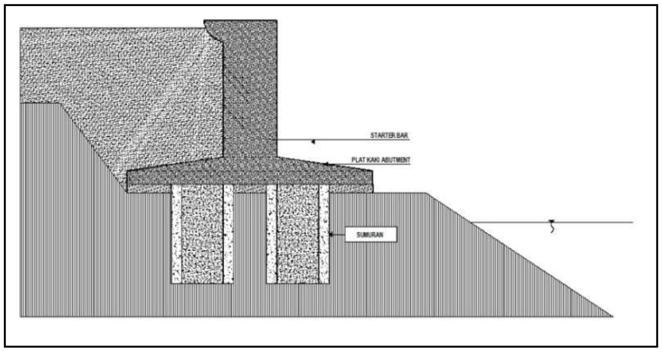

Figure 4. Abutment Foundation

3.5. Pillar Foundation

Pillar is a bridge support between the bridge heads for bridges with more than one span. Pillar foundations generally use piles. This choice is based on the consideration that the building will remain safe in case of riverbed degradation due to any cause.

To facilitate the implementation, currently many choose to make pile caps above the lowest water level. Thus, the manufacture of pillar foundations is almost no difficulty at all. The safety of the pillars against goods drifting from the river is overcome by making fender poles around the poles, especially in the upstream part [12].

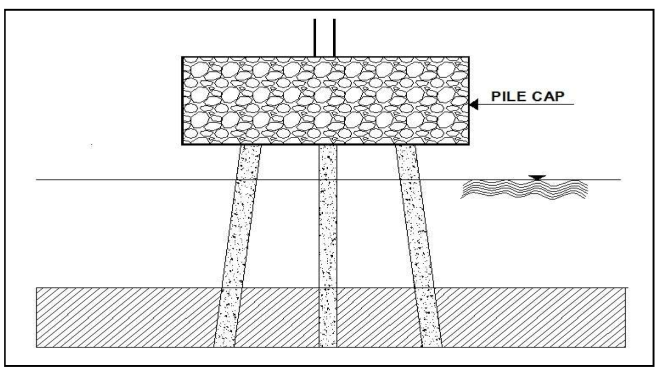

Figure 5. Pillar Foundation Casting

3.6. Stages of Planning Strous Foundation, Abutment Foundation and Pillar Foundation

1. **Strous Foundation**
   - Determining the dimensions of the foundation by means of "trial and error" then the number of piles to be used is known.
   - Determine the bearing capacity of the foundation (Q)
     According to Imam Subarkah 1980 in Irfranto Meyhendra Elfandar 2012, to calculate the bearing capacity of the foundation, the formula is used:

$$Q = \frac{A.PK}{3} + \frac{O.JHP}{5} \tag{1}$$

   - Determine the bearing capacity of the pile group

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According to Hary Christady Hardiyatmo 2002 in Irfranto Meyhendra Elfandar 2012, the formula used to support the bearing capacity of the pile is:

$$\emptyset = \text{Arc tan}\left[\frac{D}{S}\right] \quad (2)$$

$$E = 1 - \emptyset\left[\frac{(n'-1)m+(m-1)n'}{90.m.n}\right] \quad (3)$$

2. Abutment Foundation and Pillar Foundation

The forces acting on the abutments and pillars:

- Force due to dead load
- Horizontal force due to friction of moving pedestal (Hg)
  Friction coefficient = 0.25 (PPPJJR / 1987 article 2.6.2)
  Hfriction = coefficient of friction . Rvd

$$RVD = \frac{Ptotal}{2} = \ldots\ldots ton \quad (4)$$

- Force due to live charge

$$RqL = \frac{q}{2,75}\ x\ l = \ldots\ldots ton \quad (5)$$

$$RPL = \frac{P}{2,75}\ x\ k\ x\ l = \ldots\ldots ton \quad (6)$$

$$\text{Shock coefficient} = 1 + \frac{20}{50+l} = \ldots\ldots ton \quad (7)$$

- Force due to brake and traction
  Calculated 5% of the load D without a shock coefficient with a catch point of 1.8 m above the surface of the vehicle floor (PPJJR / 1987 p. 15)

$$\text{Traction Rrt} = \frac{5\%x(RPL+RqL)}{2} = \ldots\ldots ton \quad (8)$$

- Earthquake force due to superstructure
  K = determination (0,07)

$$G1 = K . Rvd \quad (9)$$

- Ground horizontal force

$$Ka = tg^2(45° - \frac{\emptyset}{2}) \quad (10)$$

$$Kp = tg^2(45° + \frac{\emptyset}{2}) \quad (11)$$

$$Pa1 = Ka . q . h1 . b \quad (12)$$

$$Pa2 = ½ . Ka . \gamma 1 . h^2 \quad (13)$$

$$Pp = ½ . Kp . \gamma 1 . h2^2 .b \quad (14)$$

3. Calculation of bearing capacity of foundation subgrade

ϕ = arc tg(Kr ϕ . tan ϕ) SNI 03 – 3446 – 1994, page 8 – 9

The bearing capacity of the foundation subgrade based on the Tarzhagi formula for square foundations on soil conditions

$$C = 3,1\ t/m^2 \quad (15)$$

$$Qult = 1,3.C . Nc + Po . Nq + 0,4 . B . \gamma . N\gamma \quad (16)$$

$$Qall = \frac{Q\ ult}{SF} \quad (17)$$

4. Calculation of Abutment and Pillar Stability

- Terms of safety against sliding

$$FK\ shift = \frac{\sum Rh}{\sum Ph} \quad (18)$$

- Terms of safety against bolster

$$FKG = \frac{\sum Mw}{\sum Mg} \quad (19)$$

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- Carrying capacity control

$$Q\ total = Q\ permission = \frac{Qu}{Fk} \quad (20)$$

$$\frac{W\ total}{m} \quad (21)$$

$$Q\ total > \frac{W\ total}{m}$$

3.7. Pillar Planning

WA = 0,2 x 0,3 x 2,2	= 0,132	ton
WB = 1,40 x 1 x 2,2	= 3,08	ton
WC = 0,7 x 6 x 2,2	= 9,24	ton
WD = 1,40 x 0,3 x 2,2	= 0,924	ton
WE = $\frac{1}{2}$ x 0,7 x 0,3 x 2,2	= 0,231	ton
WF = $\frac{1}{2}$ x 0,7 x 0,3 x 2,2	= 0,231	ton
WG = 2,80 x 1 x 2,2	= 6,16	ton +
W total	= 19,998	ton

Table 1. Moment Due The Weight Of The Pillar

Bag	LM On D (m)	Moment (tm)
WA	$\frac{0,2}{2}$ = 0,1	0,1 x 0,132 = 0,0132
WB	$\frac{1,4}{2}$ = 0,7	0,7 x 3,08 = 1,0692
WC	$\frac{0,7}{2}$ = 0,35	0,35 x 9,24 = 3,234
WD	$\frac{1,4}{2}$ + 0,7 + 0,7 = 2,1	2,1 x 0,924 = 1,9404
WE	$\frac{1}{3}$ x 0,7 = 0,23	0,23 x 0,231 = 0,05313
WF	$\frac{1}{3}$ x 0,7 = 0,23	0,23 x 0,231 = 0,05313
WG	$\frac{2,8}{2}$ = 1,4	1,4 x 6,16 = 6,7375
		Total = 16,07386

Table 2. Pillar Self Weight

No	Volume (m^3)	$\gamma\left(\frac{t}{m^3}\right)$	Weight (ton)	Arm (m)	Moment (tm)
A	0,2 x 0,3 x 1	2,2	0,132	0,1	0,0132
B	1,4 x 1 x 1	2,2	3,08	0,7	2,156
C	0,7 x 6 x 1	2,2	9,24	0,35	3,234
D	1,4 x 0,3 x 1	2,2	0,924	2,1	1,9404
E	0,5 x 0,7 x 0,3 x 1	2,2	0,231	0,23	0,05313
F	0,5 x 0,7 x 0,3 x 1	2,2	0,231	0,23	0,05313
G	2,8 x 1 x 1	2,2	6,16	1,4	8,624
Total			19,998		16,07386

The moment that occurs between the 2 pillars, based on the calculation results of SAP 2000 is 18.21 tm.

- Terms of safety against bolster

  FK roll ≥ 2

  FKG = $\frac{\sum Mw}{\sum Mg} \geq 2$

  = $\frac{16,07386}{24,97,81} \geq 2$

  = 2,06 ≥ 2 ……………OK!

- Terms of safety against sliding

  C = 2 $\frac{t}{m^2}$

  $\emptyset$ = 45°

  γ = 1,5 $\frac{t}{m^3}$

  FK sliding ≥ 2

  FK sliding = $\frac{(W\ total\ x\ tang\ \emptyset\ )}{\sum Ph} \geq 2$

  = $\frac{(19,998\ x\ tang\ 45°\ )}{7,81} \geq 2$

  = 2,56 ≥ 2 ……………OK!

- Carrying capacity control

  $\emptyset$ = 45°

  Score Nc = 172,3

  Nq = 173,3

  N γ = 297,5

  Qu = C x Nc + γ x d x Nq + 0,5 x γ x B x N γ

  = (2 x 172,3) + (1,5 x 8,3 x 173,3) + (0,5 x 1,5 x 2,8 x 297,5)

  = 3126,935 $\frac{t}{m}$

  Safety Factor = 3 (determined)

  Q total = Q Permission = $\frac{3126,935}{3}$

  = 1042,31

  W total = 19,998 (review per meter)

  $\frac{W\ total}{m} = \frac{19,998}{3,5}$

  = 7,14

So, Q total > $\frac{W}{m}$
= 1042,31 > 7,14 ……………OK!

3.8. Abutment Planning

WA = 0,3 x 1,05 x 2,2	= 0,693	ton
WB = 0,6 x 1,35 x 2,2	= 1,782	ton
WC = 0,6 x 0,6 x 2,2	= 0,792	ton
WD = 1,5 x 6,4 x 2,2	= 21,12	ton
WE = $\frac{1}{2}$ x 1,5 x 6,4 x 2,2	= 10,56	ton
WF = 3,5 x 0,5 x 2,2	= 3,85	ton +
W total	= 38,797	ton

Table 3. Moment Due to Abutment Weight

Bag	LM On D (m)	Moment (tm)
WA	$\frac{0,3}{2} = 0,15$	0,15 x 0,693 = 0,10395
WB	$\frac{0,6}{2} + 0,3 = 0,6$	0,6 x 1,782 = 1,0692
WC	$\frac{0,6}{2} + 0,3 + 0,6 = 1,2$	1,2 x 0,792 = 0,9504
WD	$\frac{1,5}{2} + 1,5 = 2,25$	2,25 x 21,12 = 47,52
WE	$\frac{1}{3}$ x 1,5 = 0,5	0,5 x 10,56 = 5,28
WF	$\frac{3,5}{2} = 1,75$	1,75 x 3,85 = 6,7375
PP		Total = 61,66105 0, 19 + 61,85105

Table 4. Abutment Self Weight

No	Volume (m^3)	$\gamma\left(\frac{t}{m^3}\right)$	Weight (ton)	Arm (m)	Moment (tm)
A	0,3 x 1,05 x 1	2,2	0,693	0,15	0,10395
B	0,6 x 1,35 x 1	2,2	1,782	0,6	1,0692
C	0,6 x 0,6 x 1	2,2	0,792	1,2	0,9504
D	1,5 x 6,4 x 1	2,2	21,12	2,25	47,52
E	0,5 x 1,5 x 6,4 x 1	2,2	10,56	0,5	5,28
F	3,5 x 0,5	2,2	3,85	1,75	6,7375
Total			38,797		61,66105

$$\emptyset = \text{Arc Tang}\left(\frac{D}{S}\right)$$
$$= \text{Arc Tang}\left(\frac{30}{79}\right)$$
$$= 20,79$$

$$E = 1 - \emptyset \left[\frac{(n'-1)m+(m-1)n'}{90.m.n}\right]$$
$$= 1 - 20{,}79 \left[\frac{(6-1)2+(2-1)6}{90.2.12}\right]$$
$$= 0{,}846$$

P permission = Eq x Q

So the load that can be carried is 12 poles = 12 x 0,846 x 2,8
= 28,43 ton

Pile Control

- Support Load = 31,56 ton

  (obtained from the calculation results of SAP 2000)
- Strous Weight = $\frac{1}{4}\ x\ 3{,}14\ x\ 30^2$ x 3 m x 2,4 $\frac{t}{m^2}$ = 0,509 ton
- Palm Weight = 5,5 x 2,8 x 0,5 x 2,4 $\frac{t}{m^2}$ = 18,48 ton +

∑N = 50,549 ton

$$P\ Pile = \frac{\sum N}{\sum Pile} + \frac{M\ max}{n.\sum x^2}$$
$$= \frac{50{,}549}{12} + \frac{25{,}195}{12\ x\ (0{,}3)^2}$$
$$= 27{,}54 \text{ ton}$$

P Pile < P Permissiom

27,54 < 28,43 ……………OK!

4. Conclusions

From this research on the bridge project in Batu Rasang Village - Mambulu, Tambelengan District, Sampang Regency, the following conclusions can be drawn:

1. From the results of the design analysis of the abutment and pillar structure calculations, the condition is able to support the bridge after it is known that the final result of a abutment and pillar planning on the bridge (total Q > W/M) is 1042.31 > 7.14.
2. Based on the characteristics of the subgrade from the sondir test results with the results of existing calculations for determining the carrying capacity, the abutment and pillar construction can be said to be stable because it is able to withstand the loads above it (P pile < P permit) of 27.54 < 28.43.

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