INFO TEKNIK
Volume 23 No. 2 Desember 2022 (233-248)

DESIGN OF MARTAPURA RIVER BRIDGE STRUCTURE, BANJAR REGENCY

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ABSTRACT

The Martapura River Bridge is located on Jalan A. Yani KM 40 Martapura, Banjar Regency, South Kalimantan. Traffic processes that occur on Jalan A. Yani KM 40 Martapura often experience problems because congestion often occurs and the condition of the old IA bridge sometimes makes driving users feel restless when crossing the bridge located on the Martapura river. So that at the location of the Martapura river, it is deemed necessary to build a bridge next to the IA bridge so that the IB bridge to be built can be more sturdy and durable so that there is no anxiety for driving users and also to reduce congestion that occurs, where later the IB bridge will be used as a road with one way only towards Banjarmasin and the martapura IA bridge will be used as a one-way road towards the Hulu Sungai so that it will make it easier for traffic on Jalan A. Yani KM 40 Martapura.

The methodology used in loading planning refers to SNI 1725-2016 concerning Loading Standards for Bridges. For the methodology in calculating the stress loss, refer to the NAASRA Bridge Design Specification on Chapter VI Bridge Design Specifications (Prestressed Concrete Design). For the methodology in calculating the moment of the vehicle floor using the Three Moment Equation method and for the method of subsidence of group pile foundations using the method of Schultze and Sheriff (1973), assuming that the pile group is the Equivalent Raft Foundation. The material used in the design of the upper structure is prestressed concrete, while the lower structure is planned to use reinforced concrete with a square pile.

The results obtained are the T-Girder Prestressed type bridge with class A, 34 m span, 7 m traffic width, and 1 m wide sidewalk. Prestressed T-Girder is designed using fc' 40 MPa (K-482) Strands used are uncoated 7 wire super strands ASTM A-416 grade 270 with a diameter of 12.7 mm and an area of 100 mm^2 with a tensile strength of 1860 MPa. As for the lower structure, the abutment uses concrete with a quality of fc' 25 MPa (K-300) with a height of 565 cm, a width of 480 cm and a length of 1050 cm.type piles Square Pile with a length of 15 m with a quality of 50 MPa (K-600) with a width of 60x60 cm with a configuration of 18 piles for each abutment. Estimated Budget Plan The cost of constructing the Martapura river bridge is IDR 8,129.511,475.00.-.

Keywords: Bridge, T-Girder Prestressed, Square Pile.

I. INTRODUCTION

Bridges must be made strong enough because damage to the bridge can cause disruption to the smooth flow of traffic, especially on roads with heavy traffic. However, this does not mean that the bridge must be made stronger and stronger in excess. Trying to use bridge construction that is economical, but has good strength, uses high quality materials, and fast manufacturing time.

Traffic processes that occur on Jalan A. Yani KM 40 Martapura City often experience problems because congestion often occurs and the condition of the old IA bridge sometimes makes driving users feel restless when crossing the bridge. So that at the location of the Martapura river, it is deemed necessary to build a bridge next to the IA bridge so that the IB bridge to be built can be more sturdy and durable so that there is no anxiety for driving users and also to reduce congestion that occurs.

The construction project of the IB martapura bridge, which is located at Jalan A. Yani KM 40, Martapura City has a length of 34 m, where later the IB bridge will be used as a one-way road to Banjarmasin and the martapura IA bridge will be used as a one-way road to Banjarmasin. Overseas so that it will make it easier for traffic on Jalan A. Yani KM 40, Martapura City. In this design, a T-type prestressed girder bridge will be built.

II. LITERATURE REVIEW

The planned bridge structure must meet the minimum requirements for loading where the load factor and load combination refers to SNI 1725-2016 concerning Loading Standards for Bridges. And for earthquake resistance loading refers to SNI 2833-2016 concerning Earthquake Resistance Planning Standards for Bridges.

The bridge girder in the form of a Prestressed T-Girder is designed with reference to the regulations of the Directorate of Road Program Development, the Directorate General of Highways of the Ministry of Public Works regarding Standards for Superstructure of Prestressed Concrete Truss Bridges (Type T – Class A) and the NAASRA Bridge Design Specification on Bridge Design Specifications.

The loads received by the abutment will be added to the abutment's own weight ,then distributed to the foundation system which will then be supported by the subgrade. Calculation of loading on abutments refers to SNI 1725-2016 concerning Loading Standards for Bridges and SNI 2833-2016 concerning Standards for Earthquake Resistance Planning for Bridges and for calculation of abutment refers to SNI 1729-2015 concerning Specifications for Structural Steel Buildings.

Calculation of bearing capacity in the form of end resistance, frictional resistance, and ultimate resistance based on SPT data using the Meyerhof method (1976), for lateral bearing capacity using the Broms method and group pile foundation settlement using the Schultze and Sheriff (1973) method, assuming that the group pile is in the form of the Equivalent Raft Foundation.

This part of the oprit is prone to landslides, landslides can occur to a certain depth depending on the type of subgrade that supports the embankment above. Therefore, it is necessary to analyze the safety factor (SF) of the slope by analyzing the stability of the slope in accordance with that required in SNI 8460-2017, namely SF = 1.5 for slopes with permanent conditions. Slope stability analysis on bridge oprit using software to obtain the most critical SF value.

The budget plan for this bridge uses the road and bridge construction work specifications from Bina Marga.

III. RESEARCH METHODOLOGY

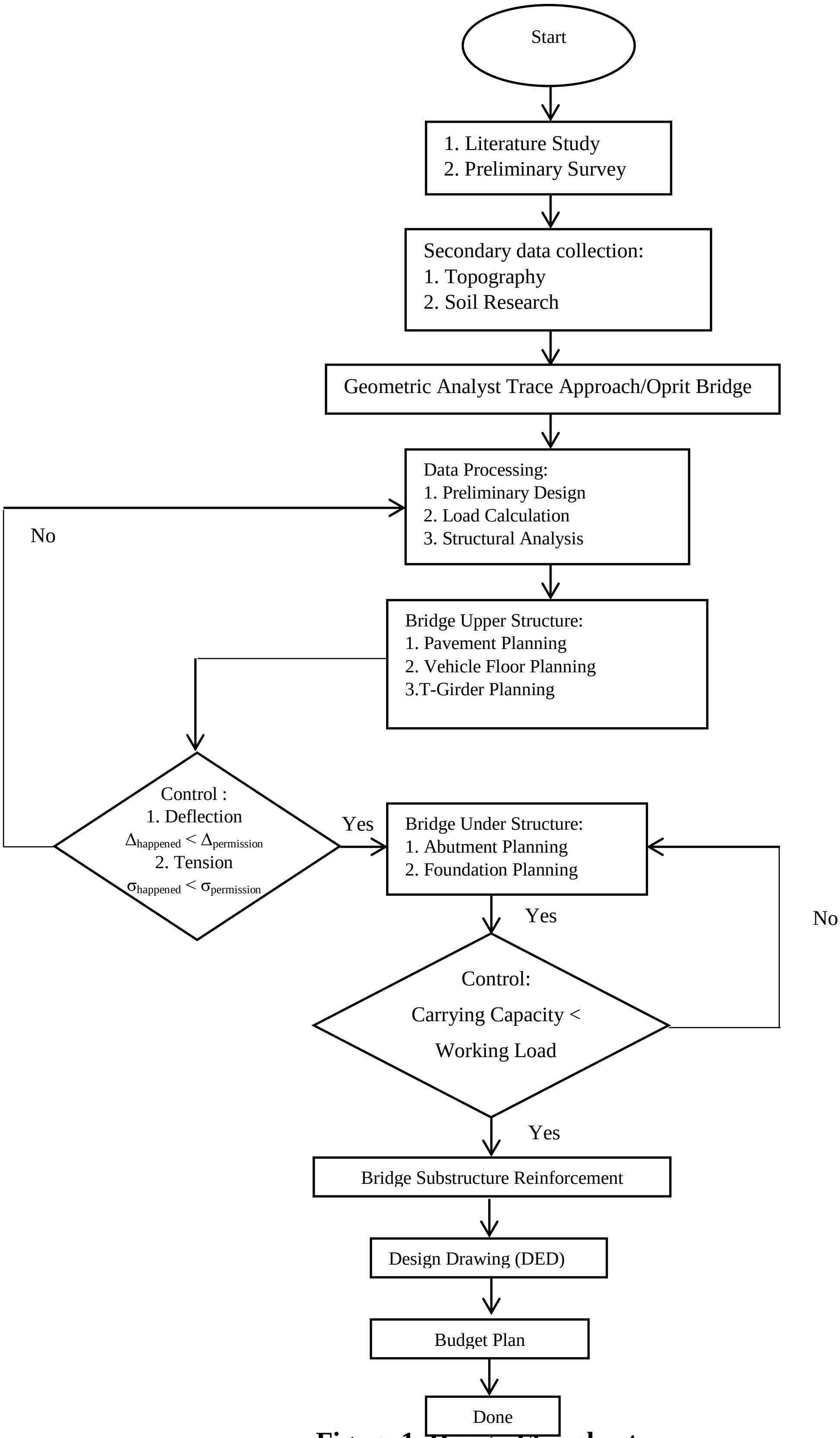

Figure 1. Design Flowchart

IV. RESULTS AND DISCUSSION

A. BRIDGE TECHNICAL DATA

The bridge to be planned is a class A bridge with a total bridge width of 9 m. The bridge girder uses Prestressed T-Girder with high strength concrete, namely fc' 40 MPa and uses prestressed steel cable with uncoated 7 wire super strands ASTM A-416 grade 270 grade. Vehicle floors, sidewalks and parafets use concrete fc' 30 MPa. The abutment uses fc' 25 MPa concrete and the foundation with a width of 60x60 cm uses 50 MPa fc' prestressed concrete.

B. STRUCTURE OF THE BRIDGE

1. Backrest Pipe Planning

Used backrest pipe ∅2 ½' – thickness = 7 mm, and carried out stress control: $\sigma = 1116{,}620\ kg/cm^2 \leq \sigma' = 3666{,}667\ kg/cm^2$.

2. Planning of Backrest

Piles The bridge supports use WF 100.100.6.8 BJ 55, and carried out stress control: $\sigma = 130.719\ kg/cm^2 \leq \sigma' = 3666{,}667\ kg/cm^2$.

3. Design of Sidewalks and Paraffels

The moment that works on the pavement is 8,40 kNm, from the calculation of the moments obtained by the pavement and parafet reinforcement, namely:

Main Sidewalk Reinforcement = D16-250.

Reinforcement for Sidewalks = D13-350.

Parafet Main Reinforcement = D16-140.

Reinforcement For Parafet = D13-150.

4. Prestressed T-Girder Planning

- The initial prestressing force is Pt = 7900,903 kN, the prestressing force due to jacking is Pj = 9295,179 kN, and the final prestressing force after stress loss (30%) is$_{Peff}$ = 6506.625 kN.
- Loss of Prestressing Force due to Anchor Friction = 9016,323 kN, Due to Cable Friction = 8263,820 kN, Due to Elastic Shortening =

654.295 kN, Due to Anchoring = 683,101 kN, Due to Shrinkage Effect = 71217 kPa, Due to Creeping Effect = 35923,095 kPa.

- Control of stress on post-tensile steel tendons after distribution of prestressing force:
  f_p = 959866,232 kPa < f_{pizin} = 1302000 kPa (Safe).
- Control of stress that occurs in the cross section of the T-Girder Prestressed beam:
  - Initial State (At Transfer)
    f_a = -1959,670 kPa < f_c' = -19200 kPa (Safe).
    f_b = -19200 kPa < f_c' = -19200 kPa (Safe).
  - The State After Losing Prestress
    f_a = -2917,280 kPa < f_c' = -18000 kPa (Safe).
    f_b = -13955,260 kPa < f_c' = -18000 kPa (Safe).
- Control the stress that occurs due to the working loads:
  - Combination-1
    f_a = -9929,344 kPa < f_c' = -18000 kPa (Safe).
    f_b = -3967,754 kPa < f_c' = -18000 kPa (Safe).
  - Combination-2
    f_a = -9529.044 kPa < f_c' = -18000 kPa (Safe).
    f_b = -4537,944 kPa < f_c' = -18000 kPa (Safe).
- Deflection control that occurs in the prestressed t-girder :
  δ = 0,014 m $\leq \delta_{permits}$ = 0,1133333 m (Safe).
- Control of the Ultimate Moment that occurs on the prestressed t-girder :
- Combination-1
  M_u = 6051,071 kPa < $M_{upermits}$ = 11912,091 kPa (Safe).
- Combination-2
  M_u = 5840.101 kPa < $M_{upermits}$ = 11912,091 kPa (Safe).
- The number of tendons = 4 Tendons and the number of strands = 69 Strands.
- Anchor = live anchor VSL with type 19 Sc.

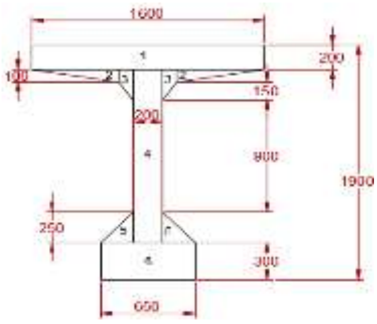

Figure 2. T-Girder Prestressed Dimensions and Number of Tendons

Figure 3. Tendon Position in the Middle of the Span and at the End of the Span

- Prestressed T-Girder

  Reinforcement : Upper Flexural Reinforcement = 18 D13.

  Body Bending Reinforcement = 8 D13.

  Lower Flexural Reinforcement = 12 D13.

  Shear Reinforcement = D16-300.

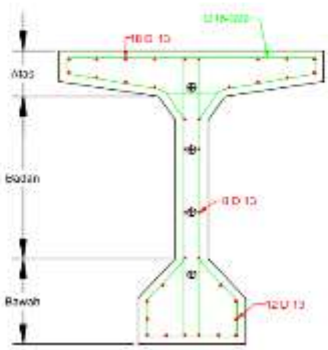

Figure 5. Prestressed T-Girder Reinforcement

- Reinforcement Bursting Steel :

No Kabel	Angkur Hidup VSL		Pj (kN)	A (mm)	a1 (mm)	ra	Pbta (kN)	Ara (m2)	Jumlah Sengkang
	Sc (ton)	Diameter (mm)							
1	19	265	1616,197	265	340	0,779	106,954	0,001	3,419
2	19	265	2558,979	265	340	0,779	169,344	0,001	5,413
3	19	265	2558,979	265	340	0,779	169,344	0,001	5,413
4	19	265	2558,979	265	340	0,779	169,344	0,001	5,413

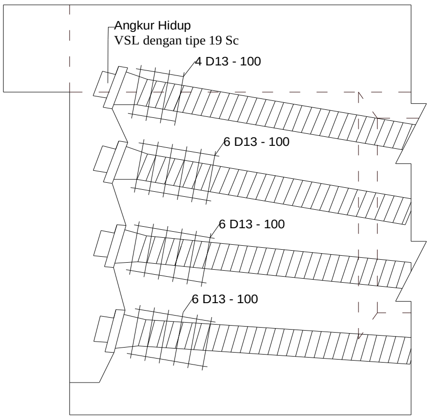

Figure 6. Bursting Steel

5. Vehicle Floor Planning

Moments that occur on the vehicle floor plate are as follows:

Aksi/Beban	Faktor Beban Ultimit		Momen		Momen Ultimit	
			Mtumpuan	Mlapangan	Mutumpuan	Mulapangan
A. Aksi tetap						
Berat Sendiri	KMS	1,3	1,30	0,65	1,68	0,84
Beban Mati Tambahan	KMA	2	0,54	0,27	1,08	0,54
B. Aksi Transien						
Beban Truk "T"	KTT	1,8	41,13	37,02	74,04	66,64
Mu Total =					76,80	68,02

Based on the moments that occur on the vehicle floor plate, the vehicle floor plate reinforcement is obtained, namely:

Support reinforcement = D16-100.

Field reinforcement = D16-100.

Reinforcement divide = D13-130.

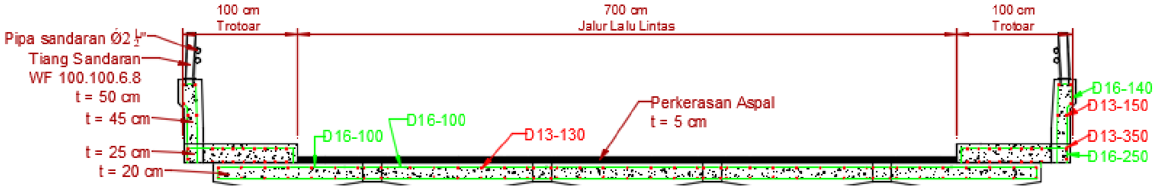

Figure 7. Reinforcement of Vehicle Floor Plate

6. Planning of the Diaphragm Beam

Moment that occurs in the diaphragm beam is as follows:

Flexural Reinforcement = 8 D-16.

Shear Reinforcement = 2 Figure13 – 150.

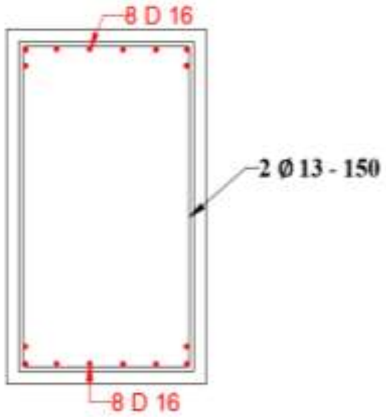

Figure 8. Diaphragm Beam Reinforcement

C. ABUTMENT BRIDGE

The results of the combined loading on abutments distributed to the piles are:

Kombinasi	Gaya Yang Bekerja						
	P (ton)	Baris I (Tiang Tegak)		Baris II (Tiang Tegak)		Baris III (Tiang Tegak)	
		Vi (ton)	Hi (ton)	Vi (ton)	Hi (ton)	Vi (ton)	Hi (ton)
Kuat I	1.244,30	83,073	11,604	69,128	11,604	55,182	11,604
Kuat II	1.169,32	77,994	11,458	64,962	11,458	51,931	11,458
Kuat III	911,78	60,487	10,946	50,655	10,946	40,822	10,946
Kuat IV	873,262	58,347	10,946	48,515	10,946	38,682	10,946
Kuat V	873,262	58,347	10,946	48,515	10,946	38,682	10,946
Ekstrem I	926,109	63,889	11,631	51,451	11,631	39,012	11,631
Ekstrem II	774,805	56,933	11,129	43,045	11,129	29,156	11,129
Daya Layan I	877,870	61,010	9,689	48,771	9,689	36,531	9,689
Daya Layan II	939,709	65,131	9,799	52,206	9,799	39,281	9,799
Daya Layan III	836,644	58,263	9,616	46,480	9,616	34,697	9,616
Daya Layan IV	671,740	47,274	9,323	37,319	9,323	27,364	9,323
Fatik	154,598	10,302	0,274	8,589	0,274	6,875	0,274

D. FOUNDATION PLANNING

The foundation used for this bridge uses a Square Pile with a width of 60x60 cm and a foundation depth of 15 m. The pile tip resistance capacity for sandy soil using the Meyerhof method (1976) was obtained by Q_b = 296.736 tons and the total pile frictional resistance capacity for clay and sand layers was Q_{fTotal} = 177.460 tons so that $Q_{permits}$ = 158.065 tons.

The group pile efficiency based on the Converse Labarre obtained by E_g = 69.30%, so that Q_{eff} = 69.30% x 158.065 = 109.539 tons. Control: 109.539 > P = 96.033 tons (Safe).

The lateral bearing capacity of the pile using the Broms method, obtained: $Q_{permit} \geq H_{work}$ = 18.72 tons 11.631 tons (Safe).

The reduction of group piles using the method of Schultze and Sheriff (1973), assuming that the group pile in the form of Equivalent Raft Foundation obtained at, S = 3.97 mm < $S_{Permits}$ = 50 mm (Safe).

E. REINFORCEMENT WINGWALL AND WINGWALL

Calculation of abutment and reinforcement is divided into several parts. From the calculation results obtained abutment and wingwall as follows:

Abutment reinforcement :

Abutment Part	Main reinforcement	Reinforcement for	Stirrup reinforcement
Part I-I	φ16-100	φ13-250	φ13-250
Part II-II	φ19-80	φ13-130	φ13-250
Part III-III	φ22-150	φ16-300	φ16-300
Part IV-IV	φ25-120	φ19-150	φ13-300

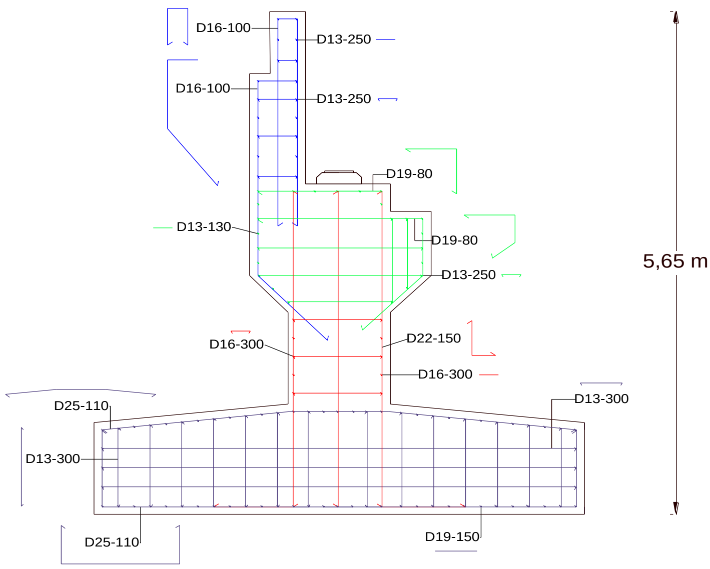

Figure 9. Wingwall

Reinforcement Flexural :

Reinforcement : D19 – 150.

Reinforcement for : D13 – 250.

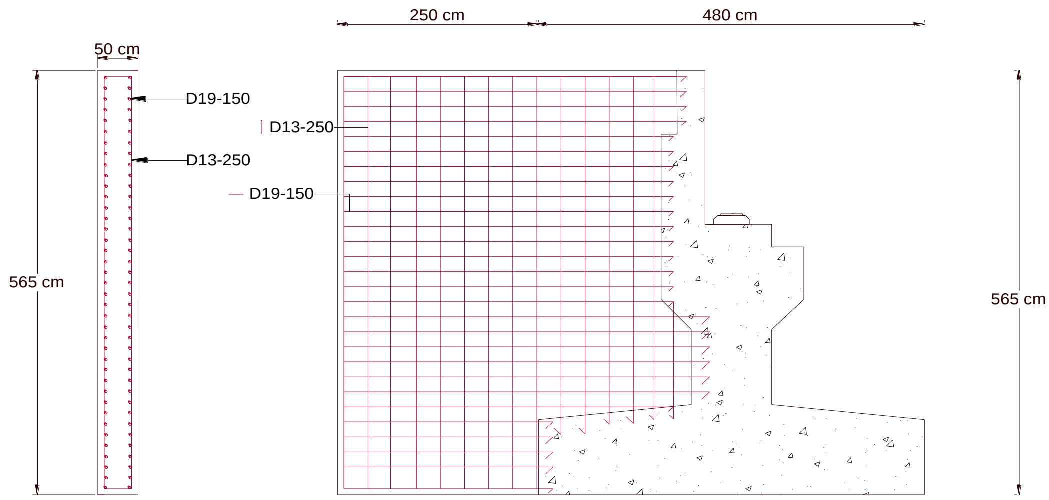

Figure 9. Wingwall reinforcement

F. OPRIT STABILITY

Obtained by SF without reinforcement with the help software GeoStudio 2018Tried strengthening the subgrade using galam 10 cm, 5 m long with S = 50/50 cm, the most critical SF value was obtained after being given galam reinforcement of 1.790, where the SF value was greater than the required SF of 1.5.

G. COST BUDGET PLAN

Calculation of the Cost Budget Plan based on the volume obtained from the plan drawings and in accordance with the provisions of Bina Marga, and the cost of building a bridge (not including labor costs) on the Martapura River, Banjar Regency is Rp. 8,129.511,475.00.- .

V. CONCLUSION

Based on the results of the design, the following conclusions are obtained:

1. Bridge superstructure design:
   - The superstructure of a class A bridge with a bridge span of 34 m, and a bridge width of 9 m, 1 m is the sidewalk on the right and left and the traffic width is 7 m.

- quality of the concrete for the superstructure (prestressed t-girder), K-482 concrete (fc' 40 MPa), while the quality of the concrete for floor slabs, sidewalks and parafets uses the concrete quality of K-350 (fc' 30 MPa).
- Used 69 strands with uncoated type 7 wire super strands ASTM A-416 grade 270, diameter 12.7 mm, area 100 mm^2, minimum tensile strength 1860 MPa and tendon sleeve diameter 84 mm, live anchor VSL type 19 Sc.
- The initial prestressing force is Pt = 7900,903 kN, the prestressing force due to jacking is Pj = 9295,179 kN, and the final prestressing force after stress loss (30%) is$_{Peff}$ = 6506.625 kN.
- Loss of Prestressing Force due to Anchor Friction = 9016,323 kN, Due to Cable Friction = 8263,820 kN, Due to Elastic Shortening = 654.295 kN, Due to Anchoring = 683,101 kN, Due to Shrinkage Effect = 71217 kPa, Due to Creeping Effect = 35923,095 kPa.
- Control of stress on post-tensile steel tendon after distribution of prestressing force:

  f_p = 959866,232 kPa < $f_{ppermits}$ = 1302000 kPa (Safe).
- Control of stress that occurs in the cross section of the T-Girder Prestressed beam:
  - Initial State (At Transfer)

    f_a = -9929,344 kPa < f_c' = -18000 kPa (Safe).

    f_b = -3967,754 kPa < f_c' = -18000 kPa (Safe).
  - State After Loss of Prestress

    f_a = -9529.044 kPa < f_c' = -18000 kPa (Safe).

    f_b = -4537,944 kPa < f_c' = -18000 kPa (Safe).
- Control of stress that occurs due to working loads:
  - Combination-1

    f_a = -9929,344 kPa < f_c' = -18000 kPa (Safe).

    f_b = -3967,754 kPa < f_c' = -18000 kPa (Safe).
  - Combination-2

    f_a = -9529.044 kPa < f_c' = -18000 kPa (Safe).

    f_b = -4537,944 kPa < f_c' = -18000 kPa (Safe).

- Deflection control that occurs in the prestressed t-girder :
  δ = 0,014 m $\leq \delta_{permits}$ = 0,1133333 m (Safe).
- Control of the Ultimate Moment that occurs in the prestressed t-girder :
  - Combination-1
    M_u = 6051,071 kPa < $M_{upermits}$ = 11912,091 kPa (Safe).
  - Combination-2
    M_u = 5840.101 kPa < $M_{upermits}$ = 11912.091 kPa (Safe).

2. Under bridge structure design:
   - abutment is 5.65 m high, 4.8 m wide and 10.5 m long, with K-300 concrete quality (fc' 25 MPa).
   - prestressed concrete piles Square Pile with a length of 15 m, with a width of 60x60 cm, with a configuration of 18 piles for each abutment, with m = 3 piles and n = 6 piles.
   - From the calculation of the forces acting on the pile:
     - The maximum vertical force (V) = 96.033 tons, while the effective carrying capacity, Q_{eff} = 109.539 tons (Safe).
     - Maximum horizontal force (H) = 11,631 tons, while the lateral bearing capacity, $H_{permits}$ = 18,72 tons (Safe).
3. In the oprit, the galam cone was reinforced with 10 cm with a depth of 5 m with S = 50/50 cm. Safety Factor using GeoStudio 2018 GeoSlope/W software, the most critical SF is 1.790.
4. The drawing of the design plan is attached in the appendix.
5. The budget plan for the construction of the bridge (not including labor costs) on the Martapura River, Banjar Regency is Rp. 8,129.511,475.00.-.

VI. SUGGESTIONS

In planning must consider the worst possible conditions. It is also recommended that the data in this final project be taken precisely and accurately so that the analysis and calculations carried out can describe the situation at the actual location.

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