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REINFORCED CONCRETE BRIDGE GIRDER DESIGN IN THE NUNUDERE RIVER, BAGUIA POST ADMINISTRATIVE BAUCAU MUNICIPALITY

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Abstract: The Nunudere River bridge is located at the Baguia Post Administrative, Baucau Municipality. In calculating the structure of this bridge, the dimensions used are 150/200 mm, sidewalk width 600 mm, traffic road width 6000 mm, bridge floor slab thickness 200 mm, the diaphragm 300/500 mm, girder 450/900 mm, and span length 13,200 mm. Furthermore, the materials used are concrete and reinforcing steel. The compressive capacity of concrete is 30 MPa and the tensile capacity of steel is 400 MPa. The maximum moment obtained at the support pillar was 2.86 KNm and the transverse force was 2.86 KN, on the sidewalk slab the moment was 15,124 KNm, on the floor slab the moment was 67.6192 KNm (M-support) and 60.20852 (M-field), on the main girder the moment was 1937.2 KNm and the transverse force was 599.3 KN, in the transverse girder (diaphragm) the moment is 55,864 KNm and in the transverse girder 153,455 kN. Thus, the dimensions of the concrete reinforcement for the main reinforcement pillars are 4Ø10 and stirrups Ø 6 – 450 mm, the pavement slab with longitudinal reinforcement Ø16 – 300 mm and transverse reinforcement Ø 13 – 700 mm, the traffic floor slab with longitudinal reinforcement Ø 13-200 mm and transverse reinforcement Ø 16 – 150 mm, in the transverse beam (diaphragm) 4 main reinforcement Ø 22 and 2 compression reinforcement rods 2 tensile reinforcement rods with stirrup reinforcement Ø 10-200 mm. 13Ø32 main girders and 3 compression reinforcement bars, 10 tensile reinforcement bars. Apart from that, shrinkage reinforcement with 4 Ø 12 - 200 mm and stirrup reinforcement Ø12-120 mm and 200 mm is installed in the girder body**.**

Keywords - Bridge, reinforced concrete, reinforcing steel

I. INTRODUCTION

The Democratic Republic of Timor-Leste (RDTL) is a country that is still in the reconstruction stage in all fields, one of which is the infrastructure sector which is still a special concern for responsibility holders in all agencies, both government and private, for this reason the Timor-Leste government has started developing this country by laying down its national development framework, which is a national strategic plan (National Strategy Plan) in which the physical development program is the main priority, efforts to provide the nation's infrastructure facilities and infrastructure, which in reality is the construction of transportation facilities such as reinforced concrete bridges. Along with the increasing development of science and technology from time to time, the world of transportation has progressed very rapidly. Starting from facilities and infrastructure to the increasing frequency of activities. Whether in land, sea, or air transportation, we strive to provide the best service. One of the measures taken is to provide maximum service to transportation service users. To support this, it is necessary to optimize transportation facilities and infrastructure for the benefit of the nation's economic wheels from productive areas to cities and vice versa from cities to rural areas because land transportation is the main target of Timor Leste's national development program which is being awaited by the community. the most important thing is the road. To improve services on land transportation, especially highways managed by the Public Works Department (Obras Publico Timor Leste), many efforts and evaluations have been carried out by repairing and building new infrastructure. This infrastructure is in the form of roads, bridges, terminals, traffic signs, and so on. But obstacles arise caused by nature in the form of rivers and ravines. To overcome this obstacle, a bridge was built. It is hoped that the bridge being built will be able to provide road transportation quickly, safely, and comfortably. As we know, currently the condition of the bridge is a construction whose purpose is to continue or connect the road through an obstacle. The Nunudere River Bridge is a means of connecting the traffic route between Baguia Post Administrative and Uatucarbau Post Administrative. It has not been on this river for several years. There is a bridge and it cannot serve the local community and vehicles during the rainy season when flooding occurs, which can cause problems with the traffic routes being used, which can have a significant negative impact on the economy and people's lives. Considering the future, and concerning the Timor Leste government program, the volume of vehicles that will increase in the area, as a human resource that is ready to be used, we want to make efforts to increase the carrying capacity and serviceability of bridges with "***Reinforced Concrete Bridge Girder Design in Nunudere River, Baguia Post Administrative Baucau Municipality***". This planning is considered to be visible in terms of serviceability, carrying capacity in response to vibrations caused by vehicle traffic loads, and practicality in implementation.

II. RESEARCH METHODS

This research uses field study and literature study methods. From the field study, data was obtained after the author visited the location or field directly, while the library study method was used to obtain references from reference books. After the data is obtained, the next step is to carry out a preliminary design to determine the dimensions of the sidewalk, the dimensions of the bridge floor, and dimensions of the girder beams. Next, carry out planning of superstructure elements, load analysis, and control of superstructure elements. This research was carried out on a bridge located in Alawa Kraik Village, Baguia Post Administrative, Baucau Municipality, which is part of the Baguia - Watukarbau road.

III. BRIDGE DATA

In the design process, the working loads are known, and what will be determined are the structural elements so that they have sufficient strength. Sometimes in determining the size of these structural elements, planning is faced with the problem of structural design with large dimensions meaning it is uneconomical, and small dimensions meaning it is unsafe. Therefore, what is desired is a "proper" design, which means the resulting structure is economical and sturdy.

a. **Bridge type: reinforced concrete (*Box Culvert*)**

- Stretch length (L) : 13.20 m
- Bridge class : B
- Traffic width (B1) : 6.00 m
- Sidewalk width (B2) : 2 X 0.6 m
- Total width (B) : 7.2 m
- Loading : 70 %

b. **Bridge floor**

- Material : reinforced concrete
- Floor thickness (Hf) : 0.20 m
- Pavement thickness (ts) : 0.05 m
- Rainfall (year) : 0.02 m

c. **Girder beam**

- Material : reinforced concrete
- Girder width Wg (b) : 0.45 m
- Girder height Hg (h) : 0.90 m
- Number of girder beams, n :5fruit
- Distance between girders(s) : 1.5 m

d. **Diaphragm beam**

- Material : reinforced concrete
- Diaphragm width Wd (b) : 0.30 m
- Diaphragm height (h) : 0.50 m
- Number of blocks in (n) : 16stem
- wine between the diaphragm : 4.3 m

e. **Material specifications**

❖ Concrete

- Press firmly fc' : 30 Mpa
- Concrete Specific Gravity (γconcrete) : 2400 kg/m3

❖ Reinforcing steel, fy : 400 Mpa

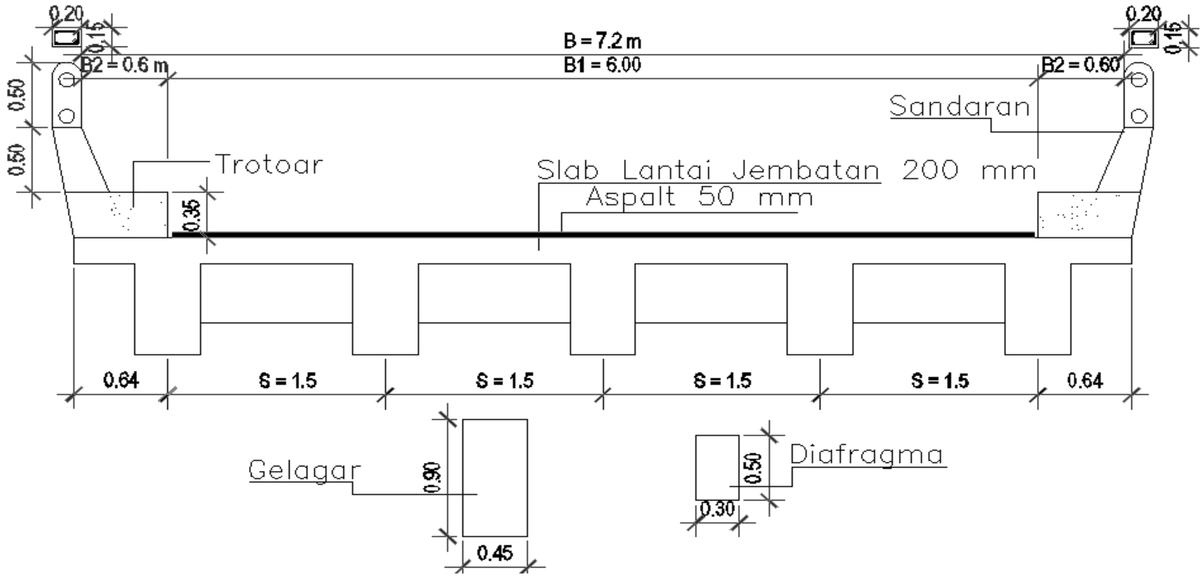


Figure 1. Transversal view

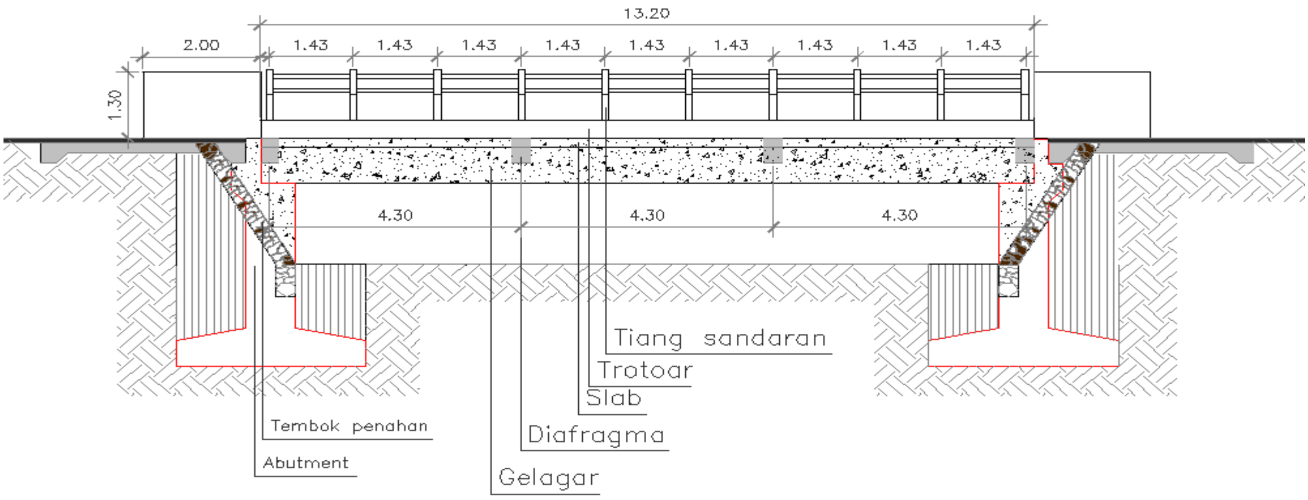


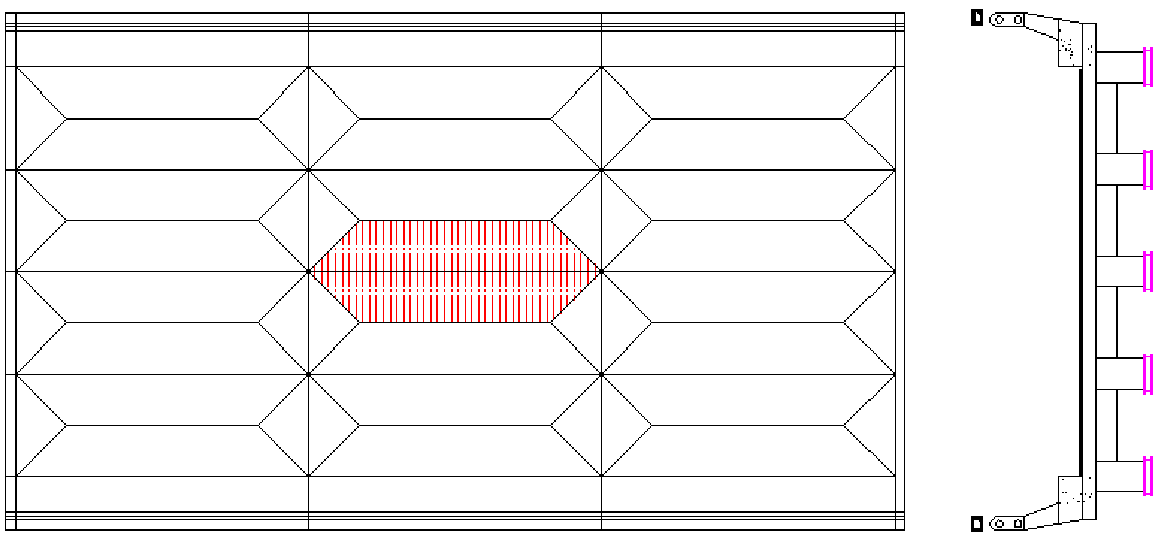
Figure 2. Longitudinal view

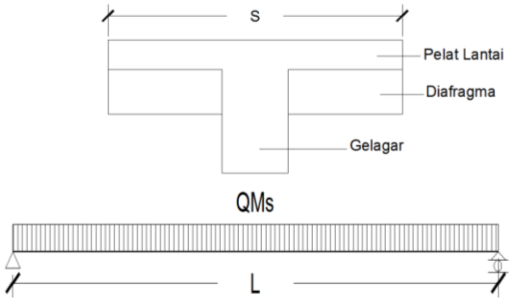
IV. RESULTS AND DISCUSSION

A. GIRDER CALCULATIONS

1. Own Weight (MS)

Ultimate load factor: KMS = 1.3





Shear force and moment in T-Gerar due to own weight (MS):
VMS = ½ * QMS * L = ½ * 17.90182 * 13.2 = 118.152 KN
MMS = 1/8 * QMS * L2 = 1/8 * 17.90182 * 13.22 = 389.902 KNm

2. Additional Dead Load (MA)

Ultimate load factor: KMA =2.0
Shear force and moment on the T-Gerar due to its weight (MA):
VMA = ½ * QMA * L = ½ * 1.95 * 13.2 = 12.87 KN
MMA = 1/8 * QMA * L2 = 1/8 * 1.95 * 13.22 = 42,471 KNm

3. Traffic Load

a. Lane "D" Load (TD)
Ultimate load factor: KTD = 2.0
Shear force and moment on the T-Ginger due to the "D" lane load:
VTD = 1 / 2 * (QTD * L + PTD) = ½ * (12 * 13.2 + 92.4) = 125.4 kN
MTD = 1/8 * QTD * L2 + 1 / 4 * PTD * L
= 1/8 *(12 * 13.22) + (¼ * 92.4 * 13.2) = 566.28 kNm

b. Truck Load "T" (TT)
Ultimate load factor: Summit =2.0
Shear force load "D" and load "T".
Maximum shear force due to load, T VTT =197,273kN
Maximum moment due to load, D MTT =602.0018kNm\

4. Brake Force (TB)

Ultimate load factor: KTB = 2.00
Maximum shear force and moment on the beam due to brake force:
VTB = M / L = 115 / 13.2 = 8,712 kN
MTB = 1/2 * M = ½* 115 = 57.5 kNm

5. Wind Load (EW)

Ultimate load factor: KEW = 1.20
Shear force and moment on Girder due to wind load (EW):
VEW = 1 / 2 * QEW * L = ½ * 1.008 * 13.2 =6.6528 kN
MEW = 1 / 8 * QEW * L2 = 1/8 * 1.008 * 13.22= 21.95424 KN.m

6. Effect of Temperature (ET)

Ultimate load factor: KET = 1.20
Shear force and moment on the Girder due to the influence of temperature (ET):
VET = M / L = 17.82 / 13.2 = 1.35 kN
MET = M = 17.82 kN.m

7. **Earthquake Load (EQ)**

Ultimate load factor: KEQ = 1.00

Shear force and moment on Girder due to vertical earthquake (EQ):

VEQ = 1 / 2 * QEQ * L = ½ * 2.212 *13.2 = 14.5992 kN

MEQ = 1 / 8 * QEQ * L2 = 1/8 * 2.212 * 13.22 = 48.1774 kN.m

8. **Ultimate Load Combination**

a. Combination of ultimate moment and shear force

No	Load type	Load factor	Comm-1	Comm-2	Comm-3
1	Own weight (MS)	1.3	✓	✓	✓
2	Additional dead load (MA)	2	✓	✓	✓
3	“D” lane load (TD)	2	✓	✓	✓
4	Brake force (TB)	2	✓	✓	
5	Wind load (EW)	1.2	✓		
6	Effect of temperature (ET)	1.2		✓	
7	Earthquake load (EQ)	1			✓

b. Ultimate moment combination

Ultimate moment combination				Comb-1	Comb-2	Comb-3
No	Load type	Load factor	Moment (KNm)	MU (KNm)	MU (KNm)	MU (KNm)
1	Own weight (MS)	1.3	389,902	506.8726	506.8726	506.8726
2	Additional dead load (MA)	2	42,471	84,942	84,942	84,942
3	Traffic load (TD/TT)	2	602,002	1204.0036	1204.004	1204.0036
4	Brake force (TB)	2	57.5	115	115	
5	Wind load (EW)	1.2	21.9542	26.345088		
6	Effect of temperature (ET)	1.2	17.82		21,384	
7	Earthquake load (EQ)	1	48.1774			48.1774
				1937.2	1932.20	1844

c. Combination of shear forces

Ultimate shear force combination				Comb-1	Comb-2	Comb-3
No	Load type	Load factor	V (KN)	Vu (KN)	Vu (KN)	Vu (KN)
1	Own weight (MS)	1.3	118.152	153.5976	153.5976	153.5976
2	Additional dead load (MA)	2	12.87	25.74	25.74	25.74
3	Traffic Load (TD/TT)	2	197,273	394,546	394,546	394,546
4	Brake force (TB)	2	8,712	17,424	17,424	
5	Wind load (EW)	1.2	6.6528	7.98336		
6	Effect of temperature (ET)	1.2	1.35		1.62	
7	Earthquake load (EQ)	1	14.5992			14.5992
				599.3	592.93	588.48

The ultimate moment of Girder's plan, Mu =1937.2KNm

Design girder ultimate shear force, Vu =599.3KN

9. Girder Reinforcement

a. Flexible Reinforcement

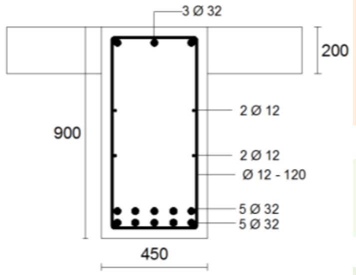
Girder's ultimate planning moment,	Mu =1937.2kNm
Concrete compressive strength,	fc' = 30 MPa
The yield strength of steel,	fy = 400 MPa
Thickness of concrete slab,	ts = 200 mm
Girder web width,	b = 450 mm
Girder Height,	h = 900 mm
The smallest value of the T-Girder flange is taken:	L/4 = 3300 mm
Distance between girders,	S = 1500 mm
The amount of compression reinforcement required,	n' = As' / As1 = 2411.52 / 803.84 = 3

Reinforcement used, 3 D 32

b. Shear Reinforcement

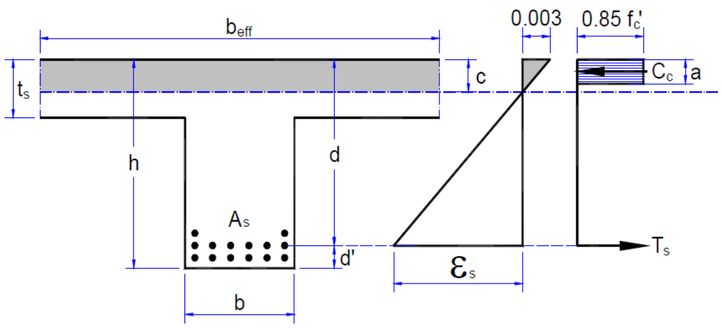
Design ultimate shear force,	Vu = 599.3 kN
Concrete compressive strength,	fc' =30 MPa
The yield strength of steel,	fy =400 MPa
Shear strength reduction factor,	Ø = 0.6
Girder web width,	b = 450 mm
Concrete covers,	d' = 40 mm
Effective height of Girder,	d = 860 mm

The number of shrinkage reinforcements used is 3D 12



B. CONTROL OF MOMENTS AND DEFLECTIONS OF GIRDERS

1. Girder Ultimate Moment Control



Planned ultimate moment,	Mu =1937.2KNm
Nominal moment,	Mn = KNm2437.1432
Ultimate moment capacity,	Mu = * Mn = 1949.715 kNmØ

Control;

Ultimate moment capacity > Planned ultimate moment

1949,715 KNm >1937.2KNm **Safe (OK)**

2. Control girder deflection

Effective inertia for deflection calculations, Ie = (Mcr / MD+L)3 * Ig + [1 - (Mcr / MD+L)3] * Icr =0.028 m4

Concrete Moludus elasticity, Ec = 4700 * = 4700*$\sqrt{fc'}$ $\sqrt{30}$ = 25742.9602 MPa

a. Deflection due to self-weight (MS)

Load due to own weight, QMS = 17.90182 kN/m
Deflection due to self-weight (MS):MS = 5/384*QMS*L4 / (Ec*Ie) = 0.00982 m δ

b. Deflection due to additional dead load (MA)

Load due to additional dead load, QMA = 5.38 kN/m
Deflection due to additional dead load (MA): MA = 5/384*QMA*L4 / (Ec*Ie) = 0.0011 mδ

c. Deflection due to "D" lane load (TD)

"D" lane load: Concentrated load, PTD = 92.4 kN
Uniform load, QTD = 12 kN/m
Deflection due to "D" lane load (TD): TDδ
= 1/48*PTD*L3 / (Ec*Ie) + 5/384*QTD*L4 / (Ec*Ie)
= 0.0061 + 0.0066 = 0.0127 m

d. Deflection due to brake force (TB)

Moment due to brake force, MTB = 115 kNm
Deflection due to brake force (TB): TB = 0.0642 * MTB * L2 / (Ec*Ie) = 0.0018 mδ

e. Deflection due to wind load (EW)

Load due to transfer of wind load to the vehicle, QEW = 1,008 kN/m

Deflection due to wind load (EW): EW = 5/384*QEW*L4 / (Ec*Ie) =$\boldsymbol{\delta}$0.0006 m

f. Deflection due to the influence of temperature (ET)

Moment due to movement temperature, MET = 17.82 kNm
Deflection due to temperature (ET): ET = 0.0642 * MET * L2 / (Ec*Ie = 0.00028 mδ

g. Deflection due to earthquake load (EQ)

Vertical earthquake load, QEQ = 2,204 kN/m

Deflection due to earthquake load (EQ): EQ = 5/384*QEQ*L4 / (Ec*Ie) =$\boldsymbol{\delta}$0.0012 m

h. Beam Deflection Control

Max maximum deflection = L/240δ		0.055	0.055	0.055
No	Load type	Comb-1 $\boldsymbol{\delta}$(m)	Comb-2 $\boldsymbol{\delta}$(m)	Comb-3 $\boldsymbol{\delta}$(m)
1	Own weight (MS)	0.00982	0.00982	0.00982
2	Additional dead load (MA)	0.0011	0.0011	0.0011
3	"D" lane load (TD)	0.0127	0.0127	0.0127
4	Brake force (TB)	0.0018	0.0018	
5	Wind load (EW)	0.0006		
6	Effect of temperature (ET)		0.00028	
7	Earthquake load (EQ)			0.0012
Total deflection (combination)		0.02602	0.0257	0.02362
		< 0.055 OK	< 0.055 OK	< 0.055 OK

V. CCONLUSIOIN

In this paper, the authors can conclude as follows:

1. In calculating the bridge structure, the dimensions used include a Railing of 150/200 mm, sidewalk width of 600 mm, traffic road width of 6000 mm, bridge floor slab thickness of 200 mm, a diaphragm of 300/500 mm, girder of 450/900 mm, and span length 13200 mm.

2. In calculating the structure of this bridge, the materials used are concrete and reinforcing steel. The compressive capacity of concrete is 30 MPa and the tensile capacity of steel is 400 MPa.

3. The planned loads follow the Indonesian bridge loading regulations RSNI T-02-2005. These related actions include dead load, live load, wind load, earthquake load, and temperature effects.

4. These planned related actions are combined to obtain a maximum moment at the support pillar of 2.86 KNm and a cross-sectional force of 2.86 KN, on the sidewalk slab the moment is 15,124 KNm, on the floor slab the moment is 67.6192 KNm M support and 60.20852 M field, on the main girder (girder) the moment is 1937.2 kNm and the transverse force is 599.3 KN, on the transverse girder (diaphragm) the moment is 55,864 kNm and on the transverse girder it is 153,455 kN.

5. From the magnitude of the moment and plan latitudinal force obtained from the calculation, the dimensions of the concrete reinforcement for the main reinforcement pillars are 4Ø10 and stirrups Ø 6 – 450 mm, longitudinal reinforcement pavement slab Ø16 – 300 mm and transverse reinforcement Ø 13 – 700 mm, slab traffic floor longitudinal reinforcement Ø 13-200 mm and transverse reinforcement Ø 16 – 150 mm, in the transverse beam (diaphragm) 4 principal reinforcement Ø 22 and 2 compression reinforcement rods 2 tensile reinforcement rods with stirrup reinforcement Ø 10-200 mm. 13Ø32 main girders and 3 compression reinforcement bars, 10 tensile reinforcement bars. Apart from that, the girder body is installed with shrinkage reinforcement with 4 Ø 12 - 200 mm and stirrup reinforcement Ø 12-120 mm and 200 mm

6. The deflection that occurs in the floor slab and beam due to each related action is combined to obtain the maximum design deflection in the table below.

   a. Maximum deflection of bridge floor slab
   Total deflection of the bridge deck slab, δmask = 1.5/240 = 0.00625 m

No	Load type	Deflection (m)
1	Own weight (MS)	0.000023
2	Additional load (MA)	0.0000064
3	Traffic load (TT)	0.00073
Total deflection		0.00076
		< L/240 = 0.00625 OK

   b. Maximum deflection in the beam

Max maximum deflection = L/240δ		0.055	0.055	0.055
No	Load type	Comb-1 (m)δ	Comb-2 (m)δ	Comb-3 (m)δ
1	Own weight (MS)	0.00982	0.00982	0.00982
2	Additional dead load (MA)	0.0011	0.0011	0.0011
3	“D” lane load (TD)	0.0127	0.0127	0.0127
4	Brake force (TB)	0.0018	0.0018	
5	Wind load (EW)	0.0006		
6	Effect of temperature (ET)		0.00028	
7	Earthquake load (EQ)			0.0012
Total deflection (combination)		0.02602	0.0257	0.02362
		< 0.055 OK	< 0.055 OK	< 0.055 OK

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