

**INVESTIGATION OF THE AQUEDUCT ON THE MTKVARI RIVER  
(LOCATION COORDINATES – 41°26'14"N 45°01'13"E)**

**REP-BR-02/26-003**



Tbilisi  
2026



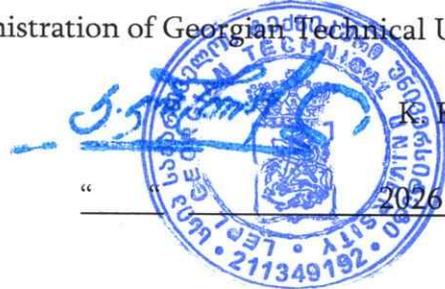
GEORGIAN TECHNICAL UNIVERSITY  
BRIDGE TESTING CENTER



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INVESTIGATION

of the aqueduct on the Mtkvari River (location coordinates –  $41^{\circ}26'14''N$   
 $45^{\circ}01'13''E$ )

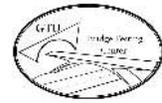
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2026

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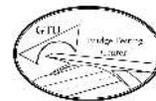
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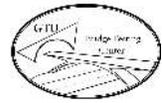


## INTRODUCTION

This report was prepared pursuant to the contract between “Georgian Water and Power” LLC and “Georgian Technical University” dated January 2026.

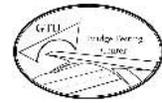
The bridge survey was based on the Aqueduct Survey Services List issued by the Purchaser, “Georgian Water and Power” LLC.

The survey methodology is based on over seventy years of experience of the Bridge Testing Center of the Georgian Technical University and on the requirements of the current normative documents: «СНиП 2.05.03-84. Мосты и трубы. Нормы проектирования», «СНиП III-43-75. Мосты и трубы. Правила производства и приемки работ», «СНиП 3,06,07-86. Мосты и трубы. Правила обследований и испытаний», «ГОСТ 8829-94. Изделия строительные железобетонные и бетонные заводского изготовления. Методы испытания нагружением. Правила оценки прочности, жесткости и трещиностойкости», «ВСН 4-81. Инструкция оп проведению осмотров мостов и труб на автомобильных дорогах», «ГОСТ 25192-82. Бетоны. Классификация и общие технические требования», «EN 1992-2 : Eurocode 2: Design of concrete structures – Part 2», «EN 1998-2: Eurocode 8: Design of structures for earthquake resistance – Part 2 Bridges», «EN 1993-2: Eurocode 3: Design of steel structures – Part 2».



## General data of the aqueduct

1. Location of the aqueduct - coordinates – 41°26'14"N, 45°01'13"E.;
2. River - Mtkvari;
3. Aqueduct scheme -  $9 \times 18.00 + 5.00 + 11 \times 18.00 + 5.00 + 9 \times 18.00$  m;
4. Aperture on the axis of the aqueduct - 530.33 m;
5. Aqueduct length -  $L=531.73$  m;
6. Aqueduct gauge -  $\Gamma=4.00$  m;
7. Span – 18.00 and 5.00 m long steel span;
8. Number of main beams in the span: – 2 pieces;
9. Distance between the axes of the beams: - 1.00 m;
10. Aqueduct piers: - 0.53 m diameter steel-clad reinforced pile-pilars and reinforced concrete crossbar;
11. Steel water pipe diameter: -  $\varnothing 0.82$  m;
12. Number of steel water pipes: - 2 pieces;
13. Distance between the axes of the steel water pipes: - 3.15 m;
14. Steel water pipe inclination: - 0.07 %;



## 1. Brief description of the aqueduct

The aqueduct on the Mtkvari River (location coordinates – 41°26'14"N 45°01'13"E) was built in the 1960s of the last century.

The design documentation of the aqueduct could not be found, as a result, its actual dimensions could not be compared with the design data, therefore the description of the aqueduct and the graphical part presented in the report (actual geometric dimensions of the aqueduct structures) are given based on the analysis of the data obtained as a result of field and measurement work carried out by the group.

According to field survey works, the aqueduct is located on the plan straight, on the facade (the head of the crossbar) with a slope of 0.13%, inclined towards the left bank of the Mtkvari. The aqueduct crosses the riverbed of the Mtkvari at an angle of almost  $\approx 90^\circ$ . The height of the aqueduct (the distance from the water pipe head mark to the water level mark) was 7.10 m.

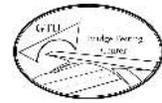
According to the steel span structure, the aqueduct is a thirty-one-section, precast girder system, with a scheme of  $9 \times 18.00 + 5.00 + 11 \times 18.00 + 5.00 + 9 \times 18.00$  m. The length of the aqueduct (the distance between the axes of the piers along the aqueduct) was 531.73 m, the overall gauge according to the carriageway (T) was 1.50 m, and the diameter of the water pipeline steel pipes according to the outer edges was 4.00 m.

The aqueduct consists of piers, steel span structures and water pipes made of steel. Steel support parts are installed on the piers (water pipes are installed on the support parts in turn) and span structures. Reinforced concrete slabs of the prefabricated structure and a railing are arranged on the spans (not along the entire length of the aqueduct).

The diameter of the water pipe was  $\varnothing 820$  mm. The size between the axes of the water pipes in the transverse direction of the aqueduct was 3.15 m, the size between the inner edges was 2.40 m. The connection nodes on each water pipe in the longitudinal direction of the aqueduct were two each. The installation of the water pipe on the support part was carried out by means of a steel yoke of the upper and lower, arcuate cross-section, composite (substrate sheet, wall, angle, stiffener) construction. The connection of the yokes to each other and to the upper balancing steel sheet of the support part is carried out by means of bolts.

The water pipes are supported on a single-roller steel support section installed on the transverse pier consoles of the aqueduct.

The structure of the support section consists of a lower and upper support plate, balancing sheets and a roller. The size of the lower support plate along the aqueduct longitudinally and transversely was 450 mm, height - 60 mm, taking into account the cross-stiffening pads - 120 mm. The size of the upper plate along the aqueduct longitudinally was 250 mm, transversely - 500 mm, height - 60 mm. The length



of the roller was 200 mm, diameter  $\varnothing 270$  mm. The steel support parts are fastened to the reinforced concrete crossbar using  $\varnothing 28$  mm diameter A-I class reinforcement anchors with a screw - M22.

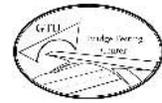
The supporting structure is the pier itself. The numbering of the piers and span structures is given in the direction upstream of the river flow.

The aqueduct has 32 piers. Reinforced concrete pumps are installed on the pier crossbars N5, N17 and N32 (unlike the other piers) to support the water pipe. Structurally, the remaining piers, except for the above, are identical to each other, each of them consists of two steel stands with a diameter of  $\varnothing 530$  mm (with a wall thickness of 12 mm) and a reinforced concrete crossbar with a rectangular cross-section mounted on them. The distance between the pier axes varies along the length of the aqueduct and varies within the range of 4.90÷18.20 m. The distance between the pier axes of the stand along the aqueduct was 3.10 m. The size of the reinforced concrete crossbar along the aqueduct was 0.7 m, in the transverse of the aqueduct was 4.80 m, and the height was 0.60 m. One vertical rubber pipe is installed in the pier and crossbar structure of N26. The depth of the pipe installed in the upper shoulder post was 3.40 m, and the depth of the lower shoulder pipe was 4.30 m. 2 steel insert details (rails) were installed in the upper girdle of the reinforced concrete crossbar. The support of the span structure was carried out on the insert detail.

The steel spans of the aqueduct are of individual construction. The spans are covered with spans of length  $L=17.65\div 18.0$  and  $L=5.0$  m. Each span consists of two main beams with an I-shaped cross-section, which are connected to each other across the aqueduct by transverse connections and reinforced concrete slabs of the carriageway installed on them. The distance between the axes of the main beams across the aqueduct was 1.00 m, the height was 0.60 m, and the shelf size (width) was 0.16 m. The vertical sheet of the main beams is through-walled (hexagonal cutout with dimensions of 310×340 mm), the connection of the beam building blocks is carried out by means of additional steel sheets of different sizes (vertical 1500×520×10 mm, horizontal 600×100×14 mm). The transverse connection structure is a paired steel channel with a N10 profile and an equal-width angle with a cross section of 56×56×5 mm. The transverse connections are connected to the vertical sheet of the main beam by means of a stiffening rib. The longitudinal connections in the beam are located at the level of the lower girdle of the main beam. The longitudinal connection is an equal-width angle with a cross section of 56×56×5 mm, which is connected to the lower girdle of the main beam by a 12 mm thick steel sheet. The steel elements of the beam structure are connected to each other by welding.

Reinforced concrete prefabricated walkway structure is installed on the span structure.

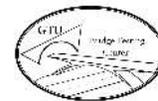
The walkway structure consists of reinforced concrete slabs and railing installed on the main beams of the span structure. The size of the reinforced concrete slab was 1.50 m across the aqueduct, 1.00 m long, and 0.08 m high (thickness). The wearing layer installed on the reinforced concrete slabs is an asphalt



concrete coating with a thickness of 2.0÷3.0 cm. The railing structure on the walkway consists of posts, handrail, and horizontal fillers located at a pitch of 1.00 m along the aqueduct. The structure of the post is a 1.27 m long, 50×50×5 mm cross-section, equal-width angle with a cross-section of 40×40×4 mm, and the filler is Ø12 mm diameter A-I class reinforcement. The height of the railing from the surface of the reinforced concrete slab of the carriageway was 1.10 m.

A Ø62 mm diameter polyethylene pipe (for carrying a fiber optic cable) is suspended from the water pipe of the lower (river flow) side of the aqueduct.

A staircase structure for accessing the carriageway of the aqueduct is installed adjacent to the 11th span building.



## 2. Investigation of the aqueduct

In January 2026, the staff of the Bridge Testing Center of the Georgian Technical University investigated the aqueduct on the Mtkari River (location coordinates – 41°26'14"N 45°01'13"E).

The field work of the aqueduct investigation included planning the crossing, measuring the aqueduct structures (visible part) and their visual and instrumental inspection.

According to the analysis of the study results, the slope of the upper (in the direction of the river flow) branch water pipe (the slope was taken at the head and bottom of the aqueduct - above the support section of the water pipe on piers N1 and N32) along the aqueduct was 0.07%, and the slope of the lower branch water pipe was 0.06%.

For the purpose of the overall assessment of the aqueduct's load-bearing structures, the strength characteristics of concrete were determined using the **Silver Schmidt** non-destructive testing method. The concrete class of the reinforced concrete crossbar is B25 determined by the compression stress.

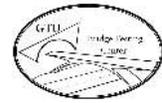
During the investigation, the reinforcement spacing, class, and thickness of the protective layer concrete in the reinforced concrete crossbar structure of various piers were checked. In a number of cases, the „*NJJ-105 Hand Search*“ scanner was used for this purpose.

According to the results of the inspection, it was determined that in the construction of the pier crossbar N1, the vertical rods (hangers) of the reinforcement are located with a pitch of 200÷250 mm. In the construction of the pier crossbar N6 - with a pitch of 160÷200 mm. In the construction of the pier crossbar N9 - with a pitch of 100÷190 mm. The diameter of the working reinforcement in the crossbar was Ø28 mm, class A-III. The number in the upper and lower girdle of the crossbar was four pieces each. The minimum thickness of the concrete protective layer in the crossbar construction was determined as 30 mm. According to the analysis of the investigation results, the thickness of the steel post wall of piers N8, N10 and N11 (the numbering of the piers is given from the direction opposite to the river flow) was Ø12 mm. In the N11 pier post, the diameter of the vertical rod was Ø14 mm, of the the horizontal (spiral) was Ø6 mm, and the minimum thickness of the protective layer was determined to be 70 mm.

The results of the measurements of the aqueduct structures (actual geometric dimensions) are given in the form of a graphic part in Appendix I.

According to the results of the research carried out during the investigation of the aqueduct, a number of damages and defects were identified, namely:

1. On the reinforced concrete crossbars of the piers, there are worn-out areas and cracks of the concrete protective layer, reinforcement rods are visible (Appendix II. Fig. 1.1);



2. In the junction of the reinforced concrete crossbars and steel posts, a large fraction (stone) filler was observed (Appendix II. Fig. 1.2);
3. There are no support structures on the pier crossbars N2, N4, N7, N8 and N10 (Appendix II. Fig. 1.3);
4. The support structures of piers N1, N2, N3, N9, N11, and N12 do not have a roller (circular cross-section roller), which is why the support node of the water pipe on the pier is broken (Appendix II. Fig. 1.4);
5. The steel bracket structures on the water pipe are displaced and do not coincide with the axis of the support structure on the pier crossbar, in addition, some of them do not have an upper bracket structure (Appendix II. Fig. 1.5);
6. The roller of the supporting part on the piers is bent to the extreme, in addition, the roller of the supporting parts on piers N3, N6, N11, N12 and N31 has fallen out of the balancing structures (Appendix II. Fig. 1.6);
7. In the construction of the crossbar, the anchors in the lower support plate fastening node of the steel supporting part are missing a wrench;
8. The steel elements of the span structures are rusted (Appendix II. Fig. 1.7)
9. Deformed longitudinal connections were observed in the span structures (Appendix II. Fig. 1.8);
10. The main beam of the upper side of the 9th span structure is deformed (Appendix II. Fig. 1.9);
11. The main beam of the lower side of the 10th span structure is deformed (Appendix II. Fig. 1.10);
12. The longitudinal beams of the 29th and 30th span structures are displaced in plan (Appendix II. Fig. 1.11);
13. The concrete of the protective layer of the reinforced concrete slabs of the carriageway is damaged, and in some sections it is completely absent (Appendix II. Fig. 1.12);
14. The railing structure on the carriageway does not extend over the entire length of the aqueduct;
15. In the riverbed, near the posts of the piers, trees and plants are piled up (Appendix II. Fig. 1.13);

### 3. Analysis of the stress-strain condition of the span

#### 3.1. Design loads

##### 3.1.1 Permanent loads

Table 3.1 Permanent loads for a single span

Load Name	Normative meaning t/m	Volumetric weight t/m <sup>3</sup>	Reliability coefficient	Reporting value t/m
Water load in pressure mode	1.006	1.0	1.0	1.006

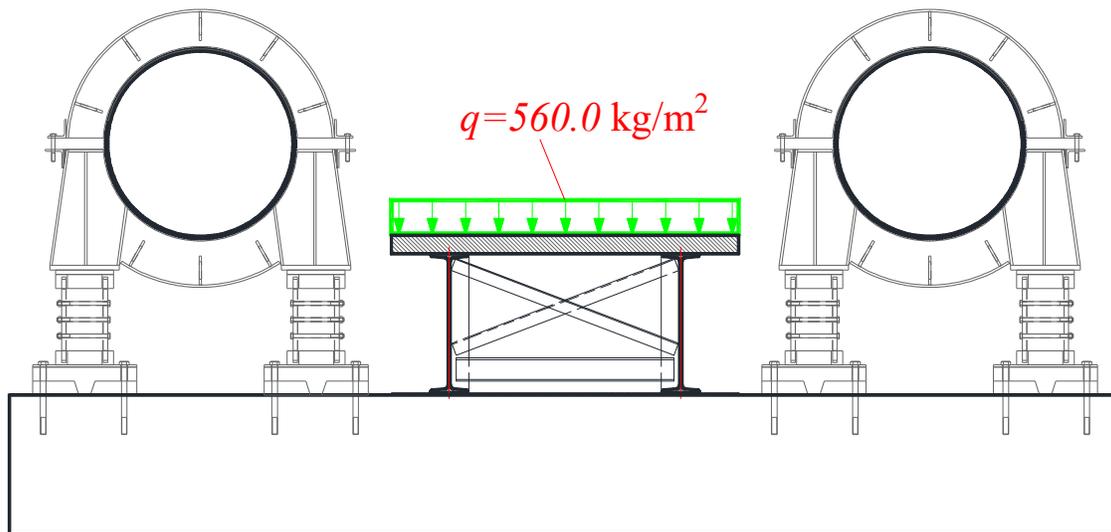
Note: The weight of the span structure and water pipeline is automatically calculated by the program, taking into account the sections and material weights of the elements of the calculation model.

##### 3.1.2 Temporary Loads

###### Pedestrian Load

The pedestrian load consists of a uniformly distributed load equal to 560 kg/m<sup>2</sup>.

A description of the pedestrian load model is given in Drawing 3.1.



DWG. 3.1

###### Temperature load

$$T_{\max} = 41 \text{ }^{\circ}\text{C}$$

$$T_{\min} = -24 \text{ }^{\circ}\text{C}$$

$$T_0 = 10 \text{ }^{\circ}\text{C}$$

(Data taken from the Technical Regulation - 'Construction Climatology')

### Seismic Load

#### Type 1 - Horizontal Elastic Spectrum Function

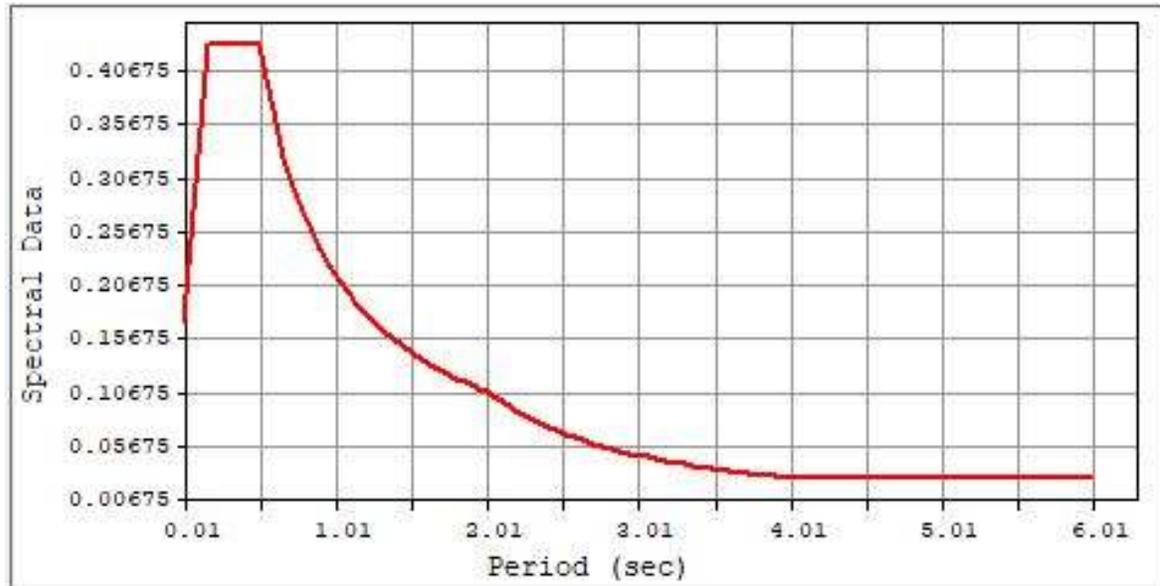


Fig. 1.1

EURO2004 H-ELA:  $G=B,S=1.2,T_b=0.15,T_c=0.50,T_d=2.00,A_gR=0.12g,I=1.2,Damping=5.00$

#### Type 1 - Vertical elastic spectrum function

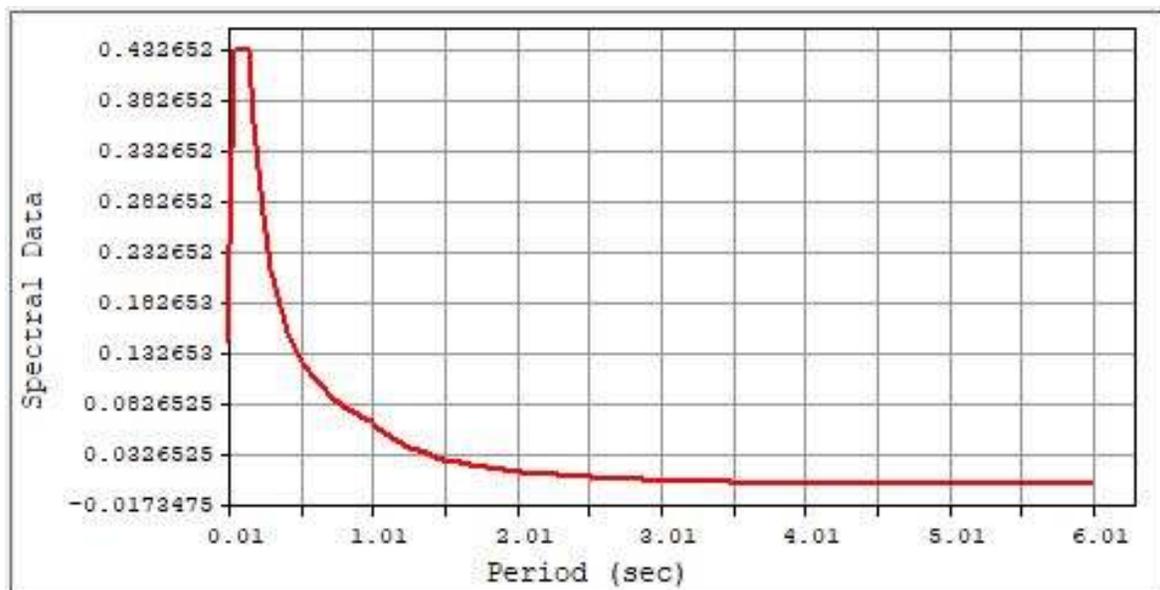
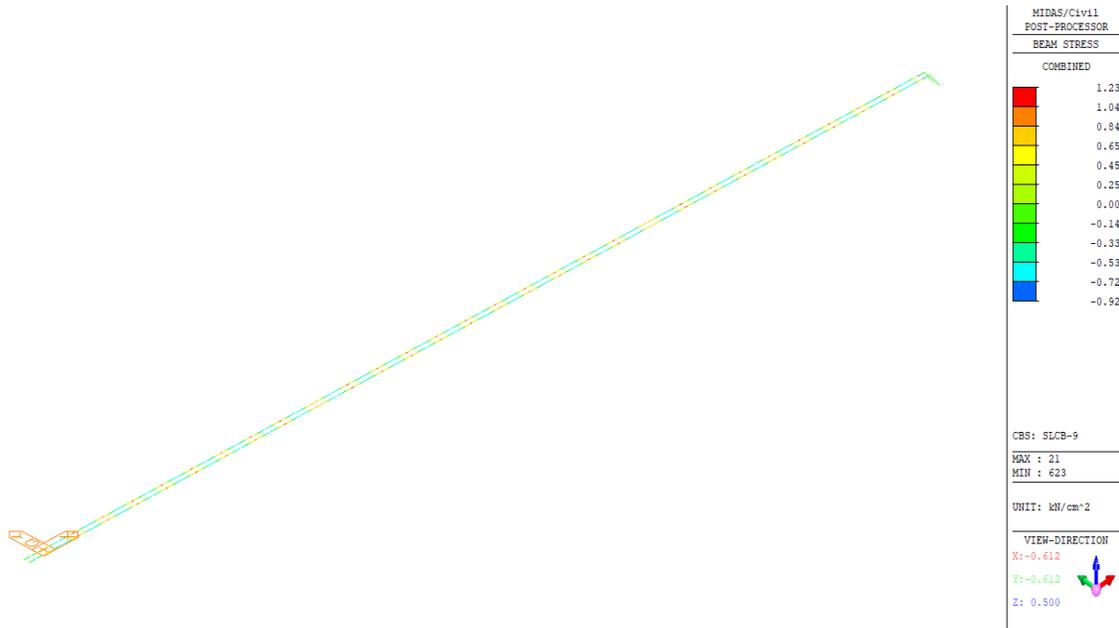


Fig. 1.2

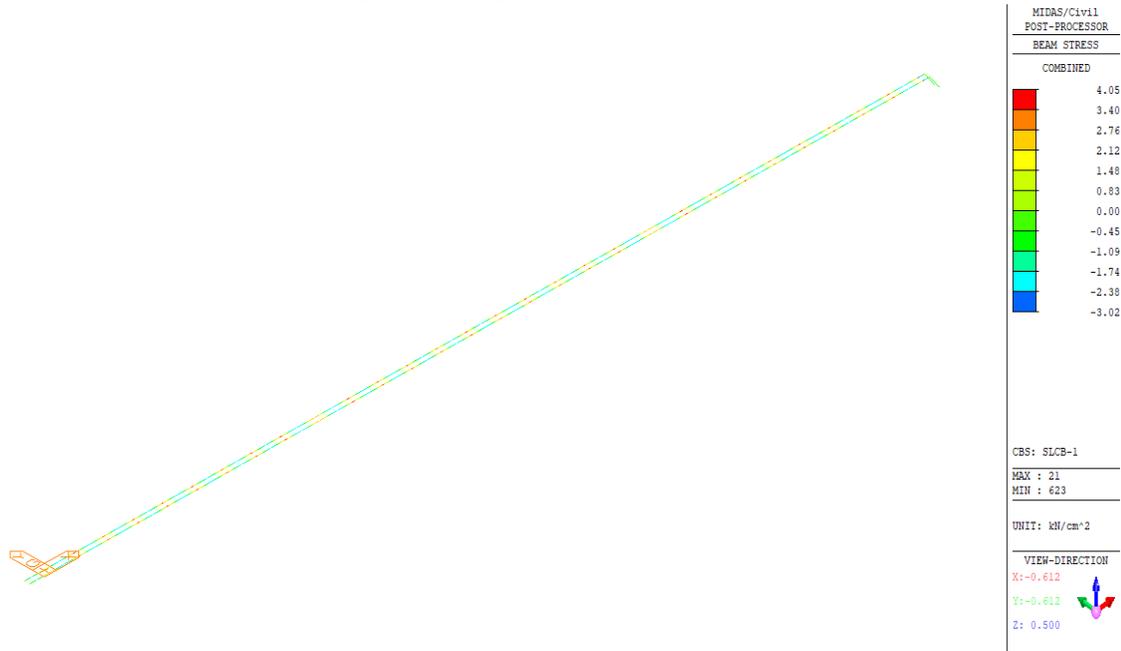
EURO2004 V-ELA:  $G=B,S=1.00,T_b=0.05,T_c=0.15,T_d=1.00,A_gR=0.12g,I=1.2,Damping=5.00$   
(A - dimensionless seismic coefficient taken from the Technical Regulation - "Seismic-Resistant Construction")

### 3.2. Results of calculations on the span deformations

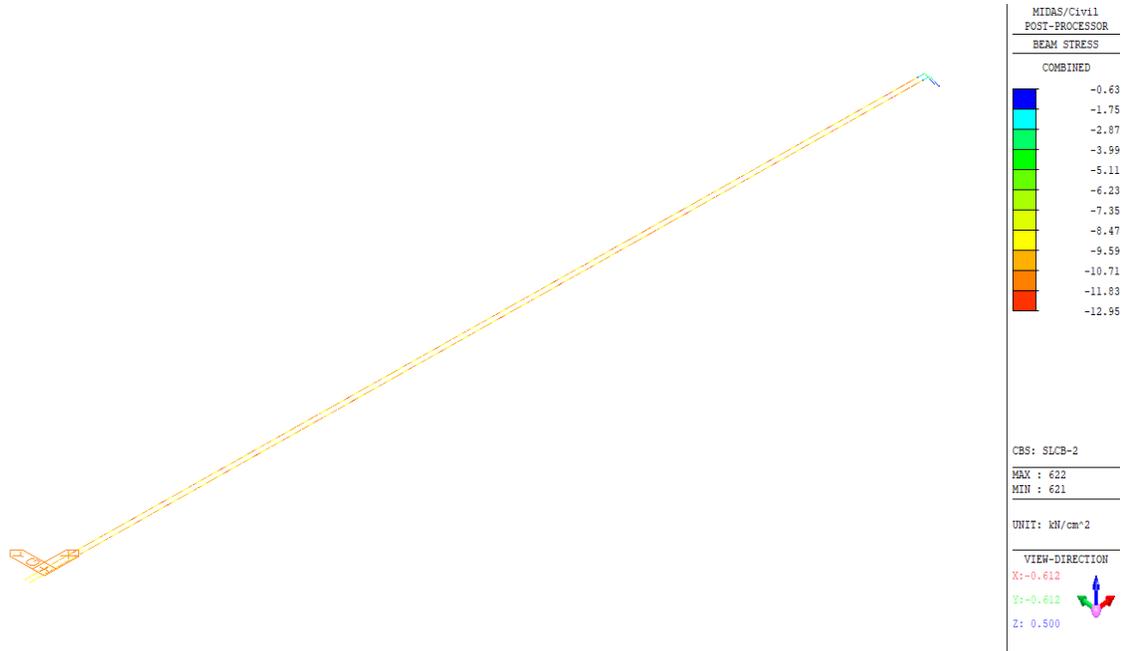
The bridge span was calculated for the load provided by the norms in the program Midas Civil 2025.



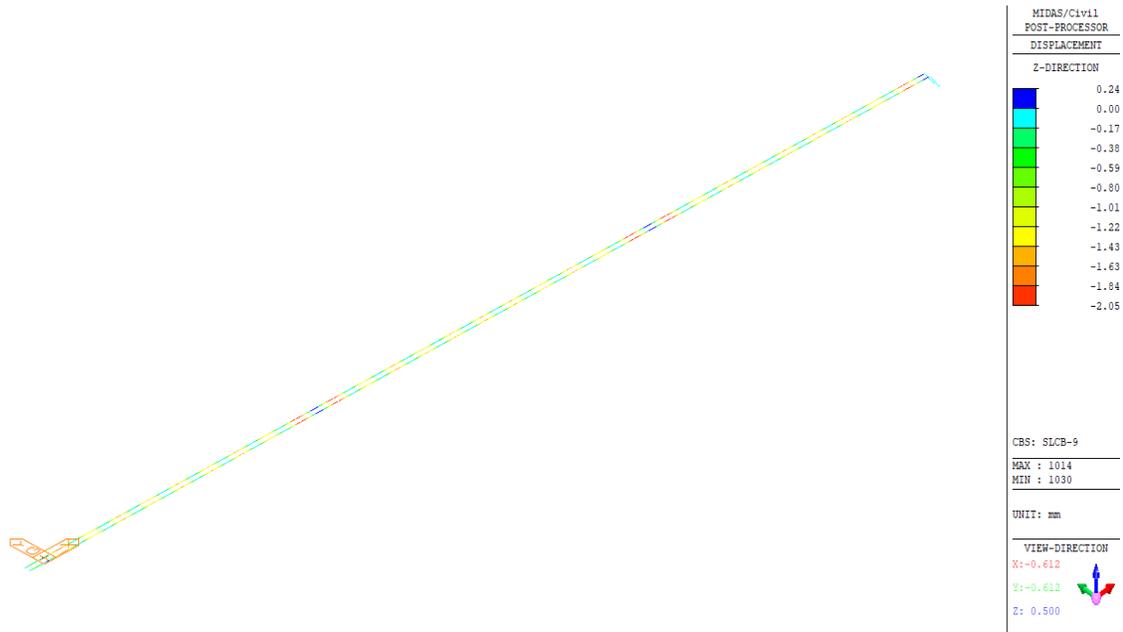
**Fig. 3.1** Stress induced in a water pipe on the pier by self weight (1.23 Kn/cm<sup>2</sup> Stage2-2:self weight)



**Fig. 3.2** Stress induced in a water pipe on the pier by permanent loads (4.05 Kn/cm<sup>2</sup> Stage2-2:SLCB-1)



**Fig. 3.3** Stress induced in a water pipe on the pier by permanent and temporary loads (12.95 Kn/cm<sup>2</sup> PostCS: sLCB-2)



**Fig. 3.4** Deflection of the water pipe on the pier  $Dz$  from self weight (2.05 mm Stage2-2: Self weight)

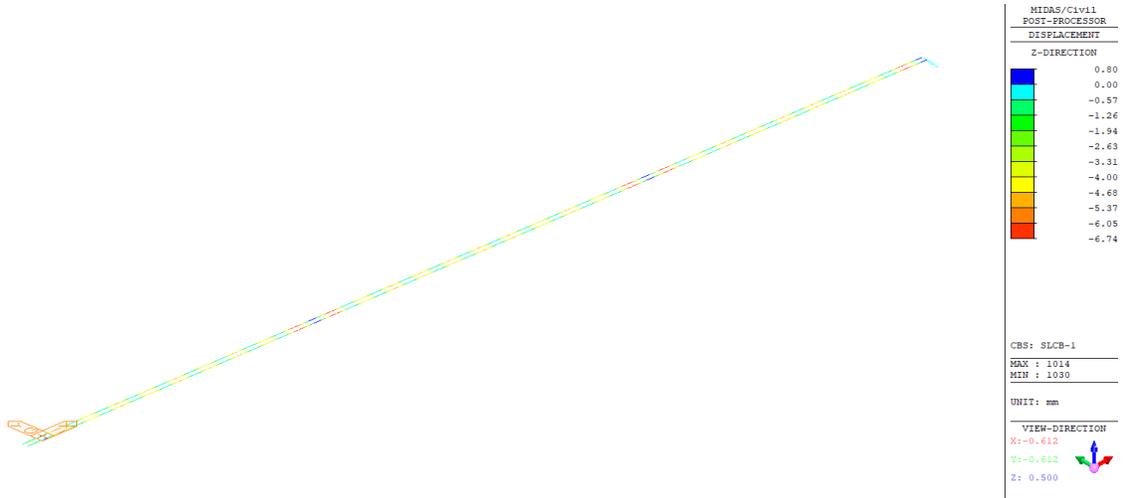


Fig. 3.5 Deflection of the water pipe on the pier  $Dz$  from permanent loads (6.74 mm Stage2-2: sLCB-1)

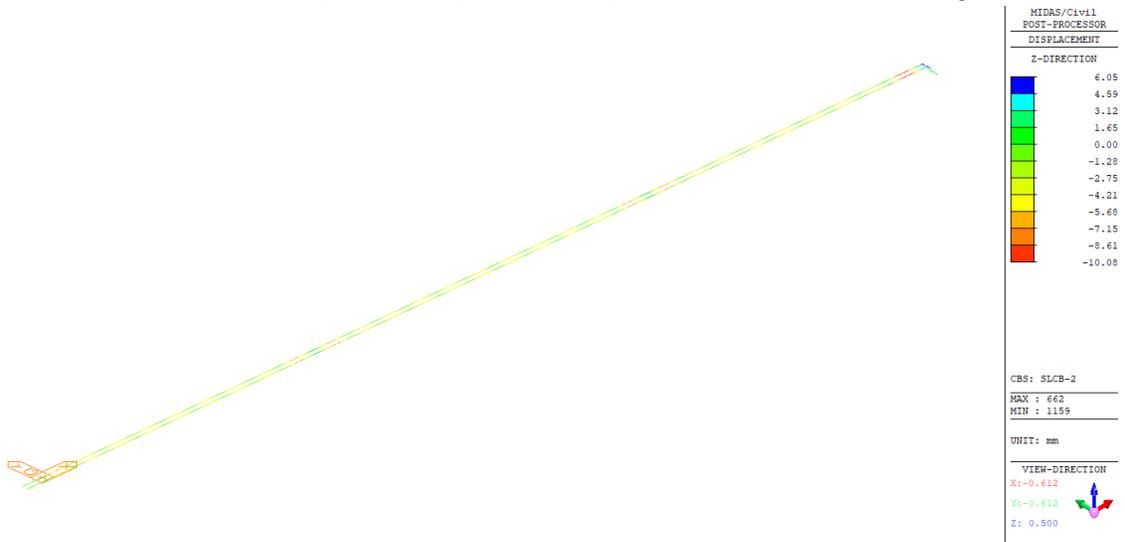


Fig. 3.6 Deflection of the water pipe on the pier  $Dz$  from permanent and temporary loads (10.08 mm PostCS: sLCB-2)

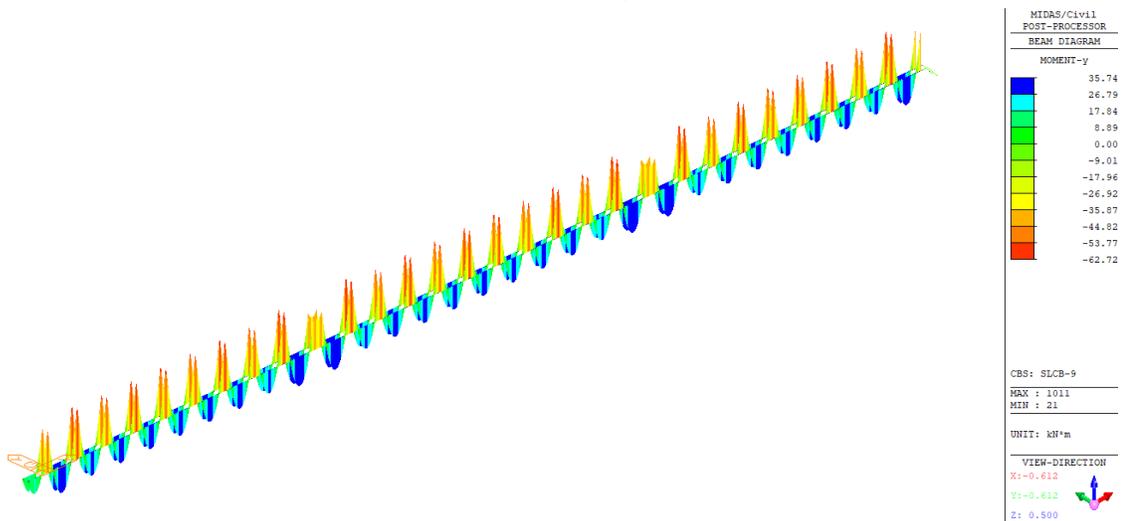
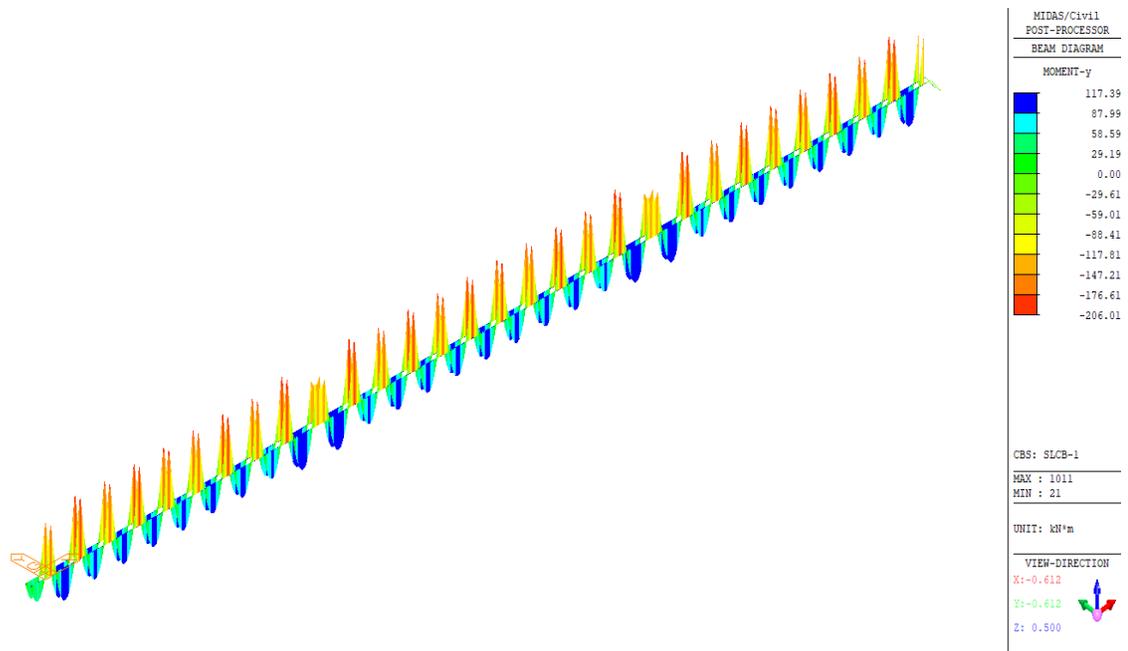
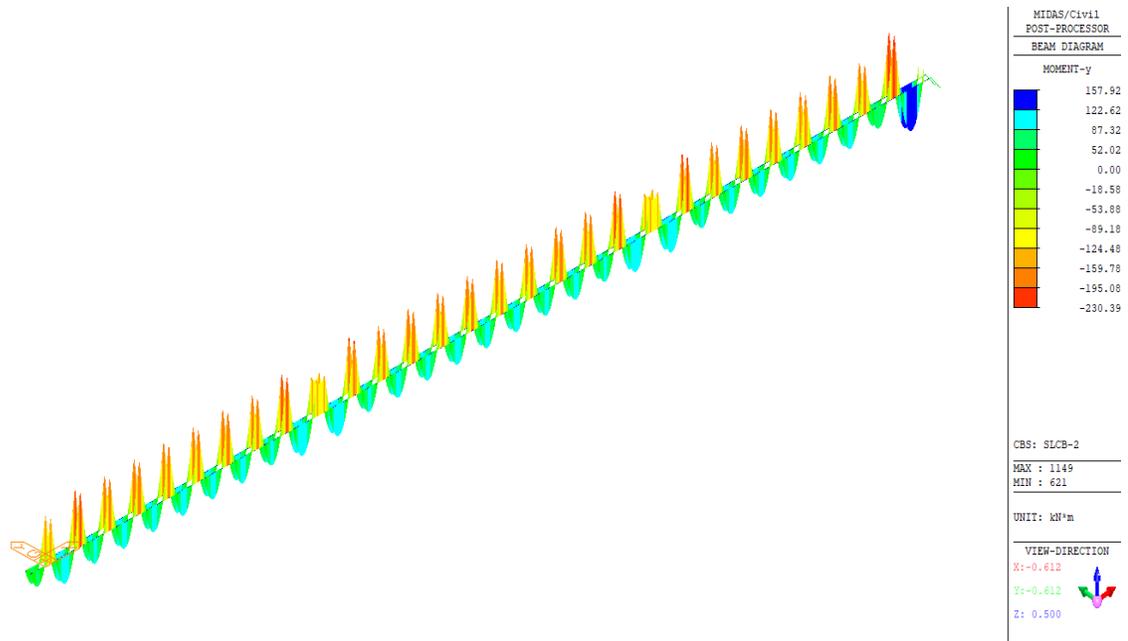


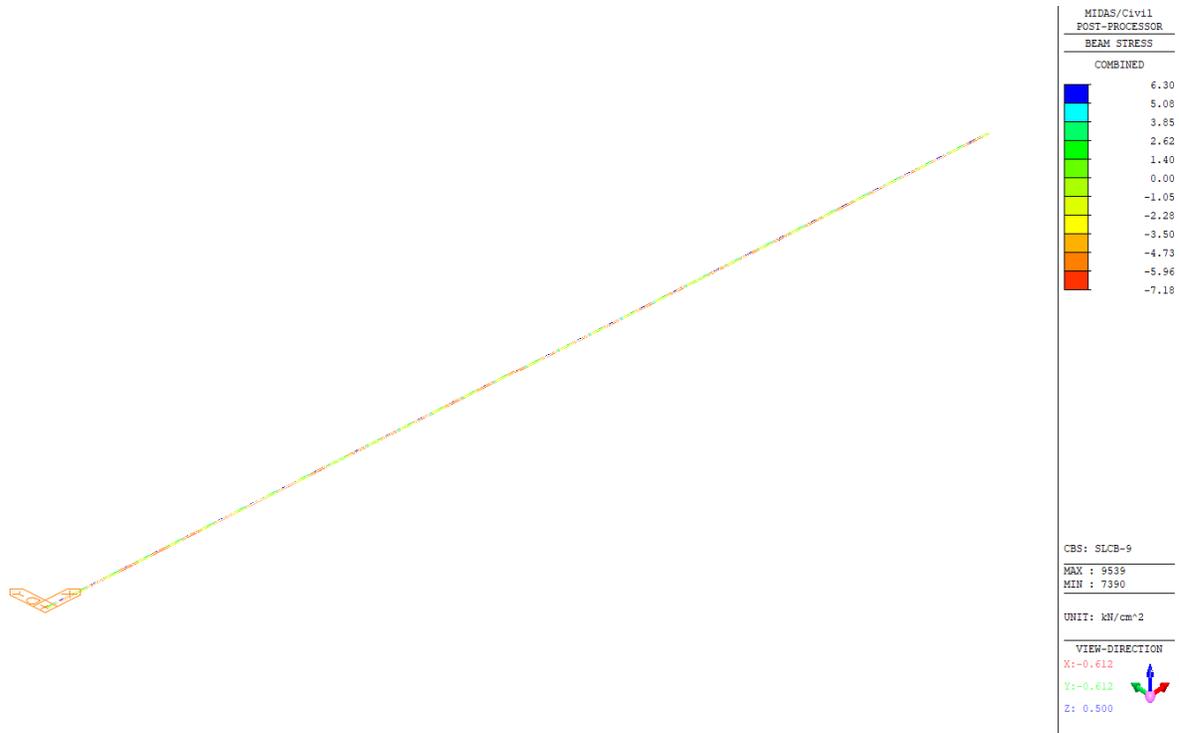
Fig. 3.7 Bending moment  $M_y$  induced in a water pipe on the pier from self weight ( $M_{max} = 62.72 \text{ Kn.m}$  PostCS: Self weight)



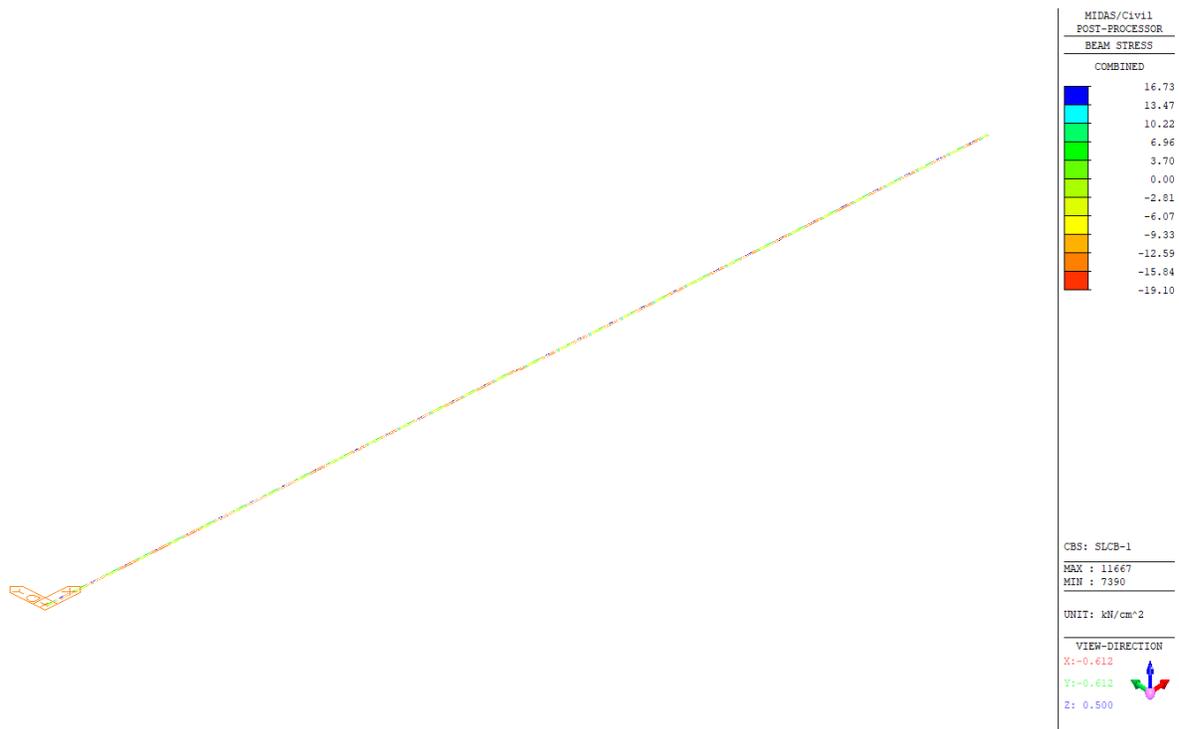
**Fig. 3.8** Bending moment **My** induced in a water pipe on the pier from permanent loads ( $M_{max} = 206.01$  Kn.m PostCS: sLCB-1)



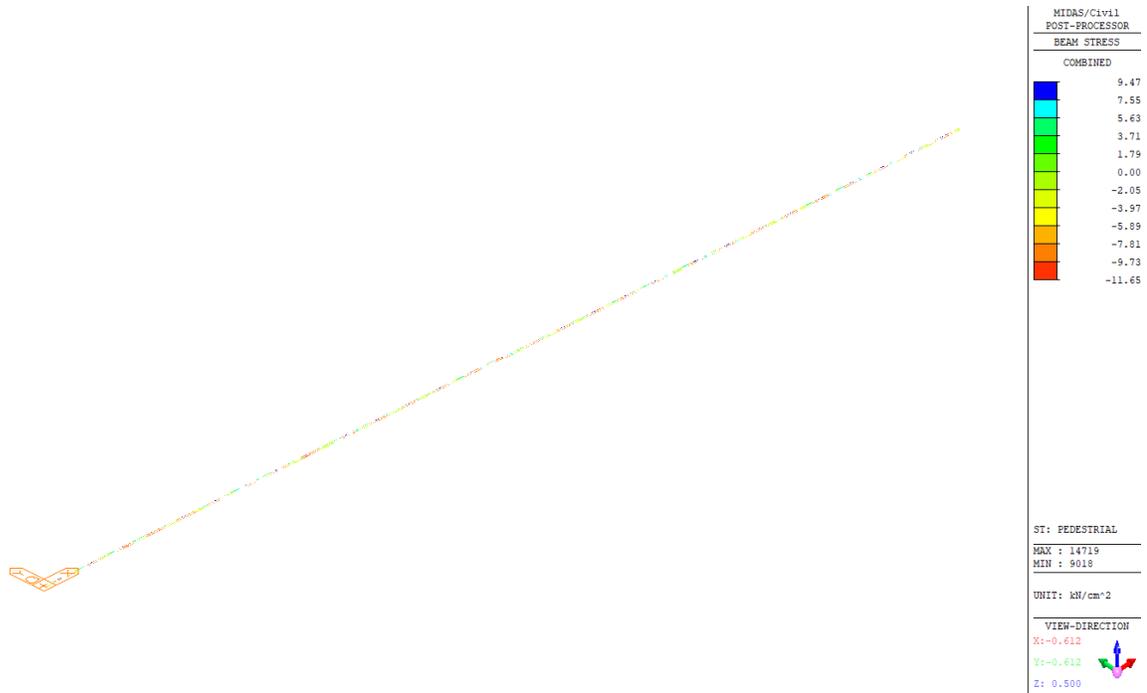
**Fig. 3.9** Bending moment **My** induced in a water pipe on the pier from permanent and temporary loads ( $M_{max} = 230.39$  Kn.m PostCS: sLCB-2)



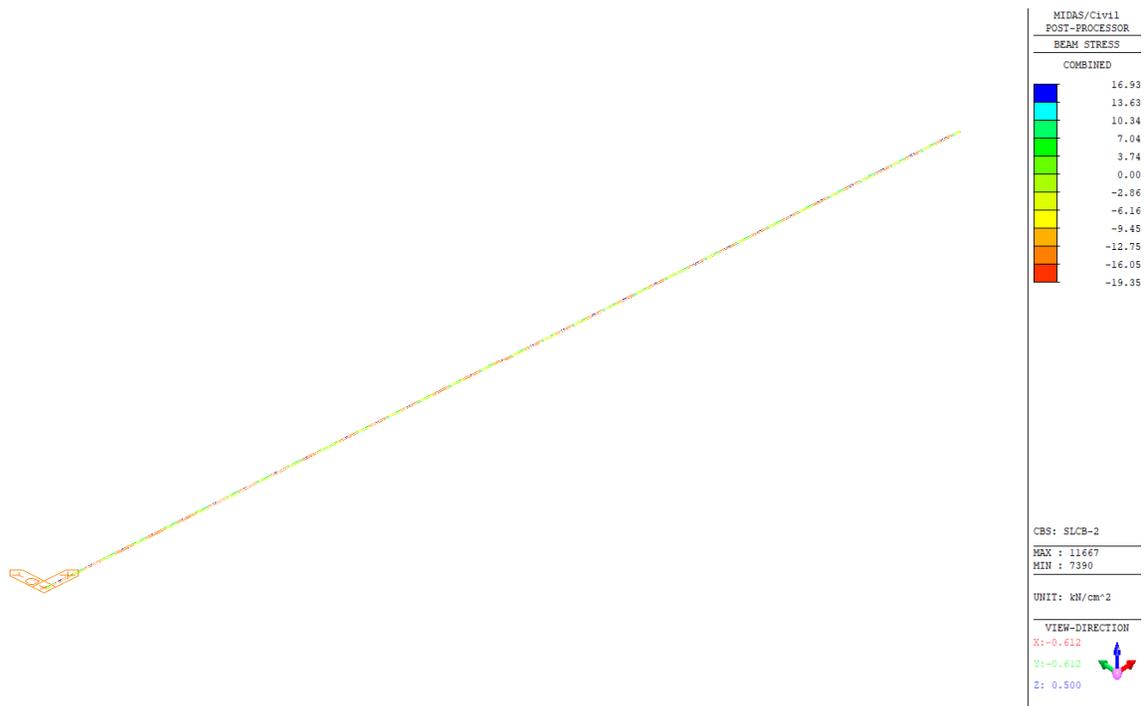
**Fig. 3.10** Stress induced in the span beams by self weight (7.18 Kn/cm<sup>2</sup> Stage2-2:self weight)



**Fig. 3.11** Stress induced in the span beams by permanent loads (18.62 Kn/cm<sup>2</sup> Stage2-2:sLCB-1)



**Fig. 3.12** Stress induced in the span beams by pedestrian loads (11.65 Kn/cm<sup>2</sup> PostCS: Pedesrial)



**Fig. 3.13** Stress induced in the span beams by permanent and temporary loads (19.35 Kn/cm<sup>2</sup> PostCS: sLCB-2)

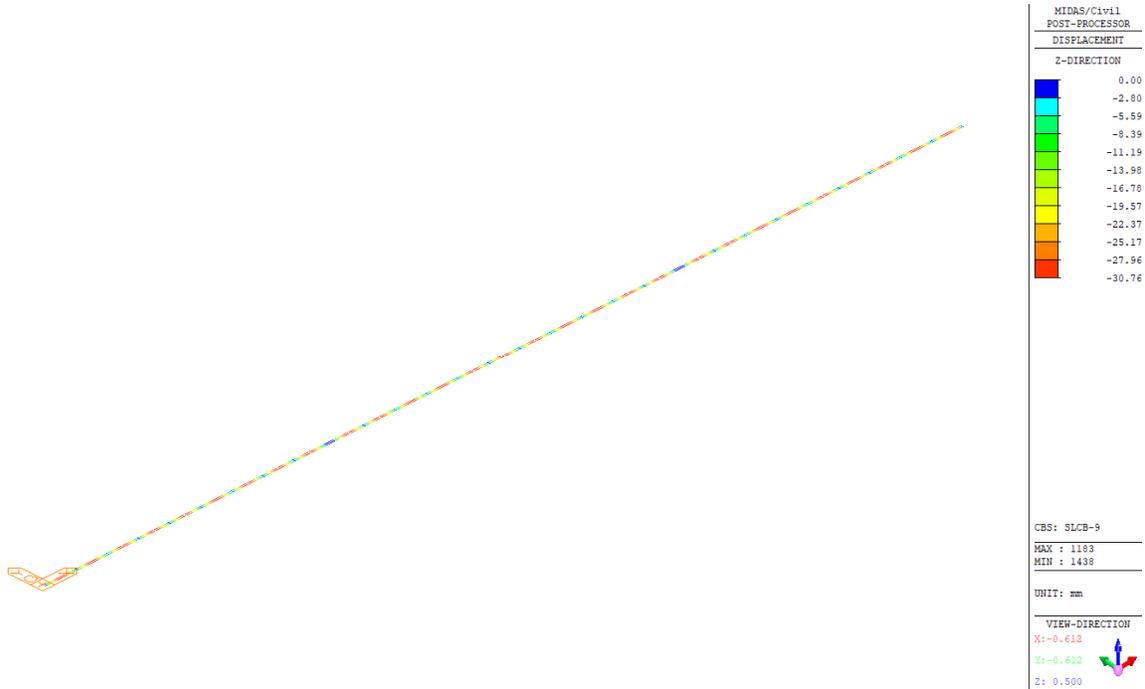


Fig. 3.14 Deflection of the span beams  $Dz$  from self weight (30.74 mm Stage2-2: Self weight)

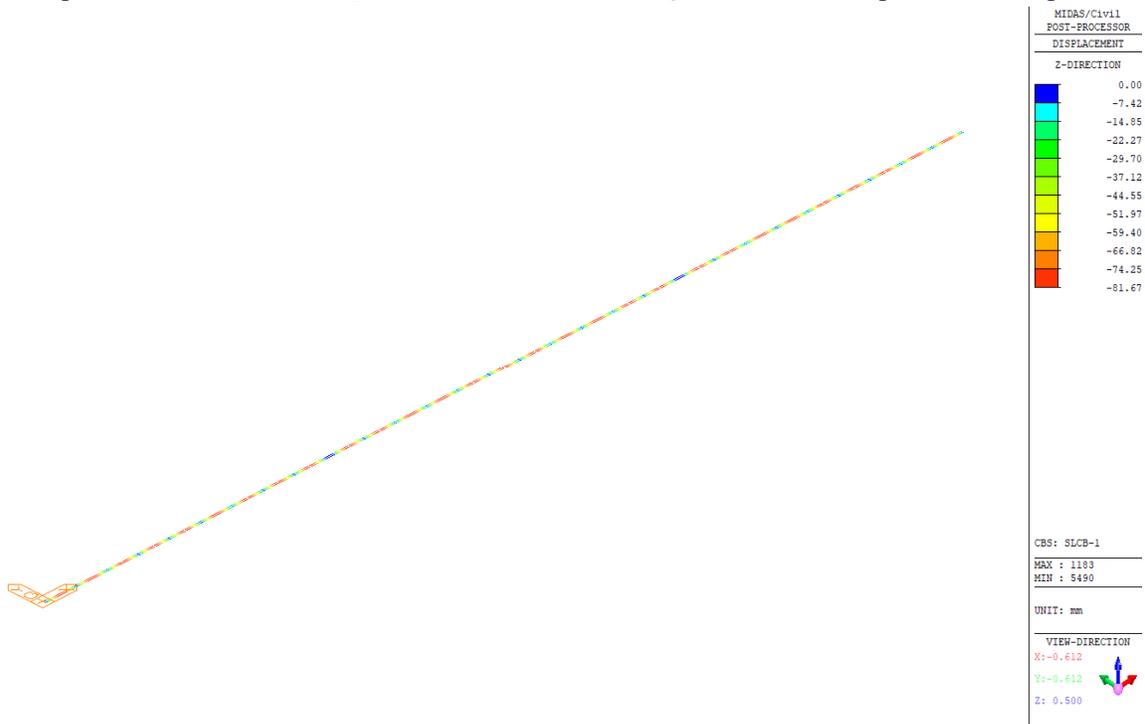
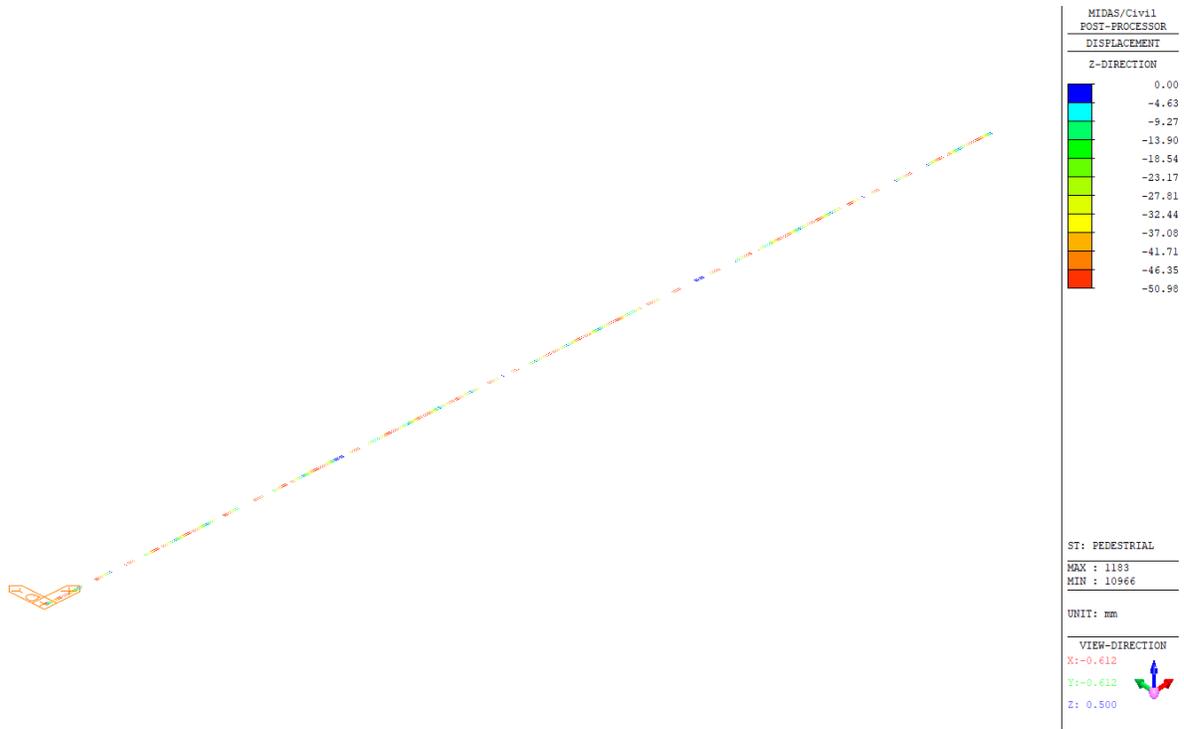
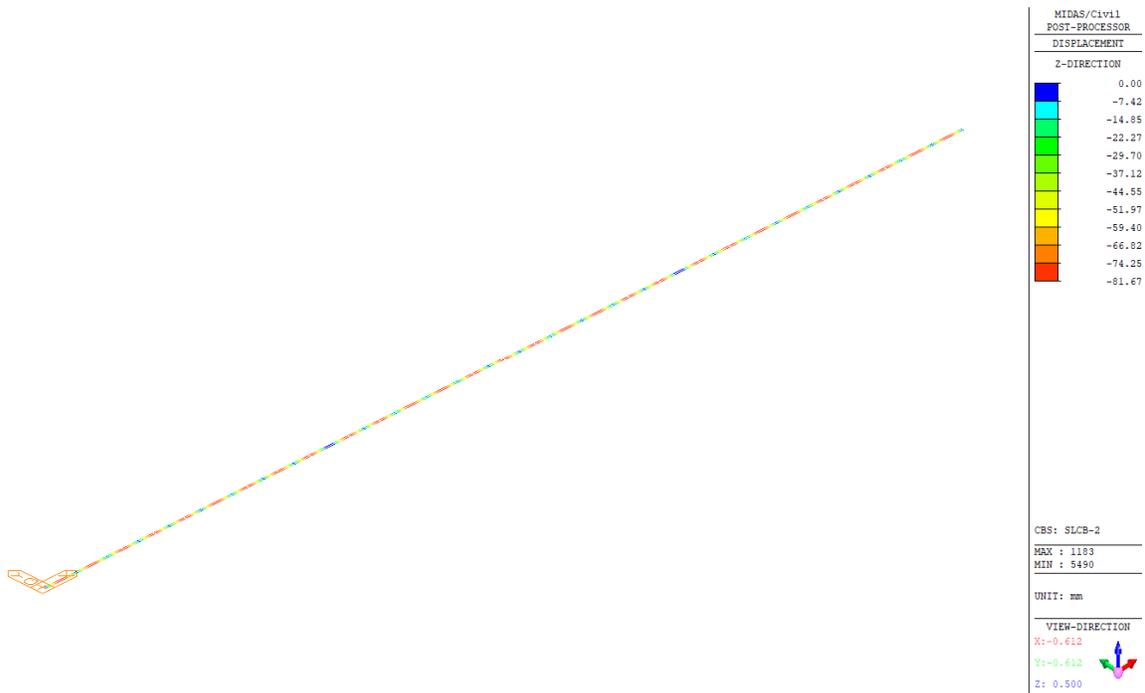


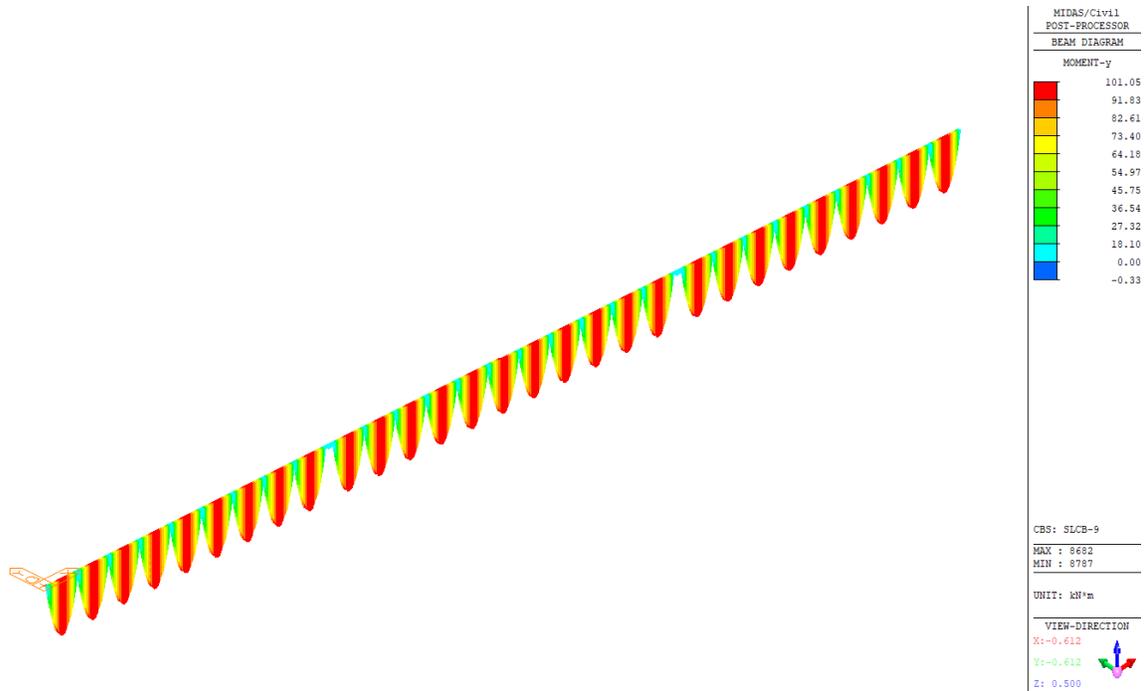
Fig. 3.15 Deflection of the span beams  $Dz$  from permanent loads (81.67 mm Stage2-2: sLCB-1)



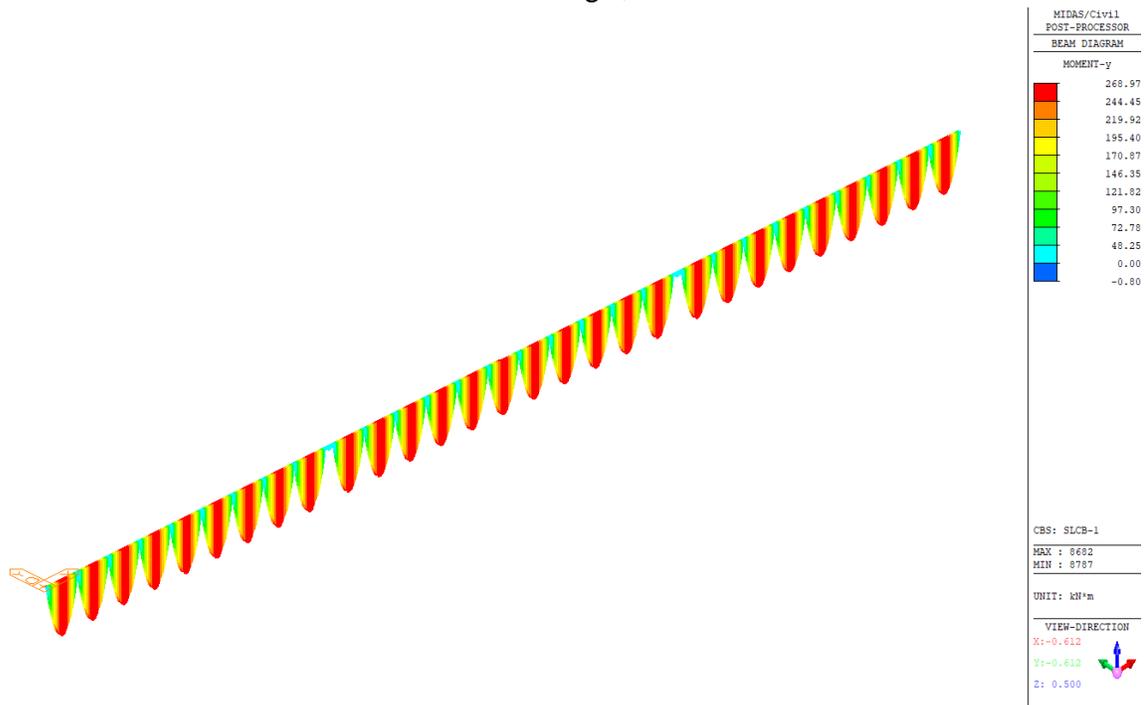
**Fig. 3.16** Deflection of the span beams  $Dz$  from pedestrian loads (**50.98 mm PostCS: Pedesrial**)



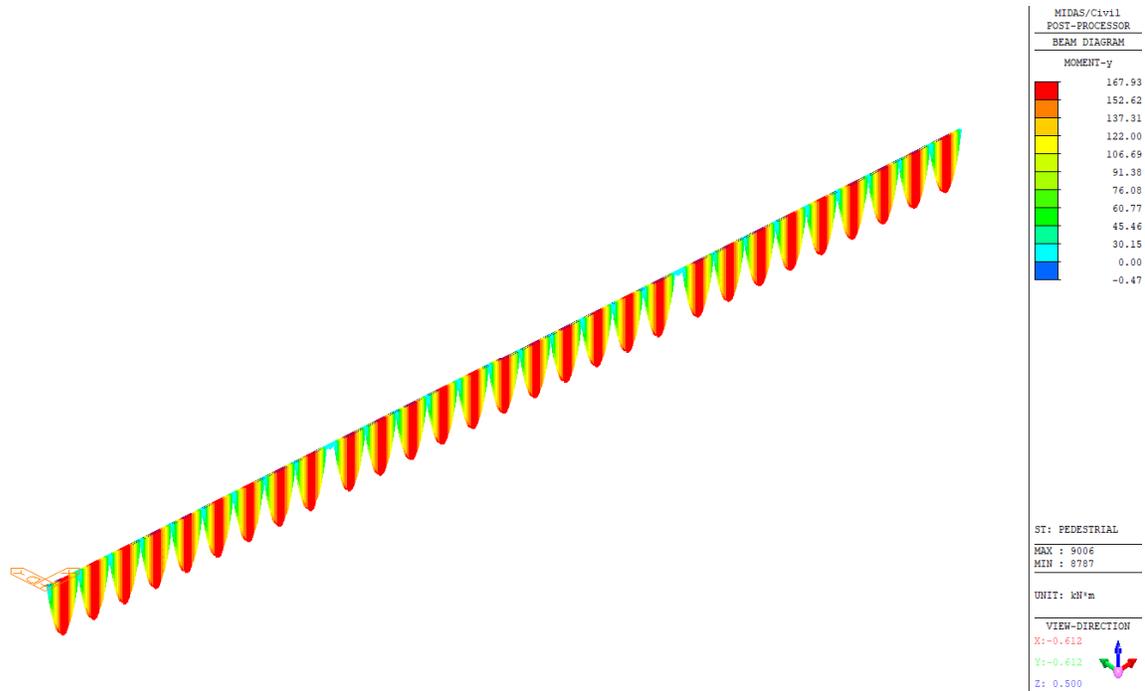
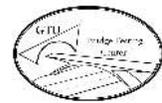
**Fig. 3.17** Deflection of the span beams  $Dz$  from permanent and temporary loads (**81.67 mm PostCS: sLCB-2**)



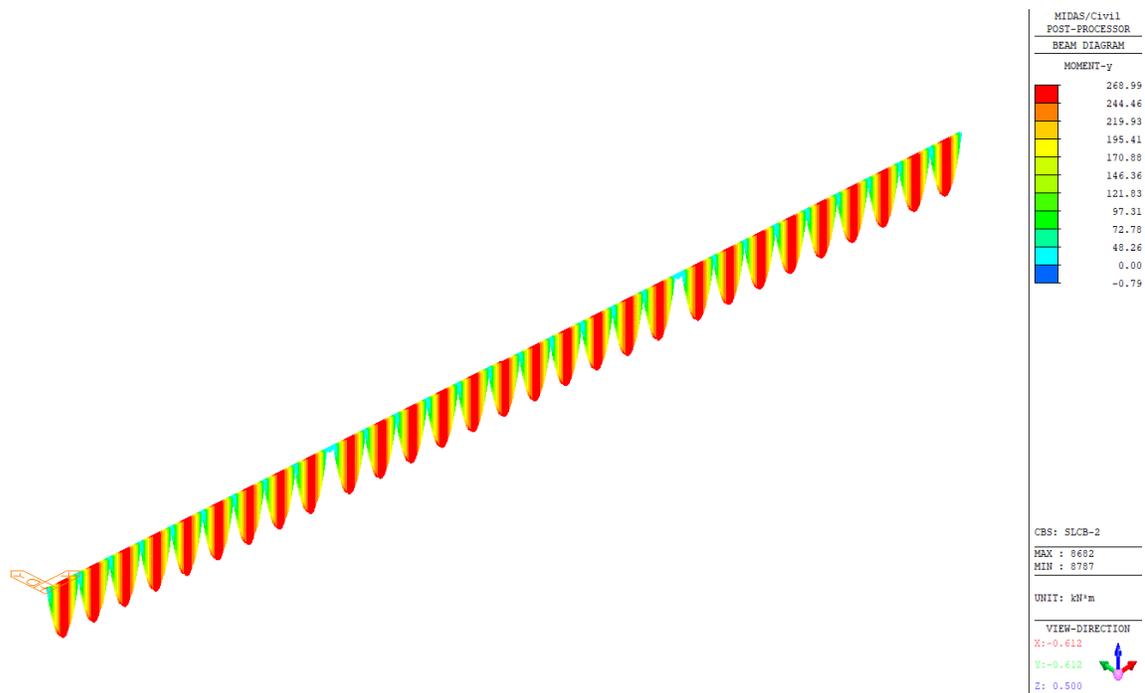
**Fig. 3.18** Bending moment  $M_y$  induced in the span beams from self weight ( $M_{max} = 101.05 \text{ Kn.m}$  PostCS: Self weight)



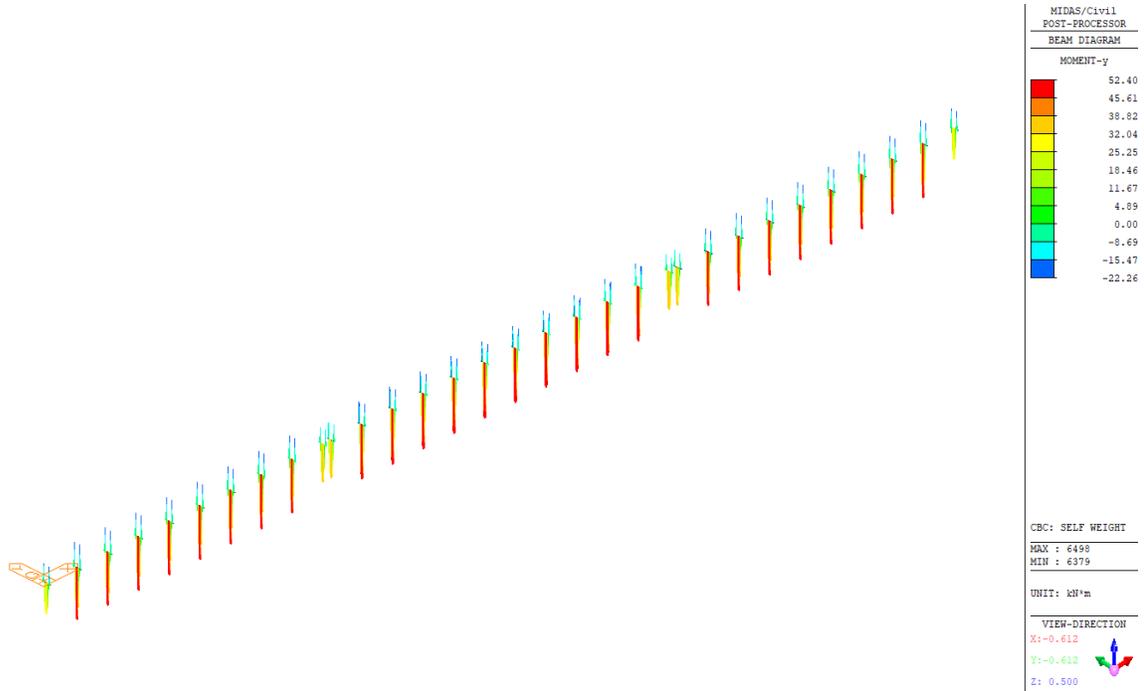
**Fig. 3.19** Bending moment  $M_y$  induced in the span beams from permanent loads ( $M_{max} = 268.97 \text{ Kn.m}$  PostCS: sLCB-1)



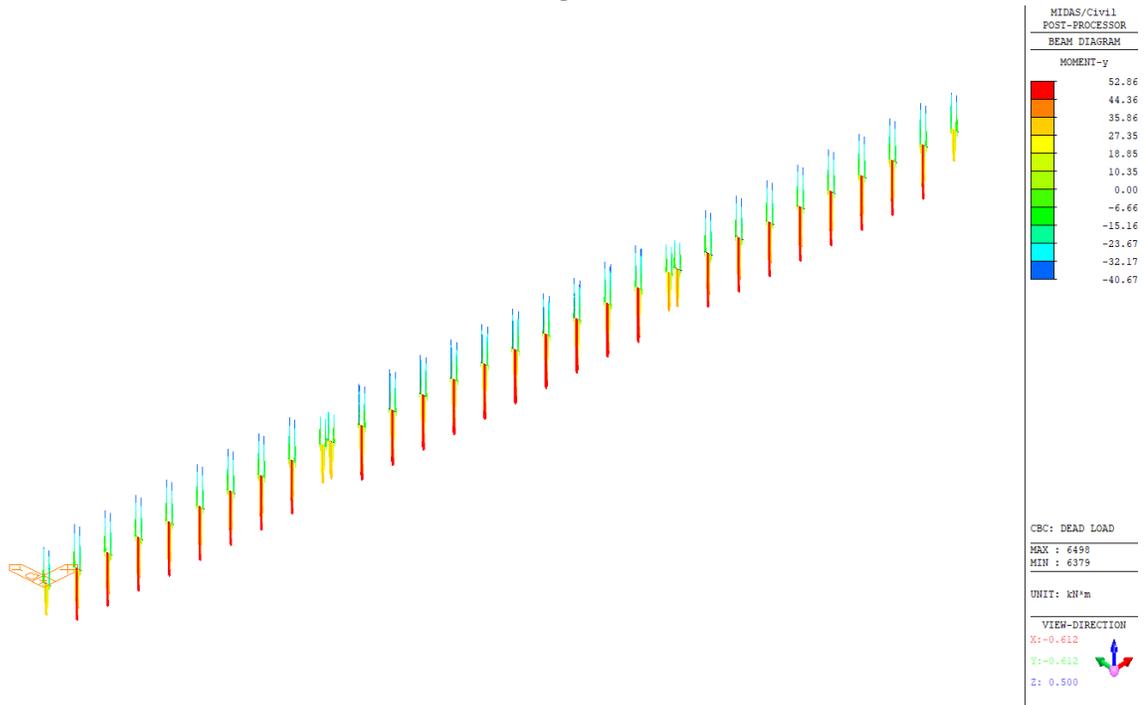
**Fig. 3.20** Bending moment  $M_y$  induced in the span beams from pedestrian loads ( $M_{max} = 167.93 \text{ Kn.m}$  PostCS: Pedesrial)



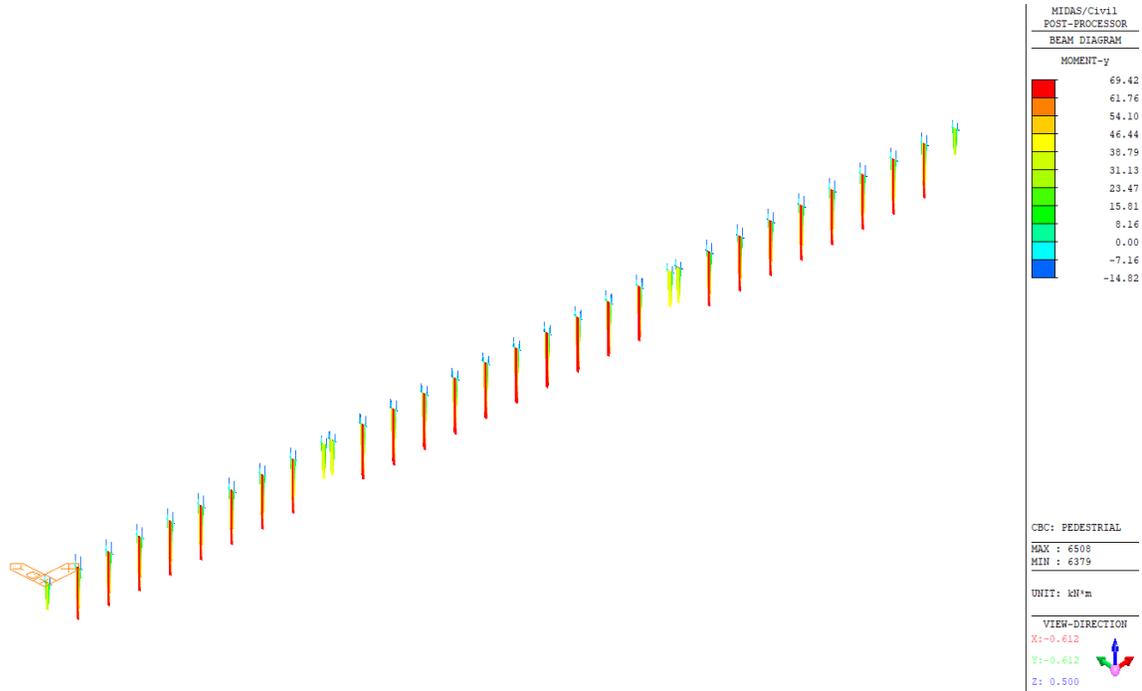
**Fig. 3.21** Bending moment  $M_y$  induced in the span beams from permanent and temporary loads ( $M_{max} = 268.99 \text{ Kn.m}$  PostCS: sLCB-2)



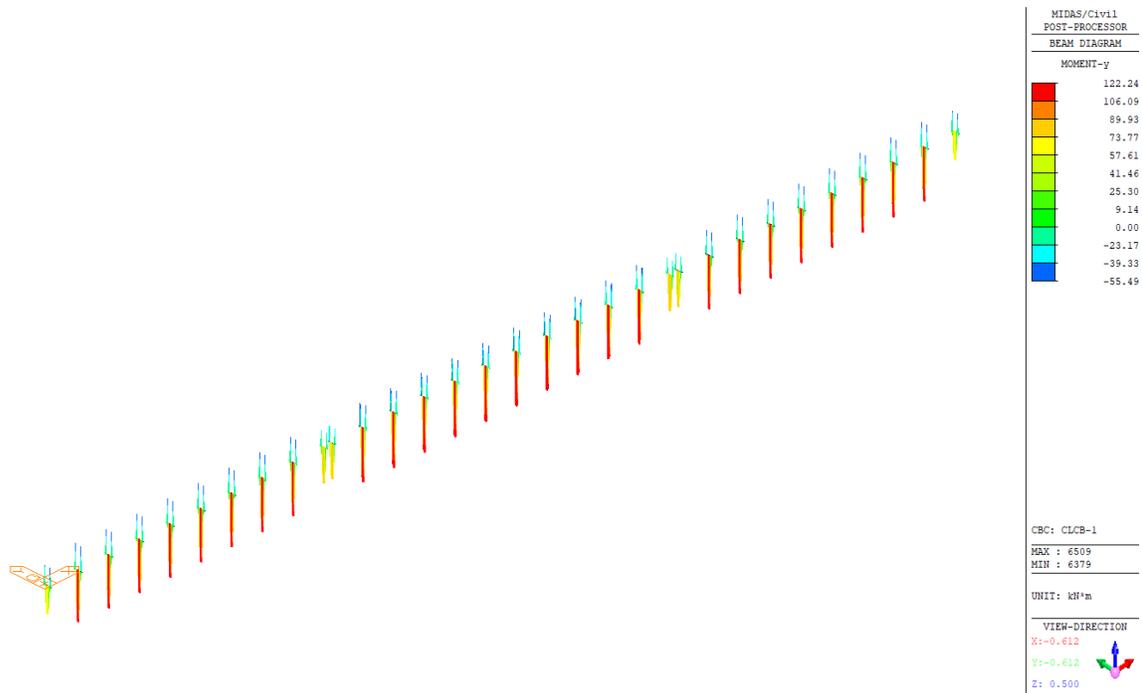
**Fig. 3.22** Bending moment **My** induced in the crossbars from self weight ( $M_{max} = 52.4 \text{ Kn.m}$  PostCS: Self weight)



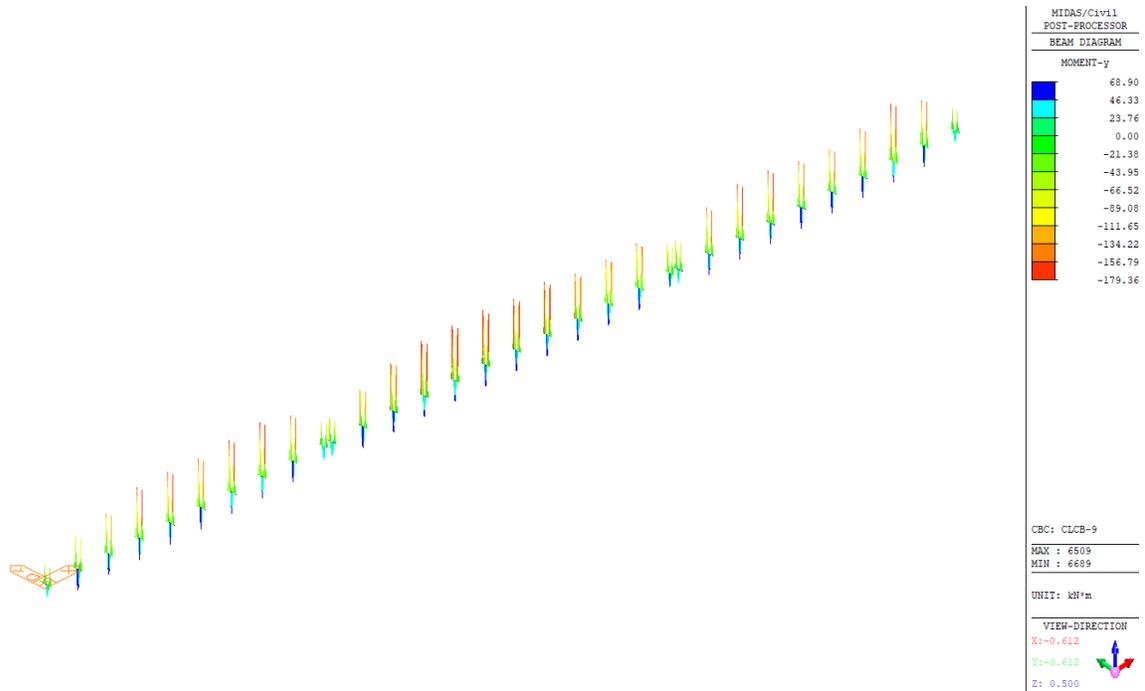
**Fig. 3.23** Bending moment **My** induced in the crossbars from permanent loads ( $M_{max} = 52.86 \text{ Kn.m}$  PostCS: Dead load)



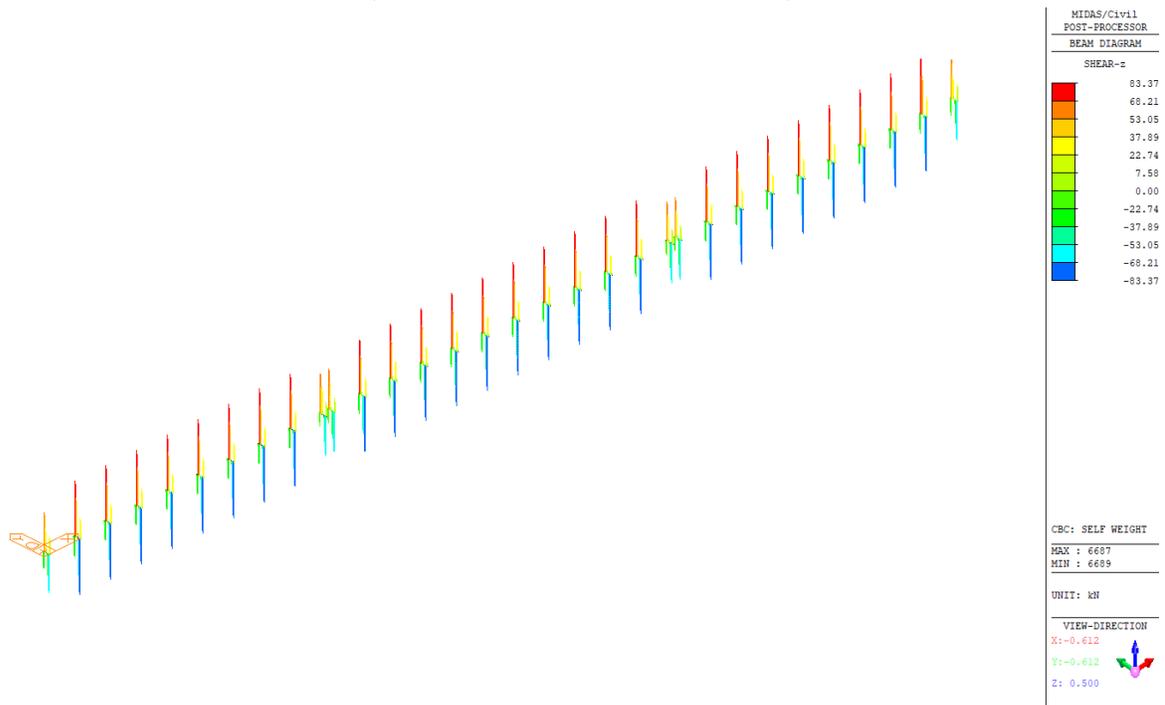
**Fig. 3.24** Bending moment  $M_y$  induced in the crossbars from pedestrian loads ( $M_{max} = 69.42 \text{ Kn.m}$   
PostCS: Pedesrial)



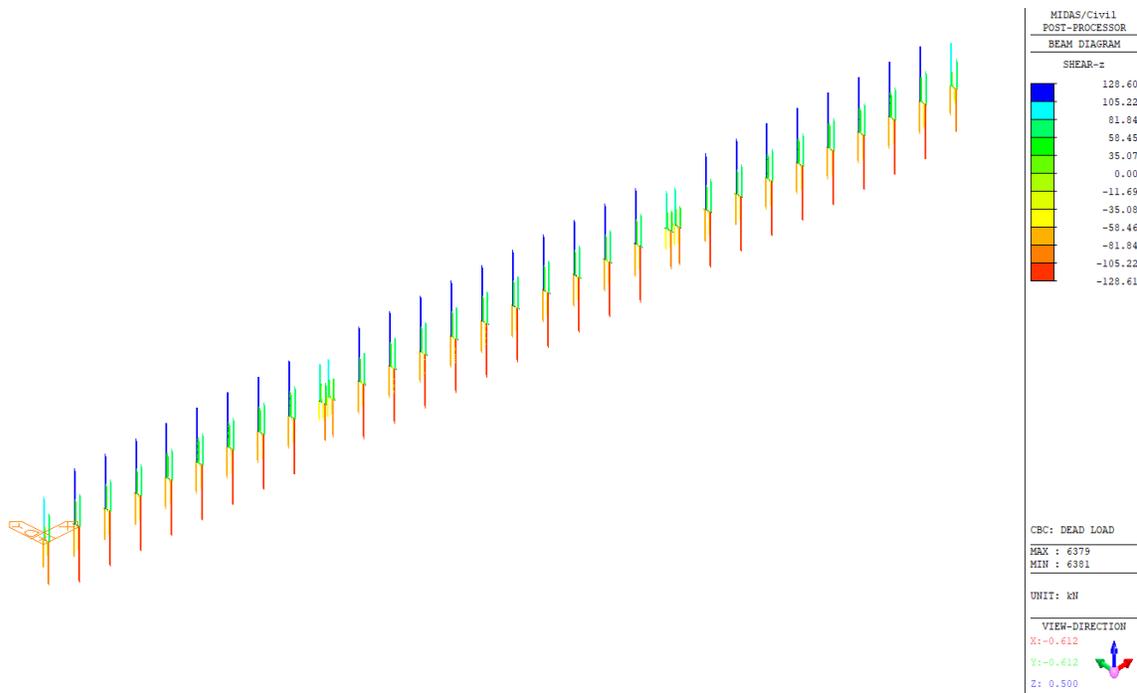
**Fig. 3.25** Bending moment  $M_y$  induced in the crossbars from permanent and temporary loads ( $M_{max} =$   
**122.24 Kn.m PostCS: cLCB-1)**



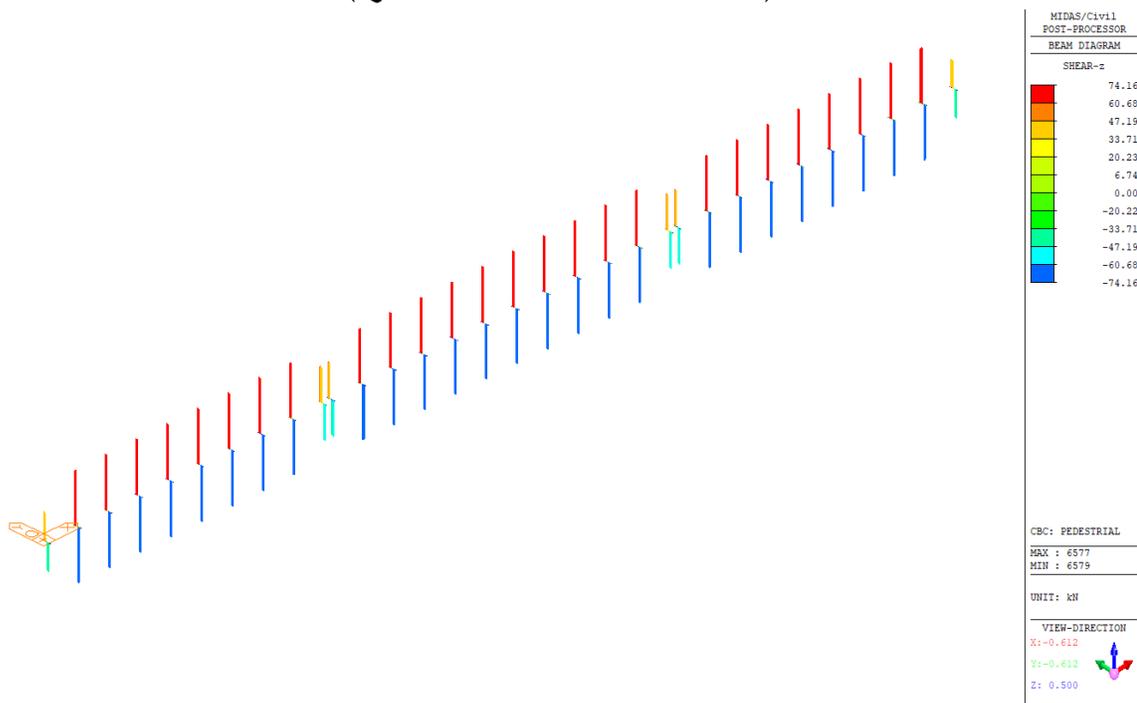
**Fig. 3.26** Bending moment  $M_y$  induced in the crossbars from permanent, temporary and seismic loads  
( $M_{max} = 179.36 \text{ Kn.m PostCS: sLCB-9}$ )



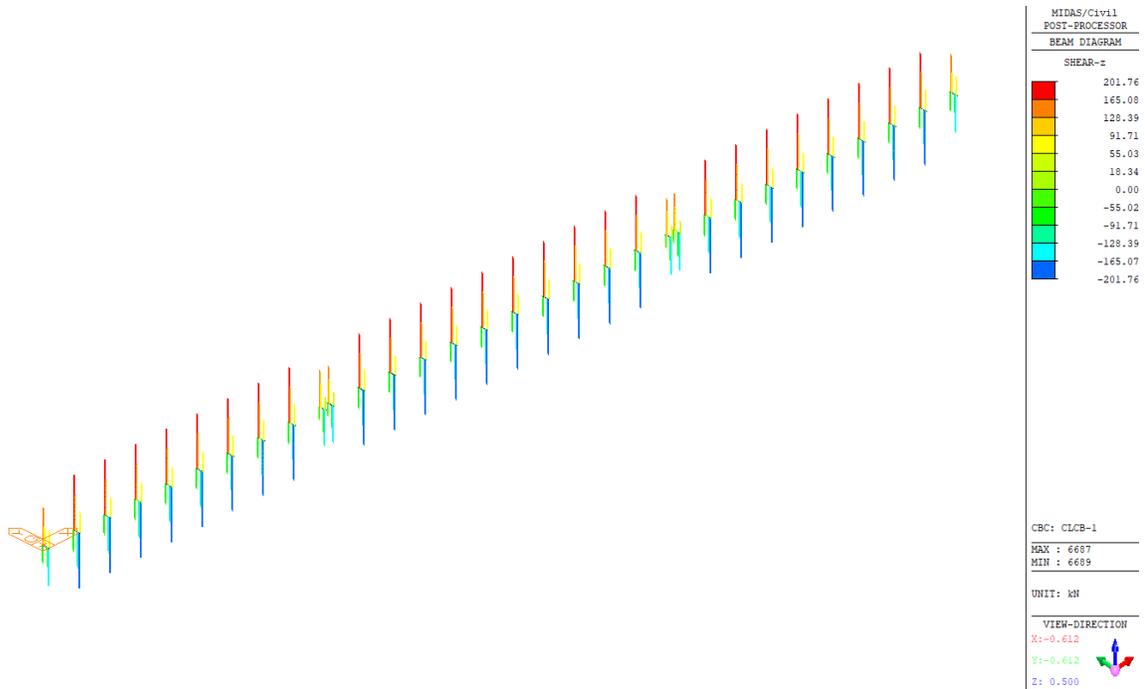
**Fig. 3.27** Shear force  $Q_y$  induced in the crossbars by self weight  
( $Q_{max} = 83.37 \text{ Kn PostCS: Self weight}$ )



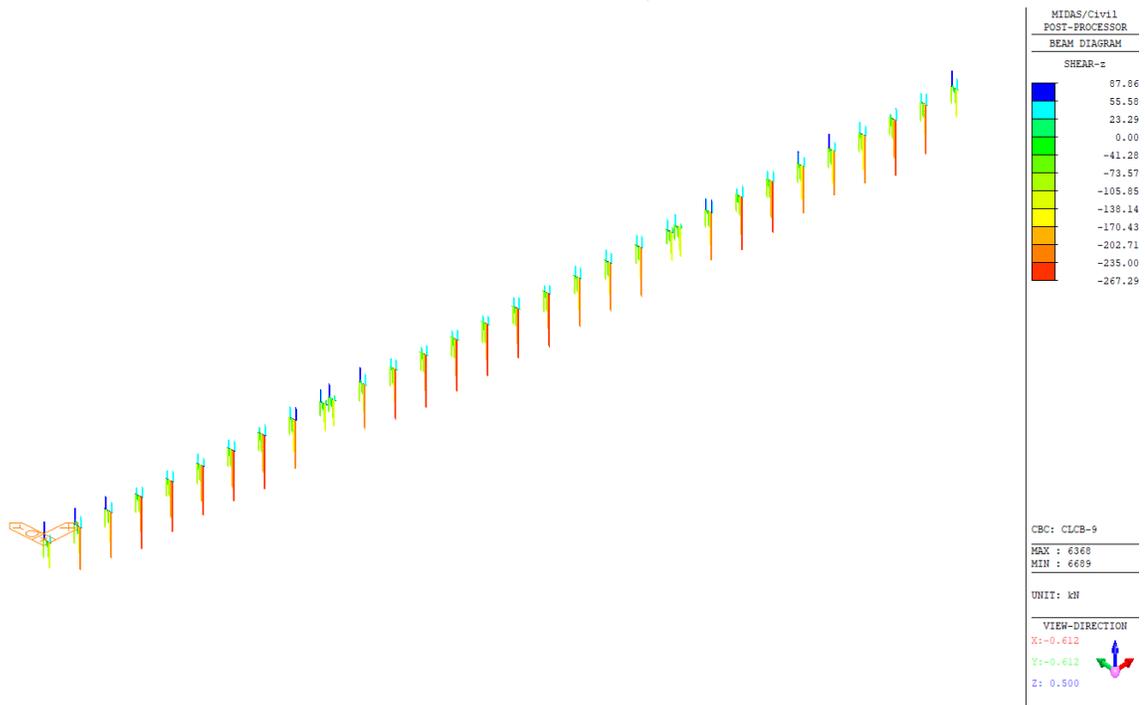
**Fig. 3.28** Shear force  $Q_y$  induced in the crossbars by permanent loads  
( $Q_{max} = 128.61$  Kn PostCS: Dead load)



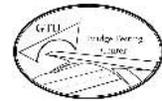
**Fig. 3.29** Shear force  $Q_y$  induced in the crossbars by pedestrian loads  
( $Q_{max} = 74.16$  Kn PostCS: Pedesrial)



**Fig. 3.30** Shear force  $Q_y$  induced in the crossbars by permanent and temporary loads ( $Q_{max} = 201.76 \text{ Kn}$  PostCS: cLCB-1)



**Fig. 3.31** Shear force  $Q_y$  induced in the crossbars by permanent, temporary and seismic loads ( $Q_{max} = 267.29 \text{ Kn}$  PostCS: sLCB-9)



### 3.3. Checking the cross-section of the water pipe

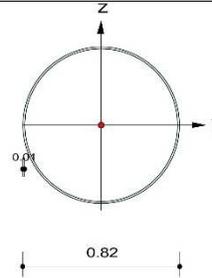
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Steel Checking Result

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	Author	p	File Name	p

#### 1. Design Information

Design Code : Eurocode3-2:05  
 Unit System : kN, m  
 Member No : 31  
 Material : St3sp4 (No:1)  
 (Fy = 245000, Es = 206000000)  
 Section Name : Pipe (No:1)  
 (Rolled : Pipe).  
 Member Length : 1.00000



#### 2. Member Forces

Axial Force Fxx = -2145.1 (LCB: 2, POS:I)  
 Bending Moments My = -230.39, Mz = 0.00000  
 End Moments Myi = -230.39, Myj = -159.78 (for Lb)  
 Myi = -230.39, Myj = -159.78 (for Ly)  
 Mzi = 0.00000, Mzj = 0.00000 (for Lz)  
 Shear Forces Fyy = 0.00000 (LCB: 3, POS:1/2)  
 Fzz = -74.140 (LCB: 2, POS:I)

Outer Dia.	0.82000	Wall Thick	0.01000
Area	0.02545	Asz	0.01272
Qyb	0.16405	Qzb	0.16405
Iyy	0.00209	Izz	0.00209
Ybar	0.41000	Zbar	0.41000
Wely	0.00509	Welz	0.00509
ry	0.28640	rz	0.28640

#### 3. Design Parameters

Unbraced Lengths Ly = 18.0000, Lz = 18.0000, Lb = 18.0000  
 Effective Length Factors Ky = 1.00, Kz = 1.00  
 Equivalent Uniform Moment Factors CmY = 1.00, Cmz = 1.00, CmLT = 1.00

#### 4. Checking Results

Axial Resistance

$$N_{Ed}/\text{MIN}[N_{c,Rd}, N_{b,Rd}] = 2145.05/4831.28 = 0.444 < 1.000 \dots\dots\dots \text{O.K}$$

Bending Resistance

$$M_{Edy}/M_{Rdy} = 230.39/1247.28 = 0.185 < 1.000 \dots\dots\dots \text{O.K}$$

$$M_{Edz}/M_{Rdz} = 0.00/1247.28 = 0.000 < 1.000 \dots\dots\dots \text{O.K}$$

Combined Resistance

$$R_{com} = N_{Ed}/(A \cdot f_y / \text{Gamma}_{M0}), R_{bend} = M_{Edy}/M_{y,Rd} + M_{Edz}/M_{z,Rd}$$

$$R_{c\_LT1} = N_{Ed}/(X_{iy} \cdot A \cdot f_y / \text{Gamma}_{M1})$$

$$R_{b\_LT1} = (k_{yy} \cdot M_{Edy}) / (X_{i\_LT} \cdot W_{ely} \cdot f_y / \text{Gamma}_{M1}) + (k_{yz} \cdot M_{sdz}) / (W_{elz} \cdot f_y / \text{Gamma}_{M1})$$

$$R_{c\_LT2} = N_{Ed}/(X_{iz} \cdot A \cdot f_y / \text{Gamma}_{M1})$$

$$R_{b\_LT2} = (K_{zy} \cdot M_{Edy}) / (X_{i\_LT} \cdot W_{ely} \cdot f_y / \text{Gamma}_{M1}) + (K_{zz} \cdot M_{sdz}) / (W_{elz} \cdot f_y / \text{Gamma}_{M1})$$

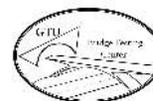
$$R_{max} = \text{MAX}[R_{com} + R_{bend}, \text{MAX}(R_{c\_LT1} + R_{b\_LT1}, R_{c\_LT2} + R_{b\_LT2})] = 0.680 < 1.000 \dots\dots \text{O.K}$$

Shear Resistance

$$V_{Edy}/V_{y,Rd} = 0.000 < 1.000 \dots\dots\dots \text{O.K}$$

$$V_{Edz}/V_{z,Rd} = 0.032 < 1.000 \dots\dots\dots \text{O.K}$$





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PROJECT TITLE:

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*. PROJECT      :
*. MEMBER NO   =    31, ELEMENT TYPE = Beam
*. LOADCOMB NO =     2, MATERIAL NO  =    1, SECTION NO =    1
*. UNIT SYSTEM : kN, m

*. SECTION PROPERTIES : Designation = Pipe
  Shape        = P - Section. (Built-up)
  Outer Dia.   =    0.820, Wall Thick =    0.010

  Area = 2.54469e-002,  Avy = 1.62000e-002,  Avz = 1.62000e-002
  Ybar = 4.10000e-001,  Zbar = 4.10000e-001,  Qyb = 1.64050e-001,  Qzb = 1.64050e-001
  Wely = 5.09093e-003,  Welz = 5.09093e-003,  Wply = 6.56133e-003,  Wplz = 6.56133e-003
  Iyy = 2.08728e-003,  Izz = 2.08728e-003,  Iyz = 0.00000e+000
  iy  = 2.86400e-001,  iz  = 2.86400e-001
  J   = 4.17456e-003,  Cwp = 1.00000e+028

*. DESIGN PARAMETERS FOR STRENGTH EVALUATION :
  Ly = 1.80000e+001,  Lz = 1.80000e+001,  Lb = 1.80000e+001
  Ky = 1.00000e+000,  Kz = 1.00000e+000

*. MATERIAL PROPERTIES :
  Fy = 2.45000e+005,  Es = 2.06000e+008,  MATERIAL NAME = St3sp4

*. FORCES AND MOMENTS AT (I) POINT :
  Axial Force   Fxx = -2.14505e+003
  Shear Forces  Fyy = 0.00000e+000,  Fzz = -7.41402e+001
  Bending Moments My = -2.30385e+002,  Mz = 0.00000e+000
  End Moments     Myi = -2.30385e+002,  Myj = -1.59784e+002 (for Lb)
                Myi = -2.30385e+002,  Myj = -1.59784e+002 (for Ly)
                Mzi = 0.00000e+000,  Mzj = 0.00000e+000 (for Lz)

*. Sign conventions for stress and axial force.
  - Stress : Compression positive.
  - Axial force: Tension positive.

(.). Determine classification of tubular section(hollow pipe).
  [ Eurocode3:05 Table 5.2 (Sheet 3 of 3) ]
  -. e      = SQRT( 235/fy ) =    0.98
  -. d/t    = DTR =    82.00
  -. DTR < 90*e^2 ( Class 3 : Semi-compact ).

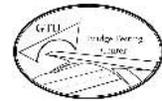
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=====  
[[[\*]]] APPLIED FACTORS.  
=====

```

(.). Calculate equivalent uniform moment factors (Cmy,Cmz,CmLT).
  [ Eurocode3:05 Annex A. Table A.1, A.2 ]
  -. Cmy,0   = 0.957
  -. Cmz,0   = 1.040

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=====

- . Cm<sub>y</sub> (Default or User Defined Value) = 1.000
- . Cm<sub>z</sub> (Default or User Defined Value) = 1.000
- . Cm<sub>L</sub>T (Default or User Defined Value) = 1.000

- ( ). Partial Factors (Gamma\_M1).  
[ Eurocode3:05 6.1 ]
- . Gamma\_M0 = 1.00
- . Gamma\_M1 = 1.10
- . Gamma\_M2 = 1.25

-----  
[[[\*]]] CHECK AXIAL RESISTANCE.  
=====

- ( ). Check slenderness ratio of axial compression member (Kl/i).  
[ Eurocode3:05 6.3.1 ]
- . Kl/i = 62.8 < 200.0 ----> O.K.

- ( ). Calculate axial compressive resistance (N<sub>c</sub>R<sub>d</sub>).  
[ Eurocode3:05 6.1, 6.2.4 ]
- . N<sub>c</sub>R<sub>d</sub> = f<sub>y</sub> \* Area / Gamma\_M0 = 6234.49 kN.

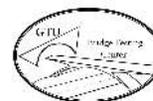
- ( ). Check ratio of axial resistance (N<sub>Ed</sub>/N<sub>c</sub>R<sub>d</sub>).  

$$\frac{N_{Ed}}{N_{cRd}} = \frac{2145.05}{6234.49} = 0.344 < 1.000 \text{ ----> O.K.}$$

- ( ). Calculate buckling resistance of compression member (N<sub>b</sub>R<sub>dy</sub>, N<sub>b</sub>R<sub>dz</sub>).  
[ Eurocode3:05 6.3.1.1, 6.3.1.2 ]
- . Beta\_A = A<sub>eff</sub> / Area = 1.000
- . Lambda<sub>d1</sub> = Pi \* SQRT(Es/fy) = 91.096
- . Lambda<sub>by</sub> = {(K<sub>y</sub>\*L<sub>y</sub>/i<sub>y</sub>)/Lambda<sub>d1</sub>} \* SQRT(Beta\_A) = 0.690
- . N<sub>cry</sub> = Pi^2\*Es\*I<sub>yy</sub> / (K<sub>y</sub>\*L<sub>y</sub>)^2 = 13097.94 kN.
- . Lambda<sub>by</sub> > 0.2 and N<sub>Ed</sub>/N<sub>cry</sub> > 0.04 --> Need to check.
- . Alphay = 0.210
- . Phi<sub>iy</sub> = 0.5 \* [ 1 + Alphay\*(Lambda<sub>by</sub>-0.2) + Lambda<sub>by</sub>^2 ] = 0.789
- . X<sub>iy</sub> = MIN [ 1 / [Phi<sub>iy</sub> + SQRT(Phi<sub>iy</sub>^2 - Lambda<sub>by</sub>^2)], 1.0 ] = 0.852
- . N<sub>b</sub>R<sub>dy</sub> = X<sub>iy</sub>\*Beta\_A\*Area\*f<sub>y</sub> / Gamma\_M1 = 4831.28 kN.
- . Lambda<sub>bz</sub> = {(K<sub>z</sub>\*L<sub>z</sub>/i<sub>z</sub>)/Lambda<sub>d1</sub>} \* SQRT(Beta\_A) = 0.690
- . N<sub>cruz</sub> = Pi^2\*Es\*I<sub>zz</sub> / (K<sub>z</sub>\*L<sub>z</sub>)^2 = 13097.94 kN.
- . Lambda<sub>bz</sub> > 0.2 and N<sub>Ed</sub>/N<sub>cruz</sub> > 0.04 --> Need to check.
- . Alphaz = 0.210
- . Phi<sub>iz</sub> = 0.5 \* [ 1 + Alphaz\*(Lambda<sub>bz</sub>-0.2) + Lambda<sub>bz</sub>^2 ] = 0.789
- . X<sub>iz</sub> = MIN [ 1 / [Phi<sub>iz</sub> + SQRT(Phi<sub>iz</sub>^2 - Lambda<sub>bz</sub>^2)], 1.0 ] = 0.852
- . N<sub>b</sub>R<sub>dz</sub> = X<sub>iz</sub>\*Beta\_A\*Area\*f<sub>y</sub> / Gamma\_M1 = 4831.28 kN.

- ( ). Check ratio of buckling resistance (N<sub>Ed</sub>/N<sub>b</sub>R<sub>d</sub>).  

$$\frac{N_{Ed}}{N_{bRd}} = \frac{2145.05}{4831.28} = 0.444 < 1.000 \text{ ----> O.K.}$$



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=====  
[[[\*]]] CHECK TORSIONAL RESISTANCE.  
=====

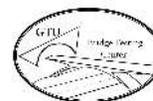
=====  
[[[\*]]] CHECK SHEAR RESISTANCE.  
=====

- ( ). Calculate shear area.  
[ Eurocode3:05 6.2.6, EN1993-1-5:04 5.1 NOTE 2 ]  
-. Avy = 2\*Area/Pi = 0.0162 m^2.  
-. Avz = 2\*Area/Pi = 0.0162 m^2.
- ( ). Calculate plastic shear resistance in local-z direction (Vp1\_T\_Rdz).  
[ Eurocode3:05 6.1, 6.2.6 ]  
-. Vp1\_Rdz = [ Avy\*fy/SQRT(3) ] / Gamma\_M0 = 2291.50 kN.  
-. Taut\_Ed = T\_Ed / Wt = 0.00 KPa.  
-. Vp1\_T\_Rdz = [ 1 - Taut\_Ed/(fy/SQRT(3)/Gamma\_M0) ]\*Vp1\_Rdz = 2291.50 kN.
- ( ). Shear Buckling Check.  
[ Eurocode3:05 6.2.6 ]  
-. HTR < 72\*e/Eta ---> No need to check!
- ( ). Check ratio of shear resistance (V\_Edz/Vp1\_T\_Rdz).  
( LCB = 2, POS = I )  
-. Applied shear force : V\_Edz = 74.14 kN.  
V\_Edz = 74.14  
-. ----- = ----- = 0.032 < 1.000 ---> O.K.  
Vp1\_T\_Rdz 2291.50

=====  
[[[\*]]] CHECK BENDING MOMENT RESISTANCE ABOUT MAJOR AXIS.  
=====

- ( ). Calculate elastic resistance moment about major axis.  
[ Eurocode3:05 6.1, 6.2.5 ]  
-. Wely = 0.0051 m^3.  
-. Mc\_Rdy = Wely \* fy / Gamma\_M0 = 1247.28 kN-m.
- ( ). Check ratio of moment resistance (M\_Edy/Mc\_Rdy).  
M\_Edy = 230.39  
-. ----- = ----- = 0.185 < 1.000 ---> O.K.  
Mc\_Rdy 1247.28

=====  
[[[\*]]] CHECK BENDING MOMENT RESISTANCE ABOUT MINOR AXIS.  
=====



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=====

( ). Calculate elastic resistance moment about minor axis.  
[ Eurocode3:05 6.1, 6.2.5 ]  
-. Welz = 0.0051 m<sup>3</sup>.  
-. Mc\_Rdz = Welz \* fy / Gamma\_M0 = 1247.28 kN-m.

( ). Check ratio of moment resistance (M\_Edz/Mc\_Rdz).  
M\_Edz 0.00  
-. ----- = ----- = 0.000 < 1.000 ---> O.K.  
Mc\_Rdz 1247.28

=====

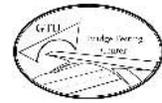
[[[\*]]] CHECK INTERACTION OF COMBINED RESISTANCE.  
=====

( ). Calculate Major reduced design resistance of bending and shear.  
[ Eurocode3:05 6.2.8 (6.30) ]  
-. In case of V\_Edz / Vpl\_Rdz < 0.5  
-. My\_Rd = Mc\_Rdy = 1247.28 kN-m.

( ). Calculate Minor reduced design resistance of bending and shear.  
[ Eurocode3:05 6.2.8 (6.30) ]  
-. In case of V\_Edy / Vpl\_Rdy < 0.5  
-. Mz\_Rd = Mc\_Rdz = 1247.28 kN-m.

( ). Check general interaction ratio.  
[ Eurocode3:05 6.2.1 (6.2) ] - Class3  
-. Rmax1 = ----- + ----- + -----  
A\*fy/Gamma\_M0 My\_Rd Mz\_Rd  
= 0.529 < 1.000 ---> O.K.

( ). Calculate yield criterion for the elastic verification.  
-. Sigx\_Ed = 129549.22 KPa.  
-. Tau\_Ed = 0.00 KPa.  
-. Rmax6\_1 = [ Sigx\_Ed ]^2 + 3 \* [ TauEd ]^2  
[ fy/Gamma\_M0 ] [ fy/Gamma\_M0 ]  
= 0.280 < 1.000 ---> O.K.



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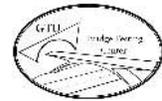
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	Author		File Name	

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```
( ). Check interaction ratio of bending and axial compression member.
[ Eurocode3:05 6.3.1, 6.2.9.3 (6.61, 6.62), Annex A ]
-. N_Ed = -2145.05 kN.
-. M_Edy = -230.39 kN-m.
-. M_Edz = 0.00 kN-m.
-. kyy = 1.162
-. kyz = 1.162
-. kzy = 1.162
-. kzz = 1.162
-. Xiy = 0.852
-. Xiz = 0.852
-. XiLT = 1.000
-. N_Rk = A*fy = 6234.49 kN.
-. My_Rk = WelY*fy = 1247.28 kN-m.
-. Mz_Rk = Welz*fy = 1247.28 kN-m.
-. N_Ed*eNy = 0.0 (Not Slender)
-. N_Ed*eNz = 0.0 (Not Slender)
-. Rmax_LT1 = ----- + kyy * ----- + kyz * -----
              N_Ed                M_Edy + N_Ed*eNy          M_Edz + N_Ed*eNz
              Xiy*N_Rk/Gamma_M1    XiLT*My_Rk/Gamma_M1    Mz_Rk/Gamma_M1
              = 0.680 < 1.000 ---> O.K.
-. Rmax_LT2 = ----- + kzy * ----- + kzz * -----
              N_Ed                M_Edy + N_Ed*eNy          M_Edz + N_Ed*eNz
              Xiz*N_Rk/Gamma_M1    XiLT*My_Rk/Gamma_M1    Mz_Rk/Gamma_M1
              = 0.680 < 1.000 ---> O.K.
-. Rmax = MAX[ MAX(Rmax1, Rmax6_1), MAX(Rmax_LT1, Rmax_LT2) ] = 0.680 < 1.000 ---> O.K.
```

**The cross-section meets the shear, axial compression, stability and bending conditions according to Eurocode 3.**



### 3.4. Checking the cross-section of the span beam

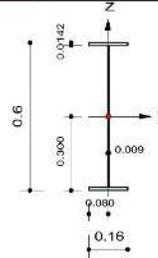
MIDAS/Civil

#### Steel Checking Result

	Company		Project Title	
	Author		File Name	

#### 1. Design Information

Design Code : Eurocode3-2:05  
 Unit System : kN, m  
 Member No : 8682  
 Material : St3sp4 (No:1)  
 (Fy = 245000, Es = 206000000)  
 Section Name : I 45-60 (No:6)  
 (Built-up Section).  
 Member Length : 0.07150



#### 2. Member Forces

Axial Force Fxx = -3.7078 (LCB: 1, POS:1)  
 Bending Moments My = 268.970, Mz = 1.82977  
 End Moments Myi = 268.970, Myj = 268.756 (for Lb)  
 Myi = 268.970, Myj = 268.756 (for Ly)  
 Mzi = 1.82977, Mzj = 1.55687 (for Lz)  
 Shear Forces Fyy = 3.81673 (LCB: 1, POS:1/2)  
 Fzz = 3.18045 (LCB: 2, POS:J)

Depth	0.60000	Web Thick	0.00900
Top F Width	0.16000	Top F Thick	0.01420
Bot F Width	0.16000	Bot F Thick	0.01420
Area	0.00991	Asz	0.00540
Qyb	0.11478	Qzb	0.00320
Iyy	0.00055	Izz	0.00001
Ybar	0.08000	Zbar	0.30000
Wely	0.00182	Welz	0.00012
ry	0.23507	rz	0.03136

#### 3. Design Parameters

Unbraced Lengths Ly = 18.0000, Lz = 5.88000, Lb = 5.88000  
 Effective Length Factors Ky = 1.00, Kz = 1.00  
 Equivalent Uniform Moment Factors Cmy = 1.00, Cmz = 1.00, CmLT = 1.00

#### 4. Checking Results

Axial Resistance

$$N_{Ed}/\text{MIN}[N_{c,Rd}, N_{b,Rd}] = 3.71/2427.50 = 0.002 < 1.000 \dots\dots\dots \text{O.K}$$

Bending Resistance

$$M_{Edy}/M_{Rdy} = 268.970/149.707 = 1.797 > 1.000 \dots\dots\dots \text{N.G}$$

$$M_{Edz}/M_{Rdz} = 1.8298/47.3671 = 0.039 < 1.000 \dots\dots\dots \text{O.K}$$

Combined Resistance

$$RNRd = \text{MAX}[M_{Edy}/M_{ny,Rd}, M_{Edz}/M_{nz,Rd}]$$

$$R_{max1} = (M_{Edy}/M_{ny,Rd})^{\text{Alpha}} + (M_{Edz}/M_{nz,Rd})^{\text{Beta}}$$

$$R_{com} = N_{Ed}/(A \cdot f_y / \text{Gamma}_{M0}), R_{bend} = M_{Edy}/M_{y,Rd} + M_{Edz}/M_{z,Rd}$$

$$R_{c\_LT1} = N_{Ed}/(X_{iy} \cdot A \cdot f_y / \text{Gamma}_{M1})$$

$$R_{b\_LT1} = (k_{yy} \cdot M_{Edy}) / (X_{i\_LT} \cdot W_{ply} \cdot f_y / \text{Gamma}_{M1}) + (k_{yz} \cdot M_{sdz}) / (W_{plz} \cdot f_y / \text{Gamma}_{M1})$$

$$R_{c\_LT2} = N_{Ed}/(X_{iz} \cdot A \cdot f_y / \text{Gamma}_{M1})$$

$$R_{b\_LT2} = (K_{zy} \cdot M_{Edy}) / (X_{i\_LT} \cdot W_{ply} \cdot f_y / \text{Gamma}_{M1}) + (K_{zz} \cdot M_{sdz}) / (W_{plz} \cdot f_y / \text{Gamma}_{M1})$$

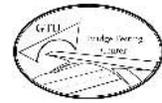
$$R_{max} = \text{MAX}[RNRd, R_{max1}, (R_{com} + R_{bend}), \text{MAX}(R_{c\_LT1} + R_{b\_LT1}, R_{c\_LT2} + R_{b\_LT2})] = 1.849 > 1.000 \dots\dots \text{N.G}$$

Shear Resistance

$$V_{Edy}/V_{y,Rd} = 0.006 < 1.000 \dots\dots\dots \text{O.K}$$

$$V_{Edz}/V_{z,Rd} = 0.004 < 1.000 \dots\dots\dots \text{O.K}$$





MIDAS/Civil

Steel Code Checking Result

PROJECT TITLE:

	Company		Client	
	Author		File Name	

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

```

*. PROJECT      :
*. MEMBER NO   = 8682, ELEMENT TYPE = Beam
*. LOADCOMB NO = 1, MATERIAL NO   = 1, SECTION NO = 6
*. UNIT SYSTEM : kN, m

*. SECTION PROPERTIES : Designation = I 45-60
Shape      = I - Section. (Built-up)
Depth     = 0.600, Top F Width = 0.160, Bot.F Width = 0.160
Web Thick = 0.009, Top F Thick = 0.014, Bot.F Thick = 0.014

Area = 9.90815e-003, Avy = 4.54400e-003, Avz = 6.17328e-003
Ybar = 8.00000e-002, Zbar = 3.00000e-001, Qyb = 1.14782e-001, Qzb = 3.20000e-003
Wely = 1.82494e-003, Welz = 1.21811e-004, Wply = 2.06607e-003, Wplz = 1.93335e-004
Iyy = 5.47481e-004, Izz = 9.74489e-006, Iyz = 0.00000e+000
iy  = 2.35065e-001, iz  = 3.13612e-002
J   = 4.47767e-007, Cwp = 8.31641e-007

*. DESIGN PARAMETERS FOR STRENGTH EVALUATION :
Ly = 1.80000e+001, Lz = 5.88000e+000, Lb = 5.88000e+000
Ky = 1.00000e+000, Kz = 1.00000e+000

*. MATERIAL PROPERTIES :
Fy = 2.45000e+005, Es = 2.06000e+008, MATERIAL NAME = St3sp4

*. FORCES AND MOMENTS AT (I) POINT :
Axial Force   Fxx = -3.70781e+000
Shear Forces  Fyy = 3.81673e+000, Fzz = 2.81691e+000
Bending Moments My = 2.68970e+002, Mz = 1.82977e+000
End Moments     Myi = 2.68970e+002, Myj = 2.68756e+002 (for Lb)
               Myi = 2.68970e+002, Myj = 2.68756e+002 (for Ly)
               Mzi = 1.82977e+000, Mzj = 1.55687e+000 (for Lz)

*. Sign conventions for stress and axial force.
- Stress : Compression positive.
- Axial force: Tension positive.

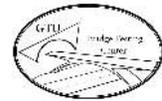
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-----  
[[[\*]]] CLASSIFY LEFT-TOP FLANGE OF SECTION (BTR).  
=====

```

( ). Determine classification of compression outstand flanges.
[ Eurocode3:05 Table 5.2 (Sheet 2 of 3), EN 1993-1-5 ]
-. e = SQRT( 235/fy ) = 0.98
-. b/t = BTR = 4.19
-. sigma1 = 128133.200 KPa.
-. sigma2 = 121094.175 KPa.
-. BTR < 9*e ( Class 1 : Plastic ).

```



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Steel Code Checking Result

PROJECT TITLE:

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]

[[[\*]]] CLASSIFY RIGHT-TOP FLANGE OF SECTION (BTR).

- ( ). Determine classification of compression outstand flanges.  
[ Eurocode3:05 Table 5.2 (Sheet 2 of 3), EN 1993-1-5 ]
- . e =  $\text{SQRT}( 235/f_y ) = 0.98$
- . b/t = BTR = 4.19
- . sigma1 = 140022.644 KPa.
- . sigma2 = 132983.620 KPa.
- . BTR < 9\*e ( Class 1 : Plastic ).

[[[\*]]] CLASSIFY LEFT-BOTTOM FLANGE OF SECTION (BTR).

- ( ). Determine classification of tension outstand flanges.
- . Not Checking the Section Classification.

[[[\*]]] CLASSIFY RIGHT-BOTTOM FLANGE OF SECTION (BTR).

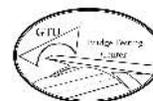
- ( ). Determine classification of tension outstand flanges.
- . Not Checking the Section Classification.

[[[\*]]] CLASSIFY WEB OF SECTION (HTR).

- ( ). Determine classification of bending and compression Internal Parts.  
[ Eurocode3:05 Table 5.2 (Sheet 1 of 3), EN 1993-1-5 ]
- . e =  $\text{SQRT}( 235/f_y ) = 0.98$
- . d/t = HTR = 59.96
- . sigma1 = 117453.201 KPa.
- . sigma2 = -116704.765 KPa.
- . Psi =  $[2*(N_{sd}/A)*(1/f_y)]-1 = -0.997$
- . Alpha = 0.502 > 0.5
- . HTR <  $396*e/(13*Alpha-1)$  ( Class 1 : Plastic ).

[[[\*]]] APPLIED FACTORS.

- ( ). Calculate equivalent uniform moment factors (Cmy,Cmz,CmLT).  
[ Eurocode3:05 Annex A. Table A.1, A.2 ]
- . Cmy,0 = 0.999
- . Cmz,0 = 0.970
- . Cmy (Default or User Defined Value) = 1.000
- . Cmz (Default or User Defined Value) = 1.000
- . CmLT (Default or User Defined Value) = 1.000



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PROJECT TITLE:

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

( ). Partial Factors (Gamma\_Mi).  
[ Eurocode3:05 6.1 ]  
-. Gamma\_M0 = 1.00  
-. Gamma\_M1 = 1.10  
-. Gamma\_M2 = 1.25

=====  
[[[\*]]] CHECK AXIAL RESISTANCE.  
=====

( ). Check slenderness ratio of axial compression member (Kl/i).  
[ Eurocode3:05 6.3.1 ]  
-. Kl/i = 187.5 < 200.0 ---> O.K.

( ). Calculate axial compressive resistance (Nc\_Rd).  
[ Eurocode3:05 6.1, 6.2.4 ]  
-. Nc\_Rd = fy \* Area / Gamma\_M0 = 2427.50 kN.

( ). Check ratio of axial resistance (N\_Ed/Nc\_Rd).  
N\_Ed = 3.71  
-. = ----- = 0.002 < 1.000 ---> O.K.  
Nc\_Rd = 2427.50

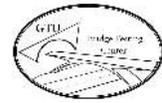
( ). Calculate buckling resistance of compression member (Nb\_Rdy, Nb\_Rdz).  
[ Eurocode3:05 6.3.1.1, 6.3.1.2 ]  
-. Beta\_A = Aeff / Area = 1.000  
-. Lambda1 = Pi \* SQRT(Es/fy) = 91.096  
-. Lambda\_by = {(Ky\*Ly/iy)/Lambda1} \* SQRT(Beta\_A) = 0.841  
-. Ncry = Pi^2\*Es\*Iyy / (Ky\*Ly)^2 = 3435.51 kN.  
-. Lambda\_by < 0.2 or N\_Ed/Ncry < 0.04 --> No need to check.

-. Lambda\_bz = {(Kz\*Lz/iz)/Lambda1} \* SQRT(Beta\_A) = 2.058  
-. Ncrz = Pi^2\*Es\*Izz / (Kz\*Lz)^2 = 573.05 kN.  
-. Lambda\_bz < 0.2 or N\_Ed/Ncrz < 0.04 --> No need to check.

=====  
[[[\*]]] CHECK SHEAR RESISTANCE.  
=====

( ). Calculate shear area.  
[ Eurocode3:05 6.2.6, EN1993-1-5:04 5.1 NOTE 2 ]  
-. eta = 1.2 (Fy < 460 MPa.)  
-. Avy = 2\*B\*tf = 0.0045 m^2.  
-. Avz = eta\*hw\*tw = 0.0062 m^2.

( ). Calculate plastic shear resistance in local-y direction (Vpl\_Rdy).  
[ Eurocode3:05 6.1, 6.2.6 ]  
-. Vpl\_Rdy = [ Avy\*fy/SQRT(3) ] / Gamma\_M0 = 642.75 kN.



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Steel Code Checking Result

PROJECT TITLE:

	Company		Client	
	Author		File Name	

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

```
( ). Check ratio of shear resistance (V_Edy/Vp1_Rdy).
( LCB = 1, POS = I )
-. Applied shear force : V_Edy = 3.82 kN.
   V_Edy 3.82
-. ----- = ----- = 0.006 < 1.000 ----> O.K.
   Vp1_Rdy 642.75

( ). Calculate plastic shear resistance in local-z direction (Vp1_Rdz).
[ Eurocode3:05 6.1, 6.2.6 ]
-. Vp1_Rdz = [ Avz*fy/SQRT(3) ] / Gamma_M0 = 873.22 kN.

( ). Shear Buckling Check.
[ Eurocode3:05 6.2.6 ]
-. HTR > 72*e/Eta ----> Need to check!

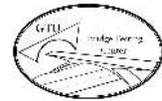
( ). Calculate shear buckling resistance in local-z direction (Vb1_Rdz).
[ Eurocode3:05 6.1, 6.2.6, EN 1993-1-5:2004 5.2 ]
-. Eta = 1.20
-. Lambda_w = hw / (86.4*tw*e) = 0.7506
-. Chi_w = 0.83/Lambda_w = 1.11
-. Vbw_Rdz = Chi_w*fy*hw*tw / [sqrt(3)*Gamma_M1] = 731.54 kN.

-. Af1 = 0.0023 m^2.
-. Af2 = 0.0023 m^2.
-. Mfk = Af1*fy*(H-Zbar-tf/2) + Af2*fy*(Zbar-tf/2) = 326.08 kN-m.
-. rf = 1-[Ned/((Af1+Af2)*fy/Gamma_M0)] = 0.9967(0<r<1)
-. Mf_Rd = rf*Mfk/Gamma_M0 = 324.99 kN-m.
-. In case of M_Ed < Mf_Rd
-. a = Ly = 18.0000 m.
-. bf = min(B, 30*e*tf) = 0.1600 m.
-. c = a*[ 0.25 + (1.6*bf*tf^2*fy)/(tw*hw^2*fy) ] = 4.8160 m.
-. Vbf_Rdz = (bf*tf^2*fy)/(c*Gamma_M1)*[1-(M_Ed/Mf_Rd)^2] = 0.47 kN.

-. Vb_Rdz1 = Vw_Rdz + Vf_Rdz = 732.01 kN.
-. Vb_Rdz2 = Eta*fy*hw*tw / [sqrt(3)*Gamma_M1] = 793.83 kN.
-. Vb_Rdz = min[ Vbw_rdz1, Vbw_rdz2 ] = 732.01 kN.

( ). Check ratio of shear resistance (V_Edz/Vb_Rdz).
( LCB = 2, POS = J )
-. Applied shear force : V_Edz = 3.18 kN.
   V_Edz 3.18
-. ----- = ----- = 0.004 < 1.000 ----> O.K.
   Vb_Rdz 732.01
```

=====  
[[[\*]]] CHECK BENDING MOMENT RESISTANCE ABOUT MAJOR AXIS.  
=====



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Steel Code Checking Result

PROJECT TITLE:

	Company		Client	
	Author		File Name	

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

( ). Calculate plastic resistance moment about major axis.  
[ Eurocode3:05 6.1, 6.2.5 ]  
-. Wply = 0.0021 m<sup>3</sup>.  
-. Mc\_Rdy = Wply \* fy / Gamma\_M0 = 506.19 kN-m.

( ). Check ratio of moment resistance (M\_Edy/Mc\_Rdy).  
M\_Edy 268.97  
-. ----- = ----- = 0.531 < 1.000 ---> O.K.  
Mc\_Rdy 506.19

=====  
[[[\*]]] CHECK BENDING MOMENT RESISTANCE ABOUT MINOR AXIS.  
=====

( ). Calculate plastic resistance moment about minor axis.  
[ Eurocode3:05 6.1, 6.2.5 ]  
-. Wplz = 0.0002 m<sup>3</sup>.  
-. Mc\_Rdz = Wplz \* fy / Gamma\_M0 = 47.37 kN-m.

( ). Check ratio of moment resistance (M\_Edz/Mc\_Rdz).  
M\_Edz 1.83  
-. ----- = ----- = 0.039 < 1.000 ---> O.K.  
Mc\_Rdz 47.37

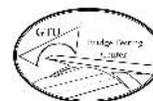
=====  
[[[\*]]] CHECK LATERAL-TORSIONAL BUCKLING RESISTANCE.  
=====

( ). Calculate lateral-torsional buckling resistance (Mb\_Rd).  
[ Eurocode3:05 6.1, 6.3.2 ]  
-. Por = 0.300  
-. Gs = Es / [ 2\*(1+Por) ] = 79230769.231 KPa.  
-. Ncr = Pi<sup>2</sup>\*Es\*Izz / Lu<sup>2</sup> = 573.05 kN.  
-. psi = 0.000  
-. C1 = 1.285  
-. Mcr = C1 \* Ncr \* SQRT [ (Cwp/Izz) + (Gs\*Ixx)/Ncr ] = 282.57 kN-m.

-. Lambda\_LT\_bar = SQRT [ Wply\*fy / Mcr ] = 1.338  
-. Lambda\_LT\_bar0 = 0.200

-. Lambda\_LT\_bar = 1.338 > Lambda\_LT\_bar0 = 0.200  
-. M\_Ed/Mcr = 0.952 > Lambda\_LT\_bar0<sup>2</sup> = 0.040  
If Lambda\_LT\_bar > Lambda\_LT\_bar0 and M\_Ed/Mcr > Lambda\_LT\_bar0<sup>2</sup>,  
Allowance for lateral-torsional buckling necessary.

-. Alpha\_LT = 0.760  
-. Phi\_LT = 0.5 \* { 1+Alpha\_LT\*(Lambda\_LT\_bar-0.2) + Lambda\_LT\_bar<sup>2</sup> } = 1.828  
-. Xi\_LT = MIN [ 1 / {Phi\_LT + SQRT(Phi\_LT<sup>2</sup> - Lambda\_LT\_bar<sup>2</sup>)}, 1.0 ] = 0.325  
-. Mb\_Rd = Xi\_LT\*Wply\*fy / Gamma\_M1 = 149.71 kN-m.



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Steel Code Checking Result

PROJECT TITLE:

	Company		Client	
	Author		File Name	

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

( ). Check ratio of lateral-torsional buckling resistance (M\_Edy/Mb\_Rdy).  

$$\frac{M\_Edy}{Mb\_Rdy} = \frac{268.97}{149.71} = 1.797 > 1.000 \text{ ---> Not Acceptable !}$$

=====  
[[[\*]]] CHECK INTERACTION OF COMBINED RESISTANCE.  
=====

( ). Calculate Major reduced design resistance of bending and shear.  
 [ Eurocode3:05 6.2.8 (6.30) ]  
 -. In case of  $V\_Edz / Vpl\_Rdz < 0.5$   
 -.  $My\_Rd = Mc\_Rdy = 506.19 \text{ kN-m.}$

( ). Calculate Minor reduced design resistance of bending and shear.  
 [ Eurocode3:05 6.2.8 (6.30) ]  
 -. In case of  $V\_Eddy / Vpl\_Rdy < 0.5$   
 -.  $Mz\_Rd = Mc\_Rdz = 47.37 \text{ kN-m.}$

( ). Check general interaction ratio.  
 [ Eurocode3:05 6.2.1 (6.2) ] - Class1 or Class2  

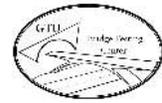
$$Rmax1 = \frac{N\_Ed}{N\_Rd} + \frac{M\_Edy}{My\_Rd} + \frac{M\_Edz}{Mz\_Rd}$$

$$= 0.572 < 1.000 \text{ ---> O.K.}$$

( ). Check interaction ratio of bending and axial force member.  
 [ Eurocode3:05 6.2.9 (6.31 ~ 6.41) ] - Class1 or Class2  
 -.  $n = N\_Ed / Npl\_Rd = 0.002$   
 -.  $a = \text{MIN}[(Area-2b*tf)/Area, 0.5] = 0.500$   
 -.  $Alpha = 2.000$   
 -.  $Beta = \text{MAX}[5*n, 1.0] = 1.000$   
 -.  $N\_Ed < 0.25*Npl\_Rd = 606.87 \text{ kN.}$   
 -.  $N\_Ed < 0.5*hw*tw*fy/Gamma\_M0 = 630.19 \text{ kN.}$   
 Therefore, No allowance for the effect of axial force.  
 -.  $Mny\_Rd = Mply\_Rd = 506.19 \text{ kN-m.}$   
 -.  $Rmaxy = M\_Edy / Mny\_Rd = 0.531 < 1.000 \text{ ---> O.K.}$   
 -.  $N\_Ed < hw*tw*fy/Gamma\_M0 = 1988.60 \text{ kN.}$   
 Therefore, No allowance for the effect of axial force.  
 -.  $Mnz\_Rd = Mplz\_Rd = 47.37 \text{ kN-m.}$   
 -.  $Rmaxz = M\_Edz / Mnz\_Rd = 0.039 < 1.000 \text{ ---> O.K.}$

-.  $Rmax2 = \left[ \frac{M\_Edy}{Mny\_Rd} \right]^{Alpha} + \left[ \frac{M\_Edz}{Mnz\_Rd} \right]^{Beta}$   

$$= 0.321 < 1.000 \text{ ---> O.K.}$$



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Steel Code Checking Result

PROJECT TITLE :

	Company		Client	
	Author		File Name	

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MIDAS/Civil - Steel Code Checking[ Eurocode3-2:05 ]  
=====

```
( ). Check interaction ratio of bending and axial compression member.
[ Eurocode3:05 6.3.1, 6.2.9.3 (6.61, 6.62), Annex A ]
-. N_Ed = -3.71 kN.
-. M_Edy = 268.97 kN-m.
-. M_Edz = 1.83 kN-m.
-. kyy = 1.006
-. kyz = 0.954
-. kzy = 0.526
-. kzz = 1.051
-. Xiy = 1.000
-. Xiz = 1.000
-. XiLT = 0.325
-. N_Rk = A*fy = 2427.50 kN.
-. My_Rk = Wply*fy = 506.19 kN-m.
-. Mz_Rk = Wplz*fy = 47.37 kN-m.
-. N_Ed*eNy = 0.0 (Not Slender)
-. N_Ed*eNz = 0.0 (Not Slender)
-. Rmax_LT1 = ----- + kyy * ----- + kyz * -----
              N_Ed                M_Edy + N_Ed*eNy          M_Edz + N_Ed*eNz
              Xiy*N_Rk/Gamma_M1    XiLT*My_Rk/Gamma_M1    Mz_Rk/Gamma_M1
              = 1.849 > 1.000 ---> Not Acceptable !
-. Rmax_LT2 = ----- + kzy * ----- + kzz * -----
              N_Ed                M_Edy + N_Ed*eNy          M_Edz + N_Ed*eNz
              Xiz*N_Rk/Gamma_M1    XiLT*My_Rk/Gamma_M1    Mz_Rk/Gamma_M1
              = 0.991 < 1.000 ---> O.K.

-. Rmax = MAX[ MAX(Rmax1, Rmax2), MAX(Rmax_LT1, Rmax_LT2) ] = 1.849 > 1.000 ---> Not Acceptable !
```

The cross-section meets the shear, local strength, axial compression, and bending conditions, but fails to meet the stability condition according to Eurocode 3.

### 3.5. Checking the cross-section of the crossbar

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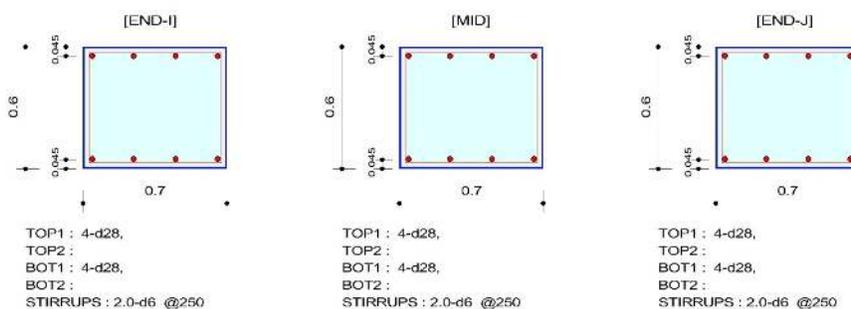
### RC Beam Checking Result

	Company		Project Title	
	Author		File Name	

#### 1. Design Information

Member Number: 6689  
 Design Code : Eurocode2-2:05  
 Unit System : kN, m  
 Material Data : f<sub>ck</sub> = 25000, f<sub>yk</sub> = 390000, f<sub>yw</sub> = 210000  
 KP a Beam Span : 4.8 m  
 Section Property: Cap (No : 7)

#### 2. Section Diagram



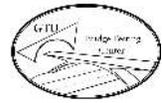
#### 3. Bending Moment Capacity

	END-I	MID	END-J
Negative Moment (M <sub>Ed</sub> )	179.36	146.07	80.01
(-) Load Combination No.	9	9	9
Factored Strength (M <sub>Rd</sub> )	437.04	437.04	437.04
Check Ratio (M <sub>Ed</sub> /M <sub>Rd</sub> )	0.4104	0.3342	0.1831
Positive Moment (M <sub>Ed</sub> )	100.88	104.67	106.36
(+) Load Combination No.	5	5	5
Factored Strength (M <sub>Rd</sub> )	437.04	437.04	437.04
Check Ratio (M <sub>Ed</sub> /M <sub>Rd</sub> )	0.2308	0.2395	0.2434
Using Rebar Top (A <sub>s_top</sub> )	0.0025	0.0025	0.0025
Using Rebar Bot (A <sub>s_bot</sub> )	0.0025	0.0025	0.0025

#### 4. Shear Capacity

	END-I	MID	END-J
Load Combination No.	9	9	9
Factored Shear Force (V <sub>Ed</sub> )	267.29	266.00	263.42
Shear Strength by Conc.(V <sub>Rdc</sub> )	152.31	152.31	152.31
Shear Strength by Rebar.(V <sub>Rds</sub> )	24.74	24.74	24.74
Using Shear Reinf. (A <sub>sw</sub> )	0.0001	0.0001	0.0001
Using Stirrups Spacing	2.0-d6 @250	2.0-d6 @250	2.0-d6 @250
Check Ratio	10.8047	10.7527	10.6486





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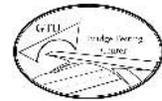
RC Beam Checking Result

PROJECT TITLE :

	Company		Client	
	Author		File Name	

-----  
MIDAS/Civil - RC-Beam Checking [ Eurocode2-2:05 ]  
=====

15 1 Self weight( 1.100) + Water( 1.000)  
16 1 Pedestrial( 1.000)  
-----



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	Author		File Name	

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=====

\*.MIDAS/Civil - RC-BEAM Analysis/Design Program.

\*.PROJECT :  
\*.DESIGN CODE : Eurocode2-2:05, \*.UNIT SYSTEM : kN, m  
\*.MEMBER : Member Type = BEAM, MEMB = 6689

\*.DESCRIPTION OF BEAM DATA (iSEC = 7) : Cap  
Section Type : Rectangle (RECT)  
Beam Length (Span) = 0.500 m.  
Section Depth (Hc) = 0.600 m.  
Section Width (Bc) = 0.700 m.  
Concrete Strength (fck) = 25000.000 KPa.  
Main Rebar Strength (fyk) = 390000.000 KPa.  
Stirrups Strength (fyw) = 210000.000 KPa.  
Modulus of Elasticity (Es) = 200000000.000 KPa.

\*.FORCES AND MOMENTS AT CHECK POINT <I> :  
Positive Bending Moment P-M\_Ed = 100.88 kN-m., LCB = 5  
Negative Bending Moment N-M\_Ed = 179.36 kN-m., LCB = 9  
Shear Force V\_Ed = 267.29 kN., LCB = 9

\*.REINFORCEMENT PATTERN :

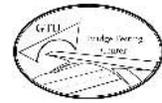
Location	i	di( m.)	Rebar	Asi( m^2.)
Top	1	0.045	4-d28	0.00246
Bottom	1	0.045	4-d28	0.00246

Stirrups : 2.0-d6 @250

=====  
[[[\*]]] ANALYZE NEGATIVE BENDING MOMENT CAPACITY.  
=====

( ). Compute design parameters.  
-. lambda = 0.8000 ( fck <= 50 MPa.)  
-. eta = 1.0000 ( fck <= 50 MPa.)  
-. Gamma\_c = 1.635 (for Fundamental).  
-. Alpha\_cc= 0.85 (Default or User Defined).  
-. fcd = Alpha\_cc \* fck / Gamma\_c = 13000.000 KPa.  
-. Gamma\_s = 1.1142 (for Fundamental).  
-. fyd = fyk / Gamma\_s = 350000.000 KPa.

( ). Check area of tensile reinforcement (Rectangular-beam).  
-. fyk = 390000.0000 KPa.  
-. fctm = 0.30 \* fck^(2/3) = 2563.23 KPa.  
-. As.min = MAX[ 0.26\*(fctm/fyk)\*bt\*d, 0.0013\*bt\*d ] = 0.0007 m^2.



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-. As.max = 0.04 \* (Bc\*Hc) = 0.0168 m^2.  
 -. As.prov = 0.0025 m^2.  
 -. As.min < As.prov < As.max ---> O.K !

( ). Search for neutral axis..... Unit : kN., m.

Trial	c	C	T	Ratio
1-st	0.119	864.52	862.41	100.245
2-nd	0.116	841.77	862.41	97.607
3-rd	0.117	853.14	862.41	98.926
4-th	0.118	858.83	862.41	99.585

( ). Check moment capacity.

-. c = 0.1180 m.  
 -. a = lambda \* c = 0.0944 m.  
 -. C = eta\*fcd\*(hf\*bf+Bc\*(a-hf)) = 858.83 kN.  
 -. T = fyd \* As = 862.41 kN.  
 -. hc = 0.3000 m.  
 -. M\_Rd = C\*(hc-a/2) + T\*(d-hc) = 437.04 kN-m.  
 -. M\_Ed/M\_Rd = 0.410 ---> O.K !

[[[\*]]] ANALYZE POSITIVE BENDING MOMENT CAPACITY.

( ). Compute design parameters.

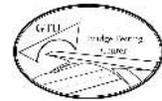
-. lambda = 0.8000 ( fck <= 50 MPa.)  
 -. eta = 1.0000 ( fck <= 50 MPa.)  
 -. Gamma\_c = 1.635 (for Fundamental).  
 -. Alpha\_cc = 0.85 (Default or User Defined).  
 -. fcd = Alpha\_cc \* fck / Gamma\_c = 13000.000 KPa.  
 -. Gamma\_s = 1.1142 (for Fundamental).  
 -. fyd = fyk / Gamma\_s = 350000.000 KPa.

( ). Check area of tensile reinforcement (Rectangular-beam).

-. fyk = 390000.0000 KPa.  
 -. fctm = 0.30 \* fck^(2/3) = 2563.23 KPa.  
 -. As.min = MAX[ 0.26\*(fctm/fyk)\*bt\*d, 0.0013\*bt\*d ] = 0.0007 m^2.  
 -. As.max = 0.04 \* (Bc\*Hc) = 0.0168 m^2.  
 -. As.prov = 0.0025 m^2.  
 -. As.min < As.prov < As.max ---> O.K !

( ). Search for neutral axis..... Unit : kN., m.

Trial	c	C	T	Ratio
1-st	0.119	864.52	862.41	100.245
2-nd	0.116	841.77	862.41	97.607
3-rd	0.117	853.14	862.41	98.926
4-th	0.118	858.83	862.41	99.585



MIDAS/Civil

RC Beam Checking Result

PROJECT TITLE :

	Company		Client	
	Author		File Name	

MIDAS/Civil - RC-Beam Checking [ Eurocode2-2:05 ]

```
( ). Check moment capacity.
-. c = 0.1180 m.
-. a = lambda * c = 0.0944 m.
-. C = eta*fcd*(hf*bf+Bc*(a-hf)) = 858.83 kN.
-. T = fyd * As = 862.41 kN.
-. hc = 0.3000 m.
-. M_Rd = C*(hc-a/2) + T*(d-hc) = 437.04 kN-m.
-. M_Ed/M_Rd = 0.231 ---> O.K !
```

[[[\*]]] ANALYZE SHEAR CAPACITY.

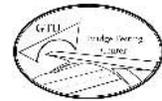
```
( ). Compute design parameters.
-. Gamma_c = 1.635 (for Fundamental).
-. Alpha_cc = 0.85 (Default or User Defined).
-. fcd = Alpha_cc * fck / Gamma_c = 13000.000 KPa.
-. Gamma_s = 1.1142 (for Fundamental).
-. fywd = fyw / Gamma_s = 218751.367 KPa.
-. Nu = 0.6*(1.0-fck/250) = 0.540 (fck in MPa)

( ). Calculate shear strength of concrete.
-. V_Ed = 267.286 kN.
-. d = 0.555 m.
-. bw = 0.700 m.
-. K = MIN[ 1.0+sqrt(200/d), 2.0 ] = 1.6003 (by d unit is mm).
-. As1 = 0.00246 m^2. (Area of tensile reinforcement).
-. Rho1 = As1/(bw*d) = 0.00634
-. C_Rdc = 0.18/Gamma_c = 0.0918
-. V_Rdc1 = [ C_Rdc*K*(100*Rho1*fck)^(1/3) ]*bw*d = 152.312 kN.
-. V_Rdc2 = [ 0.035*K^(3/2)*sqrt(fck) ]*bw*d = 150.772 kN.
-. V_Rdc = MAX[ V_Rdc1, V_Rdc2 ] = 152.312 kN.
-. Vwd = V_Ed (V_Rdc < V_Ed) ---> Shear reinforcement is required.

( ). Check crushing of concrete.
-. Theta = 45.0000 (deg)
-. V_RdMax = 1.0*Nu*fcd/{cot(Theta)+tan(Theta)}*bw*0.9*d = 1200.022 kN.
-. V_Ed < V_RdMax ---> Acceptable !!!

( ). Calculate required shear reinforcement. ( Asw1 = 0.00003 m^2. )
-. Asw/s1 = Vwd / (0.9*fywd*d) = 0.00245 m^2/m.
-. Calculate spacing s1 = 0.02314 m.
-. Rhow = 0.08*sqrt(fck)/fyw = 0.00175 (by concrete and steel classes).
-. Smax1 = Asw / (bw*Rhow) = 0.04613 m.
-. Smax2 = 0.75*d = 0.41625 m.
-. Applied spacing s_max = MIN[ s1, Smax1, Smax2 ] = 0.02314 m.
-. N_leg = 2
-. Asw/s_max = N_leg*Asw1 / s_max = 0.00245 m^2/m.
-. Aswmax/s_max = 0.5*1.0*Nu*fcd*bw/fywd = 0.01098 m^2/m.
-. Asw/s_use = N_leg*Asw1 / s_use = 0.00023 m^2/m.
-. Asw/s_max > Asw/s_use ---> Not Acceptable !!!

( ). Calculate shear strength of reinforcement.
-. V_Rds = Asw/(s*0.9*d*fywd*cot(theta)) = 24.738 kN.
-. V_Ed/V_Rds = 10.80472 ---> Not Acceptable !!!
```



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[[[\*]]] CHECK STRESS LIMITATION.

( ). Calculate stress of bottom.

-. LCB = 12  
-. k1 = 0.60000  
-. k3 = 0.80000

( Assumed Uncracked Section )

-. Mu = 100.88 kN-m.  
-. n = 12.18154( Long Term ).  
-. fctm =  $0.30 * f_{ck}^{(2/3)}$  = 2563.23 KPa.  
-. fr1 =  $(1.6 - H/1000) * f_{ctm}$  = 2563.23 KPa.  
-. fr = MAX[ fctm, fr1 ] = 2563.23 KPa.  
-. z\_bar = 0.30000 m.  
-. Iyy = 0.01618 m<sup>4</sup>.  
-. Ss\_con =  $Mu * (H - z\_bar) / Iyy$  = 1870.05527 KPa.  
-. Ss\_st1 =  $Mu * (d - z\_bar) * n / Iyy$  = 19363.13169 KPa.  
Ss\_con < fr ---> O.K !  
Ss\_st1 <  $k3 * f_{yk} = 312000.00000$  KPa. ---> O.K !

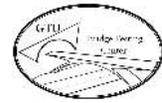
( ). Calculate stress of top.

-. LCB = 13  
-. k1 = 0.60000  
-. k3 = 0.80000

( Assumed Uncracked Section )

-. Mu = 37.28 kN-m.  
-. n = 12.18154( Long Term ).  
-. fctm =  $0.30 * f_{ck}^{(2/3)}$  = 2563.23 KPa.  
-. fr1 =  $(1.6 - H/1000) * f_{ctm}$  = 2563.23 KPa.  
-. fr = MAX[ fctm, fr1 ] = 2563.23 KPa.  
-. z\_bar = 0.30000 m.  
-. Iyy = 0.01618 m<sup>4</sup>.  
-. Ss\_con =  $Mu * (H - z\_bar) / Iyy$  = 691.03999 KPa.  
-. Ss\_st1 =  $Mu * (d - z\_bar) * n / Iyy$  = 7155.24216 KPa.  
Ss\_con < fr ---> O.K !  
Ss\_st1 <  $k3 * f_{yk} = 312000.00000$  KPa. ---> O.K !

[[[\*]]] CHECK DEFLECTIONS.



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RC Beam Checking Result

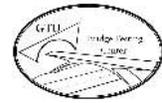
PROJECT TITLE :

	Company		Client	
	Author		File Name	

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MIDAS/Civil - RC-Beam Checking [ Eurocode2-2:05 ]  
=====

```
( ). Compute Maximum Deflection.  
-. LCB = 12 (Characteristic).  
-. Position = 0.250 m, From i-end(Node 6918).  
-. DAF = 1.000 (Deflection Amplification Factor)  
-. Def = -8.575e-006 * DAF = -8.575e-006 m.  
-. Def_Lim = L / 250.000 = 0.0124 m.  
Def < Def_Lim ---> O.K !
```

**The section meets the axial compression, stability and bending conditions, but fails to meet the shear condition according to Eurocode 2.**



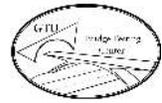
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#### 4. Conclusion

Based on the analysis of the investigation results and recalculation of the aqueduct on the Mtkvari River (location coordinates – 41°26'14"N 45°01'13"E), the following conclusion is made:

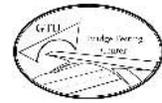
- The stability condition of the main beams of the aqueduct is not met;
- The shear condition of the aqueduct crossbar is not met;
- Based on the above conditions and due to the fact that the customer failed to submit the design and/or detailed drawings of the aqueduct, the subsidence of the aqueducts could not be determined, and therefore, it was not possible to check their cross-section using non-destructive methods alone. Therefore, it was considered inexpedient to check the cross-section of the post.

From all of the above, it can be concluded that the aqueduct requires rehabilitation and reconstruction works, taking into account the relevant operational requirements.



## 5. Recommendations

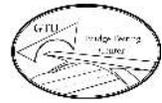
- 1) The damaged protective layer of the reinforced concrete crossbars of the piers requires rehabilitation;
- 2) The load-bearing beams of the steel span structures require rehabilitation-reconstruction;
- 3) The damaged reinforced concrete slabs of the carriageway require rehabilitation;
- 4) The carriageway structure requires rehabilitation with the arrangement of asphalt pavement and railing;
- 5) The supporting parts require rehabilitation, taking into account the roller, upper and lower balancing sheets and fastening nodes in the crossbar;
- 6) The structures of the rotated and displaced bracket (upper and lower yoke of the composite structure) require rehabilitation;
- 7) It is necessary to adjust the heights of the supporting cross-sections of the water pipes.



---

## References

1. СНиП 2.05.03-84. Мосты и трубы. Нормы проектирования.
2. СНиП Ш-43-75. Мосты и трубы. Правила производства и приемки работ.
3. СНиП 3.06.07-86. Мосты и трубы. Правила обследований и испытаний.
4. ГОСТ 8829-94. Изделия строительные железобетонные и бетонные заводского изготовления. Методы испытания нагружением. Правила оценки прочности, жесткости и трещиностойкости.
5. ВСН 4-81. Инструкция по проведению осмотров мостов и труб на автомобильных дорогах.



## Annexes



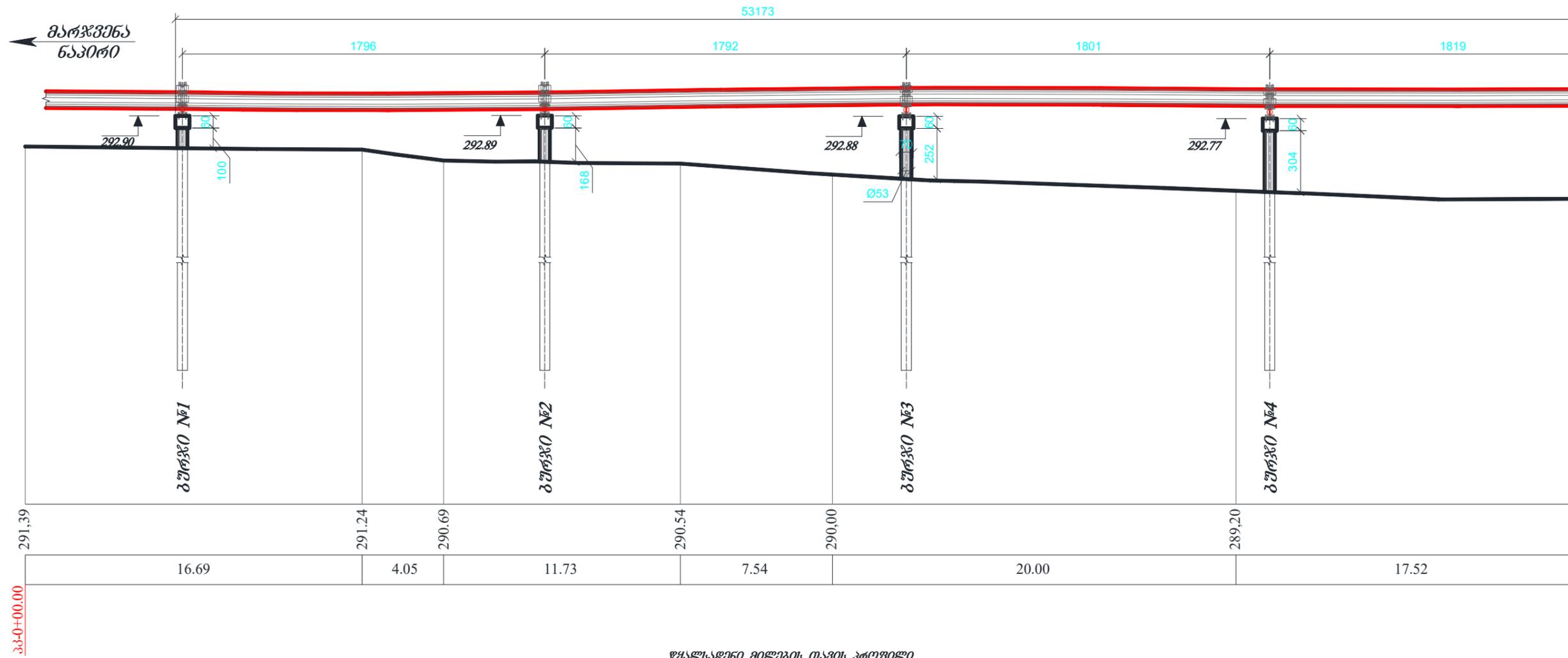
Plan (sheet 1)



Plan (sheet 2)



*Plan (sheet 3)*

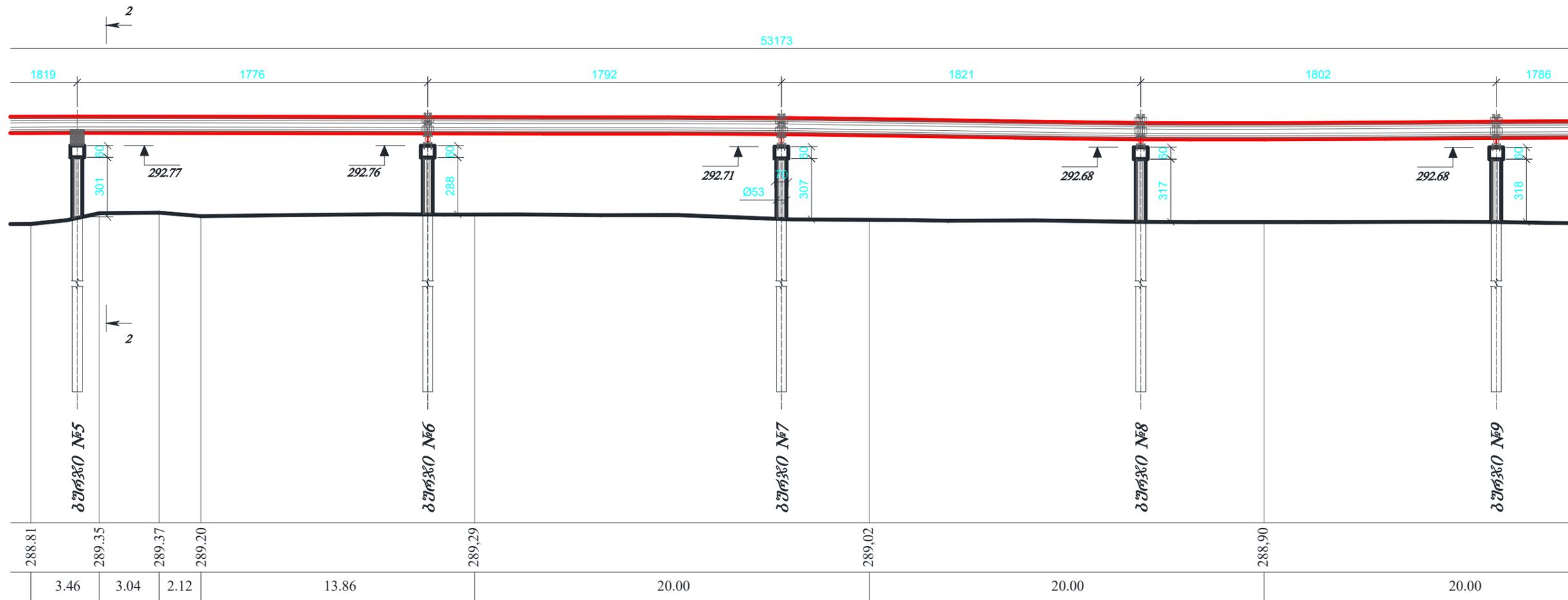


შენიშვნები:

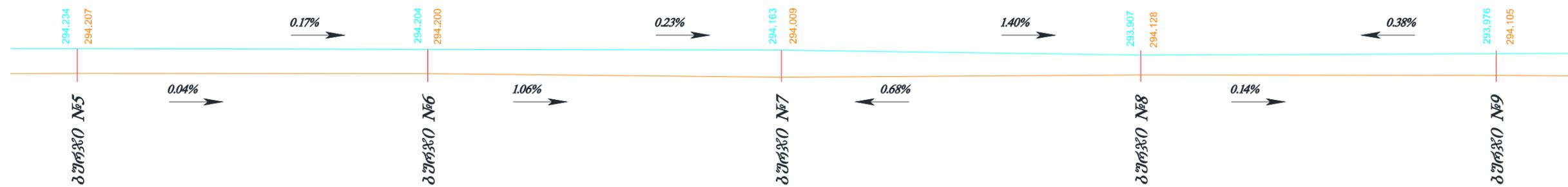
1. ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. ნახაზზე მოცემული საერთო ხელი აკრეფულია აკვედუკის ღერძზე;
3. წყალსადენი მილის თავის ნიშნულები მიღებულია საყრდენ კვითზე.

— ზედა მხრის წყალსადენი მილი  
— ქვედა მხრის წყალსადენი მილი

General view of the aqueduct (sheet 1)



წყალსარეწი მიწების თავის პროფილი

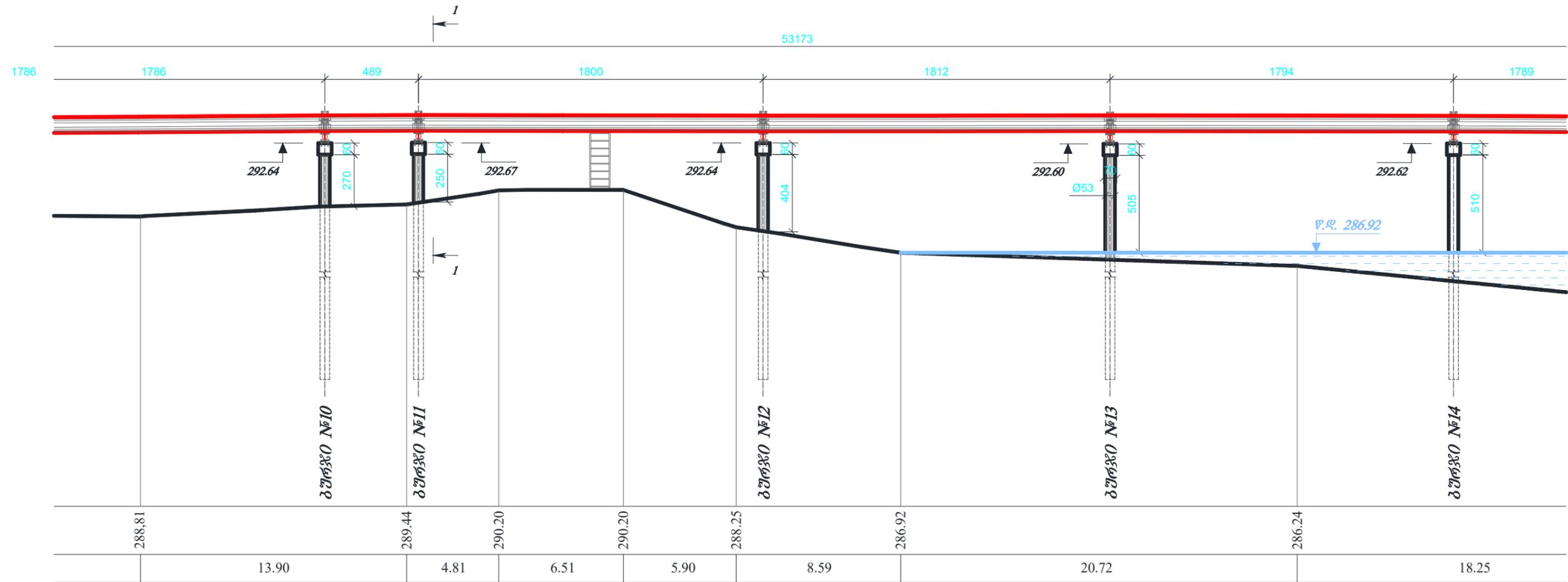


შენიშვნები:

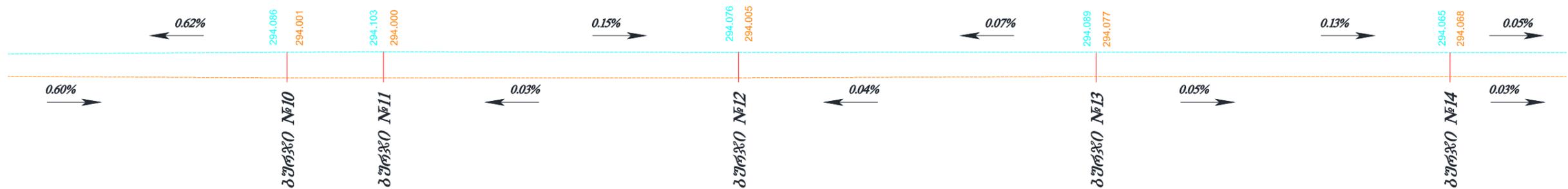
1. ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. ნახაზზე მოცემული საერთო ხაზი აგებულია აკვირების ღერძზე;
3. წყალსარეწი მიწის თავის ნიშნულები მიღებულია საყრდენ კვეთზე.

— ზედა მხრის წყალსარეწი მიწი  
— ქვედა მხრის წყალსარეწი მიწი

General view of the aqueduct (sheet 2)



წყალსაღენი მიღების თავის პროფილი

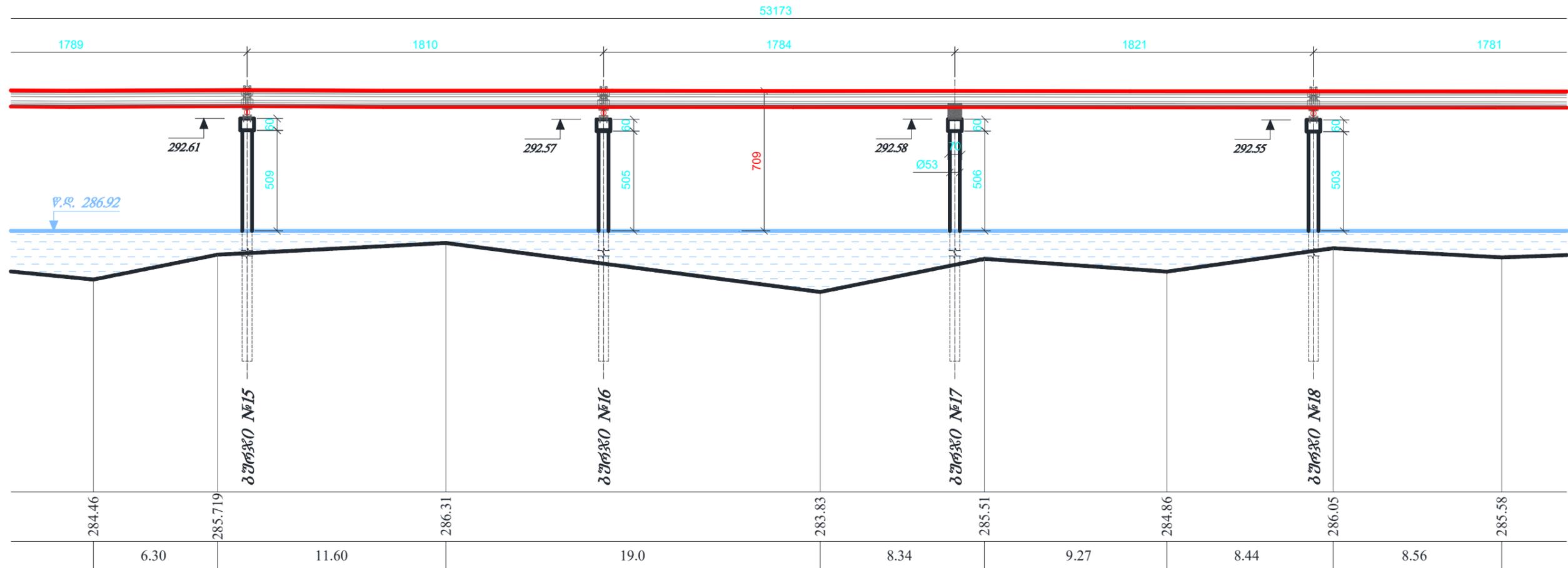


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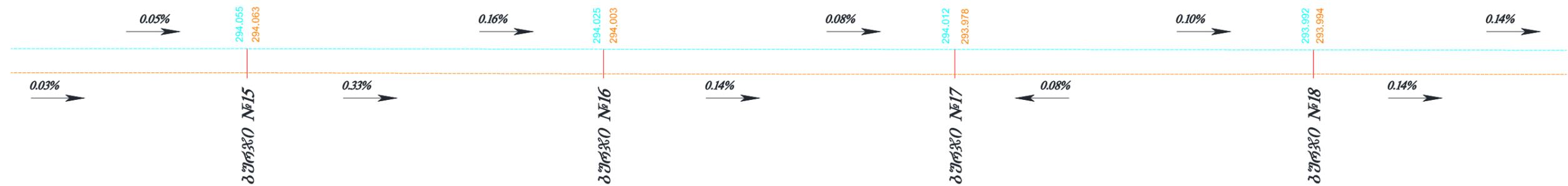
1. ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. ნახაზზე მოცემული საერთო ხაზი აკვლავს აკვლავს ღერძს;
3. წყალსაღენი მიღების თავის ნიშნულები მიღებულია საყრდენ კვითზე.

--- ზედა მხრის წყალსაღენი მიღი  
 --- ქვედა მხრის წყალსაღენი მიღი

General view of the aqueduct (sheet 3)



წყალსადენი მიწების თავის პროფილი

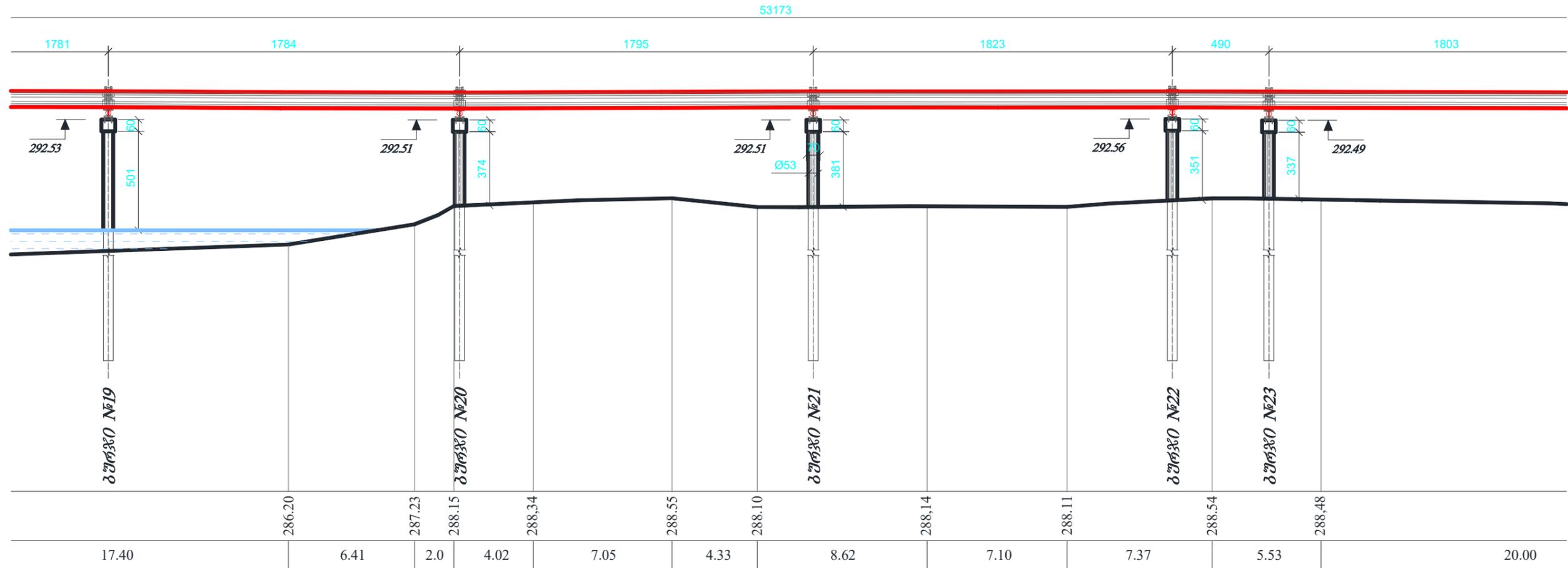


შენიშვნები:

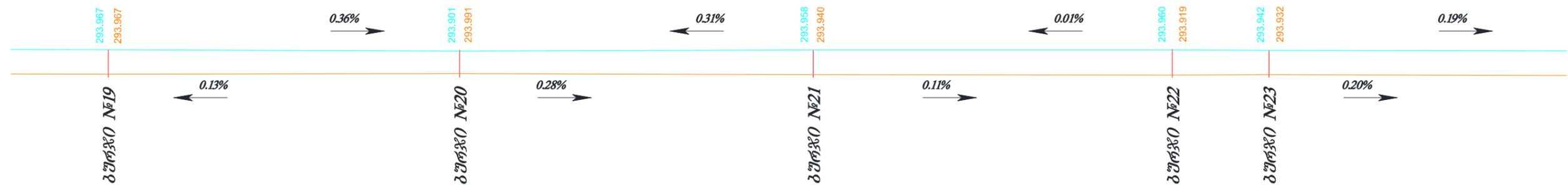
- ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
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- წყალსადენი მიწის თავის ნიშნულები მიღებულია საყრდენ კვითზე.

- ხედა მხრის წყალსადენი მიწი
- ძველ მხრის წყალსადენი მიწი

General view of the aqueduct (sheet 4)



წყალსადენი მიწების თავის პროფილი

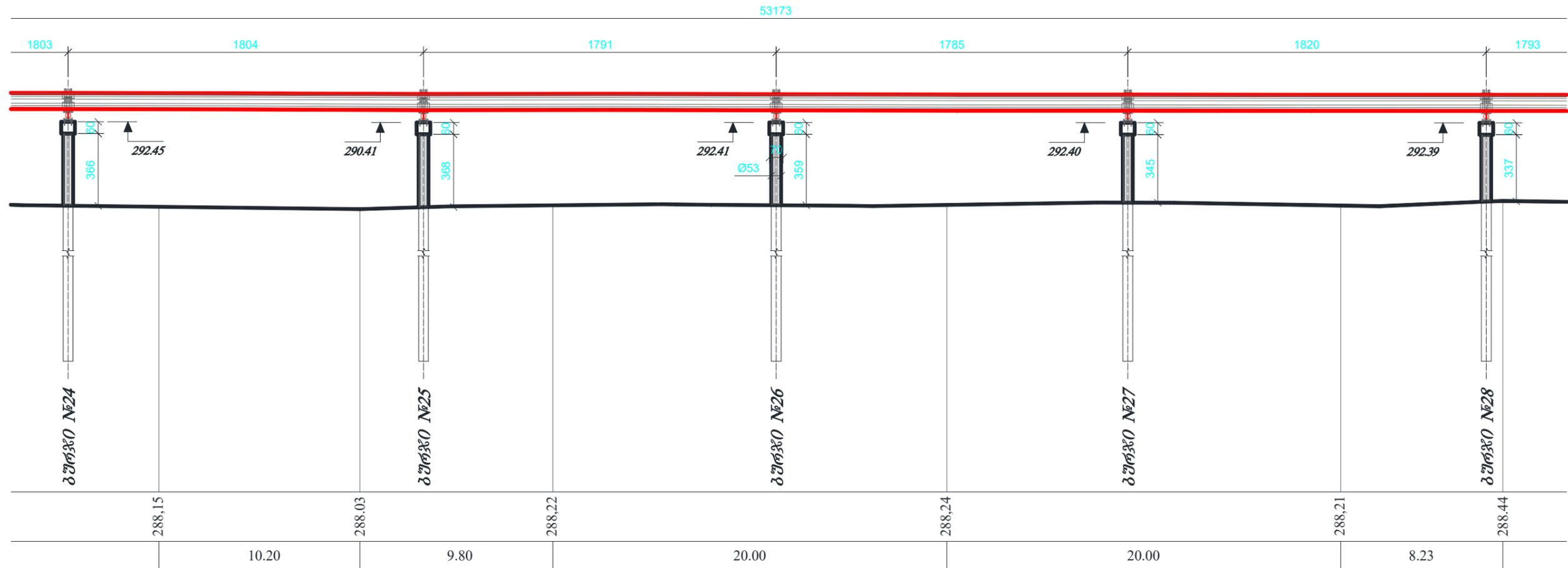


შენიშვნები:

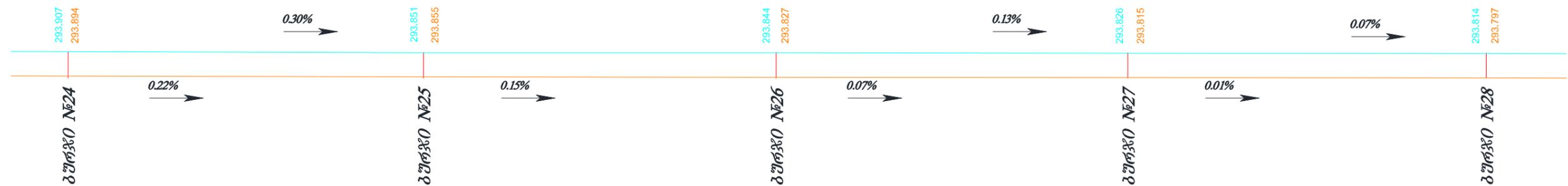
1. ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. ნახაზზე მოცემული საერთო ხაზი აბეჭეულია აკვედუკის ლერძზე;
3. წყალსადენი მიწის თავის ნიშნულები მიღებულია საყრდენ კვითზე.

— ხედა მხრის წყალსადენი მიწი  
— ძველ მხრის წყალსადენი მიწი

General view of the aqueduct (sheet 5)



წყალსადენი მიწების თავის პროფილი

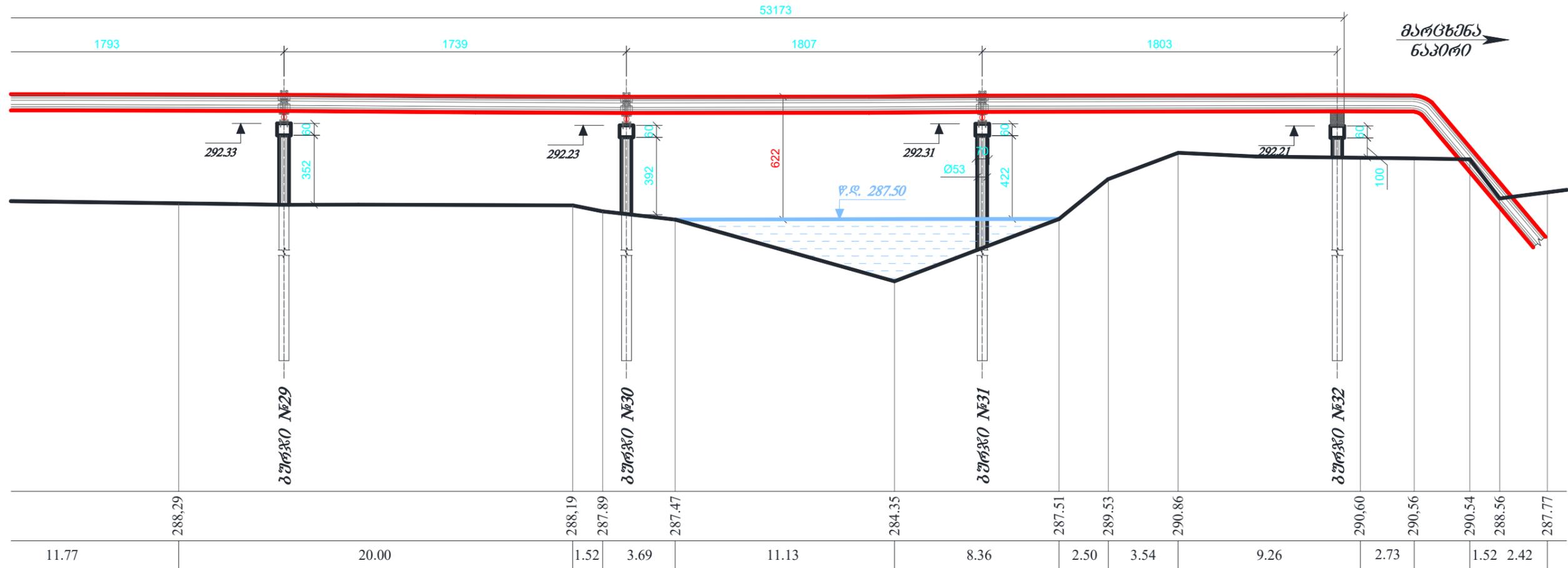


შენიშვნები:

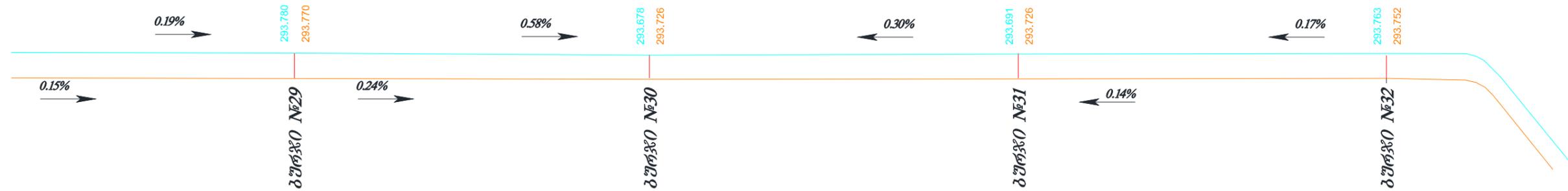
- ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
- ნახაზზე მოცემული საერთო ხაზი აბეჭდულია აკვედუკის ლერძზე;
- წყალსადენი მიწის თავის ნიშნულები მიღებულია საყრდენ კვითხე.

— ზედა მხრის წყალსადენი მიწი  
— ქვედა მხრის წყალსადენი მიწი

General view of the aqueduct (sheet 6)



წყალსაღები მიწების თავის პროფილი

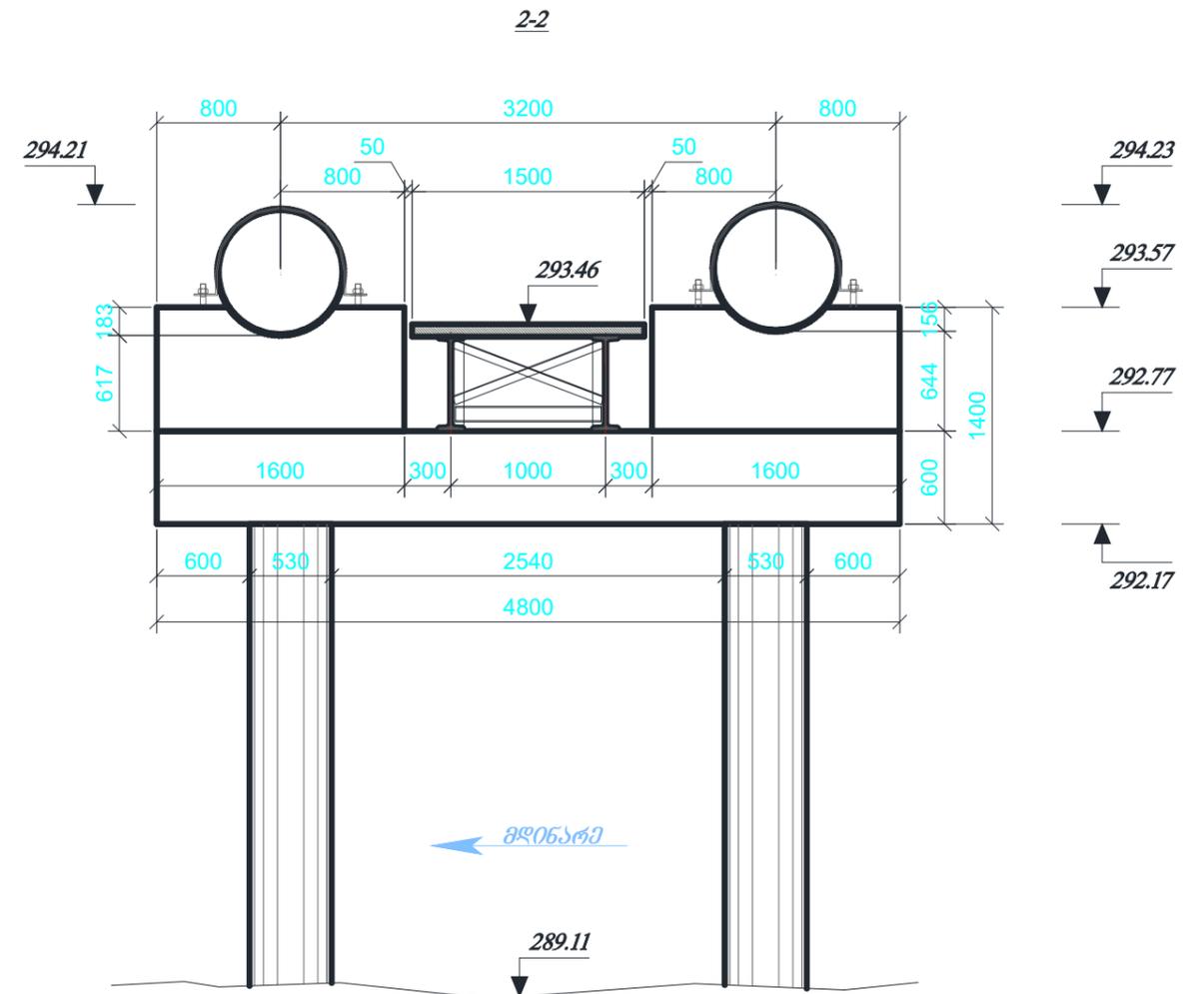
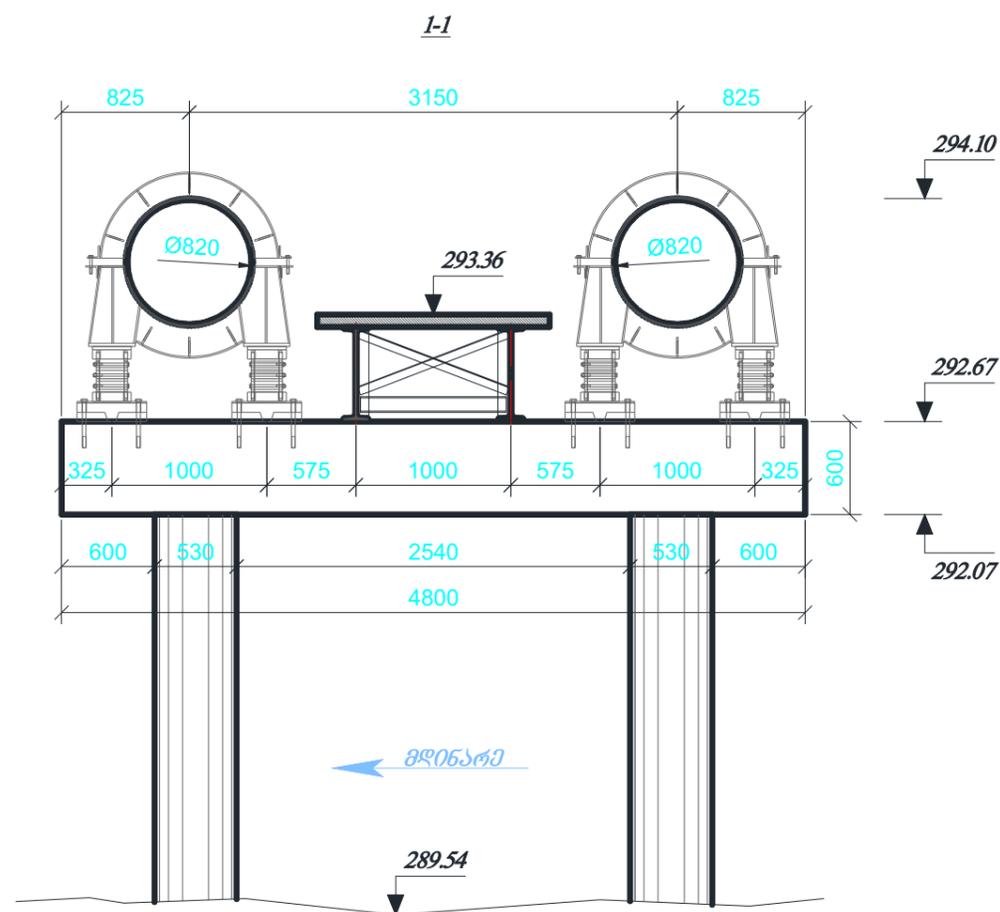


შენიშვნები:

1. ნახაზზე ზომები მოცემულია სანტიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. ნახაზზე მოცემული საერთო ხელი აგებულია აკვედუკის ღერძზე;
3. წყალსაღები მიწის თავის ნიშნულები მიღებულია საყრდენ კვითზე.

— ხელა მხრის წყალსაღები მიწი  
— ძველი მხრის წყალსაღები მიწი

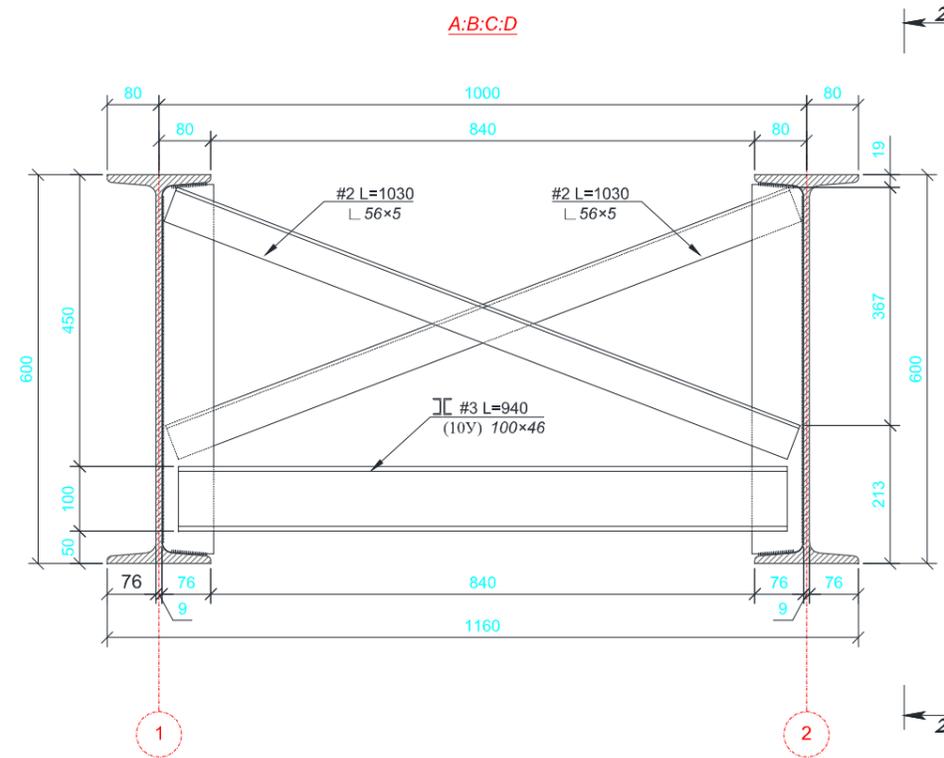
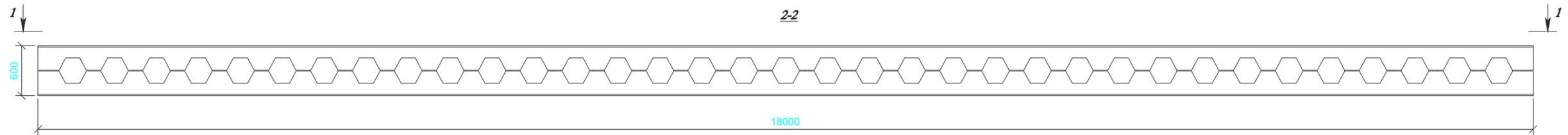
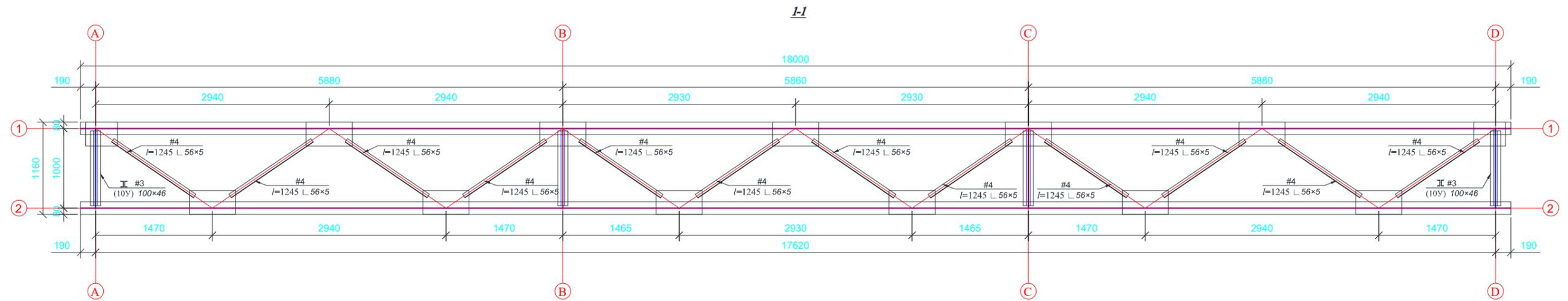
General view of the aqueduct (sheet 7)



შენიშვნები:

1. ნახაზზე ზომები მოცემულია მილიმეტრებში, ხოლო ნიშნულები მეტრებში;
2. კვეთი 1-1 და კვეთი 2-2 -ის მდებარეობა იხილეთ საერთო ხელის ნახაზზე;

*Aqueduct cross-sections*



შენიშვნა:

1. ნახაზზეა აღებული მონაცემები მოსაძიებლად;

**Steel span structures**



*Fig. 1. Damaged protective layer concrete of reinforced concrete crossbar*



*Fig. 2. View of the connection node between the reinforced concrete crossbar and the steel post*



*Fig. 3. Water pipe without supporting parts*



*Fig. 4. Support parts without rollers*



*Fig. 5. View of the steel support structures of the water pipeline*



*Fig. 6. Bearing roller falling out of the balance sheets*



*Fig. 7. Rusted steel elements of the span*





*Fig. 8. Deformed longitudinal connections*



*Fig. 9. Deformed beam of the upper side 9th span*



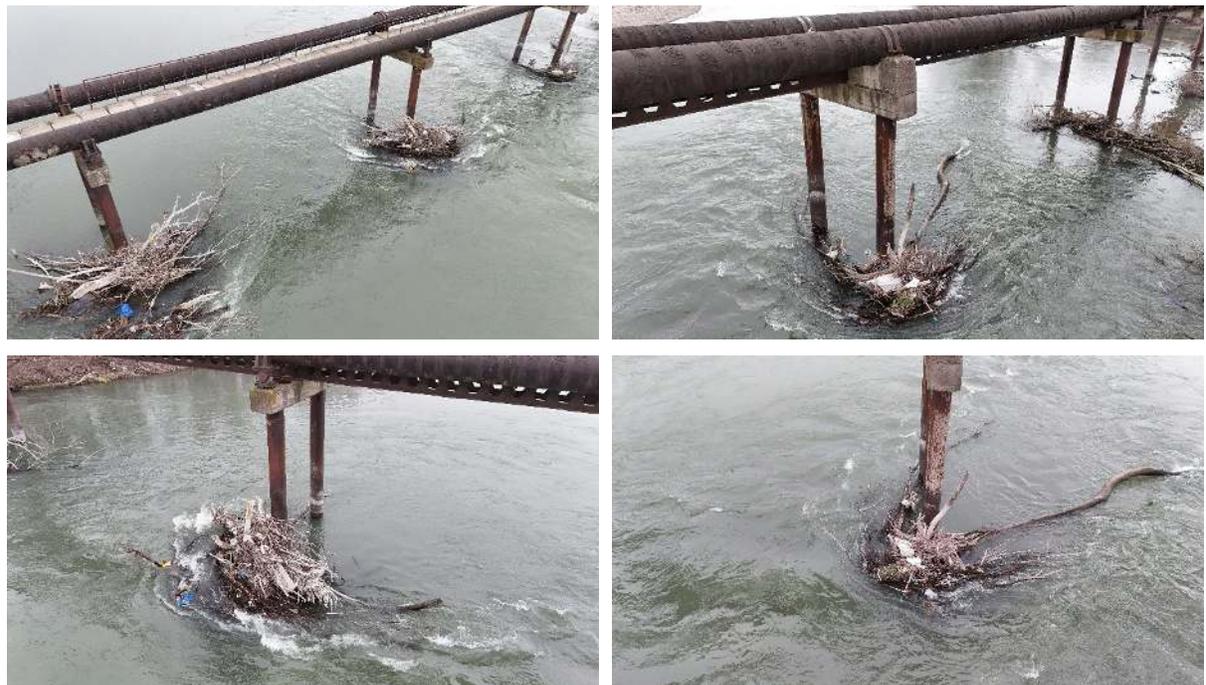
*Fig. 10. Deformed beam of the lower side 10th span*



*Fig. 11. Arrangement of longitudinal beams in N29 and N30 span*



*Fig. 12. Damaged protective layer concrete of reinforced concrete slab of the carriageway*



*Fig. 13. View of a fragment of the riverbed*



*Fig. 14. Determination of the concrete class by Silver Schmidt.*



*Fig. 15. Determination of the reinforcement location and the protective layer of concrete using "NJJ-105 Hand Search"*

სსიპ აკრედიტაციის ერთიანი ეროვნული ორგანო –  
აკრედიტაციის ცენტრი

**აკრედიტაციის მოწმობა**  
**GAC-TL-0355**

ადასტურებს, რომ

**საქართველოს ტექნიკური უნივერსიტეტის**  
**„ხიდსაცდელი ცენტრი“-ს**  
**საგამოცდო ლაბორატორია**  
აგრედიტებულია სსტ ისო/იკ 17025:2017/2018-ის  
მოთხოვნებთან შესაბამისობაზე თანდართულ სფეროში  
მის.: ქ. თბილისი, კოსტავას ქუჩა №77

ბეჭედი: 2024 წლის 27 სექტემბერი  
ძალაშია: 2028 წლის 27 სექტემბერი

გენერალური დირექტორი



იხ. სფერო და სტატუსი



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