Technical requirements for the construction of a new bridge on Bregalnica River on the regional road P1309, Section: Kochani – Zrnovci at km.4+336.00
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1 General information

1.1 Design and construction

The necessity for reconstruction – construction of a new bridge on Bregalnica River on the regional road P1309: Section Kochani – Zrnovce at km 4+336.00, arises from the fact that intense rain in the period from 01.02.2015 to 05.02.2015 caused visible damages to the existing bridge. The existing bridge has four spans of 20m each. Two main cross girders are constructed with a reinforced concrete slab above. Cross abutments and cross pillars are constructed between the two main girders, which together form a beam grid that lies on the bottom structure. Both abutments are constructed as reinforced concrete walls – canvasses with a constant cross section. The three pillars are constructed as separate pillars with round cross section of 60cm. The founding of the abutments and wing walls is on a foundation slab, while the pillars have foundation straps on two lamellas.

The on-site investigation, as well as the geodetic survey of the new condition show vertical deformations of the invert level of the bridge, i.e. displacement of the pillars in directions x, y, and z. The largest displacement is present in the vertical z direction of up to 40cm. Large cracks are also present on the pillars with the assumption that their foundations also have the same displacements and damages. In the light of all these findings, a “Professional opinion on the condition of the bridge on the Bregalnica River on the regional road P309: Section Kochani – Zrnovce at km 4+336.00” is prepared, in which the Designer concludes that the existing bridge structure is to be removed and a new modern bridge is to be constructed.

1.2 Analysis of solutions

Several possible solutions have been analyzed on the site of the existing bridge and the most favorable solution has been selected from a constructive and technological and economic aspect. All possible solutions are analyzed as a semi-prefabricated reinforced concrete structure with monolithic substructure, prefabricated main pre-stress girders and monolithic reinforced pavement slab and cross girders. The static system is a system of simple beams with mobile bearings.

The selected solution is with four spans of 24.5m for the two pillars and 23.75m for the two abutment spans, again with a pillar in the minor river bed, but the pillar spans are expanded for 4.5m from the existing ones. Due to an increase in the pillar spans, there is a displacement of one of the abutments for 16.3m from the existing pillar in the direction towards Kochani, with the purpose of achieving symmetry in the newly constructed bridge structure.
Figure 1. Cross section of the newly designed bridge with marked axes through the pillars of the existing bridge
1.3 Structural solution – elements of the structure

Taking into consideration the characteristics of the alignment and the invert level, a structural system is selected – semi-prefabricated reinforced concrete structure with monolithic substructure, prefabricated main pre-stress girders and monolithic reinforced concrete slab and cross girders over the pillars, which is a solution that fully corresponds to the entire surroundings.

The width of the bridge pavement is 5.90m, it is limited by edges, sidewalks and edged beams on both sides, which are 2*1.0 = 2.0m wide. As a result, the total bridge width is $B=5.90+2.00=7.90$ m.

The length of the bridge is solved with four spans $L=23.75+24.5+24.5+23.75 = 96.5$ m.

1.3.1 Superstructure

The superstructure is designed as a beam grid composed of five prefabricated main girders placed one next to the other at a distance of 158cm and monolithic reinforced concrete pavement slab and cross girders.

The main prefabricated girder section is selected after preparing several different solutions and it is in accordance with the condition for fulfilling the strain and the deformation requirements. The main girder is with a T-section and 130cm height. The vertical rib is with thickness of 40cm. The upper flange is 156cm wide and with variable thickness from 15cm at the ends to 30cm at the rib joint. The upper flange is with a crosswise inclination of 2.5%. The length of one main girder together with the anchor protection is $L=24.10$ m.

The main girders are pre-stressed with four cables 7T15 each of the “FREYSSINET” system with anchors 7C15 and protective pipe 60/66mm. The weight of one cable is 7,64 kg/m, with quality of $\rho_{02/10k} = 1670/1860$ MPa.

The untightened reinforcement used to reinforce the girders is ribbed RA 400/500-2.

Two edge cross girders are designed on the girder edges with width of 30cm, which are 25cm over the sleeper beams at the lower edge in order to enable auscultation and replacement of the bearings during usage.

With the monolithization of the pavement slab and the cross girders, the main girders function as simple beams supporting fresh concrete mass of the pavement slab and the cross girders. After the monolithization of the pavement slab and cross girders, the superstructure is a beam grid of main prefabricated girders and a pavement slab.

It is envisaged to construct the main girders, the pavement slab for monolithization which is part of the main girder, as well as the cross girders from concrete of quality MB 40, M-100.
The pavement slab is with thickness of 15cm. It ends on both sides with a parapet beam, while façade elements are assembled on its outer side. A sidewalk structure is constructed next to the parapet beam which is separated from the pavement slab by an elevated curbstone. The sidewalk structure is constructed with openings in cross section that could be used for installations.

The main girders rest upon the abutments and pillars through neoprene elastomeric bearings (NB 200x400x63mm).

1.3.2 Substructure

The substructure is a discontinued frame structure made of 4 fields, with a span of \( L = 23.75 + 24.5 + 24.5 + 23.75 = 96.5 \) m

The structure comprises two abutments (S1 and S5) and three pillars (S2, S3 and S4).

The abutments are designed as monolithic reinforced concrete walls with constant cross section of 100cm, which end on the top with a sleeper beam whereupon the main girders rest over neoprene elastomeric bearings.

The connection of the abutments to the foundations and the wing walls is monolithic. The wing walls are constructed as reinforced concrete walls with variable cross sections in terms of height. The wall thickness on the top is 50cm with inclination of 1:10 that increases up to the contact with the foundation. The variable height of the wall is on the side of the embankment, while the outer side of the wall is vertical.

The pillars S2, S3, S4 are designed as rectangular reinforced concrete canvasses with outline dimensions of 100/500cm and constant cross section and semi-circular edges. The top pillars are driven into the foundation, and a sleeper beam is projected in the upper part with height of 120cm and variable width with console parts.

Figure 2. Newly designed bridge cross section
1.3.3 Founding

The choice of founding is made in accordance with a previously prepared geomechanical survey. The parameters received for the lithological layers led to the selection of deep founding type with the use of piles. The piles are of the floating type, since the investigations showed no proper bearing layer or rock base. Consequently, the main bearing capacity is ensured by the friction around the pile circumference. The piles have diameter of $F=800\text{mm}$ and length of $L=15\text{m}$, under all pillar positions. Under the abutment positions, the founding is done over a group of seven piles, tied together with a pile cap slab with thickness of $120\text{cm}$ and outline dimensions of $560/960\text{cm}$. The founding under the pillars is done over a group of eight piles, tied together with a pile cap slab with thickness of $130\text{cm}$ and rectangular outline with dimensions of $500/920\text{cm}$, and round edges. The disposition of the piles in the pile group is with distance of $240\text{cm}$ and $300\text{cm}$ between the axes, with the purpose of avoiding super sinking and influence between adjacent piles.

1.4 Design solutions for the road alignment

1.4.1 Alignment position – horizontal solution

The horizontal solution for the bridge reconstruction arises from the existing road, as well as from the newly designed bridge location. It is located on the spot of the old existing bridge with minor changes in disposition.

The horizontal solution is done with one centrally positioned axis – the Zrnovci axis with length of $L=522.04\text{m}$.

The following conditions are taken into consideration during the design phase: design parameters, functionality, economic and safety factors.

Two clean round curvatures with $R=120\text{m}$ and $R=320\text{m}$ radius are incorporated in the appropriate directions, in accordance with the requirements for embedding with the existing pavement.

1.4.2 Longitudinal section

The vertical solution was prepared on the basis of the horizontal solution.

When vertically setting the road invert level, it was taken into account that the beginning and the end of the given location fit in with the existing state in terms of height.

Since the newly designed road is higher, the invert level was adjusted with the proper height as well, in order to correspond to the newly designed road.

The minimum longitudinal slope is $i_{\text{min}} = 0.30\%$ while the maximum slope is $i_{\text{max}} = 5.79\%$. 
The radius of the minimal vertical curvature amounts to $R_{\text{min}} = 400$ m, while the maximum radius amounts to $R_{\text{max}} = 450$ m.

1.4.3 Cross sections

The cross slope generally amounts to 2.5 (one-sided) and it varies in parts subject to twisting in order to fit in vertically with the existing slope of the regional road.

The graphic presentations provide all necessary data for the works construction.

The cross sections are given along the respective axis.

1.4.4 Structural solution for the pavement structure

The pavement structure has been defined on the basis of the relevant parameters, the traffic load, the climatic, topographical, and geotechnical characteristics of the terrain, as well as the Investor recommendations.

The following pavement structure is adopted:

- Asphalt concrete AB $16c$ $d = 6.0$ cm
- Bituminized bearing structure layer BHC $22cA$ $d = 7.0$ cm
- Base course $= 30.0$ cm

1.4.5 Description of the technology for construction and quality of materials used for the road construction

The Public Enterprise for State Roads has prepared technical documentation *Technical requirements for the construction of state roads in the Republic of Macedonia*, in accordance to which the works are being executed. The execution methodology is provided below.

The bridge reconstruction on the regional road commences with a geodetic survey and pavement marking. Then the existing pavement structure is demolished up to the elevation of the newly designed base course where necessary, and the alignment is cleared.

For the sections that need to be integrated, it is envisaged to cut the asphalt structure, mill it and roughen it in the specified length (required for levelling and integration), construction of an embankment (where the invert level is elevated), then construction of the base course material with thickness up to $d=30$cm, then comes the bituminized asphalt layer BHC $22cA$ with $d=7$cm, and then comes the AB $16c$ $d=6$cm, and spraying with bitumen emulsion is done prior to the placement of each asphalt layer.
The required parameters for the incorporated and used materials are provided below:

- The base course (envisaged in the sections with the new pavement structure) should be prepared with crushed stone material that should fulfil the requirements of MKS U.E9. 020 and laboratory CBR>80%;

- The bituminized load capacity layer type BHC 22cA should be prepared in accordance with the criteria of MKS U.E9. 021;

- The asphalt concrete layer, projected for the pavement structure shall be type AB 16c. The criteria for the stone bits are defined with MKS U.E4.014/90, the polymer-bitumen characteristics SBS in amount 4-6% should fulfill the MKS EN14023:2006

- In general, the manner and procedure for the construction of the substructure and superstructure, should be in accordance with: "Technical conditions for construction of state roads in the Republic of Macedonia" – so-called Book 2, issued by the Public Enterprise for State Roads.

1.5 Other works

1.5.1 Drainage

The drainage and sewage system for surface water should enable acceptance of the overall water from the surface of the structure and its continuous drainage from the superstructure. For that purpose, it is envisaged to install two drains in each field of the structure at the lower side, on a distance of 12 - 12,50m. Then horizontal and vertical pipes are used to discharge the water into the recipients.

1.5.2 Guardrail system

The fence of the type combined pedestrian guardrail was adopted, and it is in compliance with the requirement that it meets its purpose and fits into the architecture of the bridge structure. It is installed on the both sides of the structure along its entire length, to the end of the wing walls. The guardrail is extended on the places where the structure is also extended.
1.5.3 Waterproofing

The waterproofing is an integral part of the structure and is intended for protecting the concrete and reinforcement from chemical and physical water and salt influences. Protection is envisaged for all underground concrete surfaces and concrete surfaces subjected to weather conditions, as well as waterproofing of the pavement slab.

1.5.4 Extension joints

Extension joints are projected for the purpose of smooth extension of the structure, i.e. above the abutments S1 and S5. Based on the conditions and length of the structure, extension joints type T-100 have been adopted. If the Contractor suggests another type of extension joints, they need to be approved by the Designer and Investor prior to construction.

The extension joints should be accompanied by proper documentation from the manufacturer and assembly instructions. The Contractor is obliged to strictly adhere to the instructions for the materials and to the technology for the construction of extension joints received from the manufacturer. The construction of the extension joints should be done at medium temperature occurring in the region where the structure is being built.

1.5.5 Bearings

Bearings are placed in order to transfer the vertical and horizontal reactions of the bearing structure, as well as to connect the bearing structure and the substructure, which must enable vertical deformities of the main girders and extension of the bearing structure. The bearings are made of neoprene and their characteristics should fulfill the DIN regulations.

Depending on the maximum and minimum reaction, also depending on the displacement affecting one bearing, elastomer bearings with dimensions 200x400x63mm over the pillars and abutments have been adopted.
Technical description – AB Bridge

1 Preliminary works

Preliminary works comprise all activities necessary to commence the construction, but in this case they also comprise the removal of the existing bridge. The removal of the existing deformed bridge structure, abutments and pillars on dry land and in water from the location is done partly by blasting, and partly by mechanical crushing. **The Contractor shall submit together with the proposal a suggested methodology for tearing down the bridge, after inspecting the site and having into consideration the plant and equipment he has at his disposal.** It is projected part of the material not containing reinforced rods to be used for protection from river erosion, in order to decrease the total investment value of the structure.

Prior to commencement of the construction, the Contractor shall propose a technical temporary traffic solution (tractors and light vehicles) over the river. It is the recommendation of the Designer and Investor to investigate the possibility of constructing an embankment with concrete pipes that go through it (for example, with diameter of 1500 mm), which would enable temporary crossing over the river for light vehicles. The proposed technical solution must be approved by the Supervisor and the Investor prior to construction.

Prior to commencement of the construction, the Contractor shall propose a traffic solution for an alternative bypass road during the execution of the construction works. The proposed traffic solution must be approved by the Supervisor, the Investor, and the relevant authorities.

1.1 Pre-testing of materials

Before the commencement of the works execution it is necessary to pay attention to previous testing of the materials for execution, provided under this project design.

For the execution of earthworks, it is necessary to have into consideration the geotechnical investigations performed for this structure, the geotechnical survey for the location, the locations for landfills, which may provide precise information on the existing and applied materials.

For the execution of the concrete works it is necessary that the Concrete Design provides information of all its components, as well parameters for the control of the cement, water, aggregate and additions.

For the execution of the reinforcement works it is necessary to provide test certificates for the reinforcement.

For the execution of other works (waterproofing, coatings etc.) the Contractor needs to hold test certificates for the materials used for this structure.

In particular, the Contractor must take into consideration the contract documentation with the Investor (so called tender documentation) which closely defines the relations between the Contractor and the Investor in terms of the application of proper construction materials.

1.2 Organization of the construction site

The organization of the construction site shall provide the necessary space on site for execution of the technological processes envisaged for the construction of this structure.

In addition, depending on the construction site location, it is necessary to provide access roads that shall serve for uninterrupted execution of the overall construction works.
2 Marking the site and geodetic survey

The design provides the necessary number of information related to the site marking. During the construction the horizontal and the vertical position of each structural element shall be controlled with geodetic instruments. No deviations bigger than ± 10 mm is permitted.

3 Earthworks

Under this project design, the earthworks shall include: excavation of piles, excavation for the construction of pile cap slabs with the formation of a construction pit, embankment around the foundations, as well as embankment between the wing walls or embankment for the structure cones.

During the works execution the Contractor shall have into consideration the Geotechnical Investigation Study for the site under consideration, as well as the characteristics of the necessary materials of the projected borrow pit.

3.1 Excavation of foundations and formation of a construction pit

The formation of a construction pit includes activities necessary for the smooth excavation of earth material for the construction of the foundations.

First, an excavation in a wide excavation pit is made, in order to form the construction pits for the separate foundations (pile cap slabs).

The main environment for founding of the piles from the bridge structure is the zone with well graded sand.

-Excavation conditions

The excavation of foundations is fully mechanical, whereby according to the existing categorization GN 200, all materials are classified as III category. The slopes of the construction pits are 1:1.

It is recommended to do a technical acceptance of the construction pit by the authorized personnel of the Investor. Upon the acceptance of the construction pit, the authorized persons will have to check, with an appropriate procedure, the assumptions of the Geotechnical Study.

3.2 Embankment around the foundations

The embankment around the foundations is performed within the base of the formed construction pit to the elevation of the surrounding terrain.

The embankment is performed in layers of 30cm each with dispersed material that requires the minimum possible energy for compacting, which shall be approved by the Supervisor.

The compaction is controlled by an on-site method in accordance with the Investor’s technical conditions.

The embankment around the foundations can commence after the full completion of the construction of pillars.

3.3 Embankment between wing walls and abutments by forming slopes for the cones
The embankment between the wing walls is performed with materials that contain characteristics specifically defined by the Designer, according to the specifically defined borrow pits for this structure. The following characteristics were taken into consideration in the static calculation for the embankment:

- dry volume weight \( \bar{\rho}_d = 24.0 \text{ KN/m}^3 \)
- inside friction angle \( \phi = 35^\circ \)

It is projected that the embankment is constructed with large-grain gravel material over a “base” layer of waterproof material with the same defined compaction of MB100.

The embedding of the material is to be performed in layers with thickness of 30-40cm, depending on the Contractor’s available equipment, while the maximum grain size is limited to 1/2 of the layer height.

During compacting, the material should have humidity level close to the optimal level.

The control over the achieved compaction shall be performed with the proper investigations for each layer, and the required compaction for each layer shall be:

- for the finish layer with height of 2m under the invert level 100% of the modified Proctor test;
- for the layers from the bottom of the foundation to 2m under the invert level 95% of the modified Proctor test.

The embankment shall be done in two layers of gravel material with maximum grain of 70mm with small particle percentage of under 0.02mm and not bigger than 3%, while the California bearing ratio shall be CBR>8.

The required compaction is to be 100% of the maximum volume weight in dry state, calculated by the modified Proctor test, while the required compressibility module with a plate load test F300mm is to be bigger than 80 MPa.

4 Concrete and reinforced concrete works

This type of works comprise formwork, concrete, reinforcement and scaffolding works related to the structural elements.

In addition to the recommendations, the introductory part containing general information on the works also describes designer’s opinions as criteria for the execution of each structural element separately. It is understood that the Contractor competes with its own technology for high quality execution of this type of works. The method of control shall be prescribed by the Investor, in compliance with the Concrete Design, i.e. within the frames of the quality control of the site structures.

For the purpose of successful execution of the concrete works, pursuant to PBAB 87, the Contractor shall prepare a Concrete Design, which shall define: the production, transport, embedding and taking proper care of the projected concrete types as well as the manner of control for the fresh i.e. hardened concrete and its components.

The types of concrete projected for the structural elements of the structure have the following characteristics: MB 40, M-100 for all structural elements of the superstructure (main prefabricated girders, cross girders, pavement slab), and MB 30, M-100 for all structure elements of the substructure (pillars and abutments with foundations and wing walls). All sub bases in the structure are to be constructed out of MB 20.

4.1 General requirements for the construction of concrete and reinforced concrete works
The general requirements for the concrete works apply to all structural elements and they must be taken into consideration in the Concrete Design.

In addition to the technical requirements for the execution of works and the criteria for assessment of the quality of materials referred to herein above the Contractor must comply with the applicable technical and legal regulations on concrete and reinforced concrete works.

The general requirements shall also include certain recommendations as a reminder for the Contractor.

4.1.1 Execution of formwork

The formwork construction must be in compliance with the formwork design for individual structural elements.

The dimensions of the formwork as well as the means for supporting and joining of the formwork must be in compliance with the MKS.U.C9.400.

The designed formwork and the application of means for its protection shall provide ideally smooth surface free of stains.

The Contractor shall design the formwork both in compliance with all mentioned herein above and in compliance with the adopted construction technology presented throughout the Concrete Design.

When executing the formwork, the requirements expressed through the presented drawings and the present technical specification must be taken into consideration for each structural element.

4.1.2 Concrete works

a) Pre-testing of the constituent materials

Prior to the commencement of the works it is recommended that the Contractor has the sufficient number of various previously conducted investigations both for the concrete making materials (aggregate, cement, water and additions) and for the fresh, i.e. hardened concrete, in compliance with the applicable regulations and standards. In other words, the Contractor must be experienced with the already formed concrete plant, permanent annual investigations, permanent suppliers of cement and aggregate as well as established extensive production. The previous investigations guarantee that the requirement on the concrete types under this design, i.e. Concrete design prepared by the Contractor shall be successfully completed.

b) Production, transport and embedding of concrete

The production, transport and embedding of concrete under each item shall be elaborated based on previous investigation, in compliance with these design requirements and presented in the Concrete Design.

The production of concrete must be in compliance with PBAB-87 and followed by the established manner of control.

The transport of concrete must be conducted with appropriate modern, and most importantly, defect-free means of transport and followed by the established manner of control.

The embedding of concrete in the structures means inserting fresh concrete mass and compacting it. The inserting of concrete in the structures must be conducted through special means “pipes” if no concrete pump is used. The application shall be conducted in layers of maximum 30-50 cm.

During the compacting there must be a discharge of the air from the concrete mass and the homogenous concrete mass must fill the formwork completely, especially the protective layer around the reinforcement.

The embedding and compaction must be in compliance with the structures being
executed, as well as in compliance with the consistence of the fresh concrete mass, which certainly indicates once again to the correlation between this design and the Concrete Design.

c) Proper care of the embedded concrete

Conditions for smooth hydration of the embedded concrete in order to meet the required characteristics of the designed concrete. The care shall be prescribed under the Concrete Design having into consideration all factors leading to premature drying of the concrete. It is recommended to remove the formwork as late as possible depending on the structures being executed. The care as an important quality factor must not be neglected. Depending on the designed concrete and the weather conditions the time of care which shall be at least 7-14 days.

d) Base preparation

The base preparation is projected during interruptions in the concreting of work joints. Here it is projected removal of all unbound parts of the cement milk and the aggregate by chase cutting. Before applying the second cast concrete the base needs to be moistened but it should not be wet. The treated base must have smooth edges, and on the surface it needs to have protruded parts of the bound aggregate. Before the concreting it is recommended that the base is sprinkled with cement solution 1.5:1.

e) Final treatment

The concrete surfaces having no formwork shall be finally treated in order to obtain perfectly smooth, and if necessary waterproof surface.

4.1.3 Reinforcement works

For the reinforcement of the concrete elements and structures a wire shall be used with diameter $\varnothing<12$mm or rods with $\varnothing>12$mm of smooth steel GA 240/360 – smooth reinforcement and ribbed steel PA 400/500-2 – ribbed reinforcement, as well as high tensile pre-stress steel with quality $\varnothing 2/\varnothing x=1670/1860$ MPa.

Before the commencement of the reinforcement works it is necessary to conduct the reinforcement tests along the diameters and to control the most important characteristics: tear resistance, yield point, elongation at break and the contraction. It is obligatory to perform control of the quality of the reinforcement welding.

The reinforcement used in the elements of the structure must comply with the quality requirements defined in PBAB-87 and the applicable standards: MKS C.K6.020/87, MKS C.K6.120/86, MKS U.M1.091/80, MKS U.092/87, and MKS C.A4.035/66.

For the elements and structures which during the exploitation will be exposed to dynamic loads, the reinforcement used must be made of steel that meets the dynamic strength requirement, i.e. it must have the necessary fatigue strength. The reinforcement to be used for fabrication of the structural elements must be perfectly clean and precisely fabricated in accordance with the reinforcement designs. Before the preparation of the reinforcement it is necessary to control the lengths specified in the reinforcement designs. The installation of the delivered reinforcement must be precisely executed, taking care of the distances between the reinforcement rods as well as the protective distances. For that purpose cement retainers and spacers should be used.

For the pre-stress elements a reinforcement must be used in the form of cables that satisfy the terms in the existing Rulebook on the technical norms for steel wires, rods, ropes, and cables for pre-stress structures from 1988, as well as the Euronorms 138-79.

The pre-stress reinforcement in the form of cables, must be tested and its most important mechanical characteristics must be determined: tear resistance and elongation at break (1670/1860). The tear resistance of a rope should not be lower than 190 KN. The relaxation of the steel should not be higher than 2.0% after 1000 hours.

The tightening of the reinforcement should not be performed if the reinforcement investigations
are not available, as well as the experimental registered diagram for the steel. The investigations should be performed in accordance with existing standards: MKS C.K6.033/82, MKS C.K6.034/82, MKS C.K6.035/82, MKS C.K6.036/82, MKS C.K6.037/82.

Prior to commencing with the cable elongation, it is necessary to investigate the pre-stressing equipment, i.e. to calibrate the hydraulic sets.

4.1.4 Scaffolding

The steel tube scaffolding is a temporary structure for taking loads of the formwork and the freshly embedded concrete, as well as for temporary fixing the long reinforcement rods.

Scaffolding shall be executed on the basis of the design documentation with careful designing and dimensioning.

The individual pipes can withstand mainly centrical pressures, while in case of eccentric pressure their bearing capacity is reducing.

The Contractor usually has available: heavy tube scaffolding Ø48.3 mm S=4.05mm (MKS.S.V. 5222 and DIN 2441) and light tube scaffolding Ø48.3 mm S =3.50 mm (MKS.S.V. 5222 and DIN 2440).

Special attention should be paid during the execution of the joints because careless handling may jeopardize the bearing capacity and therefore the security.

The use of tube scaffolding, couplings and screws affected by corrosion should be avoided.

Before the works execution it is recommended to check the declared characteristics of the materials being used.

4.2 Special conditions for construction of concrete and reinforced concrete works

4.2.1 Reinforced concrete foundations under the abutments, wing walls, and pillars

This design envisages AB concrete foundation comprised of AB piles grouped in eight groups and connected at the top end in a pile cap slab, under the abutments and pillars.
For the construction of the piles, they are first geodetically positioned at the correct position. The surrounding terrain is cleared of any material that could interfere with the construction. It is also necessary to enable uninterrupted access of equipment to the pile positions, for both the excavation and concreting alike.

The excavation of the piles is done mechanically up to the projected elevation in the projected pile diameter, in accordance with the project design documentation. If the construction of the piles is in incoherent heterogeneous dispersed material, or material prone to grinding, as well as in presence of high levels of ground water, the excavation needs to be protected by wrapping columns (which are removed during concreting).

The reinforcement required for reinforcing the piles is prepared outside the location or at the location, in accordance with the projected reinforcement plan. The prepared reinforced sockets are mechanically lowered into the previously excavated positions for the construction of the piles. The placement of the reinforced socket should be done carefully so as to ensure its distance from the excavation spot, which can be achieved by welding spacers on the reinforced socket. This will ensure the necessary space for entering of the concrete mass between the excavation and the reinforced socket, so as to secure the protective layer of the reinforcement.

The final phase of construction of the piles is their concreting with the projected type of concrete. During concreting, it is necessary to control the concrete in accordance with the relevant regulations, whereas the concrete should fulfil all required criteria in accordance to the relevant standards.

The concreting is uninterrupted along the entire length of the pile. The concreting is done with a pipe that is lowered to the bottom of the excavated pile and is then raised as the concreting progresses. The pipe concrete opening should be kept into the concrete mass during concreting, 0,50 - 1,00 m. This type of concreting avoids the possibility of concrete mass segregation. During the concreting process, the padding column are removed, while taking care not to cause grinding of the soil material in the concrete mass, which would disturb the integrity of the concreting.

After completing the construction of the pile, the pile tip is prepared for its connection to the top structure.

Due to the specific terrain conditions for founding, the Designer is suggesting to construct a test pile, in order to confirm the projected geometry and bearing capacity of the piles.

With regard to the pile cap slab, first a layer is concreted in order to level the base under the pile cap slab. The technological design should envisage a way to prevent the loss of water from the fresh concrete mass, as well as the mixing of earth material with the concrete.
Figure. Graphic presentation of the construction of drilled piles protected with steel columns

The foundation reinforcement is placed over the spacers projected for this item. Having in consideration the height of the pile cap slab, spacers for the reinforcement from the top area are projected. The reinforcement for the abutments and pillars is placed in the projected position in accordance with the submitted reinforcement details. The assembly of the reinforcement projected with no anchors requires a scaffold with the possibility of fixing the reinforcement into the projected position.

The interconnection of the reinforcement rods and fixing the formwork should ensure immobility of the reinforcement during vibrations of the concrete mass.

The assembled reinforcement is controlled by a person authorized by the Investor, in accordance with the reinforcement details.

Construction of a foundation structure without work joints has been envisaged.

The formwork should secure the form of the projected concrete volume during construction. The selected formwork should guarantee smooth concrete surfaces suitable for placing the waterproofing later on.

Leakage of the cement milk onto the interconnections is not permitted. The spirit leveling should ensure leveling condition of the surfaces with no formwork.

Even though there is good access to the construction pit, it is still recommended to embed the concrete with an auxiliary cement pump in 30-50cm layers, mostly due to the relatively large height of the concrete cross section. The embedding in width and length should be precisely specified in the Concrete Design. The Concrete Design should contain parameters for evaluating the fresh concrete mass, which are specifically significant for this item (consistency in Slump method, binding start and binding end, etc.)

The compacting of the fresh concrete mass should be elaborated in the Concrete Design, which will incorporate the means for compacting it and time/duration for compacting of the separate layers, in accordance with the projected technology, having in consideration the start and end of the binding process for the fresh concrete mass.
Surfaces with no formwork are processed in two ways. The cross-section outside the reinforcement should be prepared for waterproofing by roughcasting and glazing. The cross-section between the reinforcement should be cleaned from the cement milk and all unbound parts 8-12 hours after cementing.

The required scaffold is planned for working platforms and abutment formwork, or for maintaining the direction of the installed reinforcement to the pillar. The scaffold is placed outside the foundations for the first phase, while for the second phase it can lie on the already constructed foundation.

4.2.2 Abutments with wing walls

This project design envisages abutment and wing walls in the form of reinforced concrete walls. The wing walls are standardly placed according to the abutment.

The concreting of the body of the abutment and wing wall is projected in more phases and, if possible, with as small a number of work joints as possible. First, the part of the abutment and wing wall is concreted in one phase up to the level where the console section of the wing begins. The second phase is used for forming the abutments up to the level of “hidden” sleeper beam immediately under the main girder bearings and up to the level of expanding of the crown for the wings. The “hidden” sleeper beam is concreted in the third phase, while having into consideration the surfaces for the placement of the bearings. The last phase includes concreting of the abutment parapet, as well as the crown of the wing walls.

It is recommended to place the concrete with a concrete pump in layers of 30-60cm. The embedding and compaction should be executed in accordance with the Concrete Design, having into consideration the start and end of the binding process, where it is necessary to define the duration for binding of the separate layers in accordance with the projected technology. 8-12 hours after concreting, it is necessary to clean the cement milk and all unbound materials from the work joints. The concrete surface under the bearings is finally processed by roughcasting and glazing until it receives a black glow. The Concrete design should provide the possibility to grade the fresh concrete mass (consistency, start and end of the binding process, etc.)

A part of the main reinforcement for the abutments with a part of the secondary reinforcement is already embedded during the construction of the foundation slab and is fixated to the projected position with a scaffold. The rest of the reinforcement is assembled in accordance with the projected technology for formwork or in accordance with the projected concreting phases, so as to enable uninterrupted embedding of the concrete mass. The protective layers are formed with spacers projected for this item. The Reinforcement for the sleeper beam and parapet beam should be assembled after completing the concreting of the abutment body and after treating the work joint.

It is projected that the formwork for the abutments and wing walls is done at the same time. The formwork can be done in a standard way or with a movable formwork. Having in consideration the height of the abutments, it is possible to do the formwork in both ways. The projected manner of doing the formwork should accord with the scaffold positioned for fixing the assembled reinforcement, as well as with the projected manner of concreting in phases. The selected formwork should guarantee smooth concrete surfaces suitable for placing the projected waterproofing and not disturb the visual effect of the visible side. The contact between the formwork and the finished concrete should be secured by profiled rubber seals.

It is required to project a scaffold for working platforms and possible supporting of the projected formwork, especially for the console part of the wing walls.

4.2.3 Pillars

The pillars S2, S3, and S4 are projected as reinforced concrete canvasses with dimensions of 100/500cm and are placed under an angle of 90 degrees to the road axle. A sleeper beam is projected on the top end of the pillars.
The other works on the pillars are subject to the same description as the works on the abutments.

4.2.4 Construction of pre-stress main girders

4.2.4.1. Introduction

The main girders of the structure, as a part of the semi-prefabricated beam grid, are projected as prefabricated pre-stress girders harnessed by a reinforced concrete pavement slab. The design projects up to five (5) main girders in cross section for the structure in one field.

In order to make the assembly as simple as possible, the girders shall be casted on the river bank elevation, from both sides.

In order to elevate the girders, openings should be left for steel pipes Ф100mm, as well as an opening for the top flange of 30/15 cm. The steel ropes are pushed through these openings and they will serve for elevating the girders.

When elevating the girders and removing the formwork (steel molds), it is obligatory to adhere to the safety standards for elevation and depositing. The removal of the girders can be only done with attested steel ropes. The workers that will be doing the lifting need to be explained the proper way of fixing the load and the possible consequences of the wrong way of doing the job.

4.2.4.2. Assembly and disassembly of the formwork

Prior to the assembly, it is necessary to clean the formwork by grinding it, until it reaches a shiny surface. The surface is then wiped with cotton cloths before applying the formwork agent.

The formwork agent is applied evenly without allowing leakage onto the surface of the formwork.

The assembly process should allow for uninterrupted assembly of the projected reinforcement, cables and anchors, to the previously positioned spacers, in accordance with projected protective layers.

The formwork is laterally closed after receiving the incorporated reinforcement from an authorized professional designated by the Investor.
The control of the assembled formwork is performed by horizontal and vertical intersections on every 2.0m. The direction of the formwork is secured through ideality of the mold bottom of the platform for formwork and concreting.

The formwork exploitation must adhere to certain safety standards.

4.2.4.3. Construction and assembly of the projected reinforcement

The reinforcement is constructed and assembled in accordance with the attached drawings.

For the connection between the hearth reinforcement and the stirrups it is necessary to secure immobility of the reinforcement rods during the incorporation and compacting of the fresh concrete mass.

The protective layers are secured with spacers.

4.2.4.4. Assembly of protective bending pipes

The protective bending pipes (metal and polyethylene) are placed over reinforced rod rafts in accordance with the attached drawings.

They have a thickness of 0.20mm and have to protect the cables for pre-stressing during exploitation.

The allowed deviation of the cable resultant from the projected position can be 2%, at the most, while the deviation of the individual pipes from the height can be 2 cm at the most, but not for shortening the protective layer.

It is important for the pipes to remain undamaged (with no holes) so as not to cause corrosion of the pre-stress steel.

The sealing of the protective pipes needs to ensure waterproofing in each construction phase.

The proper sealing and the right geometrical position should be ensured during the concreting, which is usually followed by powerful vibrations.

The protection of the pre-stress steal is done by the pipes after they are filled with pressurized grouting mixture. For this purpose, the inside of the pipes must be air-free in order to prevent creating air bubbles that will prevent the space around the cable to be filled with the grouting protective mixture. For this purpose, the Contractor is obliged to possess special equipment for vacuuming the air from the inside of the protective pipe or suggest to the Investor another proper and efficient way to perform the operation.

If the Contractor does not possess a pipe in total length as the length of the cable, i.e. if the protective pipe is comprised of more elements, than special attention needs to be paid to these elements and to the proper isolation of these connections.
4.2.4.5. Concreting of prefabricated pre-stress main girders

The concreting of the prefabricated girders comprises all technological processes, i.e. production, transport and embedding by compaction of fresh concrete mass together with the finishing of the surfaces without formwork.

The entire technological process should guarantee the realization of the technological conditions for concrete envisaged with this design, as well as adhering to other technological conditions in accordance with the legal regulations.

The Concrete Design needs to provide the opportunity for grading the fresh concrete mass prior to embedding (for example, consistency using the Slump method), as well as the start and end of the concrete binding process in accordance with the projected embedding of the fresh concrete mass in vertical and horizontal layers.

It is recommended to use a concrete pipe with the option that a pipe could be inserted between the stirrups. This design also recommends the exclusive use of formwork vibrators for compacting of the fresh concrete mass.

The disassembly of the formwork shall be defined in a Concrete Design, and it is recommended to take place at least 48 hrs. after completing the concreting.

During concreting it is necessary to continuously control the penetrability inside of the bending pipes. Equipment imitating a cable should be used for this purpose.

If certain partial or full clogs are noticed, it is necessary to use special equipment to unclog the bending pipes even before the finished process of concrete binding.

In addition to the adopted pressure strength achieved with mark MB-40, the concrete used for construction of the girders should possess the following special characteristics: waterproof mark B-6, ice resistance mark M-100, shrinkage mark $\delta(%)=0.34$, leakage $\tau=2.1$ and elasticity module $E_b = 3.50 \times 10^4$ Mpa. This concrete shall be pumped with consistency according to the Slump method of 8-10 cm. A fraction-divided aggregate shall be used during production of the concrete mixtures. The cement to be used shall be PC 400. The proper additives shall be used for improving the consistency of the fresh concrete mass and for speeding up the initial strength characteristics of the concrete mixture. An additive for preventing the concrete water from freezing shall be used when concreting at temperatures below $+5^0C$.

During the construction of the prefabricated elements, in accordance with the adopted program for control testing, it is necessary to construct control elements – cubes.

After completing the construction, each element should be marked in color and marked with a date of construction.

After completing the compacting of the concrete into the girder, the concrete care commences by covering the top surface of the concrete with a PVC foil or jute bags or blankets that will constantly be moistened with water. After a period of 12 to 16 hours, the formwork is disassembled and the girder is protected (by way of covering it) from direct sun and wind influences.
The concrete surfaces of the girder are not poured over with water up to the moment when it cools down to normal temperature. After the girder is cooled, but no later than 24hrs after the concreting, the constant concrete care begins in a period of 7 days, by keeping it covered with dampened jute bags or blankets.

4.2.4.6. Prestressing of the main girders

The prestressing of the main girders is performed in accordance with the projected static calculation. This design envisages 4 cables type 7T15 (seven ropes Φ15.2mm) from the prestressing system “FREYSSINET”, that shall be prestressed simultaneously from both sides of the main girder. It is envisaged to use high-tensile steel for prestressing with quality 602/60k=1670/1860 MPa. The weight of the cable is 7.64 kg/m; protective pipe Φ60/66mm; anchor type: 7C15; compress type: C350F, with initial prestressing strength of Np= 1330 kN in one cable.

4.2.4.6.1. Specification of the technological processes during construction

4.2.4.6.1.1. Installing of cables

The installing of cables can commence after testing the penetrability of the area projected for their placement. Having into consideration the weight and the length of the cables, the necessity for a well-planned approach is obvious, starting from the cable formation and finishing with their installment into the main girders.

The formed cables need to be ordered by the supplier in larger length than necessary. The formed cable is stored on site in the same way as it is transported, i.e. in an upright position.

Before the installment, it needs to be checked whether the ropes are in parallel position, and the formed cables to be connected in certain places.

The Contractor needs to have a hoist or a crane with minimum bearing capacity of 500 kg for the installment of cables.

During the entire process the ropes need to remain impeccably clean, which means forming yokes on wheels or other assisting devices for holding the cable during its installment.

4.2.4.6.1.2. Elongation of cables

Before commencing with the prestressing of the cables, the Contractor needs to have data on current testing for concrete probes and especially with the pressure strength.

It is first necessary to check the movability of the cables. Then, each rope is cut with proper equipment to a length suitable for the compress. For compress type C350F and anchor 7C15, this length is 125cm. The anchor with wedges is dragged onto the already prepared ropes.

Then, the compress is positioned is such a way that the ropes are installed into proper compress channels. The compress is leaned onto the hearth. The entire time the compress is supported by an assisting device – a hoist.
It is of high importance to properly lay down the anchor panel on the head of the girder (the laying down must be with the entire surface of the panel) and the panel and the beginning of the cable must be orthogonally positioned, with the purpose of ensuring proper entrance of the prestressing force without any unwanted loss of force, so the head of the girder is specially processed on the spots where the anchors are being laid down, which can be seen on the graphic supplements for the main girder (Cable line for the main girder).

The compress is activated by a proper pump. This type of compress requires that all ropes are simultaneously intercepted and tightened. The cable tightening lasts until the required elongation is achieved. The force increase for the prestressing is monitored on a manometer. This design envisages a prestressing force of 1330 kN per cable.

After the elongation is achieved, the ropes are wedged in. The compress is returned to its original position. The ropes are released and the compress is removed. The ropes are cut to the projected length.

The cable tightening schedule is provided in the design. The entire procedure is entered into a special log that needs to be verified by an authorized professional of the Investor.

In order to execute the works as precisely as possible, it is required for the Contractor to have a proper diagram “…” for the projected prestressing steel that would enable an accurate account of the prestressing process, as well as the required elongation for the standardized force per cable.

If discrepancies in the elongation appear for more than 5%, the ropes must not be cut. An authorized professional from the Investor should consult the Designer on further procedures. The decision for repeating the operation is made by a committee comprising of the Contractor, Investor, Supervisor, and Designer.

Safety measures:

The persons operating the prestressing equipment must be trained by the equipment manufacturer.

4.2.4.7. Protection of the cables and anchors (grouting mixture)

This design projects permanent protection of the cables and anchors with a mixture of cement, water, and additives.

The mixture is prepared in a special mixer according to the Contractor’s instructions that need to be approved by the Investor. The mixer can be directly connected to the grouting pump reservoir where the mixture is still being mixed, but will smaller intensity. The mixture is simultaneously grouted into the protective pipe with the cable.

A pump that functions in the described way can be used. During the entire grouting period, this pump with regulated pressure of 305 bars changes the pumping capacity until the mixture appears at the other end of the cable. Then, all openings need to be closed, and the pressure is elevated to 10 bars and it remains there for a few minutes and then the connector is disengaged and the grouting opening is closed. The grouting mixture should fulfill certain technical conditions regarding flowability, volume, water separation, pressure strength, etc.

If the grouting is done at low temperatures, the herein mentioned characteristics should be confirmed in accordance with the weather conditions on the site. The main girders i.e. the cables shall be heated if necessary, but not over 50°C within 48hrs after grouting.

4.2.4.7.1 Grouting mixture and it’s constitute components

- Cement

Great attention should be paid to the quality of the cement being used because different types of cement can have different water needs at identical fluidity degrees of the grouting mixture.

It is only permitted to use clean Portland cement without additives and with mark PC400, in accordance with the quality required by standard (MKS)B.C1.011. The cements needs to be
delivered in bags with weight of 50kg ± 1kg and it needs to be stored in dry premises. If the cement is moist and has started to lump, it must not be used for preparing the grouting mixture. The cement cannot be used before at least 3 days pass from its production.

- Water

The water must not contain matters that are harmful for the cement and for the prestressing steel. The water-supply network water is mostly usable for preparing the grouting mixture. If water from other sources is being used, it must first be tested and it must adhere to the standard (MKS)U.M1.058.

- Additives

The additives (superplastificators) that are added when preparing the grouting mixture should increase the flowability of the mixture and contribute to decreasing its shrinkage. Only additive possessing the quality delineated in standard (MKS)U.M1.035 can be used for preparing the mixture.

4.2.4.7.2. Characteristics of the grouting mixture

The grouting mixture should have the following basic characteristics: flowability, water separation, pressure strength, shrinkage, resilience to ice. The grouting mixture should be prepared with as low as possible water-cement factor and attention should be paid to the flowability of the mixture. It is recommended that the water-cement factor is 0.38-0.43, which would contribute to the preparation of a quality grouting mixture that would satisfy the characteristics mentioned herein.
4.2.4.7.2.1. Flowability

The mixture flowability is determined by measuring the time it takes the mixture to flow through the tube of the Marsh funnel, filled to the top. The flow time of a quality mixture of cement, water, and additives should be between 15 and 20 seconds.

4.2.4.7.2.2. Change in volume

The change in volume is one of the most significant characteristics of the grouting mixture regarding quality protection of the prestressing ropes from corrosion. The change in volume is determined by cylindrical vessels with diameter of 100mm filled with mixture in height of 100 mm. In order to prevent the water from evaporating, these vessels are closed immediately after they are filled. The change in volume is measured 24 hours after the sample is prepared. The maximum shrinkage of the mixture should be 2\%, while the possible expansion should not be over 10\%.

4.2.4.7.2.3. Pressure strength

The pressure strength is the second condition that needs to be fulfilled when preparing the grouting mixture. The pressure strength needs to be tested independently from the strength of the concrete in the structure, in accordance with the standards.

The pressure strength should be tested on samples after 28 days and the average value of the three samples should fulfill the minimum and maximum values, i.e. the minimum pressure strength should be fulfilled. Three samples are taken for each part of the grouting; random samples are taken from the opening of the cable being grouted.

4.2.4.7.2.4. Resilience to ice

Resilience to ice is the next factor that should be fulfilled. This should be tested and proved by two samples at least. The volume must not increase during the testing. If the mixture contains minimum of 3\% air pores and has a water-cement factor lower than 0.4, the ice resilience factor is considered to be fulfilled i.e. the mixture is resilient to ice M-100.

The preparation and grouting of the concrete mass should not be performed at temperatures below 5\(^\circ\)C.

For all other types of mixture, the ice resilience should be tested in accordance with recommended testing.

4.2.4.7.3. Preparation and incorporation of the grouting mixture

4.2.4.7.3.1. Cable check

Before starting with the grouting process, the cables need to be checked for penetrability of the mixture. This is performed by using compressed air. If removal of corrosion or dirt is required, the cables should be washed with water. The washing is done with water that fulfills the criteria for quality of water required for preparing the mixture.
If there is a blockage that could prevent complete grouting of the cables, it is obligatory to remove the blockage by using compressed air. If that doesn’t work, an opening is drilled next to the cable in the vicinity of the blockage and the grouting is performed through that opening in the usual manner.

4.2.4.7.3.2 Preparation of the grouting mixture

The connecting of the pump to the cable anchors is done through tubes and special caps that are fixated onto the anchors. All openings that could let out the concrete mass should be tightly closed, especially between the anchor and the metal panel. All mixture components should be precisely defined in terms of weight. The mixture is sieved through a sieve of 2mm before it is grouted into the cables.

The temperature of the mixture must not go above 30°C. The grouting should last until the cables are completely full and clean mixture starts coming out of the exit side. The opening is then closed with dry cement or special metal caps. The entrance is closed with dry concrete mass after the grouting cap is removed. The grouting process of the cables must not be interrupted. In case of a standstill longer than 10 minutes, the cable must be immediately washed with pressurized water and the penetrability of the cable must be checked by using compressed air.

Even though the grouting process is not a very big part of the structure creation, it is still a very important element for the longevity and quality of the structure and is therefore very important to secure good quality of the mixture and its proper incorporation.

4.2.4.8 Assembly of the main girders

The assembly of the main girders can begin after all previous construction works are completed up to the placement of the neoprene bearings to the projected position.

The assembly of the main girders shall be done at the precisely defined spots and it shall be done by steel pipes for lifting that will be placed at the ends of the main girder with diameter of Φ100mm, stated in the plan for the formwork and the reinforced part of the main girder. The assembly will be done by auto cranes, after the girders are casted on site i.e. at the river bed elevation. It is projected that 10 main girders shall be casted on each side of the river bed.

It is extremely important to adhere to the limitations of the weather conditions (strong side wind) with regard to the safety of the assembly process.

When assembling the main girders the Contractor needs to secure immobility of the bearings that are not fixated to the substructure. The Contractor also needs to secure temporary support of the main girders to the definite formation of the superstructure (cross girders and slab).

4.2.5 Construction of a pavement slab

4.2.5.1 General

This design projects the construction of a reinforced concrete slab that serves for monolithization of the superstructure. The pavement slab ends with a parapet beam on both sides, on whose outer side the façade elements are assembled. It is necessary to place anchors into the parapet beam prior to concreting in accordance with the provided design schedule.

The Contractor shall adhere to the conditions provided in this technical description, as well as to the general conditions for executing concrete and reinforced concrete works, in accordance with PBAB 87.

The construction of this item requires mobile working platforms for the movement of workers and equipment for all technological processes, concreting, reinforcing and executing of
formwork, for the successful and smooth execution of the works.

The Contractor should also study the guardrail details and undertake the required measures for the execution of this item.

4.2.5.3. Execution of Formwork

The formwork design should secure forming the projected volume intended for the formwork.

Attention was paid when selecting the dimensions of the main girders that a minimum of formwork be used when concreting the pavement slab, i.e. the top section of the main girders serves as formwork for the construction of the console section of the pavement slab.

4.2.5.4. Reinforcement

It is projected to execute the reinforcement with a ribbed reinforcement in the standard manner.

It is necessary to provide work platforms for movement of the workers working on the reinforcement.

It is necessary to study the reinforcement details and provide spacers for placing the reinforcement in the projected position.

In order to maintain the projected position, it is necessary to undertake measures for inter-connecting the reinforcement rods and stirrups from the main girders, while having into consideration the strong vibrations of the fresh concrete mass.

4.2.5.5. Concreting

The embedding of fresh concrete is performed with a concrete pump, if possible. The consistency of the fresh concrete mass needs to be adjusted to the projected embedding process.

In order to secure continuity of the reinforced concrete slab, it is necessary to define the start and end of the binding process in accordance with the time required for embedding and compacting. The width of the projected area for embedding and the time needed for delivery of the fresh concrete mass must also be taken into consideration.

When projecting the consistency of the fresh concrete mass, the Contractor needs to keep in mind the longitudinal and crosswise slope of the finishing surface.

The longitudinal and crosswise slope have to be considered during the selection of the start and end of the concreting process.

It is recommended to use a vibrating lath for compacting the fresh concrete mass.

The concreting is executed in clean formwork prepared for placement of fresh concrete.

8 - 16 hours after the concreting, it is necessary for the work joints to be processed by removing the cement milk and unbound aggregate bits.

The execution of the section that will be additionally concreted after the placement of the prefabricated elements should be done with concrete MB-40 and special characteristics as the prefabricated girders concrete.

4.2.6 Construction of reinforced concrete cross girders

4.2.6.1. General
This design projects abutment cross girders over each pillar of the structure.

During the construction of these cross girders, the Contractor needs to keep in consideration the already constructed parapet over the abutments. The cross girders are projected in such a way that their height allows for the incorporation of compresses as an exchange for the bearings.

The cross girders over the pillar serve for forming a joint connection between the main girders and the pillar.

The Contractor needs to harmonize the phases of concreting, cross girder and slab in the area between the cross girder and the parapet with the way of executing the formwork.

4.2.6.2. Scaffolding

For the execution of this item it is necessary to only form a working platform for movement of the workers and the equipment.

A classic scaffolding harmonized with the construction of the abutments is also possible.

4.2.6.3. Execution of formwork

The formwork design should ensure the projected volume of the cross girder.

The formwork design should be in accordance with the drawings provided with the design, as well as in accordance with the envisaged manner of doing the scaffolding.

The formwork design should enable easy assembly and disassembly of the formwork.

It is recommended that the side stability is achieved by inter-connecting the side formwork.

The vertical stability can be ensured in accordance with the projected scaffold, so as to ensure an easy disassembly of the formwork.

It is recommended that the contact between the formwork and the concrete is closed by a profiled rubber with an adequate cross section.

The formwork is cleaned and coated after being disassembled.

4.2.6.4. Reinforcement

It is projected to execute the reinforcement with a ribbed reinforcement in the standard manner. It is necessary to provide working platforms for movement of the workers working on the reinforcement.

It is necessary to study the reinforcement details and to provide spacers for placing the reinforcement into the projected formwork.

Prior to the assembly of the reinforcement, it is necessary to properly place all reinforcement rods incorporated in the main girders needed for the cross girder.

The reinforcement is basically done by adding the placed reinforcements in the main girders and filling the cross section with stirrups.

Measures are required to inter-connect the reinforcement rods and stirrups in order to maintain the projected position, while keeping in consideration the strong vibrations of the fresh concrete mass.

4.2.6.5. Concreting

As a technological process, the concreting is executed on site.

The embedding of the fresh concrete can be executed by a concrete pump placed over
a completed slab. The embedding is performed in layers of 30-50 cm, as it shall be defined in the Concrete Design.

The consistency of the fresh concrete mass should be adjusted to the projected manner of embedding for the projected width and height of the cross girders.

According to the envisaged embedding speed, the beginning and end of the binding process for the fresh concrete should be defined.

The compacting can be executed by pin vibrators. The vibrating duration is defined according to the projected manner of embedding.

The concreting is executed in clean formwork after removing all waste from previously completed works.

The Concrete Design should harmonize the time required to achieve the needed strength and the time for disassembling of the formwork.

It is necessary to have adequate treatment of the work joints and of the contact between the old and the new concrete.

After completing the preparations for processing the contact surfaces and after the completed concreting process of the main girders and the slab, the Contractor is recommended to apply additional measures for improving the contact (a “U” connection, for example).

5 Other works

5.1 Bearings

The design envisages elastomer bearings for the main girders above the abutments and the pillars.

The limited mobility bearings are the adopted type of elastomer bearings above the abutments, which are easy to construct, and during exploitation they allow easy control of the functioning, as well as easy replacement.

The assembly of the bearings on the horizontal parts of the supporting surfaces should be performed right before assembling the main girders.

If the supporting areas of the pillars and main girders do not provide even connection to the bearings, they should be corrected, i.e. a proper material should be casted over, so that a perfectly even and horizontal surface is achieved for supporting the bearings above the pillars and the superstructure above the pillars and the abutments.

According to the provided static calculation, and depending on the maximum and minimum reaction, as well as the dislocation affecting a bearing, the dimensions for the elastomer bearings are adopted as 200/400/63 for the abutments and the pillars. These bearings should have all characteristics delineated in the DIN norms.

5.2 Extension joints

For the purpose of smooth extension of the superstructure, over the abutments, extension joints have been projected along the entire width of the structure.

Extension joints type T-100 have been adopted for use according to the static calculations, the conditions and length of the structure.

During the incorporation of the extension joints, special attention must be paid to the average daily temperatures, or the maximum and minimum temperature expected during the use
of the structure.

The most important and most sensitive task is to properly and professionally incorporate the extension joint. The proper functioning and duration of functioning of the extension joint depend on this.

The incorporation of the extension joint should be executed completely in accordance with the instructions from the manufacturer. The extension joint is delivered prepared for incorporation at medium temperature of +10°C. If the extension joint is being incorporated at another temperature, then the designer should be asked for data regarding the extension joint opening for the suitable incorporation temperature and the accumulation and leakage of concrete into the girders and pavement slab at those temperatures should be taken into consideration as well.

5.3 Protection of concrete surfaces

This design envisages the following types of protection for the concrete surfaces.

5.3.1 Waterproofing of the pavement slab

The waterproofing is executed crosswise between the reinforced concrete parapet beams and lengthwise between the extension joints.

a) Base preparation

The pavement slab is the base for the waterproofing. Its top surface should be perfectly smooth, dry and clean before applying the waterproofing. Prior to applying the waterproofing, the base is handed over to an authorized professional of the Investor.

b) Execution

The execution can be performed with a cold or warm procedure. The Manufacturer prescribes the procedure for the execution. Waterproofing from polymerized bituminized straps are recommended. The waterproofing should possess certain physical and mechanical characteristics, such as:

1. Strength
2. Waterproof
3. Resilience to ice and other influences
4. Consistency to heat
5. Relative lengthening and shortening, etc.

The Contractor should pay special attention when waterproofing the drains. The Contractor should possess proper references and ensure proper way of control.

5.3.2 Protection of concrete surfaces in contact with soil

The protection for these surfaces should be done at the foundations, abutments and wing walls and pillars to ground elevation.

It is recommended to use modern agents, such as cement-based elastic proofing, or proofing that is easily applicable on the surface and has longer longevity, as well as proofing that does not require a perfectly dry base, in addition to the mentioned herein above.

5.3.3 Protection of concrete surface in contact with the atmosphere
The protection of these surfaces should be done at around 1.0 m above the terrain surface at the abutments and pillars. It is recommended to apply proper cement-base waterproofing in order to maintain the natural color of the cement.

5.4 Asphalt – concrete pavement

The asphalt pavement with thickness of \(d=6.0\) cm should be placed above the waterproofing. The embedding of the asphalt-concrete should be executed over the entire surface with no work joints lengthwise. Special attention should be paid to the height regulation of the invert level, the quality of the mixture and the embedding, as well as the processing around the extension joints and drains, in order to avoid possible unevenness that would increase the dynamic influences of the movable load.

5.5 Guardrail system

An elastic guardrail should be constructed along the overpass, including the wing walls on both sides of the structure, in accordance with details provided in the design. Proper anchors should be placed before concreting the parapet beam that would enable the simple assembly of pillars for the combined pedestrian guardrail.

The guardrail continues over the wing walls of the structure with extensions at the extensions of the structure.

6. Criteria for evaluating the quality of construction

The criteria for evaluating the quality of construction is based on the precision of the executed assembly, and within the dimensions provided in this design.

It is suggested that the Investor tolerates discrepancies in the measurements of \(+10\) mm from the measurements projected in this design, with regard to all three basic directions, lengthwise and crosswise horizontally and height wise vertically.

7. Regular maintenance of the structure and test load

In accordance with article 287-PBAB 87, the design defines the time interval for the control inspections of the structure during exploitation.

Fixed points are placed on both sides of the structure in order to follow possible irregularities, and they are placed above each pillar and in the middle of each field of the bridge structure.

In accordance with valid regulations and standards MKS U.M1.0.46, a test load is required prior to commencement of the structure exploitation.

The test load should be performed by an organization authorized for this type of works.

8. Hydrotechnical measures

The executed design hydrological calculations and analysis, large water was concluded at bridge profile \(Q_{100}=500\) (m\(^3\)/s).

The executed hydraulic analysis of the current state and received flow parameters before and after the bridge location, it was concluded that the calculated waters do not put the bridge slab into any danger of flooding, and that it is not necessary to elevate the bridge structure.
or the road invert level including the access ramps and abutments. It was also concluded that it is
not possible to protect the bridge foundations from erosion only by applying counter-erosion
measures due to the flow speed in the openings under the bridge, but it is necessary to additionally
expand the river bed that would decrease the upstream water level and bring the speed into
acceptable limits.

The technical solution projected for the bridge protection comprises a group of measures the
purpose of which is to prevent the occurrence of erosion due to the narrowing which the bridge
structure represents in the Bregalnica river floodplain, the local obstacles in the river bed at the
location of the pillars and the abutments as well as the possible meandering and change of the
mainstream in the space available between the bridge elements.

It is projected to extend the main river bed and even the flooded banks in the width of
the abutments. The length of extending the river bed is 15 m upstream and 25 m downstream from
the horizontal alignment of the road along the bridge, or 10 m upstream and 20 m downstream
from the pilot caps where they’re founded. The extension of the main river bed is executed in order
to increase the flowability power of the bed, to decrease the flow depth and the occurring speed.

The extension of the main river bed is limited by the pillars in the flooded strip. The
width of the newly projected river bed is 41 m at bottom and depth of 1.45 m. The connection of
the main river bed with the flooded plain is through slopes with inclination of H:V=1.5:1. The
longitudinal slope of the regulated section is So=0.16 % selected so it best suites the existing state
at the bottom. The cross section slope at this part is fixated with an upstream and downstream
concrete sill.

The upstream concrete sill is with width of 1.0 m and height of 1.5 m, for securing its
static stability the sill is extended for 1.5 m outside the slope of the bed. The downstream sill has
the same dimensions and its function is to fixate the invert level and secure the scattered stone
from scattering upstream.

In this way, the newly formed river bed is protected from erosion in the bottom with
scattered stone from the old bridge with dmin=300 mm and thickness of the layer t_dk=600 mm,
around the pillar placed in the river bed it is projected that this layer of crushed stone is executed
with dmin=400 mm and thickness of the layer t_ds=800 mm. This reinforcement is projected at a
location with width of 3.5 m around the pilot cap on which the pillar is founded. The bed slopes
should also be layered with scattered stone with dimensions and thickness as the bottom, around
the pilot cap where the pillar is founded. The slopes should also be covered with scattered rock with
the same dimensions as at the river bottom, since it will enable the rock to lay onto the slopes, no
additional enforcement is projected. It is also projected to dig out and level the flooded bed area
between the two abutments in length as the envisaged regulation.

Outside of the projected section for regulating, the main river bed is connected to the
existing river bed. The connection between chainages 0+000 and 0+044 and 0+084 and 0+124 it is
intended to level the surrounding terrain and form flooding areas according to the details provided
in the graphic drawings that will improve the flow conditions towards the bridge and from the
bridge.

It is intended to grow grass on this section and regularly maintain it in order to prevent
the occurrence of high vegetation.

9. Geotechnical drawings

9.1 On-site investigations

In order to present the location in more detail, the following on-site investigations are performed:
- Execution of investigative boreholes;
- SPT - Standard penetration;
- Mapping the investigative borehole material;
- Taking an optimal number of semi-deformed and deformed samples.

The on-site investigations are performed during March 2015. The drilling is performed with machine type GTR 150, using the rotational approach. The probe drilling is geomechanically executed, by “dry” drilling with 100% core sampling and proper taking of deformed probes. The core of the borehole probes is properly placed in cases and geomechanically mapped on site. The semi-deformed and deformed representative samples are taken selectively and they are packaged in nylon bags. The representative probes are transported to the laboratory for further testing. The data for each individual borehole, the type, number, and depth of the taken probes is shown in Table 1 Overview of investigative boreholes.

<table>
<thead>
<tr>
<th>No of boreholes</th>
<th>Drilling depth (m)</th>
<th>Drilling interval</th>
<th>PPV</th>
<th>NPV</th>
<th>Deformed</th>
<th>Semi-deformed</th>
<th>Not deformed</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-1</td>
<td>15.00</td>
<td>0.00÷3.00</td>
<td>5.10</td>
<td>5.00</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.00÷4.80</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.80÷8.40</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.40÷15.00</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BH-2</td>
<td>15.00</td>
<td>0.00÷1.00</td>
<td>5.10</td>
<td>0.80</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.00÷1.90</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.90÷9.00</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.00÷15.00</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

During the investigative drilling, standard dynamic penetration investigations (SPT test) are performed in order to evaluate the base quality in relation to density. The penetration is performed with a cone or a cylinder (cone in this instance), which is thrusted with a weight of 0.635 kN from a height of 76.30 cm up to the penetration of the cone at 30.4 cm. For the instances when the standard thrusting is not achieved at 30.4 cm, the number of thrusts is determined according to the formula:

\[ N' = 30.4 \times \frac{N'}{e} \]

\(e\) – depth of cone penetration

For the instances when a cone is used instead of a cylinder, the number of thrusts (N) is corrected by a 0.7 coefficient, so:

\[ N'' = 0.7 \times N' \]

If the corrected number of thrusts is \(N'' > 15\), the probing is under the underground water level and the material is small granular sand, an additional correction to the number of thrusts is done according to the Terzaghi and Peck formula:

\[ N''' = 15 + 0.5 \times (N' - 15) \]

The suppression module for the incoherent materials is determined by the standard dynamic penetration (SPT) investigations.
The suppression module $M_v$ is calculated by the Suklje formula:

\[
M_v = (c_1 + c_2 \times N_{def}) \ [kN/m^2]
\]

- $2000 < C_1 < 3000,400 < C_2 < 600$ (for coherent ground)
- $3000 < C_1 < 4000,600 < C_2 < 800$ (for incoherent ground)

The basic data from the standard investigations of dynamic penetration are shown in Error! Reference source not found.

### Table

<table>
<thead>
<tr>
<th>Borehole</th>
<th>Depth (m)</th>
<th>Geomechanic mark</th>
<th>Cone penetration (cm)</th>
<th>Number of thrusts</th>
<th>Corrected number of thrusts</th>
<th>Density / consistency</th>
<th>Suppression module $M_v$ (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-1</td>
<td>5.100-5.404</td>
<td>GP</td>
<td>30.4</td>
<td>18</td>
<td>18</td>
<td>13</td>
<td>12600</td>
</tr>
<tr>
<td>BH-1</td>
<td>11.500-11.804</td>
<td>SW</td>
<td>30.4</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>8400</td>
</tr>
<tr>
<td>BH-2</td>
<td>2.000-2.304</td>
<td>GP</td>
<td>30.4</td>
<td>13</td>
<td>13</td>
<td>9</td>
<td>9800</td>
</tr>
<tr>
<td>BH-2</td>
<td>5.000-5.304</td>
<td>GP</td>
<td>30.4</td>
<td>11</td>
<td>11</td>
<td>8</td>
<td>9100</td>
</tr>
<tr>
<td>BH-2</td>
<td>10.500-10.804</td>
<td>GP</td>
<td>30.4</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>8400</td>
</tr>
</tbody>
</table>

It can be concluded from the received results of the standard dynamic penetration test (SPT-test) that it is a case of loose materials, with low level of density.

### Geotechnical profile of the location

In order to determine the geomechanical characteristics of the materials found at the investigated location, an appropriate number of geomechanical tests and investigations are performed that define all geomechanic characteristics of the terrain within the required level.

The geomechanical characteristics of the terrain are defined on the basis of the results from the investigative on-site works and laboratory tests.

The physical and mechanical characteristics of each of the present materials are provided below.

- **GW (SG)** – Gravel, sandy, well graded, light-brown color.
  - $\omega = 4.06 \div 5.53 \%$ - natural humidity
  - $\rho = 2.218 \text{ Mg/m}^3$ - volume weight
  - $\rho_d = 2.074 \text{ Mg/m}^3$ - dry volume weight
  - $\varphi = 39.05^\circ$ - inside friction angle
  - $c = 0.00 \text{ kPa}$ - cohesion
  - $M_v = 8609 \text{ kPa}$ - compressibility module
- **MI/SFs (SD)** – Dust, sandy, argillaceous, dark-brown color
  - $\omega = 23.06 \%$ - natural humidity
  - $\rho = 1.902 \text{ Mg/m}^3$ - volume weight
  - $\rho_d = 1.545 \text{ Mg/m}^3$ - dry volume weight
- **GP (SG)** – Gravel, sandy, poorly graded, medium density, grey-brown color
  - $\omega = 3.89 \div 7.76 \%$ - natural humidity
  - $\rho = 2.266 \text{ Mg/m}^3$ - volume weight
  - $\rho_d = 2.102 \text{ Mg/m}^3$ - dry volume weight
\[ \varphi = 35.92^\circ \] - inside friction angle
\[ c = 0.00 \, kPa \] - cohesion
- SW (S) – Sand, well graded, fine, dark-brown color
\[ \omega = 13.97 \pm 17.89 \% \] - natural humidity
\[ \rho = 2.109 \, Mg/m^3 \] - volume weight
\[ \rho_d = 1.789 \, Mg/m^3 \] - dry volume weight
\[ \varphi = 36.68^\circ \] - inside friction angle
\[ c = 5.00 \, kPa \] - cohesion

During the investigative on-site works there is an occurrence of underground water in the boreholes. In borehole BH-1 the occurrence of underground water is registered at depth of 5.10 m below the terrain surface with underground water level ≈ 5.0 m measured from absolute elevation of the terrain. In borehole BH-2 the occurrence of underground water is registered at depth of 1.10 m below the terrain surface with underground water level≈ 0.80 m, i.e. the underground water level is registered at elevation 322.20m. 322.20 мнв. These measurements were made in March.

**Geological characteristics of the wider environment and investigated location**

The investigated location for the bridge on the Bregalnica River from a geological point of view is represented in quaternary sediments: lower river terrace (t1) and alluvial sediments (al). In the vicinity of the Bregalnica River there is lower river terrace to a height of 4 ÷ 10 meters along the river flow. The lower river terrace is mostly built from gravel, sand, dust and clay. Alluvial sediments (al) are present in the vicinity of the river. The alluvial sediments are mostly present at the investigated location for rehabilitation of the bridge and they comprise of gravel, sand and sand dust. The geological investigations confirmed the following layers: sand gravel - SG, sand dust SD and sand S.

From a hydro-geological aspect, the sandy gravel and sand represent hydro-geological collectors with grain porosity and high permeability. Due to the high permeability in the vicinity of the Bregalnica River, river erosion can be expected due to the infiltration of underground water.

On the other hand, sand dust represents a relative hydro-geological collector with medium permeability.

**Selecting a founding horizon**

The founding depth shall depend on the limitations of the designer’s requirements. In this case, the calculations for the allowed load capacity of the base are performed for a founding depth of \( t \approx 2.00 \div 3.00 \) m from elevation of performed investigations in an alluvial sediment zone that would be around 321 m for shallow founding, while the founding zone for deep founding is in the same geotechnical conditions, but depends on the structure selection.

**Excavating conditions**

The location envisaged for the construction of the bridge is on flat terrain and is easily accessible for heavy construction machinery with insignificant and small adjustments of the access roads.

The on-site investigative works detected alluvial sediments of sand and gravel at the location.

**Table no.5 Excavation categorization in accordance with GN-200**

<table>
<thead>
<tr>
<th>Zone</th>
<th>GN200 (category)</th>
<th>Excavating conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial sediments</td>
<td>III</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

**Protection and draining of the construction pit**
The Contractor is obliged to care for the excavation stability in accordance with standard procedures determined by relevant technical regulations. Due to the presence of incoherent materials at the location under consideration, there is a danger of grinding of the slopes of the construction pit. Due to the danger of grinding and high levels of underground water, it is recommended to prepare a Technical solution for protection and draining of the construction pit.

Conclusions and recommendations

Based on the results from the performed geomechanical investigations and testing and based on performed calculations and analysis, the following assertions, conclusions and recommendations can be stated:

- The scope of the performed investigative works, (2) two investigative boreholes at the site, with total depth of 30.00 m', sufficiently define the lithological composition and the physical and mechanical characteristics of the terrain;
- The laboratory testing is performed in accordance with current standards MKTC CEN ISO/TS. The results received are within the expected limits for this type of materials;
- During the investigative on-site work – March 2015, the occurrence and level of underground water is noted. The level of underground water is registered at elevation 322.20 m;
- The maximum and allowed capacity for the natural foundation ground is calculated using a strap foundation and a single pile, according to the Terzaghi method;
- The founding depth shall depend on the limitations arising from the Designer’s requirements. In this case, the calculations for the allowed load capacity of the base were performed for a founding depth \( t = 2.00\div3.00 \text{ m} \) at elevation of performed investigations in an alluvial sediment zone that would be at height of approximately 321 m for shallow founding, while for deep founding the founding zone is in the same geotechnical conditions but depends on the structure selection;
- This data is valid only for the location, conditions, dimensions, and assumptions that are the subject of this document;
- If any differences to the expected terrain composition occur during the construction phase, all issues should be resolved in coordination between the Investor, Contractor, Designer, Supervisor, and Reviewer/Consultant, if needed.

10. Geodetic drawings

An on-site geodetic survey was performed in April 2015 with the purpose of preparing a Technical documentation for the construction of a new bridge on the Bregalnica River on the regional road P1309, Section: Kochani – Zrnovci at \( km. 4 + 336.00 \).

Traverse points are stabilized on site in order to perform all geodetic measurements. These traverse points are properly marked in red color and positioned outside of the scope of works. The measurements done in a traverse net are performed with GPS Trimble R4 Juno with horizontal accuracy of \( \pm 5\text{mm} + 0.5ppm \) RMS and vertical accuracy of \( \pm 5\text{mm} + 1ppm \). When placing the traverse points, parameters are used from the Agency for real estate cadaster, valid for the Kochani area, in order to achieve the required accuracy.

The on-site geodetic survey is done with a total station Trimble M3 with angle accuracy of 3” and length accuracy of \( \pm (2\text{mm} + 2ppm) \), GPS Trimble R4 Juno with stated accuracy and GPS Trimble R4 with horizontal accuracy of \( \pm 5\text{mm} + 0.5ppm \) RMS and vertical accuracy of \( \pm 5\text{mm} + 1ppm \). The
recorded data are digitally processed.
The survey encompasses the road, the bridge with all its elements, the surrounding terrain, and all significant and characteristic details of the surroundings. A geodetic survey is also performed of the cross-sections in the river with a boat, at a distance of approximately 30m between the cross-sections on both sides of the bridge, with the purpose of preparing a real digital model of the river bed.

**Table** Traverse points coordinates

<table>
<thead>
<tr>
<th>Point no.</th>
<th>Y (m)</th>
<th>X (m)</th>
<th>Z (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7619236.818</td>
<td>4637255.605</td>
<td>327.103</td>
</tr>
<tr>
<td>2</td>
<td>7619360.288</td>
<td>4637200.759</td>
<td>326.063</td>
</tr>
</tbody>
</table>

The stabilization of the traverse net points is performed with metal bolts.