CASE STUDY

HARAKAS BRIDGE

K.LIAROMATIS

STRUCTURAL STEELWORK

DESCRIPTION

The contract was signed at the end of 2013 with regard to the operational rehabilitation - security on the provincial road Nr.25 Argostoli - Fiskardo of Kefalonia, in the area of Harakas, in order to restore part of it, which had subsided due to a tectonic fault, leaving it only with one traffic lane.

Due to the geomorphology of this area, with increased chances of unstable and landslides combined with high steep slopes and intense seismicity, the construction of a composite bridge of a 82.00m beams was made, thus bypassing the fall of the area and freeing up additional works backing. It was also considered to fit harmoniously in the relief of the area without particular aesthetic effects reducing the same time considerably the required construction time.

For the construction of the bridge, full space was required, and additional space before and after the bridge to prepare the construction. The width of the deck is 13,80m, consisting of a traffic zone width of 10,00m wide, sidewalks of 1,9m with a safety guardrail.

The basic principle of the construction methodology is that the main beams are divided into ten sub-sections, while the outermost beams are divided into three. For purely practical reasons the construction of the bridge started from the A2 hillside which is located in zone III and finished at the A1 hillside which is located in Zone II.

Both ends of the bridge were fitted with «two-way» joints with a minimum travel capacity of 180mm length and 85mm across the deck. The circulating zone was formed by sealing membrane 5-19cm variable gradient concrete and two asphalt layers of 9mm thickness simply supported.

TECHNICAL SPECIFICATIONS

The project is designed to withstand earthquakes with an increased seismic acceleration coefficient of 0.45g as Kefallonia is one of the most seismic regions of Greece, including a maximum seismic coefficient of 0.36g in the Antiseismic Regulation.

It was built as simply supported bridge because it bridges the area of the active rupture of Ag. Euphemia. Due to the widening of the fault after the earthquakes in 2014, the bridge's abutments were shifted, while for the reduction of seismic forces and movements it was insulated through four simple spherical slide bearings, allowing horizontal movement of up to 0.5m, providing the greatest possible safety of movement round Northern Kefalonia.

On the 13,80m wide deck there are two traffic sectors of 5,00m width and 1,90m wide pavements with all necessary guardrails for vehicles and pedestrians.

In order to protect the road from collapsing rocks, 3.00m high hedges have been placed in length of 340m and 10.000m2 protection mat in two layers on the upstream slopes have been installed.

PROJECT DETAILS

Employer:
Region of the Ionian Islands - Regional Unity of Kefallonia

Structural design:
A. Alexopoulos– N. Loukatos & Acossiates, ADT Omega & Domi S.A

Commencement Date:
September 2013

Contractor:
J/V Ionios S.A & K. Kourtidis S.A

Project Cost:
6.980.000 Euros

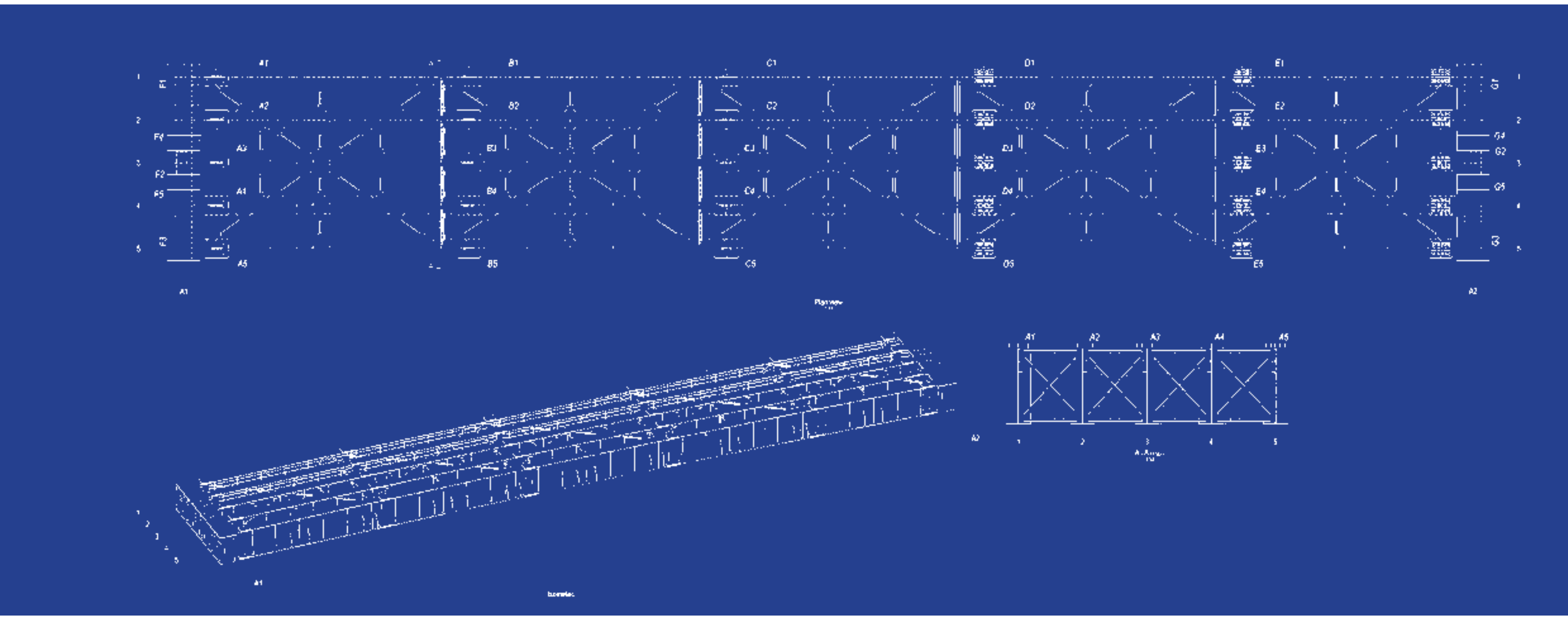
Completion Date:
June 2017

PROJECT DATA

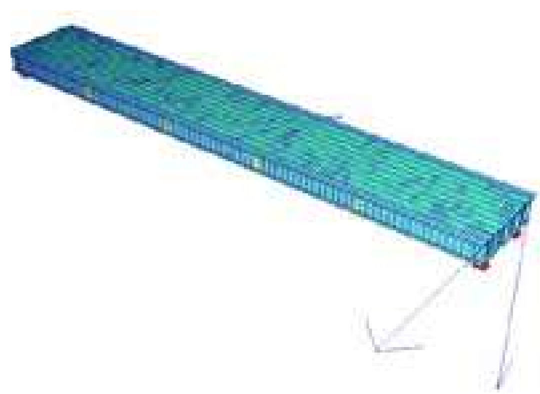
- Great attention has also been drawn to the hydraulic protection of the bridge, preventing the rainwater from falling or creating torrents causing damage. The waters, through ditches created in the mountain, are gathered and directed into a pipeline creating a peculiar bypass.
- The carrier of the bridge is divided into sub-sections welded to the manufacturing plant which are transported and assembled with locks on the spot. The limitation of the dimensions of the individual parts ensures both their smooth transportation and the requirement for smaller and more flexible forklift construction equipment.

PROJECT REQUIREMENTS

The design was carried out in accordance with Greek Instructions & Regulations, while compliance with the requirements of Eurocodes and German DIN regulations was checked. Elements covered below concerned Earthquake-planning, operational actions but also specific issues and critical controls.



- Circular MEPP for implementation
- of German DIN-Fachberichte in Greece.
- Guidelines for Road Design Studies -
- Cross sections (OEME-D, 2001).
- Guidelines for the Study of Road Works - (MUNS-Road Construction Projects - Civil Engineering Projects-2003).
- Concrete Technology Regulation (Government Gazette 317 / B / 17-4-97) and its Amendment (Government Gazette 537 / B / 1-5-02) and its Accompanying Standards.
- Steel Technology Regulation (KTX)
- and its Accompanying Standards.
- Greek Regulation of Reinforced Concrete
- (ECOS 2000).
- Greek Earthquake Regulation (EAK 2000).
- Guidelines for the Earthquake Study of Bridges
- (Circular E39-99).
- Guidelines for the Study of Seismic Insulated Bridges (OSI).



MATERIAL SPECIFICATIONS

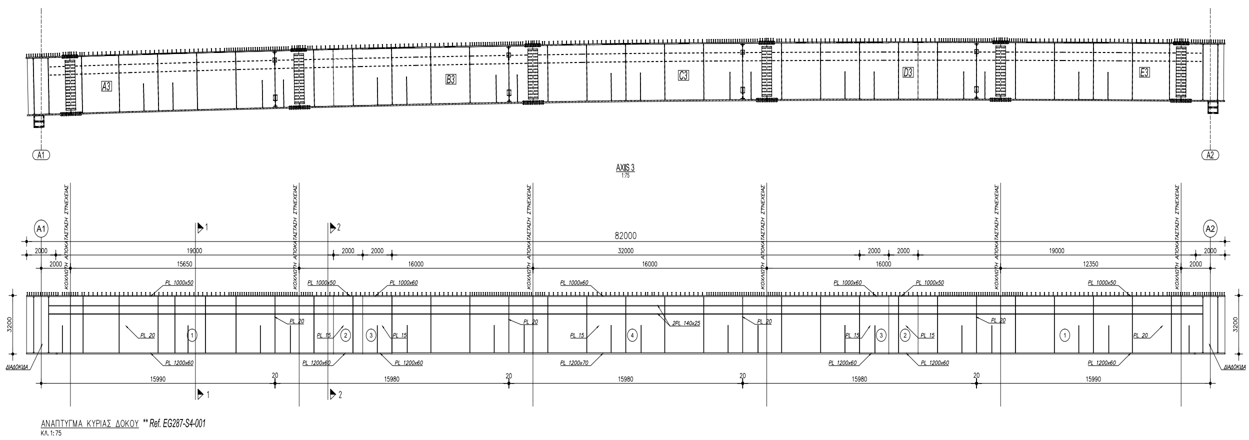
Particular attention was paid to the choice of the steelworks to supply the raw materials as the design specifications required high strength steel sheets, high thicknesses and guaranteed leakage limits.

STRUCTURAL STEEL

- Extruded sections: S 355 J2G3 & S 275 JR according to EN 10025.
- Extruded Steel Sheets: S 355 J2G3 according to EN 10025.
- Hollow sections: S 355 J263H according to EN-10210-1.
- Pre-assembled Galvanized Class GV 10.9 bolts according to EN 20898-1.
- Quality nuts 10 according to EN 20898-2.
- C 45 E Steel Flanges - Cylinders in accordance with EN 10083-1.
- Nelson F22 shears, h = 175mm, fuk = 450 N / mm2, according to DIN 32500.
- Anchors 8.8 threaded along their entire length

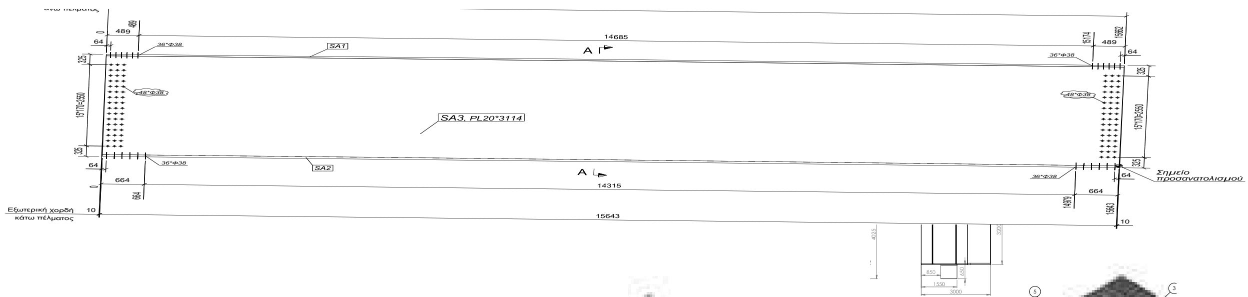
COMPOSITE DECK

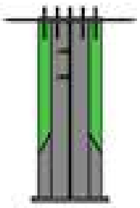
It consists of a composite cross section metal carrier and a traffic deck plate on it. It includes 5 main Twin T beams which are spaced 2660mm apart and are supported by 2 transverse beams. The upper and lower bevels of the beams have a width of 1000 and 1200mm in thicknesses of 60 and 70mm respectively while the logs are 3070mm high with a thickness of 20mm. Beams were provided with transverse and longitudinal reinforcements to prevent bending. In the upper flanges of the main beams were placed shear diameters of diameter Φ22, height 170mm and strength fuk = 450 N / mm2. The two transversal beams are supported in total at 4 points so that the carrier is simply seated. Intermediately, the carrier is supported laterally by 4 lattice beams of L sections. In addition, a horizontal cross section L is created across the entire deck for the overall stability of the carrier during the phase before the composite beam operation.

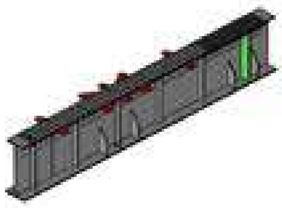


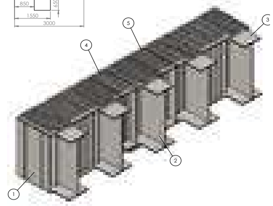
CROSS SECTIONS & SUB COMPONENTS

The beams result in two transverse beams of box-shaped form, which consist of upper and lower soles of width 2000mm and thickness 70mm. The logs of the box have a height of 3060mm and a thickness of 20mm spacing between them of 1000mm. Each beam is supported on two points and is mounted on two plain spherical plain bearings (single slip surface) of the EPS type of radius of curvature R = 2.235 m and a nominal coefficient of slip μ = 7% (± 20%). Perpendicular holes are made per 16m, which serve to stabilize the metal main beams and, above all, to secure against out-of-plane buckling during the construction phase of the bridge. These inner cross-section bars are made (upper and lower flanges, cross-sectional joints) of 2L120 x 12. In addition to the overall lateral stability of the bridge, a horizontal system of stiffeners and additional horizontal elements of 2L120 x 10 cross sections is constructed.









The bridge is supported by four ball bearings in reinforced concrete plinths, each of which is grounded in an array of 6 holes 1,20m in diameter and 15,00m deep. Its connection to the land area is made by joints with the possibility of moving up to 40cm in the longitudinal direction of the bridge.

WELDINGS

- All weldings were made on the basis of approved WPS. WPSs were made in accordance with EN ISO 15609-1: 2004. WPS reported on the WPQR certified welding method. During the welding phase, it was possible to modify it under the supervision of the welding co-ordinator.

- Welding co-ordination took place throughout the welds at the factory by mechanical welding (IIW, EWF).
- The welds were made in accordance with EN ISO 4063: 2010.
- Checkpoints determined the percent control points according to: Optical & geometrical control of edges & welding, Intrusion control with special penetrating liquids or magnetic particles, X-ray or ultrasonic inspection.

Quality Control

An integral part of the wider process of industrialization is the quality control that closely follows all the stages, aiming to achieve the correct application of the strict requirements according to ISO EN 9001 and EN 1090.

STEEL BRIDGES

Surface Treatment

All steel surfaces are protected by a paint system with a minimum life span of 15 years, suitable for Class C2 environmental conditions.

Cutting Plans

Initially, the cutting plans were created with NC files that were created automatically by the design program. This ensures that there will be no human error in programming, but indicatively are reported:

- Dimensions, type and quality of raw materials to be used.
- The corresponding pieces of the drawings that will occur.
- The machine that will take the process.
- Tips & other information to the operator.

Cutting, Drilling & Marking

The cutting and punching of the plates was carried out on a CNC pantograph. The cutting and drilling of nodal plates was carried out on a special CNC machine which carries out both stages. The cutters were cut into an automatic cutting line. All workstations also marked the traceability of each piece in terms of its design number.

Built-Up Welded Beams

After the process of preparing the individual members in the first stage, the frontal joints of the logs were placed in a boom using the method of the submerged arc to produce the final length equal to the length of the respective beam. Then the main beams were assembled and the longitudinal welding was carried out.

SandBlast

All pieces of the deck and the hangers were sandblasted in a closed blasting tunnel. All dye surfaces were prepared according to EN ISO 8501-1: 2007 equivalent to the Swedish standards: Sa 2 ½.

Assembling

The assembly was carried out on the basis of the approved designs. The components to be welded were aligned and held in place by welding. The necessary tolerances were ensured, but also that the final fitment was consistent with the dimensions regardless of further processes.

Studs

The positions of the studs were in accordance with the approved designs & requirements of EN ISO 13918: 2008. Welding's of the studs was done according to the requirements of standard EN ISO 14555: 2006 by certified welders.

Paint Coatings

The dye was made in accordance with EN ISO 12944-7: 1998 by the following procedure:
Primary primer coat: Zinc phosphate 70μm.
Intermediate layer of epoxy base - 70μm ferrous bicarbonate.
Intermediate layer of polyurethane 60μm.
Final polyurethane paint RAL 9010 - 60μm.

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