CETRA 2016

4th International Conference on Road and Rail Infrastructure
23-25 May 2016, Šibenik, Croatia

Road and Rail Infrastructure IV

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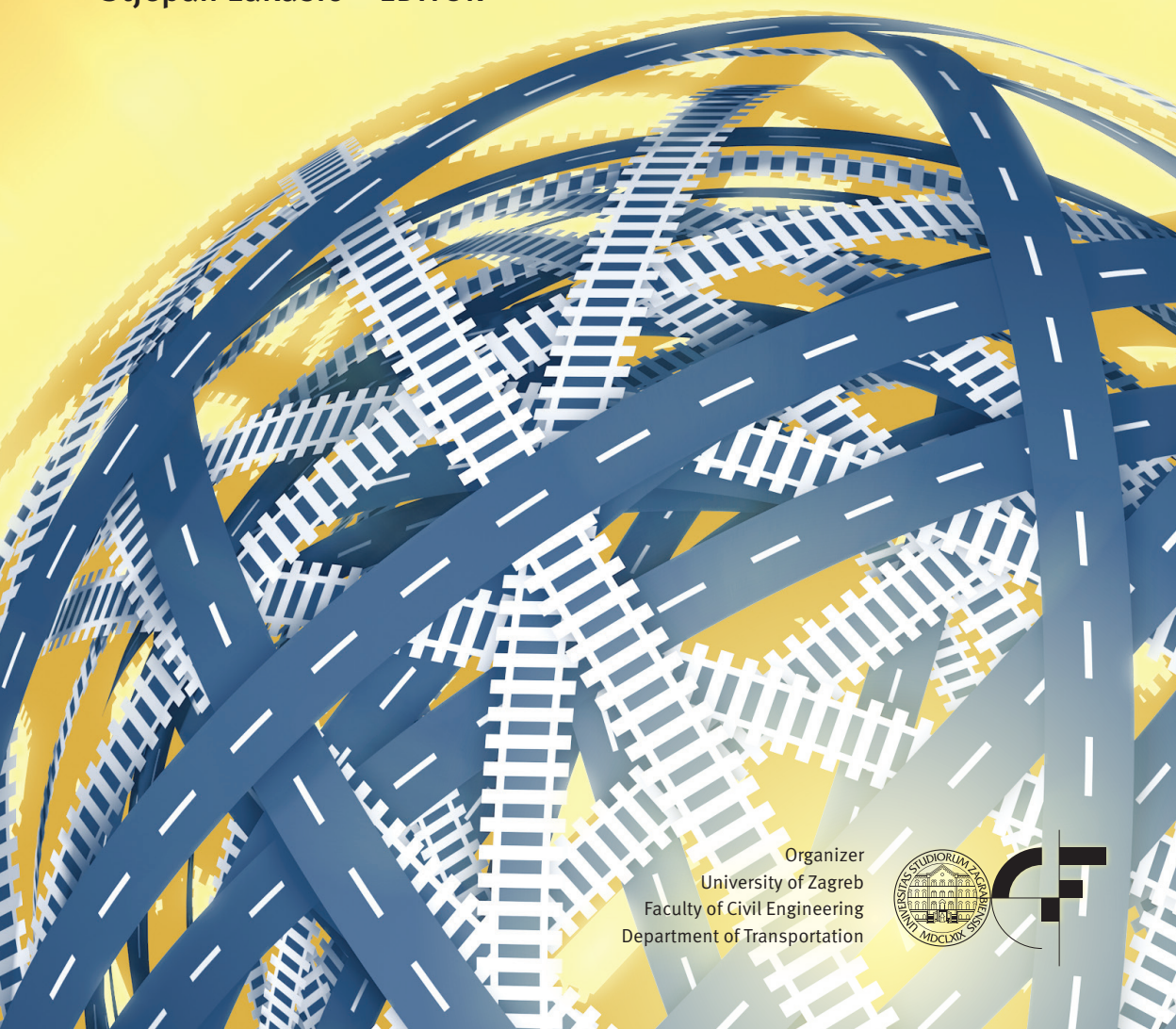

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ANALYSIS OF THE CRANE RAIL TRACKS OF BULK CARGO TERMINAL AT THE PORT OF PLOČE

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Abstract

The Port of Ploce is located on the eastern coast of the Adriatic Sea and is due to its location of great importance for the economy of Croatia and neighboring countries. Bulk cargo terminal in the port of Ploče, within which the project of crane tracks is included, is a part of a broader project development of the port of Ploče and the Gateway Corridor VC, which in the future should be an important connection of Middle Europe, Croatia and BiH. This paper presents an overview of the technical and construction characteristics of the chosen solutions for the crane rail tracks that are part of Bulk cargo terminal in the Port of Ploče.

Keywords: crane rail track, Port of Ploče, crane design, bulk cargo terminal

1 Introduction

Crane track structures present a special application of railway engineering that traditionally finds its place between the disciplines civil engineering and mechanical engineering. That is because the crane track is strongly related to the type of crane that will use the track. Crane tracks are rail tracks on which cranes and all sorts of transhipment machines ride with wheel load of 200-1000 kN and speeds of up to 150 m/min. Those may be fully or partly embedded in the supporting structure which can exist of wooden sleepers, heavy I-beams, or a concrete foundation. The permitted tolerances for cranes in operation are of major importance and are strictly regulated [1]. The specific qualities of the crane rail track will be described on the example of the Port of Ploče.

Figure 1 The geographical position of the Port of Ploče [2]

The Port of Ploče is located on the eastern coast of the Adriatic Sea and is due to its location of great importance for the economy of neighboring countries, such as Bosnia and Herzegovina (the border is 25 km from the Port of Ploče), Serbia, Montenegro, Hungary. The geographical position of the Port of Ploče enables very good maritime connection with the cities on the

Croatian Adriatic coast, Italy, and with the ports of the entire world. The Figure 1 shows the geographical position of the Port of Ploče [2]. Subject of this article is the design and construction of crane tracks which are located at the center of the open storage area.

2 General information

Bulk cargo terminal at the port of Ploče, within which the project of crane tracks is included, is a part of a broader development project of the port of Ploče and the transport Corridor VC, which in the future should be an important connection of Central Europe to Croatia and Bosnia and Herzegovina. Part of the broader project was completed earlier, i.e. Ploče Container Terminal which was completed and commissioned during 2011. Project for construction of Ploče Bulk Cargo Terminal is financed by the government of the Republic of Croatia from the state budget and through a credit granted by the World Bank (IBRD) through the Investor, Ploče Port Authority. Work on the entry terminal of the Ploče port is also in progress and it is within the framework of the same credit facility.
Construction of the bulk cargo terminal is divided into two stages, and the Main Project envisages that infrastructure works (construction of storage and handling areas, new railway tracks and roads, deepening of the channels and the access channel, construction of a dock on steel pylons, construction of administrative building and workshop and other infrastructure works which include cable distribution, drainage and water supply) and installation of technical equipment for transshipment of 3,000,000 tons of bulk cargo, which is an obligation for the future concessionaire – Luka Ploče d.d. shall be done in the first stage. The second phase of the Port of Ploče development strategy is to increase the port capacity to about 4600000 tons of bulk cargo.

3 Characteristics of foundation and crane tracks

3.1 Geotechnical conditions

The soil at the site of the crane rails consists of soft marine sediments and is unfavorable geotechnical environment. The characteristics of the soil at the construction area were investigated through several tests. Due to poor characteristics of the soil, it was necessary to implement its stabilization [3, 4]. Figure 2 shows the layout of the part of the area covered by the Port of Ploče with designated positions of crane tracks CP-101 and CV-201.

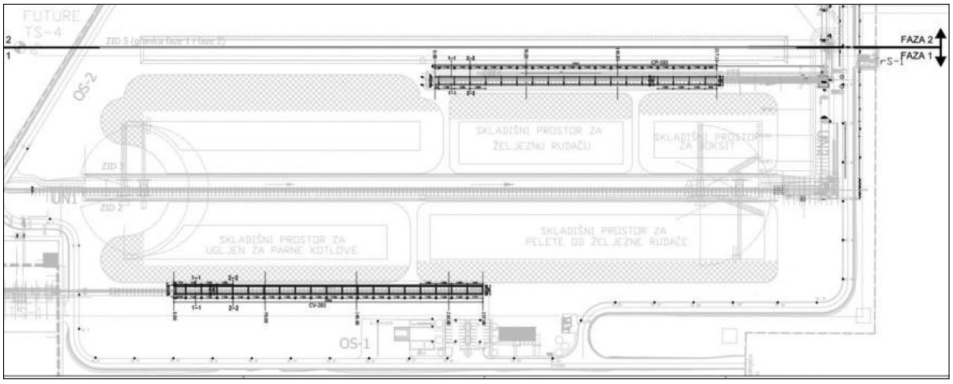

Figure 2 Layout of handling equipment

3.2 Foundation design

For two crane rail tracks, CP-101 and CV-201, concrete foundation was designed, while the foundation for crane track CV-103 was already made and the track structure was designed. Length of the crane track CV 201 is 237 m, length of the crane track CP 101 is 217.12 m and the length of the crane track CV 103 is 516 m. Figures 3 and 4 show input parameters used for the crane track design for tracks CV-103, CP-101 and CV-201.

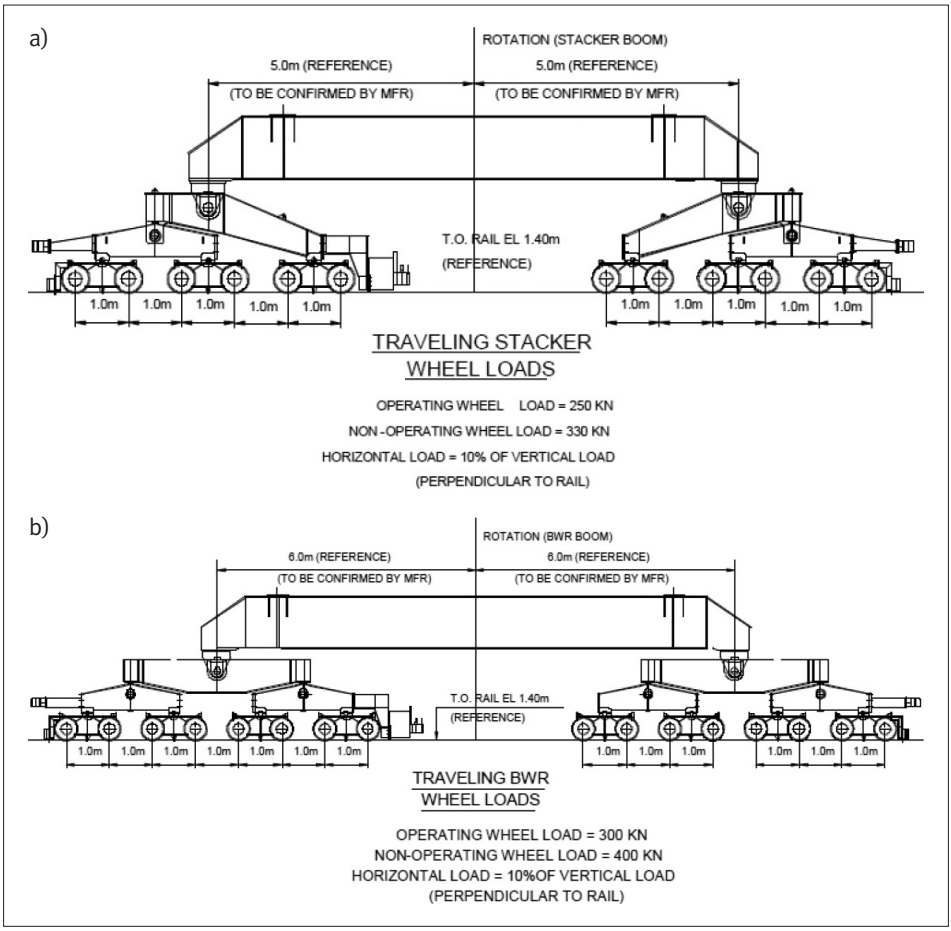

Figure 3 Load diagram on the crane track CV 103: a) Vehicle no. 1, b) Vehicle no. 2

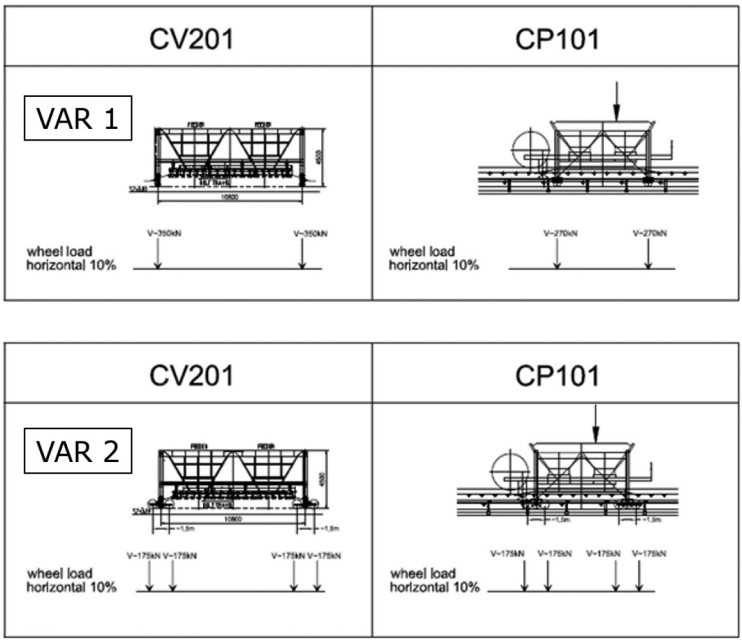

Figure 4 Load diagram for version 1 and version 2 on crane tracks CV-201 i CP-101

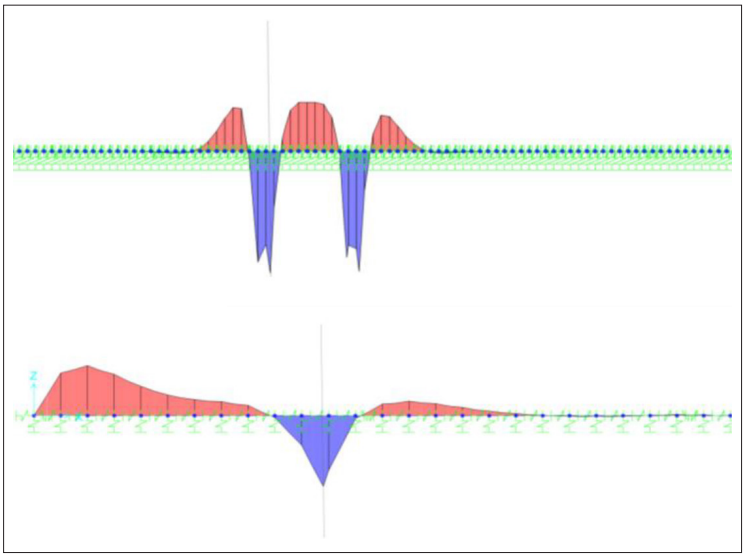

Figure 5 Moment diagrams for the crane track CV-201, SAP2000 [3]

Foundation for the crane rail tracks CP-101 and CV-201 has been sized based on these loads and the given load-bearing capacity of the base which were taken from the geotehnical project ([4]). Strip foundations of the crane tracks are made of concrete, with rectangular cross-section with a width of 90 cm and height of 60 cm, with a protective layer of concrete 5 cm thick, in accordance with the environmental conditions in the area in which the structure is located. Specified concrete class is C 30/37 and each track consists of two foundations, which

is defined by the shape of the crane (hopper) which moves along the structure. Considering the shape and spacing of the hopper wheels, axial distance between the foundations is 60 cm. Additionally, the foundations are made to act compositely by 40 x 40 cm AB beams, with an axial distance between them of 12 m, [3]. Figure 7 shows the reinforcement installed in the foundation tracks.

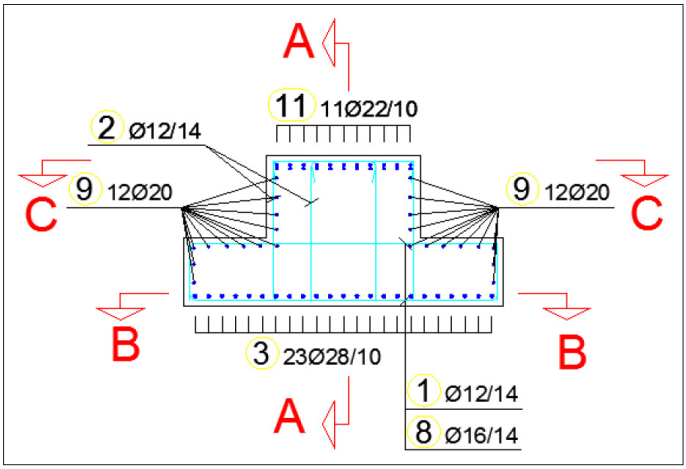

Figure 6 Cross-section of the crain track foundation with reinforcement [3]

Figure 7 Placed reinforcement of strip foundations and transversal beam

3.3 Crane track design

3.3.1 Crane tracks CP-101 and CV-201

Based on the geometry, environmental restrictions and relevant loading variants (VAR 1, VAR 2), the following parameters were designed: reinforced concrete foundation, rail, steel sole-plate, anchors, clips, elastic pads. Considering the scope of design services, for movement on the CV-201 and CP-101 crane tracks, a type A100 (74,3 kg/m') rail was chosen, which is placed on the steel plate to which it is attached by ''Gantrex'' 21/08/BK fastening clip.

Thickness, type and steel plate spacing are chosen for given crane loads and type of rail, in accordance with the characteristics of the elements of the manufacturer Gantrex. Steel plates are 2980 mm long, 20 mm thick, while the weight of these plates enables easier handling at the construction site. Steel soleplates can be continuous or intermittent depending on the requirements of the system. In this case, on the project of the Bulk cargo terminal in the Port of Ploče, according to designed loads and operating conditions, the rail is continuously supported by the steel soleplates. The continuous support is achieved by soleplates with

dimensions: 2980x372x20 mm, steel R235, while the distance between every soleplate is 20 mm, because of the possible thermal loads. Continuous soleplates are used for heavy-duty rail systems with high loads and high cycle rates.
GANTREX elastic pad with a width of 200 mm is located between the seel plate and the rail foot. Steel plate on which the tracks are positioned is connected to the AB base strip by galvanized steel screws which were precisely placed within the reinforcement cage of the strip foundation. Nuts are screwed on the steel screws on which a steel plate is placed which is tightened with a long screw, which enables accurate height adjustment of the steel plate on which the tracks will later be laid. Entire screw installation process was geodetically established and checked before and after placing the concrete in the strip foundation. Figure 8 shows a detail of CP-101 and CV-201 fastening.

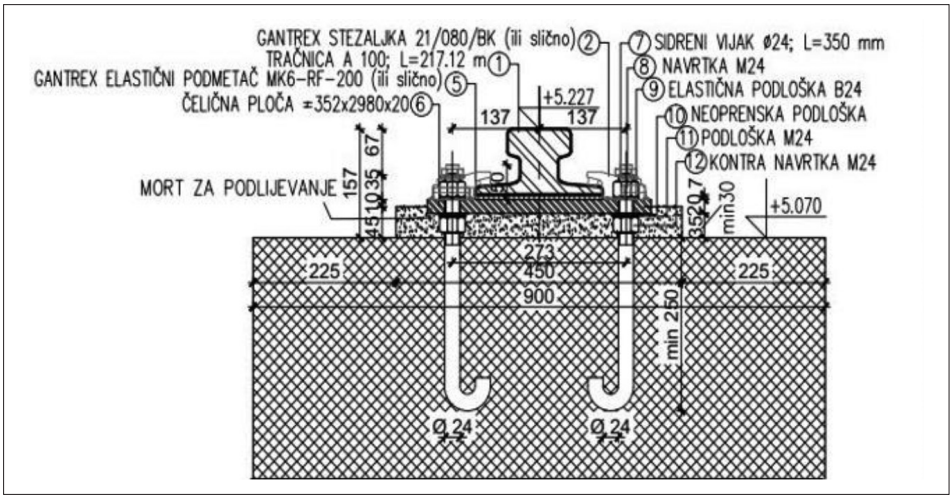

Figure 8 Fastening detail for CP-101 and CV- 201 [3]

3.3.2 Crane track CV-103

Unlike the foundations for the movement of stacker/reclaimer (CV-103) along the centre of the storage area, which is built within the scope of existing civil engineering project (the original one) for the movement of the stacker/reclaimer machine AB crane tracks of reverse "T" cross-section (Figure 9).

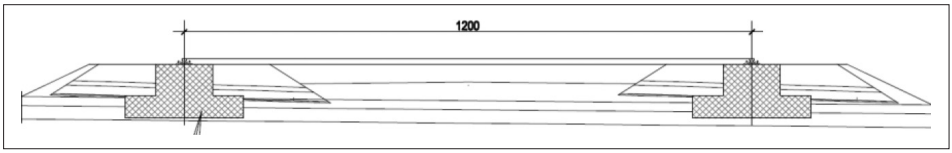

Figure 9 Layout of the crane track foundation

Considering the fact that at the time of when the main design was being elaborated, the concessionaire did not have information on the equipment which will be installed, placement of tracks for stacker/reclaimer movement was not envisaged. Due to this, anchors for rail fastening where not placed when the concrete was laid. Only after the works were performed, the concessionaire (their consultants) delivered the data for rail track calculation.
Type A120 (100,00 kg/m') rail was selected as a rail which meets the set requirements, which is placed on the steel plate to which it is fastened with the ''Gantrex'' B15/CJ fastening clip.

Between the steel plate and the rail foot there is a GANTREX elastic pad with a width of 220 mm. Since AB foundations were constructed earlier and anchoring bolts for the steel plate were not previously installed, it was necessary to drill a hole with a diameter of 32 mm for each anchor bolt, in which a galvanized steel screw with a diameter of 24 mm was installed by using the injection cement mortar.
Considering the very large loads and consequently large quantities of tightly placed reinforcement within concrete cross-section, anchor bolt arrangement was chosen which minimizes the possibility of cutting the reinforcement when drilling the holes. However, due to the fact that the installed reinforcement is pretty tightly placed, and that there are certain position tolerances at installation of reinforcement, of load-bearing capacity of crane rails for unfavorable case of cutting of reinforcement was calculated. The calculation showed that the load-bearing capacity of the crane rail for specified stacker/reclaimer device is satisfactory in the event of cutting through the reinforcement.

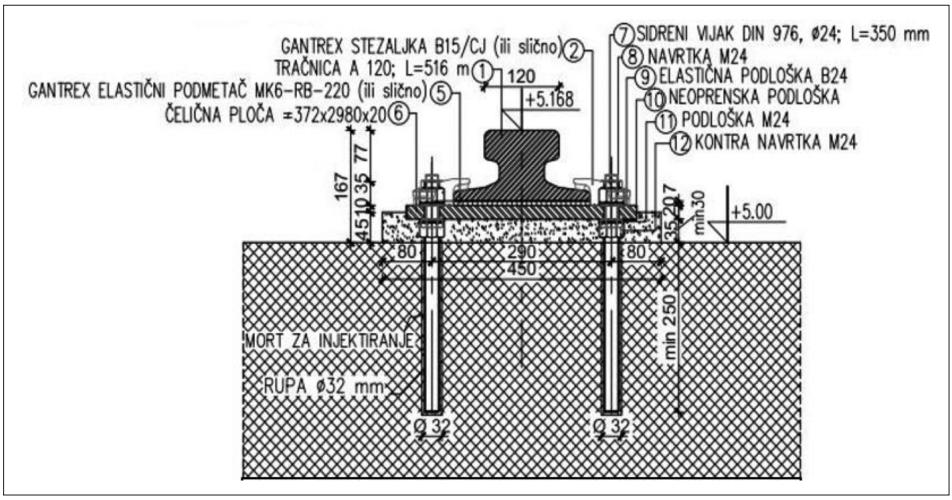

Figure 10 Detail of the fastening of the rail track crane structure CV-103 [3]

4 Building of the crane tracks

4.1 Crane tracks CP-101 and CV-201

During construction, the works have been carried out in the following order: firstly steel anchor bolts were placed in accordance with the design layout, for which tin installation patterns were used in which anchor bolts (Φ 24 mm) were placed and then fastened to the pattern with the anchors after which such assembly was placed in the reinforcement cage and geodetic control was performed. After the concrete in the strip foundation has hardened and surface was cleaned, detailed levelling of the steel plate for the purpose of placement of track was performed. Steel plates with the dimensions of 2980x372x20 mm, R235 steel quality are placed on them. Bottom nuts of the steel plate are then used to finely adjust the height with geodetic monitoring. After it is established that the plate is at a designated height, such plate is then fastened from the top side by the second nut and Gantrex 21/080/BK [6] clips are welded. On places steel plates (levelled by height) an elastic pad is placed, on which the tracks are positioned, Figure 12 (figure pertains to CV-103 but the principle is the same for CP-101 i CV-201). Finally, continuous bearing is placed underneath the steel plate. Rails are welded in a continuous welded rail (CWR) by manual metal arc welding (MMA).

Figure 11 Phases of construction: integration of the elastic pads and rails

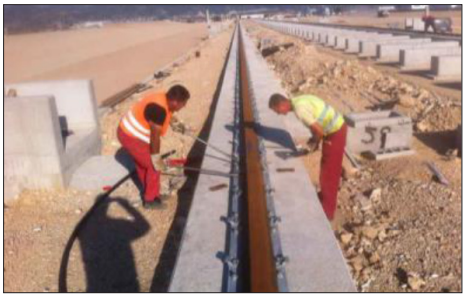

Figure 12 Phases of construction: alignment of the rails

4.2 Crane track CV-103

Basic stages of performance of works for the rail track of the CV-103 crane track differs from the previous one in that the concrete strip foundation have been done earlier, and that holes were drilled in the foundation for placement and injection of anchor bolts. Difference with regard to crane track with designations CP-101 and CP-201 is in the type of used anchor bolt and type of clip for the rails (B15/CJ) [7], which is shown in figures 8 and 10. Difference of this clip and 21/080/BK clip is that the it is not welded to the steel plate, and the fastening is instead performed by screws.

5 Conclusion

Crane track structures present a special application of railway engineering and are usually in use for heavy loads in industrial facilities where the traditional rail structure does not satisfy bearing capacity. The crane rail tracks that are part of Bulk cargo terminal at the Port of Ploče, named CP-101, CV-201 and CV-103, were designed and constructed, according to the designed loads and conditions. Special challenge on this project consisted from firstly improving the load-bearing capacity of the entire plateau of the Port of Ploče (this was done based on the getehnical project), and then from designing the foundation work of the crane tracks and rail track construction for large loads where the conditions at the site and adverse effects of the environment where the limiting factor. In order to act preventively on the environmental effects, all components of the crane structure were galvanized and larger protective layer of concrete was envisaged for strip foundations.

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