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THE TECHNOLOGY OF TRAM TRACK BUILDING IN OSIJEK

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Abstract

This work describes the flow of tram track construction. The construction of the tram track in Osijek in Divaltova street from Vinkovačka till Velebitska street is used as a real example. A new one-track tram with a tram track U-turn and all the necessary contact and cable net will be built.
The tram track consists of: 6 bypasses, 13 shunts, 9 tram stops and 1 U-turn at Velebitska street. The tram track is 4 413m long and split into 3 sections: section 1 – from Vinkovačka street to Kneza Trpimira street – 1 283m, section 2 – from Kneza Trpimira street to Srijemska street – 1 536m, section 3 – from Srijemska to Velebitska street – 1 594m.

Keywords: tram, track, rail construction

1 Introduction

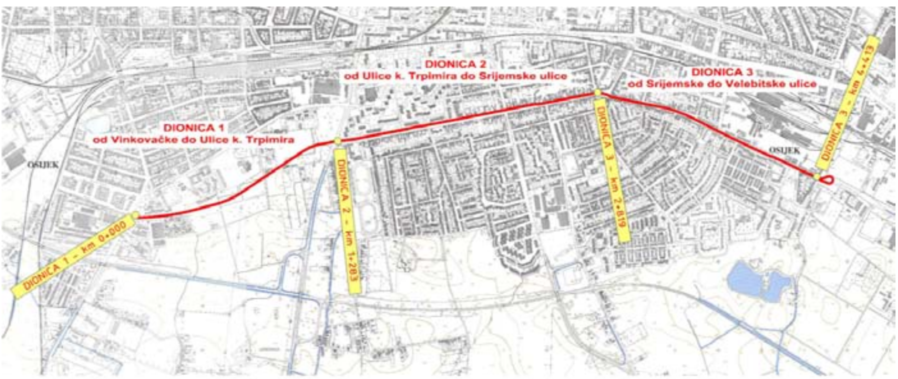

Figure 1 Sections

Tram is an electric railborne vehicle used for public transportation in cities. It has electrical motor drive. The powering of the propulsion engines is done through the contact electrical net over the roof electrical wire (pantograph). The electrical circuit is closed through the rails which serve as a return power line.
The rails are shaped steel products. There are several shapes, but T, U and H are the most common.
Trams are most often lighter than full profile railways and are used in cities, so the most commonly used rail type is the one which has protection from jumping out from the inner upper side. Before constructing the tram track, the project documentation needs to be prepared and it serves as the basis for construction. The project documentation needs to entail all the necessary data for the constructor. These are tram track outlines, calculations, budgets, price lists, etc.

Figure 2 Rail types

2 Rail construction

When constructing the tram track one must consider the quality of construction, the position of the track considering the pavement and the proximity of buildings in order not to endanger the quality of life. Likewise, if the tram track is situated in unpopulated areas of the city the General plan must be considered, so that the closeness of tram track and the noise and vibrations that it makes would not effect the future construction of residential and business buildings.

At the start of construction it is important to mark the route, which is done by geodesists. This is important in order to define its position, and the position of the nearby objects, including the elevation of the tram track route with all the following contents like tram track stops, tram U-turn or places where trams will be bypassed. This is also important because in the case of the tram track being built in Osijek the tram track will go in both directions, however using only one track, so tram track bypasses will be built on some places.

On the route which is situated in already populated area construction work needs to be carried out, such as demolition and removal of certain components (additional works) for example roadsides, parts of pavement structure, light poles, drains, drain grids, moving of underground installations. As we can see, additional work has to be predicted to achieve quality and to calculate costs which are relevant for the final price list calculation.

The construction starts with marking the route. One has to predict the removal of the mentioned parts of the route which are an obstacle to work foreseen by the project. After that the infrastructure needed to make the tram track work (electricity) is outlined. Only then can the earth work start which marks the beginning in construction work when building a tram track. According to the project plan, after demolition of the objects on the route, the next phase of work is digging the ground category C for the construction of the tram track. The material needs to be loaded and hauled. The digging is done by machinery and by hand if needed. When digging with machinery caution is needed not to damage installations and shafts if any.

The project plan should generally consist of the position of present installations and shafts in order to facilitate the construction work. The plan should also present the downsizing of costs in relation to compensation for damaged installations. Likewise, certain installations should be moved if possible.

The mentioned tram track section needs further digging (by machinery and by hand) of the new road for the tram track construction (on the section from Huttler street to U-turn). According to the project plan ground category C is dug out, loaded and hauled to the city depot.

After digging, the bed with the minimal compaction is made (compaction is Ms =20 MN/m2). In order to achieve minimal compaction the bed is compacted with the vibratory roller in 4 to 6 rollovers. The material of the bed needs to be 100 times tighter than the buffer.

If the acquired ground compaction could not be achieved or if the bed material has greater permeability than allowed the material needs to be replaced. The replacement of material is done within 20cm of depth. If needed this replacement layer can be thicker.

The replacement material is moist clay-gravel mixture or clay (with optimal moisture according to Proctor). Scattered material is compacted with spear vibratory roller in at least 6 rollovers, and more if needed. Work and replacement material are also considered.

The buffer layer is at least 30cm thick. This is very important for the level of the buffer (in our example: -52 of GRT.(+2,-3cm)).
Ground stone material is used for the buffer. The material has the following characteristics:
1 Coefficient of uniformity min Cu = 15
2 Maximum addition of grains smaller than 0,06mm – 5% of the entire mass.
Scattered material is compacted with vibratory roller in at least 6 rollovers. The inbuilt buffer has to be compacted in a way to achieve the smallest module.
After constructing the buffer layer, and before the concrete work, it is necessary to protect rail and fixed spots from dirt with geotextil or PVC foil. All the easily damaged built in materials need to be protected in such manner. Next the concrete slab from the concrete type C25/30 is constructed as the foundation for tracks, with 198cm width and cca 30cm thickness.
The upper layer of concrete slab must be done by leveling at 218mm below GRT. Deviation, which will not affect the later usage of tram track, is allowed between +0 and -5mm.
The concrete slab is constructed on a flat coating as a segment with fixed dilatation on the end of each segment. Fixed dilatation seam is made of board which serves as coating on the same spot, and is vertical to the axis of the track. The concrete needs to be poured on each segment, consisting of 6 m3 of concrete, in one go without a break. This means that pouring concrete should not be interrupted. This part of the building process is very important because one has to consider the weather, technology and workers on the construction site in order to respect the plan and deadlines. On a daily basis 100m of track is built, and the process of pouring concrete is done until 9 am in order to avoid deformations due to temperatures.
Time is a very important factor as can be seen from this example of building a tram track (section 1 from Vinkovačka street to Knez Trpimir street – 1 283m, Figure 3).

Figure 3 Section 1

After the concrete work is done, it is very important to protect the concrete, so the track needs to be covered with geotextil and kept moist continuously. The value of water-concrete factor can be maximum V/C=0.50. Before embedding the concrete, which is done by pervibrators, superfluid is added.
Minimum concrete solidity to bending can be 35 N/mm2. The level of water resistance according to HRN can be U.M1.015 designation V-4. The resistance to frost according to HRN can be U.M1.016 with C25/30. Vibrating of the concrete is done carefully without touching the fixed points or tracks. Minimum concrete solidity to bending can be 35 N/mm2. Tests should be done before pouring concrete to determine the optimal composition which is in line with project implementation terms.
After the buffer, bed and concrete work, the tracks are built with all the accompanying components. These objects need to be ordered earlier, in order to be at the arranged time in the storehouse and later on the construction site according to the deadline. It is important not to let possible delays compromise the deadline of final work.

Figure 4 Tram rails

Figure 5 Building of tram tracks

The following types of grooved tram rails are obtained and delivered to the storehouse:
1 type Ri-60/90 for tracks curved R‹100
2 type Ri-60/70 for tracks in line and curve R›100m
After delivery the tracks are bent. Technology of bending is standard. Following items are also obtained: core with siding 2m in length for in and out shunts, machines for shunts (R=50m, L=5350mm), complete switch - electrohydraulic mechanism for automatic turning of tabs.
The shants are placed on buffer provisional support according to the marked points and welded.
At the top of the shunt automatic switch machine is placed, and the tabs of the shunt are switched.
Next it is necessary to connect the drainage of the shunt with the shaft.
After this the following elements are built in:
a core (just delivery, building, welding and positioning)
b bytracks (20m of tracks on 1 piece of shunt - just delivery, building, welding and positioning)
c machine for shunt with switch mechanism (just delivery, building, welding and positioning).

Figure 7 Track protection

Figure 8 Placement of tracks on provisional support

Next the tram tracks are placed on buffer provisional support (Figure 7) according to the marked points of the track axis. Positioned tracks are welded in aluminium-termite or electrical way. The tracks are connected with the crosswise coils by drilling the holes in the neck of the tracks. The fixed equipment is installed on the track on to the double elastic fixed spot. The fixed equipment consists of: iron plate, ribbed neoprene pad, neoprene pad, two clamps SKL -1, two bolts 22mm in diameter, two nuts M 22, two plastic ribs, fixing element HE-A 200, two hooked bolts, two stop nuts M24, 4 padded plates, 2 elastic objects, 4 protective plastic caps. After installing the fixed equipment concrete prefabricated objects designation mark c25/30 are placed on the buffer. Concrete objects serve as support when placing the tracks. Placement of support is done at a distance of 3–5m along the track. Leveling and fixing the tracks on concrete support is done with portal devices. Also, the work is monitored by geodesists in order to ensure corrections of certain deviations. Deviation from the marked point is ± 3mm vertically to the track axis. Leveling, fixing and protection from deviation is very important for the quality construction of the entire tram track.

Figure 10 Bypass and stop

After the placement the fixed equipment is tightened, the equipment receives anticorrosive protection, protective plastic caps are placed on bolts, crosswise coils are removed and hauled, tracks are honed and cleaned. Ground gravel is scattered in layers and rolled from the side of concrete layer (width 0.2 to 0.4m) to the upper curb of concrete layer. The final layer of ground gravel is placed above the concrete layer 2cm below GRT (width 1.98m). Ground gravel (3 – 5cm) is used for the finishing layer. The ground gravel has to correspond to the conditions for building the upper machine on the rails.
After placing the ground gravel layer, the ground layer is placed between 0.2. to 0.5.m to the side of the rail. Terpaper is used for protection of the fixed equipment and is placed on its parts. Concrete filling is placed between and on the sides of the tracks (width 1.98 m) on the track with concrete designation mark c20/25, thickness- d=16.3cm. On the part of the road where no new road is build, the existing road is repaired. Next, after building the concrete between and on the sides of the tracks, seam is formed in the asphalt by the head of the track. Depth of the grid is 5cm, that is, up to the protective plate with additional carvings. When placing the grid it is essential not to damage the protective plate pad (width 40mm). It is necessary to fill the seam in the asphalt by the head of the track with the material called fugit. Beneath the head of the seam a plastic round object 12mm in diameter is placed to prevent oozing of the mass. Building of the asphalt AB11 is done on a concrete pad or on a ground gravel pad accordingly:

a asphalt on a concrete pad on a tram track width 1.98 to 2.6m, thickness 5cm, cleaned beforehand and sprinkled with emulbit
b asphalt on ground gravel pad, with beforehand rolled gravel with 5cm thick asphalt

After that the drainage racks with perforated tops are placed for drainage of the tram track groove. In one part of the section ground gravel 3–5cm is used for the finishing layer, which has to correspond to the conditions for building the upper machine on railway tracks. Next ground layer is placed on the side of the track from 0.2. to 0.5.m. Ground gravel plateau is placed on the part of the section from shunt to stop accordingly:

a digging (cca 20cm)
b bed
c ground gravel (d=20cm)

After digging, buffer and bed along the side of tram track, concrete poles are placed with certain distance for cables needed for functional tram traffic. Designated protective fences and canopies are placed on the part where the tram stops, which also belong to the equipment for building the tram track. These parts are placed lastly and they mark the end of building.

3 Conclusion

Tram track building is very complex and demanding work. One should consider quality of building as well as time spent. As is shown in this paper besides the building of the track other factors that affect the quality of the track building should be taken into account. All the factors must be interconnected and balanced out.

References

[1] Tram track construction project - Vendiko Ltd. Zagreb

[2] Traffic surfaces arrangement project – Rencon Ltd. Osijek