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DESIGN AND PROJECT PLANNING OF THE RENOVATION OF A RAILWAY LINE

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The railway line L50A is one of the most important lines in Belgium, connecting the capital Brussels with Ghent. The line originally consisted out of two tracks. Because this formed a constricting bottleneck for the entire railway network in Belgium, the existing capacity was expanded. Between 2008 and 2015 a third and fourth track was constructed, one on each side of the original 2 tracks. Now that the expansion works have ended, the 2 original tracks have to be refurbished. The necessary works include: renewal of ballast and rails, changing all wooden sleepers by pretensioned concrete ones, strengthening of the subgrade and renewal and improvement of the waterproofing layers at the bridges and viaducts. This article focuses on the first 10 kilometers of the trajectory, including 10 locations where the waterproofing has to be renewed. At each location, the existing ballast, sleepers and tracks have to be removed for the middle two tracks, so a new polyethylene-waterproofing layer can be installed. Afterwards the tracks have to be restored. All of this has to be performed while the 2 outer tracks remain in operation and without disturbing the electrification cables above the tracks. Because of this, the project will necessitate a combination of creative planning, use of modified and small-scale equipment and a judicious use of night-time labor. All of these items will be discussed in the article.

Keywords: Refurbishment, Expansion, Waterproofing, Labor planning, Management.

1 INTRODUCTION

Railway line L50A was expanded from two existing track to 4 tracks with an additional track on each side of the original construction. After completion of this expansion project, the two central tracks have to be refurbished. This includes:

- Renewal of the actual rails and ballast layer;
- Wooden sleepers have to be exchanged by concrete ones;
- Sanitation of the rack bed;
- Renewal of the waterproofing layers and adaptation of the ballast walls because of the additional tracks.

This section includes 10 bridge structures within a length of 10 km. The overall project planning is that in first step, the track bed is renewed at the location of all the bridge structures, including a renewal of the waterproofing and new ballast. Afterwards, the entire ballast layer will be renewed once more, but now along the entire length of the section, using a ballast work train.

The use of a thin polyester layer is preferred as waterproofing for all bridges, since they can be installed using smaller equipment, when compared with the installation of mastic asphalt. It is the intention to work at all bridges separately, and well before the actual track renovation. By planning this way, some of the bridges can be combined and the overall cost of the project should be reduced considerably.

2 SCOPE AND SAFETY

This entire project has to be constructed working in a narrow area, in between two railway tracks that remain in operation during the majority of the construction period. During the construction of the additional third and fourth track, the choice was made to use a very wide cross-section. Because of this, the new work area will always respect a safety distance of 1.5 m, measured from the outer rail of each parallel track. Pede viaduct has the narrowest safety zone and is shown in Figure 1 (De Backer *et al*. 2008).

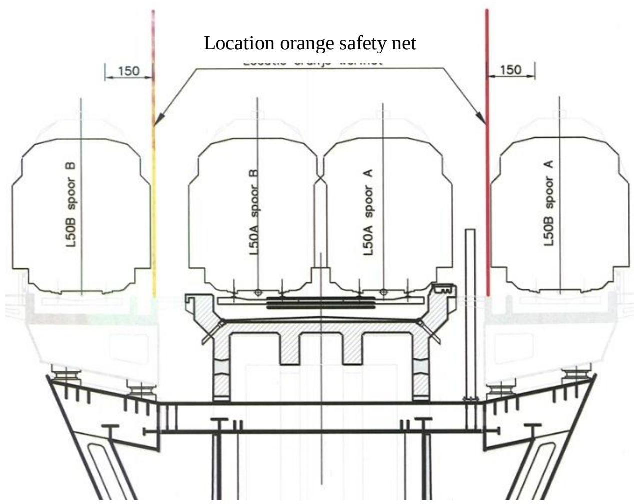

Figure 1. Safety zone vs. work area on the Pede Viaduct.

Since the work program for this location includes working with machinery, including moving cranes, safety guards will have to be present. The use of a railway crane will also be considered.

3 BRIDGE RENOVATIONS

3.1 Borrestraat Bridge

The bridge at the Borrestraat will be suppressed completely. During earlier works, the bridge opening under the railway has already been filled up, using stabilized sand and foam concrete. Since the height in length profile of the new tracks will be quite considerable, an additional filler layer will be installed on the old bridge.

The existing ballast stabilizing structures, shown in Figure 2, will additionally have to be expanded to allow for easy maintenance in the future.

Figure 2. Ballast walls for the Borrestraat bridge.

3.2 Herdebeekstraat Bridge

The bridge deck at the Herdebeekstraat has recently been renewed, which implies that the waterproofing layer should still be in good condition. However, a slight repositioning of the tracks, because of the use of a widened profile, will necessitate a repositioning of the concrete through decks. The decks are shown in Figure 3, already in their new and final position. Because of this, all of the pathways, etc. will have to be adapted as well.

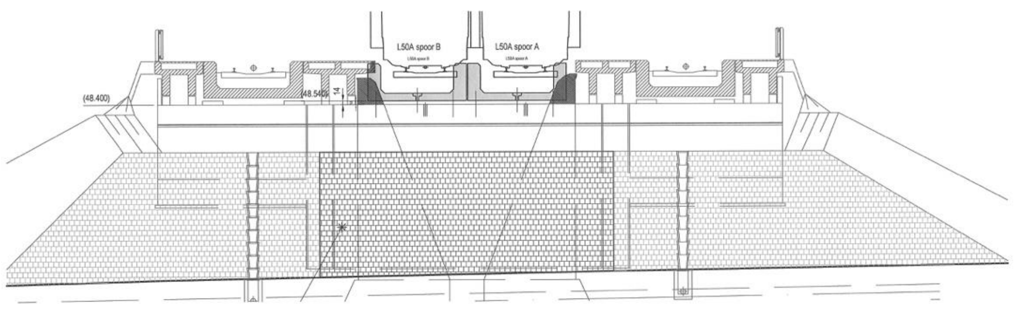

Figure 3. Cross-section of the Herdebeekstraat bridge, abutment closest to Brussels.

3.3 Pede Viaduct

The line L50A crosses the valley of the river Pede by a 523 m long historic viaduct, built in the 1930's. In those days the viaduct was chosen over large backfills in the valley due to poor soil conditions. The structure consists of 16 three-hinged reinforced concrete arches with a span of 32 m and a maximum height of 20 m. Four arches form an independent group, as they are separated from the rest of the viaduct by double pier structures, allowing for compensation of the thrust force of each group.

The viaduct is a benchmark in the rural environment through its dominance midst the gentle slopes of the Pede valley. Extension of the railway facilities to 4 tracks needed to widen the existing structure by two additional lateral viaducts, with respect to the protected work of art. Therefore, the arch structure and the existing piers were left apparent as much as possible. The arches kept their function and continued to behave as a four-span group. Important guidelines in making the new design were the contrast of old and new technology, keeping the four-span static behaviour with the repetition of 32 m spans and leaving the characteristic view of the hollow piers.

After consideration of various alternatives during the pre-design stage, the final design consists of a steel superstructure with variable hollow sections supported by integrated cantilever pier structures, as shown in Figure 4.

Figure 4. Earlier expansion works on the Pede viaduct.

The steel box girders of the superstructure are continuous over 4 spans, in accordance with the existing arches. The box section is characterised by waving patterns, both in the plan view as in the cross-sections. The upper flange of the box section is constant and stays horizontal along the structure's length. The lower flange however has a variable width of minimum 3,65 m at the piers and maximum 5,15 m at the span centre. The lower flange rises according to a sine wave from the supports towards the span centre obtaining less height and is twisted about a horizontal axis as it becomes wider. As a result, the vertical box web near the existing concrete arches has variable height, whereas the outer web plate shows torsion along the bridge axis. This creates a waving pattern of the steel structure complying with the existing arches, both in horizontal plane as in the front view, as illustrated in Figure 4. The new superstructure is supported by steel cantilever structures, fixed to the existing piers. Each vertical pier has a rectangular box section in a conical shape and fades into the lower part of the concrete pier. Two cantilever piers are joined by a transverse internal steel framework located in the hollow parts of the existing piers to ensure horizontal stability in transverse direction.

A large opening exists at the arch crown of the original concrete viaduct, as can be seen on Figure 5. This was originally intended as a drainage chamber, so it was equipped with drainage pipes. However, this greatly complicates the installation of the new waterproofing layer on the bridge. Two possible methods have been considered:

- The drainage chamber can be filled using a light concrete, after which a waterproofing layer in polyester (available in rolls) can be installed on the flat bridge surface. Because of weight restrictions the light concrete should actually be lighter than the ballast layer that is present within the drainage chamber. In addition, an arch joint is present at the arch crown, so a joint will have to be included within the filler, allowing for some rotation. This solution has the advantage that it is faster, allows for easier maintenance in the future, but the execution is slightly more complicated;
- If the drainage chamber remains in place, another waterproofing layer is necessary because of the uneven bridge surface. Acrylic resins can then be considered, because they allow for spraying on the irregular, but thoroughly cleaned, surface of the bridge. However, this method needs a considerably longer work period and the use of at least two cranes.

Since the expansion works on the viaduct assuming that the waterproofing layers would be renewed consecutively, these works will have to be carried out as soon as possible. After all, the expansion works have already resulted in some water damage.

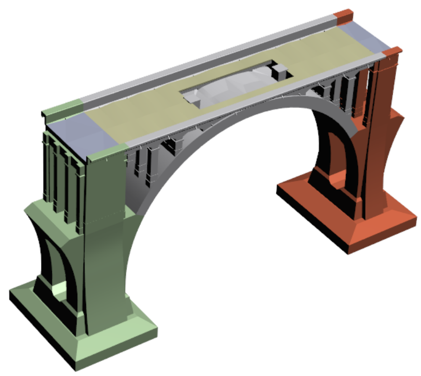

Figure 5. Original construction of the middle track supporting structure of the Pede viaduct.

3.4 Concrete and Masonry Arch Bridges: Kouterstraat, Bullenbergstraat

Both bridges, shown in Figure 6, are identical masonry/concrete arches where the most important works include the renewal and expansion of the pathways.

3.5 Concrete Culvert Bridge

For the bridges shown in Figure 7, the scope is quite similar. Special for this location is the fact that older abutments are still present from ancient arch bridges in the area behind the new culvert bridges. Since the new tracks will be installed at a lower position, these older abutments will have to be removed, working from supported trenches.

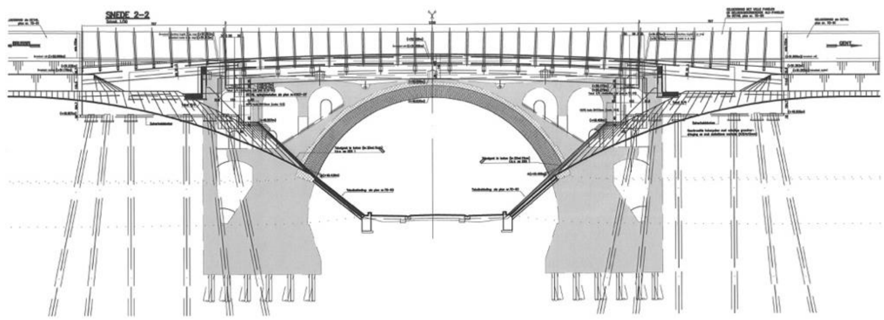

Figure 6. Masonry arch bridges at the Kouterstraat and Bullenbergstraat.

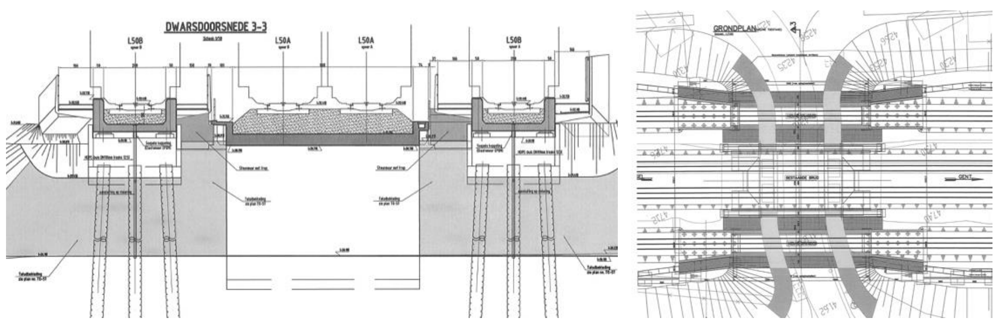

Figure 7. Concrete culvert bridges, cross-section (left) and plan view (right).

Table 1. Comparison of the project times for each bridge.

Bridge	**Necessary time (weeks)**
Borrestraat	10
Herdebeekstraat	15
Pede viaduct	23-27
Bullenbergstraat	15
Kouterstraat	14
Culvert bridges	12-14

4 CONCLUSION

Since the central tracks of Line 50A will be out of service for a period of 2 years because renewal of the track switches in a neighboring section, time is not really an issue, as is illustrated in Table 1. This will allow for a relaxed planning of the execution, where elements can be combined when they offer an opportunity for cost reduction.

References

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