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DEGRADATION OF THE CONCRETE RAILWAY TRACK BED LOCATED IN THE VICINITY OF THE LOADING WHARF

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ABSTRACT

The following article describes the damages of the concrete railway track bed at the place of unloading petroleum products located in the immediate vicinity of the cargo berth. The concrete of the track bed has been a subject to degradation as a result of many years of exploitation resulting, inter alia, in its cyclical flooding of petroleum products during the unloading and loading of rail tankers. Repairs carried out in the previous period involving the reprofiling of the top part of the board proved to be ineffective. Methods of repairing existing damages have been proposed. Due to the need to limit the time of excluding the track from operation, the repair works were divided into two stages - ad hoc, intended for urgent implementation, and target, to be carried out as a major overhaul.

Keywords: concrete corrosion, damage to the concrete substructure, concrete repair

INTRODUCTION

Petrochemicals have a negative effect, both on the natural environment resulting in contamination of the area [3], [7]-[19], [21] -[23], as well as a destructive one on concrete structural [1], [4], [20], [24] and finishing elements of building objects. It should be noted that the reasons for the destruction of the concrete structure by petroleum substances are very complex and until now have not been not fully understood and explained. In the technical literature four basic mechanisms of concrete destruction are defined: biological (1), chemical (2), physical (3) and physicochemical (4). In most cases, these mechanisms occur simultaneously, however, their quantitative share in the process of concrete destruction is diversified.

The purpose of the article is to describe the influence of oil derivatives known as so-called heavy hydrocarbons, on the properties of concrete and the impact of said changes on the technical condition of the track bed. The article also presents a proposal for repairing existing damages.

GENERAL INFORMATION

The 100 m long reinforced concrete track bed was located in the vicinity of the wharf and used for loading and unloading petroleum materials for rail tankers. The railway track was laid on a reinforced concrete track bed. The plate consists of three elements: the main part of the track bed, the drainage channel and the sewage tray (Fig.1 and Fig.2).

In the past, the reinforced concrete track bed, in the middle part at the length of ~ 40 m has undergone repair works, consisting in reprofiling and securing the top surface of the track bed with PCC mortars.

In addition, a sectional reconstruction of the outflow channel was carried out, replacing damaged concrete channels and damaged steel drains.

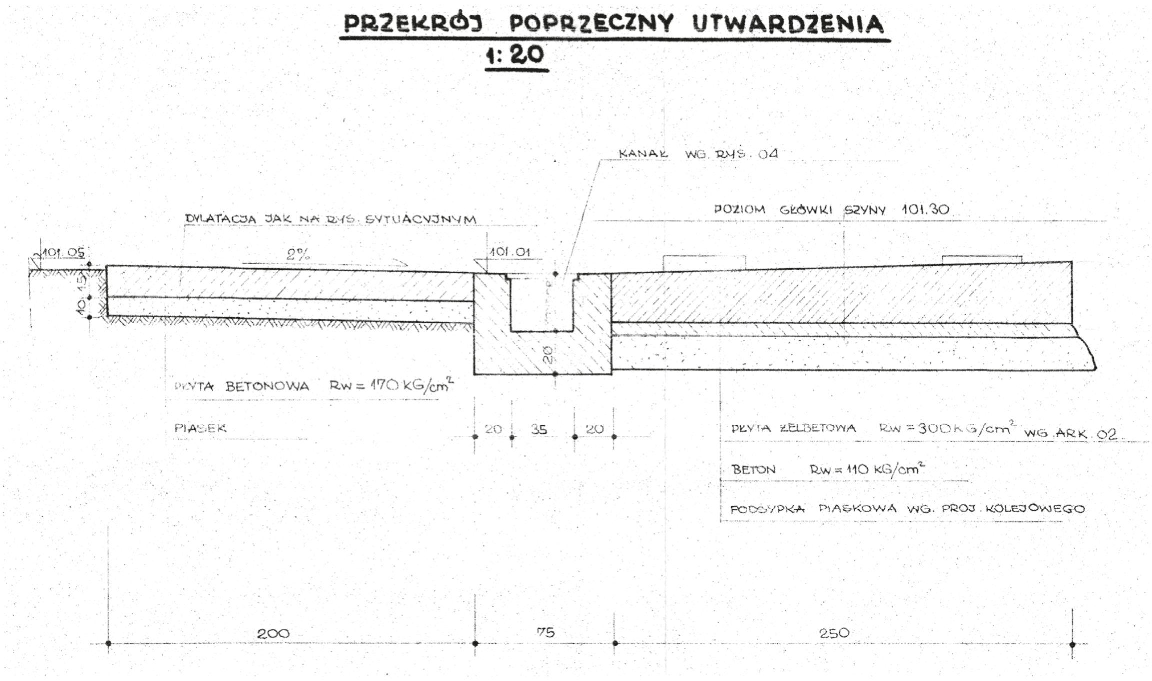

Fig. 1. The design solution of the concrete railway subgrade-cross-section (based on archival project documentation)

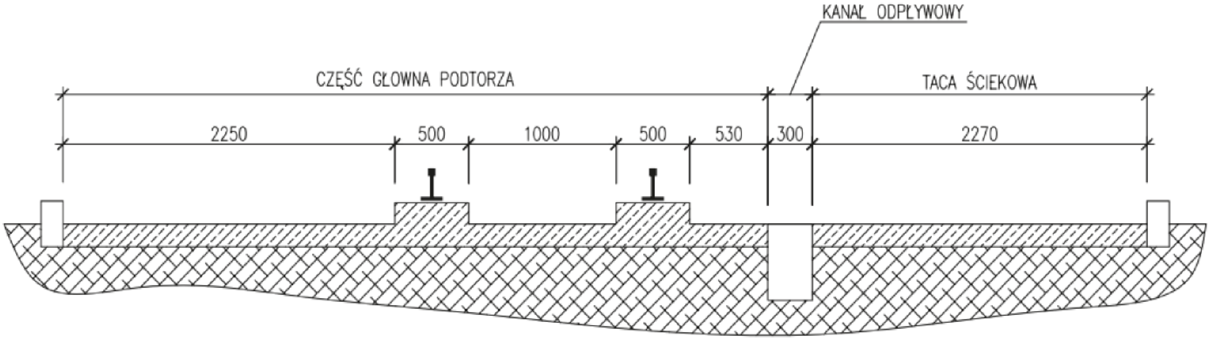

Fig. 2. Diagram of the concrete structure of the railway subgrade-stocktaking

DESCRIPTION OF DAMAGE TO THE CONCRETE RAILWAY TRACK BED

The most intense damage occurred at the length of the middle part of the track bed with a length of about 40 m. In this part the most damaged element was the middle section of the plate located between the rail heads (Fig.3a and Fig.3b). In the main part of the track bed the following damage to the upper surface of the board was found: separation of the PCC layer from the cracking ground, scratches and oil saturation of the concrete slab and PCC. Made in the past (~ 2 years ago), the layer was intensely fractured and carried traces of freezing (frosty scratches). Open pits ascertained that oil-based liquids gathered (by inflowing) from the subsurface of the subgrade due to unloading of railway tanks (Fig. 3c). The depth of damage to the concrete layer was up to 6 cm, and structural reinforcement bars were visible. The drainage channel located along the road, located between the main part of the track bed and the drainage tray (Fig.2) was deformed in an intensive manner. The concrete had extensive damage along drainage grates - a sectional drainage channel was replaced ~ 2 years ago as part of the works related to the reprofiling of the substrate. Despite the application of systemic repair solutions (built-in reinforced concrete, prefabricated elements of linear drainage) along the channel, the joints of the channel profiles were found to be broken and the surface layer of the concrete damaged (Fig.3d).

ANALYSIS OF THE TECHNICAL CONDITION OF THE CONCRETE RAILWAY SUBGRADE IN TERMS OF THE EXTENT OF ITS DAMAGE

The approximate mechanism of biological (1) and chemical (2) destruction (corrosion) of concrete lies in the destructive action of acids and bacteria. Often, both mechanisms are described together due to their simultaneous occurrence.

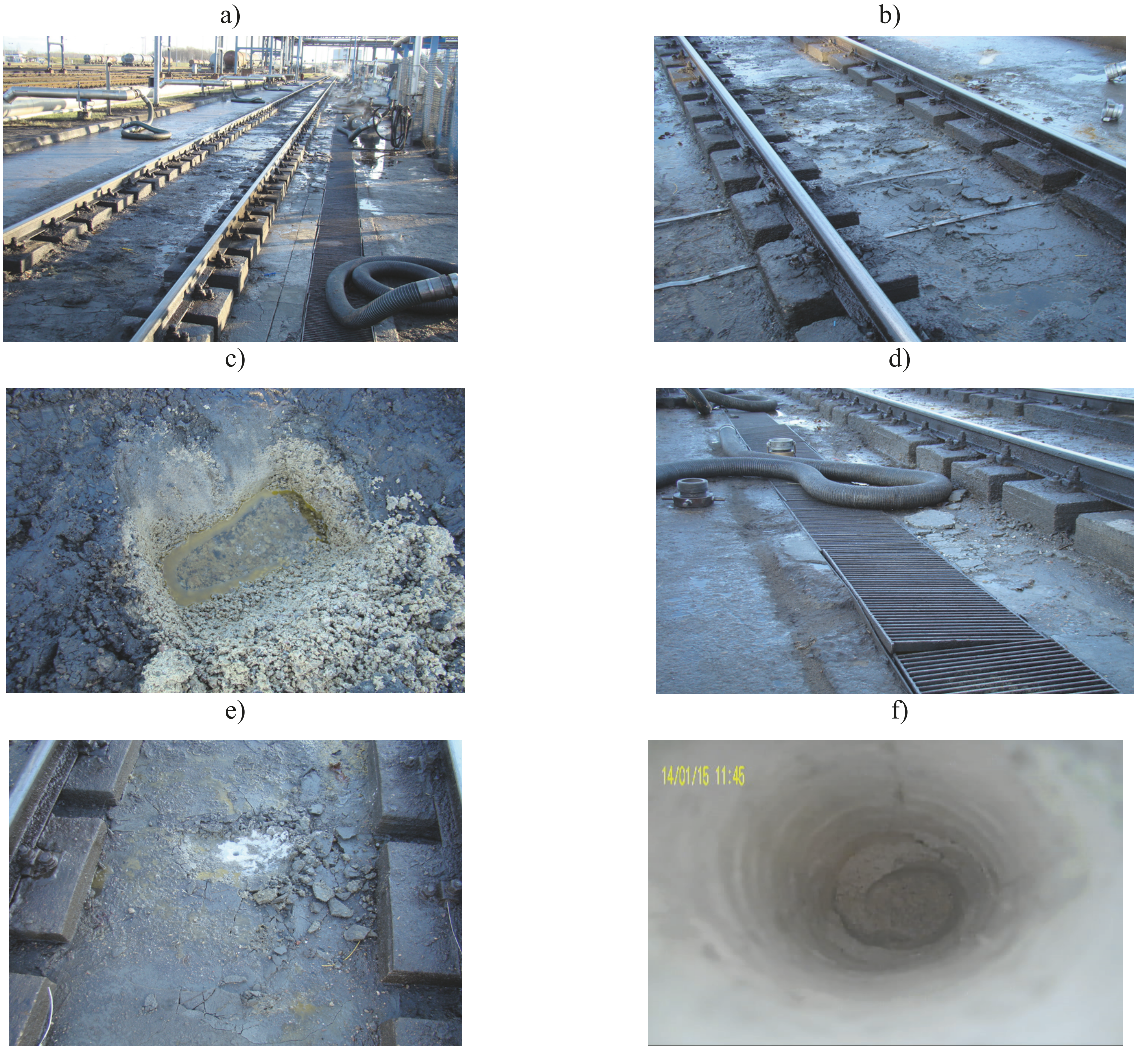

Fig. 3. Track with track bed: a) general view, b) damage to the main part of the track bed, c) open pit in the middle of the track between the rails, d) damage to the drainage channel, e) open pit - control hole, f) the interior of the control hole

In oily concrete, bacteria (aerobic and anaerobic) develop in the presence of water, while organic acids, hydrogen sulphide are produced and the pH of the water decreases. In oiled concrete durability decreases compared to the condition before oil formation - there is the phenomenon called concrete softening, and the long-term impact of organic acids results in a decrease in the mass of concrete, as a result of the dissolution of the cement binder and increase in its porosity. As a result of the dissolution of the binder, the durability of the concrete decreases significantly. The drop in concrete strength depends on the type of oil and the time of exposure of the concrete to oiling [3-4] (Fig.4).

The physical (3) and physicochemical (4) mechanism of destruction (corrosion) of concrete, which took place in the analyzed substructure, is related to the destruction of the concrete structure by the freezing water located in the concrete pores. The change in the pore pressure leads to the formation of micro-scratches in the concrete, which over time lead to the formation of macro-scratches and destruction of the concrete structure.

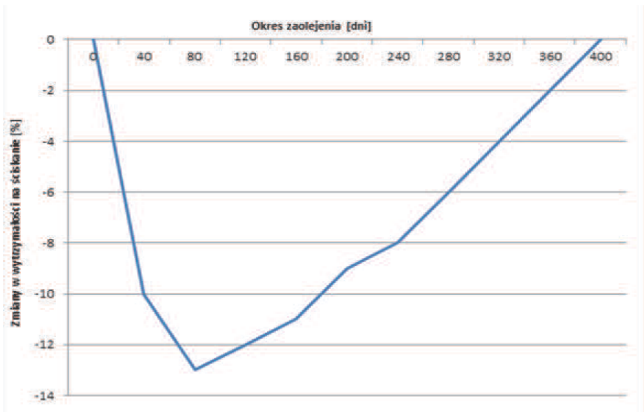

Fig. 4. Change in compressive strength of concrete (vertical axis-%) contaminated with diesel oil versus (horizontal axis-time (days)) (Błaszczyński 1995)

In order to extend the durability of concrete exposed to petroleum products, it is necessary to apply mineral-structural, surface-as well as structural protection. On the surface of the concrete it is necessary to use a multi-layer external coating, e.g. epoxy, acrylic, alkyl, vinyl, chlorinated rubber or oil-resin. An important parameter affecting the durability and effectiveness of protection is the thickness of these coatings, which should depend on the expected mechanical factors and it is recommended that it should not be less than 0.15÷0.20 mm for elements with low mechanical load and > 3,0 mm for components loaded with high mechanical load. The effectiveness of surface restorations, eg with PCC mortars, depends to a large extent on the adhesion of the selected repair system (resin) to the substrate (concrete).

In the described case of a concrete railway subgrade, soil saturation with petroleum products was found, based on the conducted ground tests. The soil did not soften despite the contamination. The homogeneity of concrete in the made-out pits was sufficient for surface repairs - the concrete had a compact structure [2], [5]-[6]. Also on the concrete surface, after removing the damaged PCC trip layer, no crayfish or caverns were found (Fig.3e and Fig.3f). The maximum depth of damaged concrete was 6 cm.

The direct cause of damage to the concrete substructure structure, including the PCC repair mortar layer, was the poor quality of the works performed and the use of materials not intended for use in the aggressive operating environment (with agents negatively affecting the concrete). The repair materials used did not provide the designed durability and resistance of the concrete railway sub-floor.

THE PROPOSED METHOD OF REPAIRING THE CONCRETE RAILWAY SUBGRADE

Due to the range of damages, renovation works had to be carried out in the STAGE system.

STAGE 1 (for urgent implementation) included:

I) ad hoc removal of loose fragments of the PCC and concrete,

II) initial geodetic surveying of rectilinearity and inclination of the track rails as well as running control measurements of the subgrade at regular intervals. It was recommended to perform geodetic measurements at intervals of 4 weeks in winter and at intervals of 2 weeks in the spring and summer. During the measurements, particular attention should be paid to the measurement of linearity, verticality and inclination of the heads of the rails with respect to each other,

III) sub-division of the subgrade to working plots and execution of works including:

a) pressure washing with water and detergents,

b) priming washed concrete surface: for matt-damp concrete applying a protective layer of epoxy resin for oily floors and sprinkling it with quartz sand (annealed with fire),

c) making buffer layer of epoxy resin and sprinkling it with quartz sand,

d) reprofiling the upper surface a mortar based on epoxy resin mixed with quartz aggregate,

e) applying a support layer of resin resistant to petroleum products.

At the same time, work related to the repair of dilatation had to be carried out in parallel with the work related to the construction of the strain, buffer and putty layers.

STAGE 2 (for the final implementation during the overhaul) included reconstruction of the main part of the track bed and the sewage tray based on systemic prefabricates made of polymer concrete resistant to oil-based liquids - in the newly designed subgrade layer system horizontal damp insulation was to be designed, also fulfilling the role of anti-oil insulation laid on the foundation layer of lean concrete B15 (C12 / 15). As insulation material, it has been recommended to use, for example, oil and bitumen protective foil with a minimum thickness of 2 mm..

CONCLUSIONS

The concrete platform bed exposed to a prolonged exposure of petroleum liquids (diesel oil, gasoline, rapeseed oil, alcohol, fatty acid esters), despite the repairs carried out in the past, was quickly destroyed. The direct cause of the damage occurred was the long-term operation period and the lack of periodic repairs carried out regularly, as well as the lack of major overhaul of the track and track bed. The lack of damp proofing which would fulfill the role of anti-oil insulation under the board resulted in concrete moisture caused by the phenomena of capillary moisture rising from the ground substrate, which contributed to the increase of damage and soil contamination.

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