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REHABILITATION OF CEMENT CONCRETE PAVEMENT STRUCTURES AT BRATISLAVA AIRPORT

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Abstract. The pavements on the movement areas of the airport are a specific group of pavements, due to their characteristics, different traffic loads and the time constraints for their repairs and maintenance. Increased requirements are on the proposed repairs already from the mentioned time point of view, as well as on the lifetime, which makes these repairs more economically demanding. Maintaining the optimal and efficient operation of the airport is primarily achieved by appropriate rehabilitation and innovation of the necessary parts of the airport. This was also subject to the replacement of the axial strips of the runway, part of the apron and the junction of the runways. The paper deals with the preparation, technical solution and implementation of these repairs with a description of individual technical parameters.

Keywords: Cement concrete pavements, runway, reconstruction, joint, pavement structure, slab, paving.

1. Design of pavements

The design of pavement structure is as a set of several activities related to the design of road construction, dimension and model calculations. This includes calculations of load effects, taking into account the properties of the materials, the subgrade conditions, and the climatic conditions.

The development of design methods of pavement structure can easily be described as a development from empirical methods to analytic-theoretical methods. This construction was replaced with a two-layer, later three- and multilayer system and with a mathematical solution to calculations of stresses and strains in the layer system was applied. In analytical design methods, individual pavements layer of different materials is characterized by deformation properties, the layer system being laid on the linear-elastic half-space. It is assumed that the layers are of the homogeneous and isotropic material.

For the calculation of stresses and strains in the individual layers of the physical model – which are subject to assessment, we apply the theory of the layered half-space. The calculation program LAYMED is part of the used design method. The analytical design method used is a complex system. Input data includes traffic load (calculate an equivalent number of design axles), classification of the water and temperature regime of the subgrade, characteristics of climatic conditions and properties of the material layers – their strength and fatigue.

Three criteria are used to assess the pavement design:

- ratio strength of bounded materials and radial stresses at the bottom of the layer,
- subgrade stability as the ration of vertical stresses and compressive strength,
- protection against frost penetration.

In the moderate climate zone, the ratio of the stress and strength of bounded material in the critical layer will be decisive. Pavements with CC cover have properties other than asphalt pavements, behave differently and other procedures and criteria in the calculation of stresses and strains are used [1].

2. Bratislava Airport

The runway system of the airport are two perpendicular take-off and landing runways and taxiways (Figure 1), which enable arrivals and departures for critical aircraft (critical aircraft B 747-400). Runway 13-31, which is the main runway, is 3 190 m long and 45 m wide. It is equipped with a system of lighting and navigation devices enabling accurate approach under III A category conditions. Runway 04-22 is 2 900 m long and 60 m wide. It is equipped with lighting and radio-navigation devices for accurate approach under category I conditions. Apron, as an integral part of every airport, must have the required functions in order to achieve the safety, smoothness and efficiency of airport operations. These requirements are ensured if all regulations and policies for the relevant type of airport and critical aircraft are fulfilled. All these surfaces have a cement concrete surface.

With development of the airport, investment priorities were ranked, while the reconstruction and expansion of the passenger terminal took first place in 2012 in terms of time and capacity. In 2016, the process of implementing operational safety management system continued – Safety Management System. The gradual

Figure 1. Runway system of Bratislava Airport.

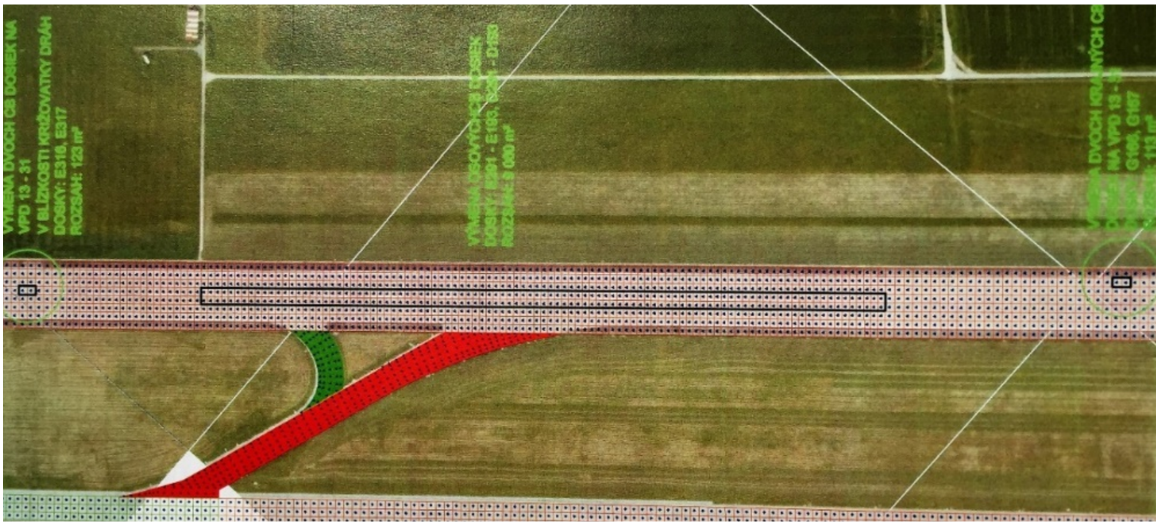

Figure 2. CC slabs replacement plan for Runway 13-31.

implementation of this system is to maintain an efficient and functional environment for the high-quality and safe performance of all activities related to the operation and maintenance of aircraft at Bratislava Airport. The runways required rehabilitation, which the airport gradually built over five years. In the years 2016–2018, the airport operator performed the repair of runway 13-31, when the axial cement concrete slabs of the cover were replaced [2].

Another reconstruction was planned in 2020, in the most complicated place – the junction of the runways, which was finally postponed for a year with the with the beginning of the pandemic. The reason for the postponement was the need for the airport to be operational during the crisis period and its importance in the critical transport infrastructure of the state. In mid-April 2021 with the one-year delay, the airport began the planned reconstruction of the runway junction. The work was realized 24 hours a day. For this reason, the airport was completely closed for all arrivals and departures, only the helipads and the apron remained in operation.

3. Replacement of axial cement concrete slabs on Runway 13-31

Regular maintenance of the runways at the Bratislava Airport, which is understood as the sum of activities that keep the pavements in operable condition in all weather conditions, is usually carried out before and after the summer season in order to ensure the safety and smoothness of air traffic. As part of the planned spring maintenance of operational areas, maintenance of operational areas, repair of dents and cracks, reconstruction of 13-31 – I. stage, replacement of emergency CC slabs at the junction of tracks and at the side asphalt strip were included replacing gutters, repairing gutters in concrete gutters, removing weeds and plants from gutters and lights and fixing lights.

Degradation of Runway 13-31 in terms of technical and operational status continued at larger repairs to ensure the required operational safety in the future. As part of these measures, the replacement of the upper layer of the cement-concrete pavement cover was proposed (Figure 2). The replacement concerned the two axial strips of the runway, which are the most heavily loaded and are in direct contact with the main landing gear of the aircraft. The length of the repaired section was 604 m in km 1 159 and the total area of the repair was 9 086 m^2 [3]. Runway 13-31 is divided in the longitudinal direction into eight strips marked from A to H (Figure 3). The strips marked A and H have an asphalt cover, and the other strips B to G have a cement concrete cover. The proposed repair concerned the replacement of the cement-concrete pavement cover together with the asphalt intermediate layer in two lanes in the runway axis marked D and E with a total width of 15 m.

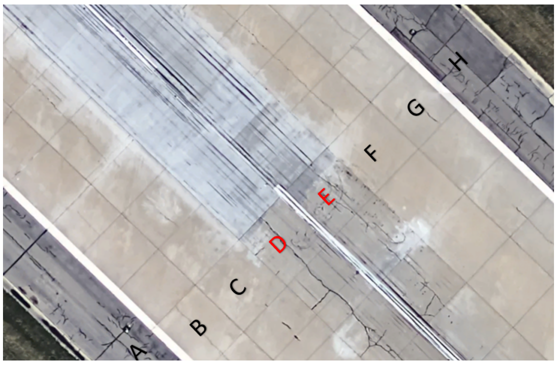

Figure 3. Strips of CC slabs on runway 13-31.

According to the project from diagnostics and exploratory drilling, the thickness of individual pavement layers on the repaired section of runway 13-31 was assumed. The construction of the pavement along the entire length of the track is not uniform, but consists of different types. Runway 13-31 is divided in terms of composition and pavement quality into five homogeneous sections, while the repair concerned part of section 3A. A two slab construction was found, where the lower CC slab was realized in the 1950s and the upper CC slab in the 1980s.

A new composition of the pavement structure was proposed. The change is in the top two layers. The other layers of the pavement were left in their original state. The transverse and longitudinal joints of the cement concrete cover were reinforced with dowels at a distance of 250 mm and tie bars of 4 per length of the slab, placed in one plane, parallel to the pavement surface and perpendicular to the joint [4–9].

The work procedure consisted of cutting transverse and longitudinal joints at the junction of slabs C-D and E-F, the existing tooth was removed in the longitudinal joint of slabs C-D, in the longitudinal joint of slabs E-F the existing groove was concreted together with CC slabs. Subsequently, the area of CC slabs with an asphalt intermediate layer was demolished. After removing the layers, a different cross-section of the lower CC slabs and the upper CC slabs than was considered in the project was found. For this reason, the project was changed and the number of longitudinal joints increased by two, on each side from the runway´s axis at a distance of 3.0 m. A bond coat spray was applied to the prepared surface and an asphalt intermediate layer with a thickness of 30 mm was laid. Subsequently, the concreting of the cement-concrete cover was using a paver in two strips from the end of the section. Strip D was implemented first, followed by strip E. Transverse and longitudinal joints were reinforced. In the places of the transverse working joints and the longitudinal joint at the junction of slabs D and E, dowels and tie bars were inserted into pre-drilled holes. After paving, transverse and longitudinal joints were continuously cut, pre-sealed and then filled with asphalt sealing (Figure 4). After the completion of the construction works, the traffic markings were restored according to the original markings before the repair.

Figure 4. Paving of cement concrete slabs on runway 13-31.

4. Reconstruction of the pavement on the apron

The Apron at the airport were built and expanded gradually according to the demands of air traffic, which results in different types of construction of cement concrete slabs, with variable thickness of individual pavement layers. The handling areas underwent a significant expansion in the 1980s and later, to a lesser extent, also after 2000. The degradation of the technical and operational condition of the apron, and especially the taxiway, reached a level that required reconstruction. Another requirement for the reconstruction was the innovation of the necessary parts of the airport in order to maintain the optimal and efficient operation of the airport, considering the change of the critical aircraft (B 747-400).

The apron is divided into two parts from the point of view of operation – the taxiway and stands for check-in and parking of aircraft (Figure 5). The mentioned part of the apron fundamentally affects the operation of the airport and the process of aircraft check-in, as they are the busiest stands and at the same time the taxiway allows aircraft taxiing even in low visibility conditions. The reconstruction of part of the apron increased the safety and technical operating conditions.

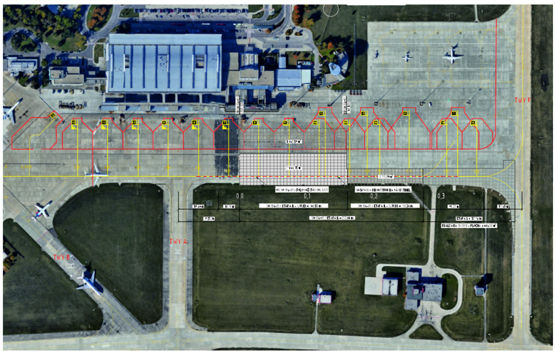

Figure 5. Apron of Bratislava Airport.

The realized part of the building is bordered on one side by a grass area and on the other side by a monolithic drainage launder. The reconstruction of the building was divided into two parts of construction. The first section is 160.5 m long and the second section is 273.0 m long [10]. Based on the results of diagnostics and construction works, the composition of the CC pavement built in the 1980s was verified as follows:

- cement concrete 240–260 mm
- asphalt concrete 25–40 mm
- cement stabilization 50–170 mm
- gravel 230–400 mm

On the mentioned section, the pavement structure was designed for the new critical (design) B747-400 aircraft, the maximum total weight of which is 397 800 kg [4–9]. The aircraft has four double tandem landing gear.

The cement concrete pavement cover is made as a single layer. The dimensions of the slabs are designed to be 5.0 m in the longitudinal direction up 4.5 to 5.5 m in the transverse direction (Figure 6, Figure 7). On the solved traffic surface, all joints are considered as transverse. The reinforcement of the transverse joints is with dowels Ø 30 mm and a minimum length of 500 mm at a mutual axial distance of 500 mm. The connection of the new CC cover to the existing CC cover is solved as an expansion joint, reinforced with dowels Ø 30 mm and min. 500 mm long at a mutual axial distance of 500 mm, with an assessment of the need for dilation and the need to guide the displacements of part of the surface (strips) due to climatic changes [11]. Between the CC cover and the base layer, there is a separation intermediate layer made of geotextile, which serves to prevent the copying of cracks.

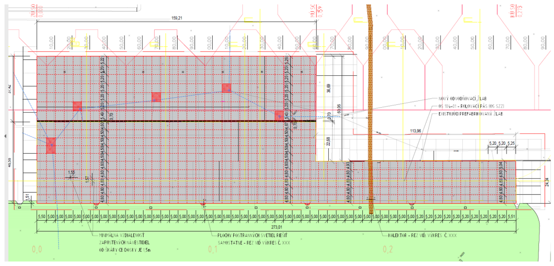

Figure 6. Jointed plain on the reconstructed part of the Apron.

Figure 7. Realization of cement-concrete pavements on the Apron.

5. Reconstruction of the junction of runways 04-22 and 13-31

The reconstruction of the junction was 11 days, from April 14 to April 24, 2021 (Figure 8). During the closure of the airport in that period, construction work was taking place at the junction of the runways, such as demolition work, removal of the cement concrete

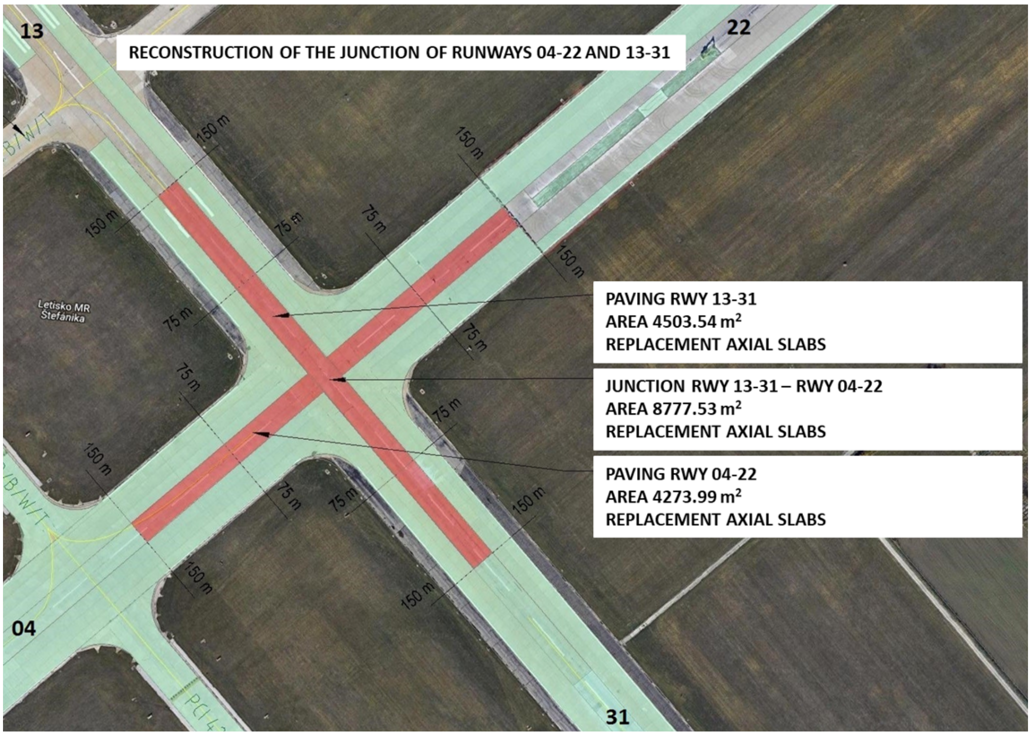

FIGURE 8. Junction runway 04-22 and runway 13-31.

cover, cutting of slabs, laying of a new cement concrete cover, installation of axis lighting or spraying of daytime markings. The reconstruction of the runway junction was in three parts. In the first week, preparatory work was on runway 04-22, which included the demolition of cement concrete slabs. During this period, the airport was closed for 6 hours at night, but this did not affect regular flights. In the final third part of the reconstruction, joint fillings were completed during night time, which also did not affect air traffic.

The system of take-off and landing runways (RW 13-31 and RW 04-22) was built gradually with a different type of construction of cement concrete slabs and variable thickness of individual pavements. The RW 13-31 has a two slab construction along its entire length, while the upper slab has a variable thickness of CC slab 200 up to 320 mm, the lower slab has a variable thickness up 220 to 260 mm. The RW 04-22 has a two slab construction along its entire length, while the upper slab has a variable thickness of CC slab up 200 to 260 mm, the lower slab has a variable thickness up 240 to 300 mm. According to the results of diagnostics and exploratory core drilling at the crossing, the pavement construction was determined in the following composition:

- Cement concrete 200–260 mm
- Asphalt mixture 25–40 mm
- Cement concrete 220–260 mm
- Cement stabilization 50–170 mm
- Gravel 500 mm

The replacement of the upper cover of the CC pavement was realized in two lanes in the runway axis at the junction of both runways (Figure 8). The building object on RW 13-31 starts at km 1 893 00 in the direction from threshold 31 and the end of the section is at km 2 199 00 (length 306.68 m, area 4 600.19 m^2, 84 pcs of slabs). The main runway was built continuously. The building object on RW 04-22 starts at km 1.288 00 in the direction from threshold 04 and the end of the section is at km 1.592 00. It is divided into two sections (I and II), the first section is 141.90 m long (area 2 131.08 m^2, 42 slabs) and II. the section is 146.62 m long (area 2 201.79 m^2, 44 slabs) [12]. The upper existing cement concrete slab was also demolished with an intermediate layer of asphalt mixture 15 m wide (two axial slabs) with an assumed average thickness of 270 mm [13]. The cutting also removed the existing connections between the slabs. Transverse joints at the beginning and end of the reconstructed section were also cut. The demolished material was taken to the landfill. At the end of the demolition work, the entire surface of the bottom slab was cleaned. Subsequently, a separation layer of geotextile was laid (area weight 1 000 $g\,m^{-2}$) and a new cement concrete cover with a thickness up 225 to 300 mm was laid. The asphalt intermediate layer was replaced by a separation geotextile.

The transverse and longitudinal joints of the cement concrete cover are reinforced. The transverse joints are reinforced with Ø 30 sliding dowels at a distance of 250 mm from each other, and the longitudinal joints with Ø 16 tie bars, 800 mm long, in the number of 4 per length of the slab. The repair of the runway junction cost the airport 2.27 million euros without VAT (Figure 9).

FIGURE 9. Rehabilitation of the junction of the RW 04-22 and RW 13-31.

6. CONCLUSION

With this rehabilitation, the airport achieved an improvement in the operational characteristics of runways and the apron. The intention of the airport in the near future is to deal with ensuring the reliability and operability of the runways by their complex reconstruction in their entire extent (over the entire width and the entire length), or by the construction of a new runway.

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