ANALYSIS OF THE SYSTEMATIC APPROACH TO DESIGN OF AIRPORT PAVEMENTS CONSTRUCTION

Ivan Koreň – Ján Kolesár

The article describes a systematic approach to process design and planning structures of airport movement areas. Article content characteristic factors on the airport movement area, affecting operational capability and overall life of the airport movement areas.

K e y w o r d s : airport, roadway, structure, subsoil, strength characteristics, freezing index.

1 INTRODUCTION

Quality of construction and treatment system of airport movement area has a significant impact on the overall operational capability, safety and durability of airport movement areas. Airport pavements are exposed during traffic to air traffic loads, climatic factors but also to other factors and factors that directly affect the safety of aircraft movements on pavements and their life. These factors should be given enough attention already in the planning and construction of airport movement areas.

2 SYSTEMATIC APPROACH TO DESIGN OF AIRPORT PAVEMENTS CONSTRUCTION

Analysis of systematic approach to the design of airport movement area is designed to develop, describe and characterize the ways and possibilities of construction of airport pavements. In this analysis is elaborated in detail particular burden on aircraft movement areas, airport pavement subgrade bearing capacity, climatic conditions affecting pavements and surface materials. Structural design of roads on the airport movement area is the collective name for several activities. When designing airfields should first make itself pavement structural design, calculations of response burden and to assess pavement using defined criteria.

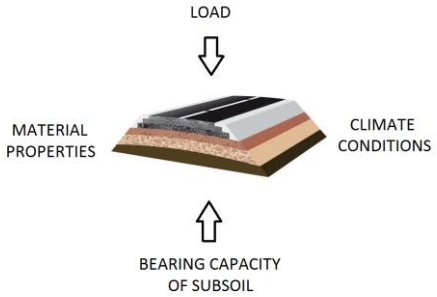

Figure 1 Systematic approach to the design of structures airport pavement

The systematic approach to the design of roads also means the calculation of dimensions conforming structure in terms of resistance, respectively what means to achieve a certain limit state. When designing airfields at first should be made itself pavement structural design, calculations of response burden and to evaluate pavement using defined criteria. The design method includes rules, requirements and criteria to be applied in designing, the calculations of road constructions at the airport.

When designing road construction and assessment of the proposal is considered standard load aircraft and standard conditions on its use, namely conditions in the subsoil road and weather conditions. The structural design must address the anticipated load non-standard and non-standard conditions for use of the road or their combination.

Analysis of a systematic approach to the design of structures airport movement area consists mainly of examination and evaluation of the following items:

1 Traffic load:
- The total number of aircraft,
- Number of heavy aircraft,
- Landing gear arrangement and number undercarriage legs,
- Load growth outlook.

2 Climatic conditions:
- Air temperature,
- Freezing index,
- Classification of the water regime.

3 Subsoil:
- Classification of soil,
- Forms of moisture and density,
- Strength of the soil and forms of resistance.

4 Material properties:
- Strength characteristics,
- Deformation characteristics,
- Thermal properties,
- Fatigue of materials.

When designing the airport movement areas must be in addition to these factors and actors interested in the economic aspect, the return on the project or the future development of the airport as well as environmental protection in the area of

construction and subsequent impacts on the ecosystem.

3 TRAFFIC LOAD

It is expressed by the number of aircraft movements on airport movement area for a certain period of time. The basis for calculating the burden of airport movement areas of analysis are:

- Evaluation of the density and volume of air transport aircraft operated by airport pavement per unit time,
- Take-off weight of the aircraft,
- Traffic-engineering survey,
- Information obtained from axle weighing aircraft.

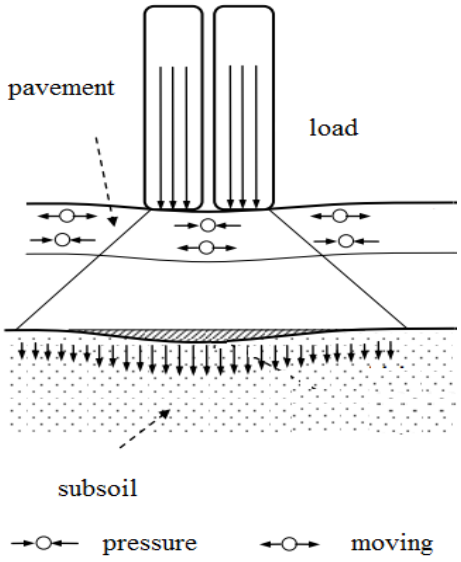

Figure 2 Effects of load

Load of roads on the airport movement areas - runways, taxiways, aprons and parking areas defined different types of aircraft and annual aircraft movements. The calculations of the effects of aircraft on the ground is necessary to know the load on one wheel main undercarriage legs and its expression in kN. The touching area of aircraft tires is usually a rectangular shape, which is topped by two half circles.

Carrying capacity of runways, taxiways and aprons must conform to the maximum load of the aircraft, the operation can be expected at the airport - critical aircraft.

Load from the aircraft to the ground depends on:

- The total weight,
- Type chassis,
- The number of wheels on the main landing gear leg,
- The spatial arrangement of wheels in the chassis,
- Pressure of tires.

When moving aircraft operate on the roadway than vertical and horizontal forces arising in the transmission of traction or braking force to the road surface in the direction of movement, while driving along the arc perpendicular to the direction of the aircraft. For the calculation of roads and dimensioning are interesting and characteristic shape of the tire contact area, specific contact pressure and contact pressure derived design.

Critical load is caused by the main gear. In the simplest case only one wheel has a load bearing capacity is calculated from the formula:

$$\mathbf{A = Q/Po} \qquad (1)$$

Where:
A-is the tire contact area,
Q - is the load transmitted main undercarriage leg,
Po - the tire inflation (Pa) multiplied by the coefficient of contraction tire m
(1.03 to 1.1). Po = p * m

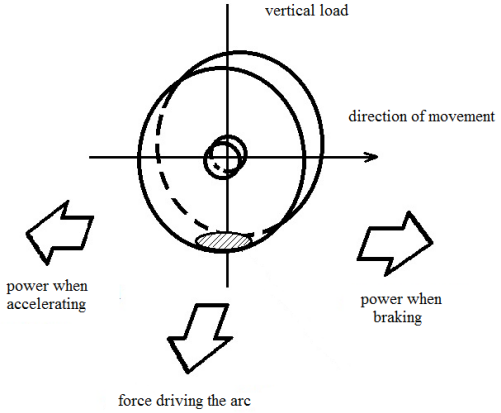

Figure 3 The forces acting on the tire contact

The main gear of aircraft have in most cases two, and four or more wheels. Effects that are caused by the individual wheels are partly added together according to the spacing of the wheels and the chassis, depending on the characteristics of the road.

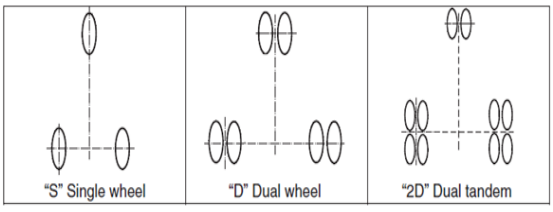

Figure 4 Traditional chassis configuration aircraft under FAA

3.1 Overloading airport pavements

Congestion can be caused by either excessively heavy load or a large increase in the number of movements along the airport road. As the road load exceeds the calculated value only in small amounts, so the effect of reducing congestion on the life of the considered minimal road.

Congestion of the road, which has no effect on life:

- For flexible pavements - isolated movements of aircraft with ACN not exceeding by more than 10% PCN road,
- For rigid pavements, and combined, where decisions transmission CB board - isolated movements of aircraft with ACN not exceeding by more than 5% PCN road
- For unknown type of pavement to be used 5% limit,
- The annual number of overload does not exceed 5% of the total annual number of aircraft movements.

4 CLIMATIC CONDITIONS

Climatic conditions affect the characteristics of the pavement layers and subgrade. Temperature significantly affects the behavior of the housing, changing its elastic modulus and fatigue characteristics. Subsoil moisture changes affect the behavior of the subgrade frost and freezing causes strokes or cracks. The biggest impact has, however, solar radiation and surface radiation, reflected on temperature. Temperature changes over the course of the day as well as during the year.

Its changes characterize:

- The average daily air temperature,
- Mean annual air temperature,
- Maximum air temperature,
- Freezing index,
- The index of heat.

When calculating aerodrome operating areas shall be considered and specific climatic conditions. Characteristics climatic conditions are different for the calculation and subsequent assessment of road with asphalt concrete pavements and roads.

The standard climatic conditions are characterized by:

a) design value index frost area:

- Im, n ≤ 700 ° C, day periodicity for n = 0.10,
- Im, n ≤ 650 ° C, a day for frequency n = 0.15,

b) the average maximum temperature of asphalt layers:

- Tm, asf ≤ 34 ° C,
- Im asf = 1.32 Tm + at 20.8 ° C

4.1 Temperature Mode

Temperature mode of airport pavement and subgrade characterize the surface temperature, the average temperature of each layer and subsoil during the year and the average annual values of these temperatures. Average daily air temperature and the average annual air temperature at the point of road construction, from which they take the surface temperature of asphalt layers are analyzed from the long-time measurements, at least 25 years.

Among the characteristics of the temperature mode does not include extremely sudden drop in temperature of the road surface (so-called thermal shock), where there may be cracks in the asphalt cover. When calculating the depth of freezing ground and subsoil and in assessing ground fault protection and freeze mode is characterized by frost index Im (° C day).

Climatic conditions crucially affect the surface properties of airport pavements. They will be in conjunction with hydrological properties of soil and subsoil water changes temperature regime the road, there is a change in the physico-mechanical properties of the individual layers of subsoil and their consequences are then reflected on the surface properties of such road.

The maximum daily air temperature is achieved most often around 15:00. An important element is the depth to which it extends the impact of air temperature. Surface temperature has a significant response to the depth of asphalt reaches 10-20 cm. Strongly manifested to a depth of 15 cm. What is the structure of airport pavement layer depth from the surface of the cover, thus its sensitivity to heat decreases. It depends on the residence time and high temperature. High achieved just below the road surface has a significant response only to a depth where lay asphalt mixture. Middle air temperature:

$$T_s = \frac{T_7 + T_{14} + 2\,T_{21}}{4} \qquad (2)$$

Where:

T7 - temperature measured at 7:00 am 2 meters above the ground,

T14 - temperature measured at 14:00 2 m above the ground,

T21 - temperature measured at 21:00 2 m above the ground.

4.2 Effects of water

The effect of the water is reflected in the reduction of the operational suitability of trouble shooting in cover of airport road, which is associated with the effects of adhesion between the asphalt and aggregate. Water affects the bond

between aggregates, reducing the adhesion of asphalt to aggregate and thus the resistance of the mixture to shear stress, which give rise to permanent deformations in asphalt pavement layers. Mixtures sensitive to the action of water are much more prone to deformation.

The basis for the assessment of water regime are:

- The level of ground water,
- Freezing depth of pavement and subgrade,
- Capillary height when fully saturated soil pore water in the soil.

5 CARRYING CAPACITY OF SUBSOIL

Carrying capacity of the subsoil is characteristic deformation properties of soils or other materials road under construction airport road. On soil properties and its processing technology has significant effect of grain size and soil compaction. According to the standards specified on a soil classification tests. The suitability of soils into soil is assessed on the basis of:

- Particle size distribution and characteristics of road components such as the presence of organic matter,
- The basic physical properties such as moisture content and porosity,
- Technical characteristics such as strength and compaction,
- Instance of freezing.

Design and technological solutions to improve airport pavement subgrade bearing capacity:
1 regulation of water / temperature schedule subsoil
2 improvement of soil properties in the subsoil,
3 subgrade reinforcement geosynthetics.

Design conditions should be set differently for fine-grained soils (F) and for coarse-grained soils (S, G).

For fine-grained states:

- Forms of moisture from the relation Wn Wn = Wopt, PS + Aw

- The design density of the formula:

$$\rho_{d,n} = \frac{\xi}{\frac{W_n}{100} + \frac{\xi}{\rho_s}} \qquad (3)$$

Where:
Wopt, PS - the optimum moisture content of soil,
Aw - the increase in humidity,
ξ - saturation of the soil pores,
ρs - density of the soil.

6 MATERIAL PROPERTIES

Properties are determined by the applicable test of Slovak and European standards. Material properties are characterized by the parameters of standards that are effective at the time of construction of airport movement areas.

The construction of the road are used in particular building materials, in particular:

- Natural raw materials and secondary raw materials,
- Modified natural materials,
- Industrially produced materials.

Among the material properties of airport movement areas include:
- Deformation characteristics,
- Strength characteristics,
- Material fatigue
- The slope surface,
- Surface roughness.

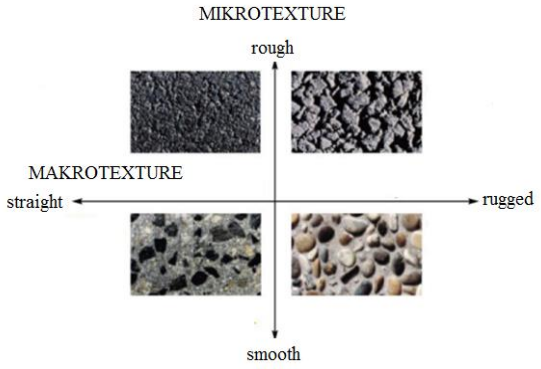

Figure 2 Example of micro-and macro-texture

CONCLUSION

These approaches for the design of the airport movement areas are not the only ones that need to be considered in the design of airport pavements. It is necessary to develop the financial, social factors, environmental effects, and more.

It is also necessary to develop the construction of forward-looking analysis of the possible extension movement areas or options of aircraft for higher categories. In practice, however, entrust the construction of airports airport movement areas specialized external companies that develop construction project on the basis of a systematic approach to the design of roads with exact specifications and needs of a particular airport.

BIBLIOGRAPHY

[1] GSCHWENDT, Ivan: Vozovky: Vysoká škola dopravy a spojov v Žiline, Žilina, 2004, ISBN 80-7100-240-2

[2] Technické podmienky MDPaT SR: Navrhovanie netuhých a polotuhých vozoviek, 2008.

[3] Technická smernica MDPaT SR: Navrhovanie cementobetónových vozoviek na pozemných komunikáciách, 2003.

AUTHORS ADDRESSES

Ing. Ivan KOREŃ, TUKE, Faculty of Aeronautics, Department of Aviation Engineering, Rampová 7, 041 21 Košice, SR, ivan.koren@gmail.com

Ing. Ján KOLESÁR, PhD., TUKE, Faculty of Aeronautics, Department of Aviation Engineering, Rampová 7, 041 21 Košice, SR, jan.kolesar@tuke.sk