RIGID AIRFIELD PAVEMENT DESIGN

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Summary: Presently the problem of strength rigid airfield pavement calculation represents the testing of pavement construction for compliance with strength limit state or cracking. Despite the problem and its solution are known for more than one decade and were brought to practical use, it is possible to find here some inaccuracies and irrationalities. This paper is aimed at improving the existing strength calculation method of rigid pavement.

Key words: rigid airfield pavement, bending moment, aircraft wheel, pavement thickness

According to normative document /1/ the limit state can be written as:

$$m_d \le m_u , \tag{1}$$

where m_d and $m_u$are respectively calculate and limit bending moments at considering slab pavement section.

Calculation algorithm, used in the present and is to test chosen airfield pavement on strength, is not very convenient. His main disadvantage is in mandatory pre-assigned layer thickness of pavement and foundation. It would be much more logical to solve the problem, determining layers thickness by calculation.

To remedy this lack, we should formulate this problem as follows: determination structural layer thickness from the limit state conditions, written as equation:

$$m_d = m_u , \tag{2}$$

The right side (2) is generally quadric parabola function for concrete and fibercrete pavement, which could be written as follows:

$$m_u = \Omega \cdot \frac{t^2}{6} ,$$

where t - is desired pavement thickness; Ω - is some constant value for calculation equal to the product of calculated concrete flexural strength on work conditions and intense ratios.

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The left side (2) is more difficult to be written, since it represents a multivariate implicit function of pavement and foundation thickness. Generally, the left side (2) can be written as:

$$m_d = \Omega_1\, m_{c,max}\, f(B_i),$$

where Ω_1 - is transitive ratio from central loading to boundary, it corresponds to the calculated scheme; $f(B_i)$ - function, includes the relation of layers' stiffness and ratios ρ and k_1 /1/; $m_{c,max}$ - maximum bending moment at the central slab loading.

Value $m_{c,max}$ can be defined as follows:

$$m_{c,max} = F_d\, \overline{m}_{c,max} = F_d\,(\overline{m}_1 + \sum_{2}^{n} \overline{m}_{x(y)i}), \tag{3}$$

where F_d - calculated dynamic load from the main landing aircraft wheel; $\overline{m}_1$ - a unit bending moment due to wheel moving, which imprint center matches with calculated section, loading is considered to be distributed on circle imprint of radius R; $\overline{m}_{x(y)i}$ - a unit bending moment produced by i-*th* wheel action, located outside the calculated section; the load from wheel is considered as a concentrated force.

Value $\overline{m}_1$ can be defined from decision of differential equal of bending of infinite plate on Winkler's foundation by next formula:

$$\overline{m}_1(\alpha) = -\frac{7}{24\,\alpha}\,\mathrm{Re}\left[\sqrt{i}\cdot H_1^{(1)}(\alpha\sqrt{i})\right], \tag{4}$$

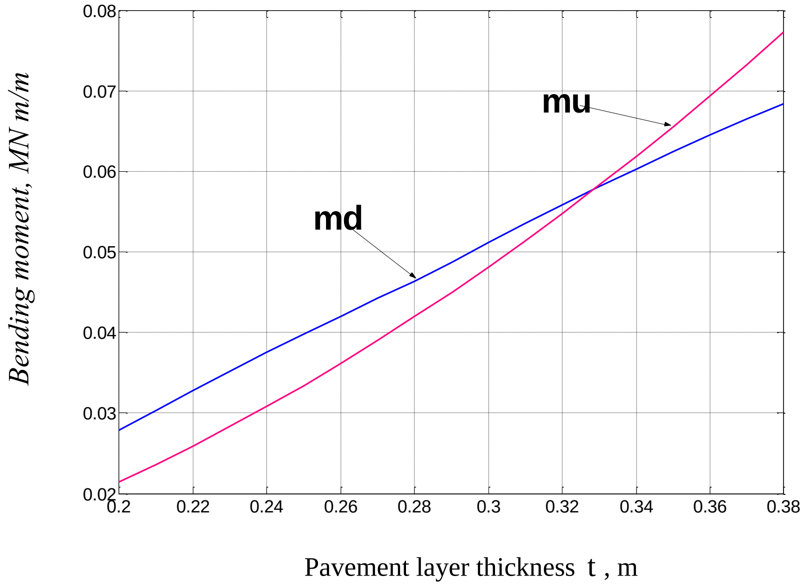

Figure 1. *Interpretation of equation (1) solution*

where $\alpha = R/l$ - reduced circle radius equal to the area of imprint from the main landing aircraft wheel; $H_1^{(1)}$ - Hankel functions of the second kind; l - radius of relative stiffness; $i^2 = -1$.

Solutions for infinite plate in cylindrical functions also can be used for calculation $\overline{m}_{x(y)i}$ values. Thus, equation (2) is a combination of implicit functions, it can be solved numerically, and the left and right sides functions are smooth, monotone and have non-singular points, which significantly simplify the solving of equation.

Analysis of equation (2) for different single-layer and multi-layer stiff pavements shows, that it has only one solution corresponding to the limit equilibrium, i. e. the optimum value of pavement thickness (Fig. 1).

Applying this approach allows us to calculate uniform strength variants of airfield pavements, which satisfy the condition (1). Fig. 2 shows graphs of ratio airfield pavement thickness and fortified foundation for aircraft B-747-400, for which the ultimate limit state is achieved (2). The choice of the optimal variant should be carried out by other criteria, such as economic.

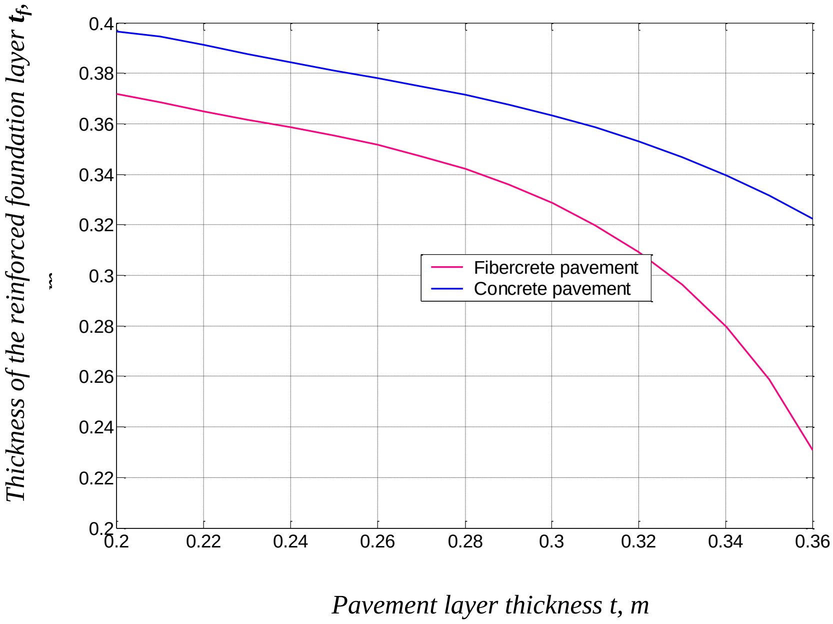

Figure 2. *The graphs of relations between rigid pavement thickness and fortified foundation, which satisfy (1)*

Algorithm, presented at this paper, allows calculating strength of aircraft pavement without preliminary appointment of layers' thickness; besides any of received solutions will be optimal in terms of building materials consumption, because there aren't any unreasonable safety margins in the calculation.

References

1. Set of Rules. SP 121.13330.2012. Airfields♦