нейшем подлежат определению или уточнению.

В таблице 1 в качестве примера расчета представлены параметры А и m в кривых усталости симметричного цикла для P_t = 10, 20, 30 тонн при $n_у$=3,2 и $n_{ур}$=7.

Как видно из таблицы, для каждого состояния грунтового основания покрытия аэродрома, характеризуемого параметром петли $P_т$, показатель кривой усталости в случае диаграммы Одинга больше, чем для случая линейной, т. е. $m_d > m_l$. Полные диаграммы усталости при вероятности появления трещин, равной 50%, получаются в виде:

$N_l = A_l (1-k) / k^{me}$;

$N_d = A_d / (kk + k^2)^{0,5m}$. (3)

Здесь k и kk – коэффициенты средней и переменной нагрузки на покрытие ВПП при посадке самолета.

Таким образом, рекомендуемое выражение (2) позволяет определить расчетный срок службы покрытия зоны приземления ВПП с учетом сезонных изменений в грунтовом основании. Это дает возможность оценить ресурс конструкции при проектировании, а также обеспечить оптимальные условия эксплуатации покрытия путем регулирования в аэропортах посадочных операций расчетных самолетов по рабочим курсам.

На наш взгляд, современные вычислительные средства способны значительно расширить задачу при расчете аэродромных покрытий (учесть изменения физических свойств грунтового основания в зависимости от климата, сезонности, времени суток и др.). Однако экспериментальные данные пока отсутствуют. Нужны надежные адреса аэродромных служб для восполнения очевидного дефицита подобной информации.

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PERFORMANCE OF RIGID PAVEMENT IN PLANES' LANDING AREA

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ABSTRACT

As it is shown by experimental studies, variable vertical loads acting on the pavement of the airdrome are random in nature. In this regard, to assess the reliability of pavements calculation method is necessary, bonding characteristics of the random loading process with the simplest fatigue behavior – Wohler curve. The article proposes methods providing for determining the design life of pavement in planes' landing area within the parameters of the foundation material and the impact of the loading dynamics of airdrome pavement. This makes it possible to properly assess structural life of the pavement in the design process, and to ensure optimal conditions of its operation by controlling the amount of landing operations of calculated aircrafts from different runway headings.

ENGLISH SUMMARY

Background. *In accordance with applicable instructions for airdrome design calculation of operating rate of pavements is determined by modular ratio, which is taken up depending on the ratio of wheel load of j-th aircraft to wheel load of a calculated aircraft.*

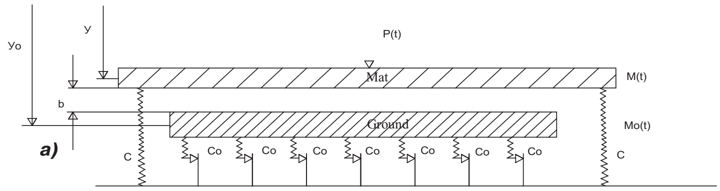
However, the most complete characteristics of load intensity are operating cycles (OC), which make it possible to estimate with a given probability the main parameters that influence integrity and life duration of pavements of airdromes. In [1] it is shown that during simulation on analog computers of the dynamic effects of aircraft wheels at landing, a transient process involves several cycles of deformation of the pavement. In that regard, it was proposed to calculate energy using coefficient of influence k_ε, whose value ranges from 1 to 1, 12.

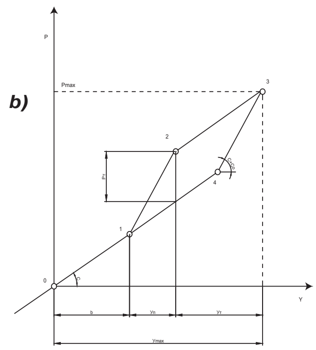
Objective.

The objective of the author is to propose a method enabling to determine the design life of pavement in planes' landing area within the parameters of the foundation material and the impact of the loading dynamics of airdrome pavement.

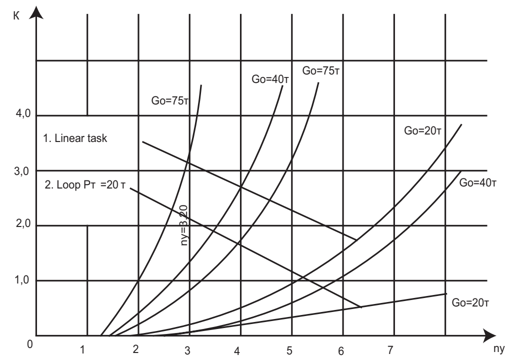
Methods. *The study is based on the model of «plate-ground» system with nonlinear dissipative and elastic properties which reflects real conditions of deformation of airdrome pavements.*

Results. *In assessing the intensity of damage of airdrome pavements it should be considered that in the process of landing the load from the aircraft wheels is determined not only by landing weight, but also by vertical load factor. Furthermore, load intensity of a pavement is largely dependent on the strength of foundation material, whose elastic-plastic characteristics in the proposed model «plate-ground»*

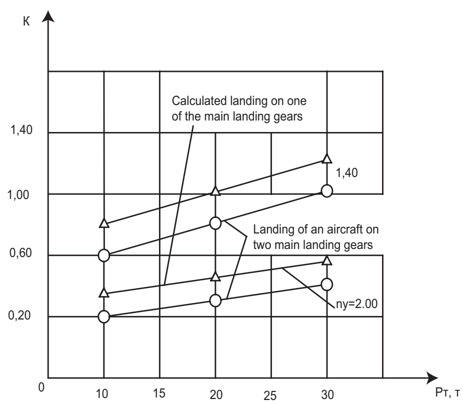




Pic. 1. Calculation model (a) and adopted diagram of stress-strain behavior of the system «plate-ground» (b).



Pic. 2. Dependence of influence coefficient of load dynamics of airdrome pavement k from overload degree at landing of an aircraft with flight weight of 75, 40 and 20 tons.



Pic. 3. Dependence of influence coefficient of load dynamics of airdrome pavement kλ from parameter Pт at landing of a calculated aircraft.

are estimated by variable stiffness $C_o=f(y)$ and the parameter of the loop P_τ (Pic. 1).

In a first approximation, accounting of damageability degree of a pavement, introduced by each landing of the plane, may be made by the expression:

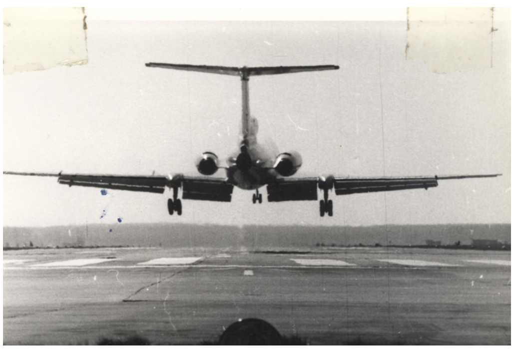
$$k_\lambda = \lambda^2 k_\varepsilon = \lambda^2 (1+\Sigma y^2 T_1/T_\iota), \qquad (1)$$

where k_λ is an influence coefficient of deflection dynamics of an airdrome pavement;

λ is a dynamic coefficient to be determined depending on the landing place and overload factor.

Pic. 2 shows dependences associated with the use of coefficient k_λ. It can be seen that value of k_λ in case of linear task is higher than in case of the pavement deformation scheme with parameter P_τ = 20 tons. Thus for normal landings with vertical load factor $n_y \leq 2$ coefficient k_λ is less than unity. However, in some cases (for example, «rough» landings) runway pavement can receive significant damage, leading to premature destruction

Pic. 3 provides a graph of dependence $k_\lambda=f(P_\tau)$, which shows that the coefficient k_λ at landing of an aircraft can vary widely. In the case of a landing on one



Pic.4–6. Examples of landing of Tupolev-154 aircraft at Moscow Domodedovo airport.

Table 1

Values of parameters A and m in curves of symmetric cycle fatigue

Type of a diagram	$P_т$=10 t		$P_т$=20 t		$P_т$=30 t	
	m	A	m	A	m	A
Linear (l) Oding (d)	0,585 1,167	0,75 0,50	0,366 0,733	0,65 0,48	0,217 0,434	0,58 0,49

of the main landing gears runaway pavement receives significantly more damage than at symmetrical landing, due to different values of given masses of a mat and foundation material. However coefficient k_λ may be higher or less than unity depending on the values of vertical load factor at the landing. Moreover, as it is shown by the results of studies, landing of aircrafts with turbine engines are performed, as a rule, on one of the main landing gears [2]. Based on the above, to determine lifetime of mats of pavement in the landing area of a runaway, the following expression is recommended:

$$T_{ЗП} = N_{l(d)}/F(x, y,)\ \Sigma k_{\varepsilon j} k_{\lambda j} N_j, \quad (2)$$

where $T_{ЗП}$ is an estimated lifetime of mats of a pavement in the landing area of a runaway in years;

F (x, y) is a density of distribution of landing impacts of aircraft wheels along the length and width of the landing area;

$N_{l(d)}$ is a linear limit diagram (denoted by index l) and Oding diagram (denoted by index d), which is determined by formulas [3] and [4];

n_c is annual operation rate of runway pavement during landing of calculated aircrafts with the magnetic heading.

Due to the fact that considered method for determining resource of mats of a runway landing area is proposed for the first time and there is a lack of a number of necessary input data (e. g., vertical load factor n_{yp} which would have a breaking effect for a pavement), it is advisable in the calculating of curves in the diagrams $N_{l(d)}$ to conduct calculation in parametric form for several values of the unknown quantities, which then must be determined or specified.

In Table 1, as an example of the calculation are introduced parameters A and m in curves of the symmetric cycle fatigue for P_t = 10; 20; 30 tons at n_y=3,2 and n_{yp}=7.

As the table shows, for each state of foundation material of an airdrome pavement, characterized by parameter of the loop $P_т$, index of the fatigue curve in case of Oding diagram is higher than for linear one, i. e. $m_d > m_l$. Full fatigue diagrams at cracking probability of 50% are obtained in the form:

$$N_l = A_l\,(1-k)/k^{me};$$
$$N_d = A_d/(kk+k^2)^{0,5m}. \quad (3)$$

Here k and kk are coefficients of average and variable loads on the runaway pavement while aircraft landing.

Thus, the recommended expression (2) makes it possible to determine the expected lifetime of a pavement in the runaway landing area, taking into account seasonal variations in the foundation material. This provides an opportunity to evaluate structural life in the design, as well as to provide optimal operating conditions of a pavement by regulating landing operations of calculated aircrafts by runway headings.

Conclusion. *In the author's opinion, modern computational tools can greatly extend the task of calculating airdrome pavements (taking into account changes in physical properties of foundation material, depending on the climate, season, time of day, etc.). However, experimental data are not yet available. Reliable addresses of airdrome services are required to compensate for apparent scarcity of such information.*

The methods proposed in the article enable to determine the design life of mats of pavement in the runaway landing area with account of parameters characterizing the state of a pavement foundation material and impact degree of the load dynamics of airdrome pavements at aircraft landing. This makes it possible to properly assess structural life of a pavement in the design process, and to ensure optimal operating conditions of a pavement in the runaway landing area by regulating the amount of landing operations of calculated aircrafts from different runway headings.

Keywords: *airdrome, operational cycles, «mat- ground» system, runways, performance, rigid pavements, calculation model.*

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