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VERTODROM COVERING CALCULATION AND DESIGNING TECHNOLOGY

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Abstract. The article is devoted to the analysis of existing methods of calculation of rigid heliport coverings, both domestic and foreign. Considerable attention is paid to the geometric dimensions in the plan and layout; location and orientation of heliports. Types of helipads are considered; materials used in the construction of heliports; type of structures (panels), designed for the construction of helicopter pads at the surface level (on any dense surface or ordinary soil), that successfully replace concrete, as well as for the reconstruction of worn and damaged concrete helicopter pads on rooftops and other heliport modifications; possible locations of helicopter pads, which may be different in size and configuration: mobile, off-road, ground, on the roofs of buildings and structures, on pontoons, on sea or river vessels and yachts, on offshore drilling platforms, by individual projects. Approaches to the improvement of the existing method of calculation and design of rigid helipads are analyzed.

A comparative analysis of ICAO, FAA, SNiP 2.05.08-85 regulatory documentation and recommendations, which do not provide a clear idea of the method of calculating the thickness of rigid heliports, do not separate the calculation of heliports from the calculation of aerodrome pavements, do not consider any critical cross sections in calculating the load from helicopters and the main differences in designing coverings for helicopters from those for aircraft maintenance, connected with the dynamics of the takeoff and landing operations.

As the weight of modern helicopters varies widely, it has been established that different types of coverings must be used for different weight categories (from structures raised above the ground level for light and medium-weight helicopters to cement concrete coverings for heavy helicopters).

Keywords: airfields and heliports, rigid and non-rigid coverings, helipad design, calculation and designing of coverings.

INTRODUCTION

The development of the modern state is impossible without the development and continuous improvement of the transport system. Priority in this matter is given to air transport. Helicopters are now an integral part of business aviation around the world (especially in metropolitan areas). Unfortunately, in Ukraine this line of transportation is still underdeveloped, the main reason for this being the ban on flights over megacities, lack of sufficient number of heliports, lack of modern regulations that would take into account design features of modern helicopter types, insufficient number of aircraft of the required type.

MAIN PART

Analysis of existing methods for calculating rigid helipad coverings. Artificial coverings became widely used in the world in the mid-30s of the last century. At the initial stage of development, the construction of cement-concrete pavements completely copied the road construction, and the determination of pavements bearing capacity and assessment of the aircraft impact on the pavement was not performed as the takeoff weight was insignificant and tire pressure was 0.3 - 0.4 MPa.

However, in the post-war period, multi-wheel landing gear appeared, and since that time onwards, helicopter construction has begun to develop actively, which necessitated the development of methods for assessing the coverings strength under the action of certain aircraft types. The impact of helicopters on the surface was considered and evaluated by the same method as the aircraft impact.

Today, the issue of calculating airfields and heliports covering is given considerable attention. Calculation of single- and multilayer coverings (with or without a separating interlayer) is considered in [1, 2].

The first and simplest method of classifying the aircraft impact on covering was to estimate it based on the aircraft weight. Thus, in the postwar years, two ICAO sessions adopted a condition under which the load category is determined only by the value of the allowable total weight of the helicopter. At the third ICAO session, it was decided to classify all loads using 7 code numbers (Table 1), each of which being a combination of equivalent single-wheel load and tire pressure.

Table 1

ICAO load indication code numbers

Code numbers of loads	I	II	III	IV	V	VI	VII
Equivalent load, thousand pounds / ton	100 / 45,6	77 / 35,0	60 / 27,2	45 / 20,5	30 / 13,6	15 / 6,8	4,5 / 2,0
Tire pressure, kg / cm^2	8,5	7,0	7,0	7,0	6,0	5,0	2,5

At the fifth ICAO session, the improvement of the classification system for covering loads was considered and published. This advanced system is called LCN (Load Classification Number). The basis of the LCN is the load classification curve, the numerical characteristics of which are given in table 2.

The classification numbers were a function of the equivalent unicycle load and tire pressure. The relationship between tire pressure and wheel load was adopted on the basis of «conditional» or «average covering». It, in turn, was adopted based on the results of destructive studies of coverings of different thickness and on different soil bases by static loads.

Table 2

Numerical characteristics of the load classification curve

Wheel load		Pneumatic pressure		LCN ordinates
Ton	Pound (lb)	kg/cm^2	lb/in.^{2}	
45,4	100000	8,44	120	100
40,8	90000	8,09	115	90
36,3	80000	7,74	110	80
31,8	70000	7,38	105	70
27,2	60000	7,03	100	60
22,7	50000	6,68	95	50
18,1	40000	6,33	90	40
13,6	30000	5,98	85	30
9,1	20000	5,62	80	20
4,5	10000	5,27	75	10

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In the case when the configuration of the real support did not correspond to the tabular values (supports of helicopters, new aircraft), to bring the equivalent load from such support to the standard classification curve, a correction was introduced, calculated by the formula [3]

$$\frac{F_e}{F_s} = \left(\frac{p_e}{p_s}\right)^{0,785} \quad , (1)$$

where F_e and F_s are the load on the wheel of the real support and the support according to the classification curve, respectively;

P_e and P_s - tire pressure according to the real support and the support by the standard classification curve.

As a result of further studies of the aircraft supports interaction with the covering, the ICAO standard, issued in 1977, was amended regarding the classification of loads. Thus, the figure in formula (4) was changed from 0.785 to 0.37. This degree indicator characterizes the supports interaction with thicker coverings more accurately. Also at the sixth ICAO Air Navigation Conference in 1974, the classification of aircraft by groups (LCG) was adopted. Each group covers a range of load classification numbers as shown in table. 3.

Table 3

Aircraft distribution by load classes

Load classification group (LCG)	Load classification number (LCN)
I (highest)	101 – 120
II	76 – 100
III	51 – 75
IV	31 – 50
V	16 – 30
VI	11 – 15
VII (lowest)	10 and less

Equivalent unicycle load in LCN and LCG methods was determined depending on the type of covering (rigid or non-rigid) as follows:

- in the case of rigid covering, the bending stress from the action of all support wheels is calculated and by means of the reverse calculation of this stress the equivalent single-wheel load (ESWL) is calculated;

- in the case of a non-rigid covering the load creating the same vertical stress as the multi-wheel support is taken as the ESWL.

The method of estimating the covering bearing capacity using the reduced load has become widely used. By the action of this load in the in the endless plate of the reference covering, there appears a bending moment equal to the maximum bending moment from the impact of the real support in the same conditions, but taking into account the support wheels, passing the same track. The disadvantage of the reduced load method is that it cannot be used for those rigid coverings, the design of which differs from the classic single-layer ones.

Since 1983, ICAO has introduced into the airfield operation practice the method of presenting data on the impact of aircraft and the pavement strength, called «ACN - PCN» (Aircraft Classification Number - Pavement Classification Number). Actually, ACN and PCN are sets of codes [5] characterizing the influence of aircraft (helicopter) support on the covering and its bearing capacity, respectively. If the ACN ≤ PCN condition is met, then the covering operation for this aircraft is permissible. In this method, special importance is given not to the covering assessment as an operating structure, but to the assessment of the nominal load caused by aircraft (ACN number). Also by this method, the covering strength data are presented in the form of the nominal aircraft load, that covering can withstand without any restrictions (PCN number). The soil base strength is set by the standard [7] and is given in table 4.

Table 4

Soil base strength codes

Base code	Strength category	Hard covering bed ratio, MN / m³	
		Standard	Range
A	High	150	More than 120
B	Average	80	60 – 120
C	Low	40	25 – 60
D	Very low	20	Less than 25

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For hard coverings, the PCN value is defined as twice the equivalent unicycle load in tonnes at a tire pressure of 1.25 MPa. The PCN value is defined as twice the equivalent single-wheel load with tire pressure according to the pressure category (Table 5).

Table 5

Tire pressure codes (ICAO)

Pressure code	Pressure category	Tire pressure change limits, MPa
W	High	No limitation
X	Average	1,01 – 1,5
Y	Low	0,51 – 1,0
Z	Very low	Less than 0,5

The procedure for calculating the ACN classification number is the following [4]:

- initial data are formed for calculation (load on the main support, pressure in the wheel tires, the number and coordinates of the main landing gear wheels, the area and size of large and small semi-axes of the tire elliptical imprint;

- the design thicknesses of the rigid covering are determined on the basis of standard strength; the effect of the calculated support should cause in the covering a bending stress of maximum value equal to the standard (2.75 MPa);

- for the design covering thicknesses on the base of different strength codes the aircraft ACN numbers are determined.

When calculating the an aircraft ACN number on a rigid covering, it is assumed that the trace of the contact with the plate surface has the shape of an ellipse or oval. According to ICAO recommendations, the central area of the helicopter parking lot, which is to withstand the static load from the helicopter, as well as the load due to the movement of taxiing helicopters is equal to:

- a diameter of at least 0.83D of the largest helicopter, the pad is designed for;

- the taxiway width, in case a helicopter parking lot is intended for through taxiing on the ground.

However, the existing ICAO recommendations [6] do not give a clear idea of the method for calculating the rigid helipad coverings thickness. Much attention is paid to the geometric plan dimensions, layout, location and orientation of the heliport. At the same time, the calculation of covering for strength is not separated from the calculation of aerodrome pavements.

When calculating hard coverings by the traditional method, it is necessary to provide compliance with the main condition:

$$m_d \le m_u,, (2),$$

where m_d – the calculated bending moment at the plate cross section;

m_u – the maximum bending moment at the plate cross section.

Moreover, when calculating strength, the transition from the stress-strain state under load at the edge to the central loading state is carried out by means of a transition factor [3] depending on the covering type. Thus, for concrete and reinforced concrete coverings without docking and plate edge reinforcement it is equal to 1.5; for concrete and reinforced concrete coverings with edge docking and edge reinforcement - 1.2; for prefabricated coverings of prestressed reinforced concrete plates - 1.0; for reinforced concrete coverings with unstressed reinforcement it is determined according to [3].

In calculating the maximum possible stress in the covering design, given the dynamics and overload, should not exceed its minimum load-bearing capacity (taking into account possible change in the material strength). The difference between the values of the two points should not be more than 5%. The FAA (Federal Aviation Administration) [7] either does not separate the calculation of helipad covering from the aerodrome pavement calculation. According to item 509 of this document, calculation of heliport coverings should be carried out in the same order as aerodrome coverings (designed for airplanes with take-off weight up to 13,8 t). When calculating coverings for such load in a critical sections are not allocated in the covering. As for the calculation and construction of the helipad rigid covering technique itself, according to § 505 [7] the covering should consist of a cement-concrete layer and underlying layer and the subgrade. To select the required thickness of the covering structural layers the FAARFIELD program (abbreviated from FAA Rigid and Flexible Iterative Layer Design) should be used. However, when calculating the covering to maintain light aircraft (and [7] refers helicopters to this class) the use of above program is not required. When designing a covering for aircraft with a take-off weight of up to

5.67 tons, it is allowed to take the cement-concrete covering thickness of 4 inches (101.6 mm) without calculation. If the take-off weight ranges from 5.67 to 13.6 kg, the covering thickness increases to 6 inches (152.4 mm). When designing a covering for heavy aircraft (takeoff weight higher than 13,607 tons) one should use paragraph 3 of these recommendations. In this case, the calculation and selection of thickness should be performed using the FAARFIELD program. This program can be used to calculate rigid and non-rigid coverings, to assess the strength of existing coverings, to calculate their reinforcement. When calculating hard coverings, FAARFIELD uses the maximum horizontal stresses at the bottom of the slab as the main indicator of the coverong service life.

According to [7], when designing helipad coverings, it is necessary to take into account the short-term (0.2 sec) overload using factor 1.5 for the case of «hard» landing (Fig. 1).

Dynamic load 1.5 x takeoff weight (TOW- 3B)

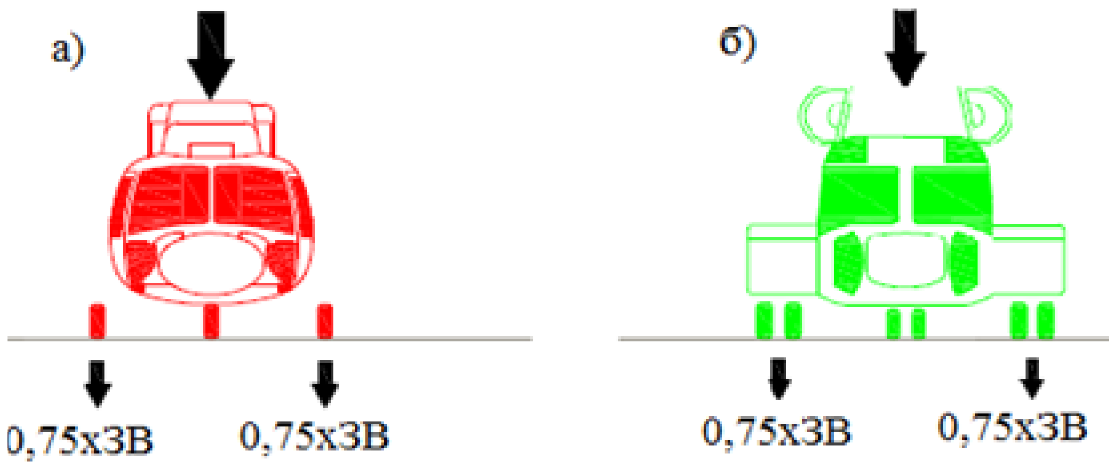


Fig. 1. *Load distribution on the helicopter main landing gear at «hard landing»: a) - typical single-wheel configuration; b) - typical two-wheel configuration*

One of the main differences in designing coverings for helicopters from thouse for aircraft maintenance is the dynamics of takeoff and landing operations (Fig. 2).

While an airplane has to develop a certain speed to take off from the ground, the helicopter takes off from the spot, in certain conditions using an «air cushion». During both helicopters and airplanes landing the phenomenon of dynamic blow is observed.

If the exact weight of the helicopter is unknown, the conditional helicopter concept is used depending on the heliport class, i.e., it is assumed that the main landing gear of a conditional helicopter will account for 75% of the maximum takeoff weight (in «hard» landing conditions).

The FAARFIELD program selects the thickness of the cement-concrete paving plate based on the assumption of edge loading, the aircraft main support is located either in the longitudinal or transversal direction relative to the covering plate edge. As a design stress a higher stress in the lower part of the plate is taken obtained from two load sets. The stress value is reduced by 25% to take into account its transfer through the pin connections.

When working with the FAARFIELD program, the input data are: tensile strength of concrete in bending, design service life (in years), covering structural layers data (elasticity modulus, thickness, Poisson's ratio), the composition of aircraft movement and the subgrade elasticity modulus (the elasticity modulus E is used, instead of the bed coefficient, since the elastic half-space model is used in calculation). There is a dependence between the value of the bed coefficient k and the subgrade elasticity modulus:

$$E_{SG} = 1{,}26 \cdot k^{1{,}284}, \quad (3)$$

where E_{SG} –elasticity modulus of the soil base, psi (pounds per square inch);

k – bed ratio, psi.

Converting the units of measurement into the SI system (kgf / cm^2) we obtain

$$E_{SG} = 0{,}9546 \cdot k^{1{,}284}. \quad (4)$$

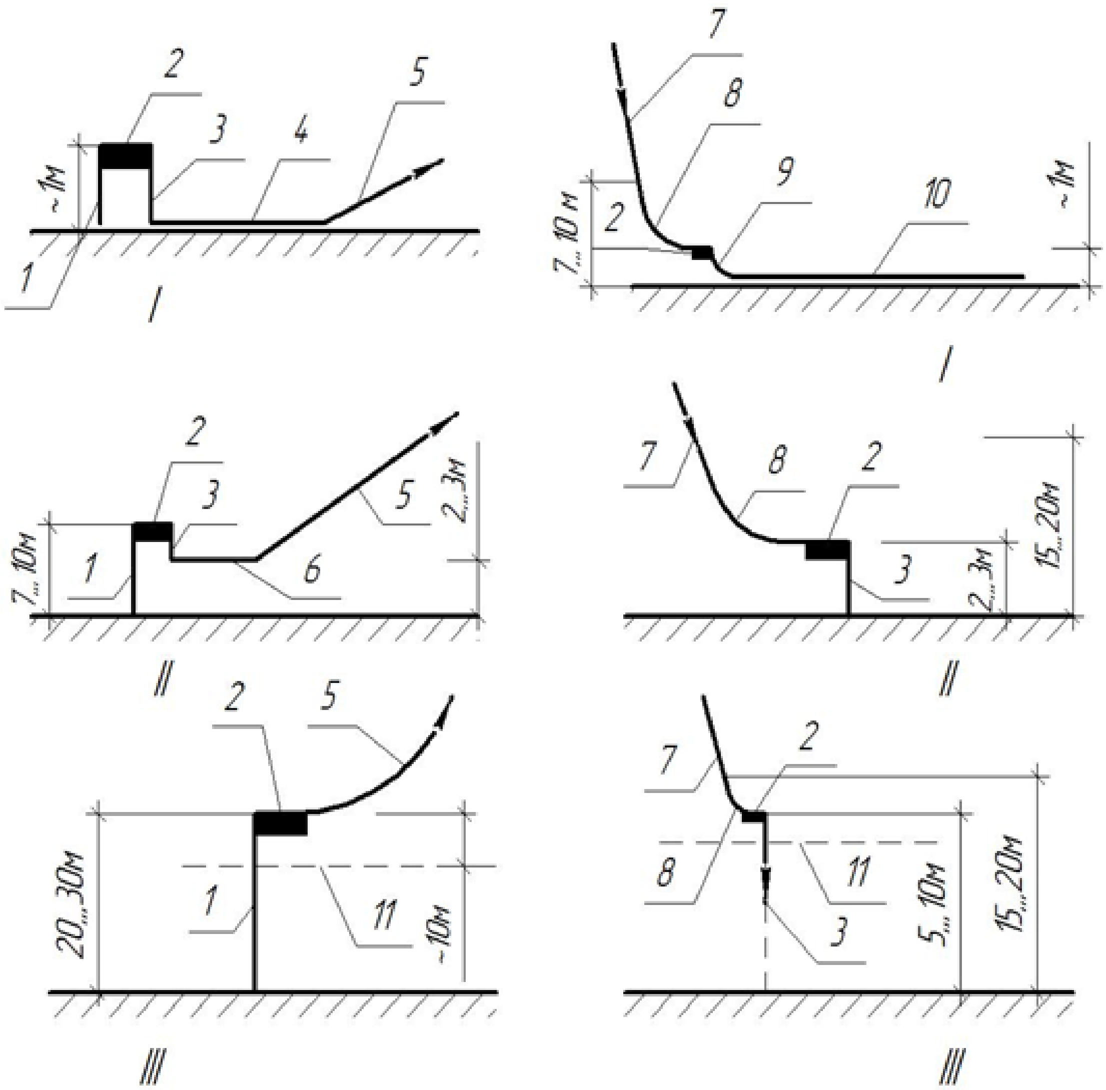


Fig. 2. *The scheme of helicopter takeoff and landing operation:*
a - take-off; b - landing; I - by airplane, II - by helicopter using the "air coushion" effect; III - the same, but without the "air coushion" effect; 1 - vertical takeoff; 2 - control hovering; 3 - vertical landing or descent; 4 – take-off run; 5 - acceleration with a climb along an inclined trajectory: 6 - almost horizontal acceleration to a speed of 20-30 km / h; 7 - slow descent with a constant trajectory slope; 8 - alignment with intense speed reduction; 9 - landing at a speed of 30-40 km / h; 10 – landing run with wheel braking; 11 - surrounding obstacles

When converting the units of measurement, it was taken into account that: for the elasticity modulus 1 psi is equal to 0.0069 MN / m^2, and for the bed coefficient 1 psi is equal to 0.272 MN / m^3.

The program calculates only the concrete covering thickness, the thicknesses of the remaining layers are set manually by the user. It should be noted that under the FAARFIELD program covering is modeled by plates of 9x9 m size [8]. To determine the stress-strain state of the covering plates, it is desirable to use the FEAFAA (Finite Element Analysis Federal Aviation Administration) software package.

The disadvantages of the above mentioned method include the fact that the recommendations are given for designing coverings only for helicopters with a takeoff weight of higher than 13.6 tons. That is, the calculation of coverings for light and medium weight helicopters is not considered at all, and for heavy helicopters it is recommended to use the same methodology as for aerodrome pavements.

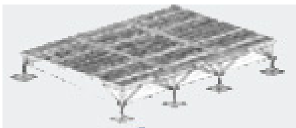
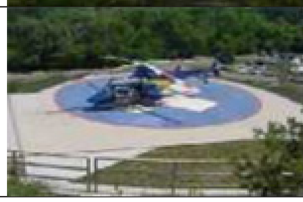
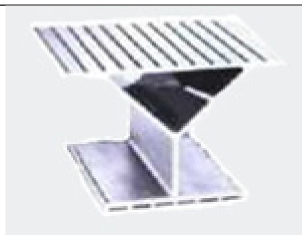
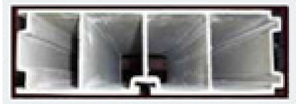
In general, there are many methods for calculating different designs of hard coverings, both domestic [1] and foreign [8]. However, none of the proposed approaches fully takes into account the specifics of helipad coverings.

Types of helipad coverings. Nowadays, in heliport construction, in addition to traditional materials, you can use aluminum and composite panels, apply a special anti-slip coating, make helipads of any shape from prefabricated blocks, etc. As for the possible location of the sites, there are almost no restrictions. They can be: mobile; on rough terrain; terrestrial; on the roofs of buildings and structures; on pontoons; on sea or river vessels and yachts; on offshore drilling rigs; by individual projects. The construction of helipads in cities should be singled out. As a rule, helicopter transport is widely used in large cities. Because of the lack of free space, take-off and landing pads are often arranged on the roofs of buildings. In this case, the use of traditional materials for coverings is undesirable because it will result in a significant additional load on the load-bearing elements of the structure. In recent years, to construct such structure solutions from prefabricated blocks have become widely used (Table 6).

PORTAPAD - aluminum pads, assembled from a standard set of prefabricated modules (assembly is performed by two people for two hours). Installation of the PORTAPAD helipad does not require either special soil preparation foundation or concrete cushions. It can also be installed on an inclined surface. The PORTAPAD helipads can accept helicopters weighing up to 7 tons. They are available in a square configuration of 6x6 and 9x9 m and may be equipped with an additional attached stairs.

Table 6

Panels used for prefabricated helipad coverings

Description of the design	Panel type	Type of pad
PORTARAD aluminum pads. Set of modules for quick assembly and disassembly of mobile platforms (within two hours)		
SOLOY aluminum pads. Mobile pads, ready for installation on rough terrain.		
HELOMAT aluminum designs. Panels intended for installation of pads on level surfaces (ground pads).		
HELISLAT aluminum designs. Panels designed for installation of pads lifted above the surface (on the roofs of buildings, sea vessels, drilling rigs, etc.).		
HELISTOP composite designs. Universal purpose panels to install pads lifted above the surface.		

SOLOY are mobile platforms ready for installation on rough terrain. They are indispensable for receiving helicopters in hard-to-reach areas. There are three size types to take helicopters of 2.7 - 5.7 tons.

HELOMAT (aluminum structures) - this type of structures (panels) is designed to construct helicopter pads at surface level (on any dense surface or ordinary soil) and successfully replaces concrete ones. They are also used for the

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reconstruction of worn and damaged concrete helipads on the roofs of buildings and in other heliport modifications. These aluminum structures can be installed directly on the concrete covering.

HELISLAT (aluminum structures) - this type of structures (panels) is an ideal solution for equipping helipads on the roofs of buildings and by special and individual projects (on sea and river vessels, on offshore drilling rigs, etc.).

The advantages of block structures include high manufacturability, speed of performing work, the possibility of relocation, resistance to chemicals, high maintainability. But such designs are used mostly for helicopters of class 3-4 (according to the ICAO classification), i.e., their behavior is unknown when using such helicopters as the Mi-8. A serious obstacle to their mass use is also the lack of regulatory documentation. At the moment SNiP 2.05.08-85 has expired validity and until the approval of a new regulatory document the ICAO regulatory documentation should be used. However, there are no recommendations for lifted helipads designing and calculation there either.

Approaches to improving the existing calculation methodology. Analysis of the above data shows that at the moment neither domestic nor foreign regulations [3, 6, 7, 9] can provide a holistic method of calculating helipads (Table 7). In Ukraine, the situation is complicated by the fact that a new regulatory document is still under development. It is proposed to use ICAO recommendations when designing helipad coverings.

To compare the existing methods of designing and calculating heliport coverings, the ICAO and FAA recommendations have been analyzed. The results of the analysis are given in table. 7.

Table 7

Comparison of existing methods of calculating coverings, their shortcomings

№	According to FAA recommendations (USA)	According to ICAO recommendations (European Union)
1	For light and medium helicopters, it is proposed to arrange the coverings without calculation, which leads to uneconomical use of the material.	ICAO recommendations pay considerable attention to determining the heliport plan parameters, its location, marking the main areas, but the strength of the coating and its calculation is not considered separately from the aerodrome pavements.
2	Designing and calculating helipads lifted above the ground level are not considered.	Heliport coverings are not separated from airfield ones, i.e., only cement-concrete coverings are considered.
3	The use of block helipads for light and medium helicopters is not considered.	There are no recommendations for designing and calculating coverings for light and medium helicopters.

Analyzing table 7, the following should be noted:

1. None of the presented methods separates the calculation of heliport coverings from aerodrome pavements;

2. The presented techniques do not consider the use of the latest materials (composite covering structures) to create helipads for light and medium helicopters (at the ground level or lifted above the ground);

3. These methods refer only to the wheel support of the helicopter, the sliding landing gear effect is not considered at all;

4. The FAA recommends to take the covering thickness without calculation in the case of a helicopter take-off weight of up to 13.6 tons. Such approach os not grounded with calculation and determination of helicopter forceful impact on the covering, it doesn't allow to determine the efficiency of covering operation in each particular case.

To eliminate these shortcomings, it is necessary to solve the following problems:

-to investigate the consistent patterns of the loading process effect onto heliport coverings from the main landing gear of new and perspective helicopters, to carry out numerical modeling of the heliport coverings stress-strain state depending on the of the main landing gear location in helicopters of different types.

-to workout recommendations for calculating and designing helipads located at the ground level, lifted above the ground level and thouse located on building roofs

CONCLUSION

1. Due to the analysis of existing methods of heliport designing and calculation (ICAO, FAA) it is found out that since the beginning of mass use of helicopter transport, the issue of selecting coverings for the landing pads has not been separated from the aerodrome coverings. The regulations do not tuch the problems of designing, selection of structure and calculation of coverings on building roofs, as well as helipads lifted above the ground level.

2. It is determined that the weight of modern helicopters varies over a very wide range (from a few quintals to 50 - 60 tons in the case of Mi-26). There are also some differences in aircraft classification. The ICAO offers a classification, dividing helicopters into 4 weight categories by the takeoff weight (1 - up to 2 tons, 2 - from 2 to 5 tons, 3 - from 5 to 10 tons, 4 - more than 10 tons). The American Aeronautics Association generally allocates 8 helicopter weight categories (up to 0.5 tons ; 0.5 - 1.0 t; 1.0 - 1.75 t; 1.75 - 3.0 t; 3.0 - 4.5 t; 4.5 - 6.0 t; 6.0 - 10.0 t, 10.0 - 20.0 t, 30.0 - 40.0 t).

3. As a result of the analysis of the regulatory documents (ICAO, FAA) - it is found out that it is recommended to use cement-concrete as a helipad covering material, explained by to the fact that the regulatory documentation does not pay attention to light aviation aircraft. The only option of joint basement of airplanes and helicopters at the aerodrome is considered, in which case the use of a cement-concrete covering is justified.

4. Given that the helicopter weight varies over a wide range, it was found that different types of coverings should be used for different weight categories (beginning from designs lifted above the ground level for light and medium helicopters and ending with cement-concrete coverings for heavy helicopters).

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АНОТАЦІЯ

Бєлятинський А., Першаков В., Акмалдінова О., Акмалдінова В. Розрахунок та технології проектування вертодромних покриттів.

Стаття присвячена аналізу існуючих методів розрахунку жорстких вертодромних покрАиттів, як вітчизняних так і закордонних. Значна увага приділяється геометричним розмірам в плані та розмітці; розташуванню та орієнтації вертодромів. Розглянуто типи вертодромних покриттів; матеріали, що використовуються при будівництві вертодромів; вид конструкцій (панелей), призначений для будівництва вертолітних майданчиків на рівні поверхні (на будь-якій

АННОТАЦИЯ

Белятинский А., Першаков В., Акмалдинова А., Акмалдинова В. Расчет и технологии проектирования вертодромных покрытий.

Статья посвящена анализу существующих методов расчета жестких вертодромных покрытий, как отечественных так и зарубежных. Значительное внимание уделяется геометрическим размерам в плане и разметке; расположению и ориентации вертодромов. Рассмотрены типы вертодромных покрытий; материалы, используемые при строительстве вертодромов; вид конструкций (панелей), предназначенных для строительства вертолетных площадок на

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щільній поверхні або звичайному ґрунті), що успішно замінюють бетонні, а також для реконструкції зношених та пошкоджених бетонних вертолітних майданчиків на дахах будинків і в інших вертодромних модифікаціях; місця можливого розташування вертолітних майданчиків, що можуть бути різними за розмірами та конфігурацією: мобільні, на пересіченій місцевості, наземні, на дахах будівель і споруд, на понтонах, на морських або річкових суднах і яхтах, на морських бурових платформах, за індивідуальними проектами. Проаналізовано підходи до удосконалення існуючої методики розрахунку та проектування жорстких вертодромних покриттів.

Наведено порівняльний аналіз нормативної документації та рекомендацій ICAO, FAA, СНиП 2.05.08-85, в яких не надано чіткого уявлення про методику розрахунку товщини жорстких вертодромних покриттів, не виокремлено розрахунок покриттів вертодромів від розрахунку аеродромних покриттів, не виділено критичні перерізи при розрахунку покриттів на навантаження від гвинтокрилів, не враховано основні відмінності проектування покриттів під вертольоти від покриттів для обслуговування літаків, що полягають у динаміці здійснення злітно-посадочних операцій.

Оскільки, вага сучасних вертольотів змінюється у великому діапазоні, встановлено, що під різні вагові категорії необхідно використовувати різні типи покриттів (починаючи від конструкцій, піднятих над рівнем землі під легкі та середні вертольоти та закінчуючи цементобетонними покриттями під важкі вертольоти).

Ключові слова: *проектування жорстких покриттів аеродромів та вертодромів, вертолітний майданчик, розрахунок та проектування аеродромних покриттів.*

уровне поверхности (на любой плотной поверхности или обычном грунте), которые успешно заменяют бетонные, а также для реконструкции изношенных и поврежденных бетонных вертолетных площадок на крышах домов и в других вертодромных модификациях; места возможного расположения вертолетных площадок, которые могут быть различными по размерам и конфигурации: мобильные, на пересеченной местности, наземные, на крышах зданий и сооружений, на понтонах, на морских или речных судах и яхтах, на морских буровых платформах, по индивидуальным проектам. Проанализированы подходы к совершенствованию существующей методики расчета и проектирования жестких вертодромных покрытий.

Приведен сравнительный анализ нормативной документации и рекомендаций ИКАО, FAA, СНиП 2.05.08-85, в которых дано четкое представление о методике расчета толщины жестких вертодромных покрытий, но расчет покрытий вертодромов не отличается от расчета аэродромных покрытий, не выделяются критические сечения при расчете покрытий на нагрузки от вертолетов, не учитываются основные отличия проектирования покрытий под вертолеты от покрытий для обслуживания самолетов, связанные с динамикой осуществления взлетно-посадочных операций.

Поскольку вес современных вертолетов меняется в большом диапазоне, установлено, что под разные весовые категории необходимо использовать различные типы покрытий (начиная от конструкций, поднятых над уровнем земли под легкие и средние вертолеты и заканчивая цементобетонными покрытиями под тяжелые вертолеты).

Ключевые слова: *проектирование жестких покрытий аэродромов и вертодромов, вертолетная площадка, расчет и проектирование аэродромных покрытий.*

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