

Application of Roads Diagnostics and Certification Results for Destination of Aircrafts Takeoff and Landing Sites

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Abstract

The information about requirements for aerodrome sections and modern methods of public roads diagnostics and certification for aircraft takeoff and landing sites definition is presented in the article.

Keywords: Aerodrome road sites, mobile scanning system Topcon IP-S3, GPA, radargram, road base, inspection, roads diagnostics and certification.

INTRODUCTION

Significant experience of takeoff and landing onto and from roads has been accumulated in different countries since spring 1945 when A.I. Pokryshkin aviation division conducted military operations by fighters Bell P-39 "Cobra" against fascists' army using motorway near the city of Gerlitz in Byelorussia. The results of the military trainings in Byelorussia with use of storm troopers SU-27 and fighters MIG-29 evidence that if it is necessary light airplanes can use any rectilinear section of length from 1,0 up to 2,5 km without bridges, barriers, posts, wires and trees as a runway.

In 2016 the technology of military airplanes landing was perfected on Minsk-Mogilyov road section. It was determined that caring capacity of road base construction of the category I allow carrying the load not only from the light aircrafts but also from the freight aircrafts IL-76.

There is planned to built more than 1600km of roads in Russia till 2020 with the sections of double function on them.

REQUIREMENTS FOR AVIATION SECTIONS OF ROADS

The sections should be horizontal with free air approaches without artificial structures and crossings with engineering

communications.

While choosing and justifying the aerodrome road sections possible unfavorable development of the situations in the world should be analyzed for 20 years ahead and it is necessary even on the stage of concurrence, surveying and projecting to provide the land reservation for service and technical area, detached grounds and lay of line.

The sections for placing the objects of landing, radio navigation and air traffic control, road – building materials store-house, fuels and lubricants and ammunition, waste treatment facilities, gas –distributing stations, transformer substations, area for road- building machines, access lanes and engineering communications are detached sections [3,10].

In his work R.I. Mogilyanetz gives the detailed information about geometrical parameters and the scheme of aerodrome road sections [8] [10].

The length of the sections of airstrip aerodrome road section in normal conditions (air temperature +15 C, the object is situated on the sea level, average slope of airstrip is 0) is taken equal to: site I-500m, site II-200m, site III - 200m, middle site -700-1100m.

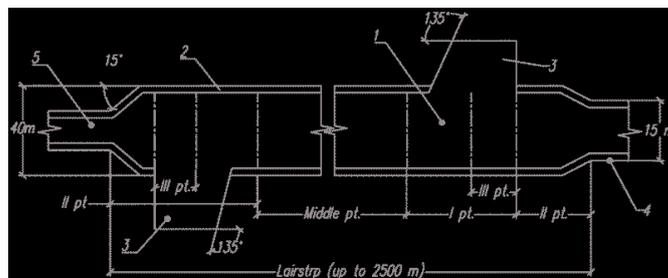


Figure 1. Scheme of aerodrome road site:

1 –airstrip with road base; 2- side safe margins, 3 – site for aircrafts, 4 – taxiway, 5 – road carriageway, 6 – roadside, L_{air} – length of airstrip

Table 1. Geometrical parameters of aerodrome road section according to the set of regulations 34.13330-2012 (Russian Federation)

Road category	Amount of strip lanes	Width of road elements			m		Width of airstrip road site elements, m		
		A	B	C	D	E	F	G	
I-a	4	7,5×2	2		20,75	11,5	17	40	
	6	11,25×2	0,75	3,75	28	8,5	23,25	40,25	
I-6	4	7×2	2		19	12	16	40	
I-B	6	10,5×2	0,5	3	24,5	9,5	21,5	40,5	

Airstrip width should be not less than 40m, but road pavement width is not less than 16m. Aviation road airstrip section width is to be taken according to the values mentioned in the table 1 in dependence on the road category.

On the roads of I-a, I- 6, I-B categories the design airstrip width is provided by road base construction on dividing strip according to the scheme of airstrip cross profile of aviation road section (fig. 2). Convex and concave curves radiuses in airstrip cross profile are not less than 8000m. On the sites I the strip profile surface should not have more than two crevasses.

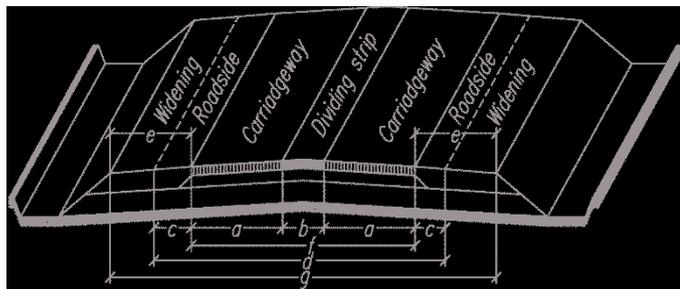


Figure 2. Airstrip cross profile scheme

A – road base; B – dividing strip; C – roadside; D- existing road bed, E – widened of the road section; F –road bed; G – aviation road section

Works and target of existing roads investigation

The situation is more difficult with the net of public roads of II –IV categories. Such sections on the local net should be also reserved for the sanitary zone and agricultural aviation. That is why it necessary to make changes in normative documents of road design and construction, taking into consideration aerodrome road sites presence. Decision about their use is possible on the base of the diagnostics and certification results after the fulfillment of the following works:

- Laser scanning for determination the geometrical parameters of wayside and assessment of road surface state by the scanning system Topcon IP-S3
- Instrumental assessment of road surface state with the

help of diagnostics movable laboratory “Trassa”, plant “Dyna -4M” and the control device of evenness in the road construction (PCRS-2Y);

- Georadar observation of the structure
- Control digging of road base through the whole depth with sampling for definition of material physical mechanical properties;
- Laboratory testing of the materials sampled from the structure for definition of the physical – mechanical characteristics of asphalt concrete
- Detection of typical road sections with road base structure of the same type;

The main target of investigation is to get Both needed information characterizing physical mechanical properties of road base structural layers and geometrical and strength properties enough for taking sustainable and reasonable characteristics to choose perspective sections with their future application in aviation. The content and volume of investigation of the nonrigid road base in every specific case can differ in dependence on specific conditions and problems during projecting, their technical economical reasonability and effectiveness of the solutions based on obtained results.

In general case the content of the works based on methodology recommended for road base investigation by some branch normative technical documents of Russian Federation [1, 4, 5, 9].

In order to define perspective for aerodrome road section and also problem sections requiring urgent repair and consequently immediate investment it is necessary to diagnose and certificate roads [5]. Nowadays there are innovation methods and modern equipment which provide maximal effectiveness while completing such work.

Usually such work is done with the help of road mobile laboratories of the type of KP-517 with “Trassa” facility, which equipped with fixation systems of sensor registration of passed way, surface evenness, adhesive capacity and additional plants such as the control device of evenness in the road construction (PCRS-2Y) and Dyna-3M. Measuring process is completed during road laboratory passing along the section under observation. At this time the sensor information is registered, and treated by on-board computer. The received data allows analyzing and determining the road sections for aerodrome road sites having deviations from Standard requirements for planning repair actions.

Wayside laser scanning technology application

Laser scanning equipment is used to define geometric characteristics of road elements, stop area and enclosed bus stops, road signs conditions, enclosures, presence of trees and bushes and other parameters on the wayside territory. It is a mobile and productive method which allows accelerating the processes of diagnostics and consequently finding the sections suitable for aviation needs.

Technology of mobile laser scanning provides application of the system consisting of satellite receiver Topcon, laser scan and panoramic – spherical video cameras, registration image data of the under investigation site area. The velocity of the geometrical parameters changes in comparison with mobile diagnostics laboratories increases in 2-3 times. In condition of dense traffic flow it is a significant factor. The problem is: the under observation road sections are usually under traffic intensive load and to do any road diagnostics works on them without creating any obstacles for main flow is difficult. Mobile system helps provide workers' safety on the roads due to the fulfillment of the part measurements by non-contact method that is why there is no need for specialists to go onto the road.

Machine registers more than 700 000 points per second with definition of their location according to the coordinates with accuracy up to 1cm. It is showed that high accuracy of geodesic survey is achieved in road diagnostics and certification.

By present time not all kinds of diagnostics can be done by mobile systems of laser scanning. For example to determine cohesion capacity, rut depth, road base stability is possible only by contact method.

The problem of using «Topcon» IP-S3 is quite serious and should be collaborated by the pilot measurements results and researches. It is connected with the ditches depth of road base influence on the road safety and safety of takeoff-landing aircrafts. While heavy raining there is appeared accumulation of water in ditches caves which at certain traffic speed promote water holes and origins the effect of aquaplaning resulting the loss of wheel contact with surface and loss of control.

The appearance and development of the laser scanning method is a significant step in the road technology development that is why this kind of diagnostics for roads certification will take a deserving place among the perspective technologies in the nearest future. Nowadays mobile scanning laboratory is a perspective and high productive means which can be used in some kinds of road works for experimental targets.

The plant is still undergone certification and the process of its recognition as the type and means of measurement that is why the results of the operation cannot be considered official in distinction of mobile road laboratories.

Inspection of road base strength properties by the plant of dynamic loading

During detailed inspection there are conducted field study of road structures which include linear tests of typical road sections and the tests on control sections to compare linear tests in different times.

Road base linear tests are done by the plant of dynamic loading Dyna -3M in the mobile diagnostic laboratory KP-514MP of «Trassa»

To determine road structure factual deflection and module of elasticity on the example of truck road M-4 Don corresponding to the assumed percent of the deformed pavement surface there were obtained the results of linear tests are subjected by static treatment. According to these results there is constructed cumulative curve (Fig. 3) and make a decision about factual deflection of the construction corresponding to the assumed percent of deformed pavement surface

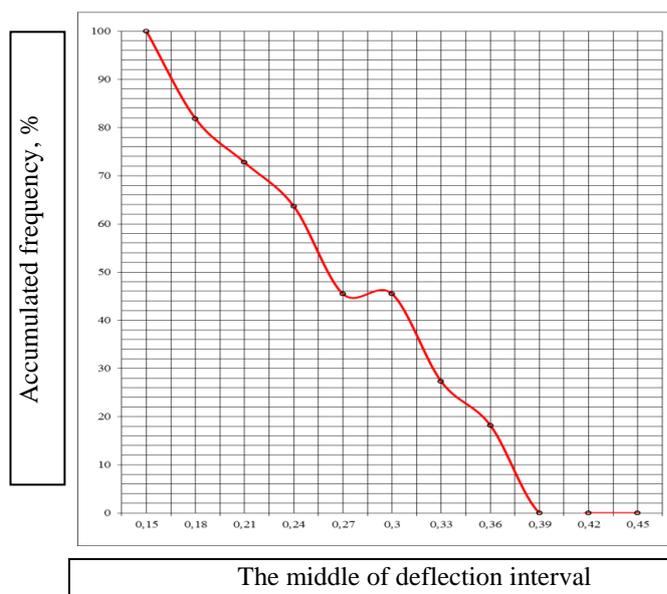


Figure3. Cumulative curve in coordinates “Accumulated relative frequency – The middle of deflection interval”

To define factual value of the deflection from the point on the ordinate axis with assumed probability of surface damage (r_{domi}) there is constructed horizontal line up to the cross with an accumulative curve. From the cross point vertical line is dropped on the axis of abscissas where the unknown value is found.

The value r_{domi} is defined by the dependence:

$$r_{\text{lim}} = 1 - K_H (1)$$

Where K_H – designed or normative level of road base reliability

By diagram of curve table find $l_{\text{fact}} = 0,35$ (fig.3).

Than the factual module of elasticity is determined: $E_{\text{fact}} = 608$ MPa



Figure 4. The example of road base operated structure on highway M-4 “Don”.

The results of analysis of road base structure cross profile shows that the thickness of asphalt-concrete pavement structure varies in the limit from 0,15 m up to 0,30 m (fig.4).

Verification of road base structure parameters with the help of georadar

Aviation road sites should have design bearing capacity that is why in accordance with the regulation п. 5.2.3 Autotodor Organization standard 10.1-2013 [9] point. 5.2.3 STO Autotodor 10.1-2013 [9] without definition of road base layer thickness or when it is necessary to make elaboration of them the inspection is conducted by the method of radio metrical probing.

Radio metrical inspection of road structure is completed in accordance with methodological recommendations of road inspection by georadars approved by Federal Agency of “Rosavtodor” [1]. According to this document road structure scanning is done along traffic lanes.

Georadar is a geophysical device intended for founding out different objects including nonmetallic ones in different environment. Georadars are used to solve different problems including:

- definition of road base layers thickness and type;
- definition of hard surface reinforcement character (frequency and depth of reinforcement location);
- detection of defects in hard surface;
- inspection of subbase with finding zones decompaction, improved moisture etc.;
- search of underground communications.

Georadar operation is based on the radio waves capacity to reflect from the borders of the media with different permittivity or conductivity.

Radiated transmitting antenna (fig.1) into media under inspection electromagnetic impulse is reflected from the objects in it (both metallic and nonmetallic) or any heterogeneities having different from the media dialectical permeability or conductivity. So heterogeneities can be hollow spaces, different rocks layer interfaces, sections with different moisture.

Reflected signal is taken by receiving antenna transforms into digital kind and remembers in the computer storage for further treatment.

At radar movement onto the surface under inspection the signal package (radar gram or profile) is on the screen which helps to determine the location, depth of location, length of objects and thickness of layers with homogeneous permittivity.



Figure 5. Horn antennas block AB -2500R automobile suspension and sensor of passed way.

Georadar is possible to operate at environmental air temperature from + 40 up to - 40 °C. To the greatest extent the temperature factor influences computer work. While using standard computer (notebook) during the operation at negative temperatures it is to be inside the automobile cab where the air temperature should be higher than the temperature at which computer operation is allowed. (usually in the limit 0...50°C). While using georadars with contact antennas it is undesirable to make measures during rains as in the case of antenna blocks depressurization electronic equipment can stop working.

Control boring is fulfilled for definition of physical-mechanical properties of road base layers and also permittivity of materials and ground of every road structure layer which allows completing depth scale calibration on the registered radar grams and increasing accuracy of measurements while received radar grams decoding.

According to the boring results there can be introduced corrections into the radar gram treatment parameters definition (fig. 6)

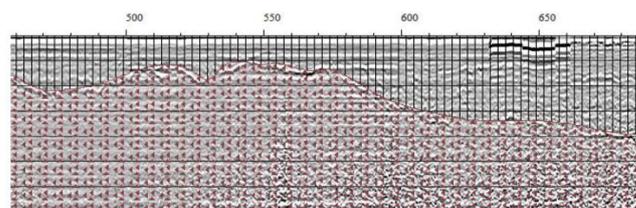


Figure6. Fragment of radar gram showing the character of changing of asphalt concrete layer thickness of the pavement on the street 20-leiya Oktyabrya in the city of

Mechanism of deformation and destruction of asphalt concrete road surfaces

One of the main factors determining the possibility of application and the service durability of road surfaces for aircraft takeoff and landing is the road structure strength.

Road structure durability is the capacity characterizing road structure to take loads from traffic means and weather – climatic factors.

Road structure durability is the main traffic operation index influencing on road technical level and operation condition [6, 7, 2].

The mechanism of forming deformation and destruction on asphalt concrete surface is:

- a) The most probable main cause of asphalt concrete exfoliation and crumbling can be binding insufficient durable cohesion with mineral components of asphalt concrete mix. Because of bitumen aging process that is the changing of group chemical content and bitumen cohesion durability in time.

During the process of asphalt concrete mix preparation for surface arrangement there is often used granitic crushed stone and granitic sifting from Pavlovsk open cast mine which is acid rock. It is known that bitumen adhesion is not enough for acid rock that is why it is needed the application of modifier (or surface active substance) to improve binding adhesion for mineral compound of asphalt-concrete. According to recommendation of Mintrans of Russia № 157 (01.11.2007) the application of modifiers allows lasting of surface life duration upon 8-10%. That is why during road repair process it is necessary to use modified bitumen.

- b) Reflected cracks on the existing cracks on public traffic stop grounds the biggest part of them can be prevented by geolattice placing during the surface arrangement process
- b) Longitudinal cracks in the frame of public stop grounds and parking can be the result of structural unequal strength on carriageway and plot as usually the plots were constructed later than carriageway had been and because of the traffic wheels influence the stone materials under the carriageway were worn more;
- c) Annually growing traffic intensity and over moisture structure sections on cracks area leads to their extension, expansion and then to transformation of small damages into depression [6,7,2].

Big amount of precipitins results water migration through the cracks under the road base and their accumulation there. Moisture evaporation from under the surface becomes difficult that is why the structure on the overmoistured earth ground begins to destruct under the traffic load.

According to the diagnostic test results and certificating of motor ways there are projected the sections suitable for aviation road sections

CONCLUSION

1. Nowadays the actuality of changing in standard documents on public road design and construction providing the sections for aircraft take-off and landing does not give rise to doubt.
2. According to the diagnosis the creation of aerodrome sections on public road provides the possibility of aircrafts take-off and landing at extraordinary situations outside the aerodromes
3. The arrangement of detached aerodromes road sections with necessary for take-off and landing infrastructure allows expanding the aerodrome net significantly.
4. The aerodromes sections on II-IV categories roads allow providing their effective use in agricultural, medical and forest protection aviation.

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