AIR TRANSPORT SAFETY MANAGEMENT AND THE RESISTANCE OF AIRPORT PAVEMENTS

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Summary: Article approaches the issue of air traffic safety in terms of airport pavement serviceability, especially their bearing capacity. It describes the importance of determining the strength of airport pavements and the factors to be taken into account the requirements of international regulations and documents. Specifically, the specified requirements for the determination of strength of airport pavements method for determining the ACN and PCN, methods of measuring the actual resistance of airport pavements and forms its processing and publication.

Keywords: Airports pavement, bearing, ACN, PCN

1. INTRODUCTION

The aim of my work is to offer insight into the problems solution resistance of airport pavements. The work contains the general characteristics of cement concrete and asphalt roads, the determination of bearing strength in air traffic safety system, by measuring the resistance of ACN and PCN methods, methods of comparison ACN / PCN approach to the design and evaluation of airport pavement bearing capacity and last but not least the practical part of the resistance of the measurement.

The primary task of every airport operator is to ensure maximum safety to ensure the smooth and unimpeded operation of the airport operational areas (AOA). Carrying capacity of airport pavements is one of the most important factors which depends on the level of security AOA affecting both take-off and landing and aircraft.

Transport Authority together with the competent authorities, based on the legislative conditions, determine the rules for determining the resistance of airport pavements. The construction of roads is dependent on the frequency of operation. Planning and continuous maintenance achieves a high life paved airfields. The main factors which significantly affect the construction of the road are mainly congestion, durability, strength soil and not least the diameter distribution of the individual layers in all structures, as well as conditions affecting the external environment.

In this work we pointed out possible innovative solutions in determining the bearing strength of airport pavements, as well as due to technical progress are gaining new methods for determination of strength and overall analysis of the technical measuring resistance of airport pavements.

2. PAVEMENT BEARING STRENGTH

In general, the Strength of runways, aprons and taxiways must comply with the maximum load exerted aircraft whose operation can be expected at the airport. Such a plane is called the critical load plane and drawn critical load.

Load of the airplane to the ground, based not only on the total weight of the aircraft, but also on other factors and by:

- the number of wheels on the main undercarriage leg,
- spatial arrangement wheel chassis
- chassis type,
- tire inflation.

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The bearing strength of a pavement intended for aircraft of apron (ramp) mass greater than 5 700 kg shall be made available using the aircraft classification number — pavement classification number (ACN-PCN) method. The aircraft can operate at airports without limitation the value ACN providing aircraft manufacturer it is less or maximum equals the value of the airport PCN.[2]

2.1. Determining the ACN/PCN

Aircraft classification number (ACN) - A number expressing the relative effect of an aircraft on a pavement for specified standard subgrade strength.

Pavement classification number (PCN) - A number expressing the bearing strength of a pavement for unrestricted operations.

At the outset, it needs to be noted that the ACN-PCN method is meant only for publication of pavernent strength data in the Aeronautical Information Publications (AIPs). It is not intended for design or evaluation of pavements, nor does it contemplate the use of a specific method by the airport authority either for the design or evaluation of pavements. In fact, the ACN-PCN method does permit States to use any design/evaluation method of their choice. To this end, the method shifts the emphasis from evaluation of pavements t o evaluation of load rating of aircraft (ACN) and includes a standard procedure for evaluation of the load rating of aircraft. The strength of a pavement is reported under the method in terms of the load rating of the aircraft which the pavement can accept on a nun restricted basis. The airport authority can use any method of his choice to determine the load rating of his pavement. In the absence of technical evaluation, he chooses to go on the basis of the using aircraft experience, then he would compute the ACN of the most critical aircraft using one of the procedures described below, convert this figure into an equivalent PCN and publish it in the AIP as the load rating of his pavement.[7]

The ACN-PCN method also envisages the reporting of the following information in respect of each pavement:

a) pavement type;
b) subgrade category ;
c) maximum tire pressure allowable; and
d) pavement evaluation method used.

In the ACN-PCN method eight standard subgrade rigid pavement k values and four flexible pavement CBR values) are used, rather than a continuous scale of subgrade strengths. The grouping of subgrades with a standard value at the mid-range of each group is considered to be entirely adequate for reporting. The subgrade strength categories are identified as high, medium, low and ultra-low and assigned.

ACNs are calculated using prescribed technical method of ICAO. Under the ACN-PCN system, each aircraft has assigned an ACN that indicates design thickness requirements for the aircraft on a more expanded scale that ranges from an ACN of 5 for light aircraft to an ACN of 130 or more for heavy aircraft. ACN values are published for both flexible and rigid pavements and at four (4) subgrade categories that span the range of subgrade and bearing support values normally encountered. The ranges of subgrade strength covered by these standard subgrade categories (designated as A, B, C and D). The ACN of an aircraft is numerically defined as two times the derived single wheel load, where the derived single wheel load is expressed in thousands of kilograms. As noted previously, the single wheel tire pressure is standardized at 1.25 MPa. Additionally, the derived single wheel load is a function of the subgrade strength.[3]

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Table 1 Standard Subgrade Strength Designations and Subgrade Strength based on Soil Classification[7]

Ubgrade Category	Designation	Pavement type	Characteristic Subgrade Strength
High	A	Rigid Flexible	150 $MN/m^2/m$ CBR 15%
Medium	B	Rigid Flexible	80 $MN/m^2/m$ CBR 10%
Low	C	Rigid Flexible	40 $MN/m^2/m$ CBR 6%
Ultra-Low	D	Rigid Flexible	20 $MN/m^2/m$ CBR 3%

Range of Subgrade Strengths	Soil Classification	
	Unified Classification	FAA Classification
All k values above 120 $MN/m^2/m$ All CBR values above 13%	GW, GP, GM	Fa, F1, F2
60 to 120 $MN/m^2/m$ CBR 8% to CBR 13%	GC, SW, SM, SP	F3, F4, F5
25 to 60 $MN/m^2/m$ CBR 4% to CBR 8%	SC, ML, CL, OL	F6, F7, F8, F9
All k values below 25 $MN/m^2/m$ All CBR values below 4%	OM , CH, MH	F10

3. THE PROCEDURES FOR THE DESIGN AND EVALUATION OF PAVEMENT STRENGTH

In all states have different procedures and the design and evaluation of pavement strength. I chose to compare countries of Canada, French, United Kingdom, the United States.

Canadian practice

This section briefly outlines Transport Canada practices for the design and evaluation of airport pavements. Further details are available in Transport Canada's technical manual series. The practices described have evolved from Transport Canada's experience as the operator of all major civil airports in Canada. Most airport sites in Canada are subject to seasonal frost penetration and the design and evaluation practices described are oriented to this type of environment. The practices described do not apply to pavements constructed in permafrost regions where special design considerations are required. The practices outlined do not cover several topics which are as associated with and essential to the design of pavement structures.

French practice

Generally speaking, the adoption of heavy aircraft leads to damage of the road.

The user will in any case be held responsible for the deterioration of this type. But in no case shall the load aircraft more than 50 percent of the permissible load in other words, real overloaded P ratio higher than 1.5 for all of the road, except the apron for which these values are limited to 20 percent, and 1.2 respectively emergency landing of this rule.

United Kingdom

England proposed for unrestricted operational use of the device according to the loads resulting from the interaction of the adjacent bogie wheel assembly where necessary.

Classification number identifies the severity level of road handling. If the aircraft operates on solid ground by a simple two-layer model is adopted. It takes into account the influence of neighboring sets the support wheels up to a distance equal to three times the radius of relative stiffness.

United States

United States Federation Aviation Administration proposes and reports on airport pavement strength of the overall weight of the aircraft for each type of chassis. This allows the assessment of the road in view of its ability to support different types and weight of the aircraft. A comparison between the resistance of roads (marked as a high burden on aircraft equipped with one wheel, double wheels and dual tandem landing gear wheels) and the actual gross weight of one particular aircraft the ability to lay down roads that helped aircraft.[4]

4. FALLING WEIGHT DEFLECTOMETER

Falling Weight Deflectometer (FWD) was first produced in France in the early 60`s, but its development was discontinued due to difficulties in reaching the corresponding deflection measurements at the time. Currently, the most commonly used models are made of the Dynatest, Carl-BRO (Denmark) and KUAB (Sweden). The diagnostic of roads has developed over thousands of technology design repair roads, roads of all categories and set PCN on a number of airports in Europe and overseas. Other field of activity is the production of FWD / HWD (Falling Weight Deflectometer / Heavy Weight Deflectometer) it is a device used to measure the deflection of roads and airfields suddenly subdued. For the needs of these facilities innovate and develop the necessary follow-up software applications.

This is a two-wheeled trailer for towing vehicle equipped with loading device, measuring frame, and control and measuring electronics. The measuring process is controlled from the measurement notebook the vehicle controlling all functions by means of hydraulic self-gasoline engine drives. All machine parts are galvanized or corrosion-resistant finish.

The principle of measurement is laying the loading board and the measuring frame deflection sensors planted on the road.

The Weight Deflectometer (HWD) can apply a loading in the range of 30-320kN, enabling it to simulate even the most extreme aircraft wheel load such as the Boeing 777, the Airbus 340 or 380. The HWD is highly versatile and can be used to test on both rigid, paver block and flexible pavements used on roads and airports.

Key Economic Benefits

- Dynamic loading enables mechanistic-empirical analysis of the pavement layers and the determination of optimum rehabilitation strategies
- Automated and rapid structural pavement testing
- Determines the layer of failure, rather than determining simply the bearing capacity
- Compares a range of rehabilitation options, including plane off and recycling rather than just applying overlays

Key Engineering Benefits

- The HWD provides accurate, reproducible and repeatable data
- The automated load or deflection sensing ensures consistent data
- Automated and real-time monitoring of load cell, geophones and data variations ensures high quality of collected data
- Uses mechanistic analysis allowing testing of most pavement structures
- The HWD is used worldwide from the hottest and driest deserts, to the humid tropics and the cooler polar regions[5].

4.1 Application

The Heavy Weight Deflectometer has been used to evaluate hundreds of airports worldwide. The airports has implemented airports pavement management system for making performance predictions over its total life cycle and optimizing maintenance cost of a network of pavements such as Runways, Taxiways and Aprons.

The foldable HWD utilized by our consulting division is used to test both roads and airports in many parts of the world. For structural surveys in remote locations, the equipment is folded up, packed into a transport frame, and shipped by air. Once at the location, the HWD is quickly unfolded and attached to a vehicle. The power for the HWD is supplied by an independent power unit.

Figure 1 Typical HWD and this application on pavements

The impact of the weights causes the pavement to deflect, closely approximating how a pavement deflects when a truck passes over. The applied load generates a deflection basin with the deflections becoming smaller further from the load plate. A series of sensors measure the pavement deflection. Specialized computer hardware and software record the load and deflection data. Apply dynamic loads to a pavement surface, simulating the magnitude and duration of a single heavy moving wheel load. This loading system delivers a transient impulse load to the pavement surface. The pavement response (vertical deformation or deflection) at various distances from the loading plate are measured by a series (usually seven) of geophone sensors (see Fig. 2).

The deflection sensors can be adjusted to variable distances from the load plate according to user's requirement. The typical spacing in pavement design and structural evaluation is 12 inches (0,3048 m) between each sensor. A typical dynamic test applies four different load levels at discrete locations; this test is completed in less than two minutes.

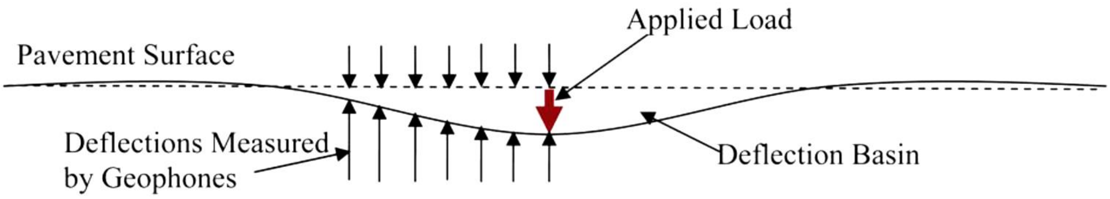

Figure 2. Schematic of load and deflection measurement

Control system, loading weight and plate, hydraulic system, and geophones.

For project level testing, test a minimum of 30 points, so the results will be statistically valid. Preferably, tests are conducted every 0.1 mile to ensure sufficient data is collected to reflect changes in soil type and pavement structure. Sufficient data allows for irregular data readings to be removed.

In forensic studies, the test pattern should also include points where the pavement is in relatively good condition, and points where distress (the cause of which the engineers are trying to isolate) is present. During testing, the air and pavement surface temperatures are measured; these factors can be taken into account later in the analysis - pavement layer thickness, layer material types, material quality, subgrade support, environmental factors, pavement discontinuities and variability within the pavement structure.

Back calculation is a complex iterative procedure in which the modulus of each pavement layer is determined. Usually is carried out using a computer program. The major inputs include surface deflection, structural layers' thicknesses, material Poisson's ratio and initial moduli estimates.

Temperature at the time of testing must be considered in estimating the initial modulus for any bituminous layers.[5]

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4.2 Software

The ICAO "Aerodrome Design Manual - Part 3 - Appendix 2" contains computer programs (source code) for the calculation of ICAO ACN's for aircraft operation on both rigid and flexible pavements. The ICAO ACN Fortran source code has been rewritten and recompiled by Transport Canada into two (2) executable stand-alone programs. The original input/output formats of the ICAO ACN programs were followed as closely as possible. The internal program calculations and equations of the ICAO programs were also followed and incorporated in the new .exe files. The result is the computation of aircraft ACN values that are fully compatible with the ICAO ACN/PCN strength reporting system for airfield pavements. The programs are available at specialist websites. ICAO has approved on October 16, 2007 the changing of the numerical coefficients entitled "Alpha factor" involved for flexible pavement in calculating the ACN of an aircraft. In the ACN of flexible pavement, the alpha factor or pavement reduction factor, is used to take into account the effect of gear geometry in computing pavement design curves for flexible pavements.[7]

PCASE, or "Pavement-Transportation Computer Assisted Structural Engineering", is a software program that incorporates all transportation design and evaluation criteria into a stand-alone software package. This package allows research to be modularized into a set of scalable and reusable software components, which are then combined to create the PCASE desktop system designed to be installed on a single computer.

Pavement **Evaluation**:

- Evaluation Equipment Support Software
  - Dynamic Cone Penetrometer (DCP)
  - Non-Destructive Testing (NDT) using Falling Weight Deflectometer (FWD) data
- Evaluation Analysis Software using empirical or layered elastic model
  - Backcalculate Modulus values based on testing data
  - Calculate allowable loads and passes based on mission traffic
  - Calculate Pavement Classification Numbers (PCN) based on mission traffic
  - Calculate overlays required to support mission traffic

understanding of the pavement design and evaluation process, the software gives them a tool to automate repetitive tasks. Calculations using ACN / PCN method are performed based on the deflection values measured by HWD. These tests give a real evaluation of the state of each construction layer. Subsequently the established PCN value expresses the real bearing capacity of the pavement structure.[6]

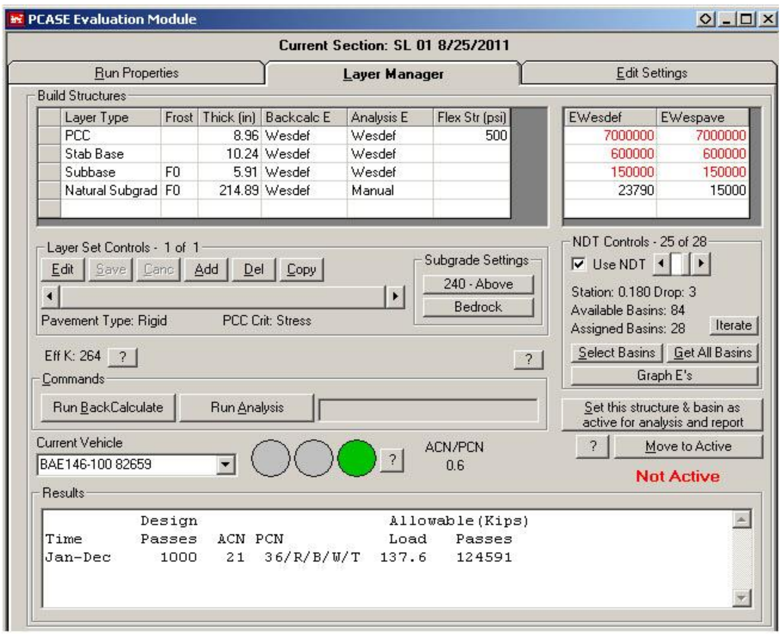

Figure 3. Bearing capacity of the pavement structure

PCN values are published in the form of percentiles for each area. This form allows the administrator of the airport to choose percentile value which:

- ensure the integrity of bearing capacity of all surfaces (i.e. the possibility of movement of the aircraft from the runway through TWY up to PRKG and vice versa)
- respects the airport marketing plans
- respects the maintenance and reconstruction plans

Practical use of percentile expression of PCN for Administrator of the airport:

- for example PCN value at level of percentile 20 expresses probability of failure appearance caused by traffic load on 20% of the assessed surface area before the expiry period. The same, 60^{th} percentile is the probability of failure of 60% of the surface
- on the new area is commonly recommended application of 20th percentile

PCN is determined for planned aircraft movement:

- for a short time period (1-5 years) in case of areas in bad condition where HWD measured deflections are extra high and therefore rapid reconstruction must be planned
- for a long time (10-20 years) in case of new areas and elderly areas in good condition.[6]

5. CONCLUSION

In practice, there are several ways the technical evaluation of airport pavement bearing capacity - and also there are a number of options processing and evaluation. In the article it is pointed out the possibility of using new methods for evaluation of pavement strength.

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