AIRPORT PAVEMENT EVALUATION AND MANAGEMENT

Since the late '80s RODECO Group has developed a Pavement Management System called RO.MA® (Road Management).

AAPMS® (Asset & Airport Pavement Management System) is the development of PMS RO.MA.®

Some recent implementations of PMS are described in this paper, with an application example of Malta International Airport.

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INTRODUCTION

The purpose of a PMS is to improve the quality of airport infrastructure and design improvements in the short, medium and long term, maximizing available resources, that are not always adequate to the needs.
AAPMS® responds to the need for an asset management tool and a PMS airport planning of interventions on airport pavement.
The survey of functional and structural characteristics of the paving, done by the use of high-performance systems, is the basis of PMS.
The most important parameters measured in the infrastructure and used by AAPMS® are the bearing capacity (measured with HWD) with ACN-PCN method, roughness and planimetric and elevation profile, surface distresses (distress and PCI-Pavement Condition Index) and skid resistance.
RODECO Group has recently developed and introduced new technologies for automatic measurement of the PCI, IRI and grip, in particular the system ADE (Automated Distress Evaluation), the PL1 (Laser Profilometer low-cost for the pavement quality control) and the micro GripTester, which allow more extensive and widespread use of high-performance systems for surveying and quality control of road and airport infrastructure.
The PMS RO.MA.® has been continuously updated in relation to the evolution of high-performance systems, the new needs expressed by users and in particular the international experience gained by RODECO in the field of Pavement Evaluation and Management System.
Particular attention was dedicated in software development, simplification and flexibility of data entry procedures, in order to reduce the amount of information necessary to obtain the results of the PMS.
The main requirements of RO.MA.® are as follows:

- provide a methodology to assess the pavement conditions (surface and structural parameters) using the definition of the Pavement Quality Index (PQI);
- provide a device to define an optimum plan of maintenance (scheduled maintenance) of a road or an airport with a priority list of interventions;
- estimate the optimal time to proceed to maintenance using appropriate models and predict paving future conditions and structural surface;
- propose planned maintenance based on optimizing the cost / benefit ratio, with any budget constraints introduced by the user.

The application of Malta has specifically highlighted as an efficient system of PMS can optimize the maintenance on a multiannual basis, substantially reducing the overall cost of management of airport infrastructure.

PAVEMENT EVALUATION

AAPMS® software was designed to process data from the analysis of the results of the Pavement Evaluation phase (field tests), divided in homogeneous sections. For the evaluation of structural and surface characteristics of pavements, there are different types of high-performance systems, which allow to quickly record all the parameters required in order for a proper evaluation of the PMS.
The phase of monitoring the condition of the superstructure is divided into several airport surveys, according to ICAO Annex 14 and ENAC "Italian Civil Aviation Authority":

- Determination of the bearing capacity of pavements with H.W.D. (Heavy Falling Weight Deflectometer) and definition of ACN and PCN parameters;
- Survey of planimetric and elevation profile and survey of longitudinal and transverse profiles using Laser Profilometer;
- 3-D Measurement of airport pavements with laser systems for definition of elevation and planimetric data;
- Measurement of pavement surface conditions, and evaluation of PCI;
- Investigations with GPR and coring to determine the pavement stratigraphy;
- Survey of the skid resistance with Grip Tester.

H.W.D. (Heavy Falling Weight Deflectometer)

The pavement structural characteristic are analyzed using the Heavy Falling Weight

deflectometer (HWD), which can adequately simulate the load conditions of an aircraft.
For each HWD measuring point, through software RO.ME. (Road Moduli Evaluation) (developed by RODECO), are estimated:

- the values of the E1, E2, E3 moduli, respectively of the asphalt layers, subbase and the subgrade under test conditions;
- the value of the asphalt layer E1 moduli layer reported at 20 ° C;
- residual fatigue life of the pavement, in years;
- the critical layer;
- the calculated reinforcement necessary to support the project traffic;
- calculation of ACN / PCN in accordance with ICAO.

Fig.1 H.W.D. test in an airport

In addition to airport pavements, bearing capacity tests of airport strips must be done, as reported in the ENAC circular of 2008.
The purpose of the surveys is to evaluate the behavior of the strips when an aircraft runs off the runway and/or emergency vehicles transit.
The strips must have enough bearing capacity to support the weight of the plane corresponding to the output of the design aircraft. The verification is done by obtaining the critical value of the subgrade modulus, which can support the weight of the aircraft.

Laser Profilometer

The Laser Profilometer is used for the survey of the pavement roughness, longitudinal and transverse profiles and the definition of the index I.R.I. (International Roughness Index), measured in mm/m.
The I.R.I. is a standardized index that contains the information required to establish the regularity of a road surface, as defined by the World Bank Technical Paper No. 45.
The irregularities of a pavement are the result of an infinite number of wavelengths that make up the longitudinal profile of a pavement.
In the airport area the size of the wavelengths that affect the regularity are generally between 0.5 - 60 meters, with widths ranging from a few millimeters to several centimeters.
The smaller irregularities are texture (macro and mega) of the road surface.
The profilometer can detect the actual profile of the pavement in the XY coordinates (relative), where X is the distance measured by the odometer and Y represents the planimetric and elevation profiles of the runway.
Generally the system is capable of storing the actual average profile every 100/200 mm of each section.
The knowledge of the amplitude to short-wave (1 - 3.3 m), medium (3.3 m - 13 m) and long (13 m - 60 m) is very important to identify the cause of the irregularities.
Where the irregularity is due to short wave is likely that the cause is to be found in the surface layers of the pavement (surface distresses), while the irregularities due to the long and medium wave may be due to problems of subsidence in the bottom layers.
The software allows, through simulation, to analyze the results filtered to obtain the values of irregularities at the wavelengths desired.
Since actual profile, the following parameters are estimated for sections of 25 m:

- I.R.I. (International Roughness Index) averaged in mm/m on 25 m sections;
- irregularities filtered to short waves from 1 to 3.3 m in mm/m on sections of 25 m;
- irregularities filtered to medium waves from 3.3 to 13 m on sections of 25 m;
- irregularities filtered to long waves from 13 to 60 m on sections of 25 m;
- simulation of a 3 m straightedge for calculating the maximum deflection, as required by ICAO standards;
- the maximum deflection on sections of 45 m and the number of irregularities that in this section exceed 20-30 mm as required by ICAO standards;
- Cross slope (%).

Fig.2 I.R.I. pavement roughness survey in the Malta Airport

The equipment includes:

- two laser to measure the cross slope for a width of about 3 meters and the longitudinal profile (IRI), with a sampling frequency of every 5 mm;
- the laser sensor located on the right wheel has a sampling frequency of 64 KHz, making it possible to detect macro texture;
- N. 3 accelerometers and N. 2 high-precision gyroscopes;
- software for data processing for the determination of cross-slope, rutting, longitudinal profiles (I.R.I.) irregularities for short, medium and long waves.

PL1 - LASER PROFILOMETER Class1 for the survey of the longitudinal profile of the airport pavements

The new profilometer PL1 was designed based on the experience acquired by the RODECO Group in over 25 years of surveys of road and airport.
The PL1 fully satisfies the need of quality checks in a systematic, continuous and low-cost way, of road and airport on every level and classification.
The measuring system consist in a kit that can be installed on any type of vehicle series, without making any substantial and permanent changes. The laser is synchronized to a precision odometer through acquisition software that controls the work.

The technical characteristics are as follows:

- 16 kHz Laser Class 1;
- 3-axis accelerometer;
- Inclinometer;
- Odometer;
- Real-time acquisition system and data synchronization.

Using the software acquisition and post-processing is possible:

- detect and process the data for the longitudinal profile of pavements and airport linked to the measured distances and the GPS signal (optional);
- calculate the IRI (International Roughness Index) in mm/m;
- produce reports and charts in 2D and 3D;
- export data in a GIS format.

Survey Distress: PCI (Pavement Condition Index) analysis

The survey on the surface distress of rigid and flexible pavements is necessary to:

- Monitoring surface degradation and its evolution over time;
- Identify degraded areas in need of emergency action;
- Provide preventive maintenance and rehabilitation to slow or halt the process of degradation and thus prolong the service life of the pavement;
- Limit the cost of routine maintenance of the pavements: preserving the surface of the pavements will greatly influence the choice of the types of maintenance in the medium and long term.

The RO.DE.CO. Group has developed advanced technologies for the automatic detection surface distress ADE (Automated Distress Evaluation).
On all airport pavements (runways, fittings, taxiways, aprons) are detected, every 4 meters, digital images using VIDEOCAR system, and simultaneously, each 25 m section, 6 different types of surface distress to 3 each level of severity are detected (ASTM-D5340-03).
Surface distresses that A.D.E. system processes are as follows:

- Longitudinal cracks;
- Transverse cracks;
- Alligator cracking;
- Potholes;
- Raveling;
- Depressions.

For rigid pavements the survey is carried out on all slabs through the use of the VIDEOCAR system and digital cameras.
A sheet is prepared for each plate including:

- one or more digital images of the slab that shows the real surface condition;
- description of existing distresses.

From ADE surveys PCI (Pavement Condition Index) of different areas (runways, taxiways, aprons) are calculated for every homogeneous sections (Reference: FAA AC 150/5380-6 of Guidelines and Procedures for Maintenance of Airport Pavements).
Are deduced from surveys:

- needs and priorities of maintenance, like sealing crack or other type of preventive maintenance;
- area or length of maintenance;
- the optimal type of maintenance;
- estimated costs of maintenance.

Each type of surface distress should be evaluated by using 2 index:

- Quantity index:% of the area needing repair of units;
- Quality index: L (low) = low severity - M (medium) = Moderate severity - H (high) = high severity.

Fig.3 Example of Automated Distress Evaluaton

The images of the pavement, as detected by the ADE system, are post-processed with a specific software "Automated Distress Evaluation" through it's possible to recognize and codify, on a database, the different types of distresses, in a completely automatic way.
The system has a license that represents a technological innovation: License n. MI2008A000307 (26/02/2008): *"Dispositivo e metodo per il riconoscimento e la valutazione automatica dell'ammaloramento superficiale delle pavimentazioni stradali ed aeroportuali".*

The PCI is a numerical index, ranging from 0 for a failed pavement to 100 for a pavement in perfect condition. PCI is divided into three classes:

- 70 ≤ PCI < 100 good
- 55 < PCI < 70 fair
- PCI ≤ 55 poor

Fig.4-5 VIDEOCAR-ADE System

Ground Penetrating Radar (GPR) Surveys

Through the use of GPR technology, it is possible to continuously detect the stratigraphy of the pavement and to estimate the thickness of the different layers.
The output of the surveys consists of numerical tables and/or graphics that provide the thickness of the different layers of the existing airport pavement.
The data obtained from the GPR surveys are used to process the H.W.D. data and for the study of PMS.
RODECO Group has a radar system equipped for the continuous survey of the stratigraphy of the airport pavements.
The system may take up to 3 antennas operating between 200 MHz and 2 GHz.
The antennas are installed on a vehicle properly equipped with the apparatus of reception, a computer process, a high-resolution color video and an odometer to measure the distances. The vehicle is able to continuously detect the stratigraphy of the airport pavements and in particular the thicknesses of the different layers, to a depth varying with the frequency of the antenna, 1 to 3 m.
The collected data can be displayed on screen in real time or processed to produce tables and graphs.
The results of investigations with the GPR are used to estimate the elastic moduli of different layers of the pavement as resulting from HWD tests.
The GPR system uses radar technology to explore the layers of the pavement, measuring the time for reflection of electromagnetic waves sent from an antenna source.
GPR is designed to make measurements of the thickness of the pavement in accordance with the ASTM Standard D4748-87.

Determination of the skid resistance with the Micro GripTester

The skid data collection of pavements has a very important rule to assess the adequacy of air traffic safety level. In addition to the traditional static methods to evaluate the friction coefficient, such as the british pendulum friction tester, there are high-performance systems that can measure the friction by a moving vehicle properly equipped.
With these measurement systems, skid resistance can be detected almost continuously, every 5, 10 meter of pavement length.
The GripTester, approved by ICAO, is a very simple device, consisting of a trailer towed to a vehicle; the trailer has two side wheels and a central wheel, braked during movement, used to measure the friction coefficient.

The braked wheel is constantly sprinkled with water by a distributor during the tests. Water comes from a tank installed on the driving vehicle.
The water flow is regulated with an electronic pump to ensure the desired thickness (eg. 1 mm of water) between the tire and pavement; this water thickness don't depend of the speed measurement.

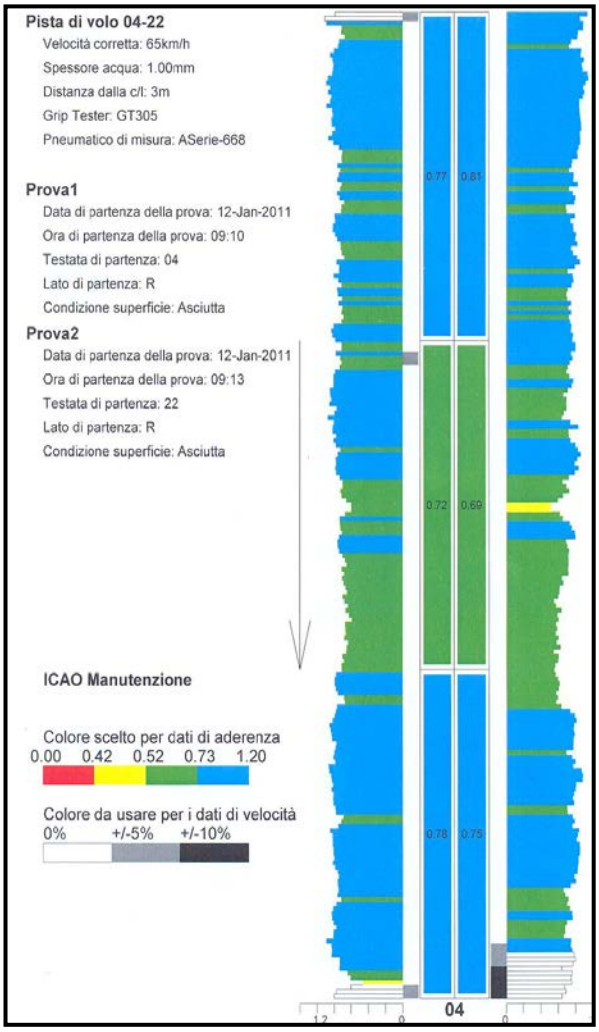

Fig.6 Output grip tests with GripTester

During the trailer movement two longitudinal strain gauges measure the strain "Fo" (which is opposed to the travel) and the vertical load "Fv", given by the weight of the trailer; "Fv/Fo" ratio is the Grip Number.
The strain gauges are connected to an electronic system that records data value of the friction coefficient measured every 10 meters on a onboard computer. The tests are performed with equipment Findlay Irvine - MK2 GripTester according to the requirements of the legislation (ICAO Annex 14 - Aerodromes Volume I - Aerodrome Design) at a speed of 65 and 95 km/h. Measurements are performed along 4 lines, at ±3 and ± 6 meters from the runway centerline.

According to the ICAO regulations, measures will be repeated for each path with two speeds: 65 and 95 km/h.

Fig.7 Grip tests with Grip Tester in an airport

Processed data can be provided in charts and graphics for every test point values, and the relative average values every third of the runway lenght, as required by ICAO standards, are reported.
In addition to the GripTester, Micro GripTester also exists for the accurate measurement of the skid resistance.
The Micro GripTester is a three-wheel manually pushed device which measures friction by the braked wheel, fixed slip principle. The device is known as a "Continuous" friction measuring equipment (CFME) as it measures continuously along the test path, rather than just taking a single spot reading.
The device carries its own water supply and has an inbuilt water control system to maintain a known water film thickness where testing of the surface in wet condition is required. Its single measuring wheel, fitted with a special smooth tread tire made to an American Society for Testing and Materials (ASTM) standard, is mounted on an instrumented axle.

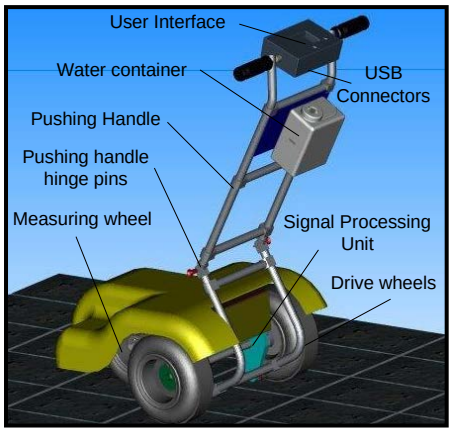

Fig.8 Micro GripTester layout