SURFACE INTEGRITY - AIRFIELD PAVEMENT CONDITION ASSESSMENT

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ABSTRACT

This paper presents current airfield pavement condition assessment and rating methodology used by the US Air Force and the Avinor (Norway). Factors included in the ratings include the Pavement Condition Index (PCI), Structural Index (ACN/ PCN), Friction Characteristics, Surface Texture, Foreign Object Damage (FOD) potential and evenness The PCI is a score from 0 to 100 that is determined by a visual survey of pavement distress based on procedures in ASTM D 5340. The Structural Index is a ratio of the Aircraft Classification Number (ACN) to Pavement Classification Number (PCN). ACN represents the structural impact an aircraft will have on a pavement. PCN represents the structural capability of the pavement to support aircraft. Friction Characteristics are primarily determined for runways using a variety of measuring equipment. Surface texture is a parameter that can be used by pilots on civil aircraft to predicting the maximum tire-to-ground wet runway breaking coefficient. The FOD Index is used to indicate the potential for FOD problems generated by the pavement. It is determined based on pavement distresses collected during the PCI survey. Evenness is essential for the ride quality of a pavement. On Airfields, there are requirements both to short- (3m) and long wave (45m) unevenness.
The paper will present procedures used in determining each of the above factors and also how these factors can be used collectively to determine the overall rating of airfield pavements.

RESUME

Cette communication présente la méthodologie utilisée pour l'évaluation de l'état et la classification des chaussées d'aérodromes par l'US Air Force et par Avinor (Norvège). Les facteurs intervenant dans la classification comprennent l'indice d'état de la chaussée (PCI), l'indice structurel (ACN/ PCN), les caractéristiques de friction, la texture de surface, le potentiel de dommages dus aux corps étrangers (FOD) et la régularité. Le PCI s'exprime en points sur une échelle allant de 0 à 100 sur la base d'un examen visuel de la dégradation de la chaussée selon les procédures exposées dans ASTM D 5340. L'indice structurel est le rapport entre le numéro de classification d'aéronef (ACN) et le numéro de classification de la chaussée (PCN). L'ACN représente l'impact structurel qu'aura un aéronef sur la chaussée. Le PCN représente l'aptitude structurelle de la chaussée à supporter l'aéronef. Les caractéristiques de friction sont déterminées avant tout pour les pistes où est utilisée toute une gamme d'instruments de mesure. La texture de surface est un paramètre qui peut être utilisé par les pilotes de l'aviation civile pour prévoir le coefficient maximum de freinage pneu/sol sur piste mouillée. L'indice FOD est utilisé pour indiquer le potentiel de problèmes FOD engendré par la chaussée. Il est déterminé sur la base des données de dégradation de la chaussée recueillies au cours de l'inspection relative au PCI. La régularité est essentielle quant à la qualité de tenue de la chaussée. Pour les aérodromes, il y a des exigences relatives à l'irrégularité à ondes courtes (3m) et à ondes longues (45m).

Cette communication présentera les procédures utilisées pour la détermination de chacun des facteurs exposés ci-dessus, ainsi que la manière dont ces facteurs peuvent être utilisés collectivement pour déterminer la classification globale des chaussées d'aérodromes.

Introduction

Airfield pavement condition assessment is essential for safe operation of aircrafts and timely performance of pavement maintenance and repair (M&R). Condition assessment is performed based on pavement condition indicators which are determined based on measurement of pavement distress, structural capacity, friction, and roughness. With the exception of roughness, all these indicators are determined on regular basis and the results combined for determining M&R priorities and requirements. Roughness measurement is performed on as need basis to help identify the source of roughness and optimum method for eliminating it. An important step before performing the condition assessment is the division of the airfield pavement into management sections. This paper presents a summary of the procedures used to divide the pavement into sections, determine the pavement condition indicators, and use of these indicators in assessing the pavement condition and M&R need and priorities. The pavement condition indicators included in this paper are the distress based Pavement Condition Index (PCI), distress based Foreign Object Damage (FOD) potential index, Non-Destructive Testing (NDT) based structural index, and skid measurement based friction index.

Pavement Network Definition

The first step in pavement condition assessment is the division of the airfield pavement network into manageable sections. Figure 1 is an example network divided into sections. The first division is based on use, i.e., runway, taxiway, or apron. Each of these facilities (also referred to as “branches”) is divided into one or more sections based on pavement structure, existing condition, and traffic distribution. The keel portion (50 to 75 ft) of wide runways (over 100 ft) are normally separated from the outside due to traffic channelization.

Pavement Condition Index (PCI)

The PCI, figure 2, is a numerical rating on a scale from 0 to 100 that is determined based on measured distress types, quantities, and severities. The PCI was developed to agree with the collective judgment of experienced pavement engineers as to the pavement structural integrity, surface operational condition, and needed level of M&R. The PCI determination procedure is described in detail in ASTM D 5340, Test Method for Airport Pavement Condition Index surveys. Figure 3 provides a list of the distresses used to calculate the PCI for asphalt and concrete pavements respectively. To determine the PCI for a pavement section, the section is divided into inspection units called “sample units”. A sample unit is 5000 SF for asphalt surfaced pavements and 20 slabs for short jointed concrete pavement. The PCI is calculated for each sample unit based on measured distress and the PCI for the section is determined as the average of the PCI of all the sample units surveyed within the section. The PCI results are displayed on the airfield layout map as shown in figure 4. For simplicity of presentation, the PCI rating scale may be presented in three categories instead of 7. The colors green (PCI = 71 – 100), yellow (PCI = 56 – 70), and red (PCI = 0 – 55) are normally used for such a presentation as shown in figure 5.

Foreign Object Damage (FOD) Potential Index

Loose objects on the runway resulting from pavement distress can be detrimental to aircraft engines specially engines that are low to the ground. The objects are ingested into the engines causing costly damage and presenting a safety hazard. Not all pavement distresses create a FOD potential, therefore a different index was identified that uses the results of the PCI distress survey but limit the distresses in the calculation to those highlighted in bold in figure 3. Figure 6 shows the FOD potential condition rating scale. The scale ranges from 0 to 100 with 0 being no FOD potential. The FOD potential condition rating is determined based on the calculated FOD index, pavement type (i.e. asphalt or concrete surfaced), and the aircraft using the runway. The lower the height between the runway surface and the bottom of the aircraft engines, the more severe the rating becomes. The FOD potential rating was determined for thee aircrafts by the US Air Force as shown in figures 7, and 8 for asphalt and concrete surfaced pavements respectively.

Structural Index

The calculation of the structural index is primarily based on the results from the non-destructive deflection testing (NDT) using the Falling Weight Deflectometer (FWD), figure 9. The procedure used to analyze the results is based on a layered linear elastic model and is performed using a set of programs known as PCASE (Pavement-Transportation Computer Assisted Structural Engineering). PCASE programs were developed and continually being updated by the US Army Corps of Engineers and can be downloaded from the following Web site “http://www.pcase.com/”. Output from the analysis include:

- Allowable loads for a selected number of aircraft passes,
- Allowable aircraft passes at a specified load, and
- Pavement Classification Number (PCN).

The structural index can be any of the above outputs but the one normally reported is the ACN/PCN where ACN is the Aircraft Classification Number. ACN represents the impact an aircraft will have on a pavement. PCN represents the capability of a pavement to support aircraft. ACN data can be obtained from different sources including the Federal Aviation Administration Advisory Circular 150/5335. Following is a brief description of the PCASE programs used in the structural evaluation:

1) BASIN: selects a representative deflection basin for each pavement section.
2) WESDEF: determines the set of layer modulus values that provides the best fit between measured and computed deflection basin.
3) TRAFFIC: determines the critical aircraft and computes equivalent passes of that aircraft based on the projected traffic mix. The critical aircraft is that aircraft from the mixture that requires the greatest pavement thickness to support its projected passes.
4) WESPAVE: computes allowable aircraft loads at the design pass level, allowable passes of the design aircraft at maximum load, required overlay thickness, and PCN. The PCN is computed based on the allowable critical

aircraft gross weight and subgrade strength. The US Air Force determines the PCN for a 50000 passes of a C-17 aircraft.

The US Air Force uses the following criterion fro evaluating the structural index; An ACN/PCN ratio < 1.1 is considered GOOD, a ratio between 1.1 and 1.4 is considered FAIR, and a ratio > 1.4 is POOR.

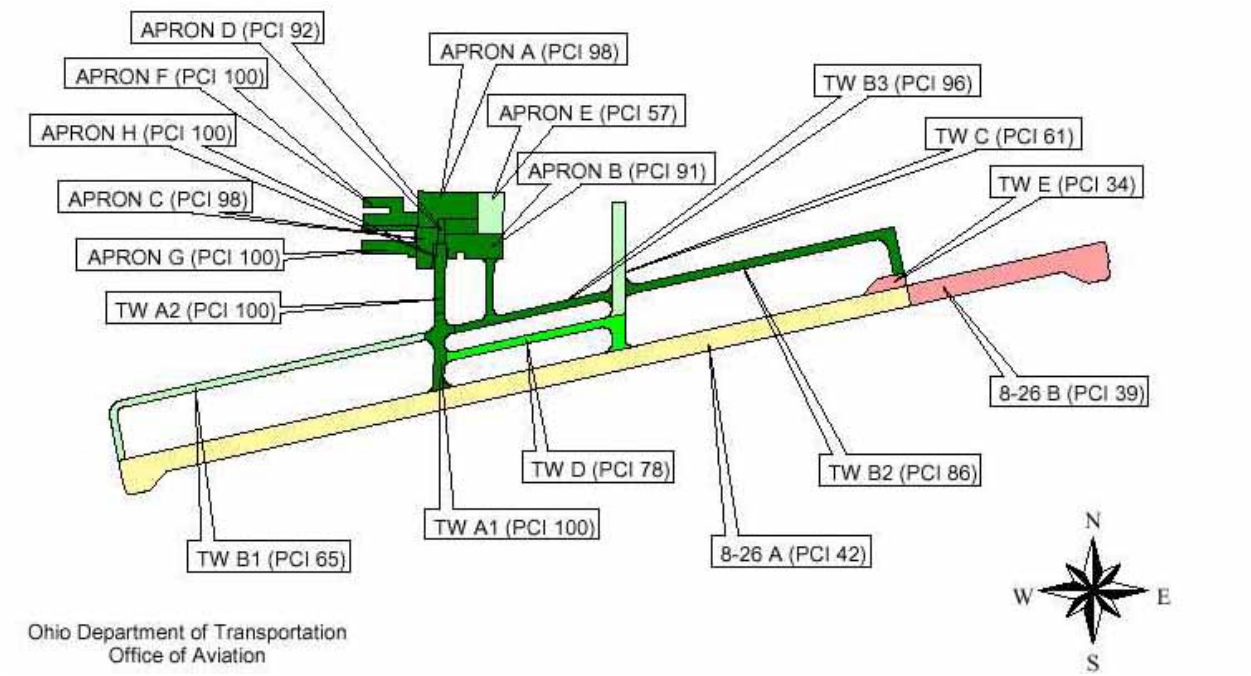

Figure 1: Airport network divided into sections.

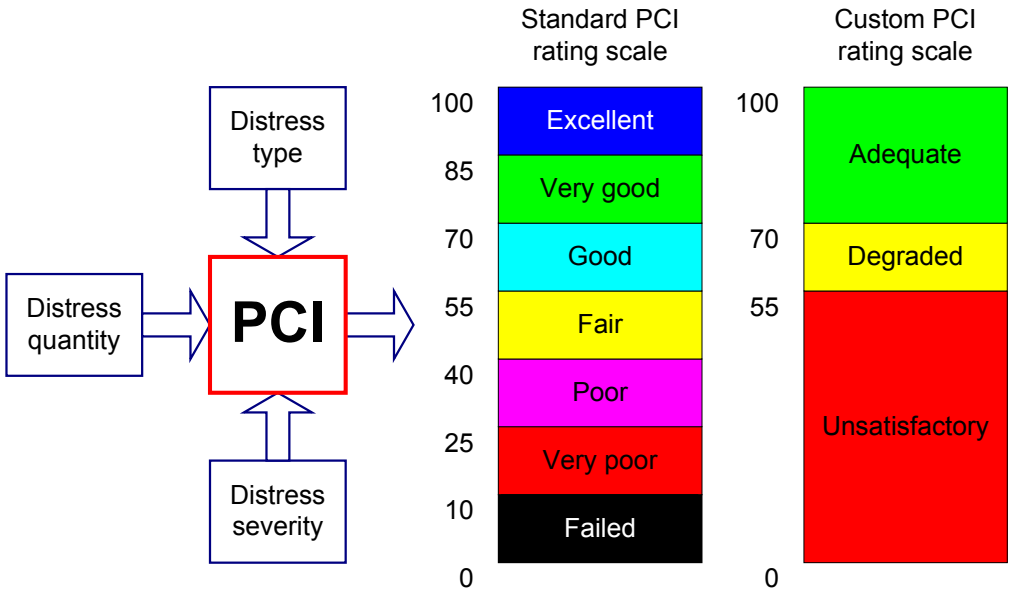

Figure 2: The Pavement Condition Index standard and custom rating scales.

PCI and FOD Asphalt distress list*		PCI and FOD Concrete distress list*	
Distress type	Severity levels**	Distress type	Severity levels**
Alligator cracking	L, **M, H**	**Blow up**	**L, M, H**
Bleeding	N/A	**Corner break**	L, **M, H**
Block cracking	L, **M, H**	**Linear cracking**	L, **M, H**
Corrugation	L, M, H	**Durability cracking**	L, **M, H**
Depression	L, M, H	**Joint seal damage**	**L, M, H**
Jet blast erosion	**N/A**	**Small patching**	L, **M, H**
Joint reflection cracking	L, **M, H**	**Large patching**	L, **M, H**
Longitudinal and transverse cracking	L, **M, H**	**Popouts**	**N/A**
Oil spillage	**N/A**	**Pumping**	**N/A**
Patching	L, **M, H**	**Scaling**	**L, M, H**
Polished Aggregate	N/A	Faulting	L, M, H
Raveling and weathering	**L, M, H**	**Shattered slab**	**L, M, H**
Rutting	L, M, H	Shrinkage cracking	N/A
Shoving	L, **M, H**	**Joint spalling**	**L, M, H**
Slippage cracking	**N/A**	**Corner spalling**	**L, M, H**
Swelling	L, M, H		

* FOD distresses are in bold.
** Severity levels are defined as (L)ow, (M)edium, and (H)igh

Figure 3: PCI and FOD distress lists for asphalt and concrete airfield pavements.

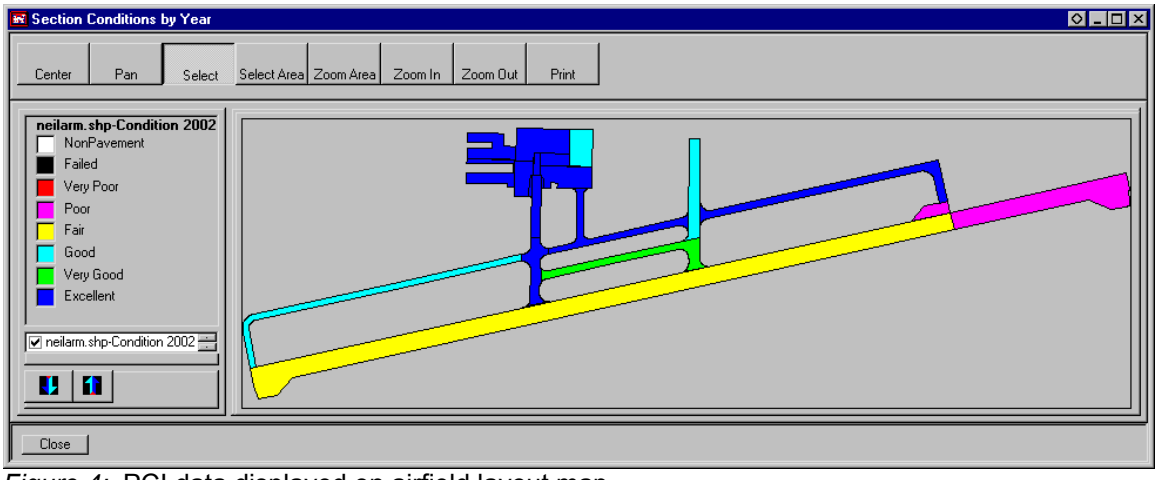

Figure 4: PCI data displayed on airfield layout map.

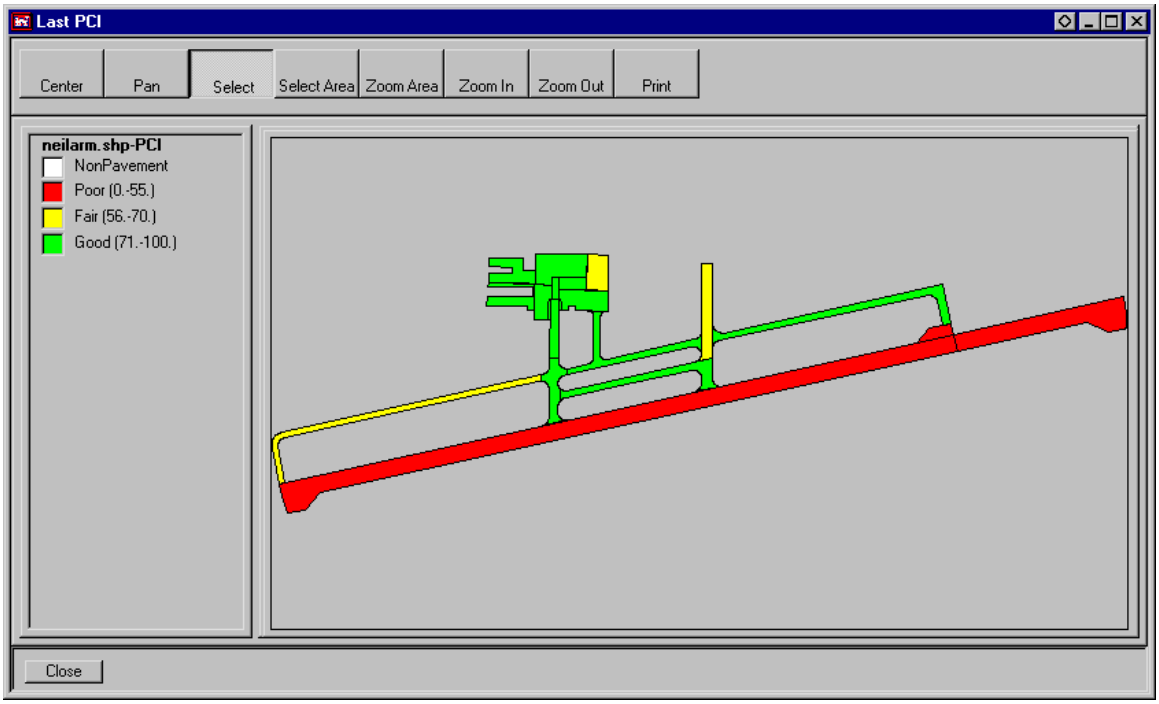

Figure 5: PCI data displayed with simplified categories, good (green), fair (yellow), and poor (red).

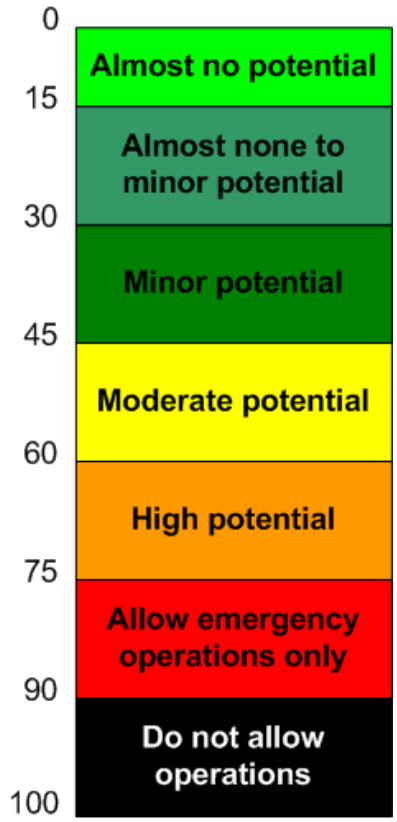

Figure 6: Rating scale for the Foreign Object Damage (FOD) Potential Index.

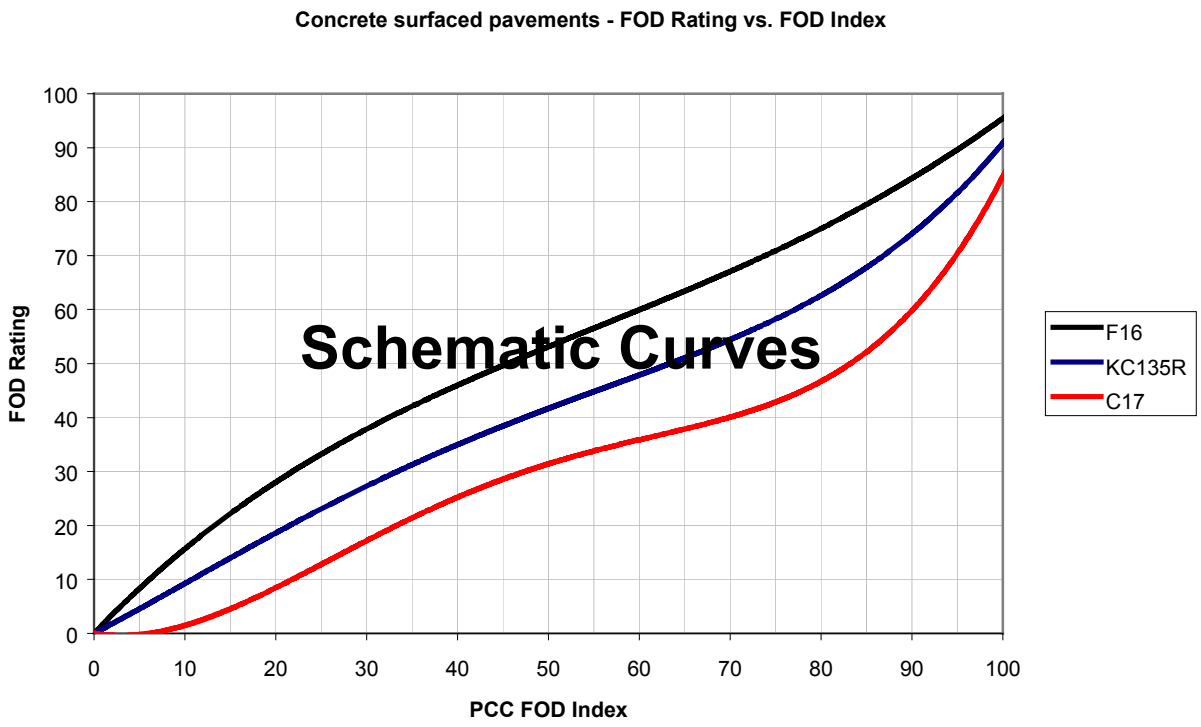

Figure 7: Schematic curves in development for 3 aircraft types on AC pavements.

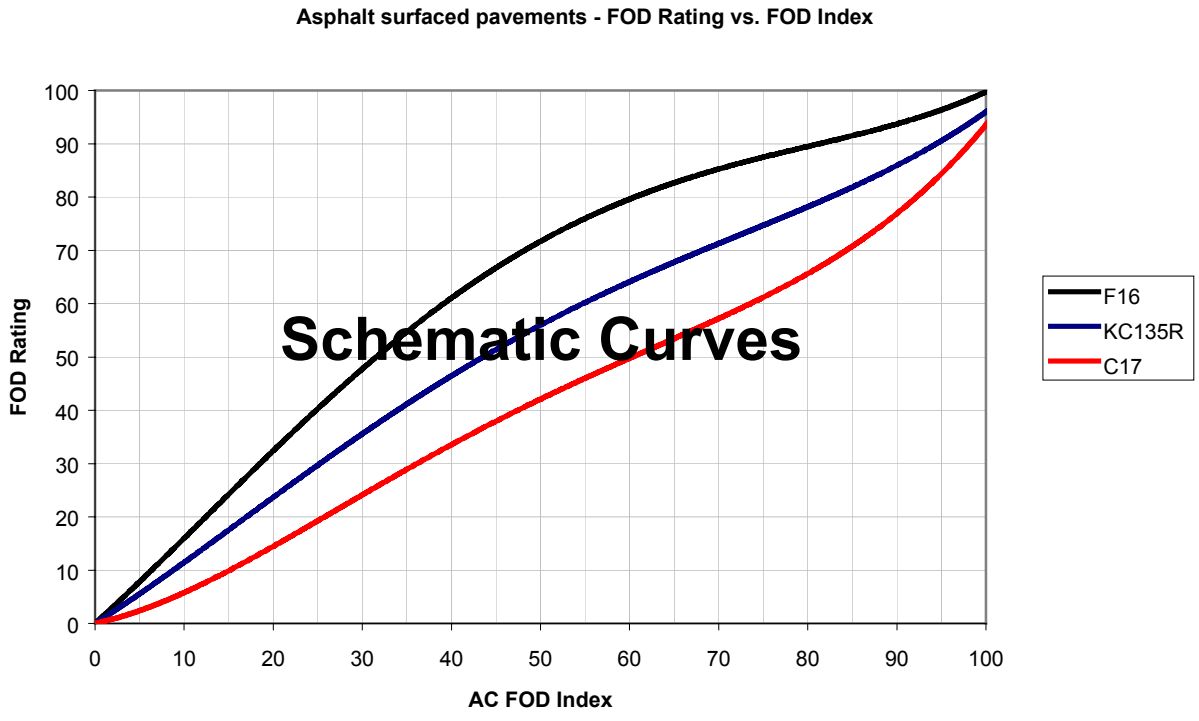

Figure 8: Schematic curves in development for 3 aircraft types on PCC pavements.

Figure 9: Falling Weight Deflectometer (FWD) testing.