CALGARY | SWIFT – CAPTG | SEPTEMBER 2006

AIRFIELD CONCRETE PAVEMENT RESTORATION (CPR) WORKSHOP

PAVEMENT DISTRESS ASSESSMENT
AND
NON-DESTRUCTIVE TESTING

JOHN EMERY

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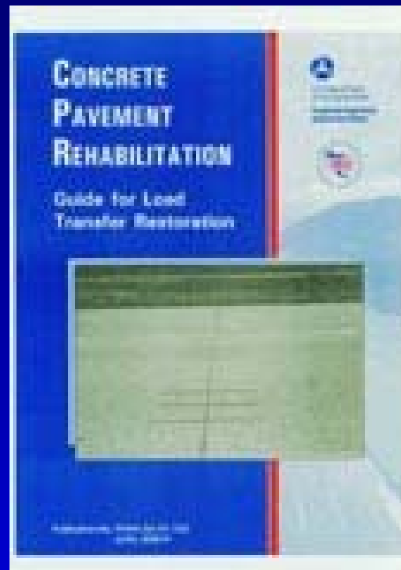
THE TECHNICAL ASSISTANCE OF ALAIN DUCLOS AND JESSICA HERNANDEZ OF JEGEL IS GREATLY APPRECIATED

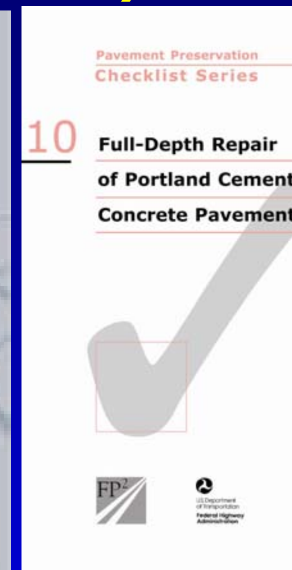
TYPICAL AIRSIDE PAVEMENTS DESIGN, CONSTRUCTION, MAINTENANCE, REPAIR, REHABILITATION AND STRUCTURAL/FUNCTIONAL MONITORING REFERENCES

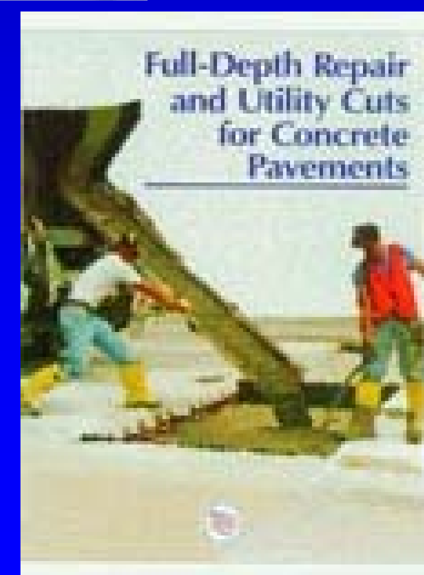
- ICAO – AERODROME DESIGN MANUAL, PART 3 "PAVEMENTS", PARTICULARLY ACN-PCN METHOD FOR REPORTING PAVEMENT STRENGTHS
- FAA – AC 150/5320 "AIRPORT DESIGN AND EVALUATION"
  - AC 150/5335 "STANDARDIZED METHOD OF REPORTING AIRPORT PAVEMENT STRENGTH EVALUATION"
  - AC 150/5370 "USE OF NONDESTRUCTIVE TESTING IN THE EVALUATION OF AIRPORT PAVEMENTS"
  - AC 150/5380 "GUIDELINES AND PROCEDURES FOR MAINTENANCE OF AIRPORT PAVEMENTS
- USAF – ETL 99-7 "PAVEMENT CONDITION ASSESSMENT STANDARDS", PARTICULARLY PAVEMENT CONDITION INDEX, FRICTION INDEX, STRUCTURAL INDEX AND FOD INDEX

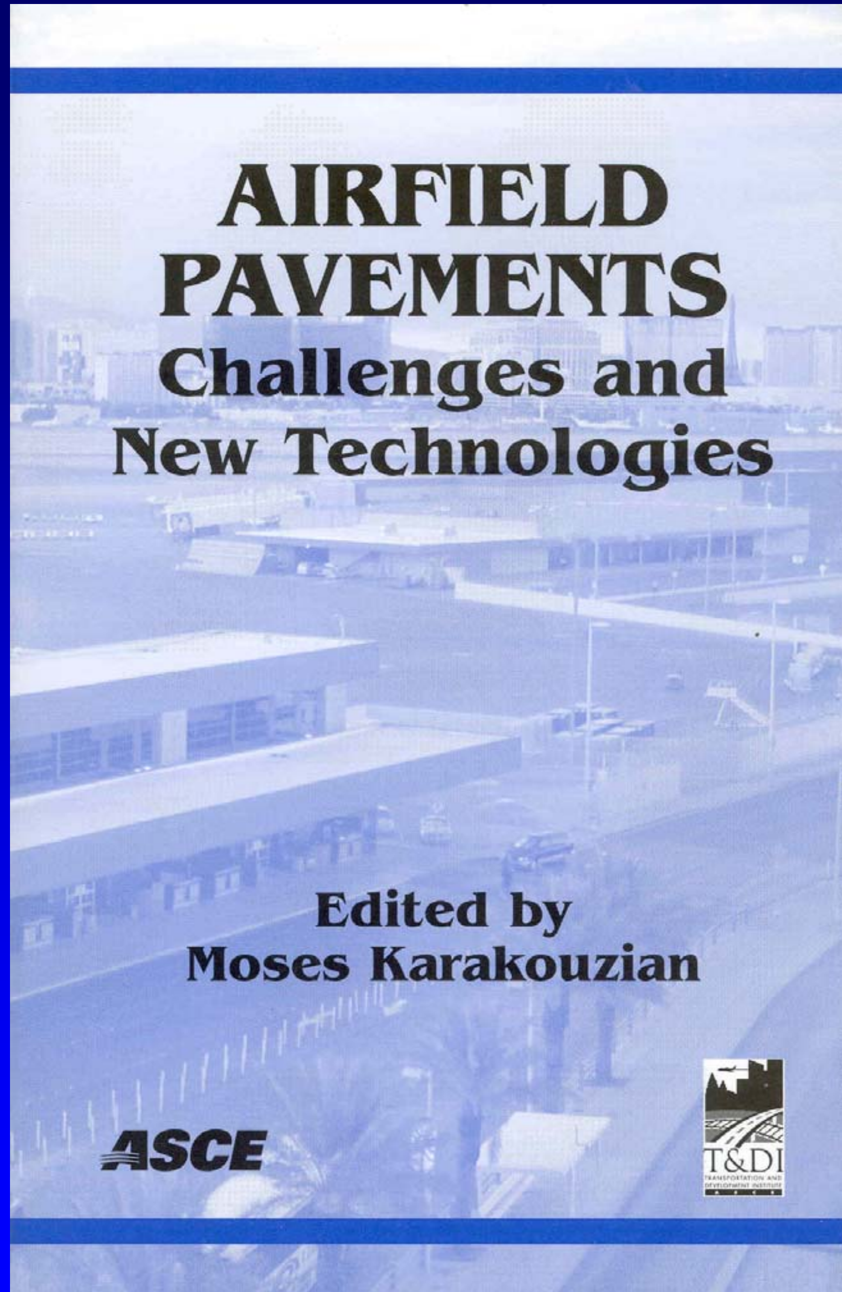
(NOTE: MOST PWGS/TC MANUALS ARE NOT CURRENT, PARTICULARLY FOR NDT.)

TYPICAL FHWA/PCA/ACPA REFERENCES FOR CONCRETE PAVEMENT RESTORATION (CPR)









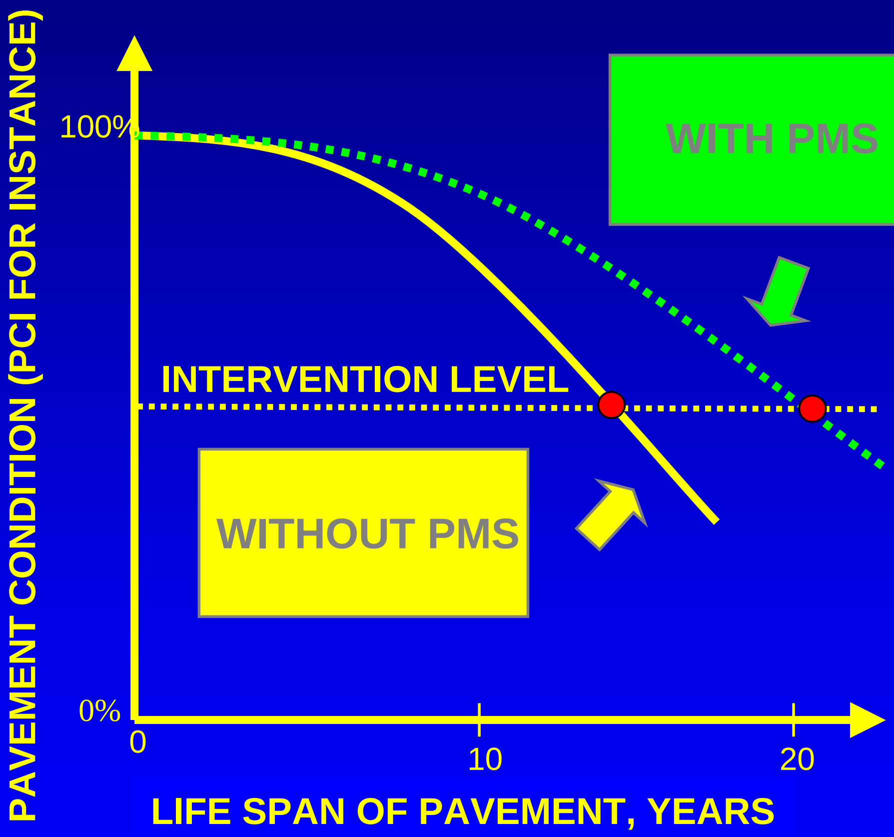
ASCE 2004
www.pubs.asce.org

PAVEMENT MANAGEMENT PHILOSOPHY

IT IS IMPERATIVE TO PRESERVE (MAINTAIN) THE EXISTING PAVEMENT INFRASTRUCTURE

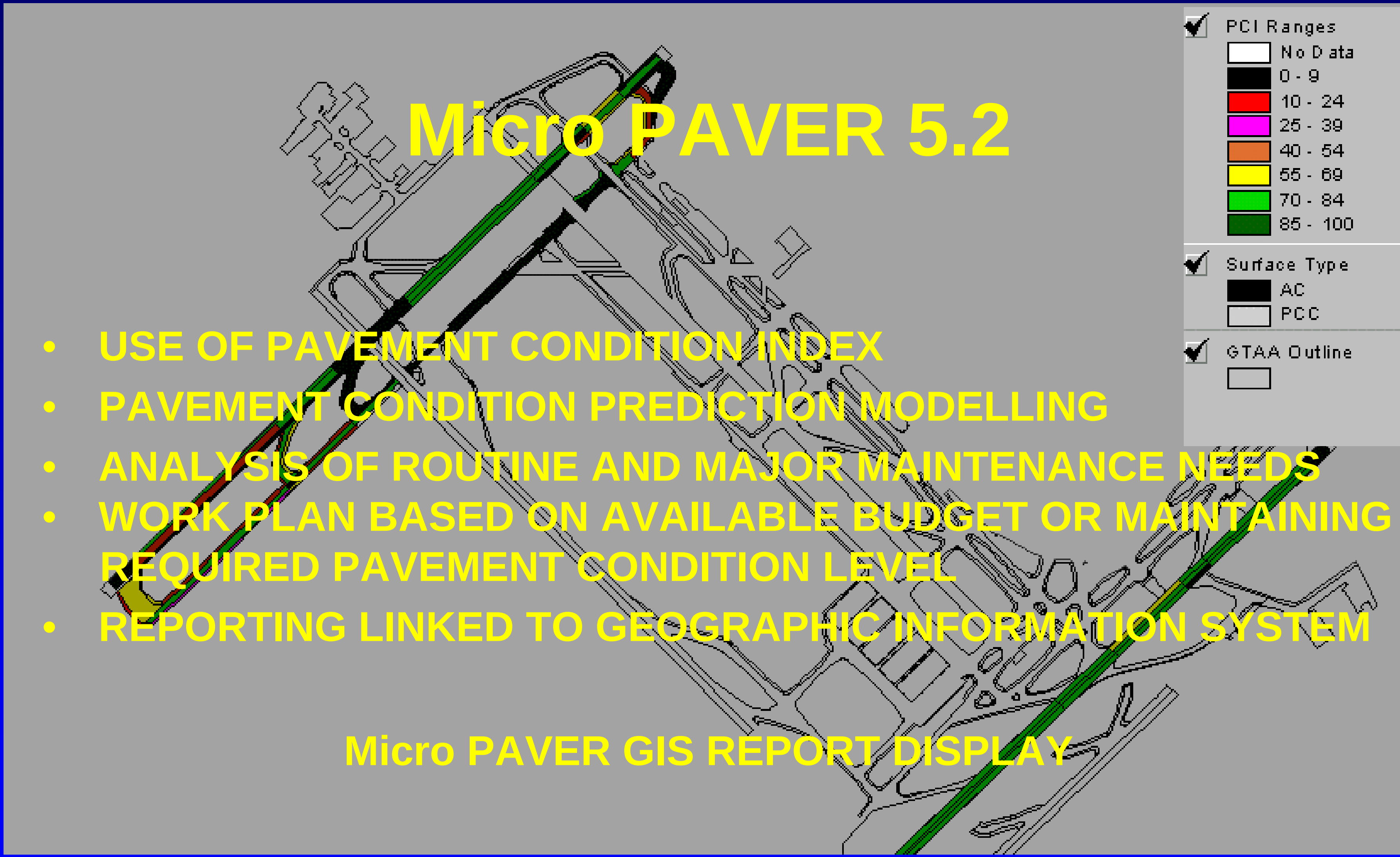
INVESTING…

- **AT THE *BEST* TIME**
- **WITH THE *BEST* METHOD**
- **WITH THE *BEST* COST/BENEFIT (LCC) RATIO**



PAVEMENT REHABILITATION IS REQUIRED WHEN SATISFACTORY FUNCTIONAL PERFORMANCE CANNOT BE MAINTAINED THROUGH SYSTEMATIC PRESERVATION STRATEGIES AND/OR THE PAVEMENT STRUCTURE IS NOT ADEQUATE

PAVEMENT MANAGEMENT SYSTEMS – PMS



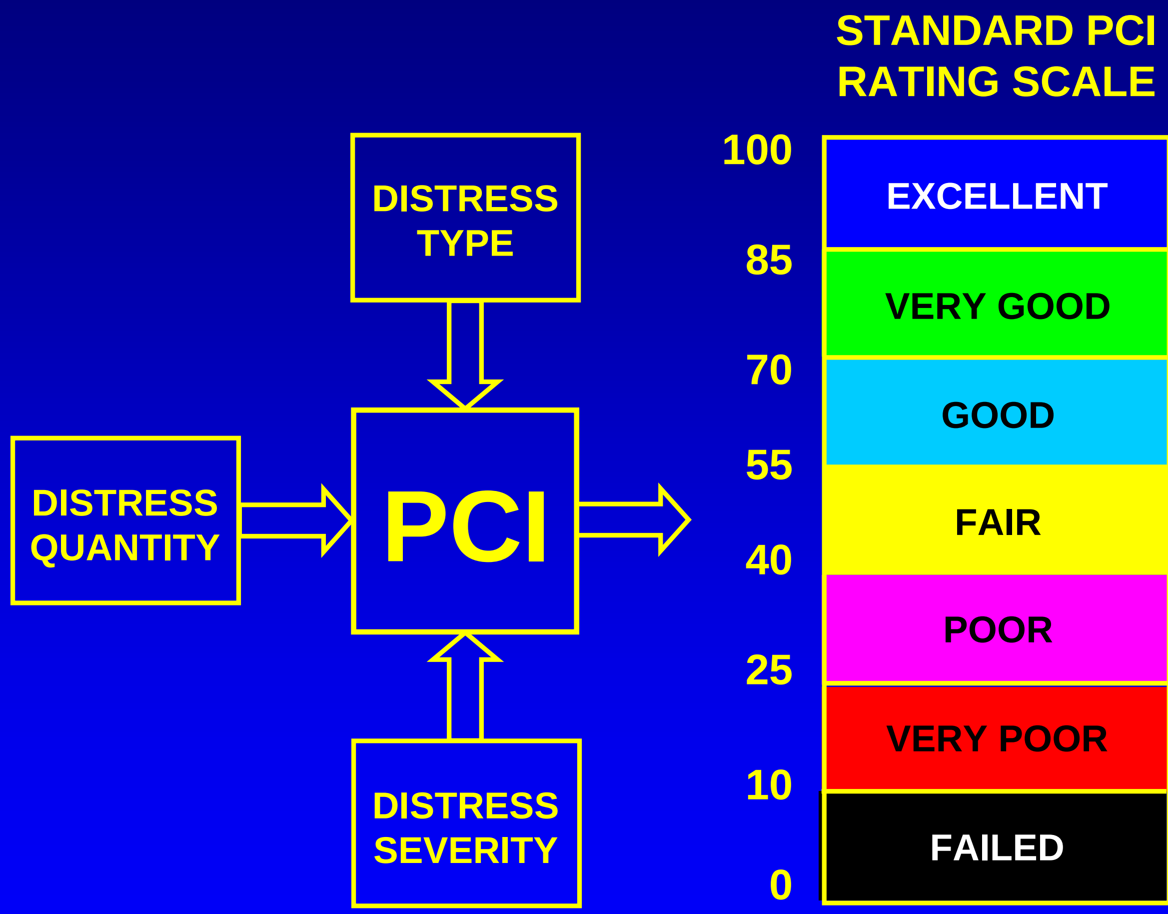
Micro PAVER 5.2

- USE OF PAVEMENT CONDITION INDEX
- PAVEMENT CONDITION PREDICTION MODELLING
- ANALYSIS OF ROUTINE AND MAJOR MAINTENANCE NEEDS
- WORK PLAN BASED ON AVAILABLE BUDGET OR MAINTAINING REQUIRED PAVEMENT CONDITION LEVEL
- REPORTING LINKED TO GEOGRAPHIC INFORMATION SYSTEM

Micro PAVER GIS REPORT DISPLAY

Micro PAVER INSTALLED AT PEARSON INTERNATIONAL AIRPORT, TORONTO (GTAA) BY JEGEL

PAVEMENT CONDITION INDEX (PCI)



CONCRETE PAVEMENT DISTRESS TYPES

61. BLOW UP*
62. CORNER BREAK*
63. LONGITUDINAL, TRANSVERSE AND DIAGONAL CRACKING*
64. DURABILITY CRACKING*
65. JOINT SEAL DAMAGE*
66. PATCHING, SMALL (LESS THAN 1.5 m^2)*
67. PATCHING, LARGE (OVER 1.5 m^2) AND UTILITY CUTS*
68. POPOUTS*
69. PUMPING*
70. SCALING, MAP CRACKING, AND CRAZING*
71. SETTLEMENT OR FAULTING*
72. SHATTERED SLAB/INTERSECTING CRACKS*
73. SHRINKAGE CRACKS
74. SPALLING (TRANSVERSE AND LONGITUDINAL JOINT)*
75. SPALLING (CORNER)*

* FOD PRODUCING DISTRESSES (MEDIUM TO HIGH SEVERITY)

FOD INDEX
CONCRETE PAVEMENTS

FOD INDEX = 100 – PCI (USING FOD-PRODUCING DISTRESSES)

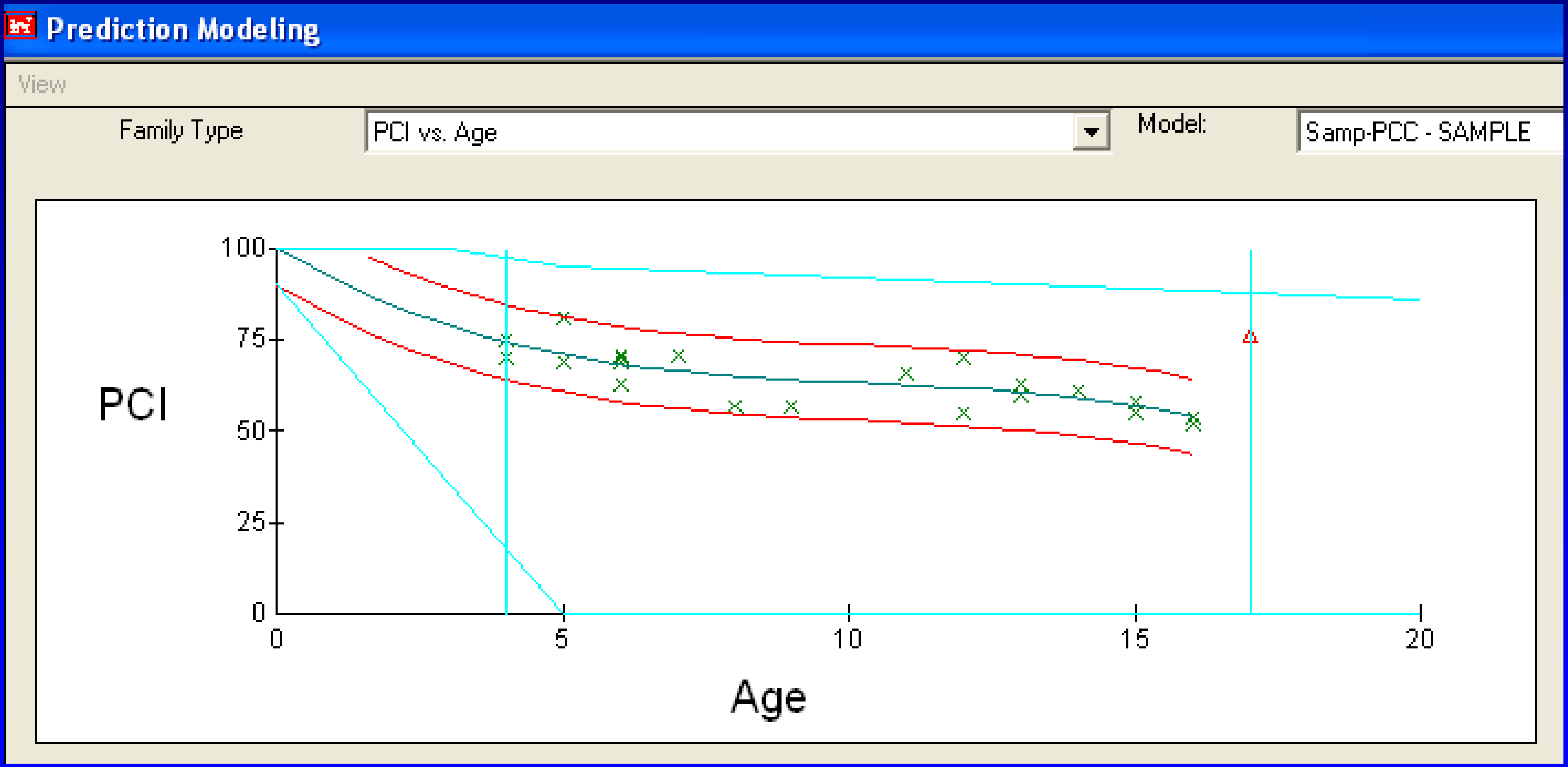
RATING	FOD INDEX
ADEQUATE	< 15
MARGINAL	15 to 30
UNSATISFACTORY	> 30

FOD: FOREIGN OBJECT DAMAGE

USAF ETL 99-7

THE FOD INDEX CAN BE CALCULATED USING Micro PAVER

PREDICTION MODELLING FOR CONCRETE PAVEMENTS



AIRPORT CONCRETE PAVEMENTS ARE SUBJECTED TO A WIDE RANGE OF AIRCRAFT LOADINGS

THE ACTUAL CARGO LOADING IS ALSO IMPORTANT FOR HEAVY AIRCRAFT ON APRONS

AIRPORT CONCRETE PAVEMENT DISTRESS ASSESSMENT AND NDT ACTIVITIES AND SUBSEQUENT CPR MUST ALWAYS BE COMPATIBLE WITH SECURE AND SAFE AIRPORT OPERATIONS

DETERMINATION OF SUBGRADE, BASE AND PAVEMENT SUPPORT CONDITIONS

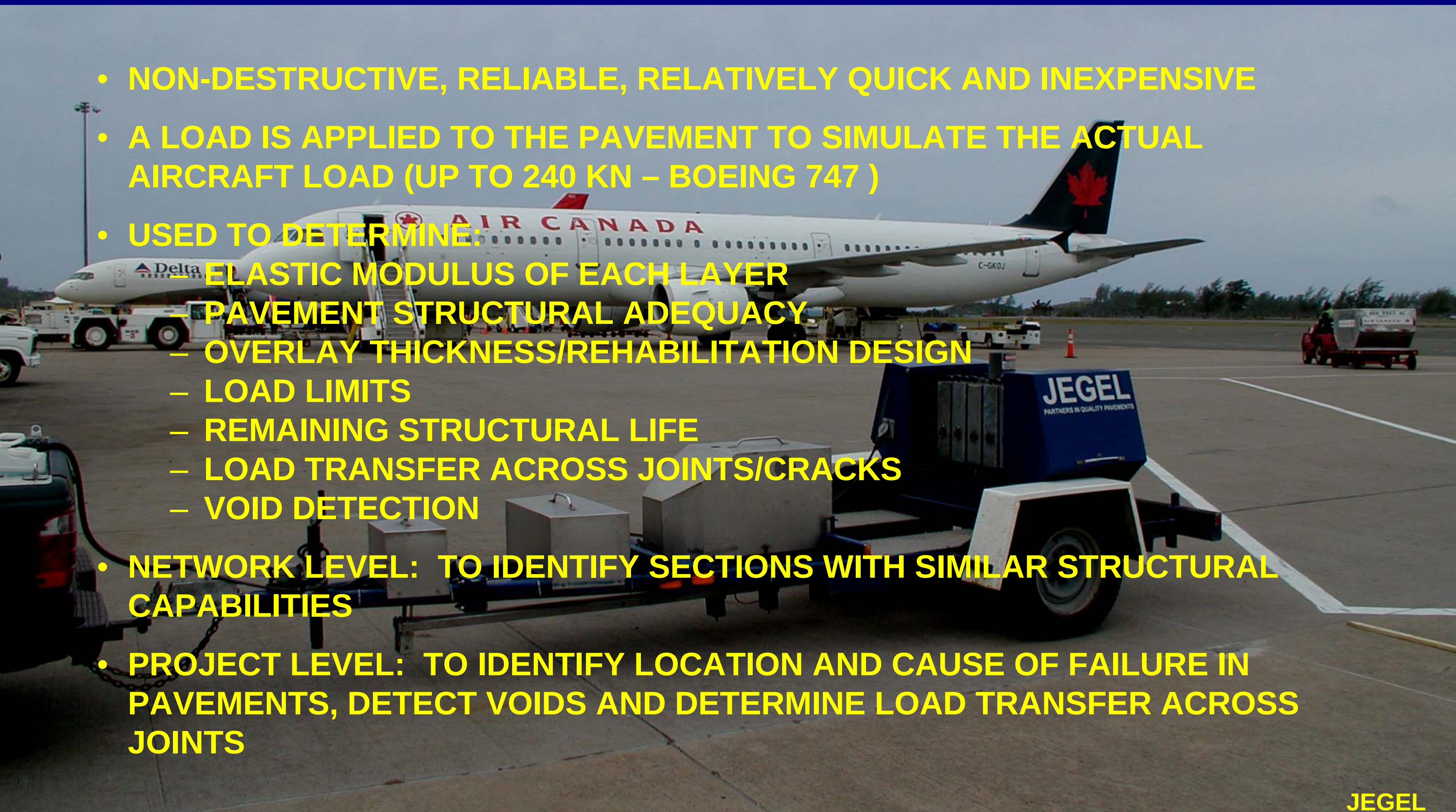
PLATE LOADING TESTS WERE COMMONLY USED IN THE PAST FOR SUBGRADE AND BASE SUPPORT CONDITION DETERMINATION

THE HWD IS NOW COMMONLY USED TO DETERMINE THE SUBGRADE, BASE AND PAVEMENT SUPPORT CONDITIONS AND Mr OF THE PAVEMENT COMPONENTS

NONDESTRUCTIVE DEFLECTION TESTING

HIGH CAPACITY FALLING WEIGHT DEFLECTOMETER

HWD



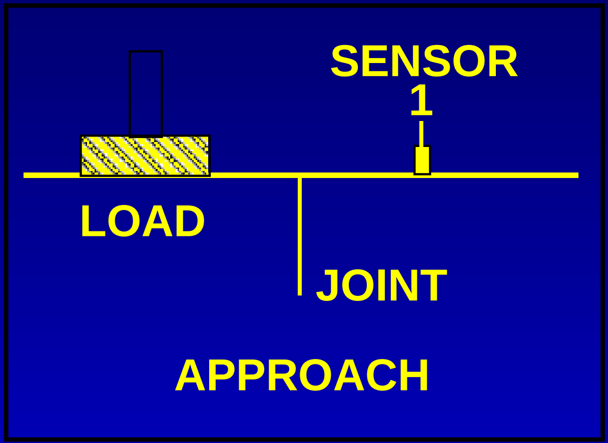
- NON-DESTRUCTIVE, RELIABLE, RELATIVELY QUICK AND INEXPENSIVE
- A LOAD IS APPLIED TO THE PAVEMENT TO SIMULATE THE ACTUAL AIRCRAFT LOAD (UP TO 240 KN – BOEING 747)
- USED TO DETERMINE:
  - ELASTIC MODULUS OF EACH LAYER
  - PAVEMENT STRUCTURAL ADEQUACY
  - OVERLAY THICKNESS/REHABILITATION DESIGN
  - LOAD LIMITS
  - REMAINING STRUCTURAL LIFE
  - LOAD TRANSFER ACROSS JOINTS/CRACKS
  - VOID DETECTION
- NETWORK LEVEL: TO IDENTIFY SECTIONS WITH SIMILAR STRUCTURAL CAPABILITIES
- PROJECT LEVEL: TO IDENTIFY LOCATION AND CAUSE OF FAILURE IN PAVEMENTS, DETECT VOIDS AND DETERMINE LOAD TRANSFER ACROSS JOINTS

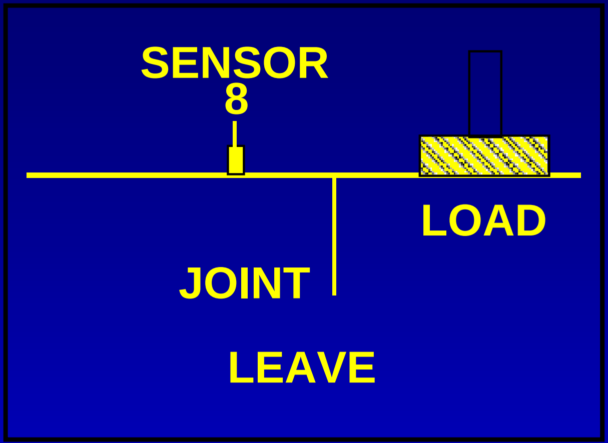
JEGEL

HEAVY WEIGHT DEFLECTOMETER (HWD/FWD), HAMILTON

NONDESTRUCTIVE DEFLECTION TESTING

HWD LOAD TRANSFER TESTING





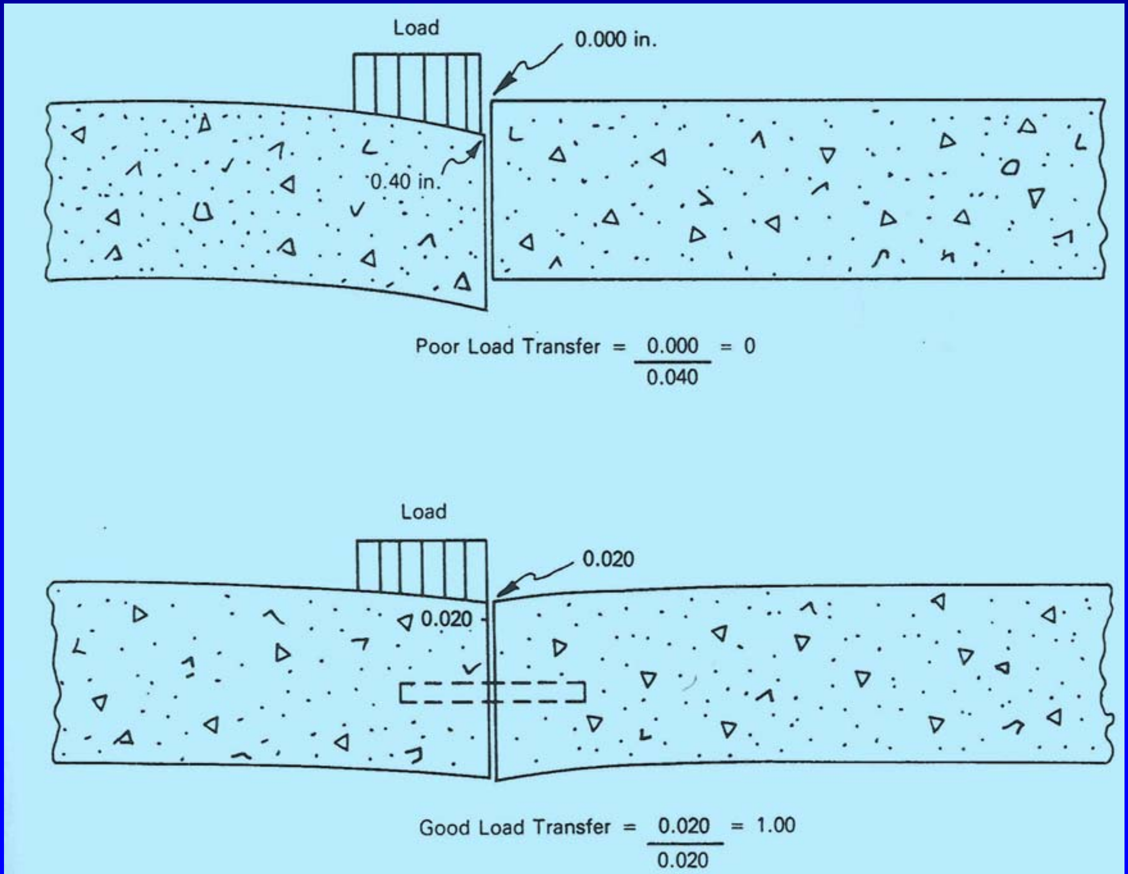
NONDESTRUCTIVE DEFLECTION TESTING

HWD LOAD TRANSFER TESTING

THE LOAD TRANSFER EFFICIENCY OF THE LONGITUDINAL AND TRANSVERSE JOINTS AND VOIDS/SOFT SPOTS DETERMINATION FOR THE CONCRETE PAVEMENT PANELS ARE CALCULATED IN ACCORDANCE WITH THE PROCEDURES DESCRIBED IN THE AASHTO 93 PAVEMENT DESIGN MANUAL

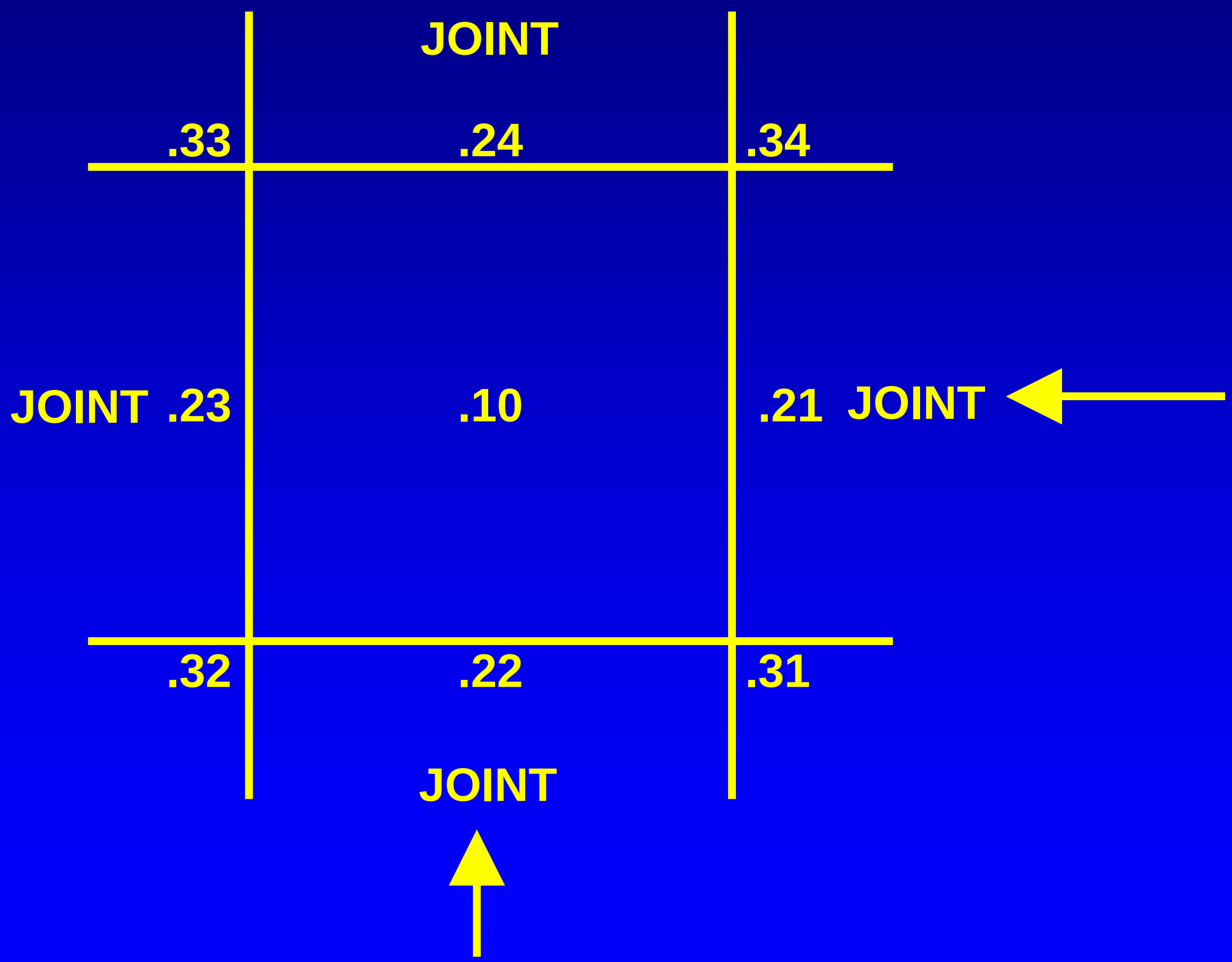
TYPICAL LOAD TRANSFER EFFICIENCY RATINGS

- EXCELLENT - > 85%
- GOOD – 75-85%
- FAIR – 65-75%
- POOR – 55-65%
- VERY POOR - < 55%



NONDESTRUCTIVE DEFLECTION TESTING

HWD TESTING PATTERN



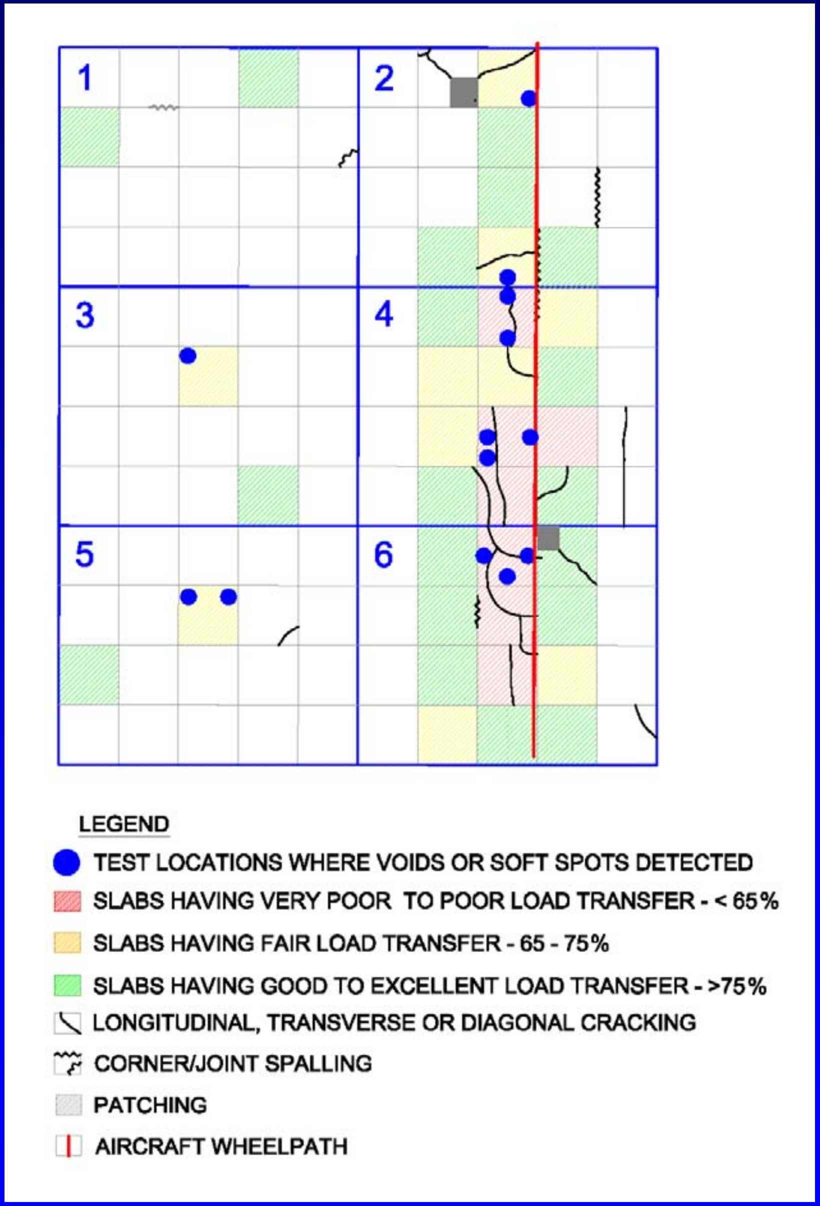
NONDESTRUCTIVE DEFLECTION TESTING

HWD TESTING OFTEN REQUIRES NIGHT WORK

ASPHALT CONCRETE SURFACING HAS BEEN REMOVED PRIOR TO HWD TESTING
HIGHWAY 401 COMPOSITE PAVEMENT NEAR TORONTO PEARSON AIRPORT (GTAA)

NONDESTRUCTIVE DEFLECTION TESTING

HWD DATA ANALYSIS



NONDESTRUCTIVE DEFLECTION TESTING

TYPICAL USE OF HWD DATA – STRUCTURAL INDEX

STRUCTURAL INDEX= ACN/PCN

AIRCRAFT CLASSIFICATION NUMBER (ACN) – A NUMBER EXPRESSING THE RELATIVE EFFECT OF AN AIRCRAFT ON A PAVEMENT.

PAVEMENT CLASSIFICATION NUMBER (PCN) – A NUMBER EXPRESSING THE RELATIVE CAPABILITY OF A PAVEMENT TO SUPPORT AIRCRAFT.

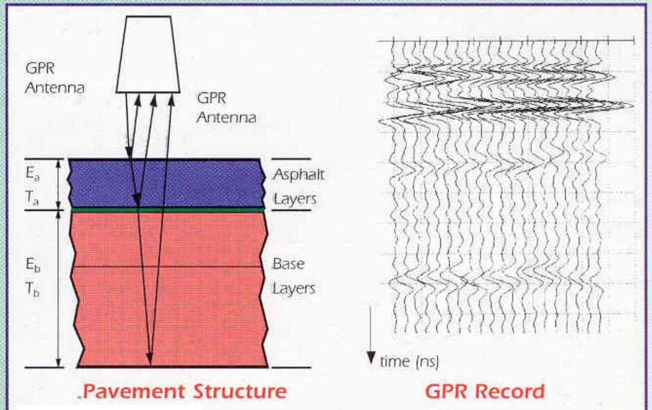
Rating	Structural Index
Adequate	<1.25
Marginal	1.25-1.5
Unsatisfactory	≥1.5

JIM GREENE, AFCESA
SWIFT 2001

THE HWD TESTING CAN BE SUPPLEMENTED BY LIGHT WEIGHT DEFLECTOMETER (LWD) TESTING ON THE SUBGRADE AND BASE, DRILLING/CORING TO DETERMINE PAVEMENT STRUCTURE AND/OR DYNAMIC CONE PENETROMETER (DCP) TESTING TO DETERMINE SUBGRADE MODULUS

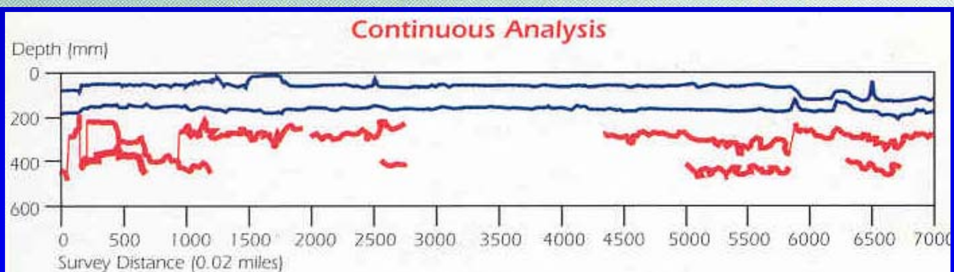
GROUND PENETRATING RADAR

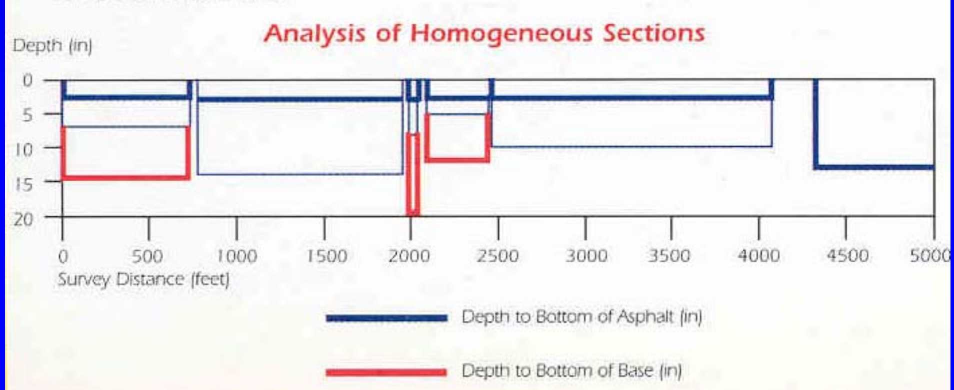
GPR is a pulse-echo method for measuring pavement layer thickness and other properties. It works like ultrasound, but uses radio waves rather than sound waves to penetrate the pavement.



Principles Used for Measuring Pavement Thickness

Antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement (see figure 1). As this energy travels down through the pavement structure, echoes are created at boundaries of dissimilar materials (such as the asphalt–base interface). The arrival time and strength of these echoes can be used to calculate pavement layer thickness and other properties, such as moisture content.





ROUGHNESS MONITORING

DIGITAL INCREMENTAL PROFILER
DIPSTICK – SIMPLE, VERY ACCURATE

ARAN UNIT (ROADWARE)
LASER PROFILOMETER

ROUGHNESS MONITORING

PORTABLE TWIN LASER PROFILOMETER (DYNATEST)

FRICTION MONITORING

FRICTION MONITORING WITH GRIP TESTER (FINDLAY IRVINE)

PAVEMENT EVALUATION SUMMARY

- **PAVEMENT CONDITION SURVEY**
  - CONDITION RATING SYSTEMS
  - DISTRESSES
  - GENERALLY USING MicroPAVER 5.2
- **STRUCTURAL CONDITION TESTING**
  - NON-DESTRUCTIVE TESTING
  - GENERALLY HWD
  - SUPPLEMENTED BY LWD, DRILLING/CORING AND/OR DCP
- **FUNCTIONAL CHARACTERISTICS SURVEY**
  - ROUGHNESS MONITORING
  - FRICTION MONITORING
- **DEVELOP FEASIBLE REHABILITATION ALTERNATIVES**
  - DETERMINE CAUSES OF DISTRESSES
  - DEVELOP ALTERNATIVES
  - COMPLETE ENGINEERING AND ECONOMIC ANALYSIS
  - SELECT PREFERRED ALTERNATIVE (S)
  - DEVELOP SPECIFICATIONS FOR PREFERRED ALTERNATIVE (S)
- **COMPLETE REHABILITATION WORK WITH QC/QA**

LIFE-CYCLE COST ANALYSIS SUMMARY

A LIFE-CYCLE COST ANALYSIS, INCLUDING VALUE ENGINEERING, IS AN IMPORTANT COMPONENT OF AIRPORT PAVEMENT REHABILITATION PLANNING

- ECONOMIC ASSESSMENT OF COMPETING, TECHNICALLY SUITABLE SYSTEMS OVER DESIGN LIFE
- COST COMPONENTS
  - INITIAL COSTS (CAPITAL COST)
  - MAINTENANCE COSTS
  - REHABILITATION COSTS
  - RESIDUAL/SALVAGE VALUE
  - USER COSTS (TRAFFIC DELAYS FOR INSTANCE)
- PRESENT-WORTH METHOD
  - DISCOUNT RATE
  - ANALYSIS PERIOD
- DETERMINISTIC AND PROBABILISTIC METHODS
  - JEGEL IS USING PROBABILISTIC METHODS BASED ON FHWA AND CRYSTAL BALL SOFTWARE

VALUE ENGINEERING

BOGOTÁ EL DORADO INTERNATIONAL AIRPORT SECOND RUNWAY, 1996

VALUE ENGINEERING IS A PROCESS CONSISTING OF THE SYSTEMATIC APPLICATION OF ANALYTICAL, CREATIVE AND EVALUATION TECHNIQUES ON A MULTI-DISCIPLINED BASIS TO ACHIEVE THE DESIRED FUNCTIONS FOR A DESIGN OR PROCESS WHILE MAXIMIZING VALUE AND MAINTAINING OR IMPROVING REQUIRED FUNCTIONS.

VALIDATE THE INFORMATION AS IT IS ASSEMBLED

ALTERNATIVES - MAKE A LIST OF ALL THE POSSIBILITIES

LOOK CLOSELY AT EACH IDEA - ANALYZE AND EVALUATE POSSIBILITIES

USE SUITABLE ALTERNATIVES - DEVELOP INTO SOUND RECOMMENDATIONS

ENHANCE UNDERSTANDING - PRESENT RECOMMENDATIONS AND ASSIST IN CONCEPTUAL UNDERSTANDING

JEGEL

CONSTRUCTION OF THE NEW RUNWAY REQUIRED DIVERSION OF THE BOGOTÁ RIVER
THIS DIVERSION REQUIRED A DETAILED ANALYSIS OF THE MOST APPROPRIATE TYPE
RIGID OR FLEXIBLE – TO DEAL WITH POTENTIAL SETTLEMENTS

EXAMPLE OF AIRPORT PAVEMENT REHABILITATION ENGINEERING

TORONTO PEARSON AIRPORT (GTAA) RUNWAY 05/23

RUNWAY 05/23 PRIOR TO REHABILITATION IN 2004 AND 2005

EXAMPLE OF AIRPORT PAVEMENT REHABILITATION ENGINEERING

METHODOLOGY

- ENGINEERING SITE VISIT
- REVIEW OF PAVEMENT HISTORY
- PAVEMENT CONDITION SURVEY – MicroPAVER, PAVEMENT DISTRESSES, PCI
- FWD LOAD/DEFLECTION TESTING – DEFLECTION, ELASTIC MODULUS, LOAD TRANSFER, PRESENCE OF VOIDS
- GEOTECHNICAL INVESTIGATION – PAVEMENT CORING AND BOREHOLE/PROBEHOLE INVESTIGATION
- LABORATORY TESTING
- SYNTHESIS OF FINDINGS
- REHABILITATION METHODS SELECTION (PAVEMENT DESIGN, VALUE ENGINEERING AND LIFE CYCLE COST ANALYSIS)

EXAMPLE OF AIRPORT PAVEMENT REHABILITATION ENGINEERING

PAVEMENT REHABILITATION ALTERNATIVES
KEEL SECTION

- CONCRETE PAVEMENT RESTORATION (CPR) AND THIN HMA OVERLAY
- THICK OVERLAY OVER EXISTING CONCRETE PAVEMENT
- CONCRETE PAVEMENT RUBBLIZATION AND THICK HMA OVERLAY
- CONCRETE PAVEMENT RECONSTRUCTION

EXAMPLE OF AIRPORT PAVEMENT REHABILITATION ENGINEERING

LIFE-CYCLE COST ANALYSIS

ALTERNATIVE	INITIAL CONSTRUCTION	MAJOR MAINTENANCE	RESIDUAL VALUE	SALVAGE VALUE	30-YEAR LCC, PW
CPR AND THIN HMA OVERLAY	$2,712,900	$2,181,312	- $500,401	- $41,822	$4,351,989
THICK HMA OVERLAY	$2,660,875	$1,253,685	- $380,928	- $41,020	$3,492,612
RUBBLIZATION AND THICK HMA OVERLAY	$3,313,500	$1,125,026	- $380,774	- $51,112	$4,006,641
CONCRETE PAVEMENT RECONSTRUCTION	3,155,400			- $48,643	$3,106,757

SELECTED FOR LOGISTICAL (OPERATIONS) REASONS

EXAMPLE OF AIRPORT PAVEMENT REHABILITATION ENGINEERING

RUNWAY RETURNED TO FULL AND SMOOTH SERVICE

EXAMPLE OF CPR TECHNOLOGY
TORONTO PEARSON AIRPORT (GTAA) RUNWAY 06/24

DIAMOND GRINDING OF CONCRETE PAVEMENT TO RESTORE SMOOTHNESS PRIOR TO OVERLAY

EXAMPLE OF NEW PAVEMENT EVALUATION TECHNOLOGY

USE OF IMPACT ECHO TO DETERMINE EARLY STAGE PAVEMENT CRACKING DISTRESSES AND PAVEMENT THICKNESS

PAVEMENT DISTRESS ASSESSMENT
AND
NON-DESTRUCTIVE TESTING