Module 2-3

Nondestructive Data Collection and Interpretation

Objectives

Describe the nature of a pavement's response to load

List NDT devices and characteristics

List factors that influence deflection

Describe procedures for conducting NDT program

Describe effects of season on NDT

Describe principles and procedures for in-situ materials characterization

Introduction

NDT - Valuable engineering tool in assessing uniformity and structural adequacy

Useful

- Identify subsections
- Identify locations for sampling / testing
- Characterize material properties
- Rational basis for structural capacity assessment

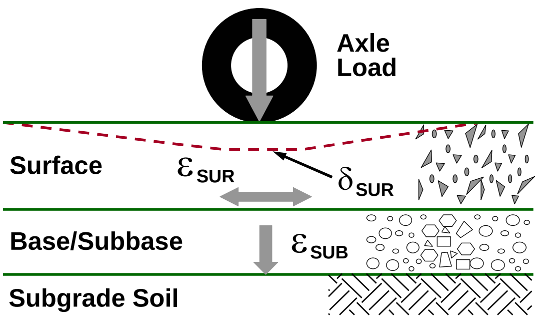
Introduction

Productive - 200 to 400 measurements per day

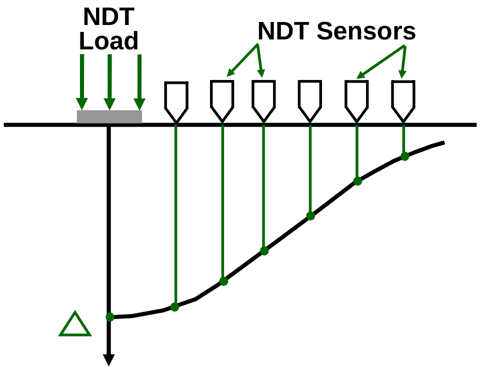
Repeatable

Used by most states for project and some network evaluations.

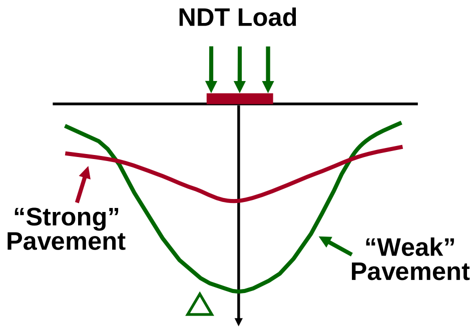
Pavement Responses Under Load



Measurement of Surface Deflection



Strong vs. Weak Pavements



Potential Results From NDT

Project variability
Subgrade soil support
Void location
Joint load transfer
Critical periods
In-situ material properties
Structural adequacy

Types of NDT Equipment

Static
Vibratory
Impulse
Surface wave propagation

"Static" Load Devices

Benkelman beam

California Traveling Deflectometer

La Croix Deflectograph

Benkelman Beam

Vibratory (steady state dynamic) Equipment

Dynaflect

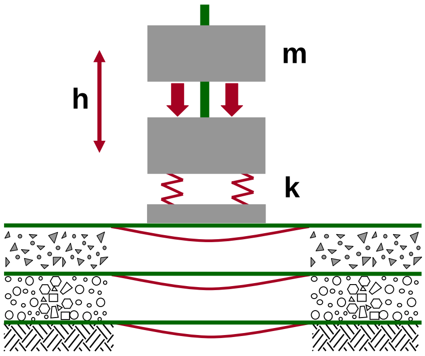
Road Rater (3 models)

Dynaflect

Dynaflect - Close-up of Sensors

Road Rater

Impulse Equipment (falling weight deflectometer)



FWD Manufacturers

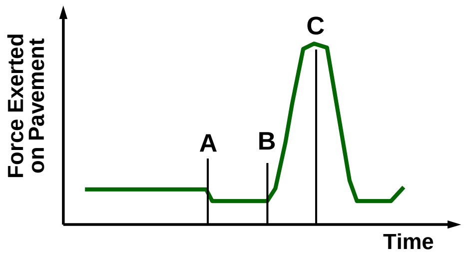
Dynatest

KUAB

Phonix

JILS

Typical Load Pulse

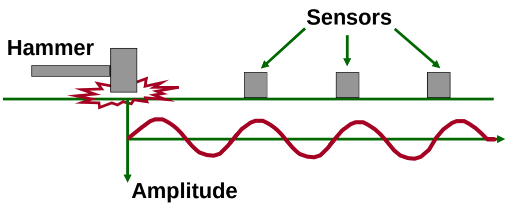


A - Time at which load is released
B - Time at which load makes first contact with load plate
C - Peak load reached

Dynatest FWD

KUAB FWD

SASW Approach



Measure speed, amplitude, wavelength

Most common device - Seismic Pavement Analyzer

SASW Equipment - SPA

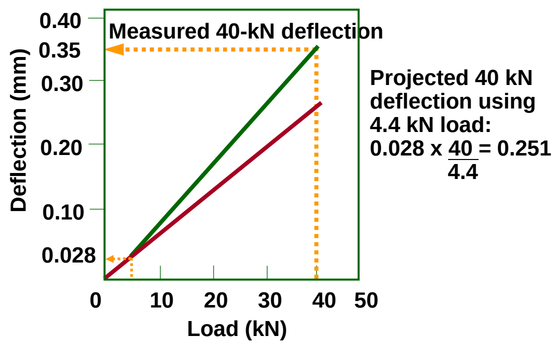
Factors That Influence Measured Deflections

Load factors

Pavement factors

Climatic factors

Load Factors - Stress Sensitivity



Pavement Factors

Distress

Transverse location

Surface discontinuities

Subsurface variations

Underlying voids

Random variability

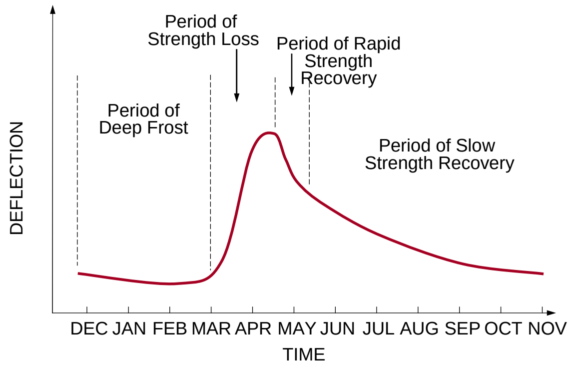
Climatic Factors

Moisture

Temperature

Frost penetration

Typical Deflection / Time Plot



Conducting NDT Surveys

Temperature measurements

- Hourly
- Multiple locations
- Air and pavement
- Correction to standard (e.g., 21° C)

Testing Locations / Frequency

30 to 150 m intervals

Typically outer lane only

Both directions - staggered

Flexible - outer wheel path

JPCP / JRCP - midslab, joint, corner

CRCP - outer wheel path - between cracks and at cracks

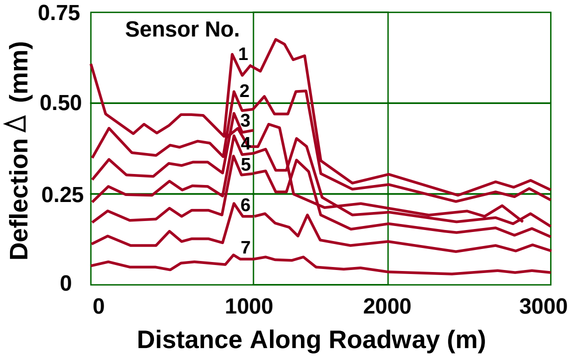
Testing at Joints

Interpretation of NDT Data

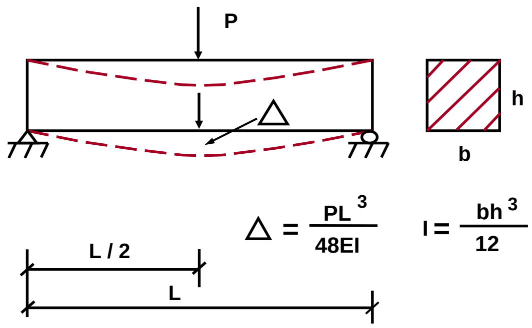
Uniformity of project
- Design sections for rehabilitation
- Locations for sampling / testing

Determining pavement layer moduli
- Insitu characterization
- "Backcalculation" process

Uniformity (Non-uniformity) of Project

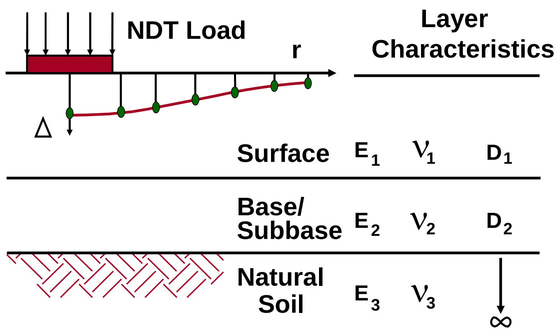


Simple Backcalculation Case



$$\Delta = \frac{PL^3}{48EI} \qquad I = \frac{bh^3}{12}$$

Typical Pavement Case



Typical Poisson's Ratios

Material	Range	Typical
PCC	0.10 - 0.20	0.15
HMA / ATB	0.15 - 0.45	0.35
Cement Stab. Base	0.15 - 0.30	0.20
Granular Base / Subbase	0.30 - 0.40	0.35
Subgrade Soil	0.30 - 0.50	0.40

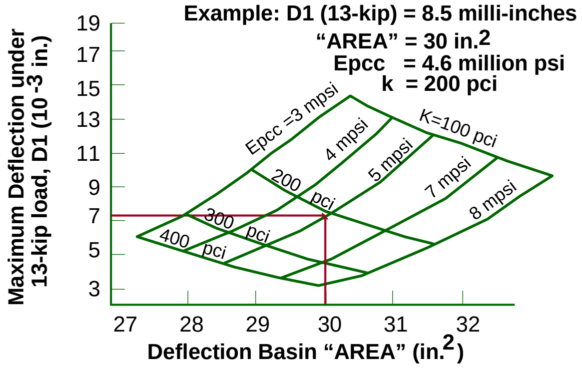
Typical Modulus Values

Material	Range (mPa)	Typical (mPa)
HMA	1,500 - 3,500	3,000
PCC	20,000 - 55,000	30,000
ATB	500 - 3,000	1,000
CTB	3,500 - 7,000	5,000
Lean concrete	7,000 - 20,000	10,000
Granular base	100 - 350	200
Granular soil	50 - 150	100
Fine-grained soil	20 - 50	30

Example Iterative Process

Iterat.	Trial Moduli (mPa)				Predicted Deflections (mm)							Avg. % Diff.
	E_1	E_2	E_3	E_4	Δ_1	Δ_2	Δ_3	Δ_4	Δ_5	Δ_6	Δ_7	
1	1724	276	138	690	.276	.201	.166	.132	.108	.075	.040	20.5
2	1724	276	207	345	.238	.167	.136	.105	.083	.055	.031	36.4
3	1724	207	103	276	.335	.257	.218	.177	.147	.104	.058	5.9
4	1793	224	107	297	.320	.245	.208	.169	.141	.100	.056	1.3
5	1862	224	107	297	.316	.243	.207	.169	.141	.100	.056	0.9
	Measured Defl. (mm):				.309	.243	.208	.171	.140	.099	.054	

Backcalculation for Two-Layer Rigid Pavement



Rules of Thumb

E_{bottom} = is a function of the deflection beyond one meter

Effect of underlying "rigid" layers

Effect of more than one bound layer

Effect of "thin" layers

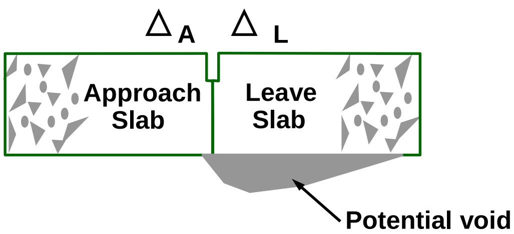
Backcalculation Programs

BISDEF
ELSDEF
CHEVDEF
MODULUS
COMDEF
WESDEF

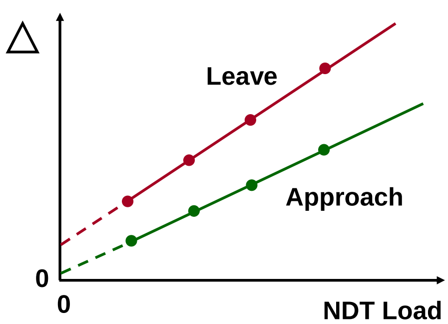
MODCOMP
BOUSDEF
ELMOD
EVERCALC
ILLI-BACK

Location of Loss of Support (voids)

Examine difference between deflections on approach slab and leave slab



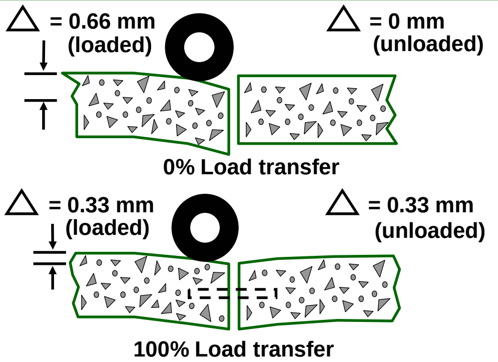
Deflection vs. Load Method



Joint/Crack Load Transfer

$$LTE = \left(\frac{\Delta_u}{\Delta_L}\right) * 100$$

Concept of Load Transfer



Summary

Background

NDT equipment

Influential factors

Conducting field surveys

Interpretation of NDT data