The Use of Non-Destructive Testing to Gain Insight into the Future at Ottawa International

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Presentation Outline

- Background
- Ground Penetrating Radar
  - Test Equipment
  - Scope of Work
  - Results
- Heavy Weight Deflectometer (HWD)
  - Test Equipment
  - Scope of Work
  - Results
- Next Steps

Background
Airport Layout

Background
Airport Planning

- Ottawa Airport preparing for “major facelift”
  - Resurfacing three runways over next three years
- Advanced Planning
  - Condition of existing pavement structure (evaluate/confirm adequate structural strength)
  - Thickness of existing structure

Ground Penetrating Radar (GPR)
Test Equipment

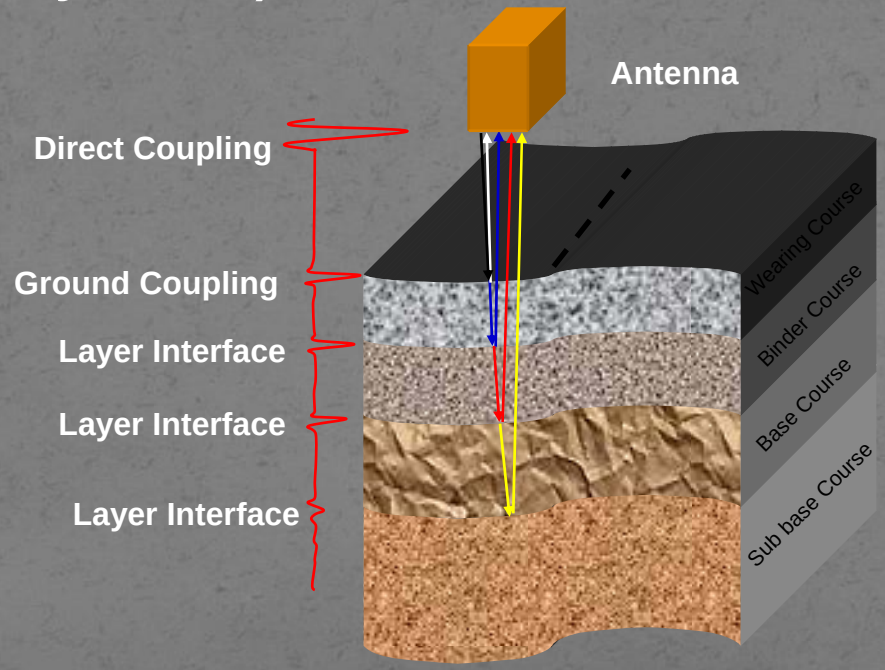
- Geophysical Survey Systems Inc (GSSI) GPR System
- 2.0 GHz air coupled horn antenna
- Wheel-mounted distance measuring instrument
- Horn antenna vehicle mounting unit
- Trimble GPS

Ground Penetrating Radar (GPR)
Scope of Work

- Runways (04-22, 07-25, 14-32) and Taxiways (A, B, C, D, E, F, J, K, L)
  - 3-metre offset from centreline (both sides)
- Aprons (I, II)
  - Selected testing

Ground Penetrating Radar (GPR)
Analysis

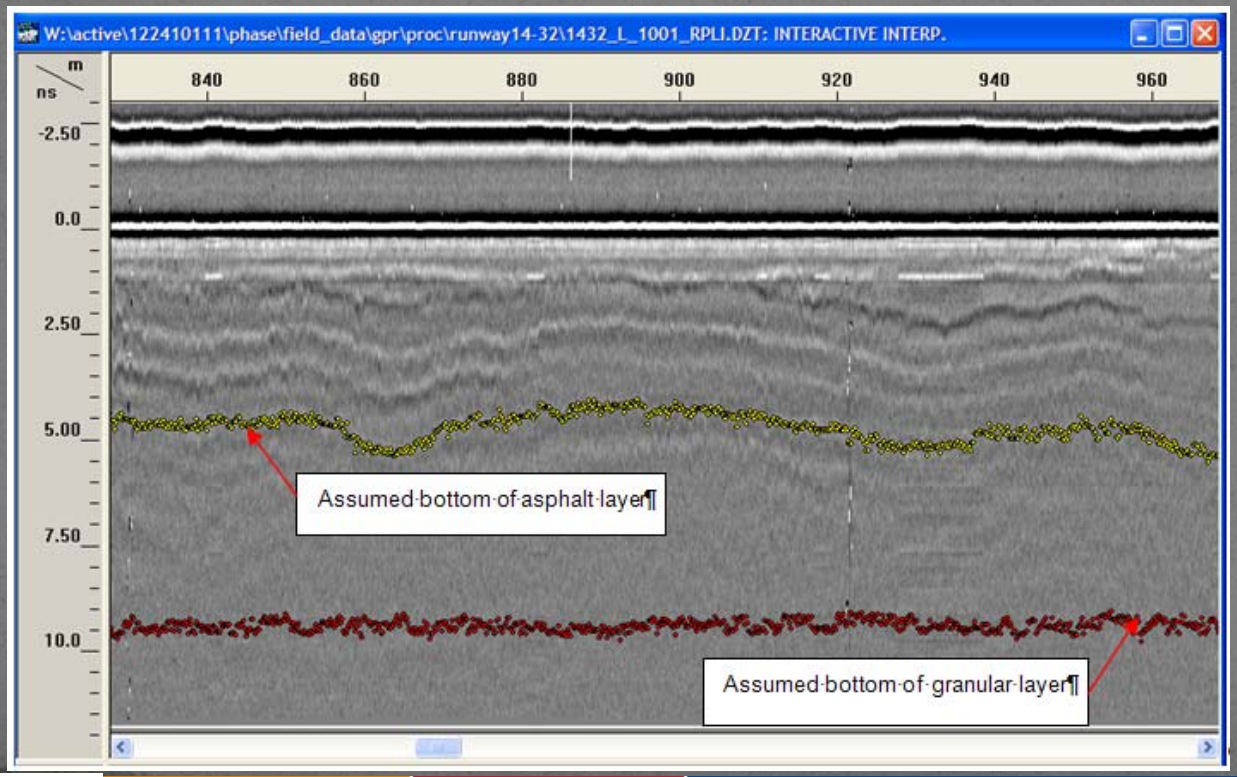
- Identify reflections caused by changes in electrical properties (dielectric, electrical conductivity, etc.) of material



Reflections are produced when the pulse encounters a material with different dielectric constant

Ground Penetrating Radar (GPR)
Analysis (cont'd)

- Data technician digitizes reflection and software converts digitized reflection into layer thicknesses



GPR layer profile is typically calibrated using ground truth information obtained by cores and boreholes

Ground Penetrating Radar (GPR)
Results – Runways & Aprons

Runway	Side of Centerline	GPR AC Layer Thickness (mm)				GPR Granular Layer Thickness (mm)			
		Min.	Max.	Avg.	Stdev	Min.	Max.	Avg.	Stdev
Runway 04/22	L	82	249	141	31	94	290	174	30
	R	78	300	143	38	59	267	154	36
Runway 07/25	L	118	545	291	70	100	334	214	49
	R	114	592	314	94	54	385	183	60
Runway 14/32	L	90	500	296	73	67	529	293	79
	R	56	507	298	90	59	480	256	64

Aprons	Side of Centerline	GPR AC Layer Thickness (mm)				GPR Granular Layer Thickness (mm)			
		Min.	Max.	Avg.	Stdev	Min.	Max.	Avg.	Stdev
Apron I	NE	285	427	344	28	107	190	132	12
Apron II	NE	317	380	363	14	148	240	173	19
	SE1	289	405	348	35	132	212	157	22
	SE2	286	441	340	46	97	154	121	16

Ground Penetrating Radar (GPR)
Results – Taxiways

Taxiway	Side of Centerline	GPR AC Layer Thickness (mm)				GPR Granular Layer Thickness (mm)			
		Min.	Max.	Avg.	Stdev	Min.	Max.	Avg.	Stdev
Taxiway A	L	97	334	223	43	133	393	224	39
	R	91	321	217	38	141	423	250	51
Taxiway B	L	157	336	237	30	128	331	233	46
	R	166	338	247	36	103	459	213	52
Taxiway C	L	127	347	245	63	223	417	305	43
	R	127	354	237	56	222	478	325	58
Taxiway D	L	208	402	278	47	195	300	242	29
	R	206	464	318	81	196	482	277	88
Taxiway E	L	173	355	248	33	157	429	291	54
	R	153	408	258	49	114	414	304	60
Taxiway F	L	75	165	119	23	114	281	175	32
	R	81	166	115	19	139	240	192	24
Taxiway J	L	78	194	121	24	289	461	342	39
	R	101	272	144	31	221	493	330	58
Taxiway K	L	194	459	250	64	210	350	250	37
	R	183	358	234	36	201	395	288	43

Heavy Weight Deflectometer (HWD)
Test Equipment & Method

- LTPP-SHRP calibrated Dynatest model HWD
- Differential GPS and distance measuring instrument
- Thermo sensors that automatically monitor air and pavement surface temperature

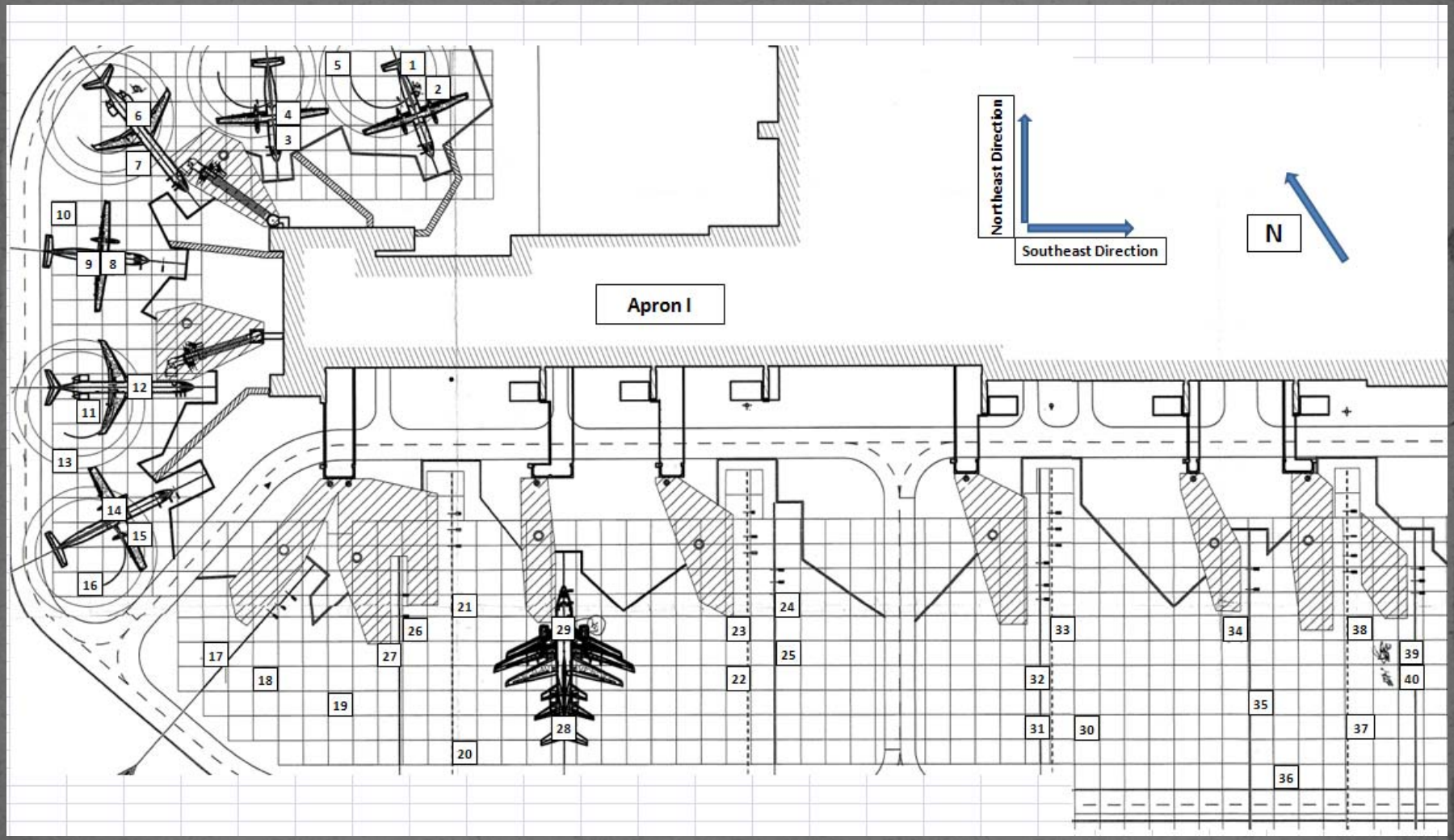
- AC 150-5370-11 Use of Nondestructive Testing in the Evaluation of Airport Pavements

Heavy Weight Deflectometer (HWD)
Scope of Work

- Runways (04-22, 07-25, 14-32) and Taxiways (A, B, C, D, E, F, J, K, L)
  - 3-metre offset from centreline (both sides)
  - Staggered for maximum coverage
- Aprons (I, II)
  - Every 30th slab for mid slab (centre) test
  - Every 60th slab for longitudinal and transverse joints

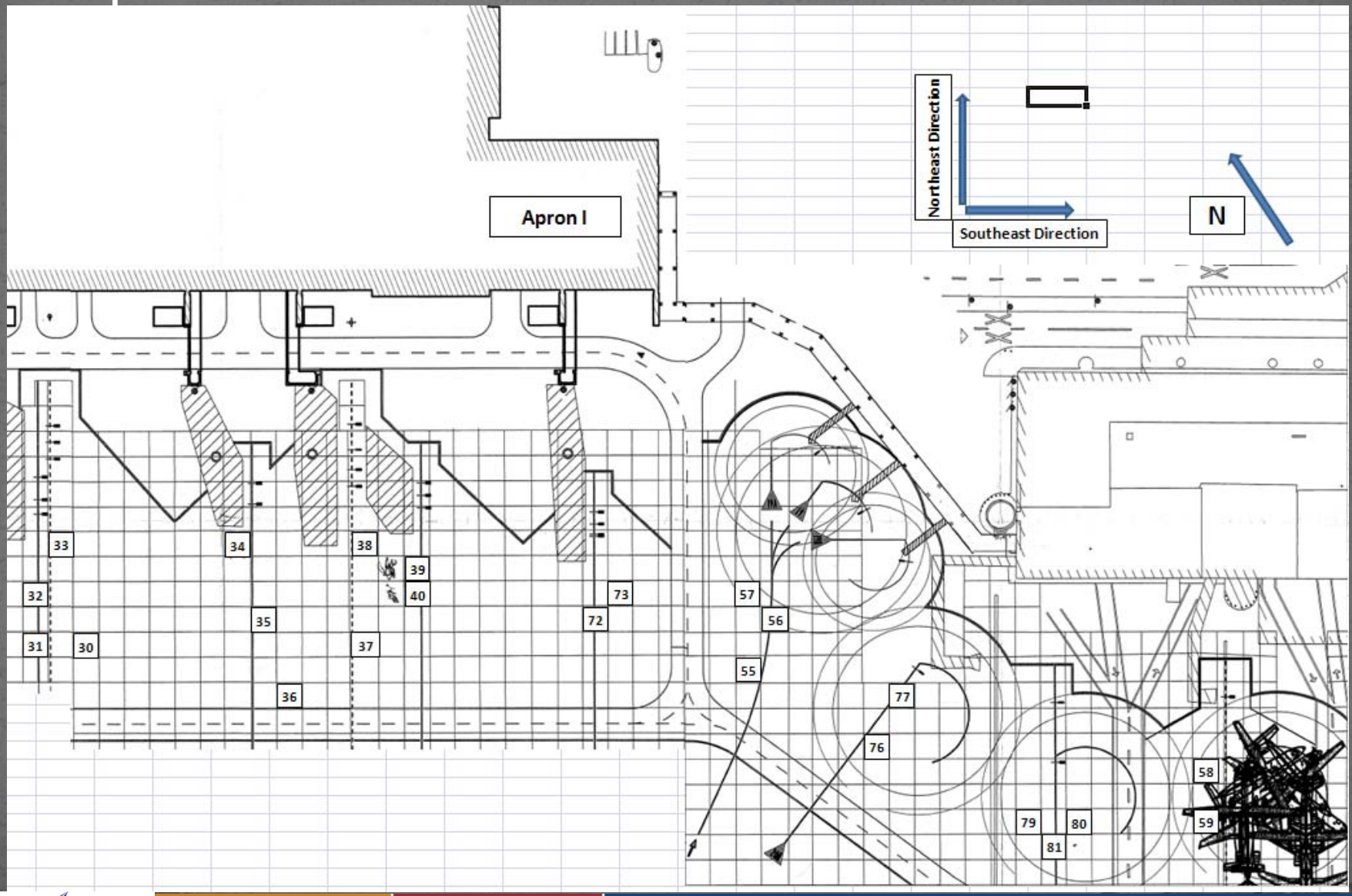
Heavy Weight Deflectometer (HWD)

Scope of Work



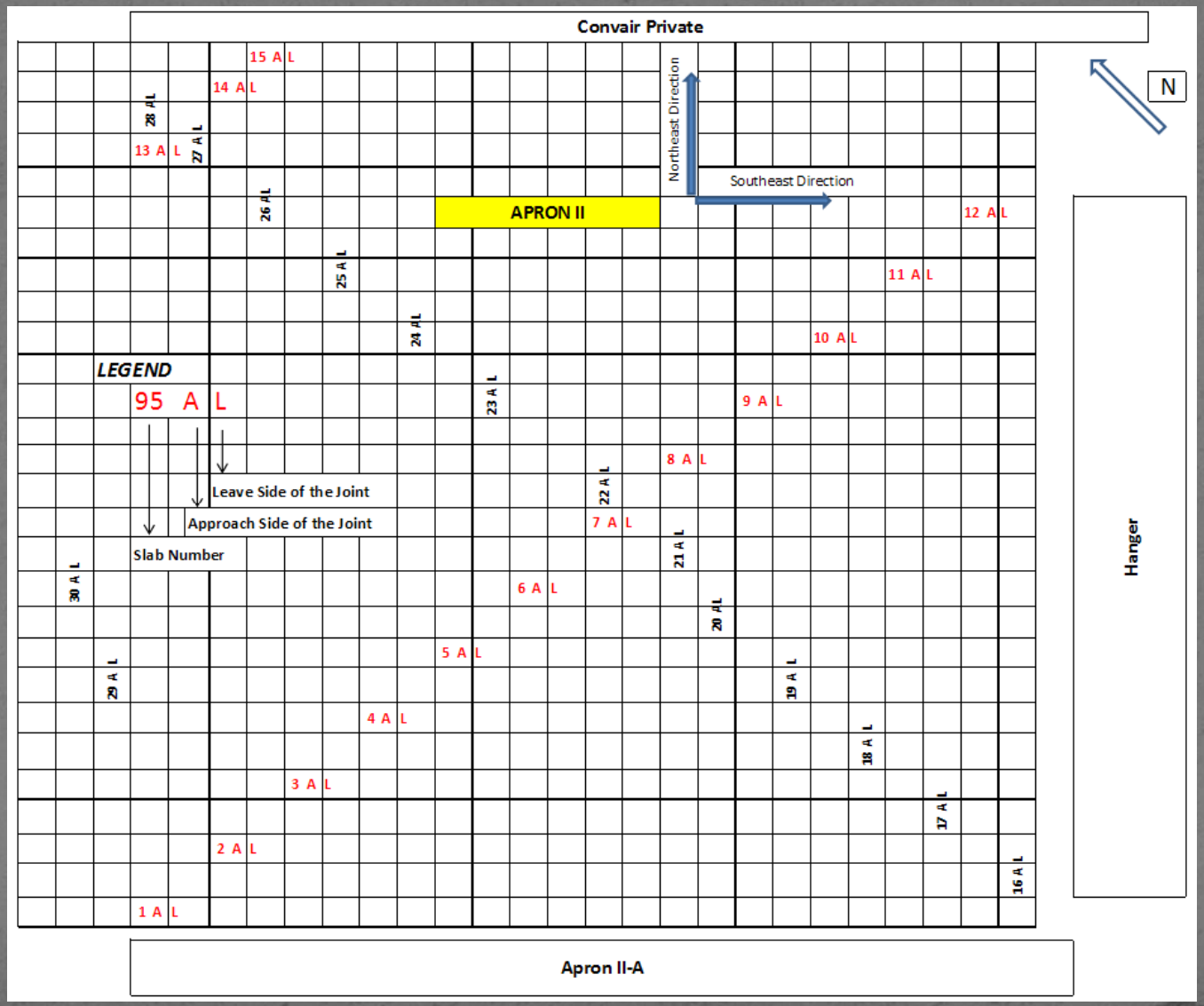
Heavy Weight Deflectometer (HWD)

Scope of Work



Heavy Weight Deflectometer (HWD)

Scope of Work



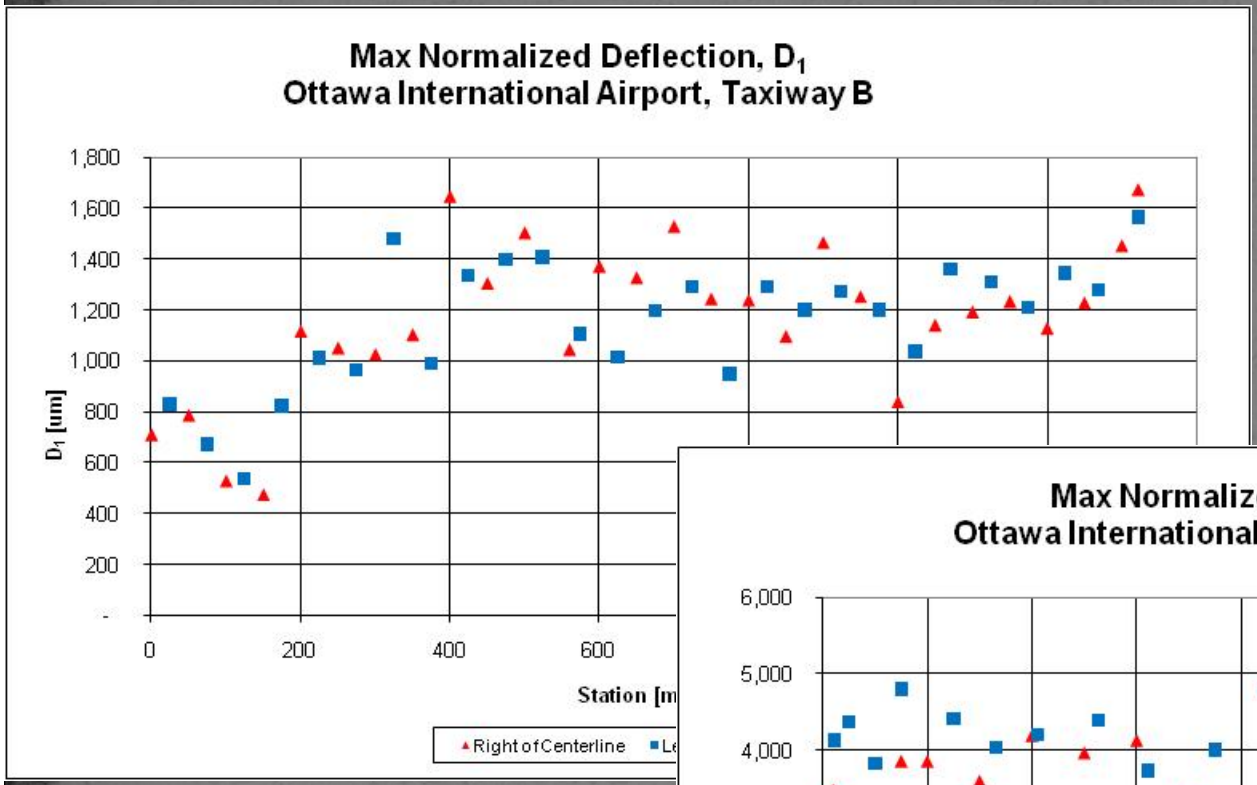
Heavy Weight Deflectometer (HWD)
Analysis – Backcalculation

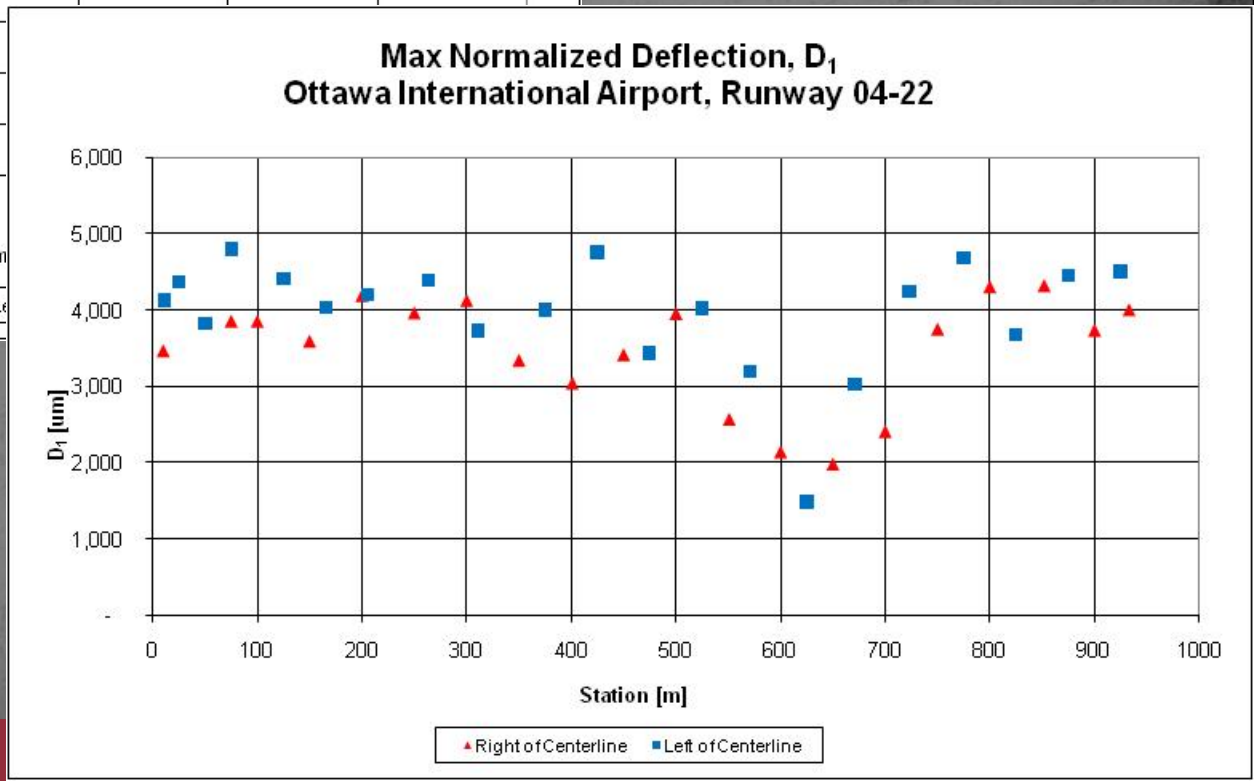
- Uses analytical pavement response models to predict deflections based on a set of given layer thickness values and moduli
- Backcalculated moduli examined to draw conclusions about degree of structural deterioration
- Backcalculated modului used for design of structural overlays

Heavy Weight Deflectometer (HWD)
Analysis Outputs – Asphalt Runways/Taxiways

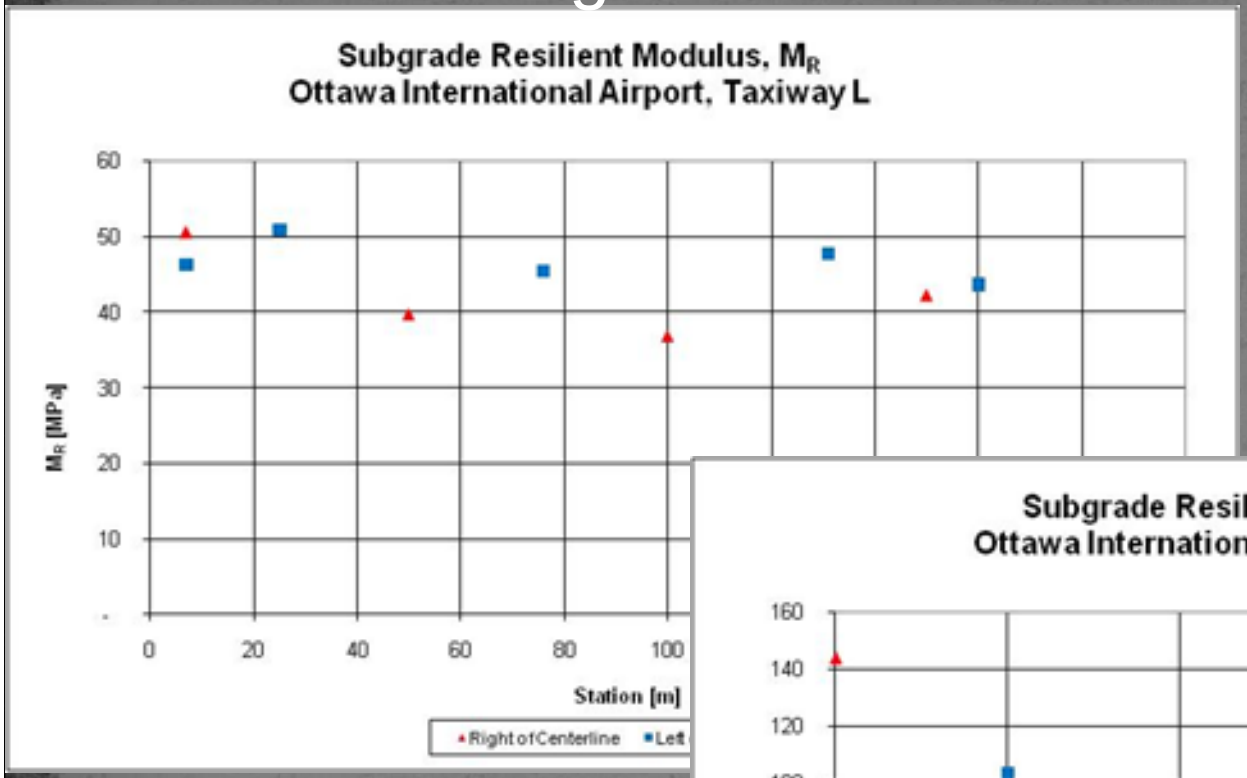
- Maximum normalized deflection (D_1)
  - Indicator of overall pavement stiffness (strength)
- Subgrade resilient modulus (M_R)
  - Representation subgrade soil strength to resist permanent deformation under loading
- Pavement layers effective structural number (SN_{eff})
  - Load carrying capacity of pavement structure
- Pavement Load Rating (PLR)
  - Pavement bearing strength

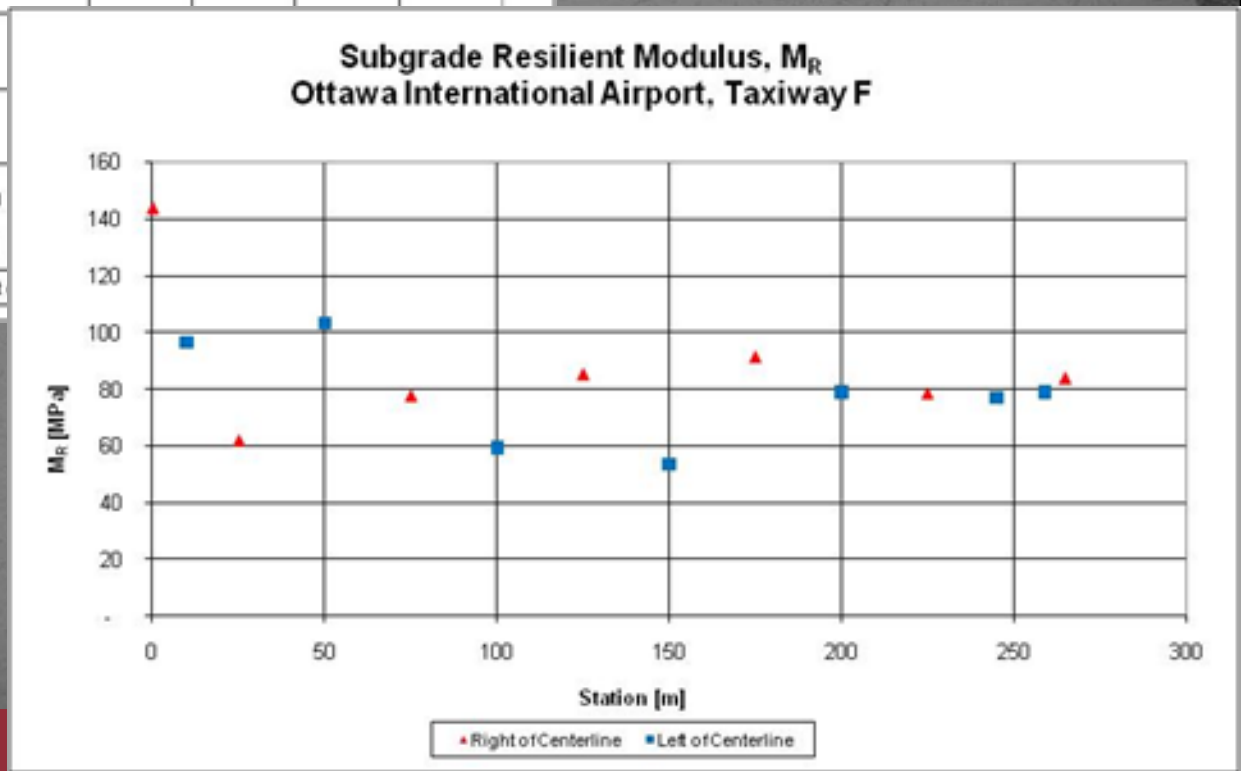
Heavy Weight Deflectometer (HWD)
Results – Maximum Normalized Deflection (D_1)



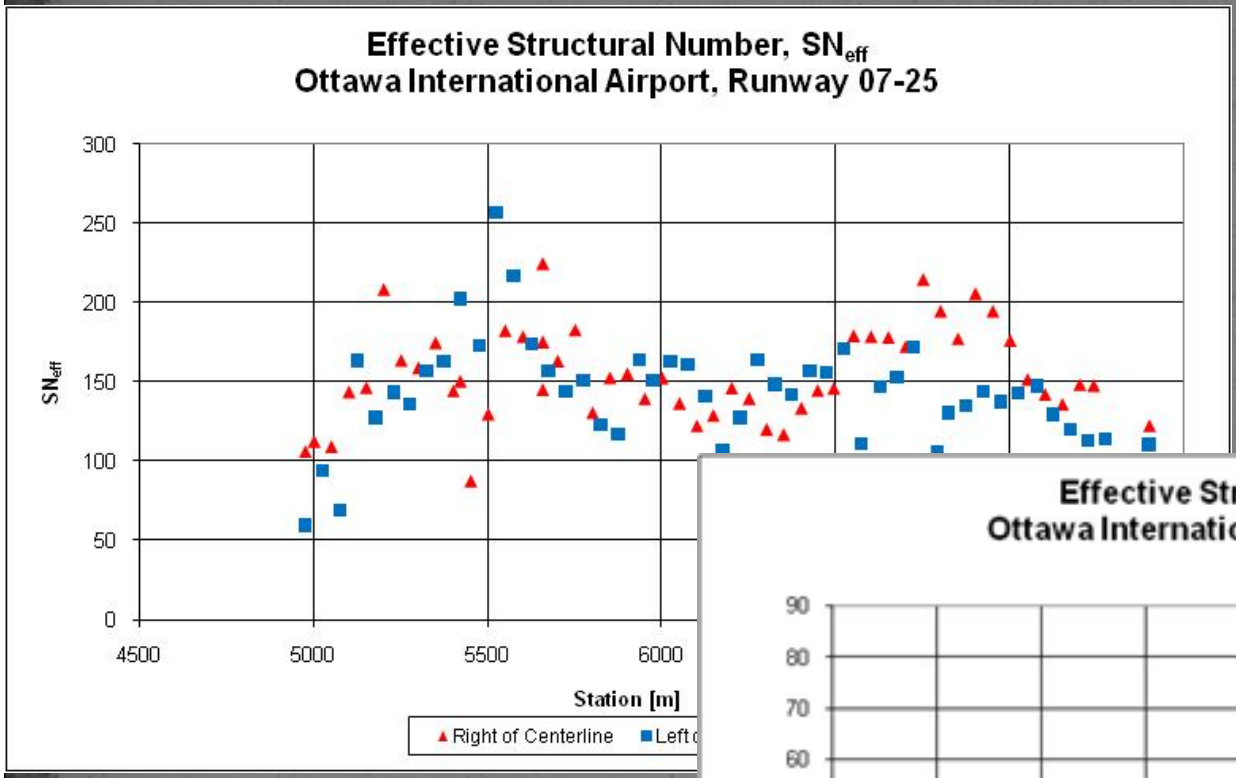


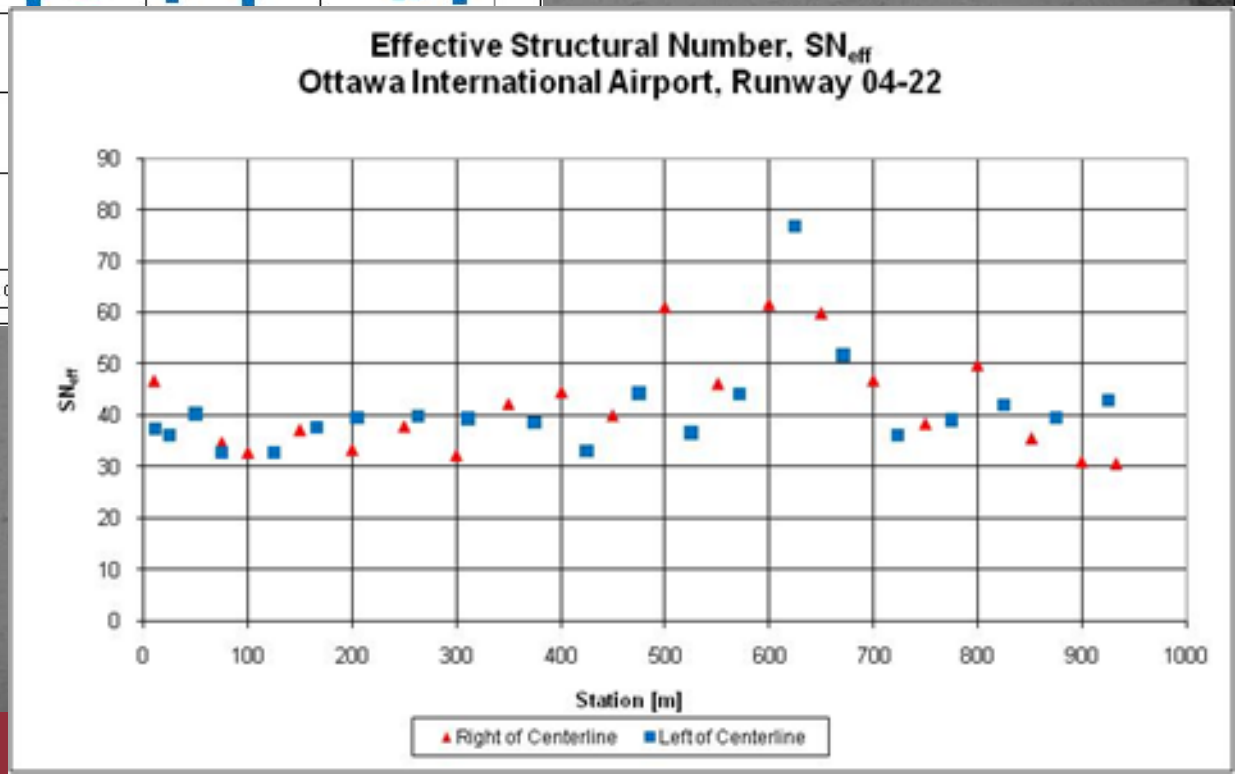
Heavy Weight Deflectometer (HWD)
Results – Subgrade Resilient Modulus (M_R)





Heavy Weight Deflectometer (HWD)
Results – Effective Structural Number (SN_{eff})





Heavy Weight Deflectometer (HWD)
Results – Pavement Load Rating (PLR)

Runway	Side of Centerline	Effective Granular Thickness [mm]	CBR %	Bearing Capacity (kN/m²)	PLR	Avg. PLR	Nominal ALR	PCN	Avg PCN	Published ACN	Operational Classification
Runway 04-22	L	375	4.2	104	7.0	6.8	10.7	23	24	72	Restricted
	R	360	3.8	96	6.5		10.7	25			
Runway 07-25	L	637	6.6	164	11.5	11.5	10.7	149	176	94	Unrestricted
	R	592	6.9	172	11.4		10.7	202			
Runway 14-32	L	740	5.6	140	11.1	10.9	10.7	114	111	94	Unrestricted
	R	699	5.4	135	10.7		10.7	109			

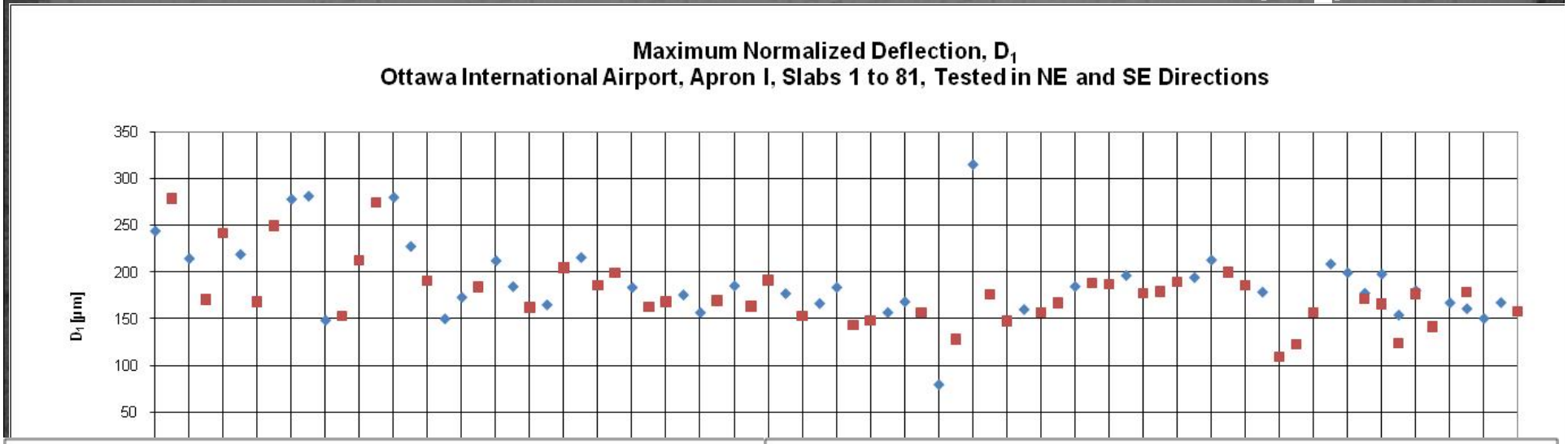
Heavy Weight Deflectometer (HWD)
Analysis Outputs – Concrete Aprons

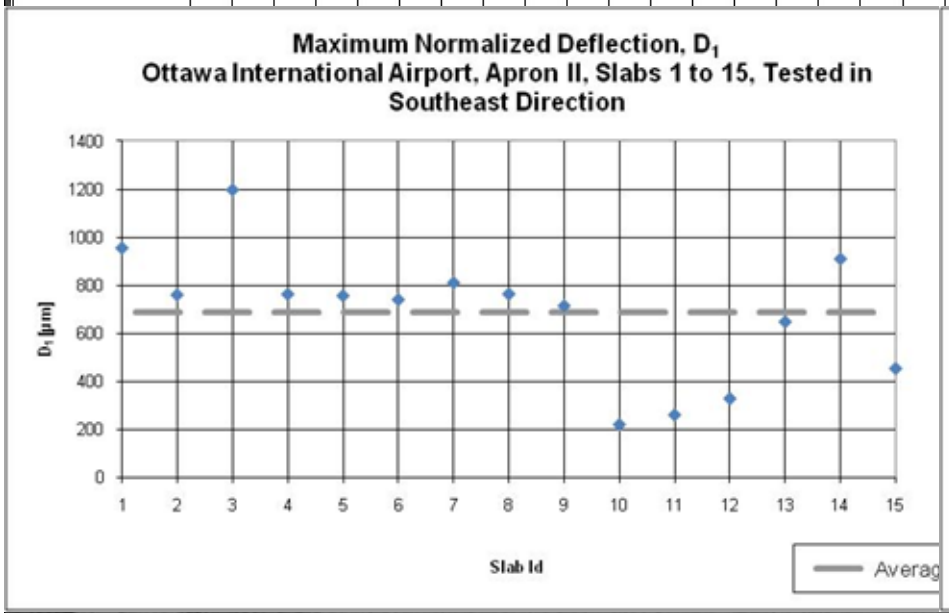
- Maximum normalized deflection (D_1)
  - Indicator of overall pavement stiffness (strength)
- Modulus of subgrade reaction (k_{static})
  - Representation subgrade soil strength
- Elastic Modulus of Concrete (E_{PCC})
  - Representation of flexibility (non-permanent deformation)
- Effective slab thickness (D_{eff})
  - Equivalent thickness of existing pavement if newly placed

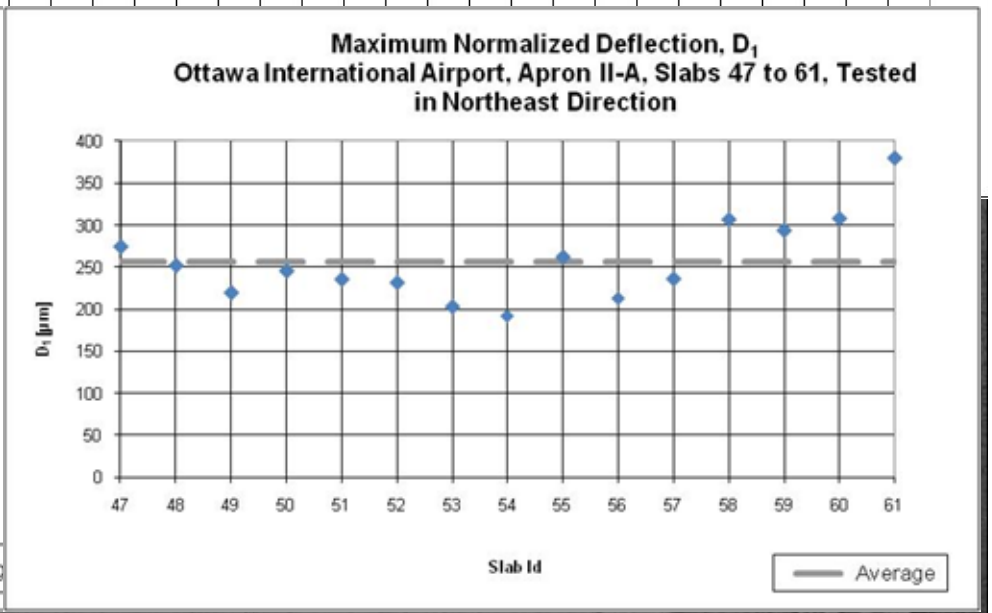
Heavy Weight Deflectometer (HWD)
Analysis Outputs – Concrete Aprons (cont'd)

- Pavement Load Rating (PLR)
  - Pavement bearing strength
- Load transfer efficiency (LTE)
  - Indication of joint performance; measure of load transfer from one slab to another
- Loss of Support (Voids)
  - Potential loss of support at joints

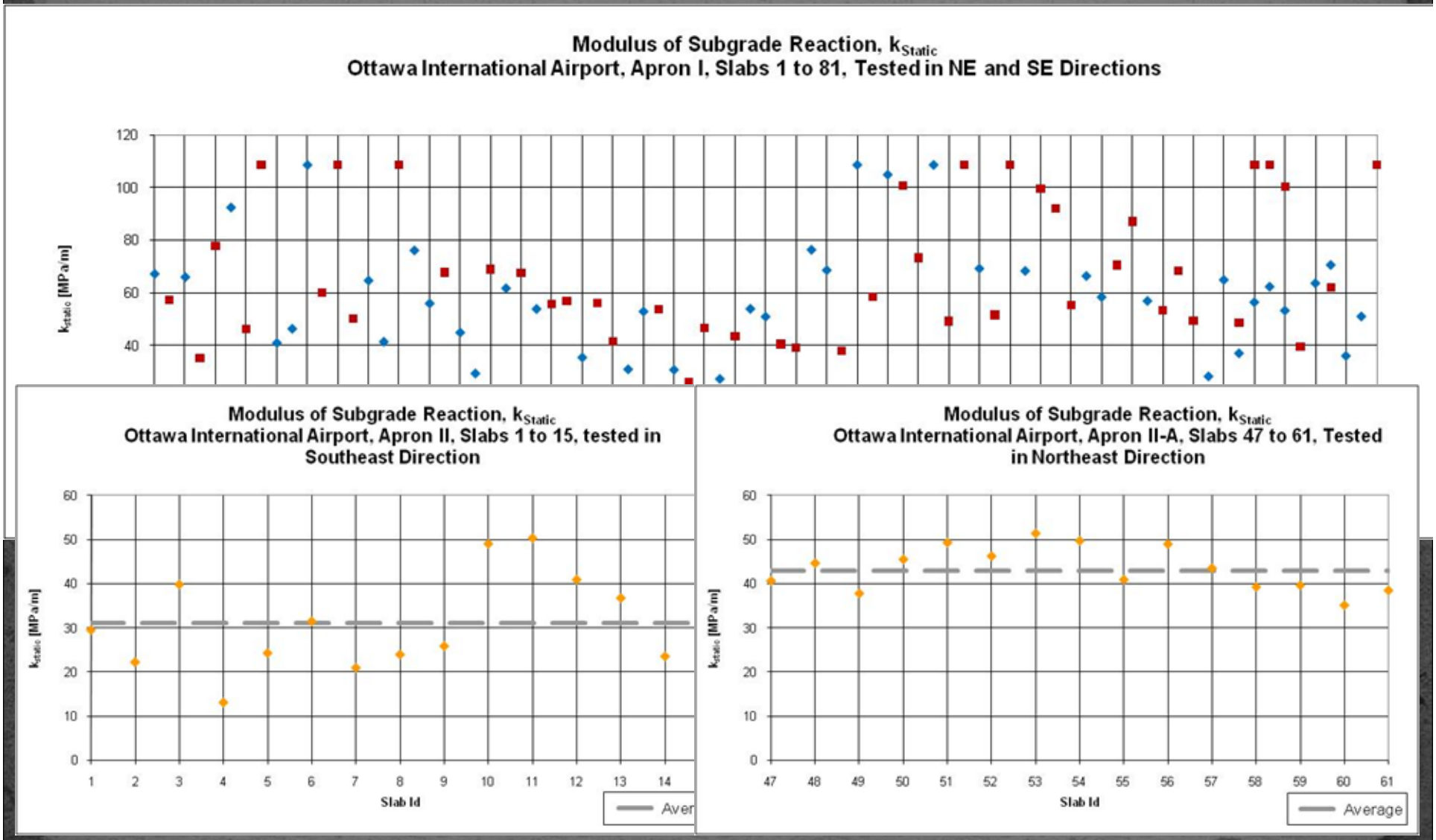
Heavy Weight Deflectometer (HWD)
Results – Maximum Normalized Deflection (D_1)



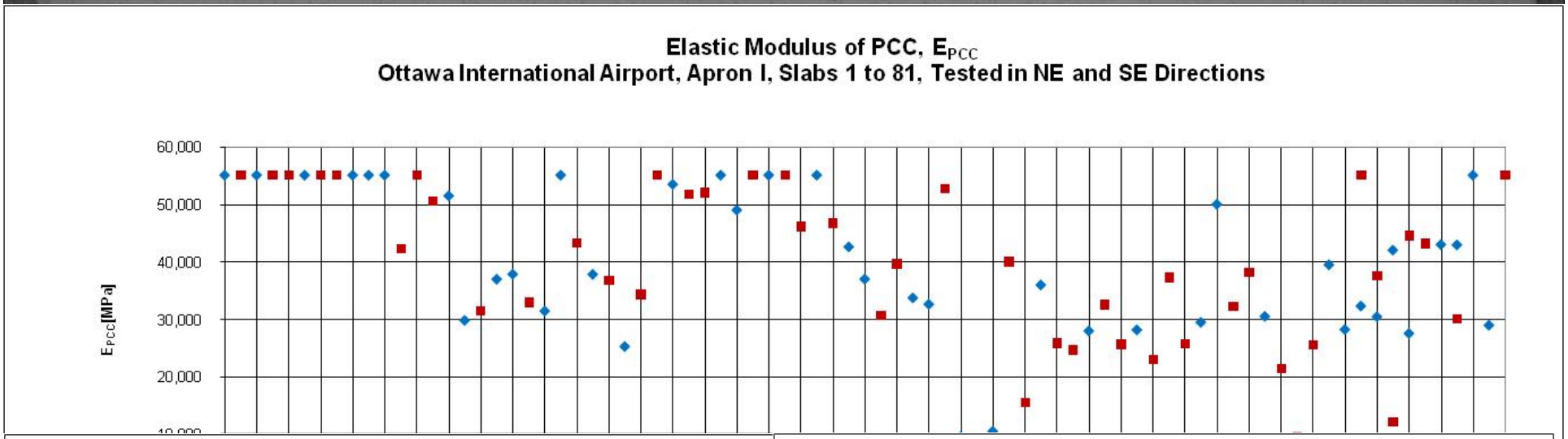


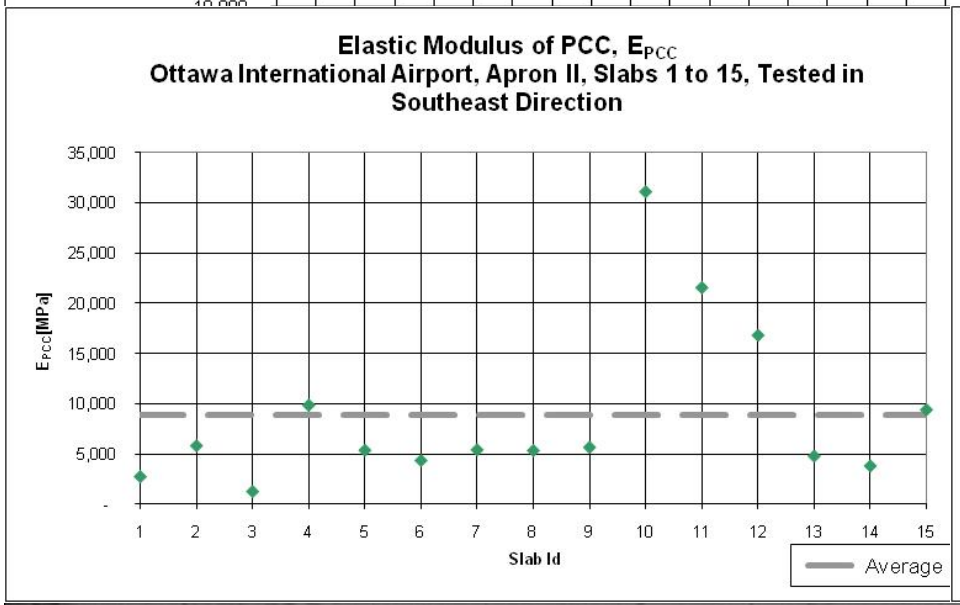


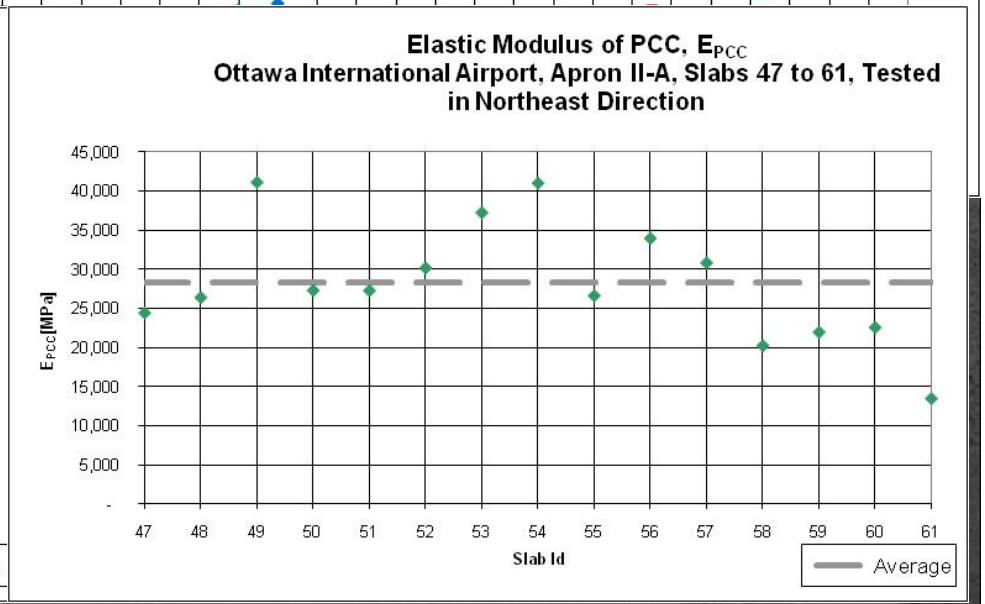
Heavy Weight Deflectometer (HWD)
Results – Modulus of Subgrade Reaction (k_{Static})



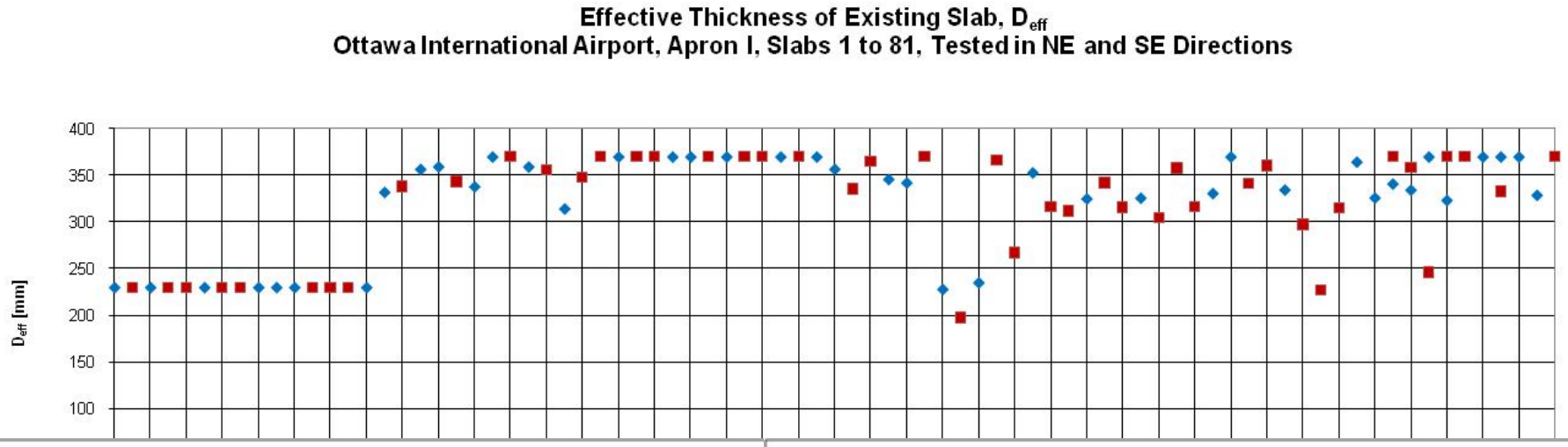
Heavy Weight Deflectometer (HWD)
Results – Elastic Modulus of PCC (E_{PCC})

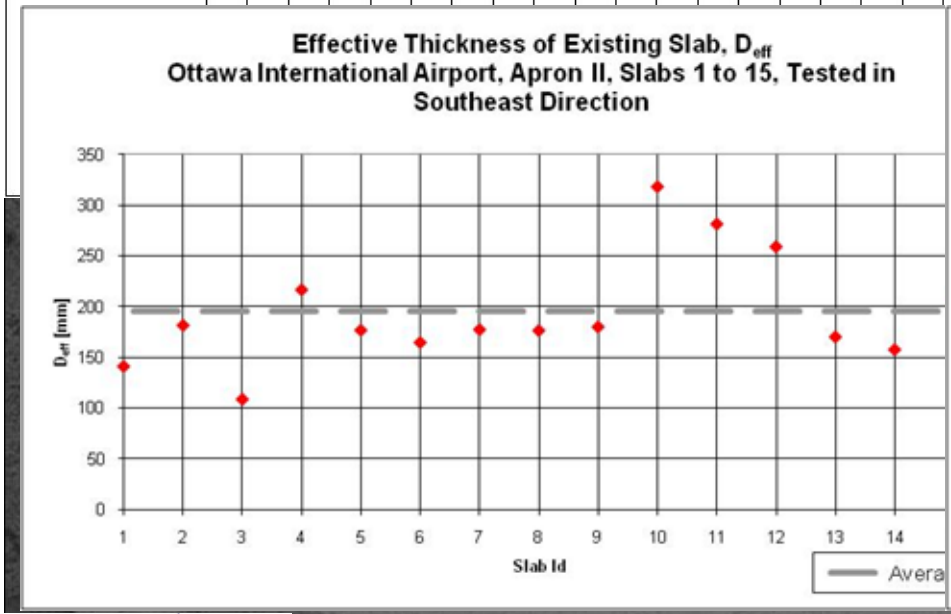


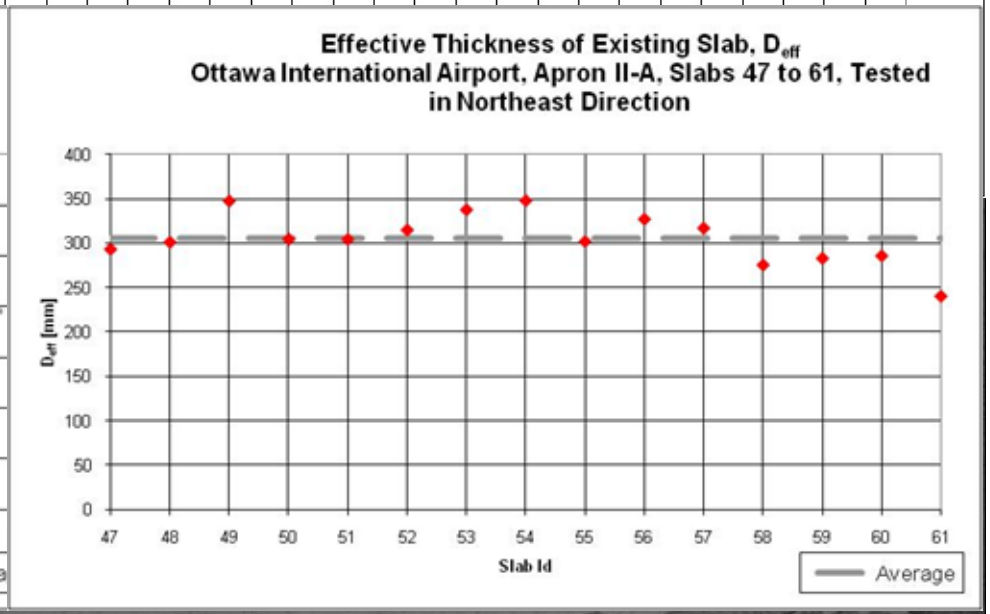




Heavy Weight Deflectometer (HWD)
Results – Effective Thickness of Slab (D_{eff})



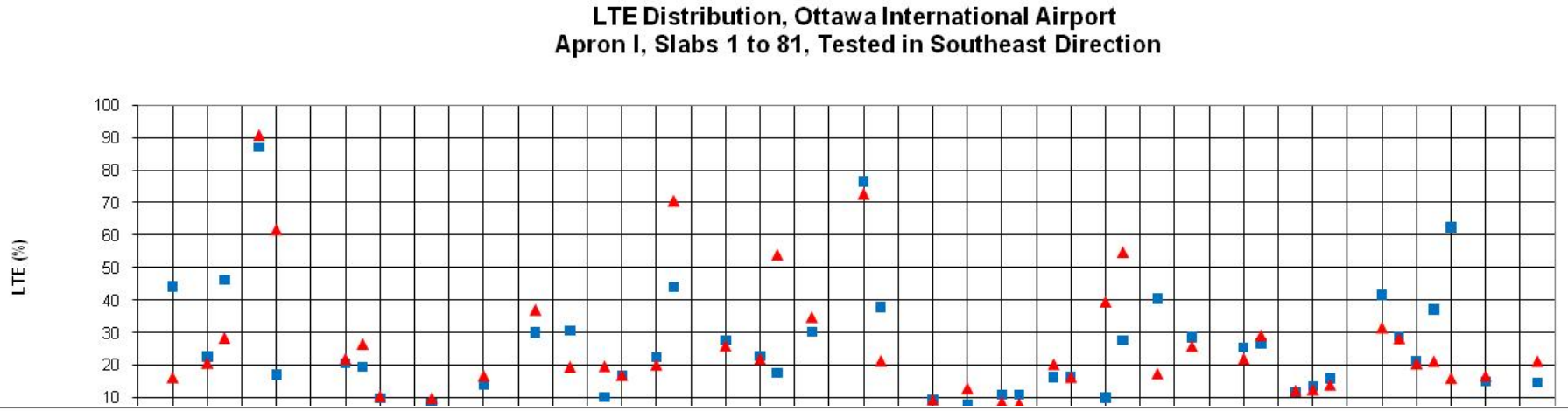


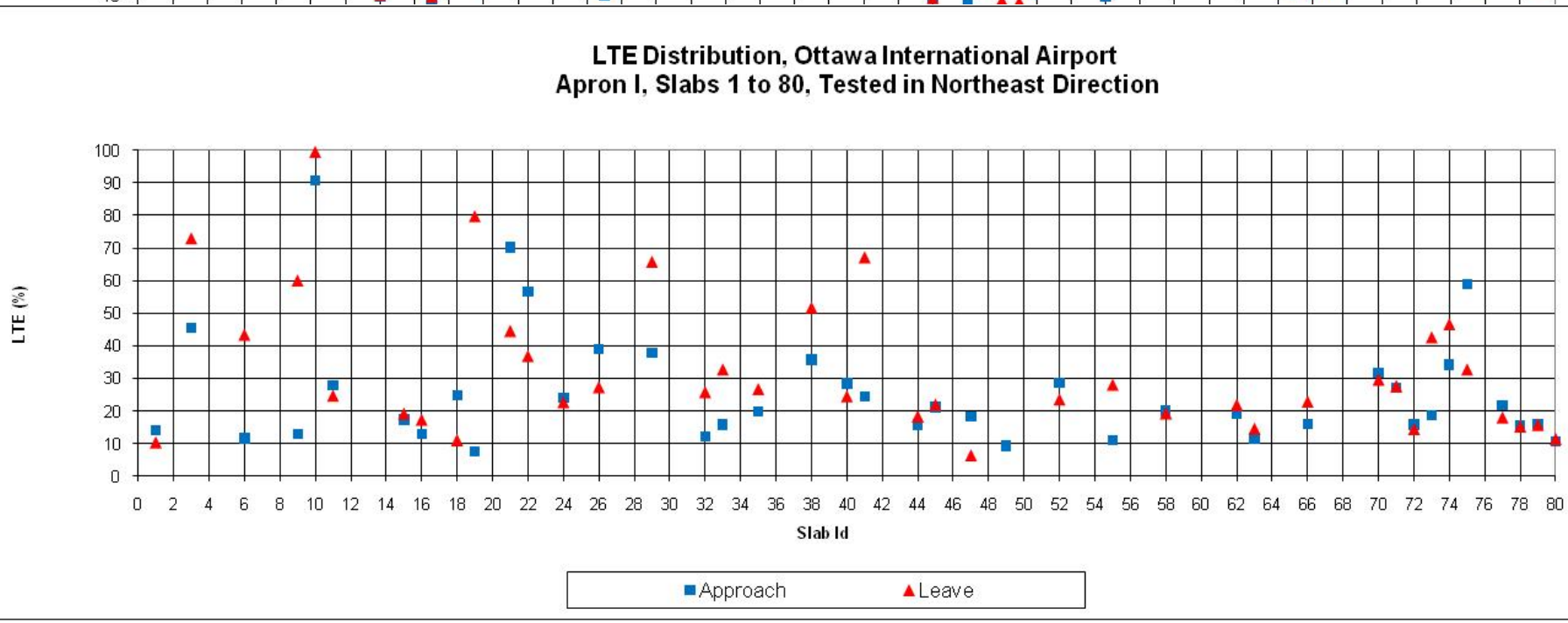


Heavy Weight Deflectometer (HWD)
Results – Pavement Load Rating (PLR)

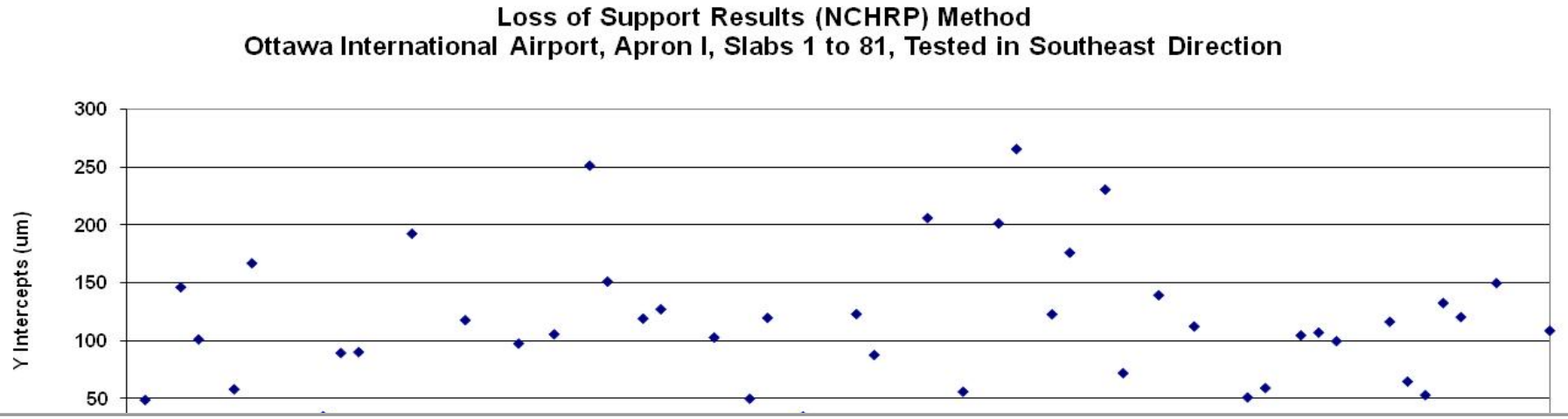
Apron	Direction	PCC Slab Thickness [cm]	Average K_{static} [MPa/m]	Average PLR
Apron II	SE	35	31	10.1
	NE	35	28	10.0
Apron II-A	SE	35	38	10.3
	NE	35	43	10.5

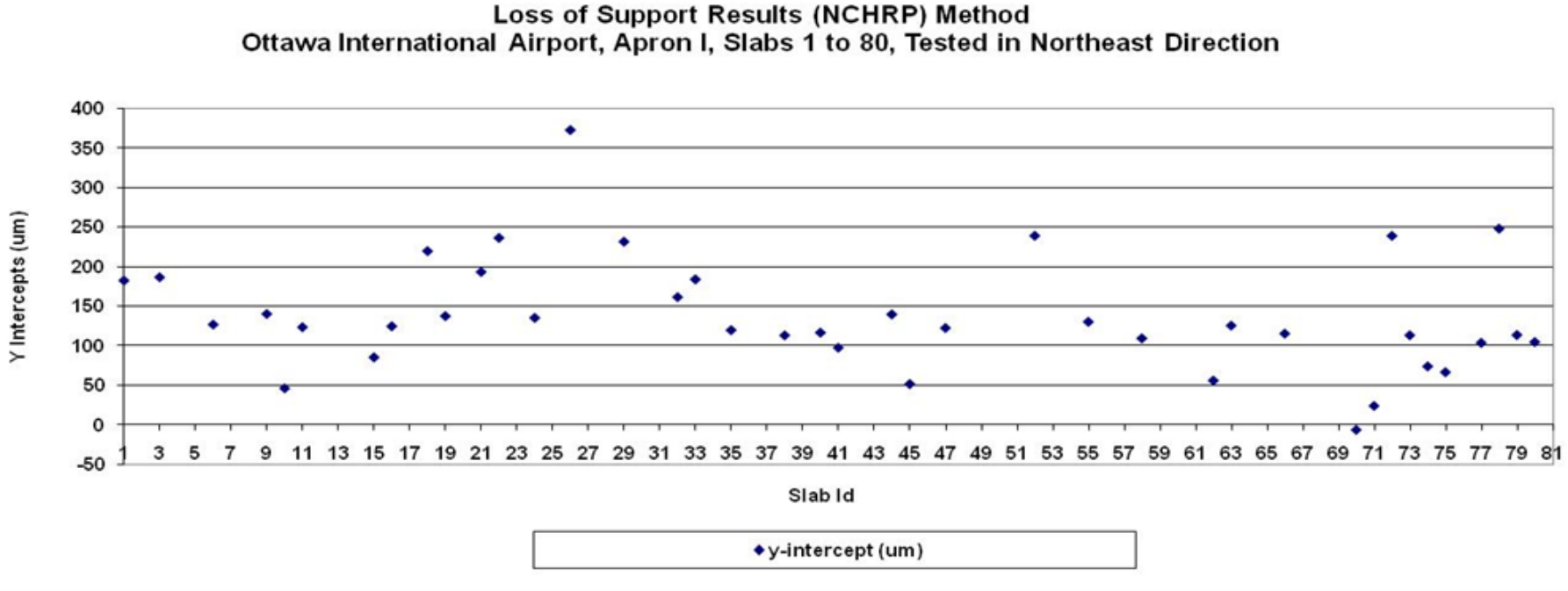
Heavy Weight Deflectometer (HWD)
Results – Load Transfer Efficiency (LTE)





Heavy Weight Deflectometer (HWD)
Results – Loss of Support (Voids)





Heavy Weight Deflectometer (HWD)
Summary Results for Runways

Runway	Side of Centerline	Number of Tests Completed	Maximum Normalized Deflection D_1 (µm)	Subgrade Resilient Modulus M_R (MPa)	Effective Pavement Modulus (E_p)	Effective Structural Number SN_{eff}
Runway 04-22	L	21	4,435	43	194	41
	R	20	3,820	40	253	42
Runway 07-25	L	50	794	68	1,875	142
	R	53	668	71	2,322	152
Runway 14-32	L	64	1,180	58	1,065	136
	R	60	1,219	56	988	126

Heavy Weight Deflectometer (HWD)
Summary Results for Taxiways

Taxiway	Side of Centerline	Number of Tests Completed	Maximum Normalized Deflection D_1 (µm)	Subgrade Resilient Modulus M_R (MPa)	Effective Pavement Modulus (E_p)	Effective Structural Number SN_{eff}
Taxiway A	L	25	1,333	52	866	100
	R	25	1,387	52	788	101
Taxiway B	L	27	1,228	65	839	105
	R	28	1,237	64	894	102
Taxiway C	L	12	1,345	59	700	115
	R	12	1,451	59	578	109
Taxiway D	L	5	1,204	54	831	119
	R	5	1,378	55	718	135
Taxiway E	L	21	1,281	54	766	116
	R	20	1,380	58	661	115
Taxiway F	L	7	1,359	78	622	114
	R	7	1,130	89	1,008	73
Taxiway J	L	6	2,251	48	344	83
	R	5	2,184	46	401	75
Taxiway K	L	5	1,859	47	491	94
	R	5	1,336	49	792	106
Taxiway L	L	5	1,813	47	542	90
	R	4	1,982	42	522	90

Heavy Weight Deflectometer (HWD)
Summary Results for Aprons

Apron	Direction	Number of Tests Completed	Maximum Normalized Deflection D_1 (µm)	Effective Slab Depth (mm)	Modulus of Subgrade Reaction K_{static} (MPa/m)	Elastic Modulus of Concrete E_{pcc} (Mpa)
Apron I	SE	45	176	318	68	32,356
	NE	41	191	325	60	33,609
Apron II	SE	15	686	195	31	8,870
	NE	15	832	168	28	5,012
Apron II-A	SE	16	269	309	38	28,986
	NE	15	257	306	43	28,283

Next Steps

How is the data being used?

- Data used in publications, such as Airport Operations Manuals (AOM)
- Assist in assessing underground infrastructure deficiencies and the detection of voids
- Assist in developing multi-year runway improvement program
- Essential in the design process of resurfacing projects


Thank you/Merci
Questions?