Use of HWD (deflection), Backcalculation, and Multilayer Elastic Analysis for Airport Pavement Evaluation

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Presentation Outline

- Project Background
- Supplemental Research Work
- FWD, Backcalculation, & ELT
- Case Study
- Decision Tree (Rehab Options)
- Evaluation
- Conclusions & Recommendations

Project Background

Scope & Objectives

- 3-year airside pavement improvement program
- Year 1 program
  - Taxiway ‘A’
  - Apron V
  - Apron I (northern two-thirds)
  - Runway 11-29 (300 m beginning at the western end)
- Objective
  - Determine the existing pavement structure
  - Analyze the structure in terms of pavement strength
  - Develop recommendations for rehabilitation

Project Background

Pavement Evaluation

- Series of 14 boreholes (BH)
  - To determine pavement structure and layer types
- Dynamic Cone Penetrometer (DCP) at 5 BH
  - To determine the strength of the granular layer underlying the pavement surface
- Visual distress survey
  - To assess surface distress condition
- Heavy Weight Deflectometer (HWD) survey
  - To determine pavement structural strength

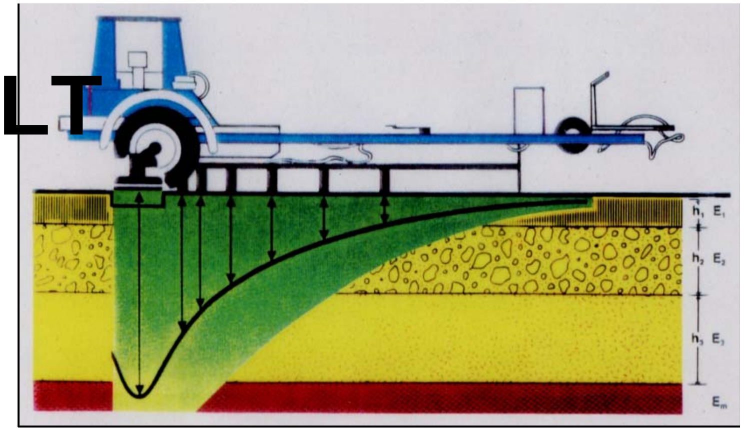

BH 1
BH 2
BH 7
BH 3
BH 6
BH 4
BH 5
BH 8
BH 9
BH 10
BH 13
BH 11
BH 14
BH 12

Supplemental Research Work

- New methodology developed within Stantec, to develop and evaluate rehabilitation options
  - FWD Analysis
  - Backcalculation
  - Multi-layer elastic analysis
- Case Study
  - Runway 11-29

FWD, Backcalculation, & ELT

Pavement Evaluation



- FWD Analysis
  - Determine in-situ structural capacity of the pavement structure (and subgrade soil conditions)
- Backcalculation
  - Procedure to determine Young's modulus of Elasticity for pavement materials, using measured surface deflections by working elastic layer theory "backwards"
- Elastic Layer Analysis
  - Measurement of deflections, stresses, and strains

Case Study

Runway Structure

Avg. Core Thicknesses	
AC	Crushed
5.9	11.8

150 mm (Asphalt layer)

300 mm (Crushed stone base and subbase layers)

Backcalculation is based on semi-infinite half-space of subgrade

Rigid Layer is present within less than 3 metres from the surface

Case Study
FWD & Backcalculation

HWD Inputs

- 2 drops at each load level
- 3 load levels
  - 60 kN (13,500 lbf)
  - 90 kN (20,200 lbf)
  - 120 kN (27,000 lbf)

HWD Analysis Outputs

- E1 - modulus of asphalt layer
- E2 - modulus of the base/subbase layer
- E3 - modulus of the subgrade layer
- Statistics - Average, Standard deviation, Maximum, Minimum, Coefficient of Variance

Case Study
Backcalculation: Layer 1 - Asphalt

Drop No.	Stress (kPa)	Load (kN)	E1 (MPa)				
			Avg	StDev	Max	Min	COV
1	859	61	3,393	1,364	6,171	1,630	40.2%
2	1362	96	3,415	1,214	6,043	1,835	35.5%
3	1793	127	3,582	1,411	6,372	1,900	39.4%
4	865	61	3,621	981	5,061	2,149	27.1%
5	1274	90	3,704	1,073	5,570	2,106	29.0%
6	1694	120	3,645	1,151	5,695	2,085	31.6%
Overall Avg		**92.5**	**3,560**				

Drop No.	Stress (psi)	Load (lbf)	E1 (psi)				
			Avg	StDev	Max	Min	COV
1	125	13,646	492,044	197,812	894,988	236,415	40.2%
2	197	21,636	495,368	176,068	876,494	266,077	35.5%
3	260	28,498	519,567	204,660	924,148	275,609	39.4%
4	126	13,752	525,117	142,271	734,007	311,704	27.1%
5	185	20,241	537,172	155,556	807,897	305,437	29.0%
6	246	26,917	528,682	166,980	826,027	302,356	31.6%
Overall Avg		**20,782**	**516,325**				

Asphalt layer is in fair to good condition

Case Study
Backcalculation: Layer 2 – Base/subbase

Drop No.	Stress (kPa)	Load (kN)	E1 (MPa)				
			Avg	StDev	Max	Min	COV
1	859	61	3,799	3,164	9,282	417	83.3%
2	1362	96	3,907	2,496	7,402	650	63.9%
3	1793	127	4,260	2,901	7,706	726	68.1%
4	865	61	4,223	2,827	8,374	761	67.0%
5	1274	90	3,819	2,570	7,441	774	67.3%
6	1694	120	4,254	2,819	8,442	839	66.3%
Overall Avg		**92.5**	**4,044**				

Drop No.	Stress (psi)	Load (lbf)	E1 (psi)				
			Avg	StDev	Max	Min	COV
1	125	13,646	550,962	458,901	1,346,201	60,436	83.3%
2	197	21,636	566,601	361,988	1,073,602	94,264	63.9%
3	260	28,498	617,822	420,988	1,117,672	105,280	68.1%
4	126	13,752	612,501	410,064	1,214,612	110,308	67.0%
5	185	20,241	553,850	372,742	1,079,249	112,279	67.3%
6	246	26,917	616,968	408,793	1,224,462	121,677	66.3%
Overall Avg		**20,782**	**586,451**				

Increased base/subbase modulus due to compensation effect of rigid layer

Case Study

Backcalculation: Layer 3 – Subgrade

Drop No.	Stress (kPa)	Load (kN)	E1 (MPa)				
			Avg	StDev	Max	Min	COV
1	859	61	384	175	547	151	45.5%
2	1362	96	394	166	567	133	42.2%
3	1793	127	398	133	566	210	33.4%
4	865	61	360	183	612	174	50.9%
5	1274	90	401	158	576	222	39.4%
6	1694	120	393	154	581	209	39.1%
Overall Avg		**92.5**	**388**				

Drop No.	Stress (psi)	Load (lbf)	E1 (psi)				
			Avg	StDev	Max	Min	COV
1	125	13,646	55,711	25,360	79,395	21,964	45.5%
2	197	21,636	57,090	24,109	82,237	19,296	42.2%
3	260	28,498	57,699	19,279	82,056	30,512	33.4%
4	126	13,752	52,182	26,573	88,768	25,248	50.9%
5	185	20,241	58,179	22,907	83,545	32,144	39.4%
6	246	26,917	57,065	22,324	84,224	30,368	39.1%
Overall Avg		**20,782**	**56,321**				

Higher variability is an indication of inconsistent layer

Decision Tree (Rehab Options)

If surface condition is **very poor to poor**

Rehab Options:

1. Hot in place recycling of the existing asphalt and overlay with a new HMA high stiffness surface layer (SMA* or Superpave* with PG 70-34* or PG 76-34* or equivalent)

2. Total reconstruction

***** Use 1.5% lime by weight for high stiffness HMA Use 0.3 - 0.5 AC% above optimum for durability
Consider use of warm asphalt mix technology

Decision Tree (Rehab Options)
If surface condition is **poor to fair**

Rehab Options:

1. Mill 80 mm (3 in) of existing asphalt and overlay with a 125 mm (5 in) of HMA high stiffness surface layer (SMA* or Superpave* with PG 70-34* or PG 76-34* or equivalent)

2. If milling is not an option, then overlay 125-180 mm (5 -7 in) after surface sealing & repair

Decision Tree (Rehab Options)

If surface condition is **fair to good**

Rehab Options:

1. Mill 50 mm (2 in) and overlay 80 mm (3 in) of HMA high stiffness surface layer (SMA* or Superpave* with PG 70-34* or PG 76-34* or equivalent)

2. If milling is not an option, then overlay with 50 mm (2 in) after surface sealing & repair

Decision Tree (Rehab Options)

If surface condition is **good to very good**

Rehab Options:

1. Mill 25 mm (1 in) and overlay with 50 mm (2 in) of HMA high stiffness surface layer (SMA* or Superpave* with PG 70-34* or PG 76-34* or equivalent)

2. If milling is not an option, then overlay 40-50 mm (1.5-2 in)

Evaluation

Rating Criteria - Scale

- 1 – 5 Rating Index Scale
  - Rating Index 5 = very good
  - Rating Index 4 = good
  - Rating Index 3 = fair
  - Rating Index 2 = poor
  - Rating Index 1 = very poor

Evaluation

Rating Criteria – Functional vs. Structural

- Functional conditions
  - Based on surface distress
- Structural conditions
  - Based on Backcalculation
  - Based on Multilayer Elastic Analysis Results
    - To reduce pavement deflection and tensile strain at bottom of asphalt layer under main gear of the design aircraft
    - Reduce surface deflection as follows:

Evaluation
Rating Criteria – Deflection Performance

- Deflection vs. Strain Relationship
  – 25 microns (4 mils) or less = Very good
  – 100 – 150 microns (4 – 6 mils) = Good
  – 150 – 200 microns (6 – 8 mils) = Fair
  – 200 – 250 microns (8 – 10 mils) = Poor
  – 250 microns (10 mils) or higher = Very Poor

Evaluation
Results

- FWD Analysis
  - Avg. deflection = 192 microns (7.9 mils)
  - Standard deviation = 53 microns (2.1 mils)
- Multilayer Elastic Analysis
  - Low subgrade deflection
  - Less than 120 micro strains for the tensile strain at the bottom of the asphalt layers

Indicating fair to good runway condition

Conclusions & Recommendations

- Rating Index = 3 - 4 (fair to good)
  - Based on calculations and visual inspection
- Rehab Options
  - Mill 50 mm (2 in) and overlay 80 mm (3 in) of HMA high stiffness surface layer (SMA* or Superpave* with PG 70-34* or PG 76-34* or equivalent)
  - If milling is not an option, then overlay with 50 mm (2 in) after surface sealing & repair

Conclusions & Recommendations

- To replace SMA/Superpave, recommend performance grades (PG):
  - Use 1.5% lime by weight for high stiffness HMA
    - Improve stiffness
    - Prevents stripping potential
    - Reduces rutting potential
  - Use 0.3 - 0.5 AC% above optimum
    - Improve durability, i.e. reduce cracking potential
  - Consider use of warm asphalt mix technology
    - Similar to Boston Logon International taxiway

Questions

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