


ADVANCED ASPHALT TECHNOLOGY TO ADDRESS SHEAR DISTRESSES ON AIRSIDE FACILITIES

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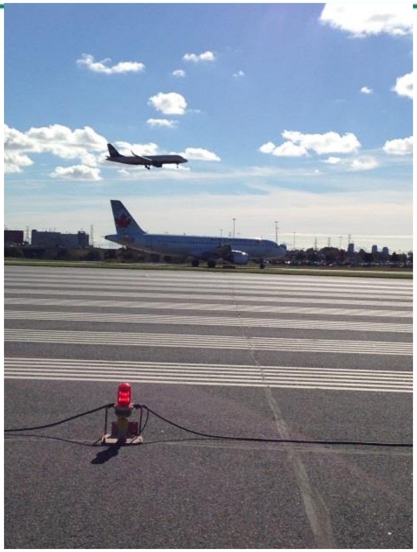
PRESENTATION OUTLINE



- Acknowledgements
- Introduction
- Research Objectives
- Background and Literature Review
- Methodology
- Testing and analysis
- Expected Contribution

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- Gazzola Paving and Coco Paving

INTRODUCTION

- Traffic at airports is continuously increasing with larger aircrafts coming into service
- Airside pavements are critical to airport capacity and revenues
- Airside pavements constitute a large portion of an airports expenditures
- Asphalt materials widely used for airside pavements

AIRFIELD PAVEMENTS

- Runways
  - Where aircrafts land and takeoff
  - Aircraft speed from very high speed to relatively slow moving
- Taxiways
  - Connect aprons to runways
  - Traffic is relatively slow moving and occasionally static
- Aprons
  - Locate adjacent to terminal building or hangars
  - Traffic is very slow moving and static

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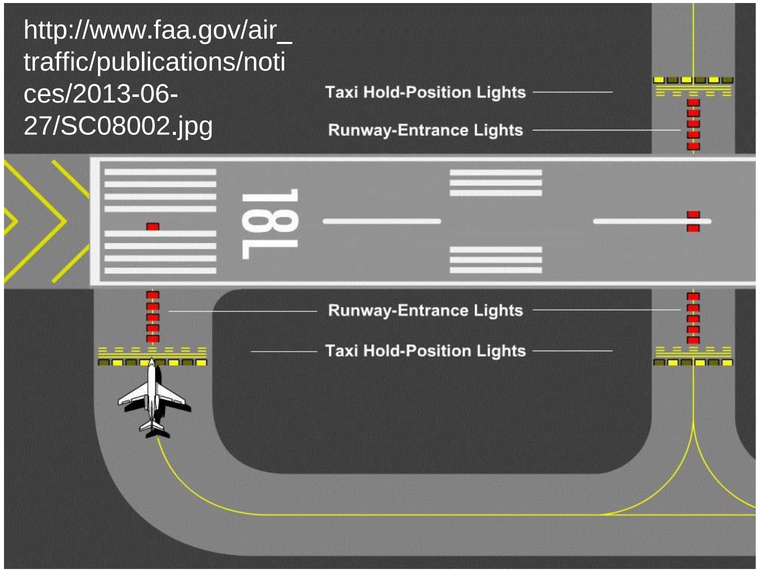
AIRFIELD PAVEMENTS

LOADING ON AIRFIELD PAVEMENTS

- Different from that on road pavements
- Varies based on location on the airfield
- Majority of areas experience high vertical loads only
- Localized areas have to accommodate very high horizontal loads
  - Aircrafts braking at the taxiway hold lines
  - Rapid exit taxiways
  - Fully loaded aircrafts turning from taxiways on to runways
  - Fully loaded aircrafts turning at runway thresholds



SHEAR DISTRESSES

- Localized areas experiencing high horizontal forces
- Asphalt shear, shoving, cracking and deformation
- Occur despite pavement being adequately structurally designed and constructed
- Observed at airports in a variety of climates
  - Canada
  - United States
  - Caribbean
  - Asia
  - Europe
- Observed at airports of varying sizes

CRACKING AND SURFACE DEFORMATION

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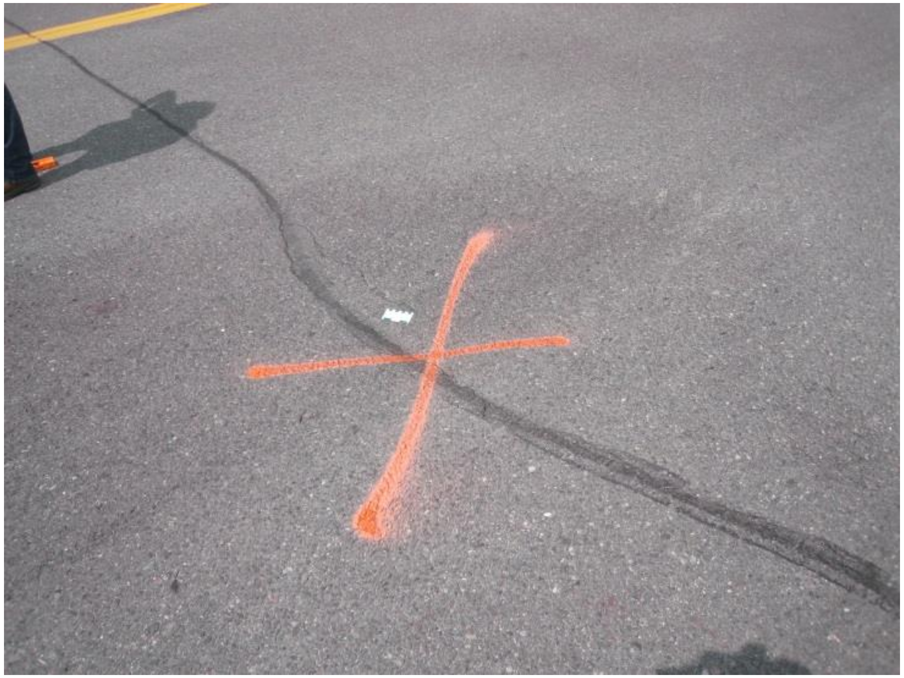
SURFACE DEFORMATION



SURFACE DEFORMATION

SURFACE DEFORMATION

IMPACT OF SHEAR DISTRESSES

- Shear cracking can pose a significant safety hazard by creating Foreign Object Debris (FOD)
- Additional strain on the airport operations budget
- No established method for long term repair of areas experiencing these distresses
- Closure of facilities for emergency repair leads to costs to the airport and the airline
- Additional dynamic stresses on the aircraft body leading to reduction in fatigue life

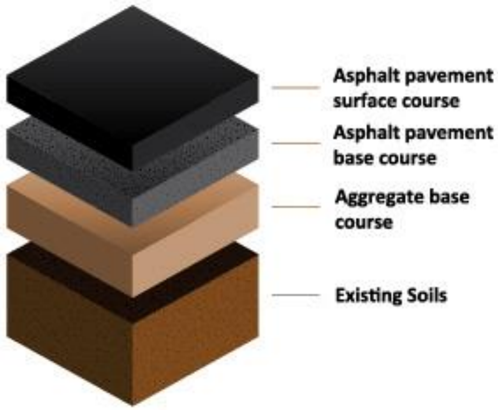
FOREIGN OBJECT DEBRIS (FOD)

RESEARCH OBJECTIVES

- Identify locations on the airfield with highest horizontal forces and potential for shear distresses
- Model the response of asphalt materials to forces applied at the critical areas
- Evaluate different asphalt mixtures for their resistance to development of shear distresses
- Provide designers a tool to evaluate candidate asphalt mixtures for use in critical areas

AIRFIELD PAVEMENT STRUCTURAL DESIGN

- Two primary methods used for pavement structural design
  - Transport Canada Methodology
  - Federal Aviation Administration Methodology
- Aircraft traffic loading in the design methods is considered differently
- Both structural design methods only consider vertical loads
- Pavement structural design considers two primary failure mechanisms
  - Subgrade rutting
  - Fatigue failure of the asphalt layers



http://www.myasphaltpavingproject.com/

AIRFIELD ASPHALT MIXES

- Marshall and Superpave mix design methods
- Marshall method used almost exclusively for airfield asphalt mix design in Canada
- Marshall method is being successfully replaced by Superpave method for road pavements
- Airport industry is hesitant in adopting the Superpave method
  - Limited field experience with Superpave method for airfield pavements
  - Method was developed for road pavements taking into consideration truck traffic loading
- Transition to Superpave will not address shear failure

MARSHALL MIX DESIGN

- Specimens are produced using the Marshall Hammer
- Specimens are prepared at varying asphalt cement contents
- Asphalt cement selected to optimize different properties of the produced mixture
  - Air void content
  - Marshall stability and flow
  - Voids in Mineral Aggregate (VMA)
  - Voids Filled with Asphalt (VFA)

MARSHALL MIX DESIGN

SUPERPAVE MIX DESIGN

- Developed to address deficiencies with the Marshall method
- Compaction of larger specimens using a gyratory compactor
- Includes requirements for aggregate properties and grading which was not part of Marshall method
- New grading system for asphalt cement based on performance testing at high and low in service temperatures

AIRFIELD ASPHALT MIX REQUIREMENTS

	Airport Surface Course Mix	Road Paving Surface Course Mix (MTO, 2010)
Asphalt Cement Content	Minimum 5.3%	Minimum 5.0%
Target Air Void Content	3.5%	4.0%
Minimum Stability	14 kN	12 kN
Flow	2 mm – 4 mm	Minimum 1.6
Asphalt Cement Grade	PG 70-28 Polymer Modified	PG 64-28

SHEAR RESISTANCE OF ASPHALT

- No consideration during pavement design process
- Only considered asphalt rutting resistance and interlayer bonding
- Asphalt materials are highly shear sensitive
  - Modulus from compression loading is higher than modulus from shear loading
- Linear elastic does not take into consideration that asphalt is shear sensitive and anisotropic

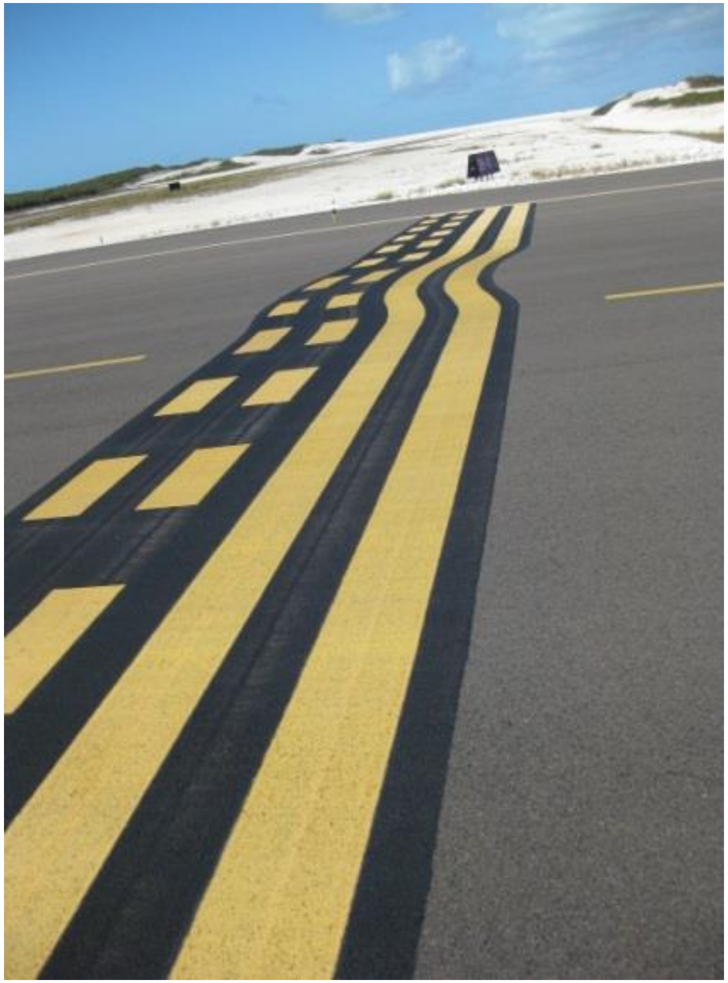
SUPERPAVE SHEAR TESTER

- Developed as part of Superpave mix design
- To be used to evaluate asphalt mixes for facilities experiencing high traffic volumes
- Can carry out four different types of tests
- Testing device is not widely used today
- Only very few testing devices are in use today

ASPHALT DISTRESSES

Cracking	Surface Deformation	Aggregate Loss	Surface Abrasion
• Alligator Cracking • Map Cracking • Block Cracking • Transverse/Thermal Cracking • Joint (transverse or longitudinal) Cracking • Slippage • Shear cracking	• Rutting (permanent deformation) • Shoving • Rippling	• Weathering • Raveling • Potholing	• Scuffing • Polishing

SURFACE DEFORMATION



- Vertical and horizontal deformation
- Can be measured using a number of different tools
- Number of different factors including asphalt mix properties can cause deformation

CRACKING

- Different types depending on the cause of the cracking
  - Inadequate load bearing capacity of pavement
  - Asphalt shrinking during cold weather
  - Oxidation of asphalt cement
  - Slippage of asphalt layer over underlying layer
  - Excessive shear forces on asphalt layers

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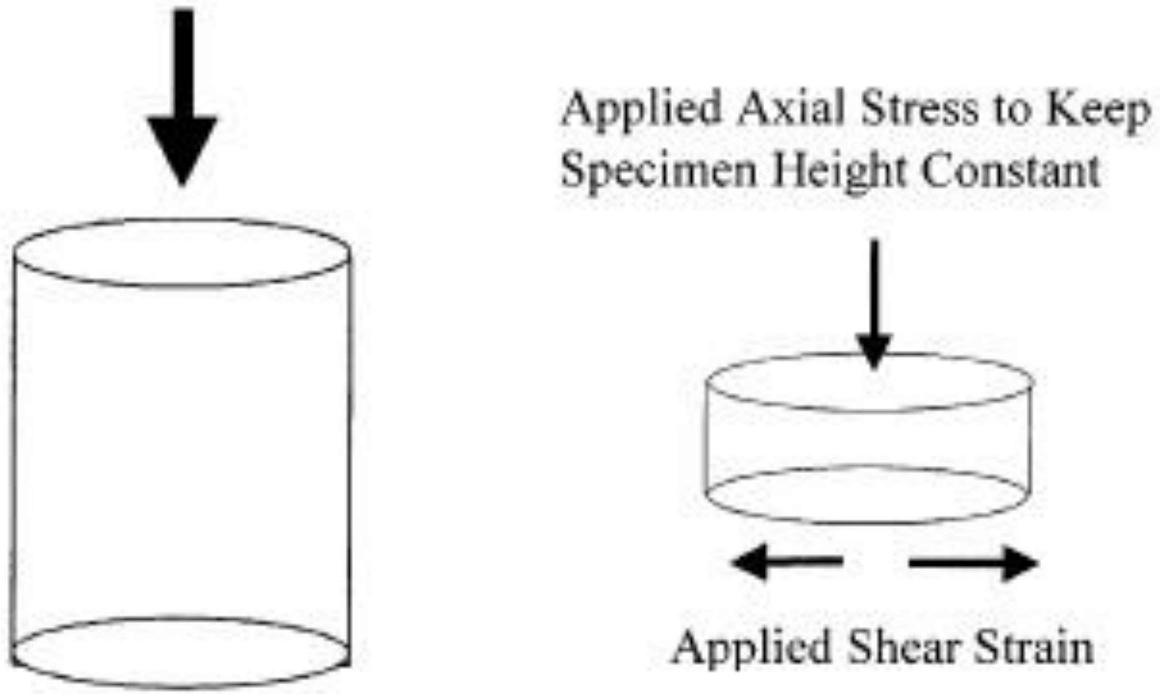
ASPHALT MIX TESTING

- Mix design stage
  - Aggregate properties and gradation
  - Asphalt mix volumetrics
  - Marshall stability and flow
- Limited to no performance testing during the mix design stage
- Number of field performance tests can be used
  - Tests of fundamental mechanistic properties e.g. dynamic modulus
  - Empirical tests e.g. Marshall stability and flow
  - Simulative tests e.g. Asphalt Pavement Analyzer (APA)

COMPLEX MODULUS

- Fundamental mechanistic property to determine strains developed due to applied stresses
- Strains developed in asphalt mixtures have two major properties
  - Recoverable and non-recoverable
  - Time-dependent and time-independent
- Complex modulus can be determined by application of
  - Compressive load i.e. dynamic modulus
  - Shear load i.e. shear modulus

COMPRESSIVE VERSUS SHEAR LOADING

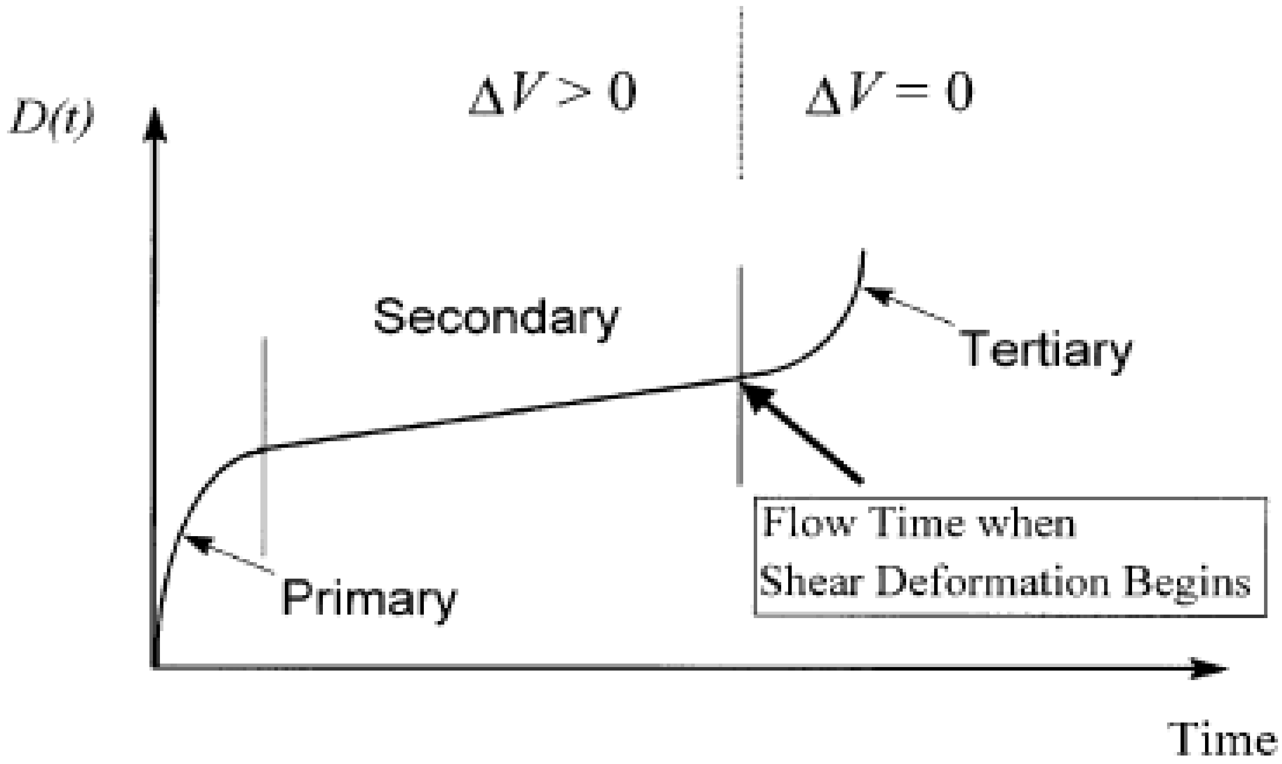


onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_465.pdf

COMPLIANCE

- Complex modulus does not allow for separation of the time-dependent and time-independent strain
- Compliance (D) - reciprocal of the modulus
- Divided into three phases for asphalt materials
  - Primary – Rate of strain development decreases with loading time
  - Secondary – Rate of strain development is constant with loading time
  - Tertiary – Rate of strain development increases with loading time
- Start of the tertiary phase (flow time) indicates start of shear distress in asphalt
- Been used to evaluate rutting susceptibility of asphalt

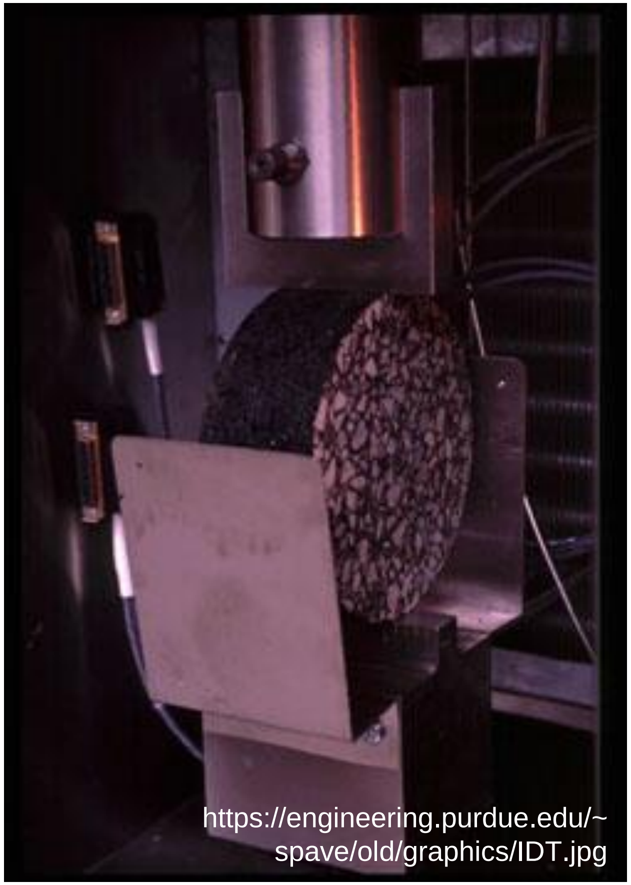
ASPHALT MIX COMPLIANCE



http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_465.pdf

ASPHALT FRACTURE RESISTANCE

- Multiple different test methods
- Most common test is the indirect tensile strength test
- Sample is loaded diametrally to failure
- Stress at the centre of the sample is calculated
- Indirect tensile strength (IDT) is the maximum stress
- Horizontal strain at maximum stress level has been noted to correlate well with cracking in the field



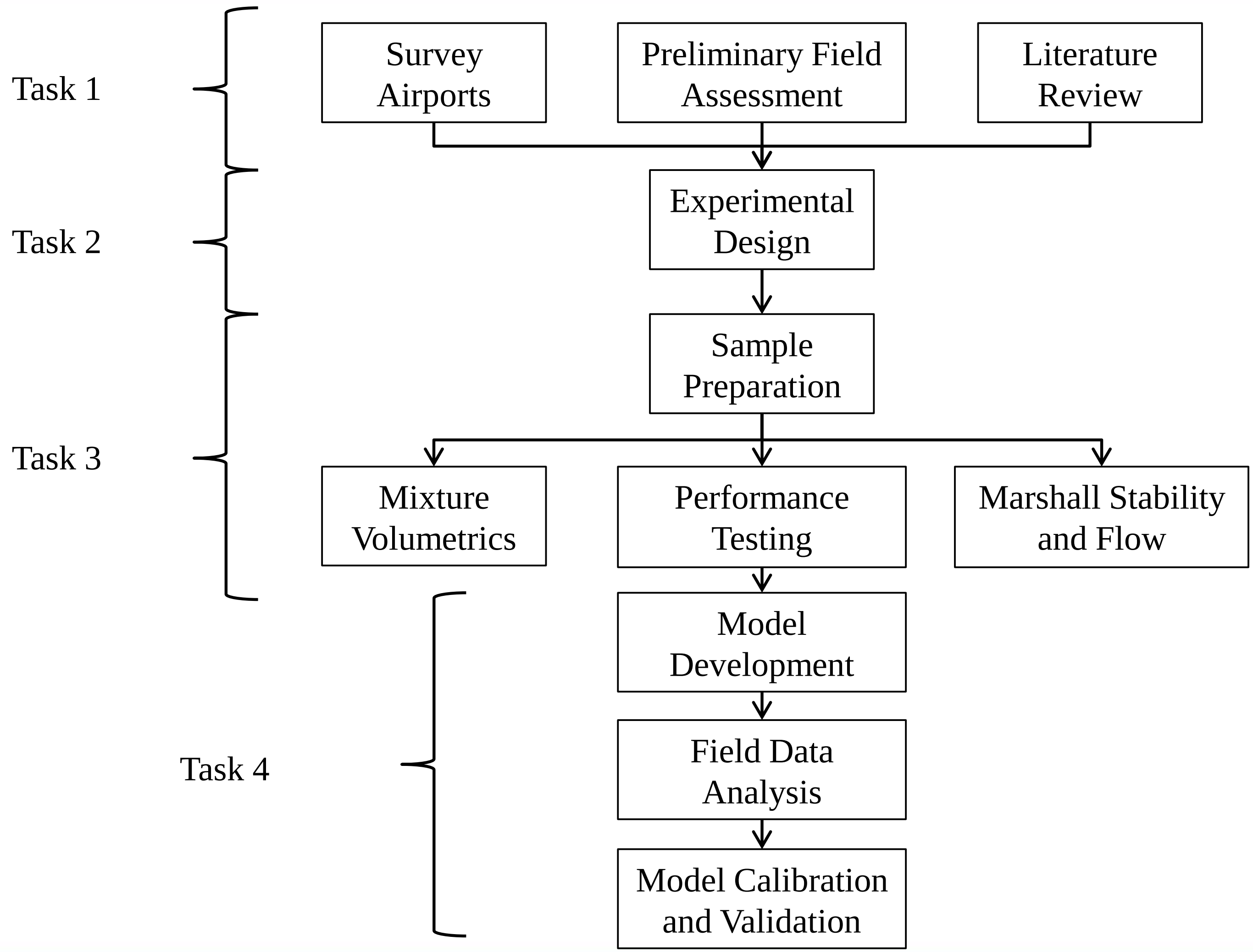
FINITE ELEMENT MODELLING

- Discretization tool that can be used to obtain approximate numerical solution to complex mathematical model
- Simulate the response of an asphalt material to an applied loading
- Asphalt layer is divided in to smaller elements
- Each element connected to others at nodes
- Each element is assigned a set of parameter values that governs its response to an applied load
- Previously utilized asphalt material models include linear elastic, viscoelastic, and viscoplastic

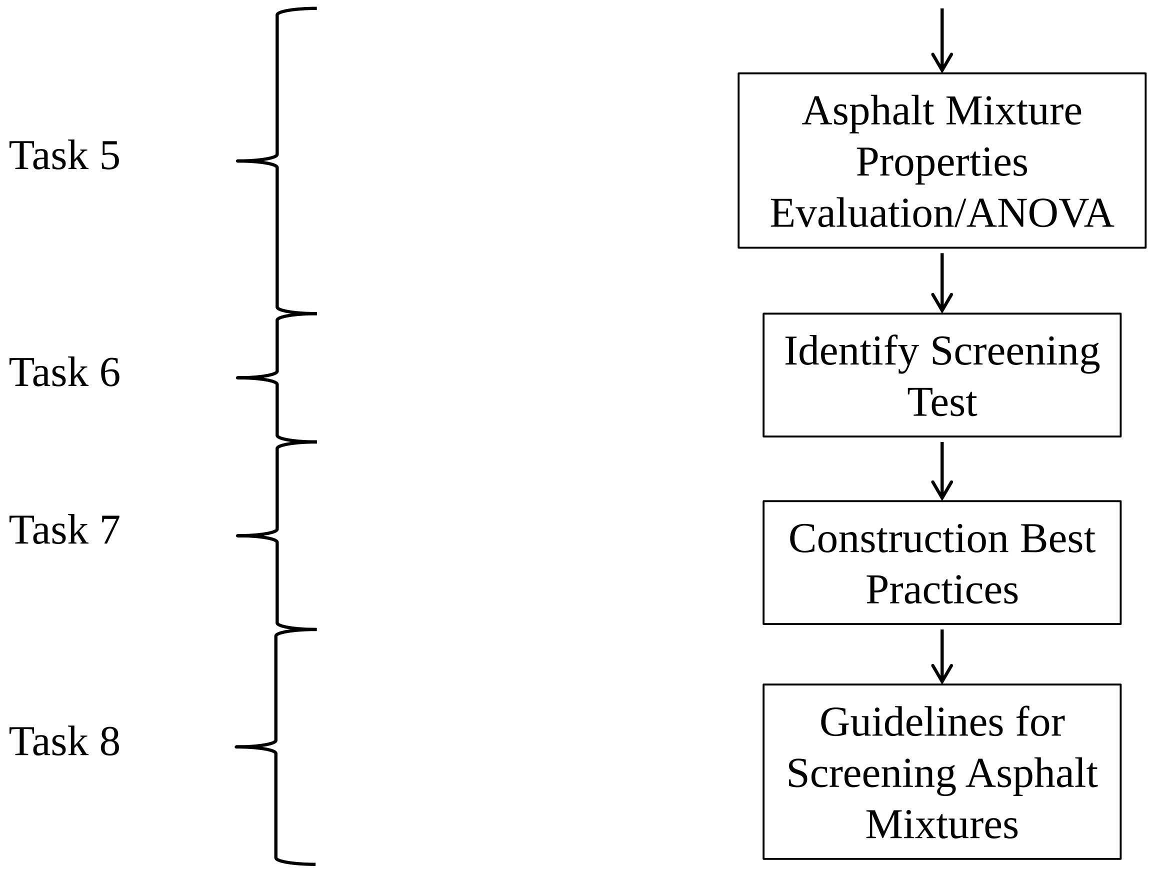
CONSTRUCTION PRACTICES

- Has a significant impact on the performance of the final product
- Some construction practices that affect asphalt shear resistance are
  - Existing asphalt surface should be thoroughly cleaned
  - Tack coat should be an emulsified asphalt
  - Tack coat should be allowed to fully cure before placement of new asphalt
  - Excessive tack coat should be avoided
  - If asphalt is being placed on an existing concrete layer or cement treated base, the existing surface should be roughened

RESEARCH METHODOLOGY



RESEARCH METHODOLOGY



EXISTING INFORMATION

- Survey airport operators and review of existing literature
- Initial review of literature and preliminary field assessment have found
  - Shear distresses observed at airports of varying sizes
  - Distresses are occurring at locations where fully loaded aircrafts are stopping or turning
  - Distresses are not occurring at locations where the aircraft is slowing down after landing
  - Distresses include vertical and horizontal deformation and cracking

EXPERIMENTAL DESIGN

- 2^3 factorial experiment
- Factors to be evaluated
  - Stiffness of asphalt cement
  - Proportion of crushed aggregate
  - Proportion of coarse aggregate
- Each of the mixes is designed for
  - 3.5 % air voids
  - Marshall stability of 14 kN
  - Within a specified gradation band

Run	Asphalt Cement Grade	Percent Two Faces Crushed	Percent Coarse Aggregates
1	PG 70-28 PMA	85	55
2	PG 70-28 PMA	85	65
3	PG 70-28 PMA	100	55
4	PG 70-28 PMA	100	65
5	PG 82-28 PMA	85	55
6	PG 82-28 PMA	85	65
7	PG 82-28 PMA	100	55
8	PG 82-28 PMA	100	65

PARAMETER DETERMINATION

- Parameters required will be confirmed when asphalt material model is finalized
- Laboratory testing includes
  - Volumetrics
  - Marshall stability and flow
  - Dynamic modulus and shear modulus
  - Creep testing using compressive load and shear load
  - Indirect tensile strength test
- Minimum of three samples for each treatment level is tested

MODEL DEVELOPMENT

- Utilize the ABAQUS software
- Asphalt is modeled as a viscoplastic material
- Extent of the model from applied load is established iteratively
- Parameter values from both the compressive and shear loading tests
- Data from in place pavement is used for model validation

EVALUATE DIFFERENT ASPHALT MIXES

- Results from modelling and lab testing are analyzed
- Analysis of Variance (ANOVA)
- Will not prescribe the exact mix to be used to prevent shear distresses
- Will identify if factors being studied have an impact on asphalt shear resistance
- Will provide designers with direction on how to increase asphalt mix shear resistance

IDENTIFY SCREENING TEST

- Procedures developed during this research are only intended to be used for critical areas
- Correlation between lab testing and modelling
- Identify a test that may be used by designers to evaluate and compare different asphalt mixtures
- Previously flow time and number have been used for evaluating susceptibility to rutting
- May consider Marshall stability and flow

GUIDELINE DEVELOPMENT

- Final deliverable for this research
- Guidelines will include
  - Recommendations for grade of asphalt cement
  - Angularity of aggregates
  - Proportion of coarse aggregates
- Recommendations for additional testing of asphalt mixtures to be used in critical areas
- Limits for the testing results to provide asphalt material with superior shear resistance

EXPECTED CONTRIBUTIONS

- Address a significant short coming of airfield asphalt pavement industry
- Minimize safety hazard resulting from the shear related distresses
- Minimize economic burden to the airport operations budget
- Minimize lost revenues to airport operators and airlines due to reduced emergency closures
- Minimize the dynamic forces on the aircraft body by enhancing pavement smoothness

THANK YOU!

QUESTIONS?

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