RPA P-5
Airport Pavement Design
FAARFIELD Update

Presented to: REDAC Briefing to Sub-committee on Airports
By: David R. Brill, P.E., Ph.D.
Date: September 9, 2021
Advisory Circular Status

- **New AC 150/5320-6G, Airport Pavement Design and Evaluation.**
  - Posted 6/7/2021

- **New AC 150/5335-5D, Standardized Method of Reporting Airport Pavement Strength - PCR.**
  - In FAA final review. Some remaining PCR reporting issues to be resolved.
  - Release expected Fall 2021.

- **Both ACs incorporate FAARFIELD 2.0 for design & PCR computations.**
No change to thickness design.

- Updated aircraft library.
- Ability to work with multiple defined vehicles.
- Ability to add, save and edit user system.
- Support for the new ICAO ACR-PCR computational library, FAA3R3D.
- A new 3D finite element based navigation.
- Completely redesigned GUI with improved screen flow and explorer.

Major update from version 1.4.

Current Version 2.0.5

FARFIELD 2.0

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Federal Aviation Administration

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FAARFIELD 2.0
FAARFIELD 2.0 Organization

Aircraft Library

Aircraft Traffic Mix

Pavement Structure

INPUT

LEAF Layered Elastic Analysis

FAAMesh 3D Mesh Generation

FAARFIELD MAIN PROGRAM

3D FEM Analysis

OUTPUT

• Thickness Design
• Life
• Compaction
• PCR

FAARFIELD LIBRARIES

Federal Aviation Administration
FAASR3D –
FAA Structural Analysis in 3D

• Visual Basic.NET library.
• Replaces obsolete NIKE3D Fortran program.
  – Managed Code - compatible with Microsoft .NET memory management services.
  – Improves performance. Old code was subject to memory conflicts and crashing.
  – Freely distributable code.
• Continued updates to improve speed & efficiency.
GUI Modernization

Major improvements:

- Easier job and section entry.
- Explorer-based navigation.
- Improved screen re-sizing and appearance.
- Improved flow between screens.
- Ability to store traffic mixes.
- Rationalized data file structure.
- On-demand report generation.
- Remove program logic from GUI controls.
- Etc.
Navigating in FAARFIELD 2.0

TOOLBAR

SECTION AREA

EXPLORER

OPTIONS

TRAFFIC AREA
FAARFIELD 2.0 Toolbar

Job & Section Tools

User-Defined Aircraft Tools

Batch Job Tools

Help File
Explorer Navigation

- FAARFIELD 2.0 supports multiple jobs open at the same time.

- Use the Explorer to navigate between jobs, and display:
  - Sections
  - Section Reports
  - PCR Reports/Graphs
  - 5010 Reports
  - Summary Reports (high-level run information on selected sections in a job)
Aircraft Library

Aircraft library has been completely reorganized and updated for the FAARFIELD 2.0 release!

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Four Functions in FAARFIELD 2.0

- **THICKNESS DESIGN** – Compute required thickness per AC 150/5320-6.
- **LIFE** – Compute structural life for a given structure and traffic mix.
- **COMPACTION** – Compute subgrade compaction requirements per AC 150/5320-6 for a given structure and traffic mix. (Applies to completed designs.)
- **PCR** – Compute Pavement Classification Rating (PCR) for the structure and traffic mix.
**FAARFIELD 2.0 Provides PCR**

- Directly uses FAARFIELD structure and traffic list.
- Replacement for COMFAA 3.0 & support spreadsheets.
- Method yields uniquely defined PCR – no more looping through all aircraft in the list.
- Implemented in FAARFIELD 2.0
  - Solves problem of computing PCR for mixed traffic (narrow bodies and LR aircraft) without unnecessary operating weight restrictions.
  - Seamlessly handles HMA overlays on rigid pavements.

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Diagram:

1. Compute ACR of all aircraft in list at operating weight. Find maximum ACR.
2. Run FAARFIELD Life for the full aircraft traffic list.
3. Run FAARFIELD Life for the critical aircraft only. Equivalent passes = no. of passes giving same CDF as original traffic list.
4. Run FAARFIELD Life for equivalent passes of the critical aircraft only. MGW of critical aircraft = GW giving CDF = 1.0 for the design life.

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**PCR = max(PCR)**

ACR of critical aircraft = maximum ACR in list?

- Yes: REPORT PCR
- No: Remove critical aircraft from traffic list.

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**Find critical aircraft:** Aircraft with the highest CDF contribution at critical offset.

**Federal Aviation Administration**

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User-Defined Aircraft Mode

Create, edit and save user-defined aircraft within the program.
User-Defined Aircraft

• FAARFIELD treats UDA just like other library aircraft, except they have (UDA) appended to the aircraft name.

• UDA data are stored in files in:
  \C:\Users\[user]\Documents\My FAARFIELD\User Defined Aircraft

• UDA data are also saved to the job file – useful if a job is sent to another user.
FAARFIELD 2.0 is the standard software accompanying the following FAA Advisory Circulars:

- AC 150/5320-BG - Airport Pavement Design and Evaluation
- AC 150/5335-50 - Standardized Method of Reporting Pavement Strength - PCR

FAARFIELD 2.0 is the FAA’s standard software for airport pavement thickness design and evaluation (AC 150/5320-6G, Airport Pavement Design and Evaluation) and pavement strength reporting using the ACR/PCR method (AC 150/5335-50, Standardized Method of Reporting Pavement Strength – PCR). FAARFIELD 2.0 features include:

- A completely redesigned graphical user interface (GUI) with improved screen flow and explorer-based navigation
- A new 3D finite element computational library, FAASR.3D, written in Visual Basic.NET
- Support for the new ICAO ACR-PCR system
- New graphical vehicle editor provides the ability to add, save and edit user-defined vehicles
- Updated aircraft library
- Ability to work with multiple jobs/sections at once

Notes:

- FAARFIELD stands for FM Rigid and Flexible Iterative Elastic Layered Design. FMRFIELD 2.0 incorporates full 3D finite element responses to aircraft loads (for new rigid pavements and rigid overlays). The 3D finite element models used for rigid pavement designs are computationally intensive and may result in long run times, depending on the computer characteristics. We would appreciate your comments concerning this program and your suggestions on how it could be improved.
- FAARFIELD 2.0 runs on Windows operating systems. Windows 7 or higher is recommended. Please follow installation instructions in the readme file.

For questions, comments or further information concerning this program, please contact Dr. David R. Brill, FAA Airports Technology R&D Branch, ANG-E262.

FAARFIELD 2.0 replaces all previous versions of FAARFIELD. To download the previous version, FAARFIELD 1.42, use the following link: [FAARFIELD 1.42](http://www.airporttech.tc.faa.gov/Products/Airport-Pavement-Software-Programs)
FAARFIELD Training Workshops
(All Virtual)

• May 11, 2021 – ASCE Transportation & Development Institute (T&Dl)
  – 308 participants from 33 countries

• May 24, 2021 – International Conference on Transportation Geotechnics (ICTG)

• Sept. 27, 2021 – International Conference on Concrete Pavements (ICCP)
Current Projects

- FAARFIELD / PAVEAIR Integration
- Design Criteria for Seasonal Frost and Permafrost.
- Design Criteria for Stabilized Bases
- Machine Learning (ML) for Design Stresses
- Reflection Cracking Model Development
FAA PAVEAIR Integration

- Use your PAVEAIR login for library updates
- Data exchange with PAVEAIR via WebAPI.
- Access to user-owned databases.
  - Download: Job information, existing sections, NDT data.
  - Upload: FAARFIELD job files (alternate designs).
Improve Data Exchange via WebAPI in PAVEAIR

LCCA Analysis

- LCCA Alternative Data
- LCCA Layer Structures
- LCCA Results
- Section Size
- Existing layers
- Design Traffic

XML Exporter

- Section Condition
- Inventory Tables
- Existing layers
- Design Traffic

XML Importer

- Non-PAVEAIR Data
- LCCA Analysis
- Engine

WebAPI

- LCCA Tables
- LCCA Job (ready to run)

FAARFIELD

- Build FAARFIELD section from PAVEAIR data
- FAARFIELD Analysis Routines
- FAARFIELD Section Layer Data
- Upload to PAVEAIR using XML

FAARFIELD

- Format as FAARFIELD job file

Download from PAVEAIR using XML
One section per Alternative/Cycle
- OR-
Optimum FAARFIELD-supplied section identified

complete
in progress
Design Criteria for Seasonal Frost and Permafrost

- Research request dated 1/27/20.
- Collaboration with Alaskan Region (AAL) and Alaska DOT.
- Major Subtasks:
  - TASK 1: Identify Subject Airports
  - TASK 2: Collect Relevant Documentation
  - TASK 3: Conduct Interviews
  - TASK 4: Design Review and Analysis
- Focus on identifying design criteria used at airports exhibiting frost-related performance issues.
- Account for global warming trends.
- Final report may recommend revisions to FAA design guidance.
Seasonal Frost and Permafrost Status and Current Activities

• Selected four airports for detailed study:
  – Nome (discontinuous permafrost zone)
  – Barrow (continuous permafrost zone)
  – Kotzebue (continuous permafrost zone)
  – Noorvik (continuous permafrost zone, gravel-surfaced)

• Interim report (Tasks 1-3) completed Nov. 2020.

• Task 4 (Design Review and Analysis) was delayed due to contract transition, but now in progress.
  – Completed detailed design review of Nome and Kotzebue airports for seasonal frost and permafrost design criteria.
  – Final report anticipated March 2022.
Design Criteria for Stabilized Bases and Subbases

- Research request dated 8/13/18.
  - When should stabilized base be required or recommended?
  - What are the minimum requirements for a material to be considered a stabilized base?
  - What performance benefits are expected from use of stabilized base courses?
  - What are the appropriate stabilized base thickness requirements for rigid pavements/ flexible pavements?

- Major Subtasks:
  - TASK 1: Literature Search
  - TASK 2: Desktop Study
  - TASK 3: Laboratory Study
  - TASK 4: Full-Scale Test (CC11)
Stabilized Base Design
Status and Current Activities

• Interim report covering tasks 1 and 2 completed Nov. 2020.

• Tasks 3-4 were delayed due to contract transition, but now in progress.
  – Identified list of materials and tests.
  – Reviewed AIP 2021 funded airport construction projects as potential sources for base materials. Several airports including FLL have shown interest in this research. Working with AAS-110 to facilitate sample production.
  – Preliminary full-scale test plan for incorporation in CC11 anticipated November 2021.
Machine Learning for Top-Down Cracking

• OTA to ARA Inc., under BAA solicitation (ARAP0002).
• Rapidly compute stress for top-down cracks (rigid).
• Combined curling and aircraft loading.
• Replace direct 3D-FEM computation for most gears.
  – “Deep Learning” approach removes the need to train a separate neural network for each aircraft.
  – General model is suitable for D, 2D and 3D gear configurations.

FEAFAA Response Model
Machine Learning for Top-Down Cracking

- **Task 1 – Training Database.** (COMPLETED).
  - Contractor ran >125,000 combinations of structural, thermal, and aircraft gear parameters.
  - Used output matrix to train the deep ANN model.
- **Task 2 – Machine Learning Model Development** (COMPLETED).
  - Report submitted July 12.
  - Models are significantly more accurate than previous ML techniques for similar problems.
- **Task 3 – Implement ML Model** (IN PROGRESS).
- **Final model and report delivery expected March 2022.**

Next: Use Open Neural Network Exchange (ONNX) to port the developed Pytorch ML model to a .NET framework (so it will run in FAARFIELD).
Reflection Cracking Model Development

- OTA to Arizona State University (ASU), with participation from University of Illinois, under BAA solicitation ARAP0002.
- Project awarded May 5, 2021.
- Three-year effort will produce a practical reflective cracking model using fracture mechanics principles, for implementation in FAARFIELD.
- Data from NAPTF reflection cracking rig and outdoor full-scale tests.
- Model inputs include both aircraft load and temperature cycling (joint opening/closing).

A key element in this project is the development of transfer functions to relate the theoretical crack growth (governed by Paris’ Law) to the condition of the affected pavement (PCI). This project will make use of real-world data in FAA PAVEAIR and related databases.
Questions?