

Rigid Overlay Design

FAARFIELD 1.3 Workshop

Presented to: IX ALACPA Seminar on Airport Pavements
Ciudad de Panamá, Panamá

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Federal Aviation
Administration



FAARFIELD Overlay Design

- **HMA Overlays on Flexible Pavement**
 - Same as designing a new flexible pavement, except the design layer is the HMA overlay.
- **PCC Overlays on Flexible Pavement**
 - Same principle as new rigid design.
- **HMA Overlays on Rigid Pavement**
- **PCC Overlays on Rigid Pavement**
 - More complex than new rigid pavement design.
 - Both slabs (base PCC and overlay) deteriorate with applied traffic. Stresses are computed for both slabs.
 - E -modulus of the base slab is a function of reduced SCI.
 - Subroutines were completely rewritten for FAARFIELD.

FAARFIELD Overlay Design – PCC on Rigid Overlays

- **Fully bonded overlays**
 - Treat as a new rigid pavement design.
 - Thickness of overlay slab is $h_{overlay} = h_{design} - h_{exist}$.
- **Unbonded overlay**
 - Bond breaker or leveling course is used.
- **Partially bonded overlay**
 - No longer a standard design in AC 150/5320-6E.
 - Default in FAARFIELD is off.
 - May be enabled from the Options window, but displays a “Non Standard Structure” message.

FAARFIELD Overlay Design

Required Inputs

- Existing rigid pavement condition is characterized by the Structural Condition Index (SCI).
- SCI derived from PCI as determined by ASTM D 5340 Airport Pavement Condition Index Surveys. The new AC gives guidance on SCI.
- SCI is computed using only structural components from the PCI survey.
- **SCI = 80, FAA definition of structural failure (50% of slabs with structural crack)**
- **For existing pavements with structural damage (SCI < 100)**
 - The user inputs a value of SCI for the existing pavement. The range of allowable values depends on the overlay type:
 - Rigid on Rigid Overlays: SCI 40–100
 - Flexible on Rigid Overlays: SCI 67–100 (was 50-100)
 - The Help file gives approximate formulas for relating SCI to Cr and Cb factors in earlier method.

FAARFIELD – PCC Unbonded Overlay Design Structural Condition Index (SCI)

Rigid Pavement Distress Types Used to Calculate SCI

Distress	Severity Level
Corner Break	Low, Medium, High
Longitudinal/Transverse/Diagonal Cracking	Low, Medium, High
Shattered Slab	Low, Medium, High
Shrinkage Cracks (cracking partial width of slab)*	Low
Spalling–Joint	Low, Medium, High
Spalling–Corner	Low, Medium, High

* Used only to describe a load-induced crack that extends only part of the way across a slab. The SCI does not include conventional shrinkage cracks due to curing or other non load-related problems.

Cumulative Damage Factor Used (CDFU)

- **For existing pavements where SCI=100 (no structural distress):**
 - There is no visible distress contributing to reduction in SCI (no structural distress types). However, some pavement life has been consumed by the applied traffic.
 - The amount of pavement life consumed is the percent CDF Used (%CDFU).
 - Need to estimate a value of %CDFU.
 - The Help file gives guidance on estimating %CDFU using the Life key.

Cumulative Damage Factor Used (CDFU)

- CDFU defines the amount of structural life used.
 - For structures with aggregate base:

$$\begin{aligned} CDFU &= \frac{L_U}{0.75 L_D} \quad \text{when } L_U < 0.75 L_D \\ &= 1 \quad \text{when } L_U \geq 0.75 L_D \end{aligned}$$

- L_U = number of years of operation of the existing pavement until overlay
 - L_D = design life of the existing pavement in years
- FAARFIELD modifies this relationship for stabilized subbases to reflect improved performance.

HMA on Rigid Overlay Example

- **Pavement Structure:**

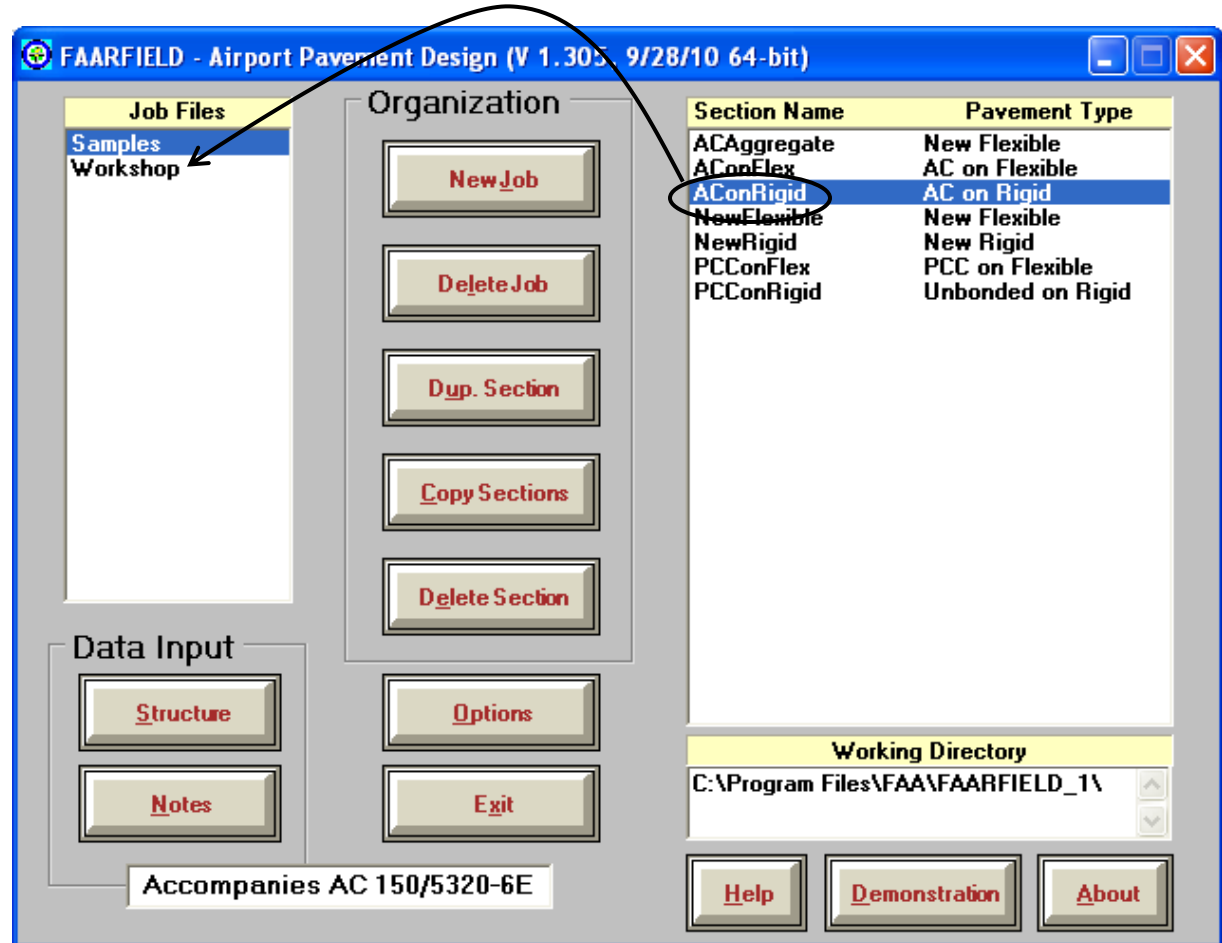
- Flexible Overlay (P-401)
- PCC Slab (P-501), 400 mm,
 $R = 4.85 \text{ MPa}$, $\text{SCI} = 70$
- Cement Treated Base (P-304), 150 mm
- Crushed Aggregate Base (P-209), 200 mm
- Subgrade $k = 27 \text{ MPa/m}$

- **Traffic Mix:**

- Use the traffic mix from the new rigid design example, but remove B777 and A380 from the mix.

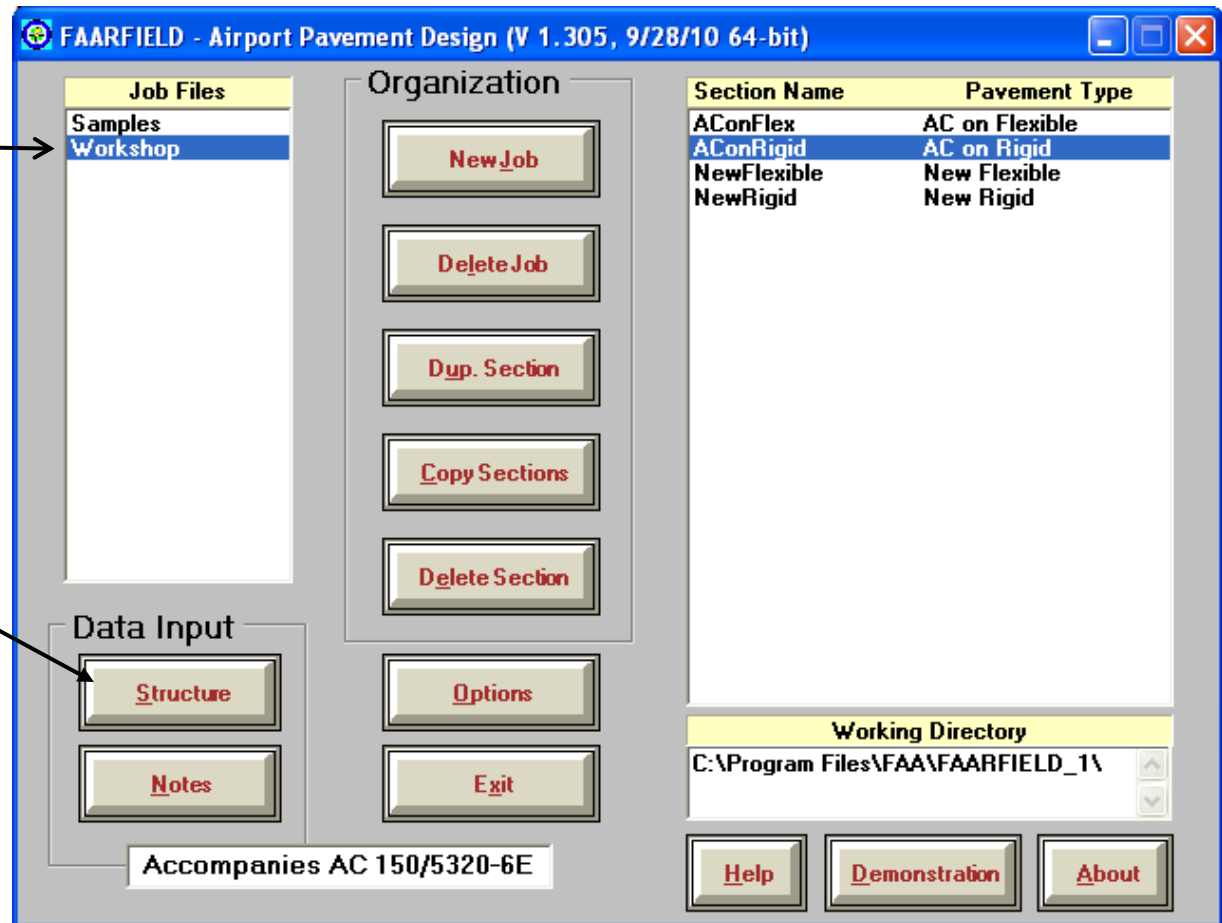
HMA on Rigid Example Set-Up

Create a new section in job Workshop by dragging section AConRigid in Samples to Workshop.



Change Pavement Structure

Double click on the job “Workshop.” (The section “AConRigid” is highlighted.) Click the “Structure” button to open the Structure window.



Change Pavement Structure

Click “Modify Structure.” Make changes to the PCC, base, subbase and subgrade layer properties.

FAARFIELD - Modifying Section AConRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Design Stopped
229.17; 228.20

Airplane

Back Help Life End Modify Add/Delete Layer Save Structure

Workshop AConRigid Des. Life = 20 SCI = 67 %CDFU = 100

Layer Material	Thickness (mm)	Modulus or R (MPa)
→ P-401/P-403 HMA Overlay	304.8	1,378.95
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	517.11
Subgrade	k = 27.0	65.84

Total thickness to the top of the subgrade, t = 1,054.8 mm

Change Pavement Structure

Click on the label “SCI=67” at the top of the display. In the “Changing Existing SCI” dialog box enter 70 and click OK.

Click “End Modify” then “Save Structure” to save changes.

FAARFIELD - Modifying Section AConRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop AConRigid Des. Life = 20 SCI = 67 %CDFU = 100

Layer	Material	Thickness (mm)	Modulus or R (MPa)
→	P-401/P-403 HMA Overlay	304.8	1,378.95
			4.85
			447.38
			17.11
	Subgrade	k = 27.0	65.84

Total thickness to the top of the subgrade, t = 1,054.8 mm

Design Stopped 229.17; 228.20

Airplane

Back Help Life End Modify Add/Delete Layer Save Structure

Copy Airplane List

Click on Airplane

FAARFIELD - Modify and Design Section AConRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Design Stopped
229.17; 228.20

Airplane

Back Help Life Modify Structure Design Structure Save Structure

Workshop AConRigid Des. Life = 20 SCI = 70 %CDFU = 100

Layer Material	Thickness (mm)	Modulus or R (MPa)
P-401/P-403 HMA Overlay	304.8	1,378.95
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	517.11
Subgrade	k = 27.0	65.84

Total thickness to the top of the subgrade, t = 1,054.8 mm

Copy Airplane List

Click “Clear List to remove the sample airplanes.

Then click “Add Float” to add the float airplanes.

FAARFIELD - Create or Modify Airplanes for Section AConRigid in Job Workshop

Airplane Group	Airplane Name (3)	Gross Taxi Weight (tns)	Annual Departures	% Annual Growth	De
Generic	DC10-10	207.745	2,263	0.00	45
Airbus	B747-200B	395.986	832	0.00	10
Boeing	Combi Mixed				
Other Commercial	B777-200 ER	287.804	425	0.00	8
General Aviation					
Military					
External Library					

Library Airplanes

- SWL-50
- Sngl Whl-3
- Sngl Whl-5
- Sngl Whl-10
- Sngl Whl-12.5
- Sngl Whl-15
- Sngl Whl-20
- Sngl Whl-30
- Sngl Whl-45
- Sngl Whl-60
- Sngl Whl-75
- Dual Whl-10
- Dual Whl-20
- Dual Whl-30
- Dual Whl-45
- Dual Whl-50
- Dual Whl-60
- Dual Whl-75
- Dual Whl-100

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Back, Help, CDF Graph, View Gear

Float Airplanes

- A320-100
- A340-600 std
- A340-600 std Belly
- A380-800
- B737-800
- B747-400B Combi
- B747-400ER Passeng
- B757-300

Modify Airplane List

Double-click on the A380-800 and B777-300ER. This will remove those airplanes from the design list. (Alternatively, highlight the airplane and click “Remove” once.)

When done, click “Save List” then “Back.”

FAARFIELD - Create or Modify Airplanes for Section AConRigid in Job Workshop

Airplane Group	Airplane Name (11)	Gross Taxi Weight (tns)	Annual Departures	% Annual Growth
Generic	A320-100	68.400	600	0.00
Airbus	A340-600 std	365.200	1,000	0.00
Boeing	A340-600 std Belly	365.200	1,000	0.00
Other Commercial	A380-800	562.001	300	0.00
General Aviation	B737-800	79.243	2,000	0.00
Military	B747-400B Combi	397.801	400	0.00
External Library	B747-400ER Passenger	414.130	300	0.00

Library Airplanes

- SwL-50
- Sngl Whl-3
- Sngl Whl-5
- Sngl Whl-10
- Sngl Whl-12.5
- Sngl Whl-15
- Sngl Whl-20
- Sngl Whl-30
- Sngl Whl-45
- Sngl Whl-60
- Sngl Whl-75
- Dual Whl-10
- Dual Whl-20
- Dual Whl-30
- Dual Whl-45
- Dual Whl-50
- Dual Whl-60
- Dual Whl-75
- Dual Whl-100

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Back, Help, CDF Graph, View Gear

Float Airplanes

- A320-100
- A340-600 std
- A340-600 std Belly
- A380-800
- B737-800
- B747-400B Combi
- B747-400ER Passeng
- B757-300

Run Design

Click “Design Structure” to run the overlay design.

FAARFIELD - Modify and Design Section AConRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop AConRigid Des. Life = 20 SCI = 70 %CDFU = 100

Layer Material	Thickness (mm)	Modulus or R (MPa)
→ P-401/P-403 HMA Overlay	304.8	1,378.95
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	517.11
Subgrade	k = 27.0	65.84

Total thickness to the top of the subgrade, t = 1,054.8 mm

Design Stopped 229.17; 228.20

Airplane

Back Help Life Modify Structure Design Structure Save Structure

HMA on Rigid Overlay – Final Design

FAARFIELD - Modify and Design Section AConRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop AConRigid Des. Life = 20 SCI = 70 %CDFU = 100

Layer Material	Thickness (mm)	Modulus or R (MPa)
→ P-401/P-403 HMA Overlay	129.7	1,378.95
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAq	200.0	193.42
Subgrade	k = 27.0	65.84

N = 4; Str Life = 19.9 yrs; t = 879.7 mm

Design Stopped 555.05; 554.55

Airplane

Back Help Life Modify Structure Design Structure Save Structure

PCC on Rigid Overlay Example

- **Existing PCC structure will receive a P-501 PCC overlay to support additional traffic.**
 - Assume R for new concrete = 4.65 MPa
- **Existing Pavement Structure:**
 - PCC Slab, 400 mm, $R = 4.85$ MPa
SCI = 100. Estimate %CDFU from traffic history.
 - Cement Treated Base, P-304, 150 mm
 - Crushed Aggregate Base, P-209, 200 mm
 - Subgrade $k = 27$ MPa/m
- **Design Traffic Mix:**
 - Use same traffic mix as in the new rigid pavement design example.

Estimate %CDFU (Example)

- Assume the following traffic mix was applied to the existing pavement:

No.	Name	Gross Wt., Tonnes	Annual Departures
1	Adv. B727-200C Basic	78.000	1,200
2	B737-700	70.000	500
3	DC8-63/73	161.000	260

- Assume that at the time of the overlay the pavement will have been in operation 12 years.

Procedure to Estimate %CDFU

- Input the original pavement structure.
- Estimate the annual traffic applied to the existing pavement up to the time of the overlay.
- Set “Design Life” to the number of years the pavement will have been in operation at the time of the overlay. Assume that at the time of the overlay the pavement will have been in operation 12 years.
- Run “Life” to obtain %CDFU.

Estimate %CDFU (Example)

In the Workshop job, open the section **NewRigid**. In the **Structure** window, enter the existing pavement structure (no overlay).

Change the design life to the number of years that the pavement will have been in service at the time of overlay (12 years in this example.)

Click *Airplane* to go to the Airplane window.

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 12

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Surface	400.0	4.85
Non-Standard Life		
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

Total thickness to the top of the subgrade, t = 750.0 mm

Design Stopped 555.05; 554.55

Airplane

Back Help Life Modify Structure Design Structure Save Structure

Estimate %CDFU (Example)

Enter the annual traffic applied to the existing pavement structure.

Click *Back* to return to the Structure window.

FAARFIELD - Create or Modify Airplanes for Section NewRigid in Job Workshop

Airplane Group	Airplane Name (3)	Gross Taxi Weight (tns)	Annual Departures	% Annual Growth	De
Generic	Adv. B727-200C	78.000	1,200	0.00	14
Airbus	Basic				
Boeing	B737-700	70.000	500	0.00	6
Other Commercial	DC8-63/73	161.000	260	0.00	3
General Aviation					
Military					
External Library					

Library Airplanes

- An-124
- An-225
- BAe 146
- Concorde
- DC3
- DC4
- DC68
- DC7C
- DC8-43
- DC8-63/73
- DC9-32
- DC9-51
- DC10-10
- DC10-30/40
- Fokker F100
- IL62
- IL76T
- IL86
- L-1011

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Help, CDF Graph, View Gear

Float Airplanes

- A320-100
- A340-600 std
- A340-600 std Belly
- A380-800
- B737-800
- B747-400B Combi
- B747-400ER Passeng
- B757-300

Estimate %CDFU (Example)

Click *Life* to run Life.

The calculated %CDFU will appear on the Structure window, at the lower left of the pavement section.

%CDFU = 54.58 (Say 55%).

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 12

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Surface	400.0	4.85
Non-Standard Life		
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

%CDFU = 54.58; PCC CDF = 0.33; Str Life (PCC) = 36.4 yrs; t = 750.0 mm

Life Stopped 9.72; 9.66

Airplane

Back Help Life Modify Structure Design Structure Save Structure

PCC on Rigid Overlay – Change Structure

In the Structure window, click *Modify Structure*.

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 12

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Surface	400.0	4.85
Non-Standard Life		
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

%CDFU = 54.58; PCC CDF = 0.33; Str Life (PCC) = 36.4 yrs; t = 750.0 mm

Life Stopped 9.72; 9.66

Airplane

Back Help Life **Modify Structure** Design Structure Save Structure

PCC on Rigid Overlay – Change Structure

Click *Add/Delete Layer*.

Select the PCC surface layer by clicking on it with the mouse. In the dialog box, select Add and click OK. A new PCC surface layer appears.

FAARFIELD - Modifying Section NewRigid in Job Workshop

Section Names

- AConFlex
- AConRigid
- NewFlexible
- NewRigid

Workshop NewRigid Des. Life = 12

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Surface	400.0	4.85
Non-Standard Structure and Life		
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

N = 0; PCC CDF = 0.33; t = 1,150.0 mm

Life Stopped 9.72; 9.66

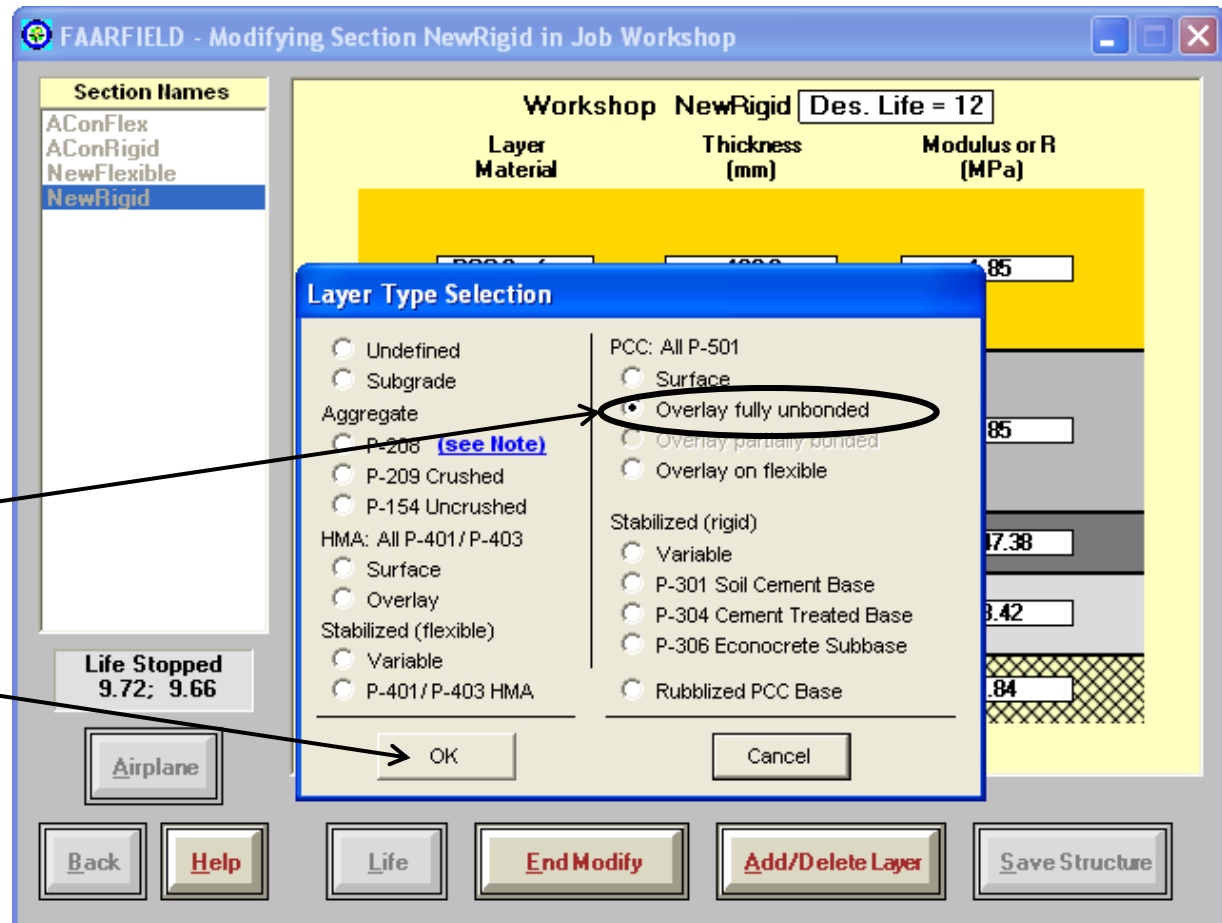
Airplane

Back Help Life End Modify Add/Delete Layer Save Structure

PCC on Rigid Overlay – Change Structure

You must change the top layer to an overlay. Click on the Layer Material box.

In the Layer Type Selection Box, select “Overlay Fully Unbonded” and click OK.



PCC on Rigid Overlay – Change Structure

In the upper right corner of the Structure window:

- Change “Design Life” to 20 years (standard).
- Change SCI to 100.
- Change %CDFU to 55.

Change *R* (overlay) to 4.65 MPa.

Click *End Modify*.

FAARFIELD - Modifying Section NewRigid in Job Workshop

Section Names

- AConFlex
- AConRigid
- NewFlexible
- NewRigid

Workshop NewRigid Des. Life = 20 SCI = 100 %CDFU = 55

Layer Material	Thickness (mm)	Modulus of R (MPa)
PCC Overlay Unbond	400.0	4.65
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 Cr Ag	200.0	193.42
Subgrade	k = 27.0	65.84

Life Stopped 9.72; 9.66

N = 0; Str Life = 19.9 yrs; t = 1,150.0 mm

Back Help Life End Modify Add/Delete Layer Save Structure

PCC on Rigid Overlay – Change Structure

Click **Save Structure**.

Click **Airplane** to go to the Airplane window.

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 20 SCI = 100 %CDFU = 55

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Overlay Unbond	400.0	4.65
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 Cr Ag	200.0	193.42
Subgrade	k = 27.0	65.84

N = 0; Str Life = 19.9 yrs; t = 1,150.0 mm

Life Stopped 9.72; 9.66

Airplane

Back Help Life Modify Structure Design Structure Save Structure

PCC on Rigid Overlay – Change Airplane List

Click **Clear List** to clear all aircraft from the list.

Add the design aircraft list manually or using the **Add Float** function.

FAARFIELD - Create or Modify Airplanes for Section NewRigid in Job Workshop

Airplane Group

- Generic
- Airbus
- Boeing
- Other Commercial
- General Aviation
- Military
- External Library

Library Airplanes

- An-124
- An-225
- BAe 146
- Concorde
- DC3
- DC4
- DC6B
- DC7C
- DC8-43
- DC8-63/73
- DC9-32
- DC9-51
- DC10-10
- DC10-30/40
- Fokker F100
- IL62
- IL76T
- IL86
- L-1011

Airplane Name (3)	Gross Taxi Weight (tns)	Annual Departures	% Annual Growth	De
Adv. B727-200C Basic	78.000	1,200	0.00	24
B737-700	70.000	500	0.00	10
DC8-63/73	161.000	260	0.00	5

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Back, Help, CDF Graph, View Gear

Float Airplanes

- A320-100
- A340-600 std
- A340-600 std Belly
- A380-800
- B737-800
- B747-400B Combi
- B747-400ER Passeng
- B757-300

PCC on Rigid Overlay – Change Airplane List

Click **Save List**

Click **Back** to return to the Structure window.

FAARFIELD - Create or Modify Airplanes for Section NewRigid in Job Workshop

Airplane Group	Airplane Name (11)	Gross Taxi Weight (tns)	Annual Departures	% Annual Growth
Generic	A320-100	68.400	600	0.00
Airbus	A340-600 std	365.200	1,000	0.00
Boeing	A340-600 std Belly	365.200	1,000	0.00
Other Commercial	A380-800	562.001	300	0.00
General Aviation	B737-800	79.243	2,000	0.00
Military	B747-400B Combi	397.801	400	0.00
External Library	B747-400ER Passenger	414.130	300	0.00

Library Airplanes

- An-124
- An-225
- BAe 146
- Concorde
- DC3
- DC4
- DC68
- DC7C
- DC8-43
- DC8-63/73
- DC9-32
- DC9-51
- DC10-10
- DC10-30/40
- Fokker F100
- L-62
- IL76T
- IL86
- L-1011

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Help, CDF Graph, View Gear

Float Airplanes

- A320-100
- A340-600 std
- A340-600 std Belly
- A380-800
- B737-800
- B747-400B Combi
- B747-400ER Passeng
- B757-300

Run Overlay Design

Click *Design Structure* to run the overlay design.

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 20 SCI = 100 %CDFU = 55

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Overlay Unbond	400.0	4.65
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

N = 0; Str Life = 19.9 yrs; t = 1,150.0 mm

Life Stopped 9.72; 9.66

Airplane

Back Help Life Modify Structure Design Structure Save Structure

Example: PCC on Rigid Overlay Final Design

FAARFIELD - Modify and Design Section NewRigid in Job Workshop

Section Names
AConFlex
AConRigid
NewFlexible
NewRigid

Workshop NewRigid Des. Life = 20 SCI = 100 %CDFU = 55

Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Overlay Unbond	226.7	4.65
PCC Surface	400.0	4.85
P-304 CTB	150.0	3,447.38
P-209 CrAg	200.0	193.42
Subgrade	k = 27.0	65.84

N = 13; Str Life = 26.5 yrs; t = 976.7 mm

Design Stopped 8710.94;

Airplane

Back Help Life Modify Structure Design Structure Save Structure



Job Files	Organization	Section Name	Pavement Type	
PROJECT	<div>New Job</div> <div>Delete Job</div> <div>Duplicate Section</div> <div>Create Section</div> <div>Delete Section</div>	AConRigid	AC on Rigid	
Samples		NewFlexible	New Flexible	
		NewRigid	Unbonded on Rigid	

Data Input		Working Directory
<div>Structure</div>	<div>Options</div>	C:\Program Files\FAA\FAARFIELD\
<div>Notes</div>	<div>Exit</div>	

Accompanies AC 150/5320-6E

Help

Demonstration

About

Thank You
Questions?

