

Software support is available through the PCASE website at [WWW.PCASE.COM](http://WWW.PCASE.COM).

### Significant Changes in PCASE2.09.04 (Since release of PCASE2.09.03)

#### Evaluation module

- Updates the evaluation module to adjust the vehicle load to 75 percent for traffic areas C and D.
- Updates the evaluation module to allow load transfer to be adjusted from 0 to 25 percent for rigid road evaluation.
- Corrects usage of pass to coverage ratios in evaluation.
- Corrects depth of frost calculation to consider high quality stabilized base.

#### Added one new vehicle

- Combi-LIFT SC3T container carrier

#### Traffic module

Corrected names of the following Army standard traffic patterns

- |   |    |  |
|---|----|--|
| • ARMY IV <= 5000 FT (C-130)            | to | ARMY CLASS IV <= 5000 FT (C-130)         |
| • ARMY IV <= 5000 FT (C-17)             | to | ARMY CLASS IV <= 5000 FT (C-17)          |
| • ARMY IV > 5000 FT AND < 9000 FT<br>FT | to | ARMY CLASS IV > 5000 FT AND < 9000<br>FT |
| • ARMY IV > 9000 FT                     | to | ARMY CLASS IV > 9000 FT                  |
| • ARMY V                                | to | ARMY CLASS V                             |

## **Significant Changes in PCASE2.09.03 (Since release of PCASE2.09.02)**

### **Design module**

- Eliminated runtime error in View Alternatives.
- Corrected column heading in report for design of PCC Shoulder to read "K" instead of "CBR".
- Renamed Equivalent Single Wheel Load (ESWL) to Equivalent Single Axle Load (ESAL) in the design grid.
- Default slip for stabilized base in rigid LED changed to zero to match UFC.
- Added message to show when either asphalt or base thickness is less than the minimum.
- Modified reports to show controlling vehicle and passes for mixed traffic designs

### **Traffic module**

- Fixed Heavy and Modified Heavy Standard Traffic Patterns to match UFC.

### **Evaluation module**

- Modified evaluation results to show overlays if pavement ACN/PCN ratio > 1.
- Made corrections to the calculations for the estimated depth to bedrock for asphalt pavements.
- Fixed display error in LEEP evaluation with evidence of frost.
- Fixed error in evaluation of unsurfaced pavements.

### **NDT**

- Fixed error in reading KUAB FWD file.
- Added ability to read GPS data from FWD file and LAT and LONG into data table.

### **General**

- Added permission instructions for Office 2010.
- Added permission instructions for Office 2013.

### **Vehicle Edit module**

- Eliminated duplication of tires.
- Made corrections to the surface thickness and base layer thickness tables.
- Corrected standard load for C-17A to 585,000 lbs (from 580,000 lbs).
- Added 50 new vehicles to vehicles database
  - AASHTO AML
  - AASHTO H15-44
  - ASHTO H20-44
  - AASHTO HS15-44
  - AASHTO HS20-44
  - AASHTO HS25-44
  - AASHTO P5
  - AASHTO P7
  - AASHTO P9
  - AASHTO P11
  - AASHTO P13
  - ATLAS 6000 LB CARRIAGE LOADED
  - ATLAS 6000 LB CARRIAGE UNLOADED
  - ATLAS 10000 LB CARRIAGE LOADED

- ATLAS 10000 LB CARRIAGE UNLOADED
- C-146A Wolfhound
- C-160 TRANSALL
- DROTT 650A1 C TRAVELIFT CRANE
- FAA DUAL TAN-100
- FAA DUAL TAN-150
- FAA DUAL TAN-200
- FAA DUAL TAN-300
- FAA DUAL TAN-400
- FAA DUAL WHL-10
- FAA DUAL WHL-20
- FAA DUAL WHL-30
- FAA DUAL WHL-45
- FAA DUAL WHL-50
- FAA DUAL WHL-60
- FAA DUAL WHL-75
- FAA DUAL WHL-100
- FAA DUAL WHL-150
- FAA DUAL WHL-200
- FAA SNGL WHL-3
- FAA SNGL WHL-5
- FAA SNGL WHL-10
- FAA SNGL WHL-12.5
- FAA SNGL WHL-15
- FAA SNGL WHL-20
- FAA SNGL WHL-30
- FAA SNGL WHL-45
- FAA SNGL WHL-60
- FAA SNGL WHL-75
- FAA SWL-50
- MJ 100 TRAVELIFT CRANE
- MJ 750 D TRAVELIFT CRANE
- NASA INTER TANK ON KAMAG
- NASA LH2 TANK ON 4 SPMTS
- NASA LOX TANK ON 4 SPMTS
- TE TRANSPORT ERECTOR

## Significant Changes in PCASE2.09.02 (Since release of PCASE2.09.01)

**Subgrade Category Ranges:** The subgrade category ranges in PCASE were changed to be consistent with the ranges published by the Federal Aviation Administration. The following tables illustrate the changes made.

| Flexible Pavements |               |                          |              |                          |
|--------------------|---------------|--------------------------|--------------|--------------------------|
| Subgrade Category  | Old Range     | Old Representative Value | New Range    | New Representative Value |
| A                  | CBR > 13      | 15                       | CBR >= 13    | 15                       |
| B                  | 8 = CBR <= 13 | 10                       | 8 < CBR < 13 | 10                       |
| C                  | 4 = CBR < 8   | 6                        | 4 < CBR >= 8 | 6                        |
| D                  | CBR < 4       | 3                        | CBR <= 4     | 3                        |

| Rigid Pavements   |                    |                          |                    |                          |
|-------------------|--------------------|--------------------------|--------------------|--------------------------|
| Subgrade Category | Old Range (psi/in) | Old Representative Value | New Range (psi/in) | New Representative Value |
| A                 | k > 400            | 554                      | k ≥ 442            | 552.6                    |
| B                 | 200 ≤ k ≤ 400      | 295                      | 221 < k < 442      | 294.7                    |
| C                 | 100 ≤ k < 200      | 147                      | 92 < k ≤ 221       | 147.4                    |
| D                 | k < 100            | 74                       | k ≤ 92             | 73.7                     |

**CBR-Beta Criteria:** The new CBR-Beta criteria for the design and evaluation of airfields was accepted by DoD for implementation into PCASE 2.09.02 and later versions. The CBR-Beta criteria for roads was implemented in PCASE2.09.01. The final CBR-Beta equation is as follows:

$$\text{Log}_{10}(\text{Beta}) = (1.5441 + 0.0730 \log_{10}(\text{Coverages}) ) / (1 + 0.2354 \log_{10}(\text{Coverages}))$$

**Revised ICAO Alpha Factors:** The revised ICAO Alpha Factors for calculation of Aircraft Classification Number (ACN) was implemented. A letter on 16 October 2007 by ICAO directed the following action be taken with regard to defining the ALPHA factor used in computing the ACN for aircraft:

- 1) The ALPHA factor for four wheel gear changed from the current 0.825 to 0.80.
- 2) The ALPHA factor for six wheel gear is retained at 0.72.

**Interface condition for Layered Elastic:** Set the interface condition for the layered elastic design and evaluation of rigid pavements over a stabilized base to 10 from the previous value of 1000. Reason: A value of 10 is more representative of a partial bonded condition which is considered to be the most realistic interface condition.

**Default modulus of a stabilized base in Layered Elastic:** Set the default modulus of a stabilized base in the layered elastic design and evaluation of flexible pavements to 100,000 psi from the previous value of 650,000 psi. Reason: A modulus of 100,000 psi is more in agreement with the modulus that would be obtained from the chart in the manual using typical values of the unconfined compression strength of the stabilized material.

**Relationship for converting CBR to modulus for the purpose of establishing the minimum thickness:** Change the relationship for converting CBR to modulus for the purpose of establishing the minimum thickness. Reason: The relationship,  $1500 * \text{CBR}$ , was developed for fine grain soils and seems to give satisfactory results up to CBRs of 10. Above 10 CBR the materials tend to be more granular and the  $1500 * \text{CBR}$  will yield CBRs that are too large. For CBRs above 10 the new relationship,  $e = 3214 * \text{CBR}^{.669}$  was developed to better agree with the modulus values for granular material as determined from  $E_{n+1}$  procedure as given in the layered elastic design procedure.

**Changes to Traffic module:**

Added Standard traffic patterns Hardstands for Heavy, Infantry, and Stryker Brigade Combat Team Tactical Equipment Maintenance Facilities (BCT TEMF)

- Added Unloaded M998B
- Added Terex TFC 45 LX Superstacker W/35K Load
- Added Terex TFC 45 LX Superstaker unloaded to the vehicle database
- Corrected the UAV Warrior "ERMP"

**Changes to Design module:**

- Added message for layered elastic flexible design when unable to satisfy asphalt strains.
- Corrected the edit button in the layer grid and corrected the rigid design so it does not allow you to set all layers to "Calculate" in Layered Elastic.
- Design Builder, rigid K screen - corrected subgrade description.
- Cost Module - changed units for Mat from "SY" to "SF".
- Restricted stabilized base strength to 100 CBR.

**Changes to Evaluation:**

- Added an Air Force 14 Group report showing all numeric values for allowable loads.
- Corrected evaluation for Mats.
- Corrected evaluation for Unsurfaced.

Fixed PCASE 2.09.02 to work with files changed in PAVER 6.5.1 or 6.5.2.

**Significant Changes in PCASE2.09.01 (Since release of PCASE2.09)**

The rigid pavement calculations were corrected to properly account for the change made in PCASE2.09 from constant contact area to constant contact pressure. In PCASE 2.09 constant contact area was used for rigid pavements, but in PCASE 2.09.01 this was corrected to use constant contact pressure. This change has little impact on calculated thicknesses as long as the design loads are close to the maximum load of the vehicle. If the design load is close to the maximum load, the contact area more closely matches the tire loads and pressures in the database. However, as the design loads move way from the maximum load (greater difference in load) the re-calculated contact area will have a greater influence on the calculated thicknesses.

The pass-to-coverage ratio was corrected to account for the change from constant contact area to constant contact pressure. The impact on design calculations is minimal.

The rigid pavement routines were modified to improve the tolerances when checking for thickness, allowable passes and allowable loads. This was necessary to smooth the creation of design and evaluation curves.

Air Force 14 Groups Report corrected to allow the use of both "New" and "Old" 14 Group traffic patterns.

Modified the evaluation report tool to allow the use of section or branch or both, in either order.

## **Significant Changes in PCASE2.09 (Since Release of PCASE2.08)**

Design Builder module added with capability to do frost and drainage calculations (multiple designs are calculated on one screen).

Cost module added (ability to assign costs to material types for design result cost comparison).

GIS capabilities added and GIS data added to the BAAF file shipped with setup to use as an example.

Incorporated the renovated CBR procedure for road design (only applicable for asphalt and aggregate surfaces).

Design Index removed from road design. Minimum thickness and compaction requirements are now based on 18-kip equivalent single axle load (ESAL) range.

Smoothed the fundamental CBR curve.

Longer calculation time for tracked vehicles; more stress points are being calculated. Recommend users keep designs for tracked vehicles in a separate file/database.

Design module will automatically set traffic type to Individual for a layered elastic design.

Minimum asphalt required for roads changed to 2-inches.

Additional stations added to the database for calculating depth of frost.

Updated default densities and moisture contents used for calculating frost depth.

User-requested data added to the design and evaluation reports.

In the Evaluation module, the frost defaults changed to zero.

In the Evaluation module, overlays for thaw and non-thaw seasons are now calculated using full mission passes and loads.

Flexible pavements with no structural requirement for an overlay may still require an overlay to guarantee the minimum thickness requirements for surface and base layers are met.

Added ability to use the Evaluation module for Roads.

Changed the calculation procedure for equivalency factors.

More vehicles added to the database.

Renamed original Air Force 14 Group vehicles to Old Air Force 14 Group vehicles and added New Air Force 14 Group vehicles

Vehicle data updated; affects the ACN values for some aircraft.

Changed constant contact area to constant contact pressure.

Navy Standard Design traffic patterns added.

Renamed original Air Force 14 Groups Traffic Pattern to Old Air Force 14 Groups Traffic Pattern and added New Air Force 14 Groups Traffic Pattern

Default weight for C-17 now set at 585,000 pounds (previously 580,000 pounds).

Contact area is recalculated when a vehicle weight is changed in Vehicle Edit.

Help/Utilities: UFC designations updated and unused tools removed.

Ability to pack databases to a specific location (packing a database allows a user to send design and/or evaluation results to another user).

## **Changes to PCASE2.09 Affecting Calculated Results (from PCASE2.08)**

There are four changes we have made to the criteria that will affect the calculations and the results obtained with PCASE 2.09. These changes are listed below along with a brief explanation.

1. **Changed constant contact area to constant contact pressure:** The standard flexible pavement design procedure is based on the classical CBR equation. In its current form, this equation applies to only single-wheel loads. In order to handle multi-wheel gear assemblies, the equivalent single-wheel load (ESWL) concept was introduced. To simplify the calculations of the ESWL, a procedure was devised where the contact area of a tire imprint was to remain constant. This assumption gave relatively good results as long as the tires in a gear were all the same size and the number of tires selected was small. With the introduction of the new beta criteria and the ability of today's computers to performed millions of calculations per second, it was deemed appropriate at this time to change to a more logical constant tire pressure assumption, since it is well known that tire contact area changes significantly at different loads while maintaining the tire pressure relatively constant. However, it is expected that this change will only introduce small changes in the results (thickness, allowable passes, allowable gross loads, etc). This change will also affect rigid pavement calculations since the resulting tire contact area is now based on a constant contact pressure.
2. **Smoothing of fundamental CBR curve:** The classical CBR curve that has been used for many years was digitized and put in a lookup table. New procedures and software utilizing this table to generate design and evaluation curves for specific aircraft have brought to light that this digitized curve is not as smooth as previously thought. Design curves at high CBR subgrade values (thin pavement sections) had a tendency to be jagged and resulted in design/evaluation curves with kinks in them. This fact did not show up before because these curves were drawn by hand and were smoothed out manually. To resolve this problem and use the automated software, it was necessary to take a look at the CBR digitized curve and perform a new smoothing procedure. This change also results in small differences in the calculations from PCASE 2.08 to PCASE 2.09.
3. **Equivalency factors procedure:** The procedure that handles how the equivalency factors are applied for pavement layers with less than the minimum thickness was changed to always apply the minimum equivalency factors even when the actual thickness was less than the minimum. This was done to stay consistent when performing forward (design) and backward (backcalculation) calculations.
4. **Vehicle database updates and enhancements:** The new vehicle data to be used in PCASE2.09 was updated during an internal validation and enhancement effort. Numerous corrections and optimization of evaluation points and number of tires selected for a specific calculation were implemented for a number of vehicles in the database. These changes will impact, also to a minor extent, the resulting calculations from PCASE 2.09 and will significantly speed up calculations for vehicles with a large number of tires.