# ITD, AASHTO, and MEPDG Pavement Design Methods - A Comparison

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# Background

- Several design methods for flexible pavements are currently practiced in the U.S. and around the world.
- These methods range from very simple empirical methods to more advanced and sophisticated mechanistic based methods.
- Idaho Transportation Department (ITD) and AASHTO 1993 are examples of the empirical pavement design method.
- The empirical pavement design methods have many limitations.

# Background (Cont'd)

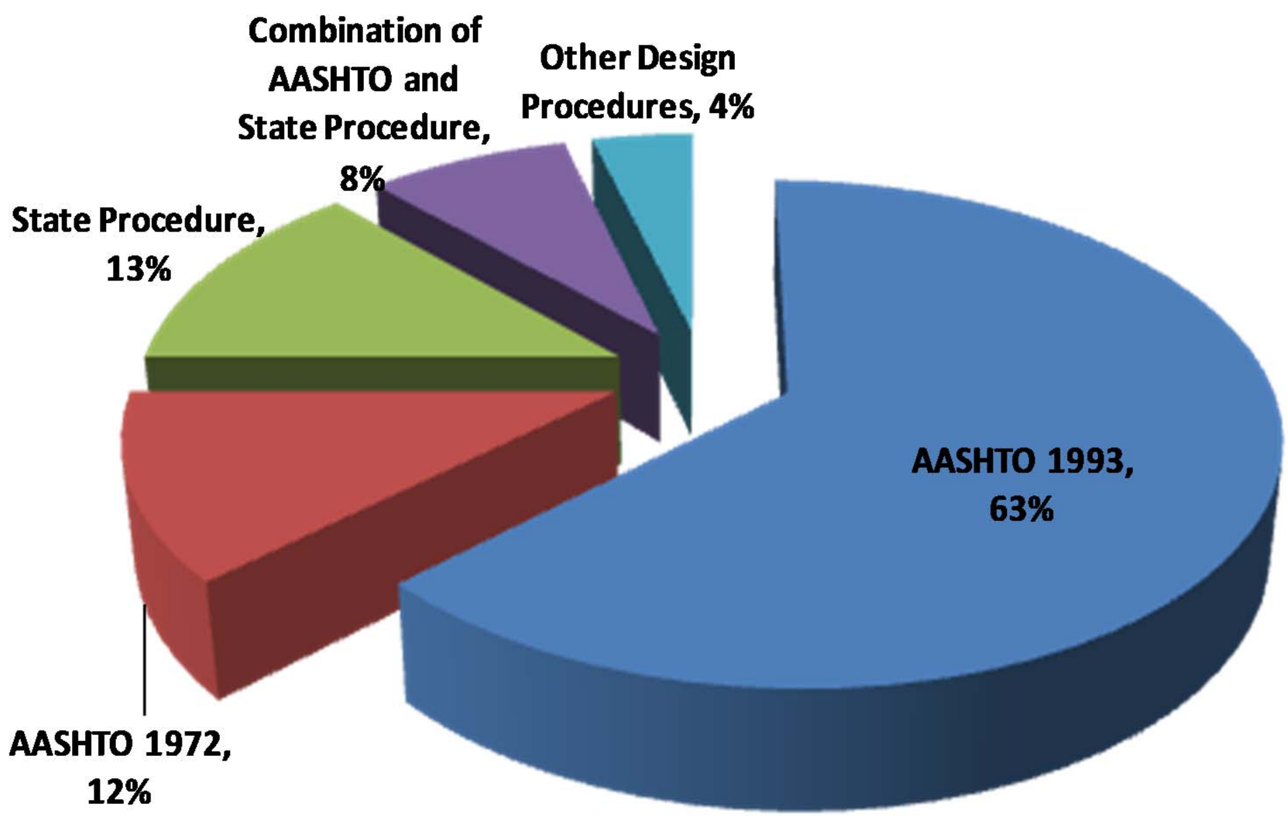
- Many existing roadways that have been designed with ITD method, have **performed beyond their calculated design lives**, yet still perform adequately.
- With **limited funding**, there is increased emphasis on building structurally adequate, yet cost effective, flexible pavements.
- ITD needs to **evaluate existing design methodology** to determine if they are still applicable to current needs or if modifications can improve performance and reduce costs.

# Objectives

**Compare** current ITD design method for flexible pavements with AASHTO 1993 and MEPDG methods.

# Current Design Practice in the U.S.

## FHWA Survey, 2007

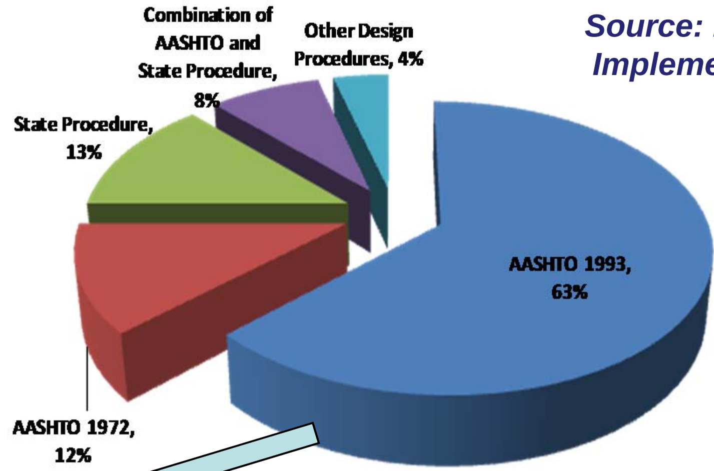


# Current Design Practice in the Western Sates

| State | Pavement Design Method |
|---|---|
| **Idaho** | **State Design Procedure** |
| **California** | **State Design Procedure** |
| Montana | AASHTO 1972 & 1993 |
| Nevada | AASHTO 1993 |
| Utah | AASHTO 1993 |
| Washington | AASHTO 1993 |
| Wyoming | AASHTO 1993 |
| Colorado | AASHTO 1993 |
| Arizona | AASHTO 1993 |
| New Mexico | Combination of AASHTO 1972 and Sate Procedure |
| Oregon | Combination of AASHTO and Sate Procedure |

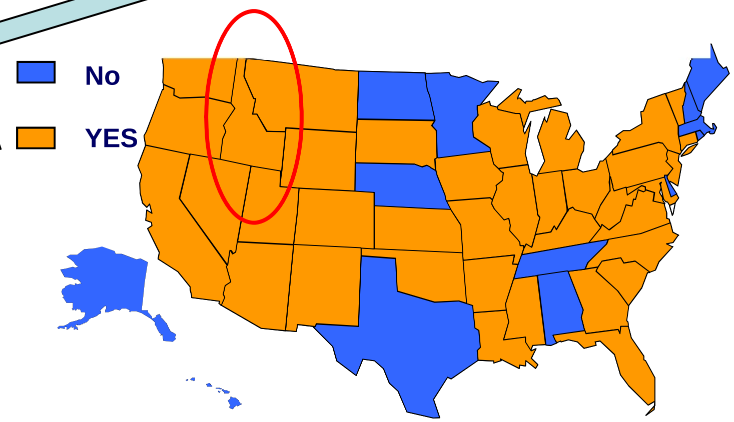
***Source: FHWA, 2007 DG Implementation Survey***

# Selected Design Procedures




*Source: FHWA, 2007 DG Implementation Survey*

- **ITD**
- **AASHTO 1993**
- **MEPDG**



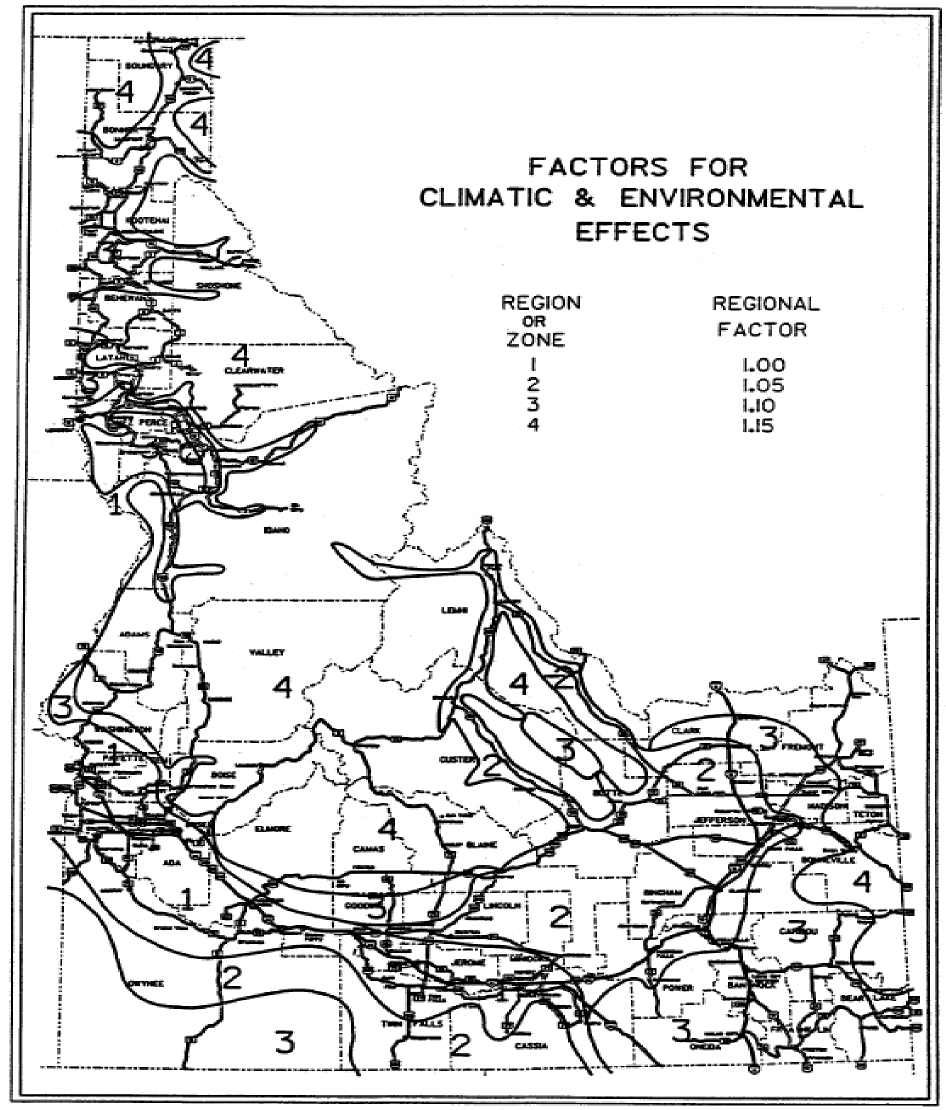

*80% of the State DOTs have Implementation Plans for MEPDG*

# ITD Design Method

- **Empirical** procedure adapted from Caltrans.
- Based on the R-value of the subgrade.
- Traffic is expressed in terms of Traffic Index [***TI=f(ESALs)***].
- Climatic Factor (**CF**) to reflect the various geographical regions in the State of Idaho.
- Determines the pavement thickness as a Gravel Equivalence (GE).
- GE is then transferred to various layer thicknesses through a gravel factor ($G_f$) for each type of material.
- No reliability included.

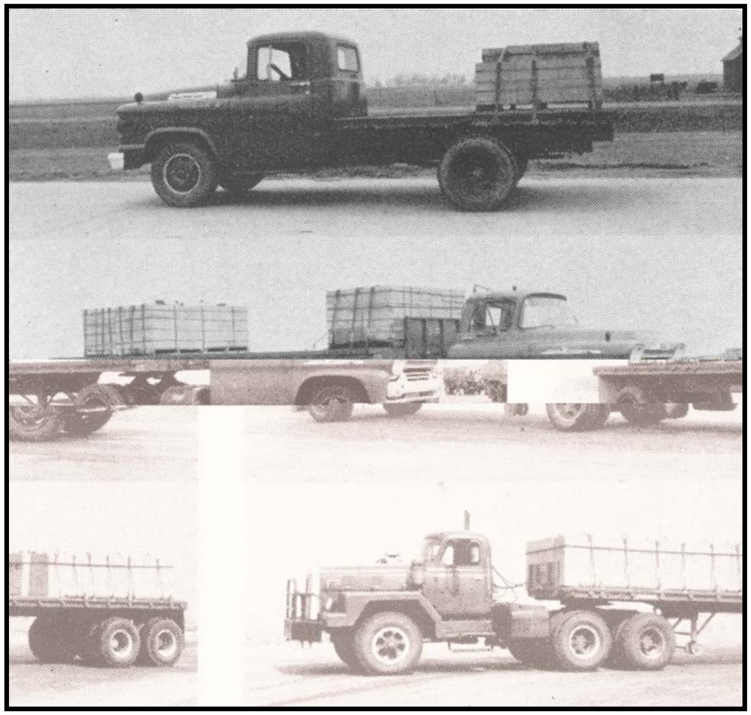
# ITD Climatic Regions and Factors

- Idaho is classified into:
  - 4 different climatic zones
  - Each of these zones is assigned an empirical regional (climatic) factor.
- This classification was based on 30-year of monthly:
  - Temperatures
  - Precipitation
  - Freezing periods
  - Spring breakup periods

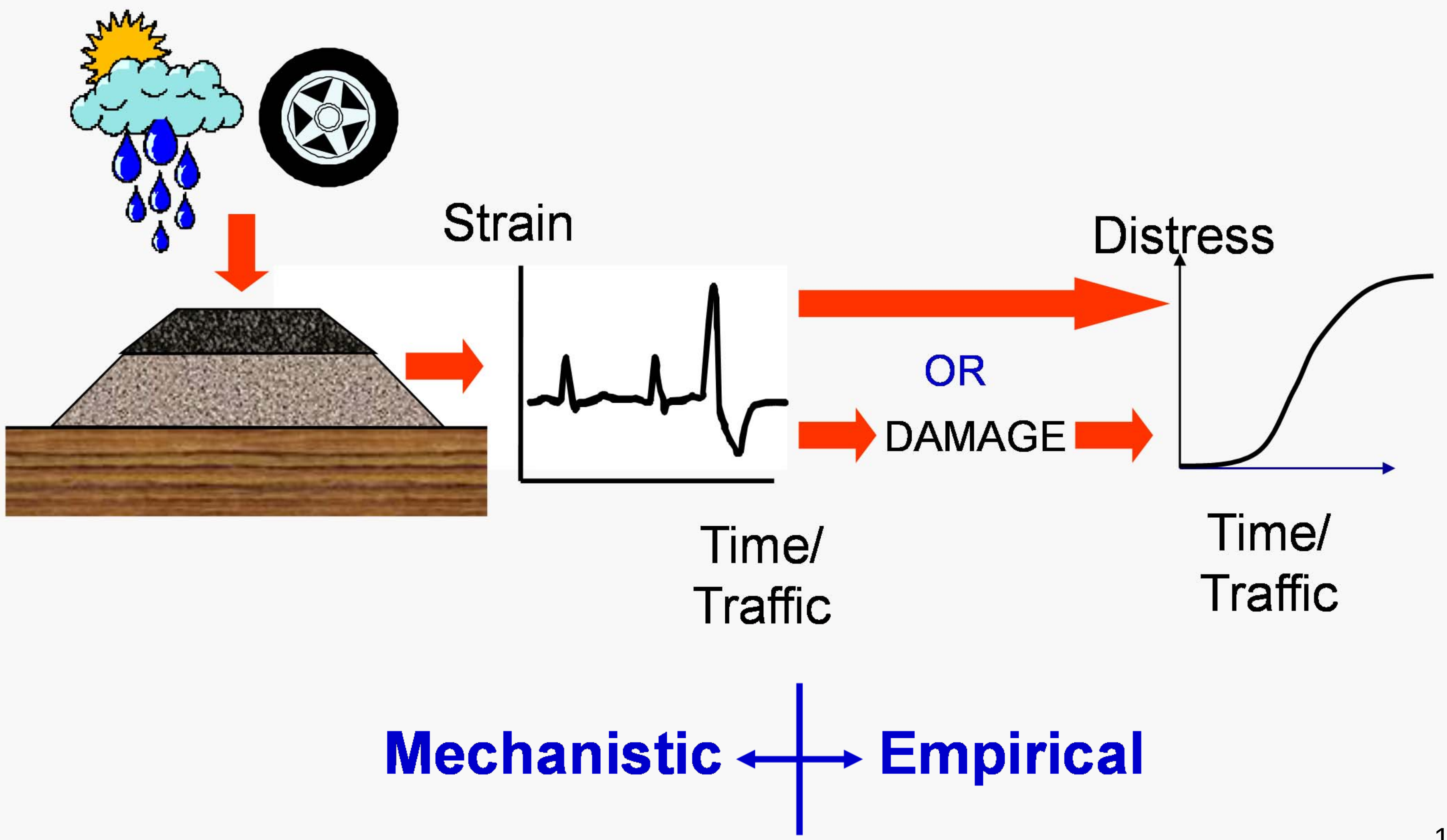


# AASHTO 1993

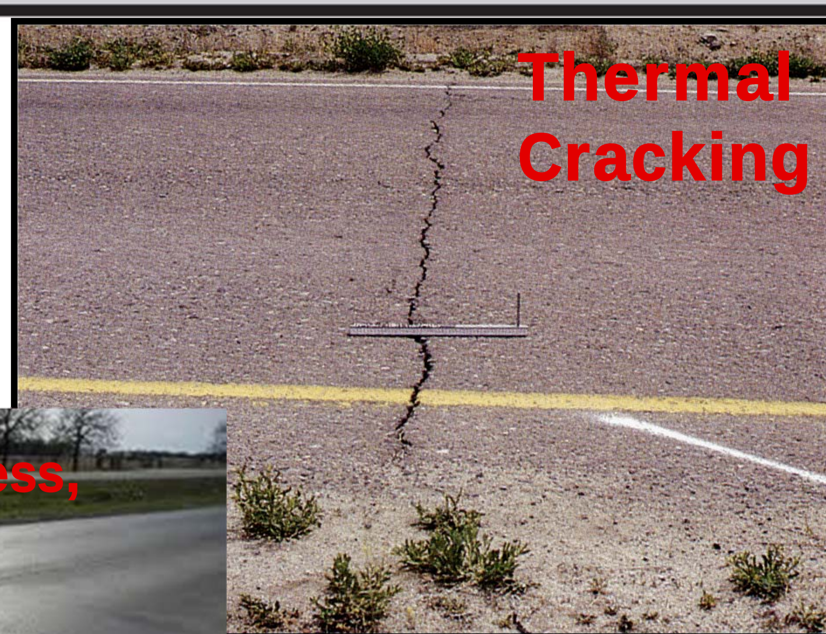
- Based on **empirical** models drawn from field performance data measured at the AASHO road test in the late 1950's.



# Mechanistic-Empirical Pavement Design Guide



# MEPDG Predicted Distresses & Smoothness




# MEPDG Recommended Failure Criteria

| Distress | Threshold Value at Design Reliability |
|---|---|
| **Terminal IRI (in/mile)** | Interstate: 160<br>Primary/Secondary: 200 |
| **AC Alligator Cracking (%)** | Interstate: 10<br>Primary: 20<br>Secondary: 35 |
| **Thermal Fracture (Transverse Cracking), (ft/mile)** | Interstate: 500<br>Primary/Secondary: 700 |
| **Total Rutting (in)** | Interstate: 0.40<br>Primary: 0.50<br>Others < 40 mph: 0.75 |

***Source: Mechanistic-Empirical Pavement Design Guide: A Manual of Practice," Interim Edition, American Association of Highways and Transportation Officials, July 2008.***

# Design Reliability

MEPDG

| Functional Classification | Recommended Level of Reliability | |
|---|---|---|
| | Urban | Rural |
| Interstate/Freeways | 95 | 95 |
| Principal Arterials | 90 | 85 |
| Collectors | 80 | 75 |
| Local | 75 | 70 |

***Source: MEPDG Manual of Practice, 2008***

AASHTO 1993

| Functional Classification | Recommended Level of Reliability | |
|---|---|---|
| | Urban | Rural |
| Interstate/Freeways | 85-99.9 | 80-99.9 |
| Principal Arterials | 80-99 | 75-95 |
| Collectors | 80-95 | 75-95 |
| Local | 50-80 | 50-80 |

***Source: AASHTO Guide for Design of Pavement Structures, 1993***

# Research Methodology

- **Select 1 or 2 in-service projects** from different districts that have been designed using ITD design method.
- **Re-design** these projects using **AASHTO 1993 & MEPDG**, at different reliability levels.
- **Compare** resulted pavement structures from ITD design method with AASHTO 1993 and MEPDG methods.

# Investigated Projects

| | US-2(a) Wrenco loop to Dover | US-2(b) Wrenco Loop to Dover | US-2(c) Wrenco Loop to Dover | SH-62 Oak Street | SH-3 Arrow to Turkey Farm | SH-19 Greenleaf to Simplot | US-95 Devils Elbow | US-93 Tom Cat Hill, East |
|---|---|---|---|---|---|---|---|---|
| **Project No.** | F-5121(019) | F-5121(019) | F-5121(019) | ST-4749(612) | STP-4170(101) | STP-RS 3712(008) | F-3112(42) | ST-6350(652) |
| **Key No.** | 0717 | 0717 | 0717 | 9338 | 5956 | 135 | 2224 | 7768 |
| **Location** | | | | | | | | |
| County | Bonner | Bonner | Bonner | Lewis | Nez Perce | Canyon | Washington | Butte |
| District | D1 | D1 | D1 | D2 | D2 | D3 | D3 | D6 |
| Climatic Region | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 |
| **Traffic** | | | | | | | | |
| Traffic Index (TI) | 11.51 | 11.51 | 11.51 | 8.78 | 10.51 | 9.57 | 9.9 | 10.27 |
| Design ESALs, $10^6$ | 7.920 | 7.920 | 7.920 | 0.816 | 3.696 | 1.677 | 2.240 | 3.034 |
| **Subgrade** | | | | | | | | |
| R-value | 20 | 50 | 15 | 8 | 25 | 44 | 5 | 50 |

# Performance Indicators of the Selected Pavement Sections

| Design Project | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
|---|---|---|---|---|---|---|---|---|
| Years in Service | **6** | **6** | **6** | **New** | **10** | **11** | **18** | **2** |
| **Roughness Index (RI)** | 4.7 | 3.4 | 4.1 | - | **3.1** | **3.9** | **3.5** | 3.7 |
| **Crack Index (CI)** | **5.0** | **4.7** | **5.0** | **-** | **5.0** | **5.0** | **3.0** | **5.0** |
| Skid Number | 44.0 | 44.0 | 44.0 | - | 51.0 | 47.0 | 47.1 | 57.0 |
| **Rut Depth, in** | **0.23** | **0.16** | **0.24** | **-** | **0.17** | **0.14** | **0.18** | **0.10** |

***Source: ITD PPMIS***

**ITD Pavement Deficiency Criteria**

| Pavement Condition | Interstates and Arterials | Collectors |
|---|---|---|
| Good | (CI or RI) > 3.0 | (CI or RI) > 3.0 |
| Fair | 2.5 ≤ (CI or RI) ≤ 3.0 | 2.0 ≤ (CI or RI) ≤ 3.0 |
| Poor | 2.0 ≤ (CI or RI) < 2.5 | 1.5 ≤ (CI or RI) < 2.0 |
| Very Poor | (CI or RI) < 2.0 | (CI or RI) < 1.5 |

# Design Input Data for ITD Design Method

| Design Input | Design Project | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
| Design Life, years | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Traffic Index | 11.51 | 11.51 | 11.51 | 8.78 | 10.5 | 9.57 | 9.9 | 10.27 |
| Climatic Factor | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.05 |
| Base R-Value * | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| Subbase R-Value * | 65 | 65 | 65 | - | - | 65 | 65 | 60 |
| Subgrade R-Value ** | 20 | 50 | 15 | 8 | 25 | 44 | 5 | 50 |

***Estimated values**

****Laboratory measured values**

# Design Inputs for the AASHTO 1993 Design Guide

| Design Input | Design Project | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
| **Design Reliability, %** | 50% & 85% | | | | | | | |
| **Design ESLAs, $10^6$** | 7.920 | 7.920 | 7.920 | 0.816 | 3.696 | 1.677 | 2.240 | 3.034 |
| **ΔPSI (Loss of Serviceability)** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Structural layer Coefficients ($a_i$)** | | | | | | | | |
| **$a_1$** | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 |
| **$a_2$** | 0.14 | 0.14 | 0.14 | 0.14 | 0.17 | 0.17 | 0.17 | 0.17 |
| **$a_3$** | - | - | - | - | - | - | 0.19 | - |
| **Drainage Coefficients ($m_i$)** | | | | | | | | |
| **$m_2$** | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.0 | 1.0 | 1.0 |
| **$m_3$** | - | - | - | - | - | - | 1.2 | - |
| **Mr (psi), Base*** | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 |
| **Mr (psi), Subbase*** | - | - | - | - | - | - | 32,000 | - |
| **Mr (psi), Subgrade**** | 12,255 | 28,905 | 9,480 | 5,595 | 15,030 | 25,575 | 3,930 | 28,905 |

** Estimated Values*   *** Mr(Subgrade) = 1155+555*R*

# Design Inputs for MEPDG

| Input Parameter | Input Level |
| --- | --- |
| Environment | Closest MEPDG weather station to the project or Virtual weather station |
| Binder | Level 3 |
| HMA stiffness | Level 2 |
| Traffic | Level 3 |
| Unbound base/Subbase layers | Level 3 |
| Subgrade | Level 2 |

# Design Inputs for the MEPDG

## Climate and Traffic (Level 3)

| Project | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
|---|---|---|---|---|---|---|---|---|
| | | | | Location | | | | |
| Latitude, Deg.Min. | 48.15 | 48.15 | 48.15 | 46.14 | 46.28 | 43.4 | 44.19 | 43.26 |
| Longitude, Deg.Min. | -116.39 | -116.39 | -116.39 | -116.14 | -116.45 | -116.46 | -116.55 | -113.37 |
| Elevation, ft | 2,085 | 2,085 | 2,085 | 3,215 | 8,50 | 2,330 | 2,490 | 5,641 |
| | | | | Main Traffic Inputs | | | | |
| Design Life, years | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Speed, mph | 60 | 60 | 60 | 35 | 55 | 60 | 60 | 65 |
| AADTT (design lane) | 542 | 542 | 542 | 56 | 253 | 115 | 153 | 208 |

*+ Other traffic Input data are taken as default values*

# MEPDG Traffic and Unbound/Subgrade Materials Characterization

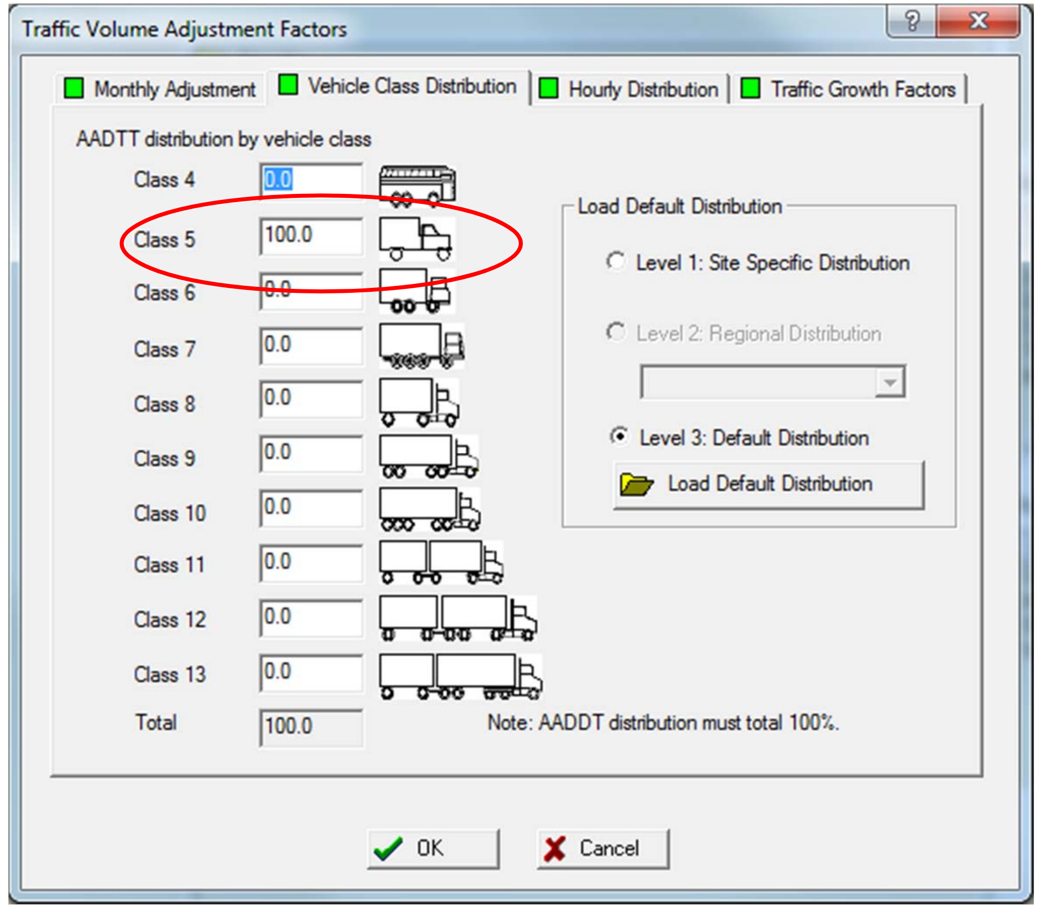
In order to simulate ITD and AASHTO 1993 design methods using MEPDG based on the same assumptions :

- Traffic characterization in terms of **ESALs** instead of axle load spectra **(ALS)** was used in MEPDG runs.

- **Representative** modulus for unbound base/subbase layers and subgrade materials was used in all MEPDG runs. ➔ (**EICM** was deactivated)

# ESALs in MEPDG

- 100 percent FHWA Truck Class 5 and zero percent for all other truck classes.
- 100 percent 18,000 lb single axle load and zero percent for all other single axle loads.



# Design Inputs for the MEPDG (Cont'd)

## HMA Material Characterization (Level 2) using NCHRP 1-37A Witczak Viscosity based Model

| Project | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
|---|---|---|---|---|---|---|---|---|
| Binder Type | PG58-28 | PG58-28 | PG58-28 | PG58-28 | PG70-28 | AC-10 | AC-10 | PG64-34 |
| Cumulative, % Retained 3/4" | 1 | 1 | 1 | 0 | 3 | 0 | 0 | 0 |
| Cumulative, % Retained 3/8" | 27 | 27 | 27 | 15 | 23 | 27 | 26 | 26.4 |
| Cumulative, % Retained #4 | 53 | 53 | 53 | 45 | 54 | 49 | 49 | 53 |
| % P #200 | 6 | 6 | 6 | 8.2 | 4 | 5.6 | 4.9 | 5.3 |
| % $V_{beff*}$ | 9.95 | 9.95 | 9.95 | 11.01 | 11.6 | 9.66 | 9.38 | 10.09 |
| % Air Voids** | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

* *Effective Asphalt Content by Volume*

** *In-Situ Air Voids directly after construction*

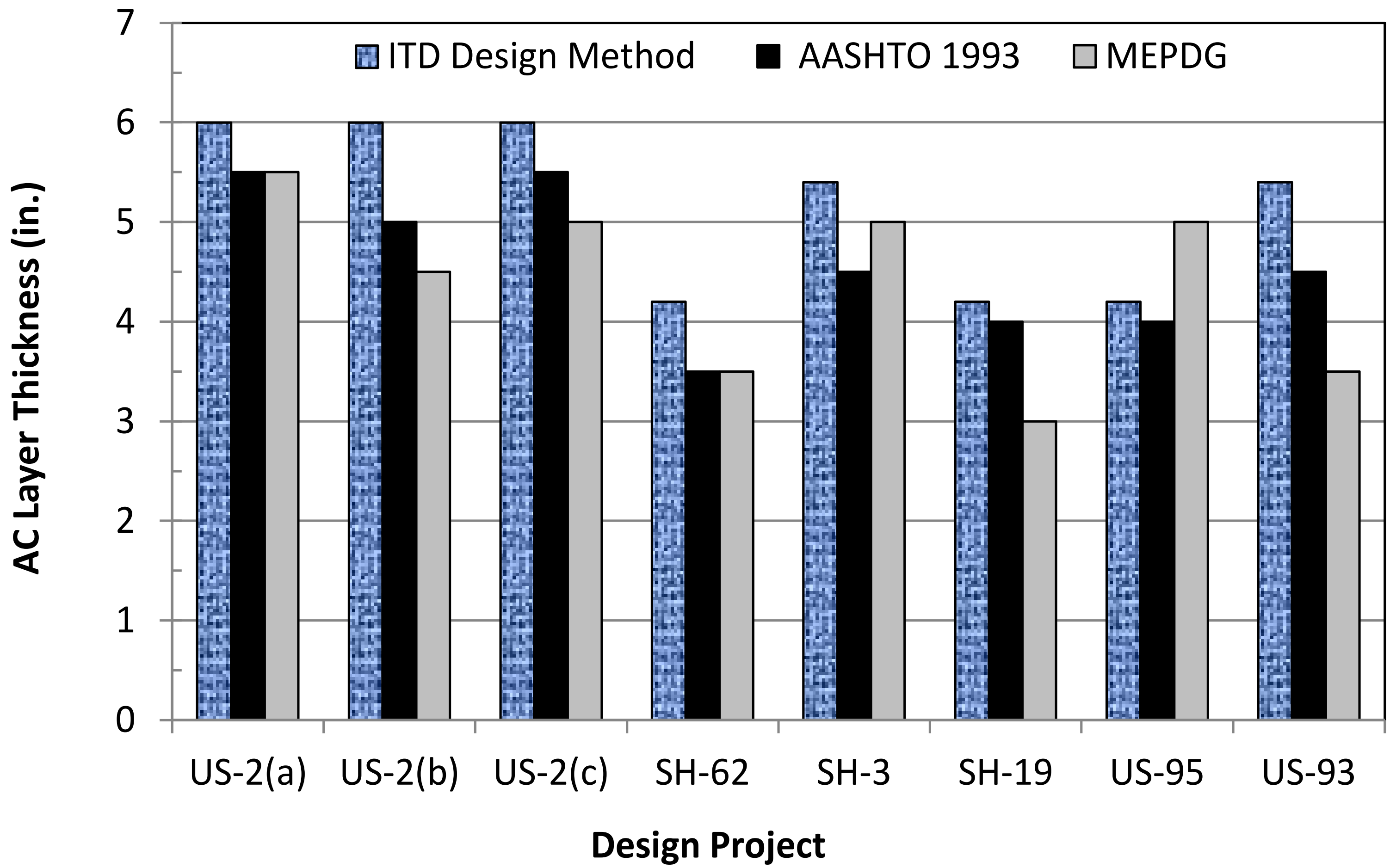
# Design Inputs for the MEPDG (Cont'd)

## Unbound/Subgrdae Material Characterization (Levels 2/3)

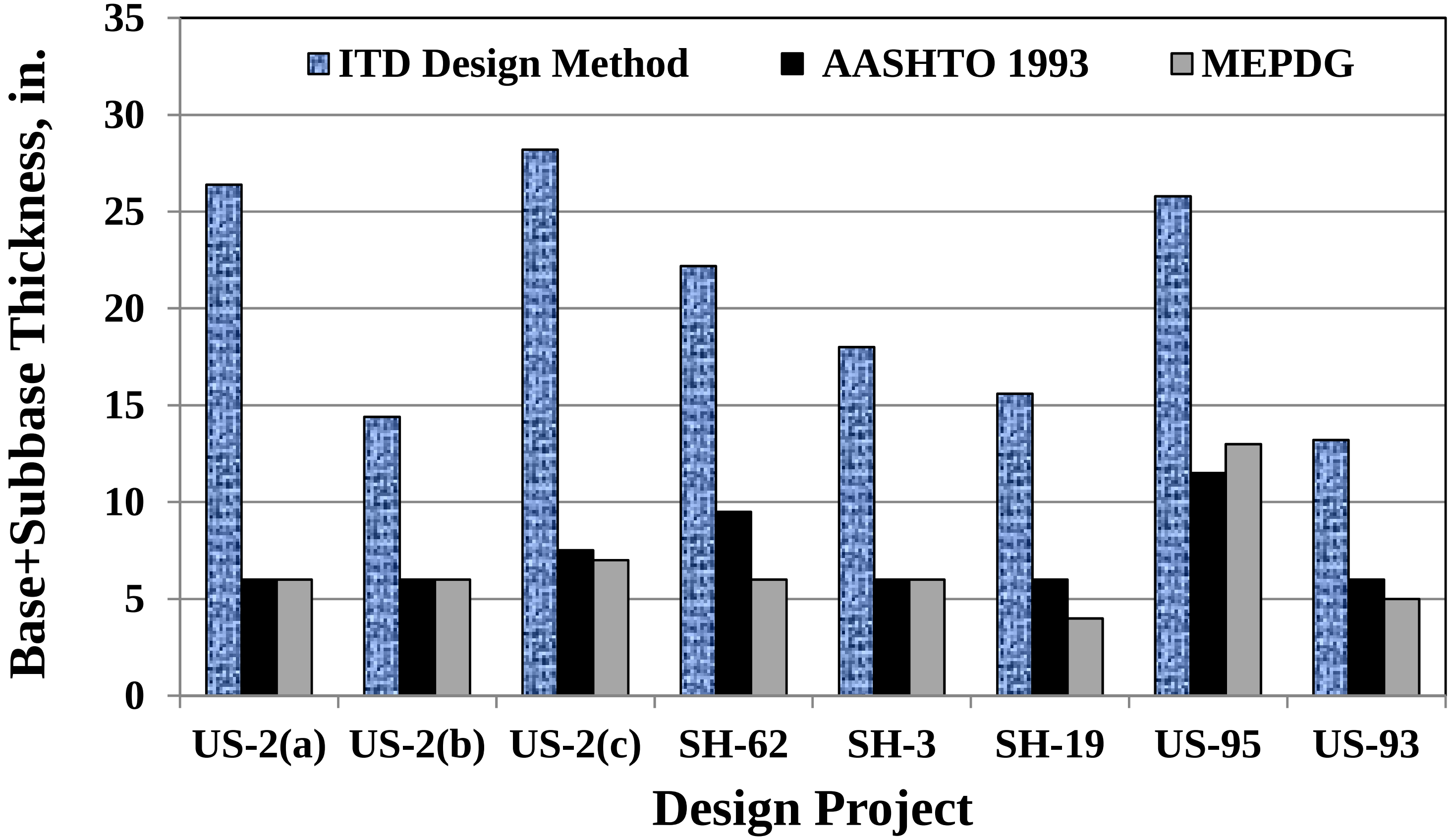
| Project | US-2(a) | US-2(b) | US-2(c) | SH-62 | SH-3 | SH-19 | US-95 | US-93 |
|---|---|---|---|---|---|---|---|---|
| **Unbound Granular Base Course Properties** | | | | | | | | |
| **Material Type** | A-1-a | A-1-a | A-1-a | A-1-a | A-1-a | A-1-a | A-1-a | A-1-a |
| **Mr, psi** | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 | 38,000 |
| **Unbound Granular Subbase Course Properties** | | | | | | | | |
| **Material Type** | Permeable Aggregate | Permeable Aggregate | Permeable Aggregate | - | - | Permeable Aggregate | Permeable Aggregate | Permeable Aggregate |
| **Mr, psi** | 32,000 | 32,000 | 32,000 | - | - | 32,000 | 32,000 | 32,000 |
| **Subgrade Properties** | | | | | | | | |
| **Material Type** | ML | SP-SM | CL | CL | SM | ML | MH | SW |
| **Mr, psi*** | 12,255 | 28,905 | 9,480 | 5,595 | 15,030 | 25,575 | 3,930 | 28,905 |
| **GWT Depth, ft** | 10 | 10 | 10 | 6 | 45 | 7 | 7 | 30 |

**** Level 2***
***+ Gradation, LL, and PI***

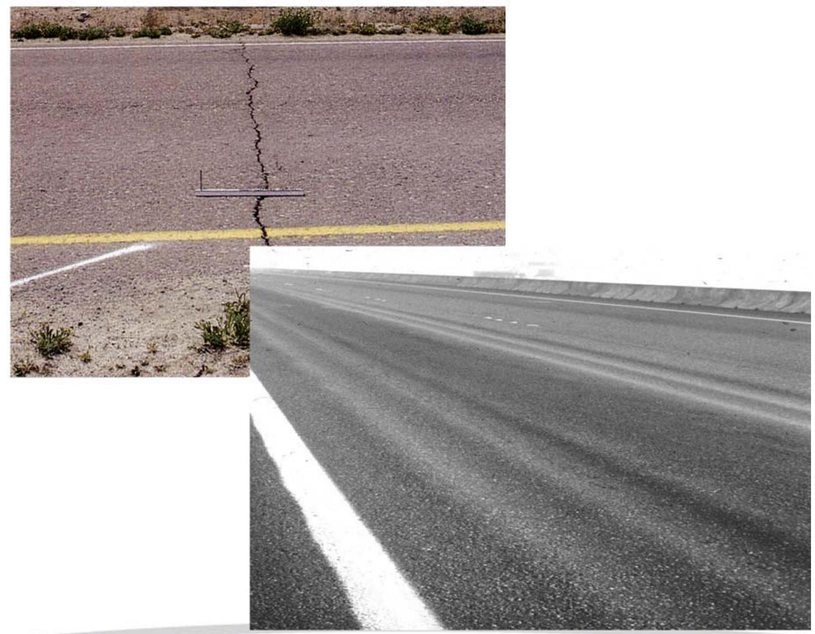
# AC Layer Thickness Comparison at 50% Reliability



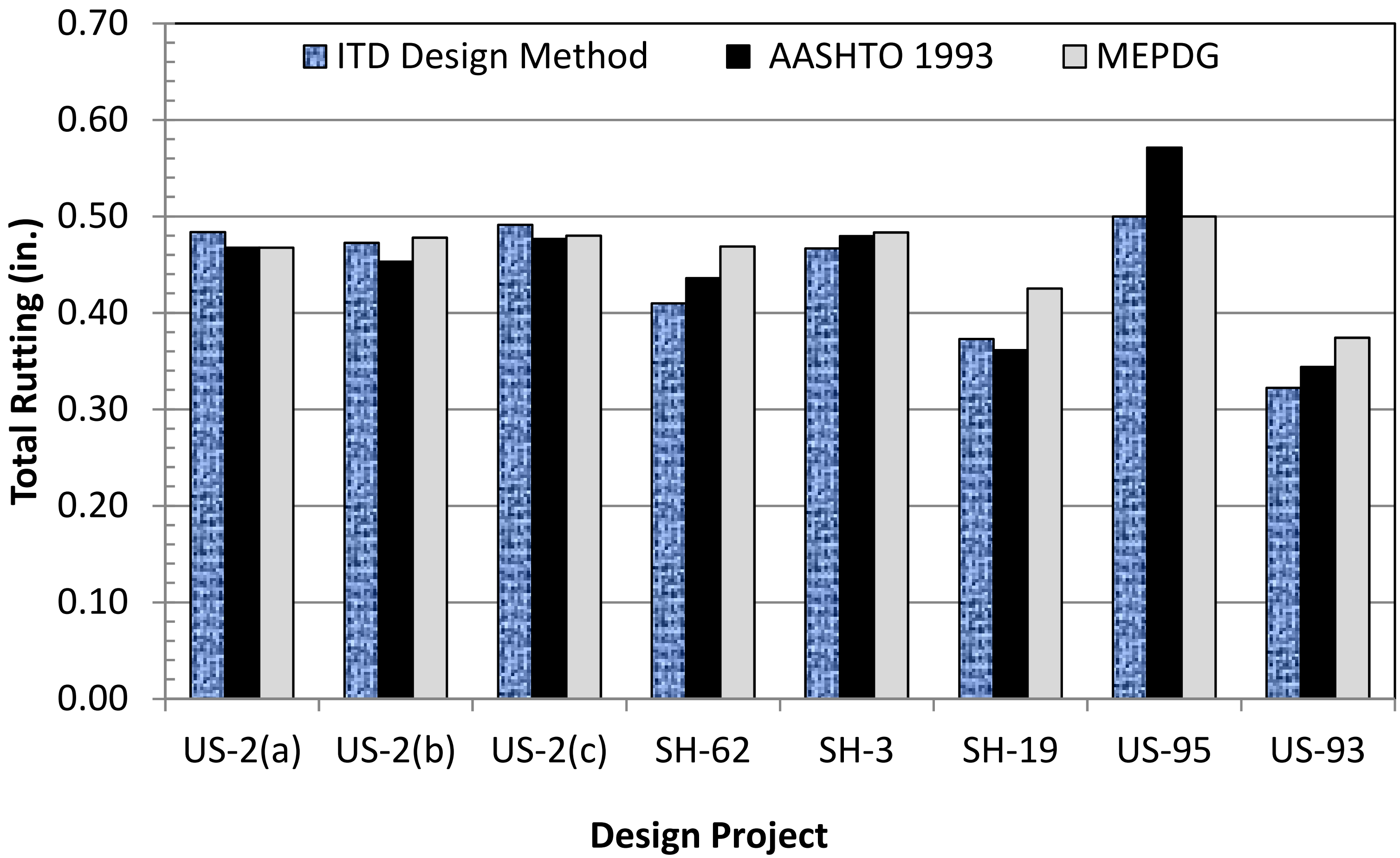
# Total Unbound Base/Subbase Layer Thickness At 50% Reliability



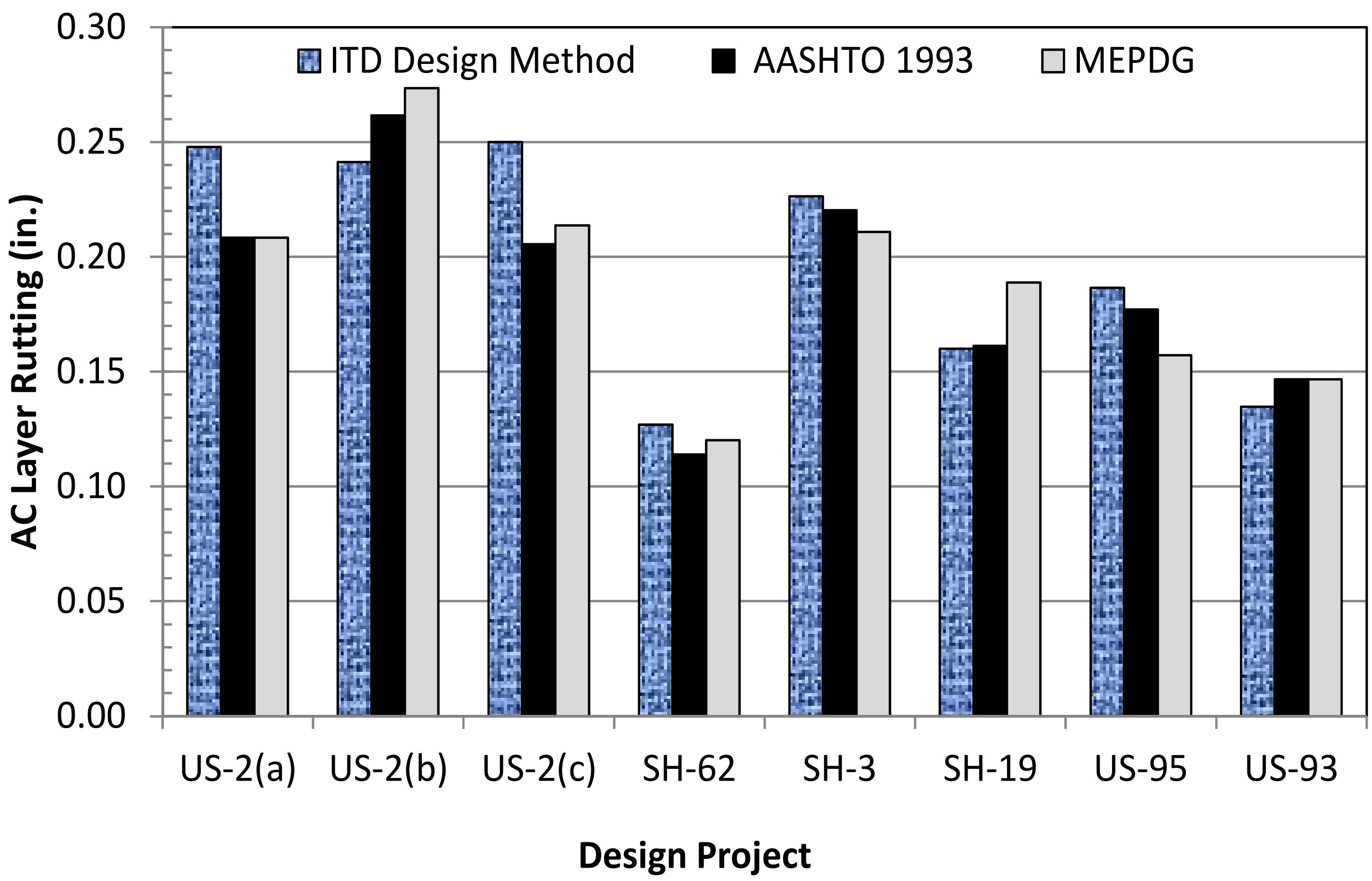
# MEPDG Predicted Distresses for the Resulting Pavement Structure Designs using ITD, AASHTO, and MEPDG



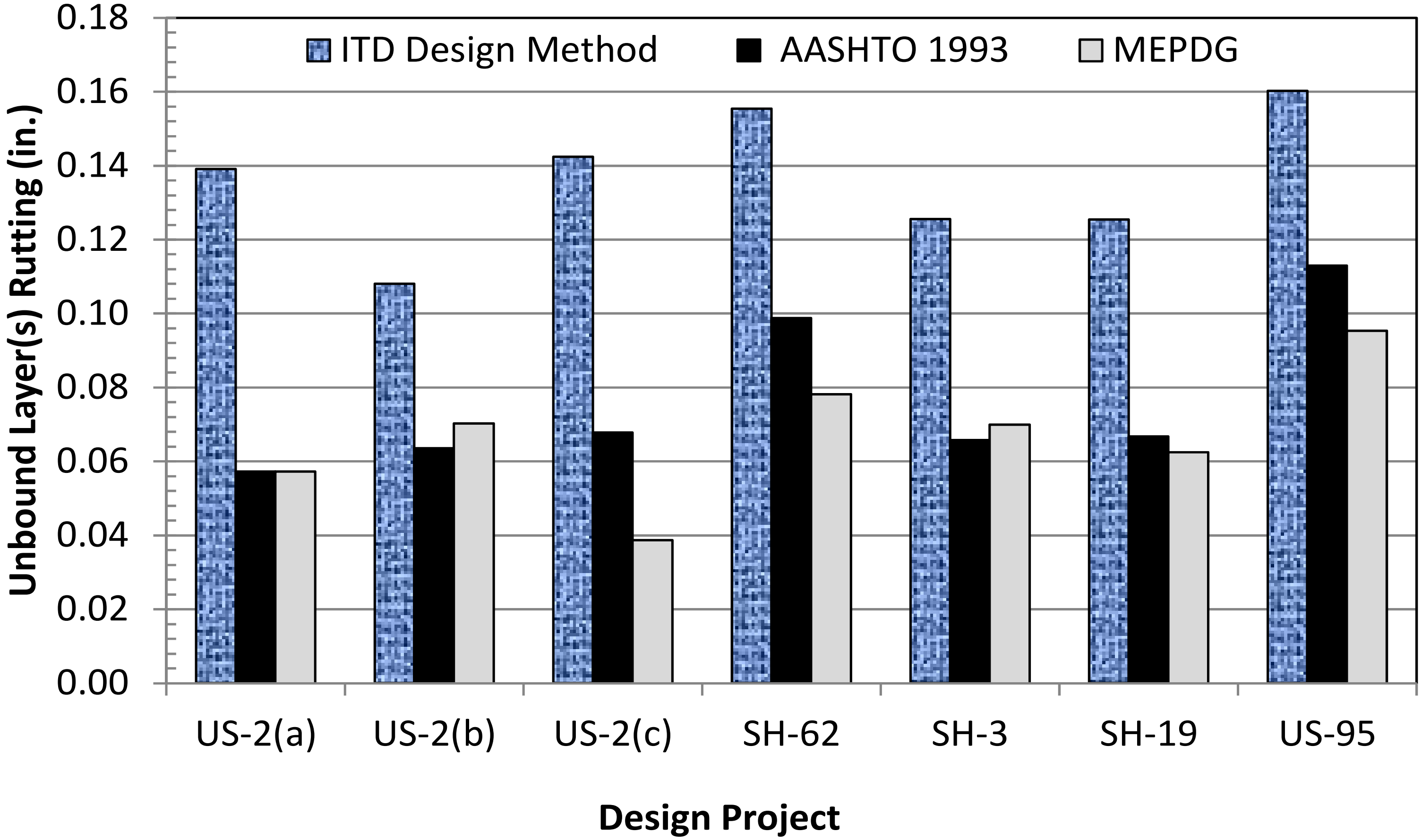
# MEPDG Predicted Total Pavement Rutting (At 50% Reliability)



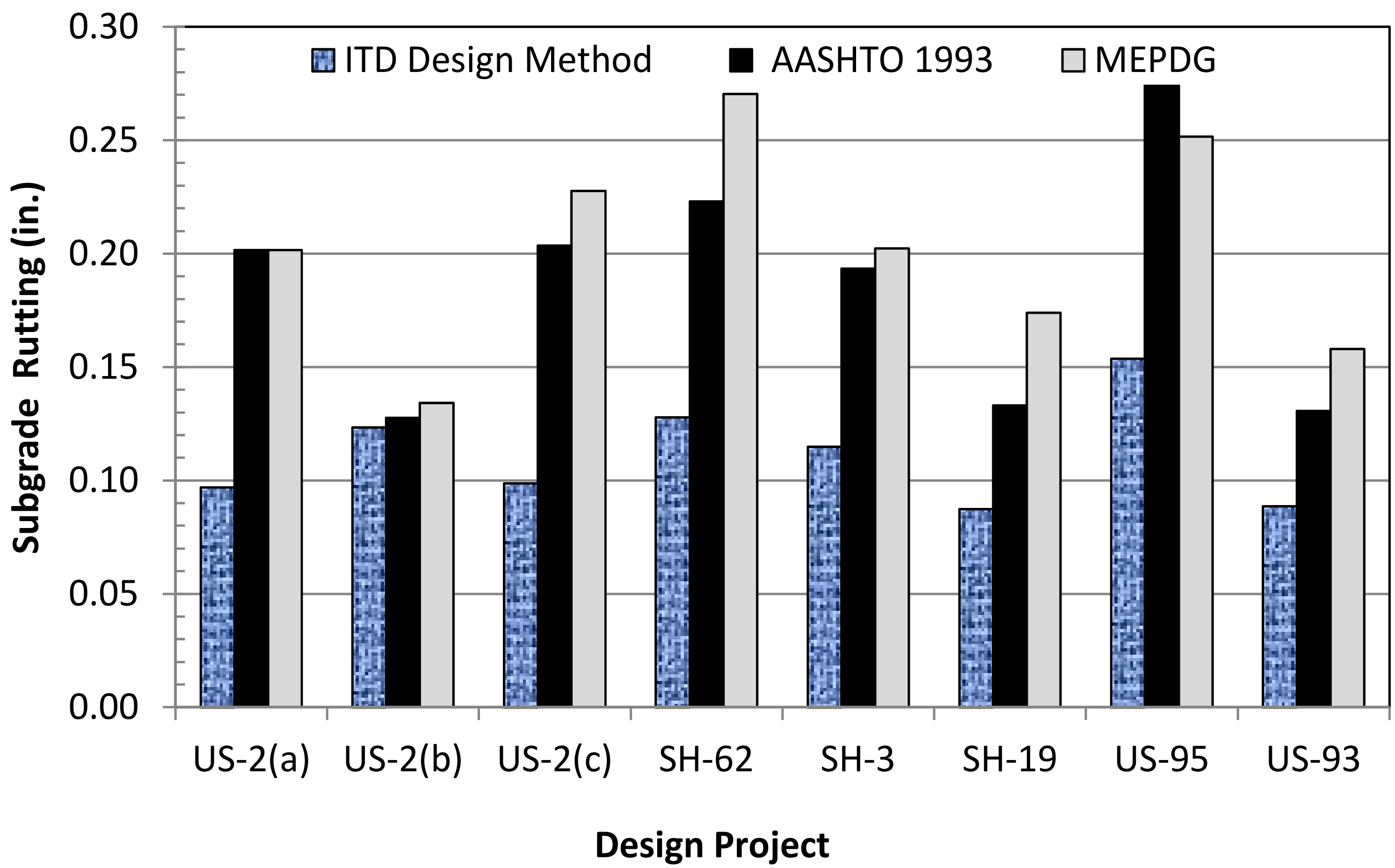
# MEPDG Predicted AC Rutting (At 50% Reliability)



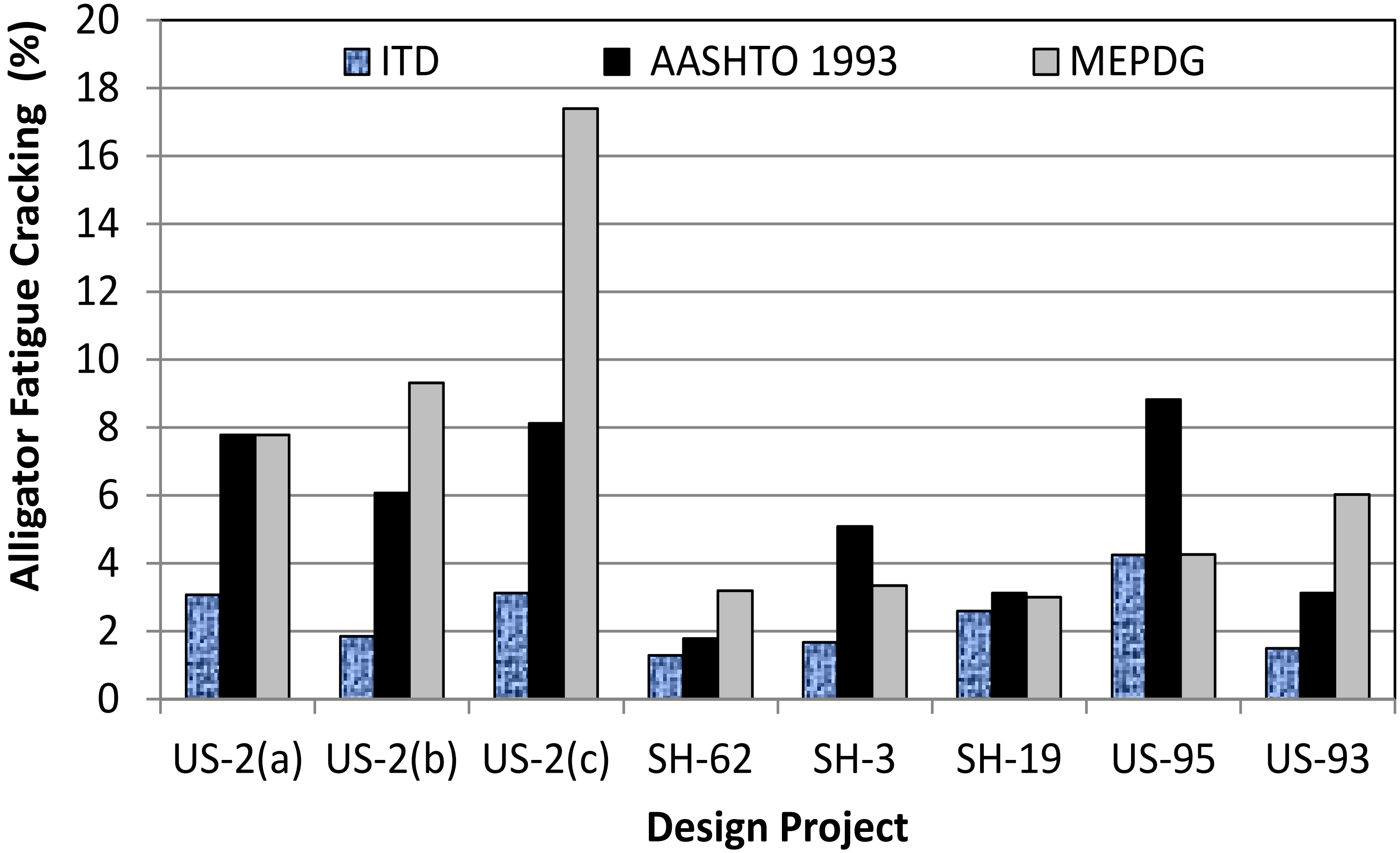
# MEPDG Predicted Unbound Base/Subbase Rutting (At 50% Reliability)



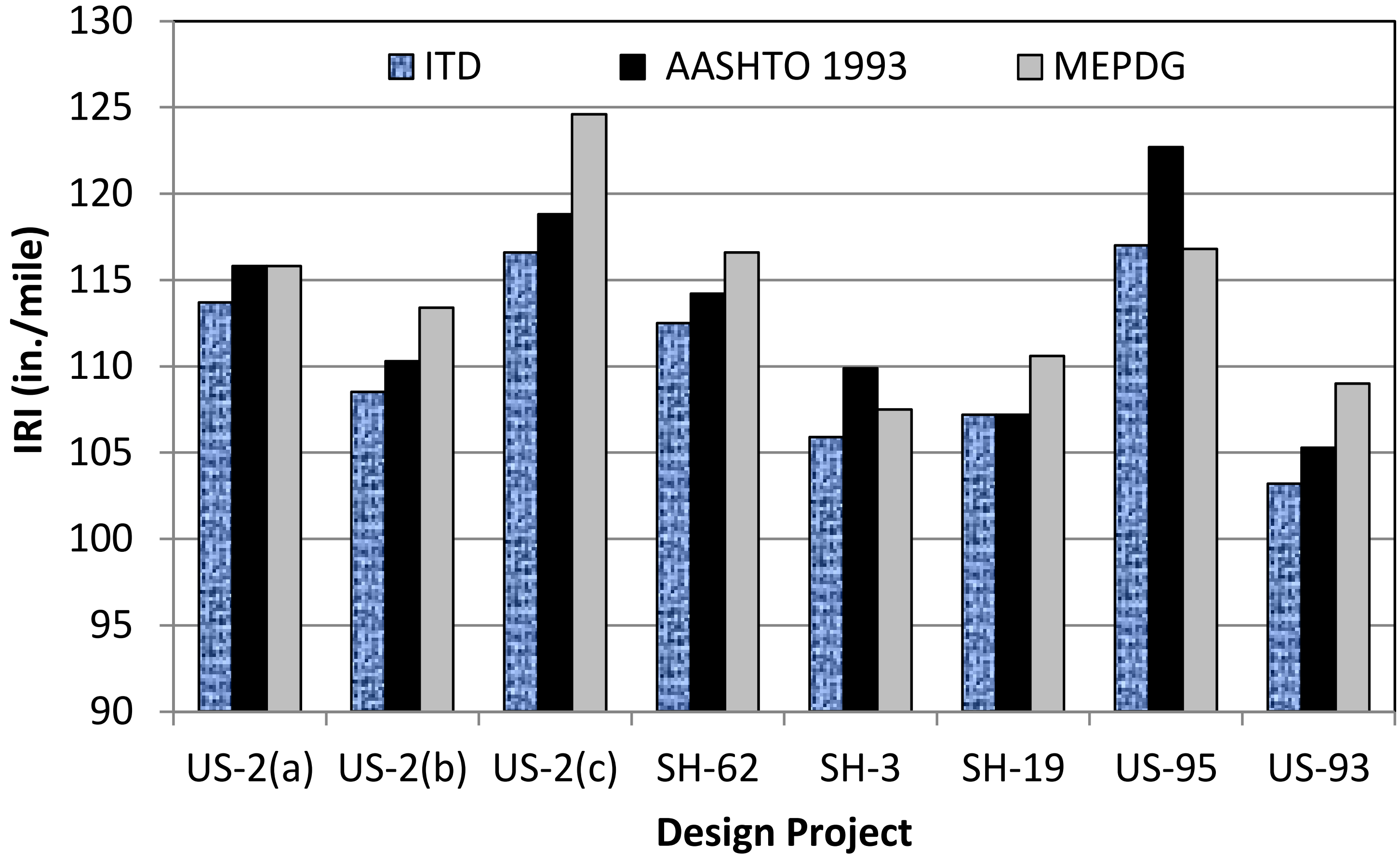
# MEPDG Predicted Subgrade Rutting (At 50% Reliability)



# MEPDG Predicted Alligator Cracking (At 50% Reliability)

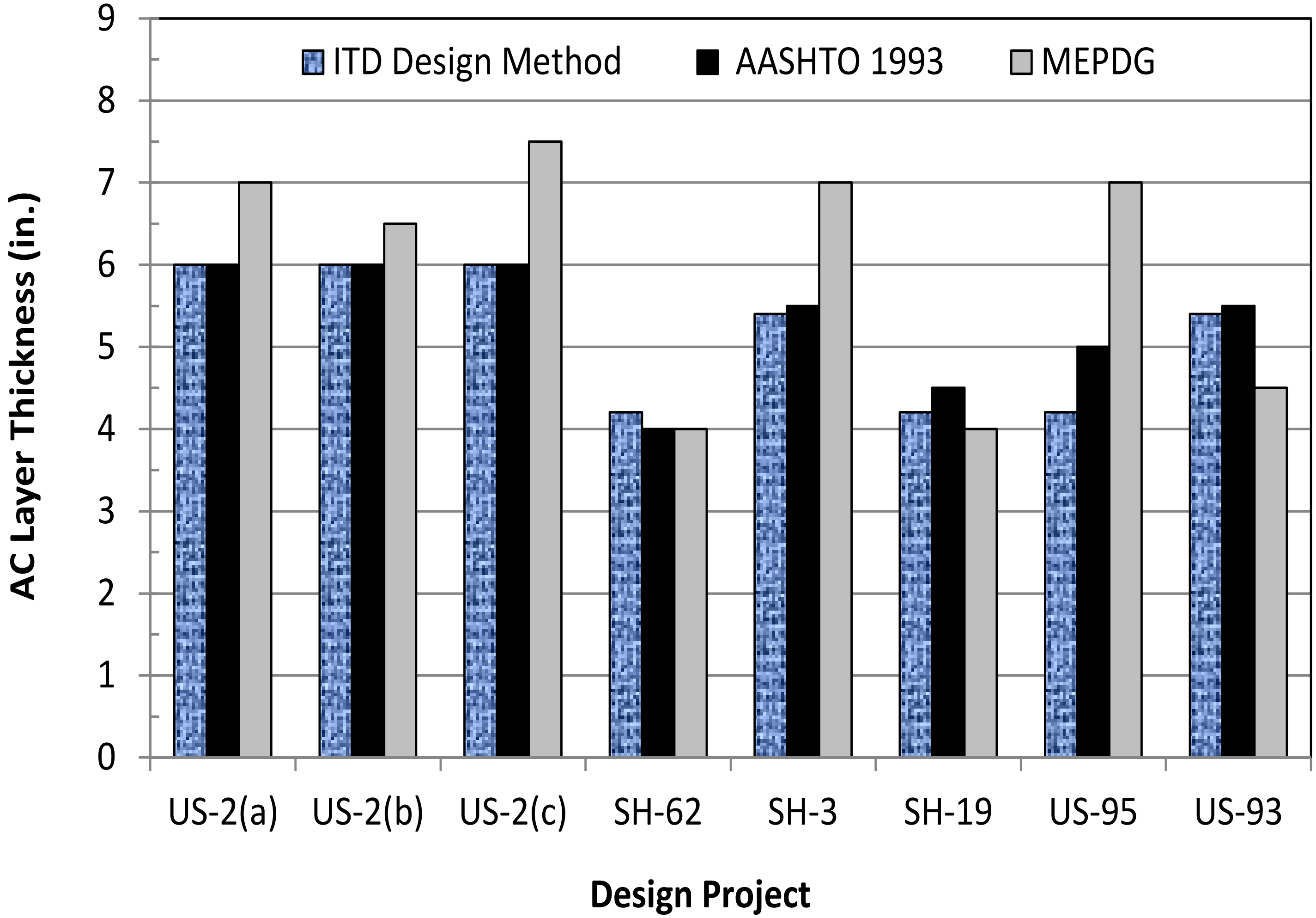


# MEPDG Predicted IRI (At 50% Reliability)

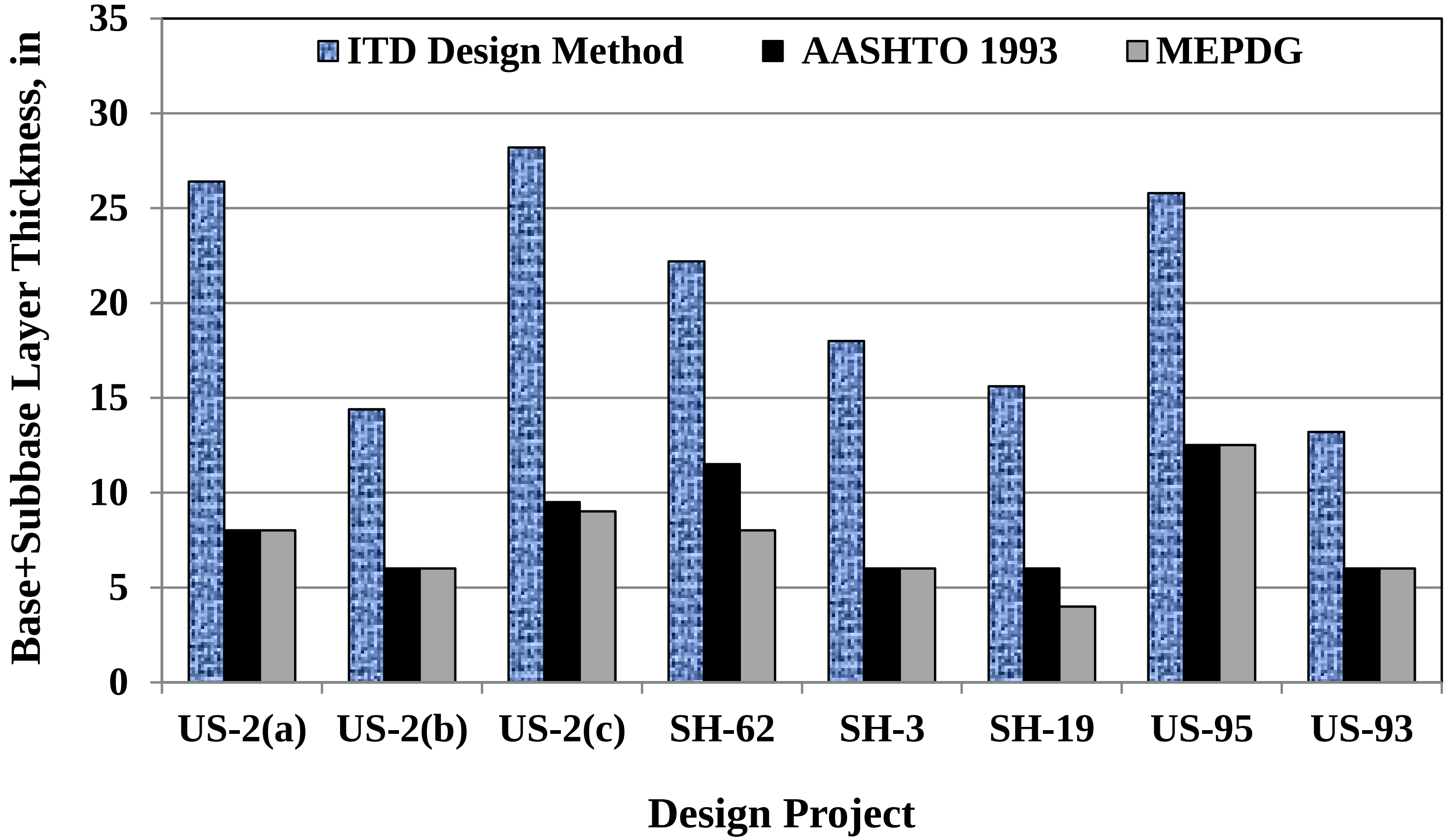


# Comparison at 85% Reliability Level

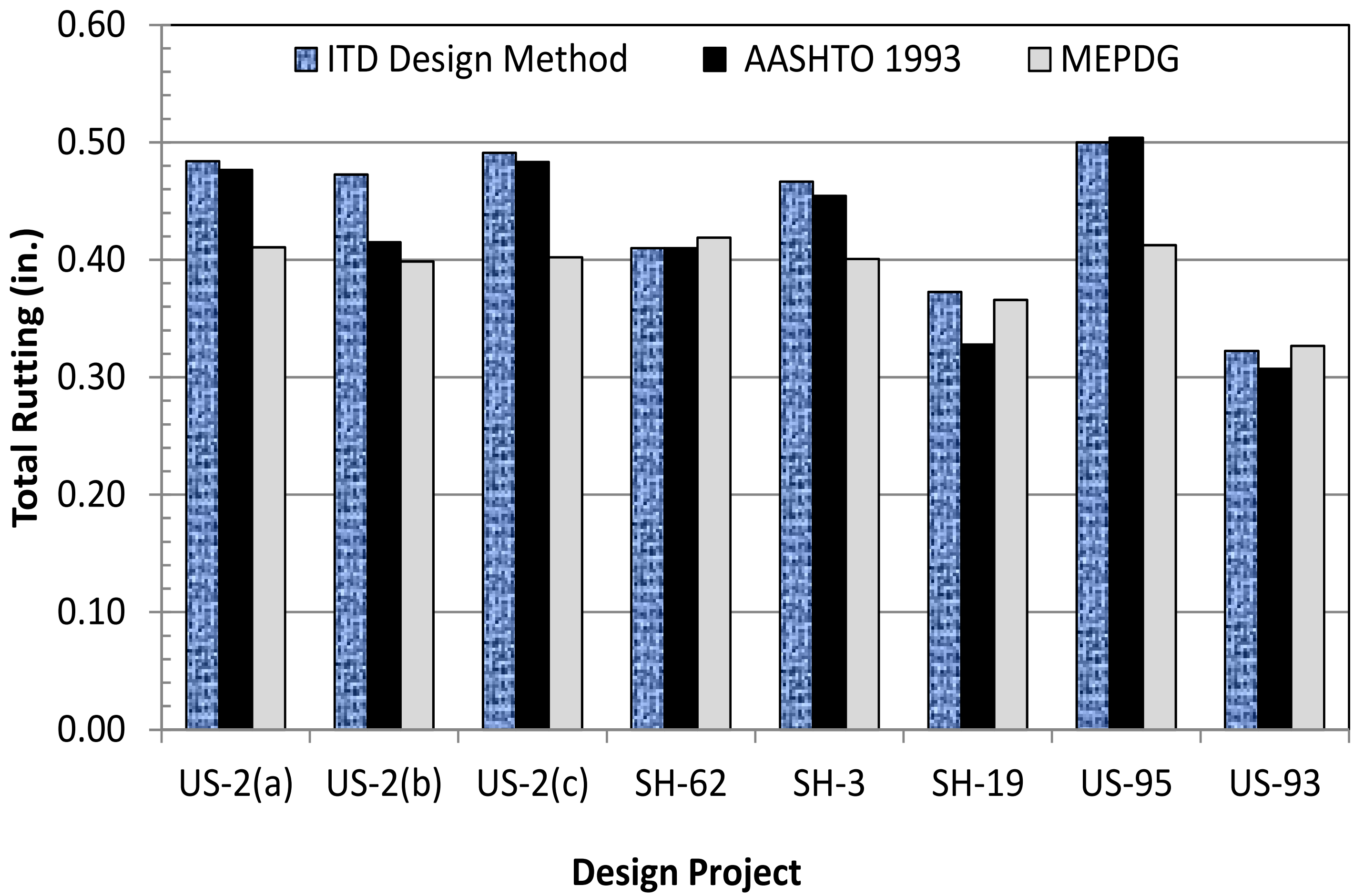
# AC Layer Thickness (AASHTO and MEPDG at 85% Reliability)



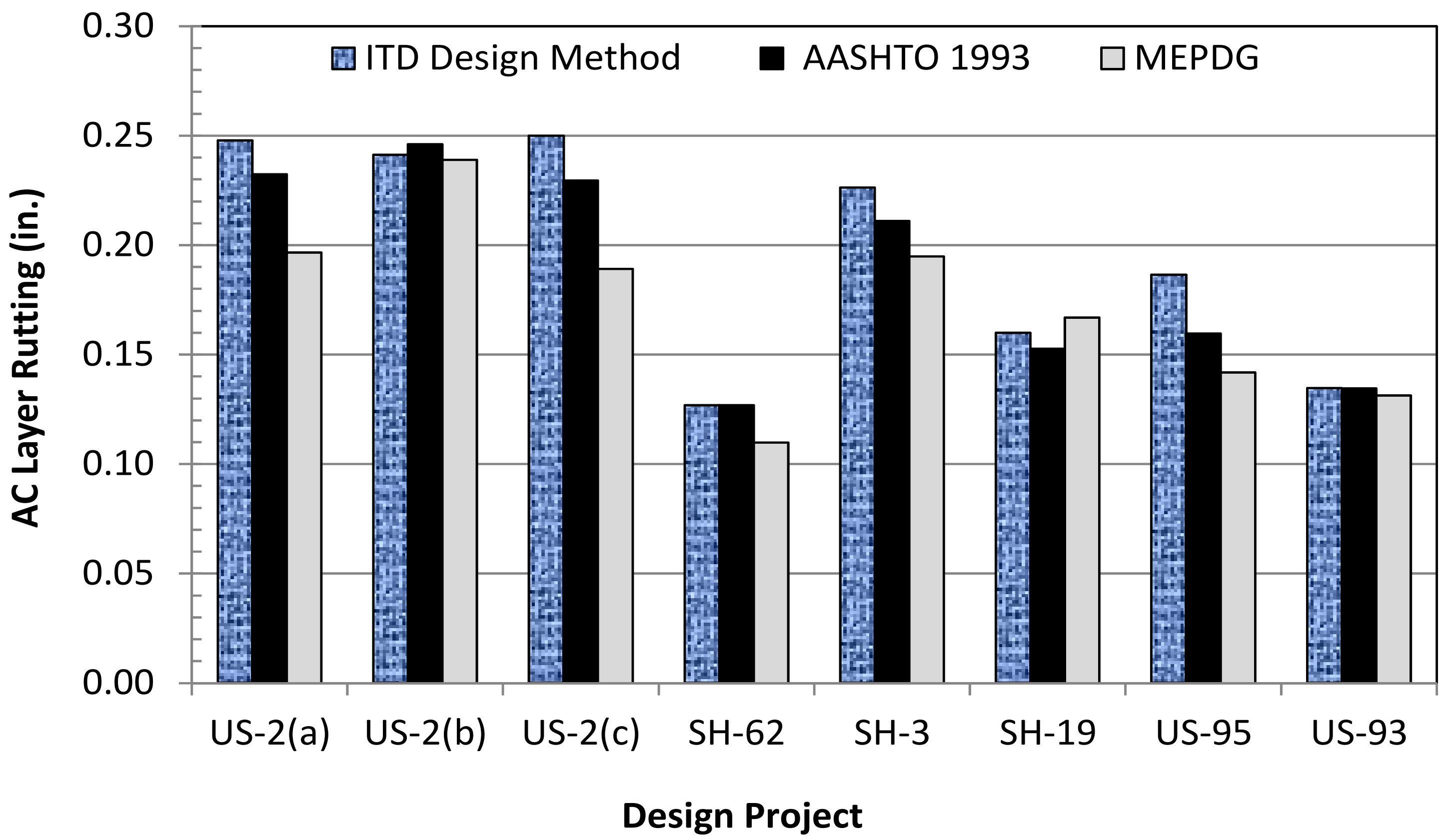
# Total Combined Base/Subbase Layer Thickness



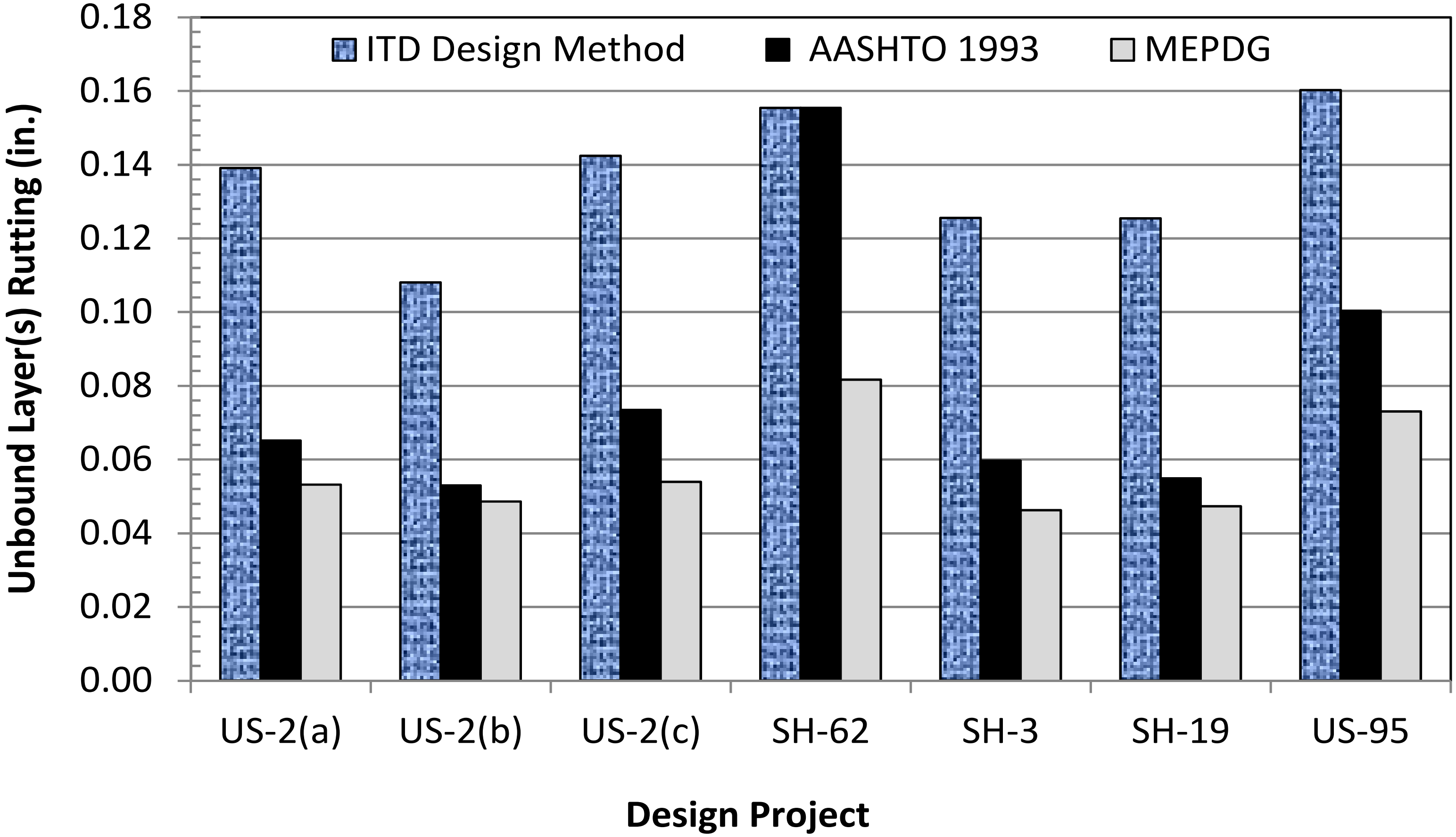
# Predicted Total Rutting Comparison



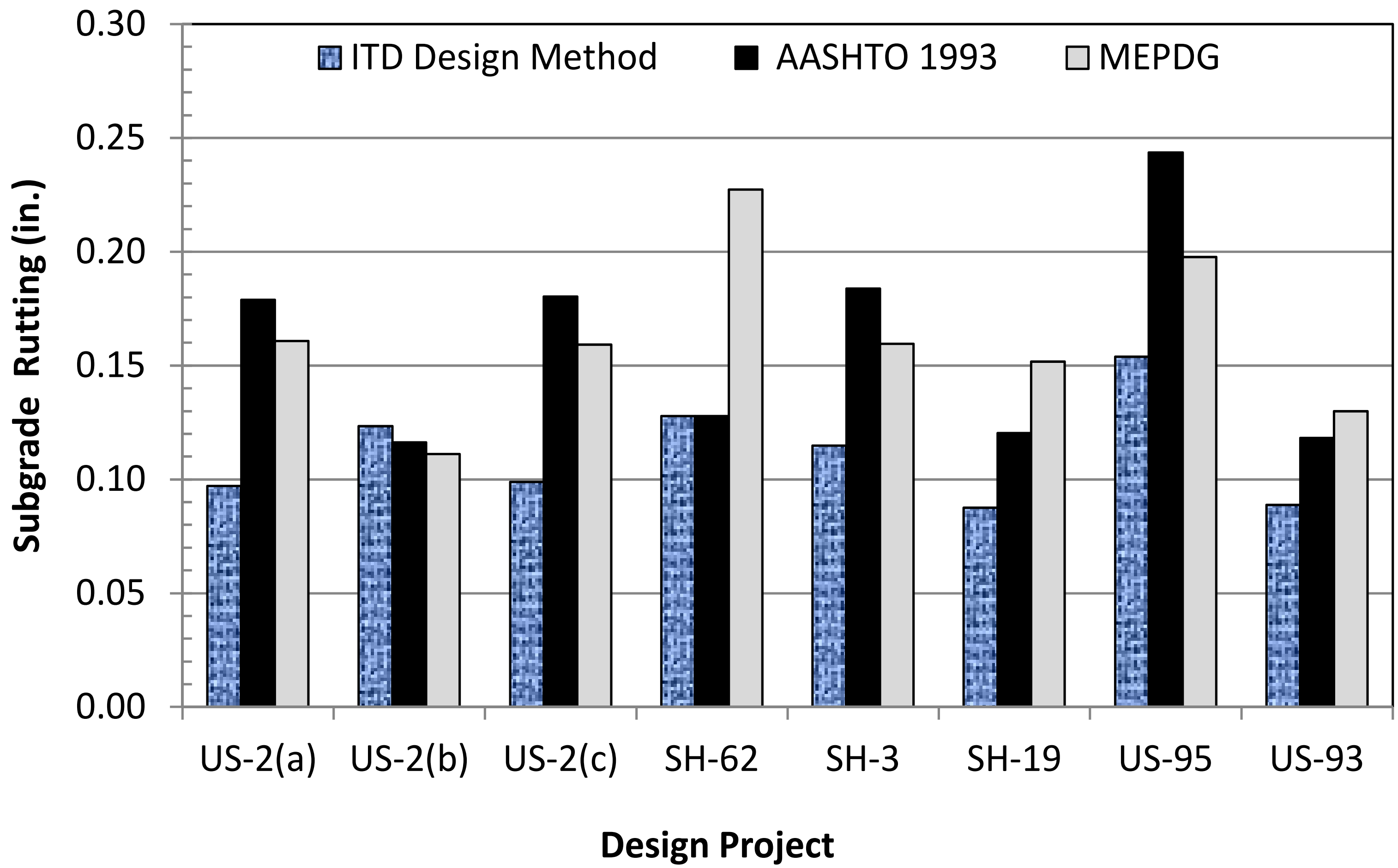
# Predicted AC Rutting Comparison



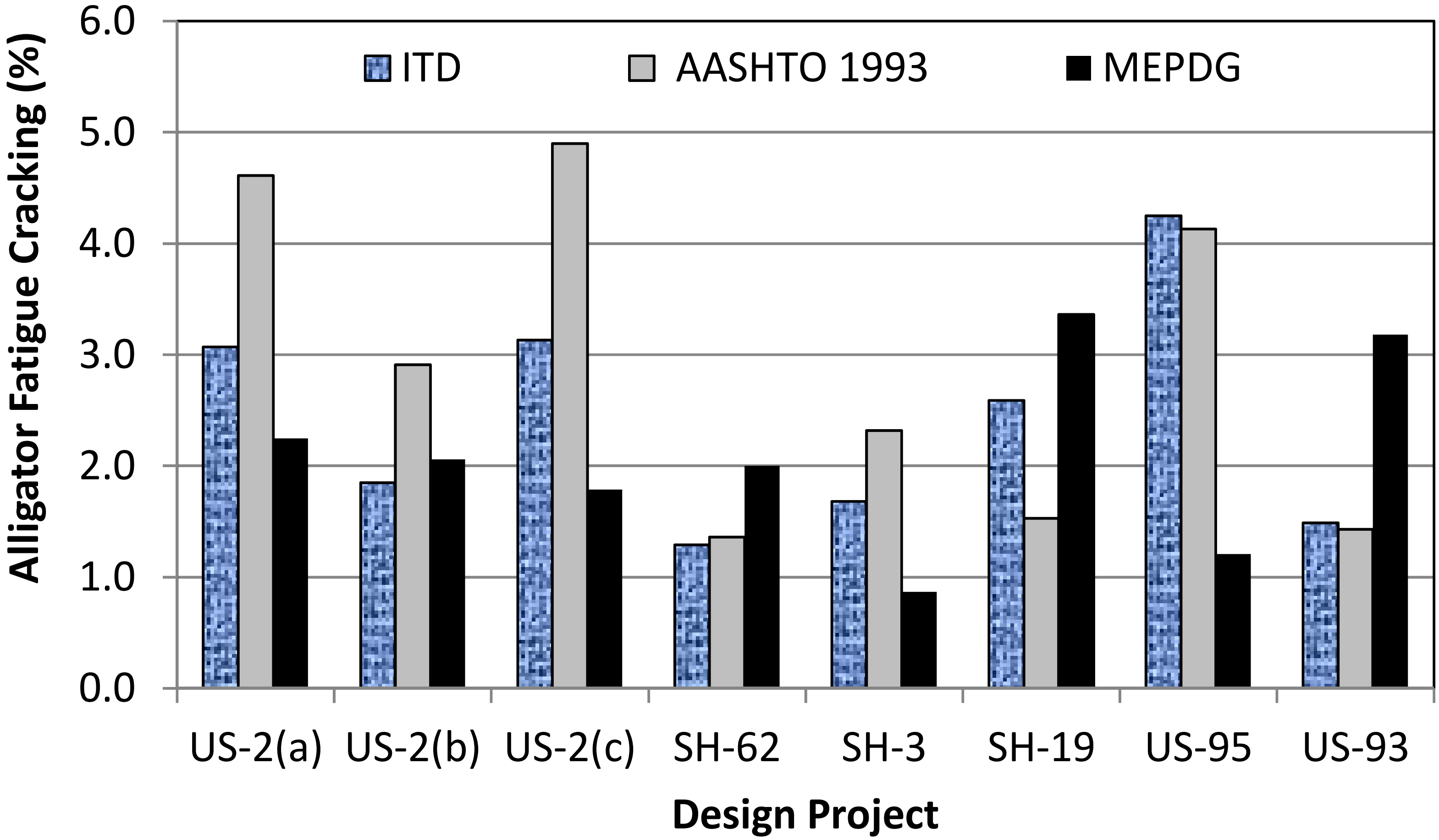
# Predicted Unbound Layers Rutting Comparison



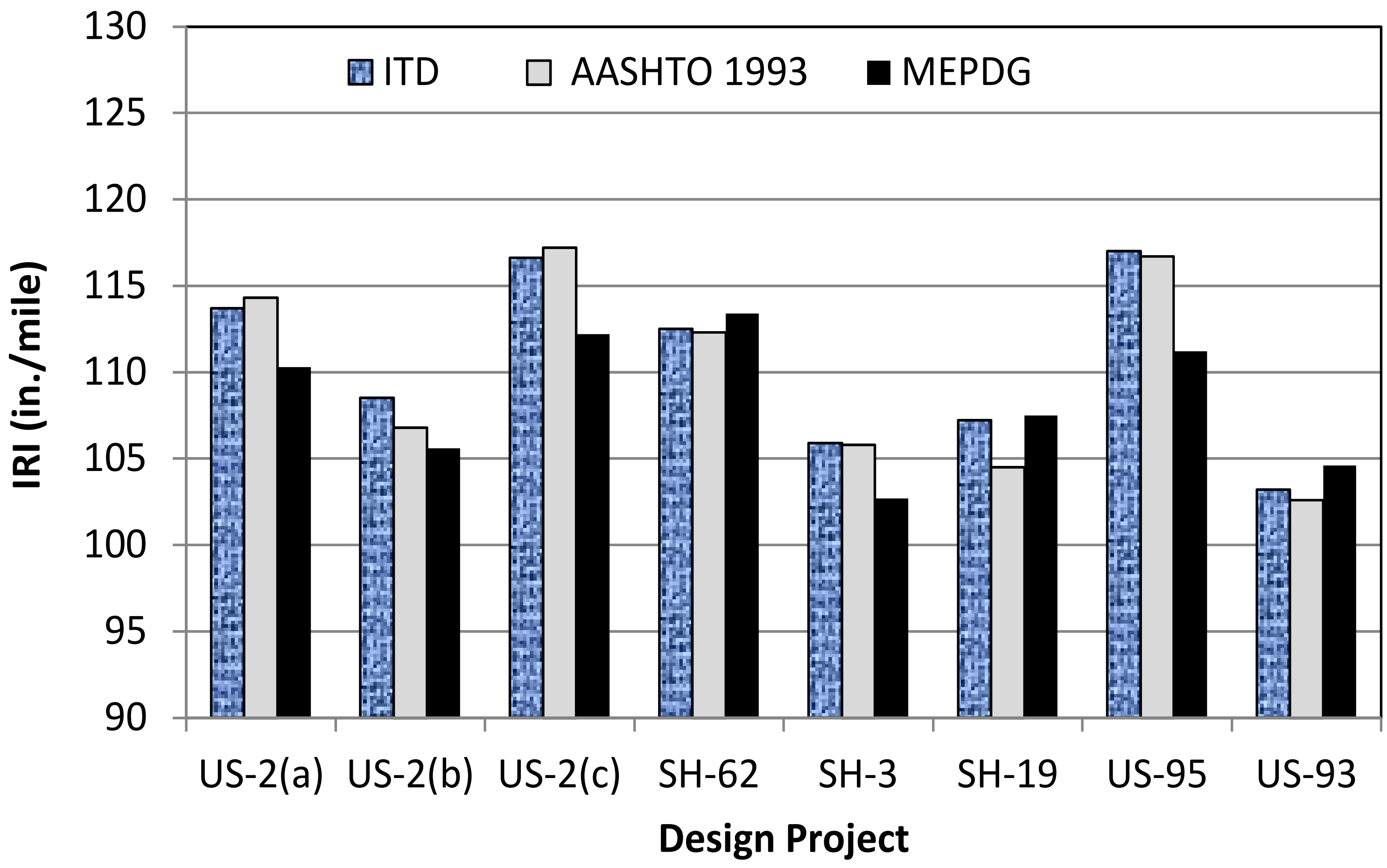
# Predicted Subgrade Rutting Comparison



# Predicted Alligator Cracking Comparison



# Predicted IRI Comparison



# Conclusions

- In general, both ITD and AASHTO 1993 methods yielded pavement structures that conform to **MEPDG criteria**.
- The unbound granular layer(s) thickness(s) resulted from the ITD design methods were much thicker (**2 to 4.5 times as thick**) compared to the AASHTO 1993 and MEPDG designs.
- A reasonable agreement was found between the AASHTO 1993 and MEPDG design methods regarding the resulting pavement structure.
- In general, the three design methods yielded reasonably similar thicknesses for the asphalt layer at 50% reliability.
- At a higher reliability level, MEPDG yielded thicker AC thicknesses compared to both methods especially in case of very weak subgrade strength.
- **Subgrade strength** is overemphasized by the ITD design method.
- The resulting structure for each of the investigated pavement sections, using the **nationally calibrated MEPDG**, was found to be governed by the predicted total pavement rutting.

# Questions are welcome

Thank you for your interest