Manual of Refined Analysis

T-5 at 2016 SCOBS
Background

• Manual development spread over 2 tasks
  – Task 1 Complete
  – Draft manual is available on FHWA website
• Task 2 is underway
  – 60% submittal this summer
Task 2 - Scope

• Deliverables are additional material for the manual of refined analysis and any AASHTO ballot items

• Continues the work of Task 1 into more material-specific areas and nonlinear behaviors
Review Objectives and Approach

• Provide greater consistency in application of FEA to bridge structures
  – Raise the level of basic understanding to encourage wider application of FEA
  – Avoid blunders
  – Understand behavior
  – Introduce economies
How?

• Keep flexible
• Encourage initiative and creativity
• Avoid deep mathematics
• Concentrate on application
• Avoid software specifics to extent possible – try to stay generic
2.1 Concrete Bridges

- Modeling creep and shrinkage
- Made continuous for live load
- Gross vs. cracked vs. effective stiffness
- Reference other design manuals

- Not included:
  - Construction staging
  - Section design
  - 3D deck behavior
2.2 Prestressing and Post-tensioning

• Applying P/T in an FEA – trajectory or equivalent loads
• External P/T and ductility
• Secondary P/T effects, creep and shrinkage
2.3 Steel Bridges

• Handling mixed materials
• Cross-frames and diaphragms, geometric positioning (layover)
• Staged construction
• Localized fatigue analysis
• Distortion induced fatigue
• Not included: detailed “fit” issues
2.4 Soil Structure Interaction and Substructures

- Methods of including substructure/foundation stiffness
- When to include
- Pile foundation modeling methods
- Bearing stiffnesses
2.5 Steel Connections

- Actual stress distributions vs. typical design assumptions vs. FEA
- Localized yielding and redistribution
- Fastener load-displacement relationships
- Reference FHWA gusset plate guidance
2.6 Nonlinear Considerations

• Causes and types of nonlinear behavior
  – Material
  – Geometric
  – Lift-off, i.e. changed boundary conditions during analysis
  – Slip-stick and friction

• When to include
2.7 Stability Analysis

- Typical stability issues encountered
- Types of buckling analyses
- Imperfections and initial stresses, e.g. residual stresses
- What the design equations account for and what is typically modeled.
- Stability during erection
2.8 Dynamic Analysis

• Mass and stiffness modeling
  – Mass moment of inertia

• How many modes are enough?

• Using the mass participation percentage

• Time history, modal (spectral) analysis
2.9 Examples

• Focused on unique aspects – little detail on standard aspects
• 3 Examples to be included:
  • Dynamic analysis
    – PEB response spectra analysis
    – Substructure included (SSI)
    – Vibration criteria check
    – Push-over analysis
Examples Continued

• Stability example
  – Tall, slender concrete pier
  – Show various methods of determining buckling load and magnified moments
Examples Continued

• Concrete creep and shrinkage
  – Box girder, probably span-by-span construction with external tendons
  – Show how to include external tendons in model, account for creep and shrinkage, and the effects on final moments.
2.10 Refined Analysis and Reliability

- Much confusion, and difference of opinion, exists
- Different ways in which a refined analysis affects reliability
- Philosophy adopted in current AASHTO LRFD
- Conclusions/recommendations
2.11 Assemble Manual

- Combine results of Task 1 and Task 2
- Resolve any conflicts/inconsistencies
- Make it flow
2.12 Ballot Items

- Identify potential ballot items early
- Contact committee chairs and obtain feedback
Schedule

- NTP in August 2015 to MM
- Currently in month 10 of 21
- Examples just getting underway