Recent AASHTOWare / BridgeWare Developments

AASHTO SCOBS T-19 Meeting
Norfolk– May 2011
Virtis/Opis Project

FEA Investigative Study
Introduction

• Investigative study requested by Virtis/Opis Task Force.
• Addition of 3D (FEA) capabilities into Virtis/Opis for the 2011-2012 work plan.
• This work will also consider curved girder analysis.
• It will include details for modeling and loading both straight and curved steel girders.
Basic Questions That Were Asked During the Investigative Study

1. What finite element modeling techniques are currently used for straight and curved multi-girder steel superstructures for:
   - Deck
   - Beam
   - Deck-to-beam connection
   - Cross-frames?

2. What techniques are used for applying the live load (both truck and lane) to the model?

3. How are the resulting actions resolved for specification checking?

Eight Technical Sources were consulted.
1a. What finite element modeling techniques are currently used for straight and curved multi-girder steel superstructures?

Deck Element Type

- Shell: 5
- Brick: 1
- Both: 2
• For the deck, a shell element is recommended.
• A shell element is currently used in Virtis/Opis for the deck.
• Additional testing may be required for curved bridge applications.
1b. What finite element modeling techniques are currently used for straight and curved multi-girder steel superstructures?

**Beam Element Type**

- **6** Chord
- **2** Curved
Recommendation

- For the beam, straight chorded elements are recommended.
- The length of the elements will be a function of the girder depth and possibly the degree of girder curvature.
- A shell element is recommended for the girder web.
- Beam elements are recommended for each flange.
1c. What finite element modeling techniques are currently used for straight and curved multi-girder steel superstructures?
Recommendation

- For the deck-to-beam connection, a line element (beam) is recommended.
1d. What finite element modeling techniques are currently used for straight and curved multi-girder steel superstructures?

Cross-frame Element

- Truss and Beam: 3
- Truss: 2
- Beam: 1
- Shell: 1

BRIDGEware Ltd.
Recommendation

- For the cross-frames, separate beam elements for each individual member of the cross-frame are recommended.
- Depending on the connections, the beam element will either provide the desired degree of rigidity in the connections or they will be released to represent a truss element.
- A beam element can be used to model both rigid connections and pinned connections.
- It is therefore more versatile than a truss element.
2. What techniques are used for applying the live load (both truck and lane) to the model?

   - **Option 1** – Place the truck and/or lane at all possible locations and save the controlling effects
   - **Option 2** – Develop an influence surface, and then place the truck and/or lane at all possible locations and save the controlling effects
   - **Option 3** – Develop an influence surface, develop a way to find only the controlling peaks and valleys, and then place the truck and/or lane in those regions only to determine the controlling effects
   - **Option 4** – Other
2. What techniques are used for applying the live load (both truck and lane) to the model?

Analysis Technique

- Option 1: 2
- Option 2: 1
- Option 3: 1
- Option 2&3: 3
- Option 4: 1
Recommendation

• It is recommended that two techniques be developed for applying live load to the model:
  • Technique 1 – Develop an influence surface, and then place the truck and/or lane at all possible locations and save the controlling effects (brute force method)
  • Technique 2 – Develop an influence surface, develop a way to find only the controlling peaks and valleys, and then place the truck and/or lane in those regions only to determine the controlling effects
  • If both techniques are developed, then Technique 1 can be used to test Technique 2
3. How are the resulting actions resolved for specification checking?

Resolution Technique

- Calculate moments from stresses at flange tips
- Only publish stresses with no specification checks
- Calculate moments indirectly from deflections
• Further study of what actions will be produced by Virtis/Opis for the various elements that are being recommended for use.

• Further study of what actions are required for specification checking.
Additional Information Provided During Interviews

- MDX is based on a 2D analysis.
- DESCUS is based on a traditional grid analysis, which is also a 2D analysis.
Additional Information Provided During Interviews

- Will the finite element analysis be based on linear analysis or non-linear analysis?
- This decision affects the entire analysis process.
- A combination of the two approaches is also an option.
Additional Information Provided During Interviews

- **Linear analysis**
  - Based on elastic behavior
  - Small-deformation approach
  - Simplest approach
  - Based on basic beam theory

- **Non-linear analysis**
  - A second-order approach
  - Does not require that plane sections remain plane
  - More complicated
  - Solution may be iterative
States’ Survey Results

Substructure Software
What types of software does your state use to perform substructure analysis?

2    In-house software
20   Commercial software
29   Both
If commercial software is used by your state to perform substructure analysis, which programs does your state use? Check all that apply.

- BridgeWare Opis Substructure (6 votes)
- BRUFEM (0 votes)
- STAAD (15 votes)
- SAP 2000 (15 votes)
- Florida Pier (4 votes)
- Georgia Pier (5 votes)
- FB-Pier/MultiPier (13 votes)
- RC-PIER (32 votes)
- BRASS PIER (LRFD) (5 votes)

Other commercial software used: GT-STRUDL, VBent, ABLRFD, BPLRFD, PAPIER, Penn DOT software, SHAFT, LARSA, COM624, WinRECOL, MATHCadd, WEAP, and RESSA.
What software does your state utilize for pile and drilled shaft lateral load analysis?

3 DFSAP
44 L-Pile
21 COM624P
16 FB-Pier

Other software used: Driven, ALLPILE, GROUP, RC-PIER, DS SAP, and Strain Wedge
What substructure design features does your state feel are currently not available in commercial software and need to be developed?

- Strut and Tie Method
- Micropile Design
- Drilled Shaft Design
- Wave Load Design
- Skew Effects for Stiffness
- Tie Beam Design
- Trapezoidal Columns and Pier Shapes
- Ability to Perform Load Combinations
- Soil Structure Interaction and Analysis
- Lateral Spread Analysis
- Liquefaction Analysis
- Scour Analysis
Element Migrator Update
The “Element Migrator” will mass convert CoRE elements to new elements.
Will handle State developed elements.
Recommend migrating existing elements and then checking.
Migrator is software / DB independent and free to AASHTO states.
Difficulty with SMART Flags.
Questions & Comments

Thanks for your continued support