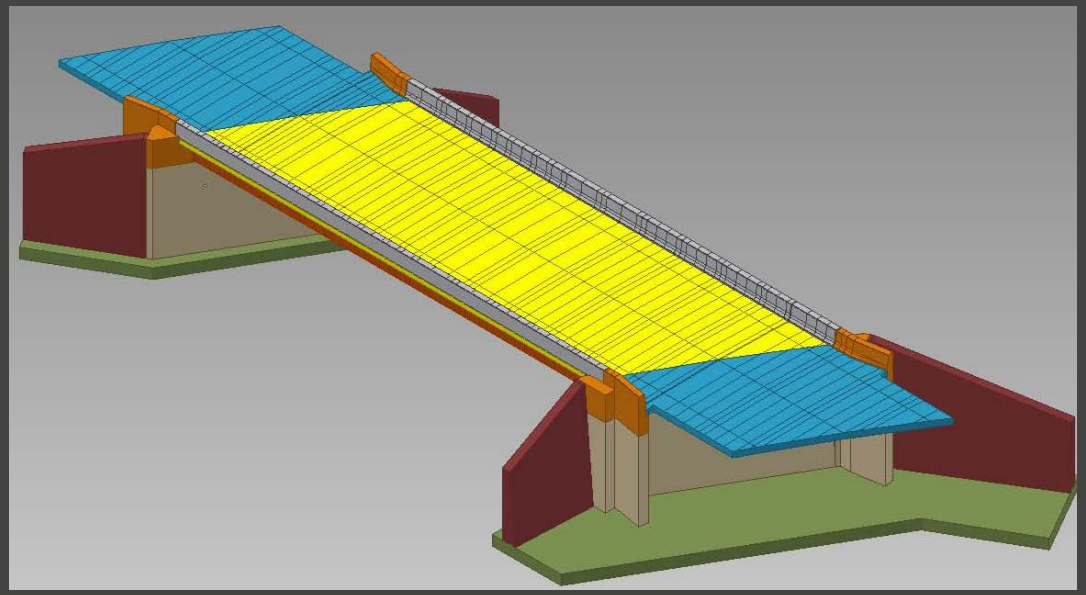
BRADD TO 3D CADD



Modeling for Structures

JOE BRENNER, P.E.
NICK SEMAN, E.I.T.
GANNETT FLEMING, INC.

pennsylvania
DEPARTMENT OF TRANSPORTATION

Gannett Fleming

OVERVIEW

- BRADD Background
- Why a 3D Model?
- Setting the Course
- Overview of Model
- Building the Model
- Using the Model
- Conclusions
- Moving Forward

BRADD PROGRAM

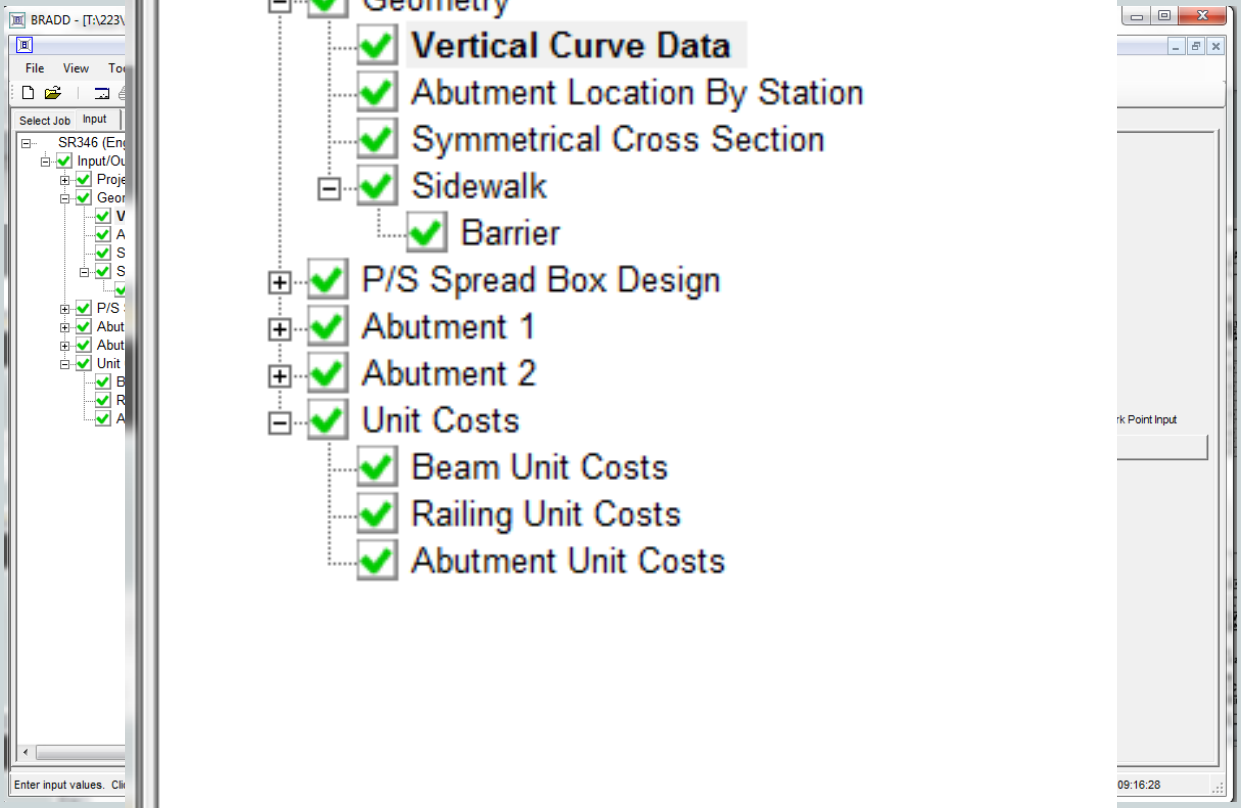
PennDOT's BRADD – Software Application

- BRADD = BRidge Automated Design and Drafting
- Automates production of scaled bridge contract drawings

Engineering Input → Design → Drawings

BRADD PROGRAM

Enginee



BRADD PROGRAM

Design

Bridge Geometry, Version 1.1 — Page 14
Input File: BRADD Generated Input — 05-Aug-2014 10:18

BRADD v3.2.0.0, Lic. No. 437009 — jbrenner@PC68702

BRADD CALCULATED OUTPUT

* BEGIN BRADD CALCULATED OUTPUT *

TABLE OF DECK ELEVATIONS

STATION (ft)	LEFT CURB (ft)	LEFT BREAK (ft)	P.G.LINE (ft)	RIGHT BREAK (ft)	RIGHT CURB (ft)
480+76.74	-999.000	-999.000	-999.000	-999.000	1492.131
480+78.47	-999.000	-999.000	-999.000	1492.251	1492.131
480+80.00	-999.000	-999.000	-999.000	1492.250	1492.130
480+84.82	-999.000	-999.000	1492.468	1492.248	1492.128
480+90.00	-999.000	-999.000	1492.464	1492.244	1492.124
480+91.17	-999.000	1492.243	1492.463	1492.243	1492.123
480+92.90	1492.122	1492.242	1492.462	1492.242	1492.122
481+00.00	1492.112	1492.232	1492.452	1492.232	1492.112
481+10.00	1492.094	1492.214	1492.434	1492.214	1492.094
481+20.00	1492.070	1492.190	1492.410	1492.190	1492.070
481+30.00	1492.039	1492.159	1492.379	1492.159	1492.039
481+40.00	1492.002	1492.122	1492.342	1492.122	1492.002
481+50.00	1491.959	1492.079	1492.299	1492.079	1491.959
481+60.00	1491.909	1492.029	1492.249	1492.029	1491.909
481+60.74	1491.905	1492.025	1492.245	1492.025	1491.905
481+62.47	1491.896	1492.016	1492.236	1492.016	-999.000
481+68.82	1491.860	1491.980	1492.200	-999.000	-999.000
481+70.00	1491.853	1491.973	-999.000	-999.000	-999.000
481+75.17	1491.822	1491.942	-999.000	-999.000	-999.000
481+76.90	1491.811	-999.000	-999.000	-999.000	-999.000

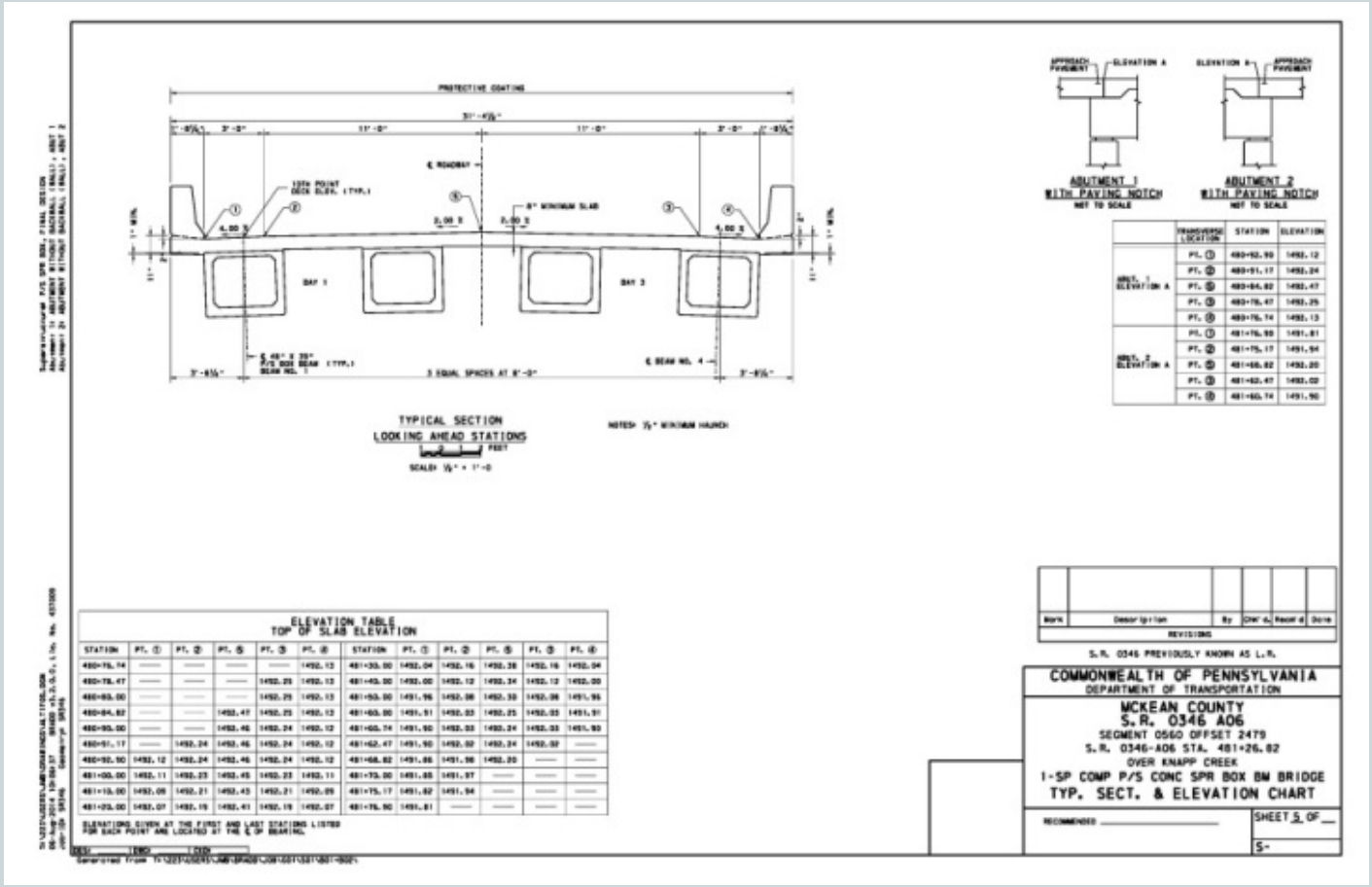
NOTE : -999.0 INDICATES ELEVATION IS NOT ON THE BRIDGE.

PRESTRESSED BOX BEAM DATA

P/S BOX DEPTH (in)	39.000
P/S BOX WIDTH (in)	48.000
BEARING PAD 1 THICKNESS (in)	2.598
BEARING PAD 2 THICKNESS (in)	2.103
SOLE PLATE THICK. AT C.L. BRG. (in)	0.000
SLAB THICKNESS (in)	8.000

BRADD PROGRAM

Drawings



BRADD PROGRAM

PennDOT's BRADD (cont.)

- BRADD is a design and drafting tool
- Primary use is design/detailing simple span bridges
- Works in conjunction with PennDOT Bridge Program Suite including:
  - PSLRFD – LRFD Prestressed Concrete Girder Analysis and Rating
  - STLRFD – LRFD Steel Girder Analysis and Rating
  - ABLRFD – LRFD Abutment and Retaining Wall Analysis and Design
  - BPLRFD – LRFD Bearing Pad design and Analysis

WHY A 3D MODEL?

Q. Why did we consider modeling a bridge in 3D?

A. Aware of the many potential benefits based on case studies from other bridge owners and from our work in other disciplines and wanted to determine what aspects we could use to improve bridge design

WHY A 3D MODEL?

Why did we choose a BRADD Bridge project as the basis for a 3D Model?

- All design information all ready existed in digital format
- Utilized PennDOT design applications and standard details
- Design Drawings (BRADD output) directly reflected the design input parameters
- Wanted to investigate the possible automation of model creation process by using the BRADD design documentation

WHY A 3D MODEL?

What benefits did we feel that a 3D model might bring to the project workflow?

- Ability to view and interact with the proposed design from any perspective, illustrating any aspect of the proposed structure
  - Better convey design – validate concepts
  - Allow virtual inspection / review
  - Review of aesthetics (public outreach)

WHY A 3D MODEL?

What benefits did we feel that a 3D model might bring to the project workflow? (cont'd)

- Improved interface to study complex/congested reinforcement details
- Ability to isolate and analyze individual bridge components with analysis applications
- Automatically generate and update 2D drawings of specific components

WHY A 3D MODEL?

What benefits did we feel that a 3D model might bring to the project workflow? (cont'd)

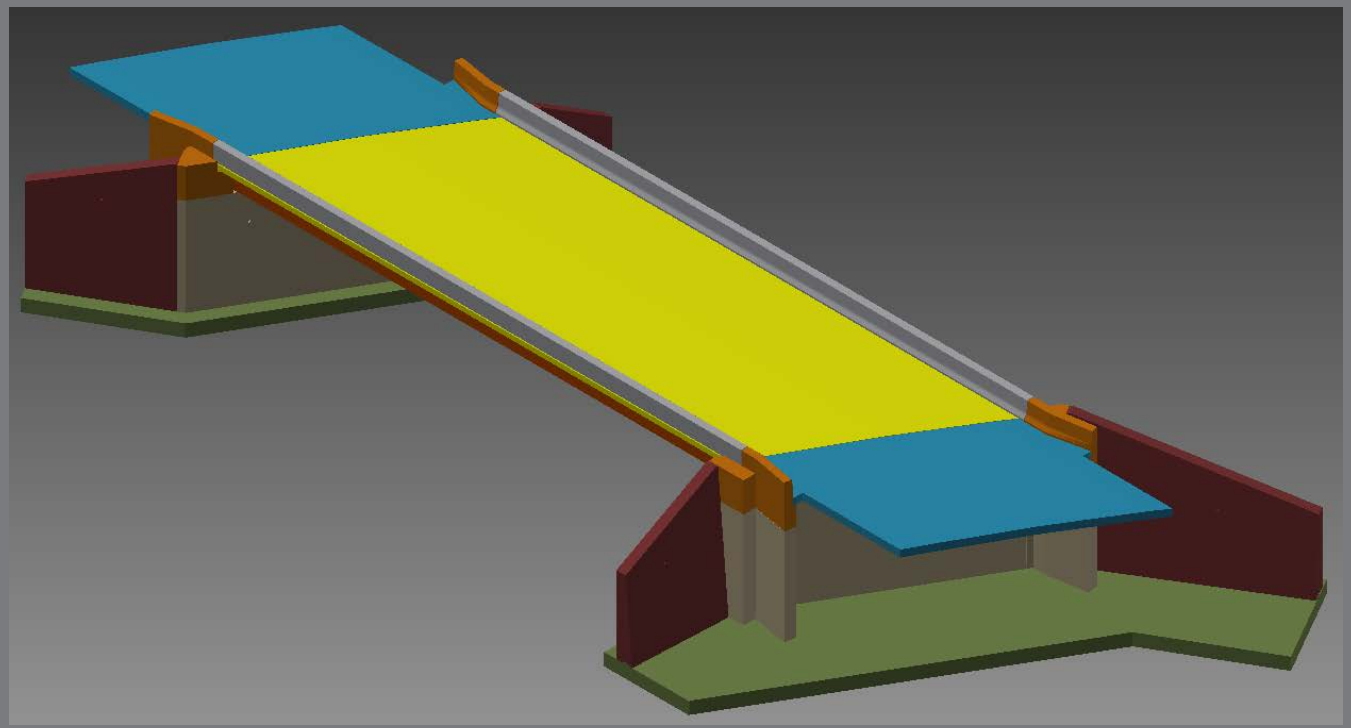
- Improve observation of the interactions between bridge, highway and other disciplines by providing a common platform for the integration of design content.
- Provide the ability to perform virtual construction analysis including site preparation and scheduling

SETTING THE COURSE

Determine the Approach

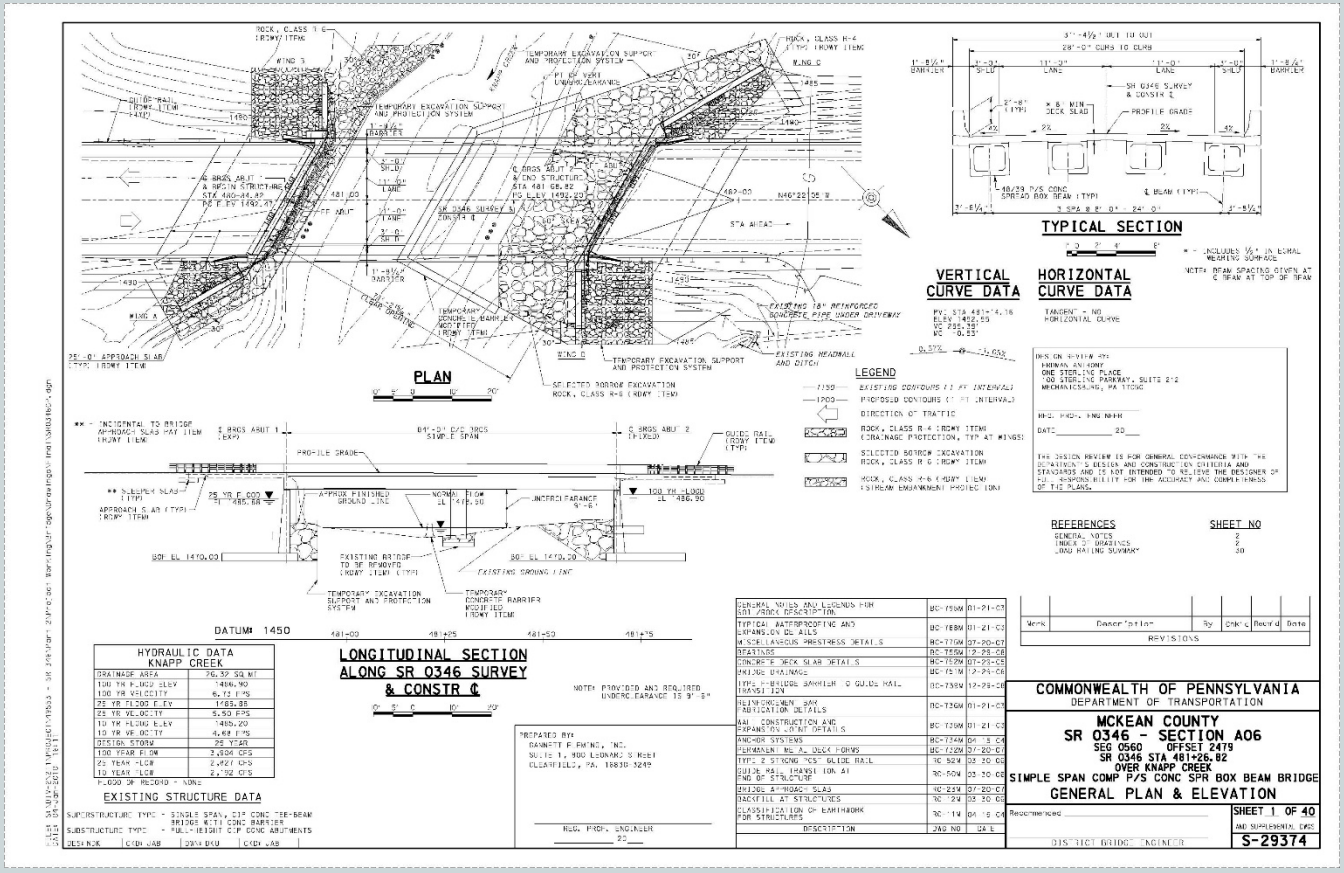
- Set goals for the model
- Select software to be used
  - 3D Solid Modeling /Analysis / Simulation
    - Provides tools specific for advanced 3D design and documentation
    - Proven track record through use on extensive facility projects
    - Available from multiple software publishers
      - We selected Inventor
- Develop workflow and procedure
- Build tools for future use
- Evaluate model for future implementation into workflow

OVERVIEW OF MODEL - SR 346 OVER KNAPP CREEK



3D FOR

General Plan and Elevation



SR 346 OVER KNAPP CREEK

McKean County
PennDOT District 2-0

Single-span composite prestressed spread box beam bridge

PennDOT skew angle of 60 deg.

Vertical curve

CIP abutments on spread footings

Replacing an existing 2-span concrete encased steel I-girder bridge

SR 346 OVER KNAPP CREEK

McKean County
PennDOT
District 2-0

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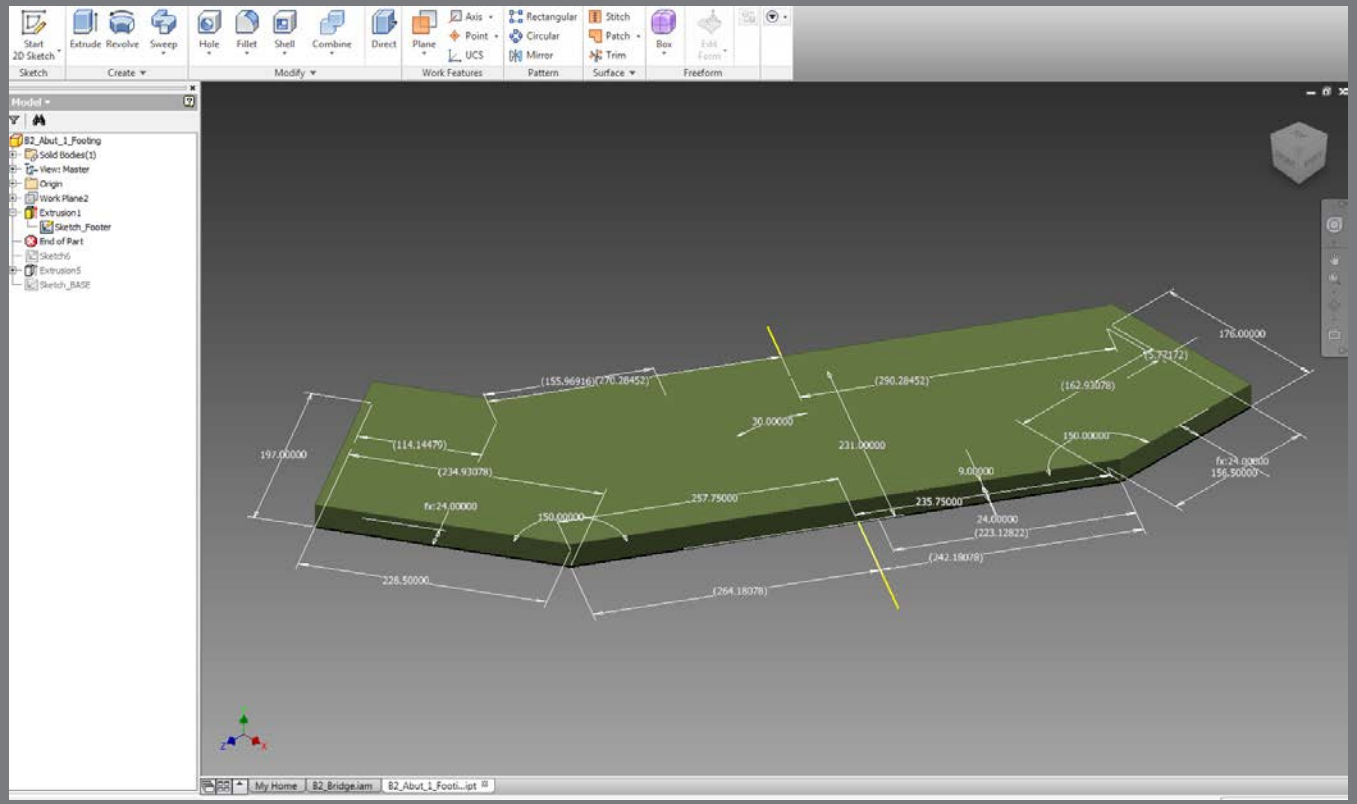
BUILDING THE MODEL



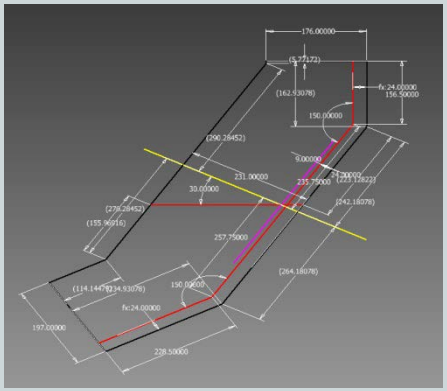
3D

MODELING FOR STRUCTURES

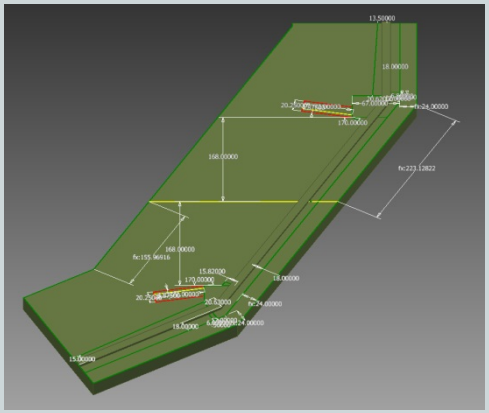
BUILDING THE MODEL

- Not just build a one-time model but create model components that could be tied to output directly so as to automate the process
- Design intelligence and logic into the model components allowing their use on different geometries such as no skew, extreme skew.
  - Eliminates the need for multiple base components
- Ability to re-use components for future designs
  - Allows for more efficient what-if scenarios

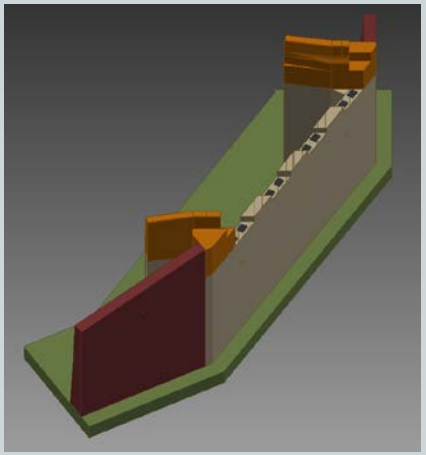
BUILDING THE MODEL



Sketch



Part



Assembly

(Of Parts)

BUILDING THE MODEL

- Two Key Points
  - Create/input design information only one time
    - “Refer” to it down stream from the single source
  - Design process is Parametric
    - Changes to the design can automatically update dependent components

BUILDING THE MODEL

- Base Sketch
  - Geometry used throughout project
    - Horizontal / Vertical alignments
    - Superstructure Template
    - Plan View
    - Beam Camber “Alignments”
    - Positioning Tool

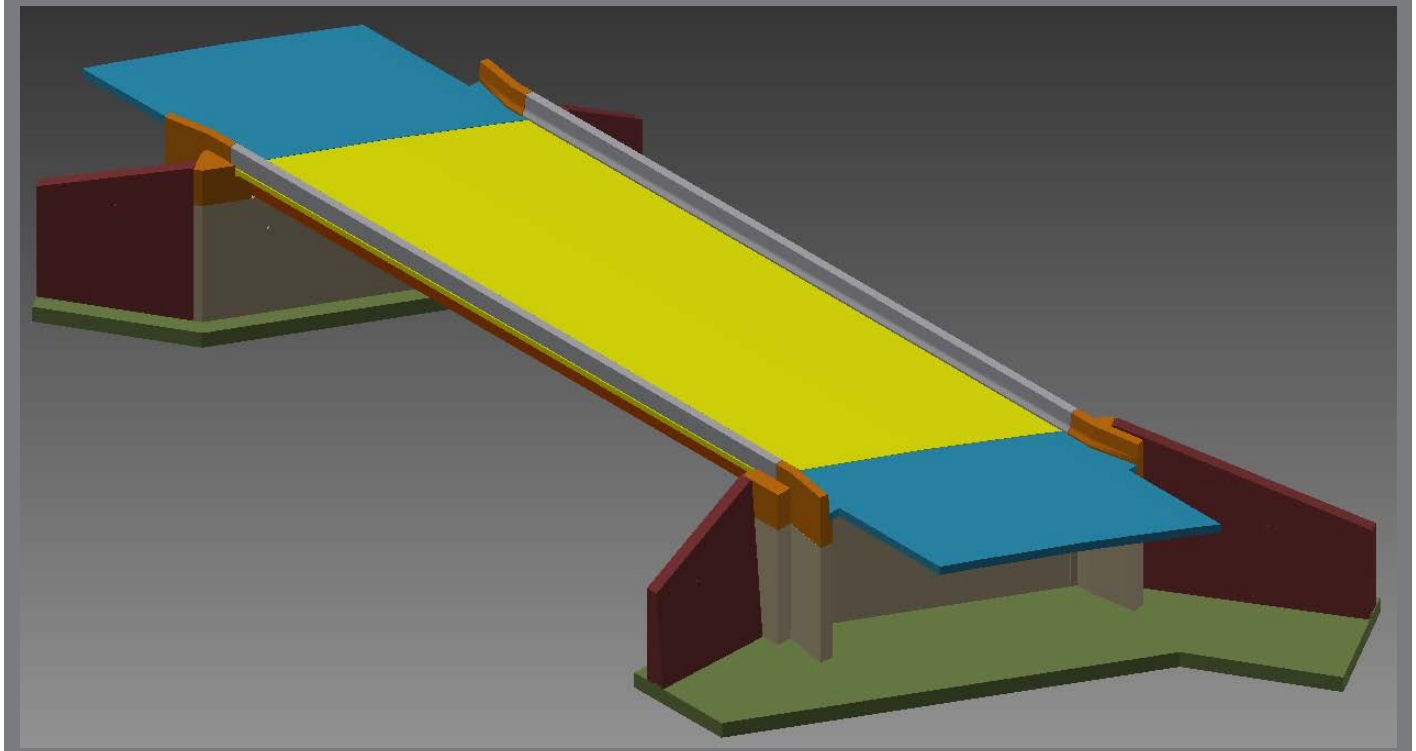
BUILDING THE MODEL

- Sketch Contents
  - Graphical Geometry
  - Dimensions
    - Manually input / Calculated from other geometry / Driven from parameters
  - Constraints
    - Relates geometry to other geometry
  - Goal is to minimize manual input and relate as much geometry to other geometry or drive from parameters

BUILDING THE MODEL

- Parameters
  - User defined or calculated variables
  - May be used within host part or shared with other parts and assemblies
  - Helps maintain single source
- Deriving Information from Parts
  - Similar to CAD reference but includes parameters also
  - Allows geometry from other parts to be used in additive and subtractive fashion

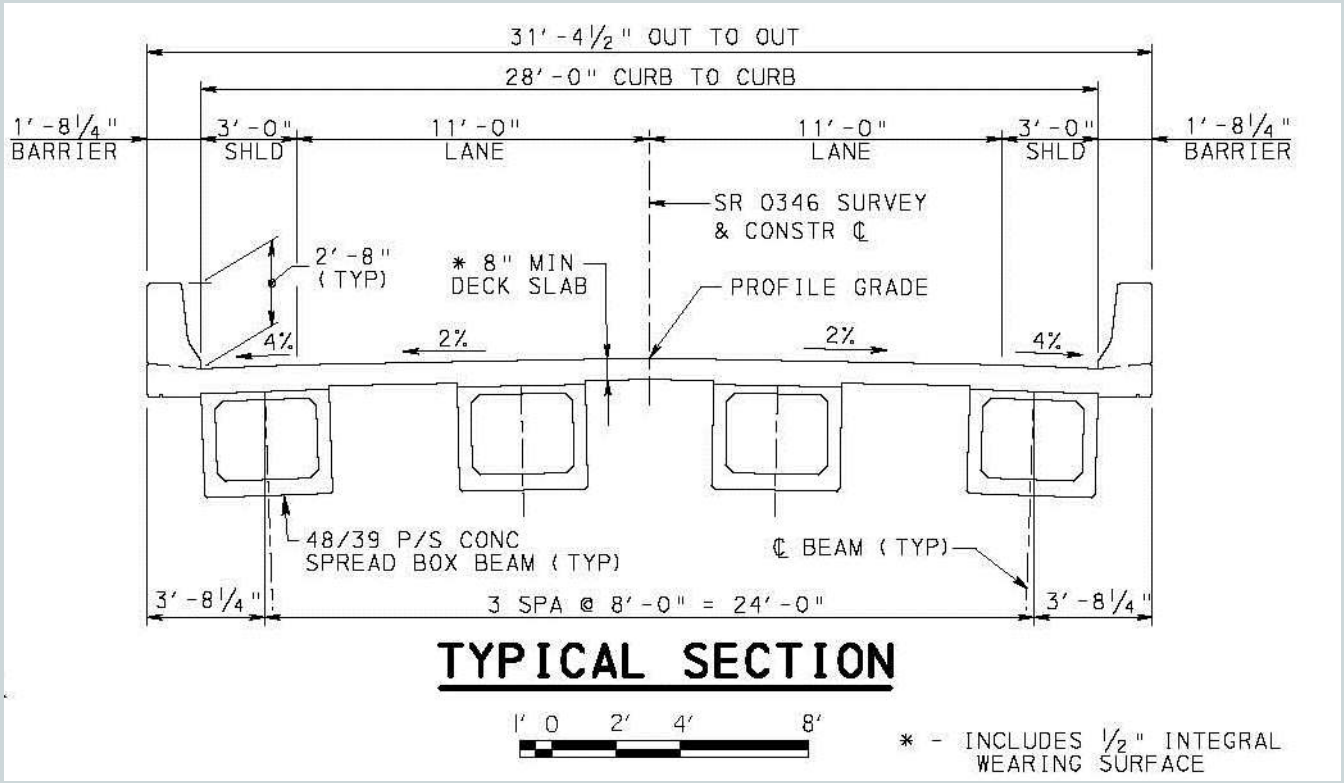
USING THE MODEL



3D

MODELING FOR STRUCTURES

Typical Section



SR 346 OVER KNAPP CREEK

McKean County
PennDOT District 2-0

Single-span composite prestressed spread box beam bridge

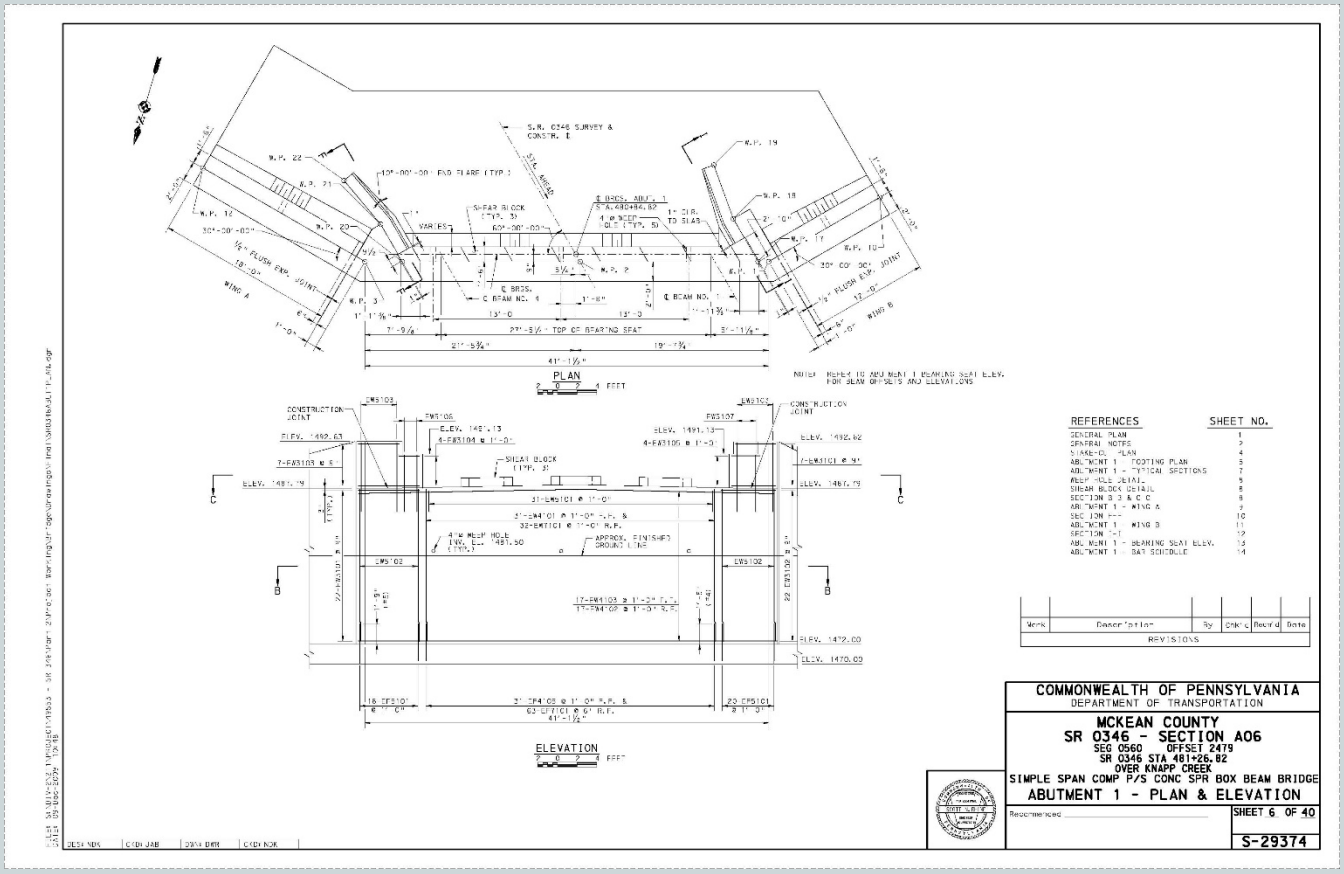
PennDOT skew angle of 60 deg.

Vertical curve

CIP abutments on spread footings

Replacing an existing 2-span concrete encased steel I-girder bridge

Abutment Plan and Elevation



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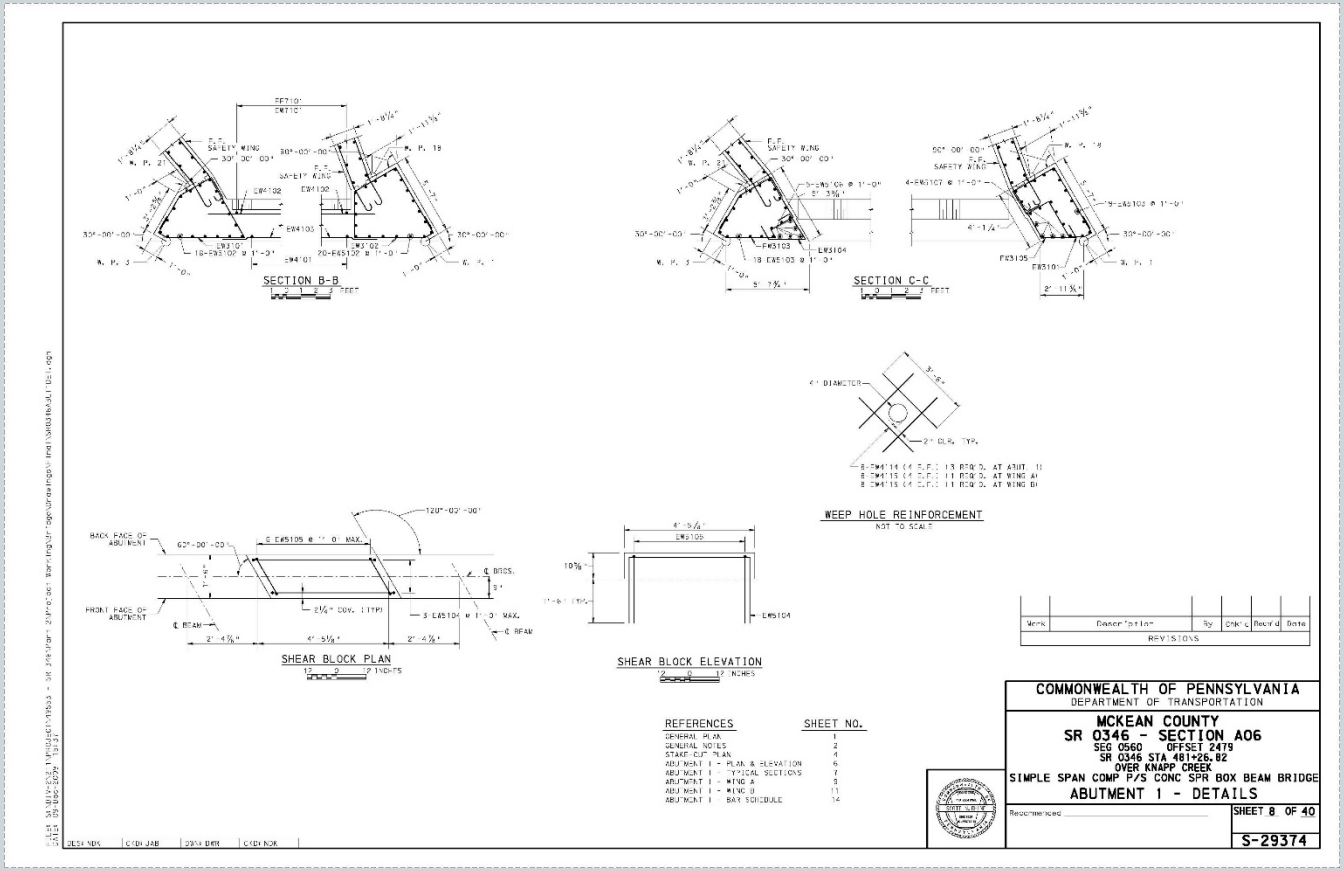
Abutment Corner Details



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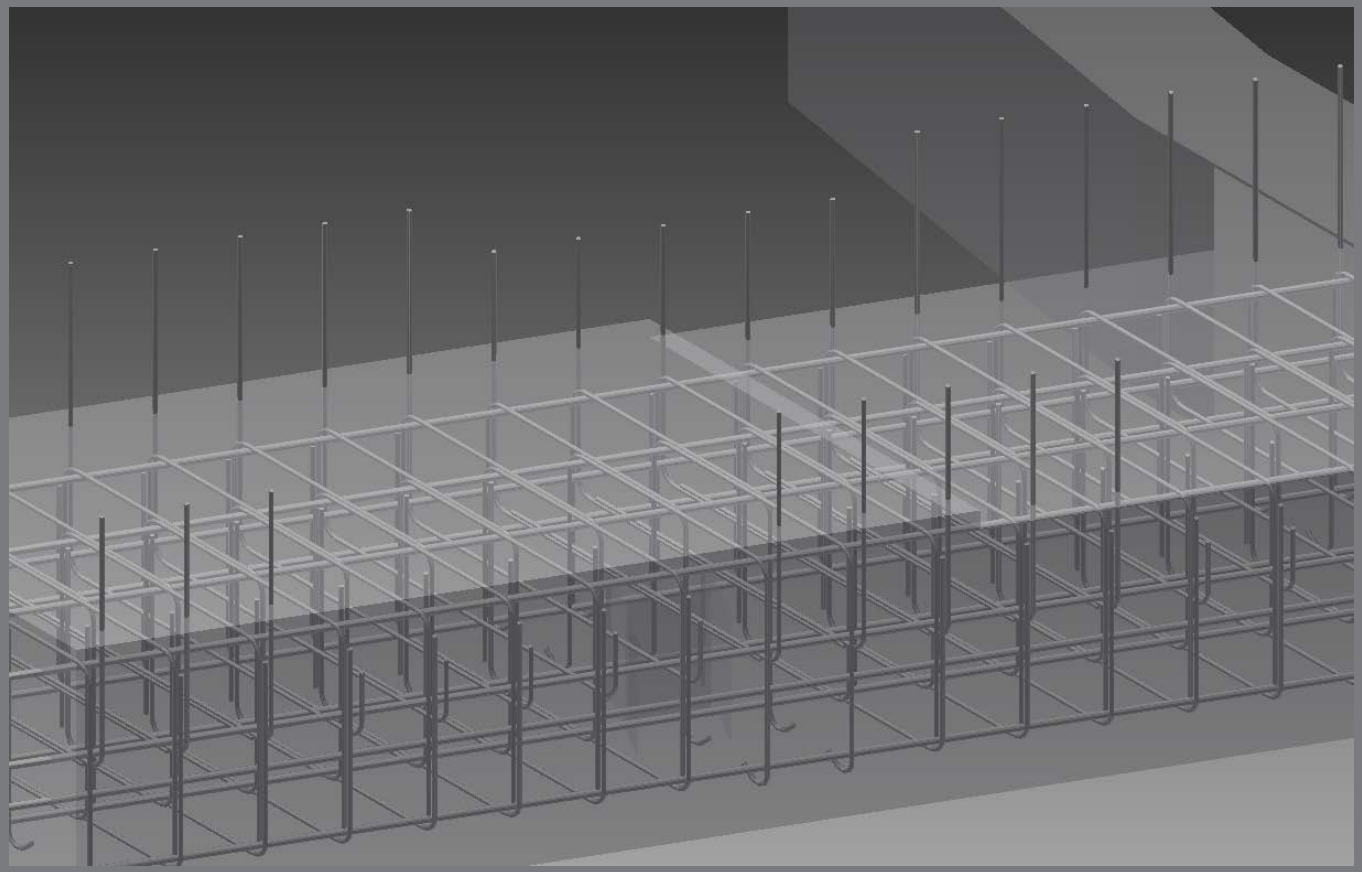
COMPLEX REINFORCEMENT DETAILS



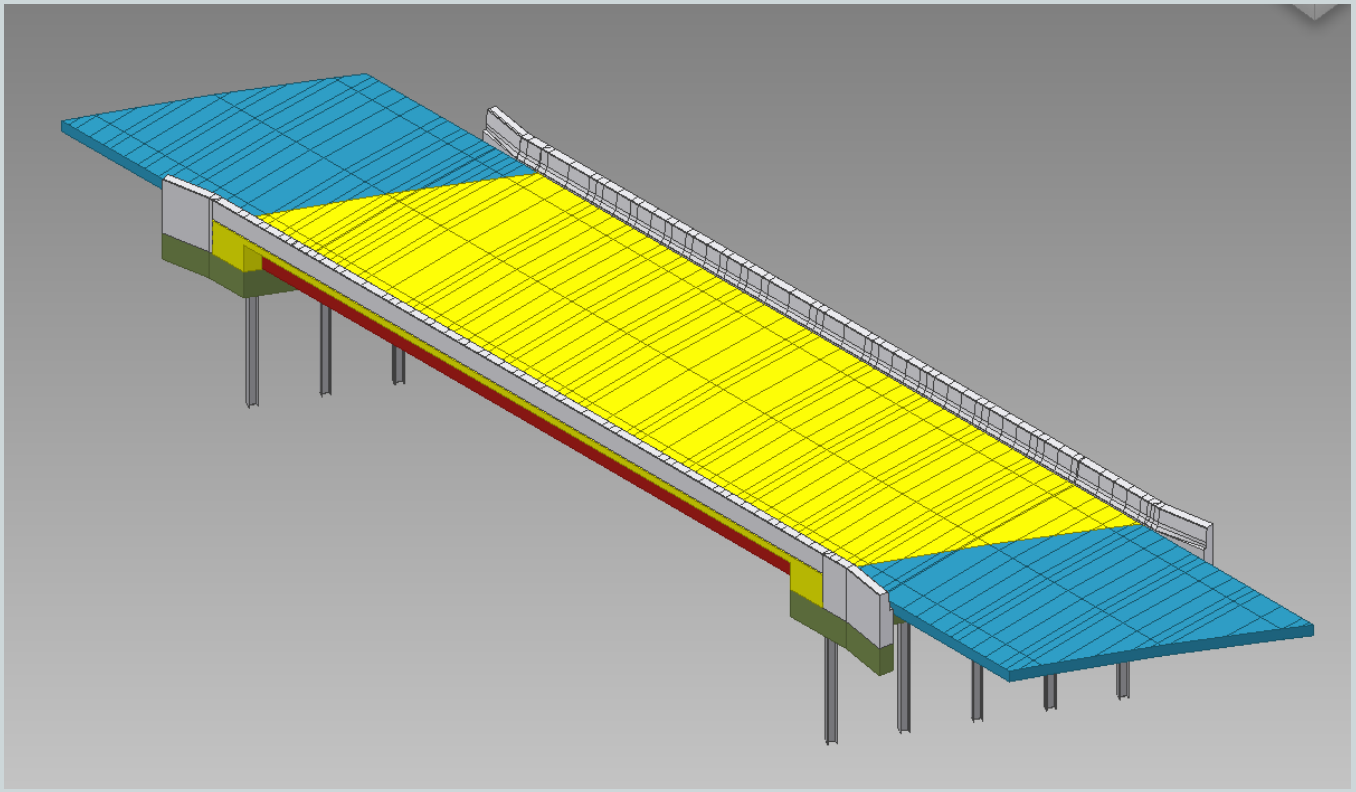
REINFORCEMENT MODELING

Investigation Topics

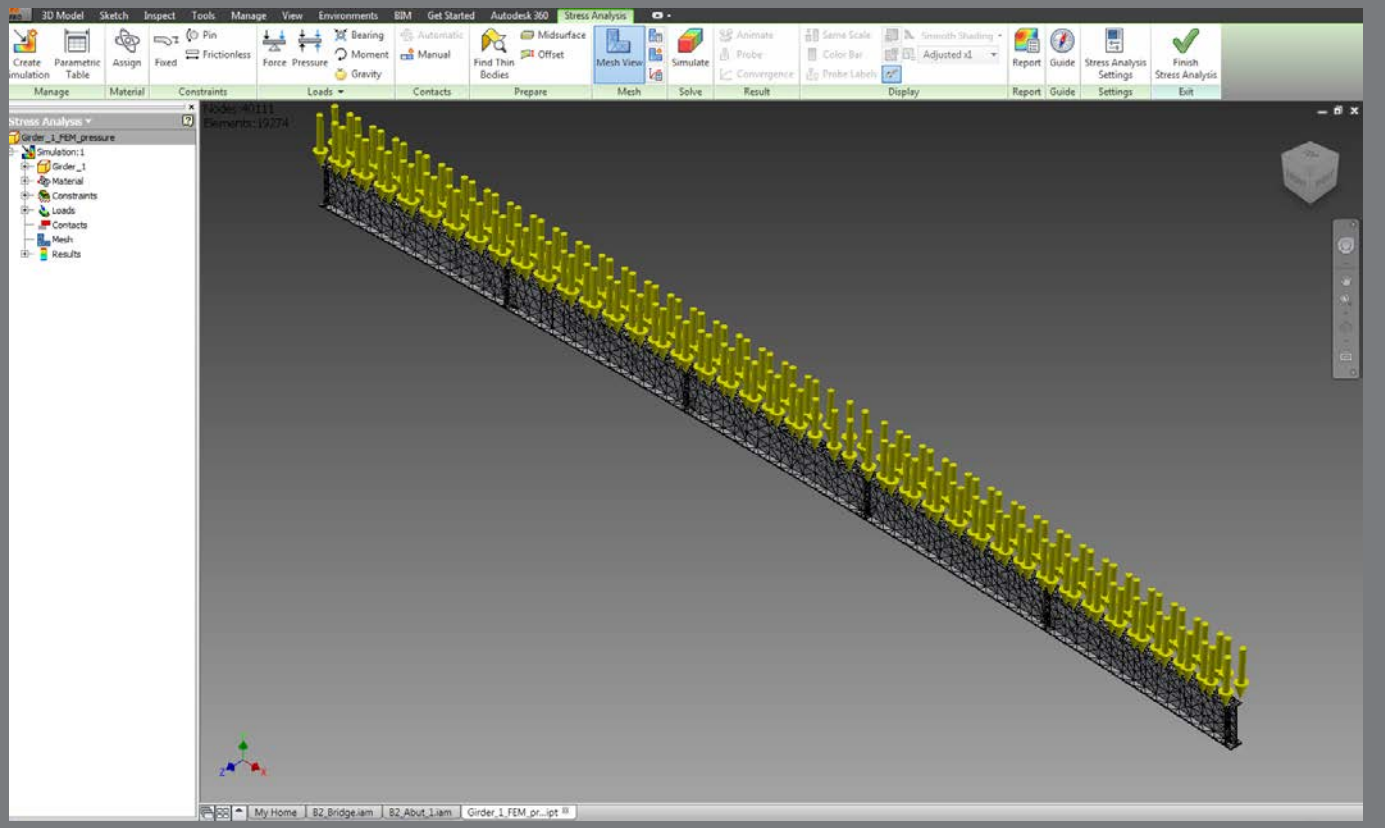
- Visualization of complex rebar details
- Clash Analysis
- Automation of rebar schedules and quantities

REINFORCEMENT MODELING

Integral abutment bridge model



STRUCTURAL ANALYSIS APPLICATIONS

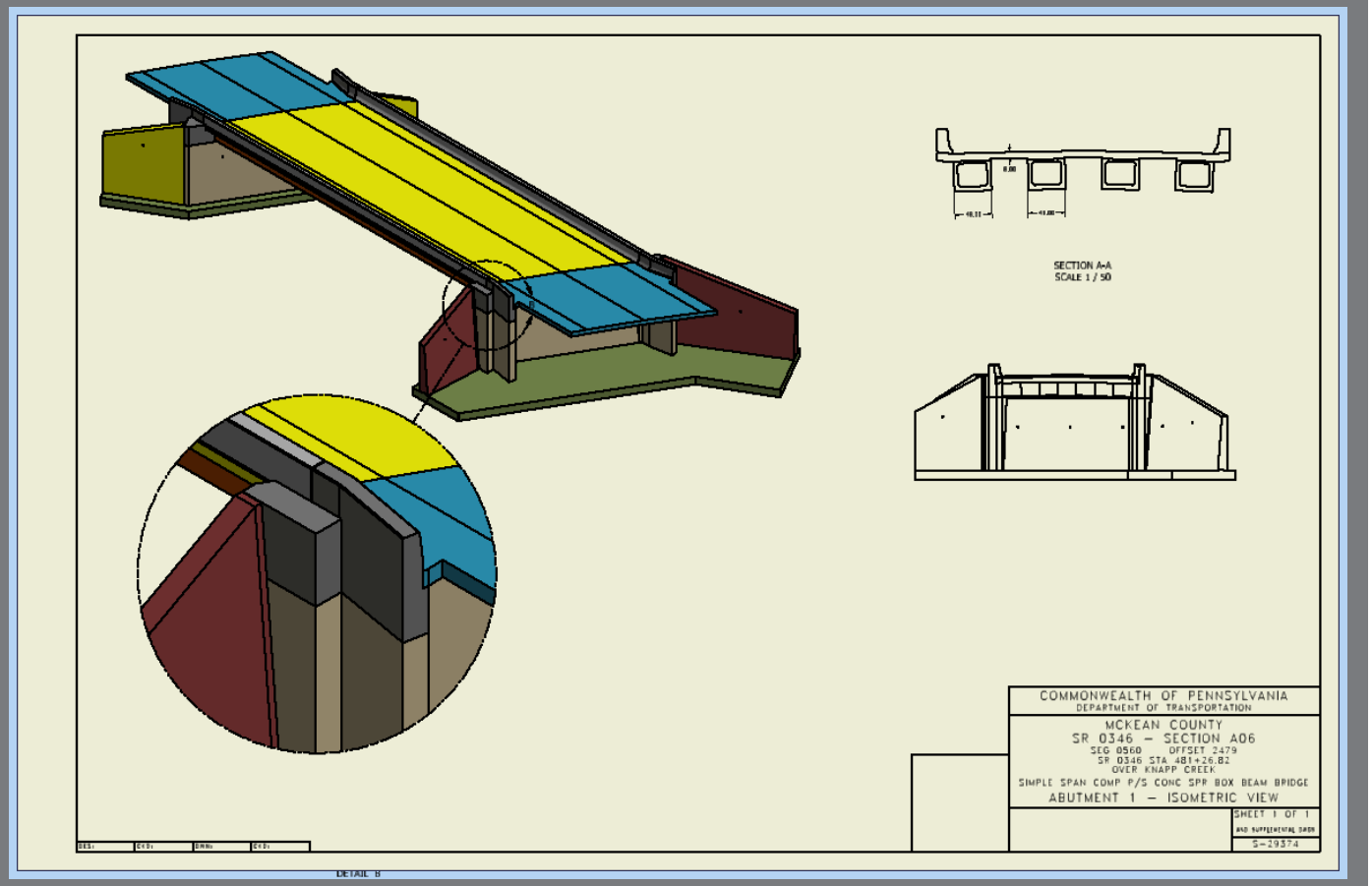


STRUCTURAL ANALYSIS APPLICATIONS

Investigation Topics

- Analysis of model inside software used to create model
- Plug-ins are available for additional analysis options
  - Multi-body and Multi-material
- Export to other external structural analysis software

DRAWING GENERATION

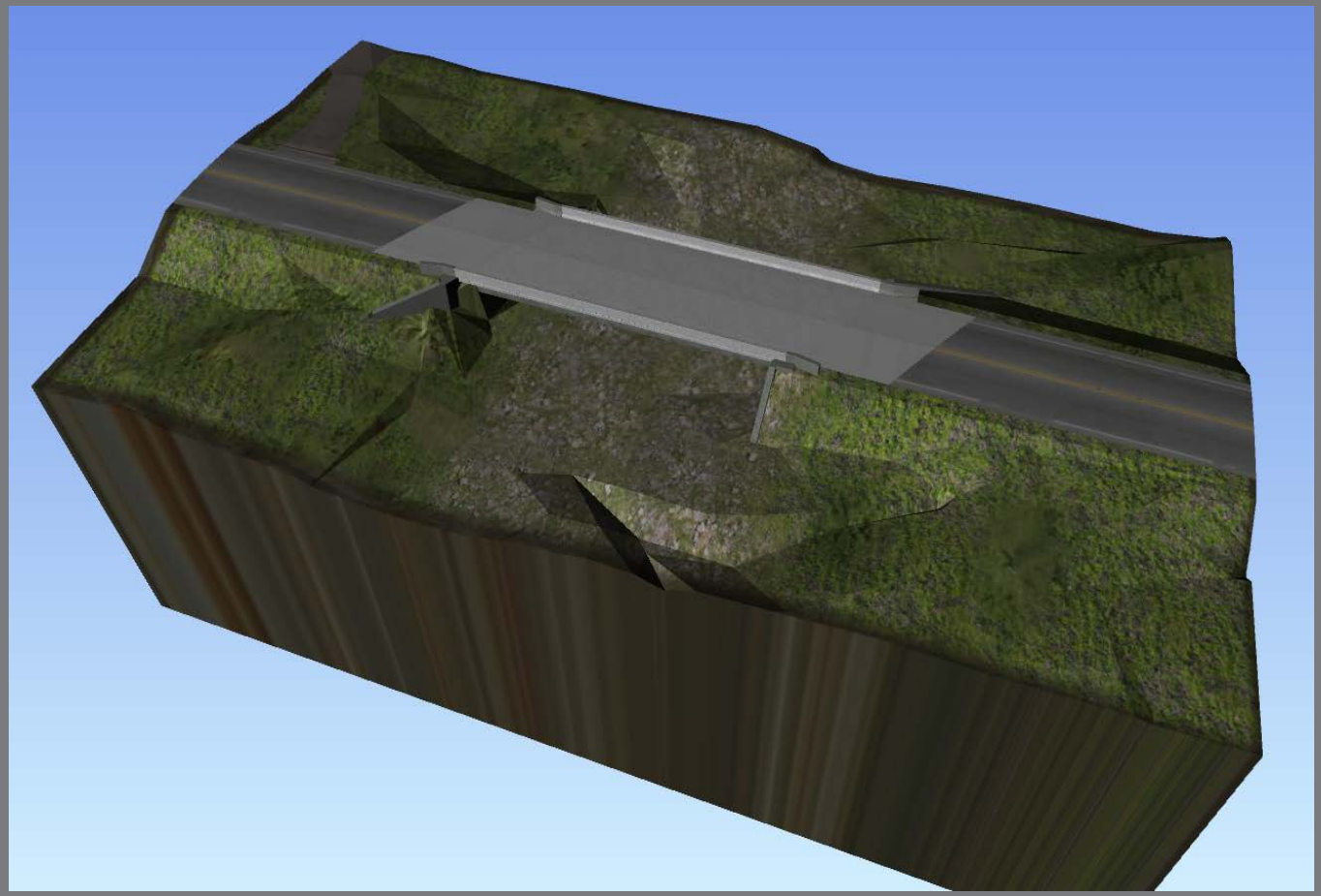


DRAWING GENERATION

Investigation Topics

- Isometric view of bridge or specific components
- Supplement with additional detail views
- Export to different CAD software

INTEGRATING DESIGN CONTENT FROM MULTIPLE DISCIPLINES



3D

MODELING FOR STRUCTURES

INTEGRATING DESIGN CONTENT FROM MULTIPLE DISCIPLINES

Investigation Topics

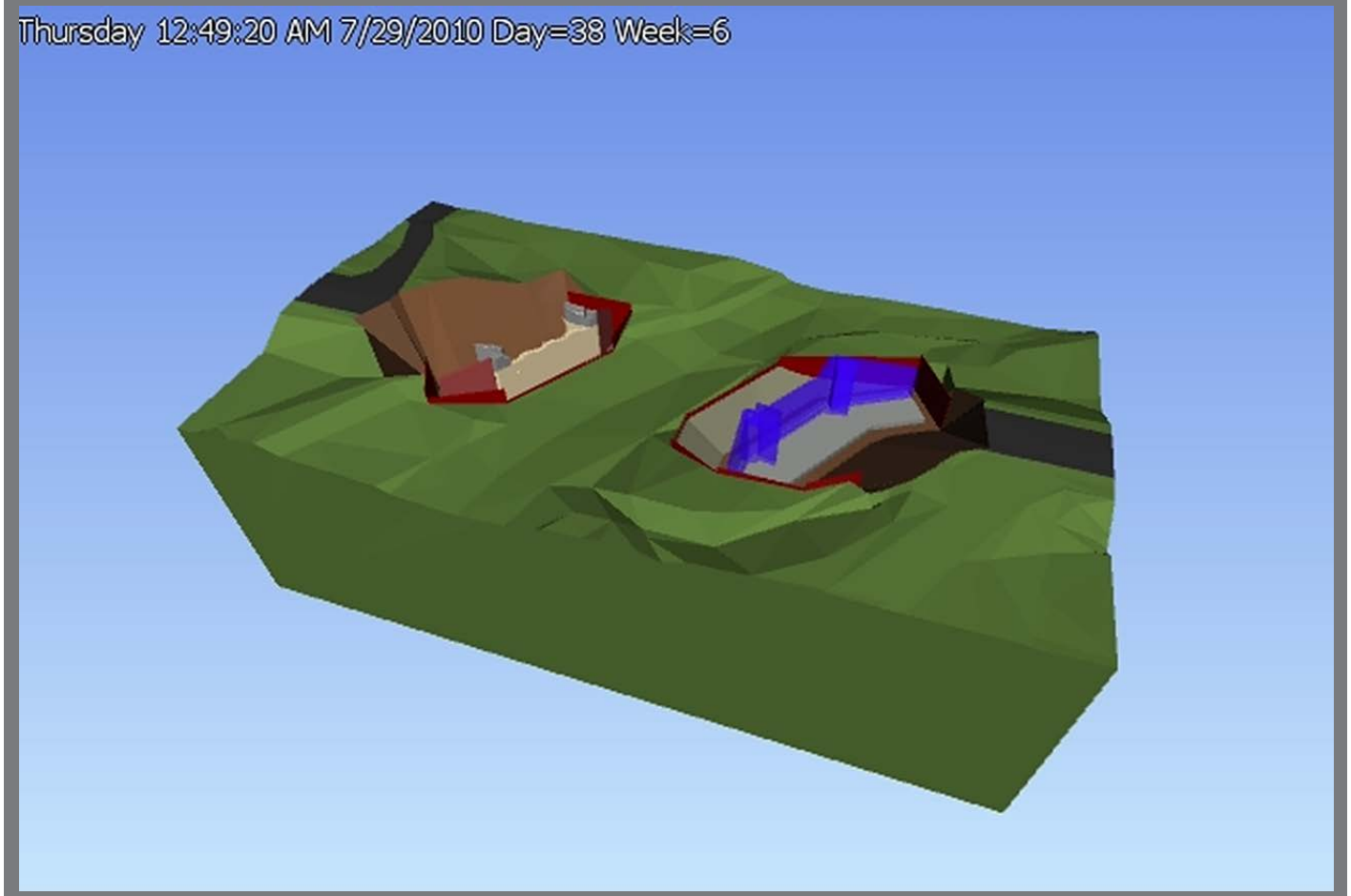
- Integration of bridge model with site and roadway models
- Perform Clash analysis between construction and existing features (utilities)
- Quantities

INTEGRATING DESIGN CONTENT FROM MULTIPLE DISCIPLINES

Project Review Software

- Import 3D model data from numerous sources
- Provides first person POV interface
- Interface to perform clash detection and manage clash resolution
- Interface to perform quantification through identification of takeoff items

CONSTRUCTION SIMULATION AND ANALYSIS



3D

MODELING FOR STRUCTURES

INTEGRATING DESIGN CONTENT FROM MULTIPLE DISCIPLINES

Project Review Software (cont'd)

- Import project task, scheduling, resource, and cost information
  - Link information to 3D models
- Review project activity chronologically
  - Enables the user to view project in its environment at any point in time (4D)
  - Running tally of resource cost
- Perform project logistical planning
  - Model equipment and resource staging and movement

CONSTRUCTION SCHEDULE

SR 346 Over Knapp Creek

Project: SR-346
Time Now: 28May2010
Start: 28May2010
Finish: 15Oct2010
Run: 05Feb2010

SR-0346 Section A06

Constructibility Schedule

Planned
Critical
Late Dates
Milestone
Progress
Summary
Float

Activity ID	Activity Desc.	Duration	Total Float	Early Start	Early Finish
010	Notice to Proceed	0	0	28May2010	28May2010
015	Mobilize	5d	0	28May2010	04Jun2010
020	Set-Up Detour & Traffic Control	2d	0	07Jun2010	08Jun2010
025	Initial E&S Controls	3d	0	09Jun2010	11Jun2010
027	Clear Trees	3d	0	09Jun2010	11Jun2010
030	Remove Guiderail	1d	72d	14Jun2010	14Jun2010
033	Construct Causeway	5d	0	14Jun2010	18Jun2010
034	Relocate Overhead Utilities (By Others)	3d	95d	28May2010	02Jun2010
035	Demo Bridge	5d	0	21Jun2010	25Jun2010
045	Excavate/Fill, 479+10-483+50	5d	57d	07Jul2010	13Jul2010
050	Subbase, 479+10-483+50	2d	57d	14Jul2010	15Jul2010
055	PBD, 479+10-483+50	1d	57d	16Jul2010	16Jul2010
060	Base Course,479+10-483+50	2d	5d	29Sep2010	30Sep2010
065	Binder Course,479+10-483+50	1d	5d	01Oct2010	01Oct2010
070	Wearing Course,479+10-483+50	1d	5d	04Oct2010	04Oct2010
075	Guiderail,479+10-483+50	2d	1d	11Oct2010	12Oct2010
080	Stripe, 479+10-483+50	1d	1d	13Oct2010	13Oct2010
085	Exc. Abut. 1	3d	0	28Jun2010	30Jun2010
090	Exc. Abut 2	3d	5d	01Jul2010	06Jul2010
095	FRPC Footer 1	5d	0	01Jul2010	08Jul2010
100	FRPC Footer 2	5d	3d	09Jul2010	15Jul2010
105	FRPC Abut 1	8d	0	09Jul2010	20Jul2010
110	FRPC Abut 2	8d	0	21Jul2010	30Jul2010
115	Place R-8 & R-4 Rock	4d	0	02Aug2010	05Aug2010
120	Backfill Abutments	4d	0	06Aug2010	11Aug2010
125	FRPC Beam Seats	5d	0	12Aug2010	18Aug2010
130	Set Beams	1d	0	19Aug2010	19Aug2010
135	FRPC Diaphragms	5d	0	20Aug2010	26Aug2010
140	FRPC Deck	15d	0	27Aug2010	16Sep2010
145	FRPC Approach Slabs	8d	0	17Sep2010	28Sep2010
150	FRPC Parapets & Safety Wings	8d	0	29Sep2010	08Oct2010
155	Protective Coating	1d	0	11Oct2010	11Oct2010
160	Remove Causeway	3d	0	12Oct2010	14Oct2010
165	Project Complete	0	0	15Oct2010	15Oct2010

CONCLUSIONS

Summary of the Benefits

- Improved visualization of project
  - Ability to view any aspect
  - Especially useful on complex details
  - Removes need to interpret 2D information
- Interaction with other disciplines
  - Ability to bring all design data together
    - Highway / Utilities / Site
  - Clash identification / logistics
  - Visual impact analysis

CONCLUSIONS

Summary of the Benefits (cont.)

- Construction scheduling integrated with model components
- Reinforcement review
- Quantity generation
- Structural analysis applications
- Automated parametric drawing generation has potential to reduce errors while speeding up documentation time

CONCLUSION

- Process demonstrated that there are definitive advantages to having 3D models
- Established methods to reduce effort to create models more efficiently
- Some uses of the models are more relevant than others investigated
- Example structure/project not complex enough to realize full potential of these models

MOVING FORWARD

Further investigation:

- Determine at what point in the project timeline to build model
  - Basis of the design process
  - Part of the design process
  - After the design process
- Investigate other software packages
- Study exporting to different structural analysis programs for further use in design
- Develop model for more complex project

QUESTIONS?