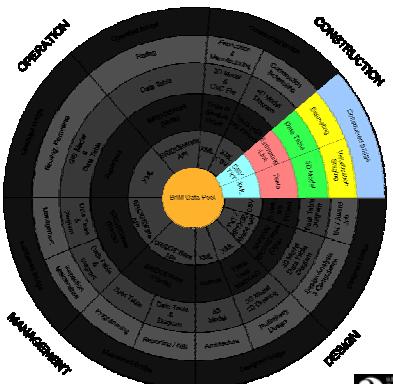


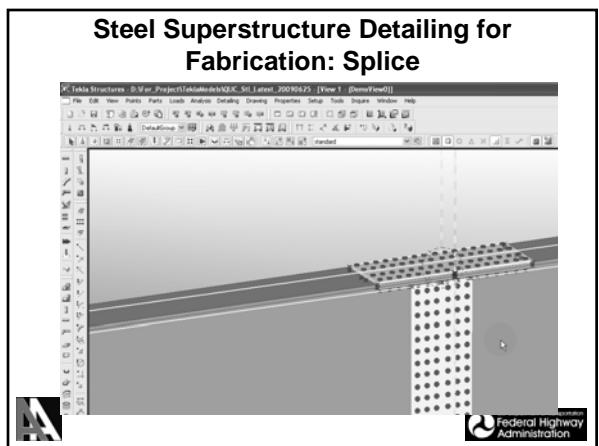
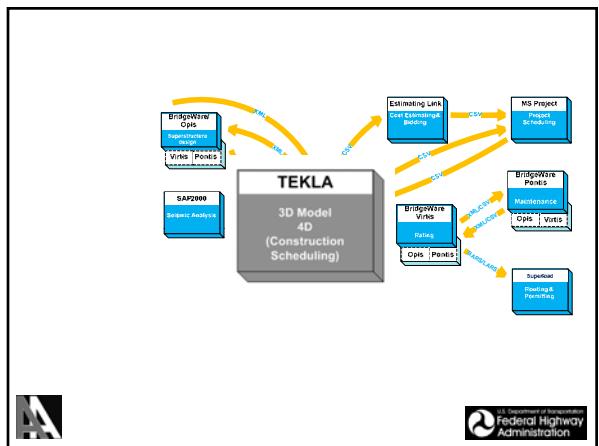
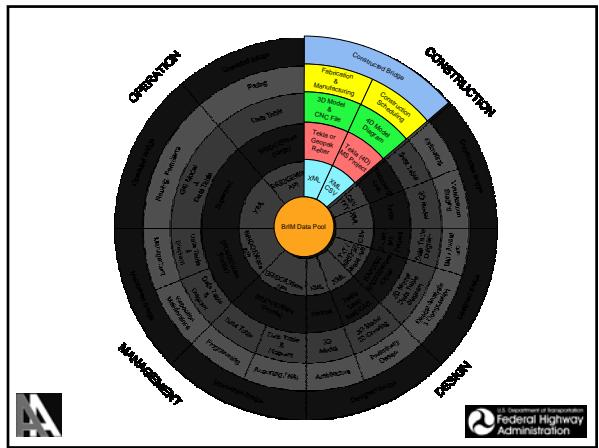
Part D3:
Construction



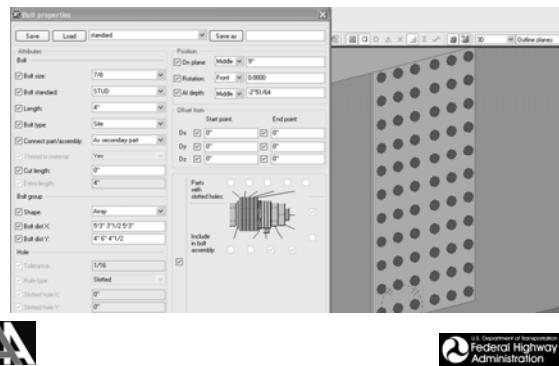
Overview (D3-Construction)

- Portion of Modeling Environment & Workflow
- Steel Superstructure Detailing (Splice, Stiffeners, Diaphragms)
- Superstructure Detailing (Rebar, Strands)
- Substructure & Overall Bridge Modeling
- Linkages and Workflows: Estimating
- Linkages and Workflows: Scheduling
- Feedback to 3D/4D Modeling Environment for downstream needs



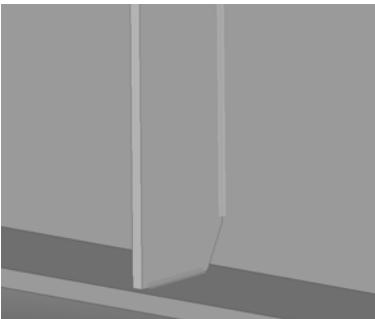


Steel Superstructure Detailing for Fabrication: Splice



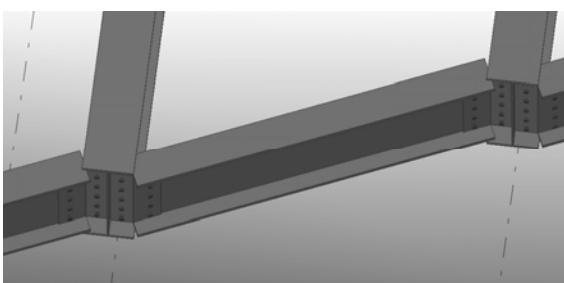
A

Steel Superstructure Detailing for Fabrication: Stiffener Welds



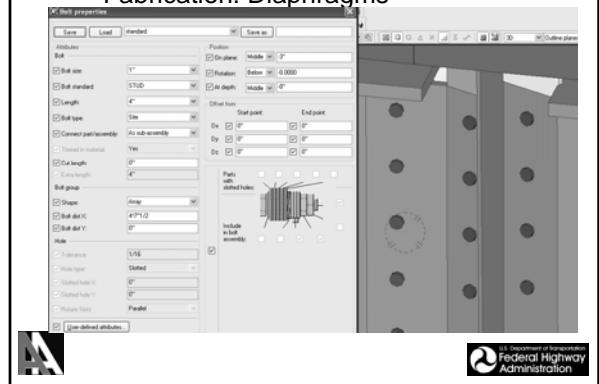
A

Steel Superstructure Detailing for Fabrication: Diaphragms

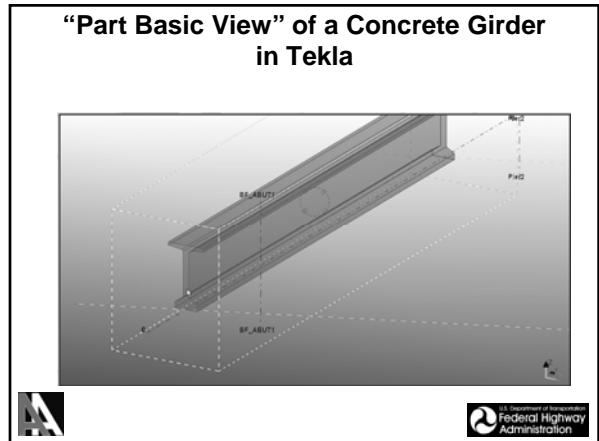


A

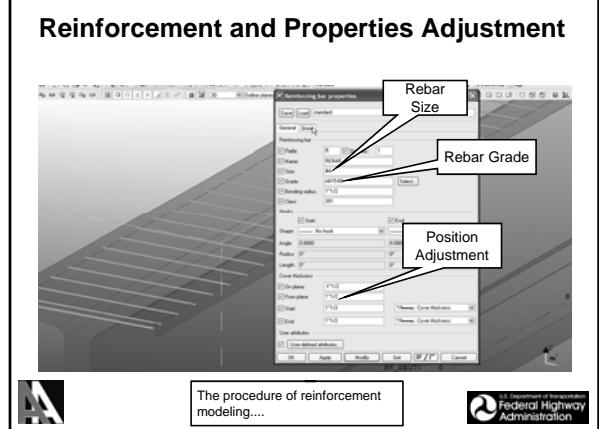
Steel Superstructure Detailing for Fabrication: Diaphragms



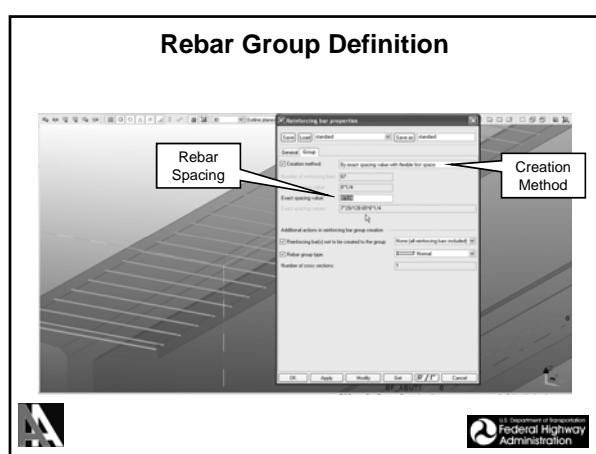
"Part Basic View" of a Concrete Girder in Tekla



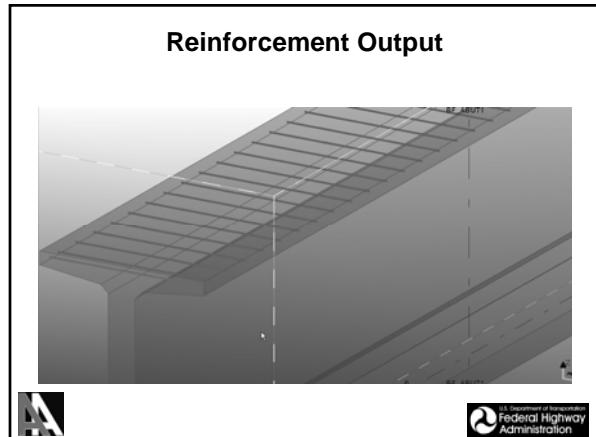
Reinforcement and Properties Adjustment



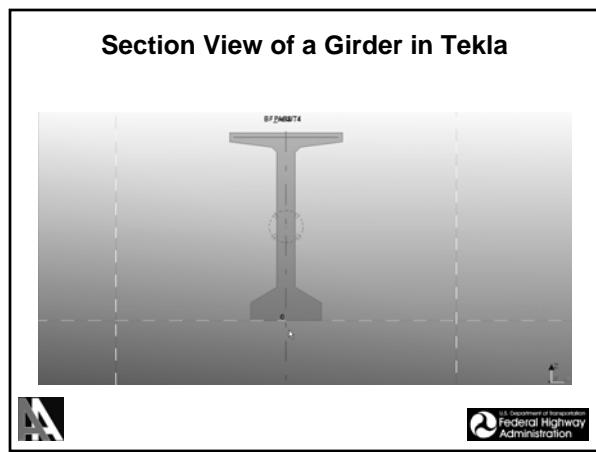
Rebar Group Definition



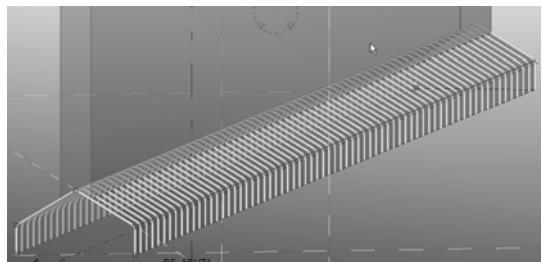
Reinforcement Output



Section View of a Girder in Tekla



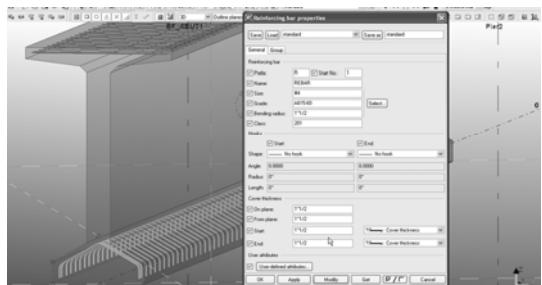
Rebar Group Creation (before adjustment)



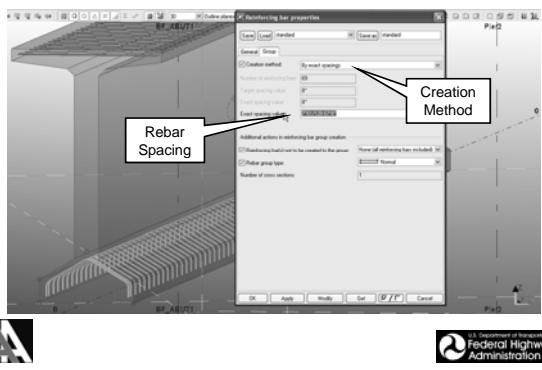
Stirrup reinforcement modeling....



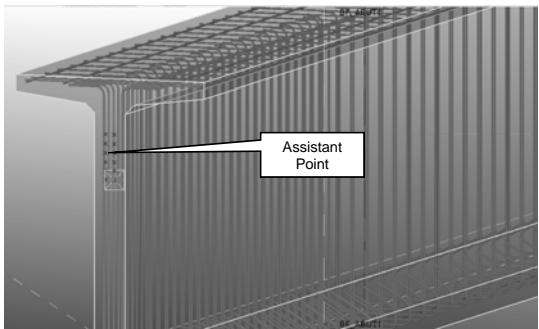
Properties and Positions Adjustment



Rebar Group Definition



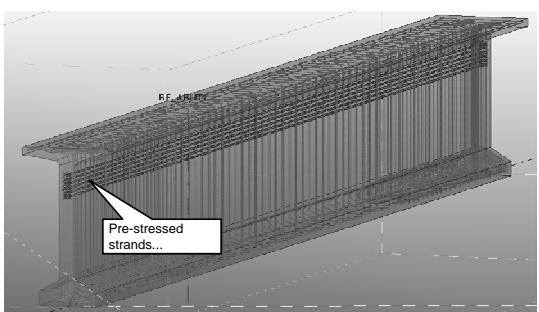
Strand End Positions



A

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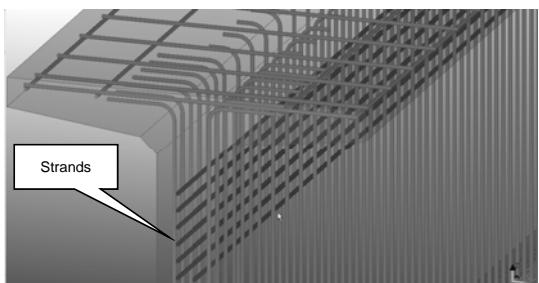
Pre-stressed Strands Generation



A

U.S. Department of Transportation
Federal Highway
Administration

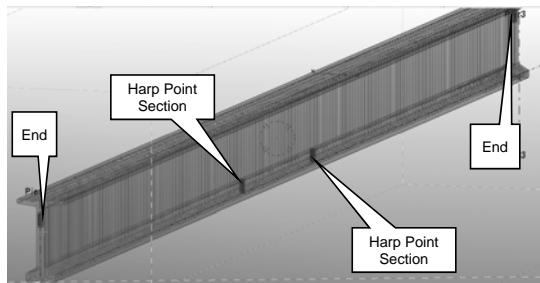
Pre-stressed Strands Generation



A

U.S. Department of Transportation
Federal Highway
Administration

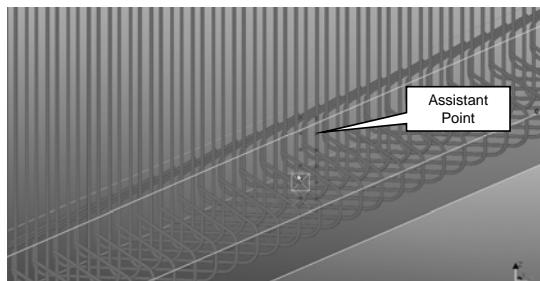
Strand Ends and Harp Point Sections



A

U.S. Department of Transportation
Federal Highway Administration

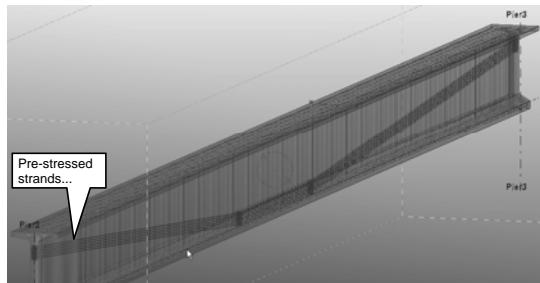
Harp Point Section



A

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Federal Highway Administration

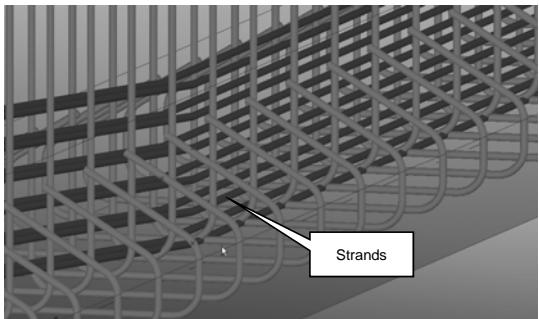
Pre-stressed Strands Generation (Harped Pattern)



A

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Federal Highway Administration

Harp View of Pre-stressed Strands



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Federal Highway
Administration

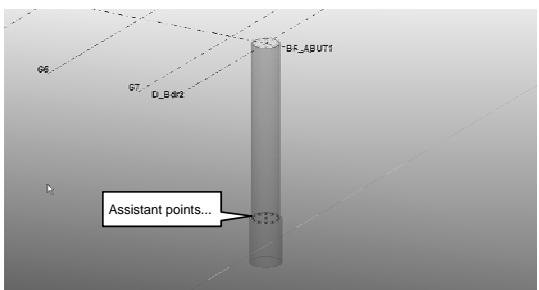


Pier Column Reinforcement Modeling

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Federal Highway
Administration



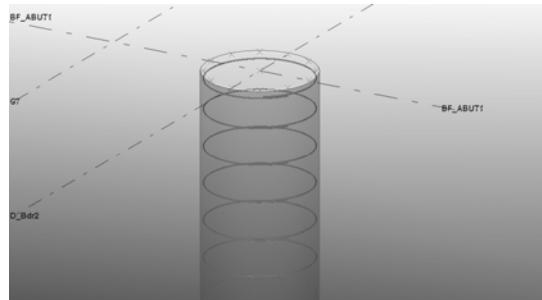
Pier Column Without Reinforcement



U.S. Department of Transportation
Federal Highway
Administration

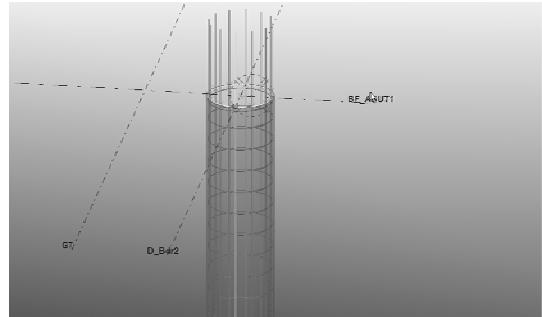


Stirrup Reinforcement Generation



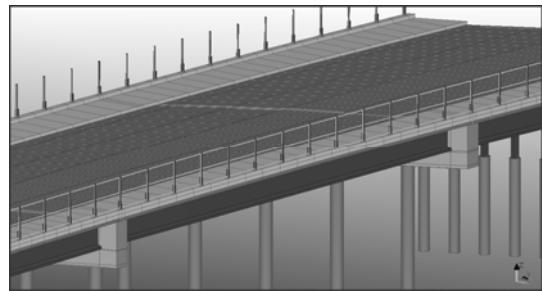
U.S. Department of Transportation
Federal Highway
Administration

Pier Column Reinforcement Output



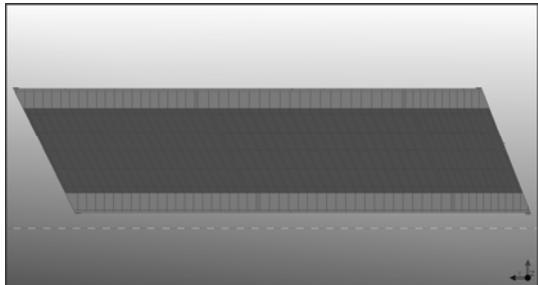
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Federal Highway
Administration

Bridge Model in Tekla



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Bridge Model in Tekla



Plan View

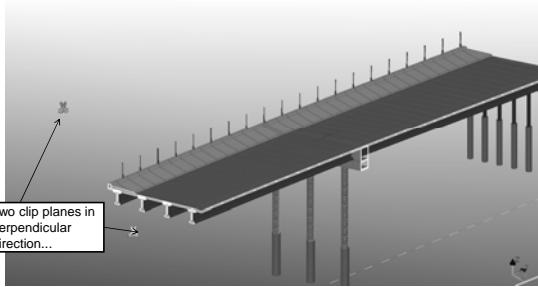
U.S. Department of Transportation
Federal Highway
Administration

Bridge Model in Tekla Reinforcement



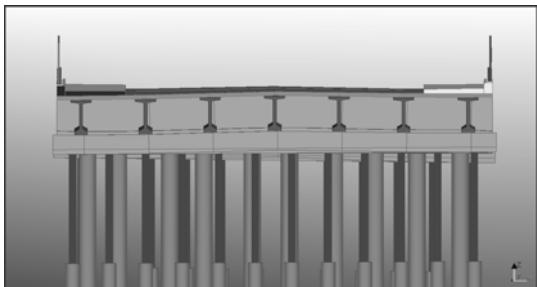
U.S. Department of Transportation
Federal Highway
Administration

Bridge Model in Tekla Clip Plane Tool

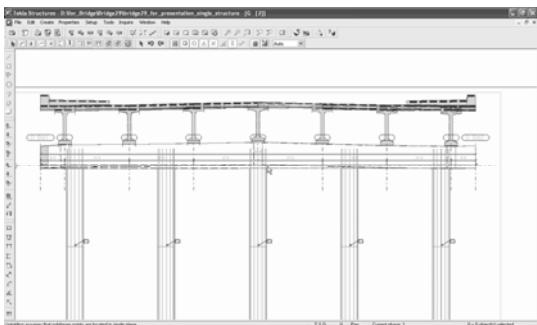


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Bridge Model in Tekla



Drawing from Tekla Model



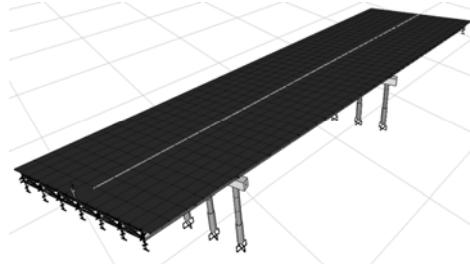
Steel Design Example

Virtual (pre)Assembly Aspects



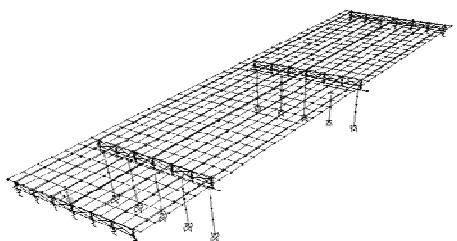
Virtual (pre)assembly Aspects

3D Model
of Quincy
Avenue
Bridge
(Extrude
View)



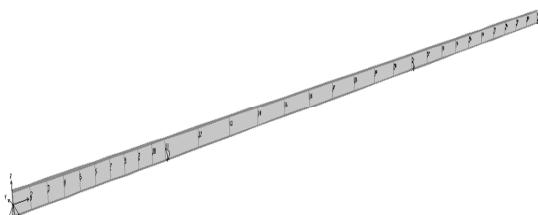
Virtual (pre)assembly Aspects

3D Model
of Quincy
Avenue
Bridge



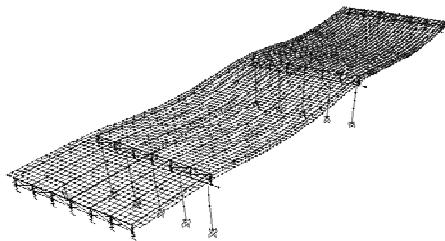
Virtual (pre)assembly Aspects

3D View of Exterior Girder



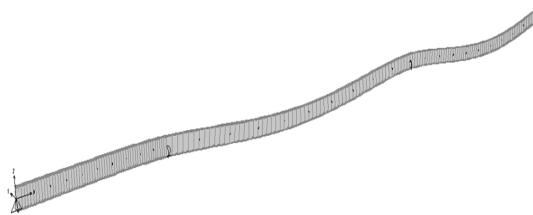
Virtual (pre)assembly Aspects

Deflection
of Girders
under Full
Dead Load
(→
camber
opposite)



Virtual (pre)assembly Aspects

Deflection of the Exterior Girder under Full Dead Load



Virtual (pre)assembly Aspects

Deflection
Values at
Tenth
Points
under Full
Dead Load

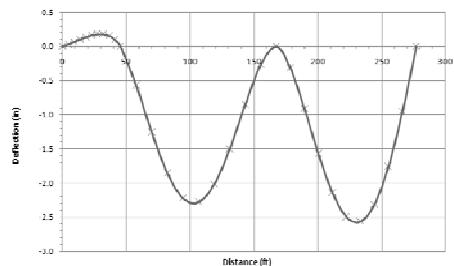
Joint	Displacement Type	Case type	U1	U2	U3	R1	R2	R3
1	DEAD	LoadStatic	0	0	0	0	0.00061	0
2	DEAD	LoadStatic	0	0	0.00324	0	-0.00014	0
3	DEAD	LoadStatic	0	0	0.06770	0	-0.00011	0
4	DEAD	LoadStatic	0	0	0.102915	0	-0.00077	0
5	DEAD	LoadStatic	0	0	0.138172	0	-0.00050	0
6	EXTR	LoadStatic	0	0	0.173430	0	-0.00015	0
7	DEAD	LoadStatic	0	0	0.181009	0	-0.00009	0
8	DEAD	LoadStatic	0	0	0.181954	0	-0.00095	0
9	DEAD	LoadStatic	0	0	0.157953	0	0.00099	0
10	DEAD	LoadStatic	0	0	0.100293	0	0.00202	0
11	DEAD	LoadStatic	0	0	0	0.00544	0	0
12	DEAD	LoadStatic	0	0	0.00171	0	0.00014	0
13	DEAD	LoadStatic	0	0	-0.256009	0	0.00415	0
14	DEAD	LoadStatic	0	0	-1.951432	0	0.00307	0
15	DEAD	LoadStatic	0	0	-2.225209	0	0.00309	0
16	DEAD	LoadStatic	0	0	-2.27962	0	0.00093	0
17	DEAD	LoadStatic	0	0	-2.01142	0	0.00345	0
18	DEAD	LoadStatic	0	0	-1.95798	0	0.00246	0
19	DEAD	LoadStatic	0	0	-0.945644	0	0.00449	0
20	DEAD	LoadStatic	0	0	-0.267191	0	0.00294	0

Record [1..4] | [2..5] of 21 Add Tables Done



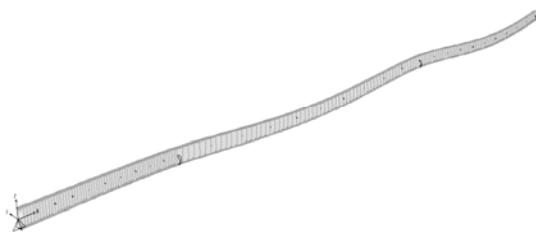
Virtual (pre)assembly Aspects

Deflection
Diagram
under Full
Dead Load



Virtual (pre)assembly Aspects

Deflection of Exterior Girder under Steel Portion of Dead Load



Virtual (pre)assembly Aspects

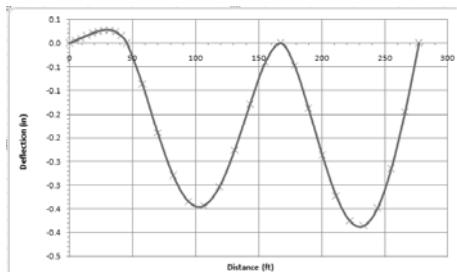
Deflection
Values at
Tenth
Points
under
Steel
Portion of
Dead Load

Joint	Test	Output Case	Case Type	U1 (in)	U2 (in)	U3 (in)	R1 (Radians)	R2 (Radians)	R3 (Radians)
2	DEAD	LstStatic		0	0	.004995	0	.000093	0
3	DEAD	LstStatic		0	0	.01022	0	.000092	0
4	DEAD	LstStatic		0	0	.01938	0	.000090	0
5	DEAD	LstStatic		0	0	.02953	0	.000074	0
6	DEAD	LstStatic		0	0	.024713	0	.0000486	0
7	DEAD	LstStatic		0	0	.02729	0	.0000721	0
8	DEAD	LstStatic		0	0	.027376	0	.0000593	0
9	DEAD	LstStatic		0	0	.02772	0	.0000736	0
10	DEAD	LstStatic		0	0	.015198	0	.000045	0
11	DEAD	LstStatic		0	0	0	0	.000034	0
12	DEAD	LstStatic		0	0	.00932	0	.000029	0
13	DEAD	LstStatic		0	0	.169007	0	.000066	0
14	DEAD	LstStatic		0	0	.277016	0	.000049	0
15	DEAD	LstStatic		0	0	.334472	0	.000073	0
16	DEAD	LstStatic		0	0	.343731	0	.000105	0
17	DEAD	LstStatic		0	0	.304005	0	.000140	0
18	DEAD	LstStatic		0	0	.220701	0	.000064	0
19	DEAD	LstStatic		0	0	.120144	0	.000041	0
20	DEAD	LstStatic		0	0	.039865	0	.000043	0
21	DEAD	LstStatic		0	0	0	0	0	0



Virtual (pre)assembly Aspects

Deflection
Values at
Tenth
Points
under
Steel
Portion of
Dead Load



Distinct Geometries

1. Under full dead load condition (complying with the highway geometry):



2. Under steel portion of dead load condition (resulting from having full-size holes line up):



3. Under no-load condition (e.g., to cut-camber the girder web):



One Way to Calculate and Transfer Cambering Information in BrIM System

- Step 1:
 - Calculate the deflections of girders and export the new coordinate data of each point of interest along the girders;
- Step 2:
 - Calculate the cambering geometries in different load conditions (full dead load, steel portion of dead load and no load) based on the deflection data (e.g., multiplied by -1) in linkage software between SAP2000 and Tekla Structures;

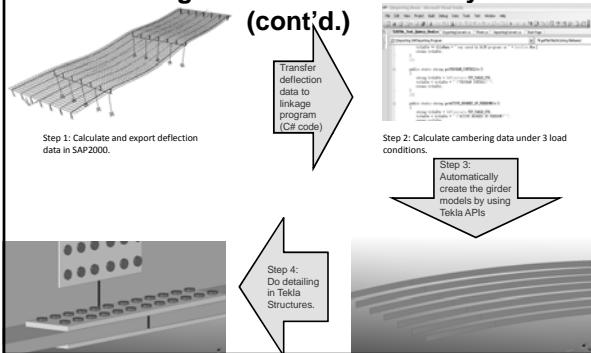


One Way to Calculate and Transfer Cambering Information in BrIM System

- Step 3:
 - Based on the cambering geometries, the Tekla models of steel girders for 3 distinct geometries can be automatically created by calling Tekla APIs in our linkage program;
- Step 4:
 - Do detailings in Tekla Structure; e.g., cutting girder web based on "no-load" geometry; installing bolted field splices based on the one with steel portion of dead load condition; the geometry with full load is the one to be transferred to downstream applications in workflow.



A Way to Calculate and Transfer Cambering Information in BrIM System (cont'd.)



Some Considerations and Notes

- Q: Why not using SAP2000 to model the cambering?
A: It is not convenient to model the cambering based on the original (entire) bridge model., we'd have to build other distinct geometries in the same way we'd build an entire new structure (which is not needed).
- Q: Why not using the direct link between SAP2000 and Tekla Structures provided by these two vendors?
A: 1) That link requires starting from the Tekla model, whereas we need to calculate the deflection in SAP2000 first;
2) the geometry changes cannot be updated from SAP2000 to Tekla directly. Only member section changes can be updated so far.

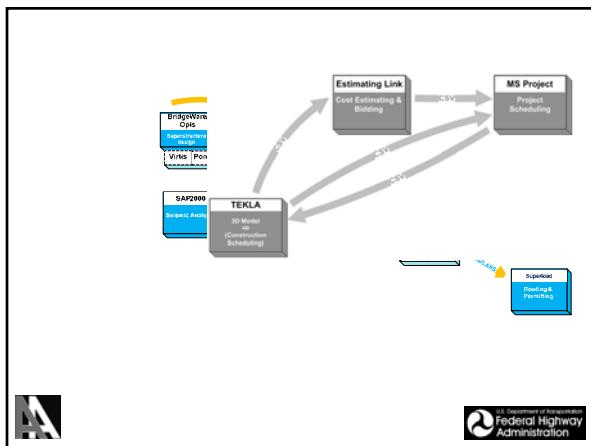


Some Considerations and Notes

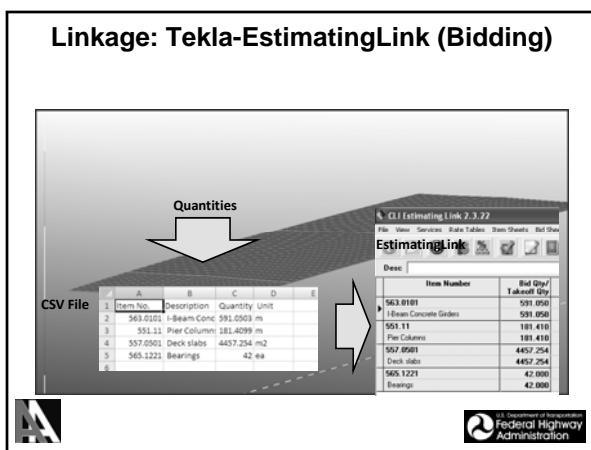
- The cambering data are calculated based on the deflections of the points of interest, so the number of points selected has an impact on the accuracy of cambering and hence the accuracy of detailing.
- Here presented is one possible conceptual approach, which may not be the ideal way to go.



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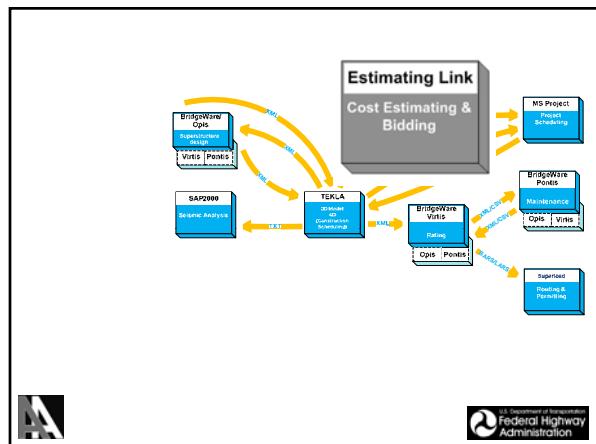
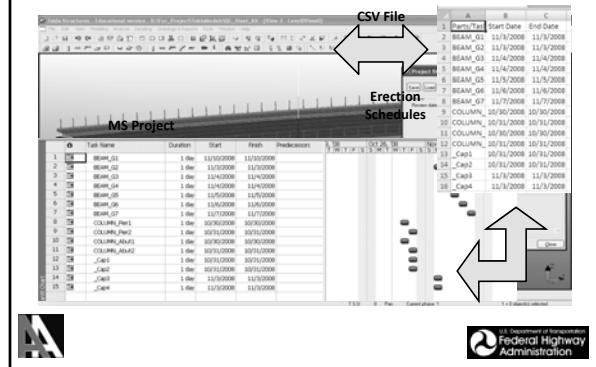


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Federal Highway Administration



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Linkage: Tekla 4D-MS Project (Scheduling)



A screenshot of the 'Create a new project' dialog box in Microsoft Project. It shows the 'Project Properties' dialog with fields for Project Name (QUINCY AVE), Description (QUINCY AVE BRIDGE), Location (Colorado), Bid Date (03/15/2009), Revision Date, Contact, Additional Info, and Customer. Buttons for OK and Cancel are at the bottom.

Create a new project

Another way:

Copy from another existing project whose rate tables can be shared



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Administration

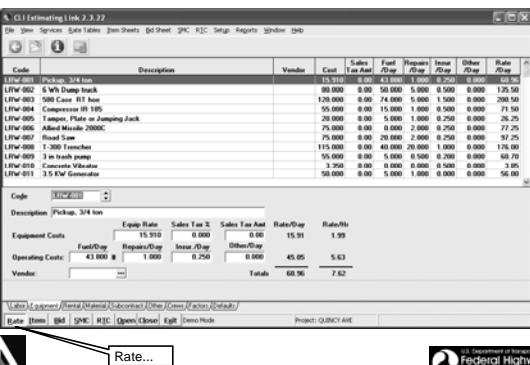


Rate Tables: Define Labor



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Rate Tables: Equipment



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Rate...

Rate Tables: Material

S.01 Estimating Link 2.3.22

Code	Description	Unit	Vendor	Unit Price
AGG000002	Rin of Bank Gravel	tun	EBER BRODS	4.000
AGG000003	Screened Gravel	tun		4.250
AGG000004	Pea Gravel	tun	EBER BRODS	4.400
AGG000005	Bank Sand	tun	EBER BRODS	2.800
AGG000006	Rin of Bank Sand	tun		4.000
ASPH000001	Type 1 Base Asphalt Concrete	tun		24.000
ASPH000002	Type 2 Base Asphalt Concrete	tun		24.500
ASPH000003	Type 3 Binder Asphalt Concrete	tun		25.000
ASPH000005	Type 5 Stone Asphalt Concrete	tun		26.000
ASPH000006	Type 6 Stone Asphalt Concrete	tun		27.000
ASPH000007	Type 7 Top Course Asph. Conc.	tun		28.500
ASPH000008	Type 8F Top Course (Hf) Asph.	tun		23.000

Code: **AGG000002**

Description: Crusher Gravel

U/W: **ton** Discount%: **0.00** Sales Tax%: **0.00**

Rate: **2.000** Disc Amt: **0.00** Total: **2.000**

Vendor: **EBER BRODS** Eben Brothers Sand and Gravel

Utility Equipment/Material/Contract/Other/Cross/Factory/Details

Rate Item: **84** SMC: **RTIC** Open/Close: **Exit** Demo Mode

Project: QUINCY AVE

A Rate...

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Define Items

S.01 Estimating Link 2.3.22

Description	Quantity/U/W	Factor	Rate	Costs	Total Cost	Unit Cost
I. Forklift	1.0	1.25	345.156	431.46	\$14,565.34	
I. Skid Steer Loader	2.0	1.00	332.250	664.50	\$10,820	
I. Backhoe	2.0	1.00	332.250	664.50	\$10,820	
I. Asphalt Paver	2.0	1.00	335.918	671.84	\$12,699.75	
L. Class A Operator	1.0	1.00	425.762	425.76	\$425.76	
L. Class B Operator	2.0	1.00	425.762	851.52	\$851.52	
E. Pickup, 3/4 ton	1.0	1.25	76.200	95.25	\$95.25	
R. Asphalt Pavers	1.0	1.00	1167.500	1167.50	\$1,167.50	
R. Asphalt Pavers	1.0	1.00	580.000	580.00	\$580.00	
M. Type 7F Top Course (Hf) Asph.	430.5 km	1.00	79.500	1239.75	\$9,273	
Z. 1 1/2 inches of top	0.0	0.00	0.000	0.00	\$0.00	
S. CERTIFIED - MSE	4.0 EA	1.00	325.000	1300.00	\$5,200	

Unit Cost: **\$53.238**

Total Cost: **\$21,327.41**

Production: **Days** Hr/Day: **10** 10.0 **Cost Code:** **---** Subcontract: **\$1,360.00**

Bill Quantity: **410.000** Take Off Qty: **410.000** Unit of Measure: **TONS** \$3.17

Man Hours: **120.000** Units/MH: **3.417** Min/Unit: **0.2527** Units/Dap: **410.00** Days Req'd: **1.00**

Other: **\$0.00**

Rate Item: **84** SMC: **RTIC** Open/Close: **Exit** Demo Mode

Project: MAIN_ST

A Item...

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Item Table

Note:

It can be defined manually or imported from other software models, such as Tekla model.

A

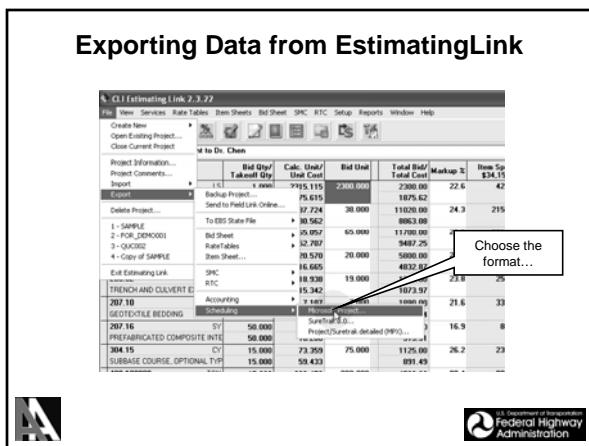
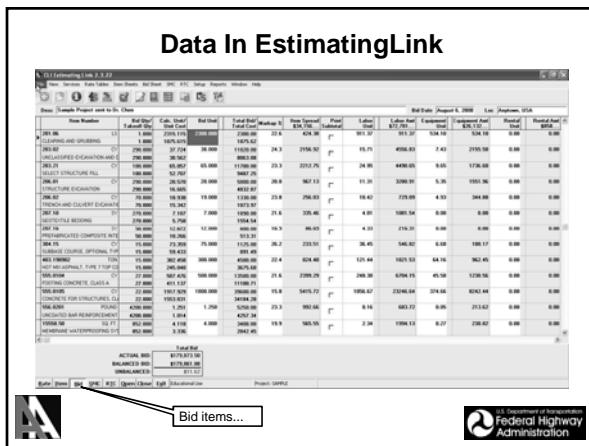
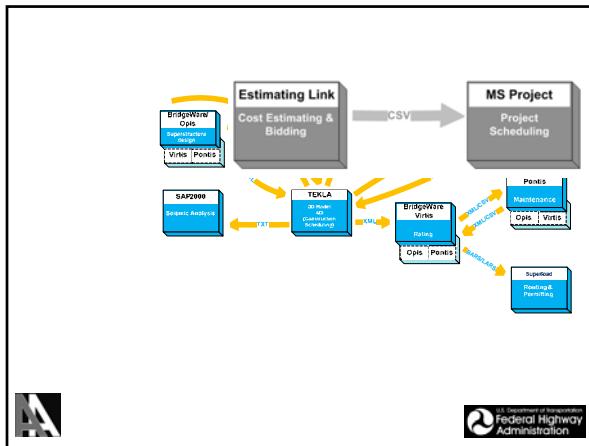
Select Item

Item Number	Description	U/W
880.11	Pipe Column	m
557.050	Deck slab	m ²
563.010	I Beam Concrete Girders	m
565.1221	Bearings	ea

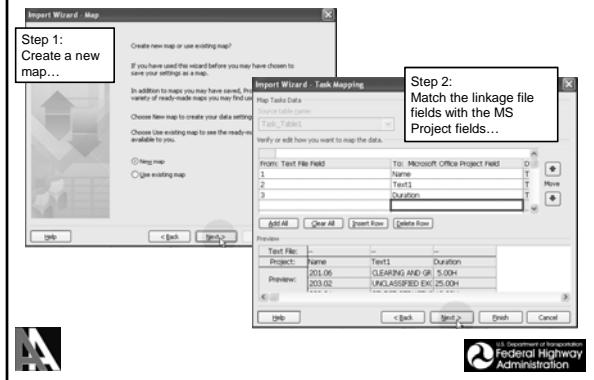
Search: **End**

OK Cancel

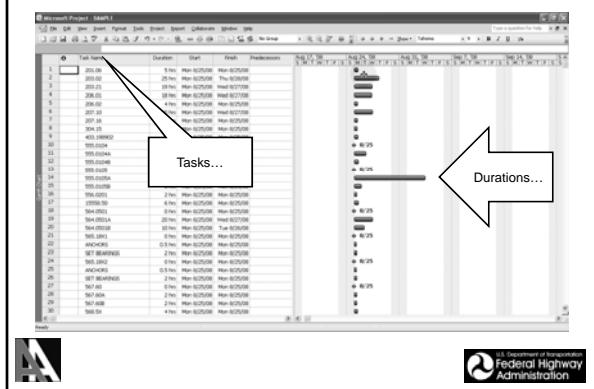
U.S. Department of Transportation
Federal Highway Administration



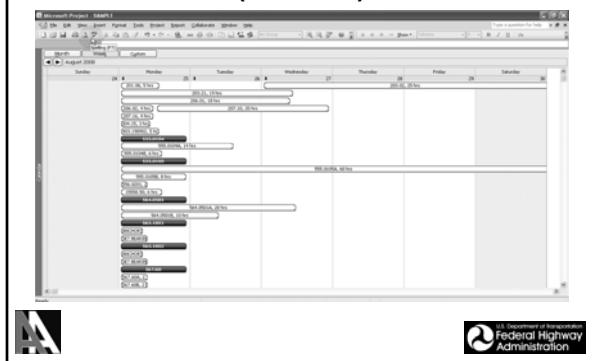
The Steps of Importing Data into MS Project



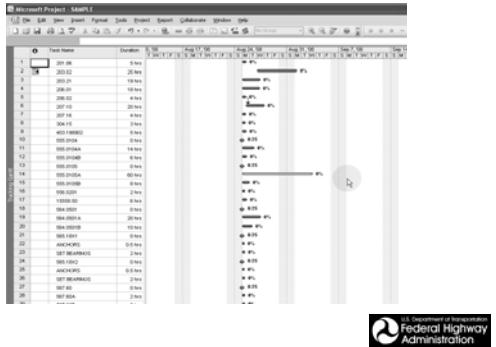
Imported Data in MS Project

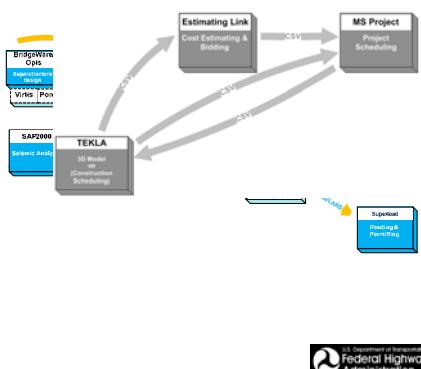


Imported Data in MS Project (Calendar)

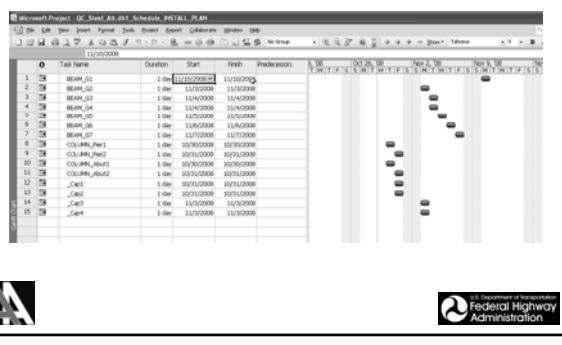


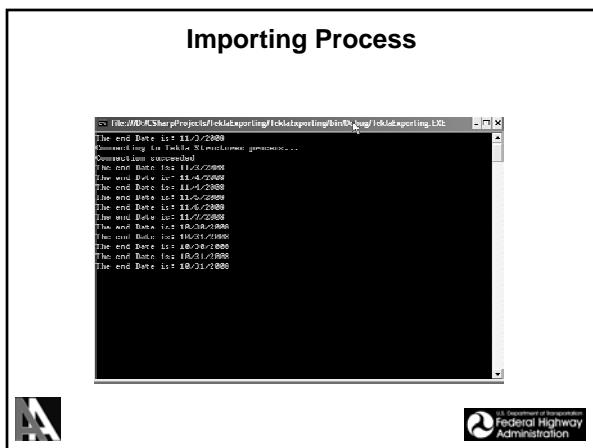
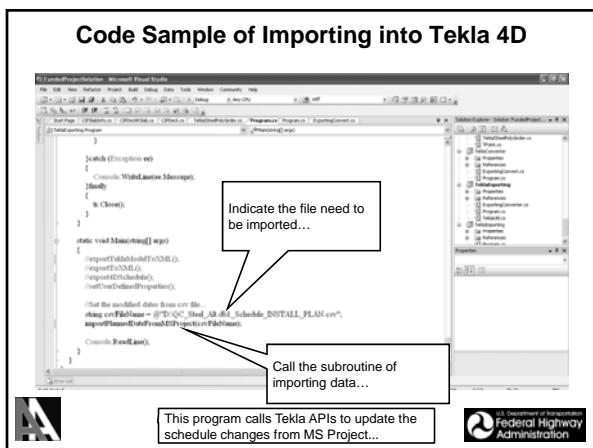
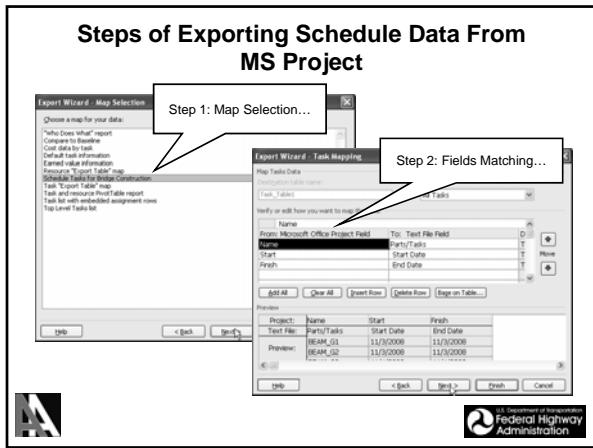
Imported Data in MS Project (Tracking Gantt Chart)



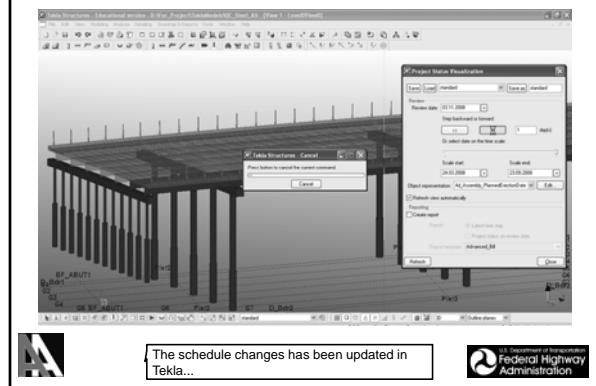


Schedule Data to Be Exported

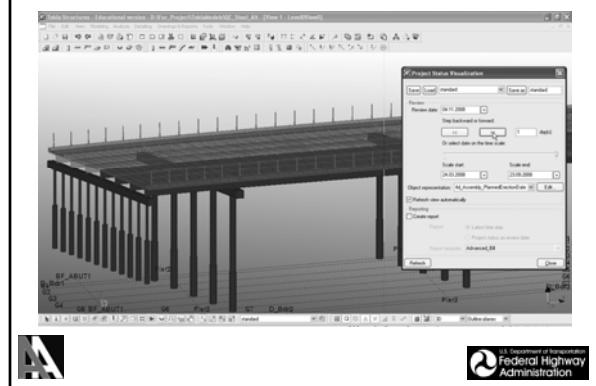




Updating Schedule in Tekla 4D



Construction Schedule in Tekla 4D



Link to Fabrication



Summary (D3-Construction)

- Workflow demonstrated leveraging design (model) downstream into construction, estimating, scheduling, etc.
- One of several possible such workflows
- Encompassing detailing for fabrication for construction, cost estimating, construction scheduling, and feedback into 3D/4D modeling environment for downstream uses