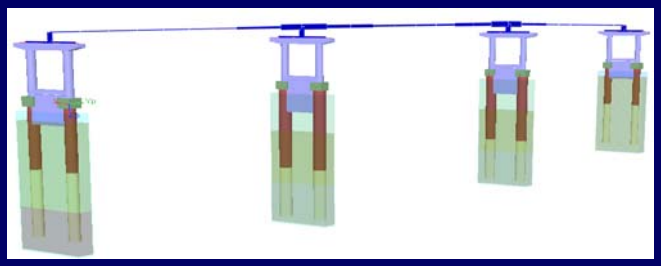
2008 FICE-FDOT Design Conference
FB-Multipier update



FB-MultiPier bridge model

Henry T. Bollmann, P.E., Jay Jung, Ph.D., Marc Hoit, Ph.D.

Bridge Software Institute, Gainesville, FL, USA

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Overview

- SR 20 / Apalachicola River Bridge model used to demonstrate some program features
- Coupled vessel / pier dynamic impact analysis (on going)
- Design Tables (on going)

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SR 20 / Apalachicola River Bridge Construction

VU 53 2Dsdodfklfrod Ulyhu Frqwuxfwlrq Vlwh
+ylhz hg iurp wkh Hdvw/4<<:,

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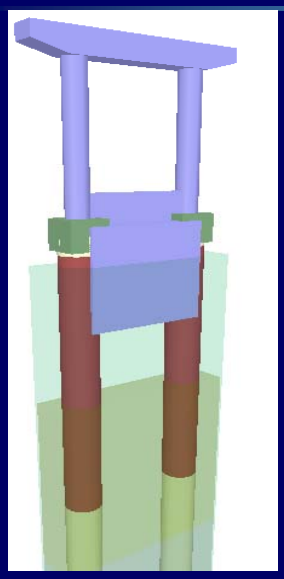
FB-MultiPier Single Pier Model



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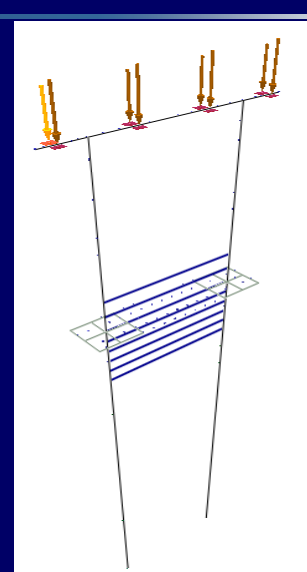

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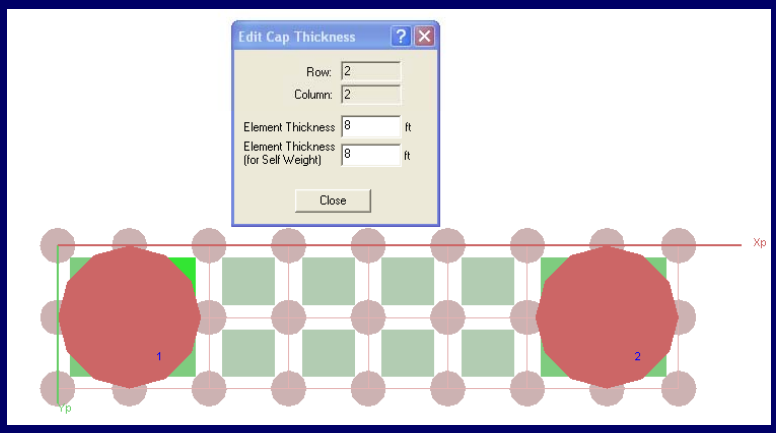
Pile Cap Modeling



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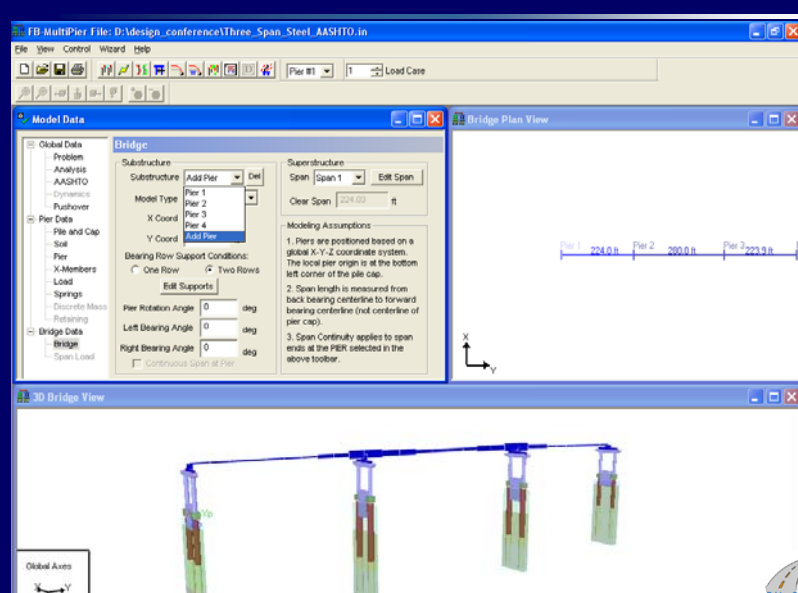
Graphic User Interface of FB-MultiPier



Vfuhhq vkrwrieulgjh p rghogdwd sdjh

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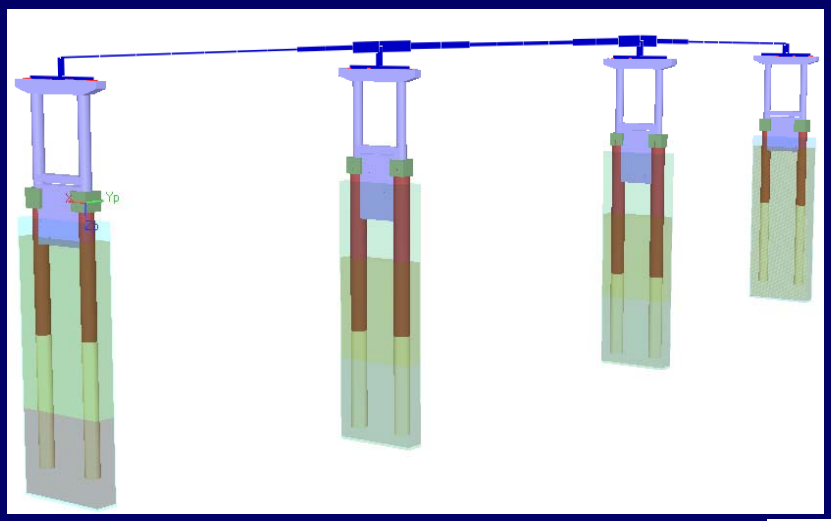
FB-Multipier model of SR 20 / Apalachicola River Bridge



55725;32557 iwwhhovsdqvdfurvwkh ulyhu

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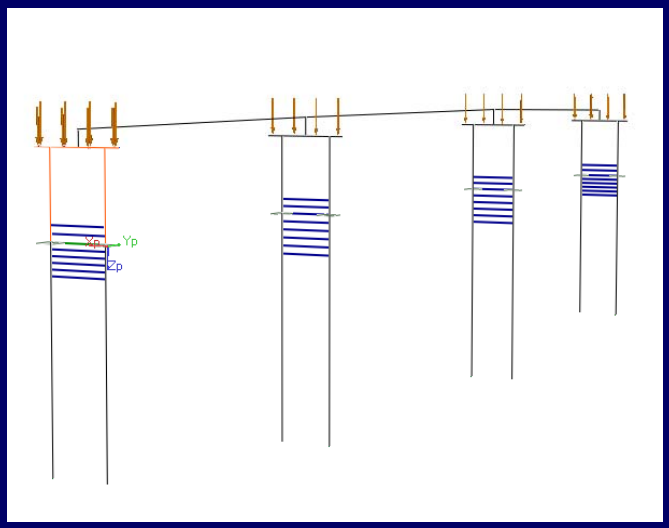
FB-MultiPier 3-D Finite Element Model : SR 20 / Apalachicola River Bridge



"Thin View Mode"

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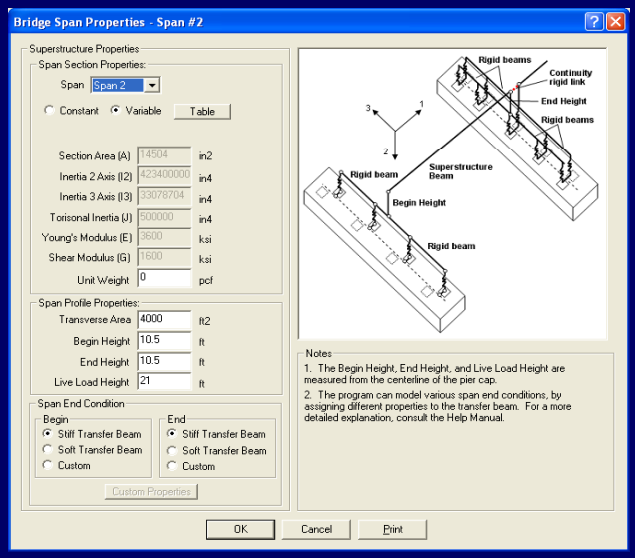
Modeling of Bridge Span Properties



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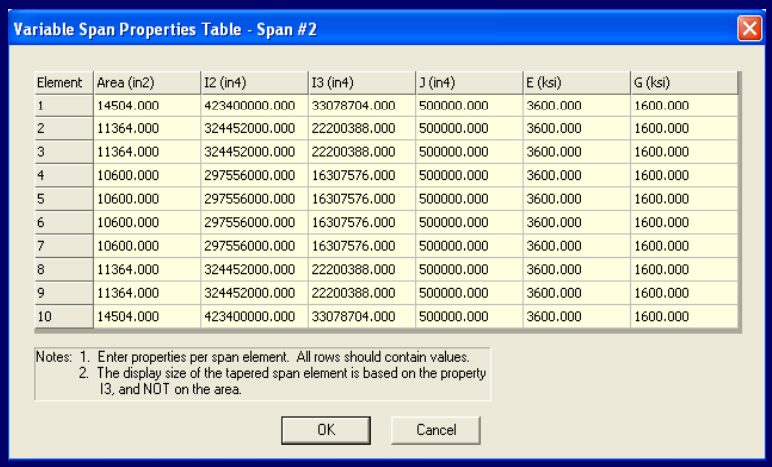
Modeling of Composite Decks



Variable Span Properties Table - Span #2

Element	Area (in2)	I2 (in4)	I3 (in4)	J (in4)	E (ksi)	G (ksi)
1	14504.000	423400000.000	33078704.000	500000.000	3600.000	1600.000
2	11364.000	324452000.000	22200388.000	500000.000	3600.000	1600.000
3	11364.000	324452000.000	22200388.000	500000.000	3600.000	1600.000
4	10600.000	297556000.000	16307576.000	500000.000	3600.000	1600.000
5	10600.000	297556000.000	16307576.000	500000.000	3600.000	1600.000
6	10600.000	297556000.000	16307576.000	500000.000	3600.000	1600.000
7	10600.000	297556000.000	16307576.000	500000.000	3600.000	1600.000
8	11364.000	324452000.000	22200388.000	500000.000	3600.000	1600.000
9	11364.000	324452000.000	22200388.000	500000.000	3600.000	1600.000
10	14504.000	423400000.000	33078704.000	500000.000	3600.000	1600.000

Notes: 1. Enter properties per span element. All rows should contain values.
2. The display size of the tapered span element is based on the property I3, and NOT on the area.

OK Cancel

Iqsxwwdedh rifrp srvlwh ghfn surshuwlhv/vsdq &5

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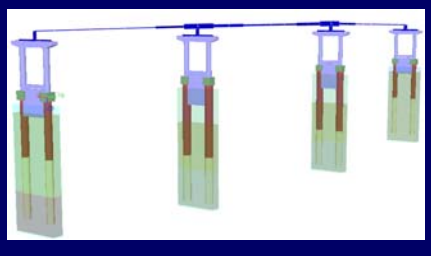
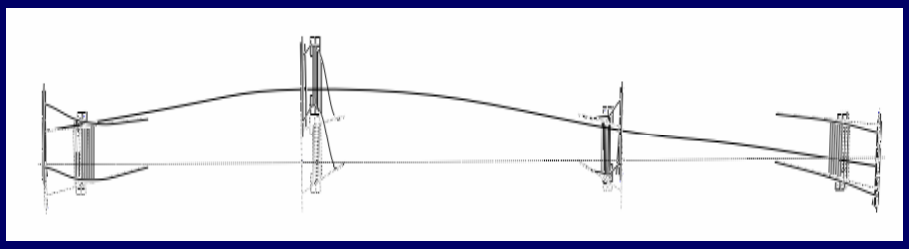
2550 kip at pier 2, scaled up 200 x

- Case I : Guided Bearings

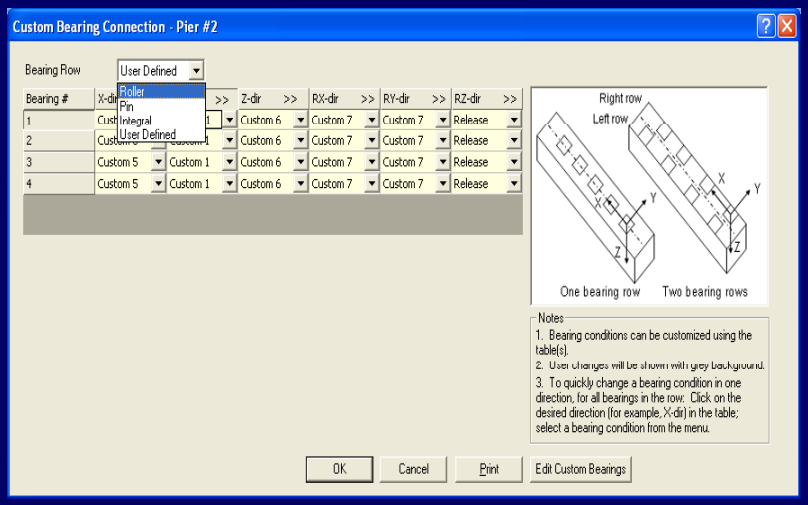
Plan view shows relation of deck to substructure when bearings ARE guided. (400 kip transferred to deck)





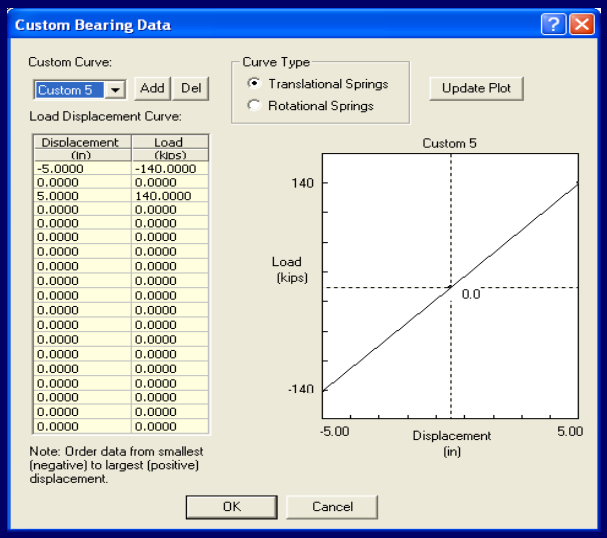
Scalq ylhz righirup hg eubgjh

Modeling of Boundary Condition (Bearings)



Modeling of boundary conditions of girders - Custom Bearings

Modeling of Bearing Properties

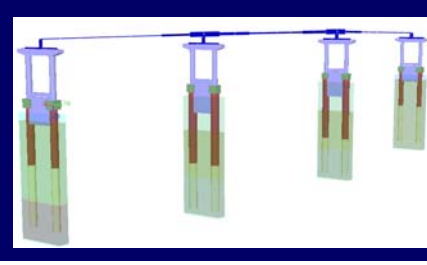


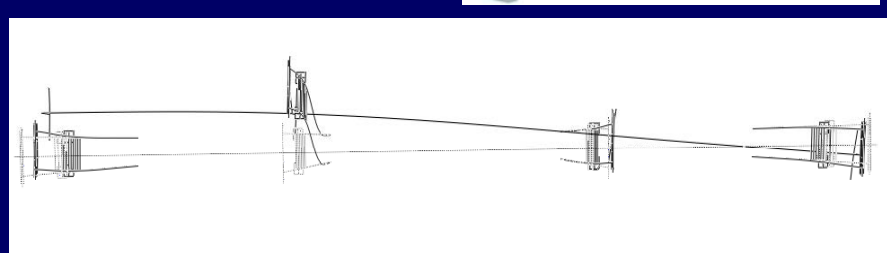
Ordg@G lvsodfhp hqwfxuyh irudqhdu+ruQ rq@dqhdu, ehdulqj vsulqjv

2550 kip Applied at Pier 2 (scaled up 200 x)

- Case II : Un-Guided Bearings

relation of deck to substructure when bearings are NOT guided. (130 kip transferred to deck)

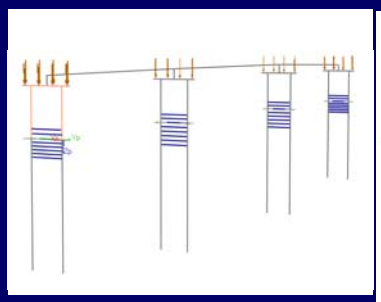




Sodq ylhz righirup hg eulgjh

Overview of Deflected Shape (scaled up 100 x)

- Case II : Un-Guided Bearings



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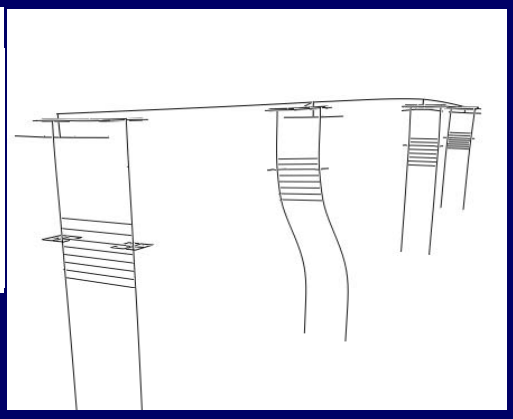
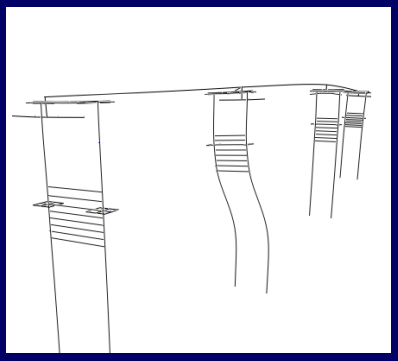


6 G ylhz righirup hg eubgjh

Deflected Shape of Pier 1 (scaled up 150 x)

- Case II : Un-Guided Bearings



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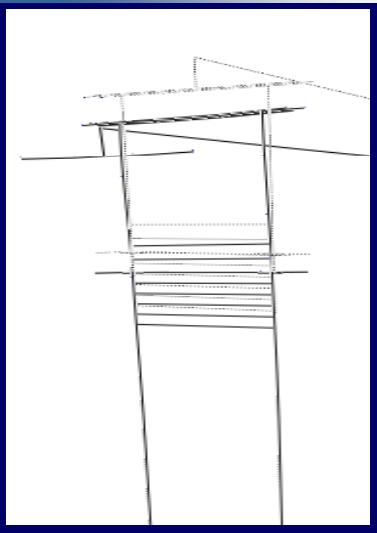

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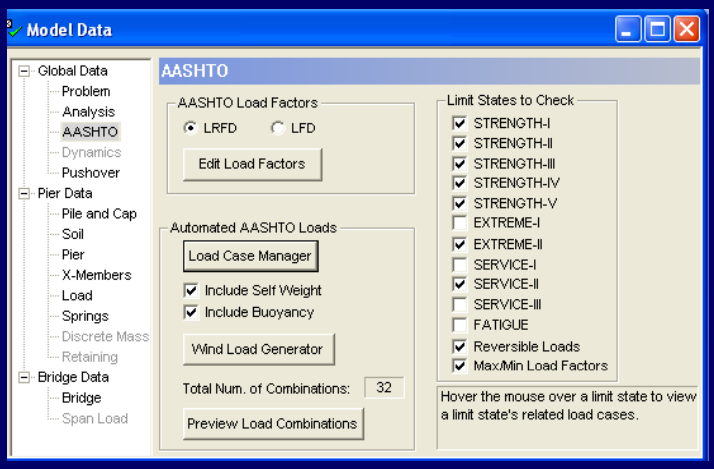
diwhuordglqj dwSlhu 5

Automated AASHTO Load Comb. Generation



DDVKWR Ordg Frp e1J hqhudwlrq G ldorjxh Er{

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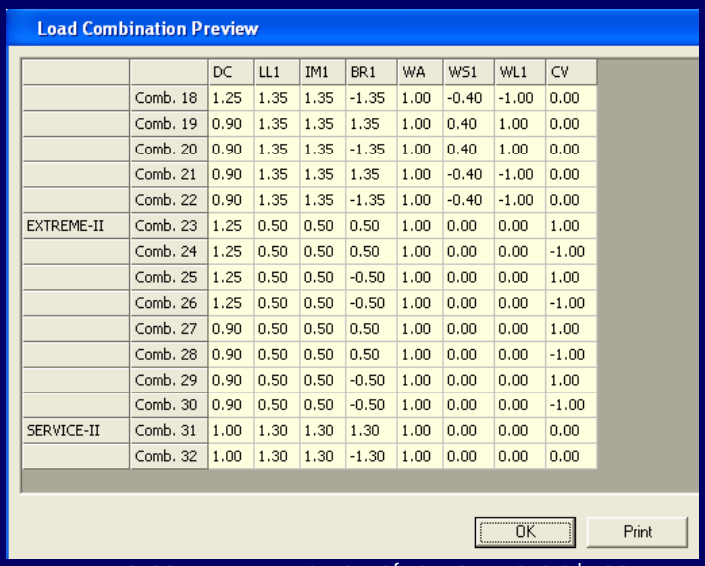
Result of AASHTO Load Comb. Generation



		DC	LL1	IM1	BR1	WA	WS1	WL1	CV
	Comb. 18	1.25	1.35	1.35	-1.35	1.00	-0.40	-1.00	0.00
	Comb. 19	0.90	1.35	1.35	1.35	1.00	0.40	1.00	0.00
	Comb. 20	0.90	1.35	1.35	-1.35	1.00	0.40	1.00	0.00
	Comb. 21	0.90	1.35	1.35	1.35	1.00	-0.40	-1.00	0.00
	Comb. 22	0.90	1.35	1.35	-1.35	1.00	-0.40	-1.00	0.00
EXTREME-II	Comb. 23	1.25	0.50	0.50	0.50	1.00	0.00	0.00	1.00
	Comb. 24	1.25	0.50	0.50	0.50	1.00	0.00	0.00	-1.00
	Comb. 25	1.25	0.50	0.50	-0.50	1.00	0.00	0.00	1.00
	Comb. 26	1.25	0.50	0.50	-0.50	1.00	0.00	0.00	-1.00
	Comb. 27	0.90	0.50	0.50	0.50	1.00	0.00	0.00	1.00
	Comb. 28	0.90	0.50	0.50	0.50	1.00	0.00	0.00	-1.00
	Comb. 29	0.90	0.50	0.50	-0.50	1.00	0.00	0.00	1.00
	Comb. 30	0.90	0.50	0.50	-0.50	1.00	0.00	0.00	-1.00
SERVICE-II	Comb. 31	1.00	1.30	1.30	1.30	1.00	0.00	0.00	0.00
	Comb. 32	1.00	1.30	1.30	-1.30	1.00	0.00	0.00	0.00

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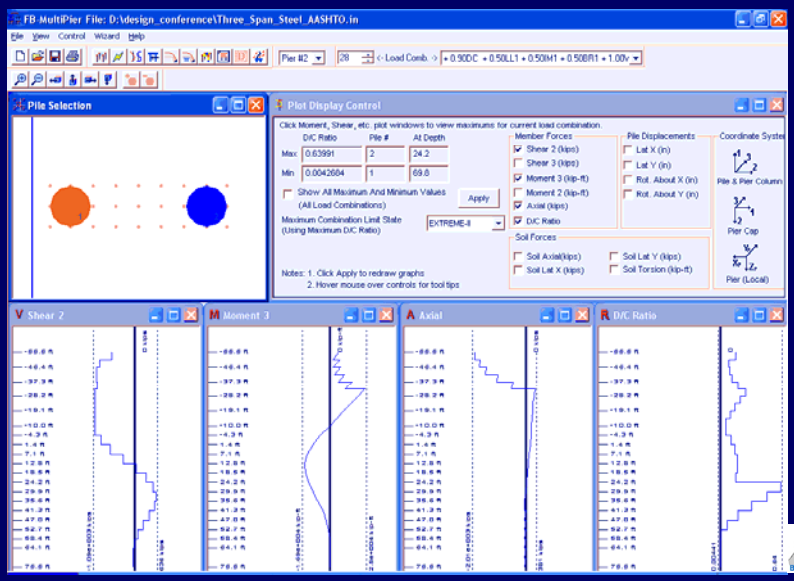
Display of Pile Member Forces (Load Comb. 28)



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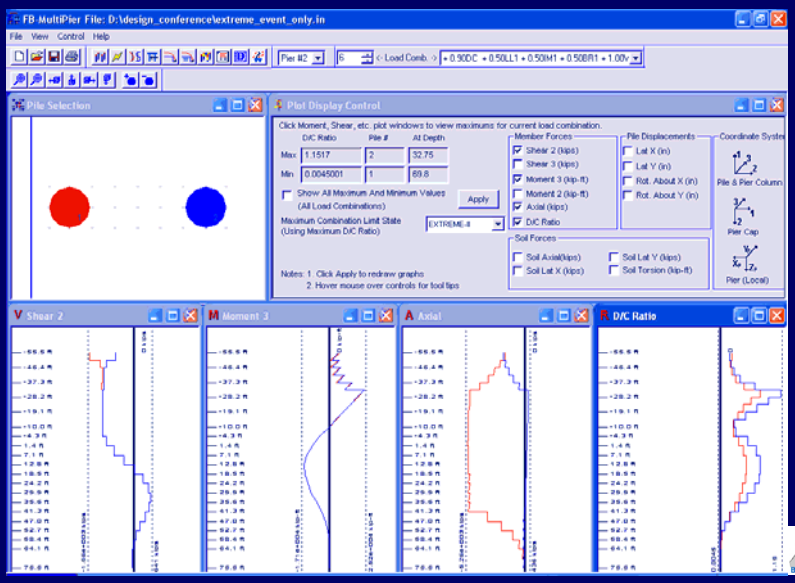
Display of Pile Member Forces (removed steel casing)



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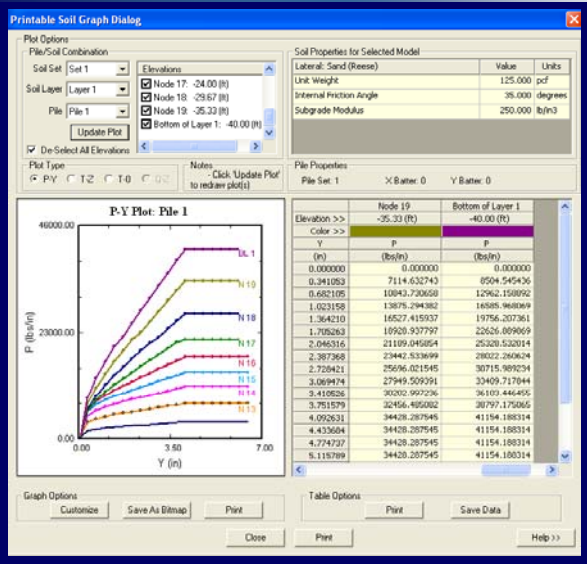
Soil PY Plot (Soil-Structure Interaction)



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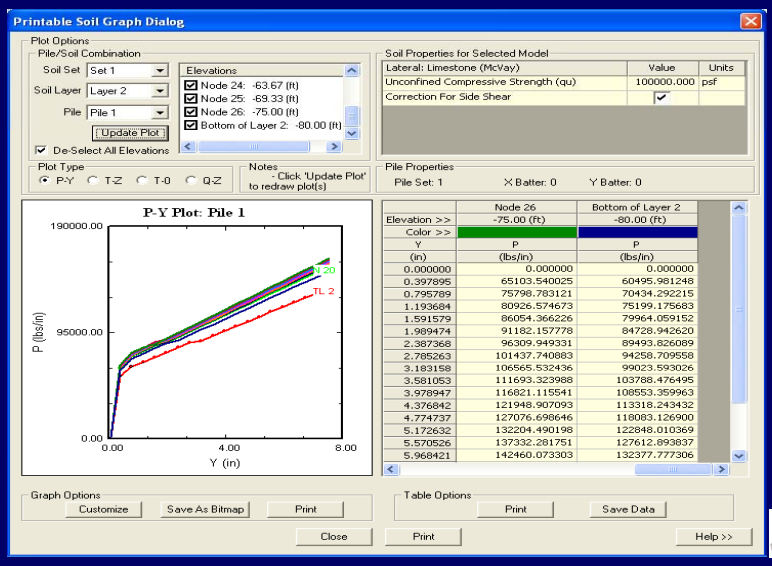
Lime stone McVay, P-Y curves



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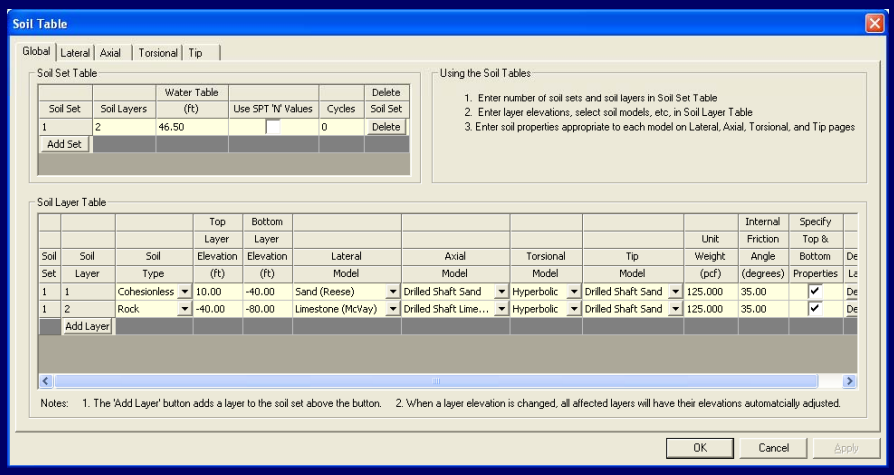
Soil Table (Material Modeling Feature)



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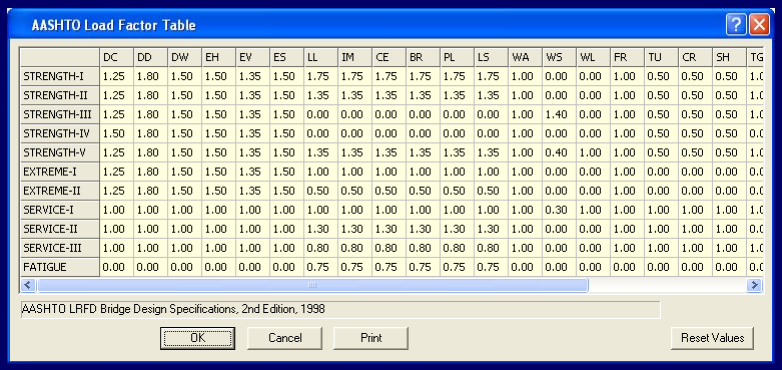
AASHTO Load Factor Table



	DC	DD	DW	EH	EV	ES	LL	IM	CE	BR	PL	LS	WA	WS	WL	FR	TU	CR	SH	TG
STRENGTH-I	1.25	1.80	1.50	1.50	1.35	1.50	1.75	1.75	1.75	1.75	1.75	1.75	1.00	0.00	0.00	1.00	0.50	0.50	0.50	1.0
STRENGTH-II	1.25	1.80	1.50	1.50	1.35	1.50	1.35	1.35	1.35	1.35	1.35	1.35	1.00	0.00	0.00	1.00	0.50	0.50	0.50	1.0
STRENGTH-III	1.25	1.80	1.50	1.50	1.35	1.50	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.40	0.00	1.00	0.50	0.50	0.50	1.0
STRENGTH-IV	1.50	1.80	1.50	1.50	1.35	1.50	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.50	0.50	0.50	0.0
STRENGTH-V	1.25	1.80	1.50	1.50	1.35	1.50	1.35	1.35	1.35	1.35	1.35	1.35	1.00	0.40	1.00	1.00	0.50	0.50	0.50	1.0
EXTREME-I	1.25	1.80	1.50	1.50	1.35	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
EXTREME-II	1.25	1.80	1.50	1.50	1.35	1.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
SERVICE-I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.30	1.00	1.00	1.00	1.00	1.00	1.0
SERVICE-II	1.00	1.00	1.00	1.00	1.00	1.00	1.30	1.30	1.30	1.30	1.30	1.30	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.0
SERVICE-III	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.80	0.80	0.80	0.80	0.80	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.0
FATIGUE	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.75	0.75	0.75	0.75	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

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New Analysis Models of FB-Multipier

- Coupled vessel / pier dynamic impact analysis using a single pier with discrete mass system
- Design Tables that identify the controlling forces from all load combinations needed to accomplish the AASHTO design checks.

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Barge Impact Tests at St George Island Bridge

Barge Impact Tests were conducted at St. George Island Bridge during March / April 2004. A total of 15 impact tests were conducted

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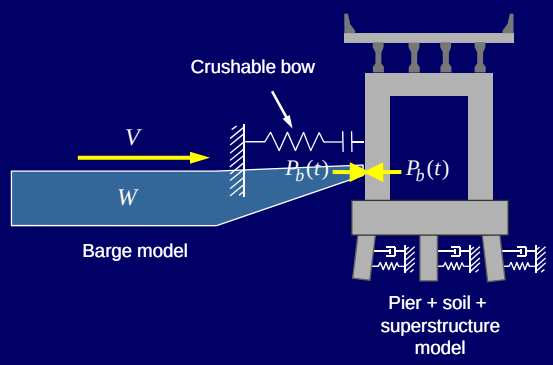
Coupled Vessel Impact Analysis of FB-Multipier

- Dynamic bridge model (FB-MultiPier)
- Simplified dynamic barge model
- Crushable barge bow section



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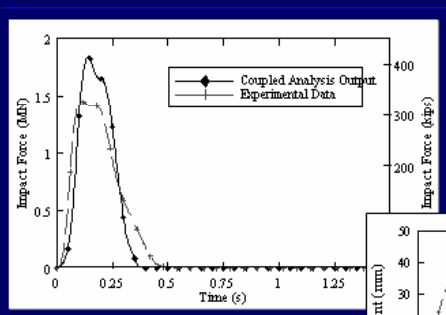
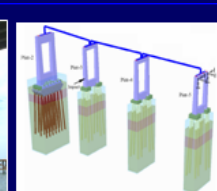
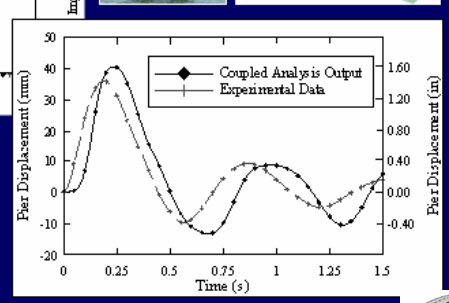
Validation of Coupled Vessel Impact Analysis (CVIA) Models of FB-Multipier



Impact force time history





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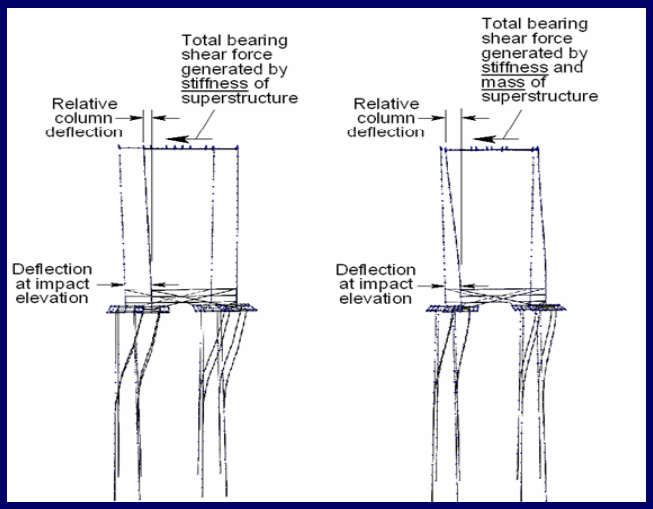
Dynamic Amplification Effects



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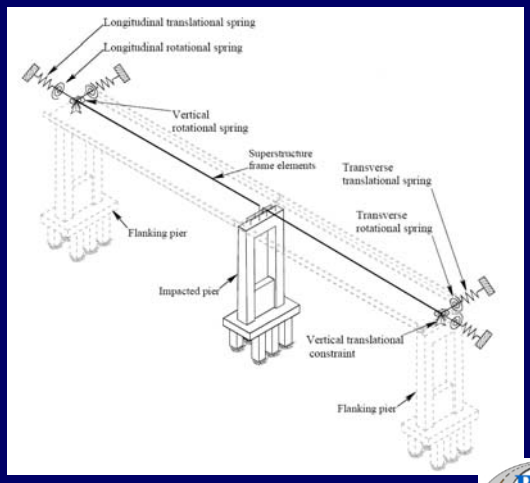
Simplified Superstructure Analysis Model

- Full bridge models : computationally expensive
- One-pier two-span (OPTS) model
  - Impacted pier and two adjacent spans are retained
  - Remainder of bridge modeled with springs & point masses



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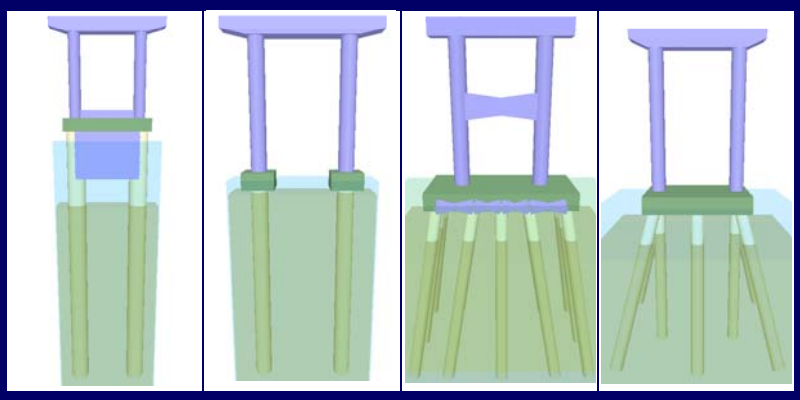
FB-Multipier Model Development

- CVIA and OPTS have been implemented in FB-MultiPier
- Several Florida bridge-configurations are currently being analyzed:



SR-20 at Blountstown channel pier | SR-20 at Blountstown off-channel pier | New St. George Island channel pier | New St. George Island off-channel pier

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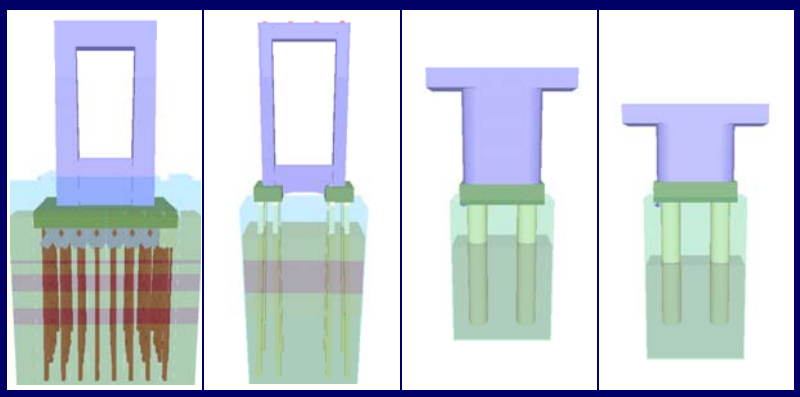
FB-Multipier Model Development

- Florida bridge-configurations analyzed:



Old St. George Island channel pier | Old St. George Island off-channel pier | Ringling channel pier | Ringling off-channel pier

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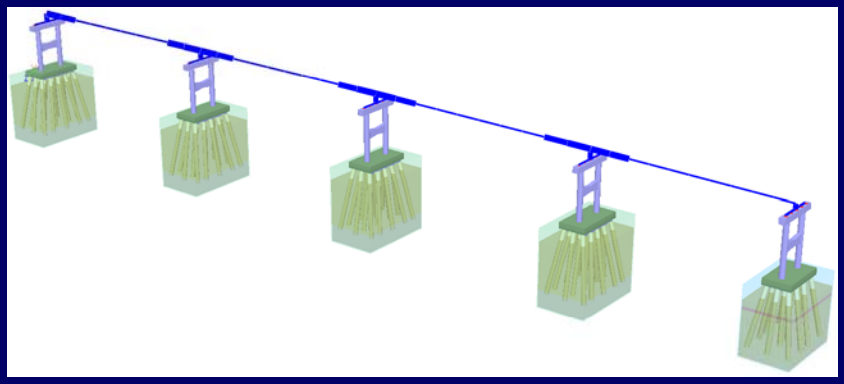
Numerical model: bridge

- New St. George Island Bridge (constructed: 2004): Channel pier



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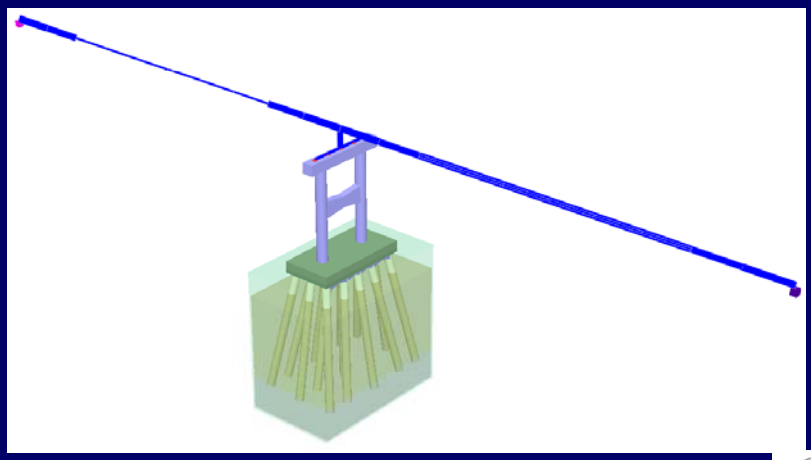
Numerical model: OPTS

- New St. George Island Bridge (constructed: 2004): Channel pier



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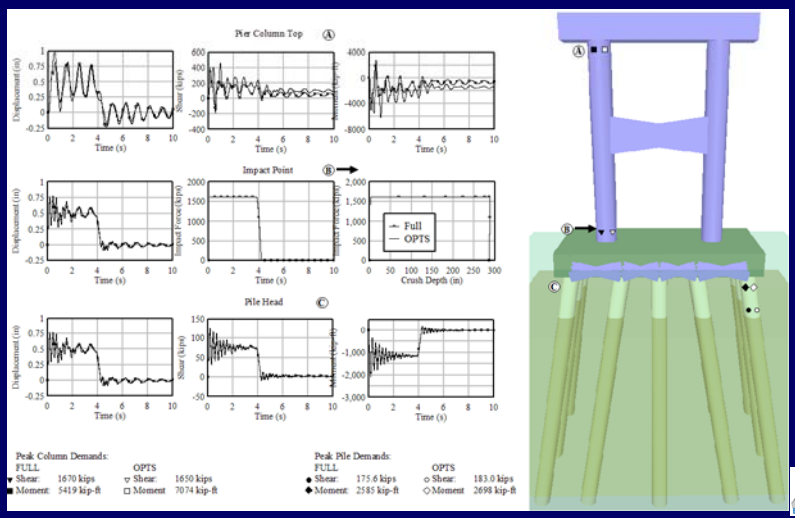
CVIA output: OPTS vs. Full Bridge Analysis

- New St. George Island Bridge (constructed: 2004): Channel pier



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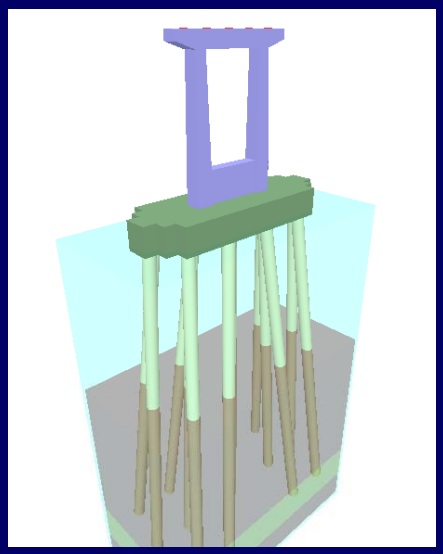
Design Table Application (controlling forces)



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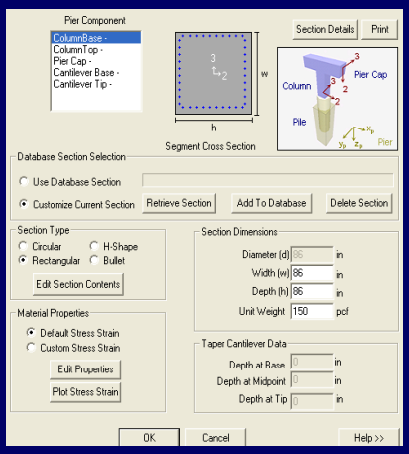
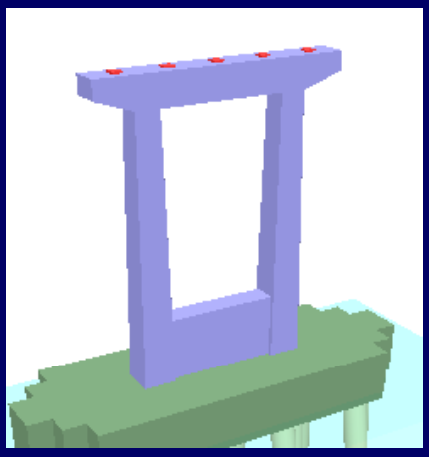
Design Table Application (controlling forces)





Tapered column and cap sections

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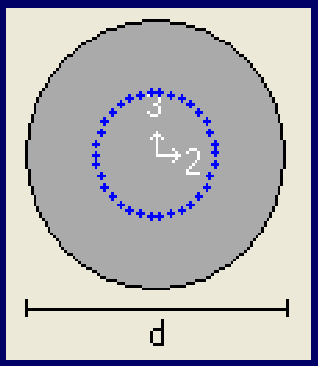
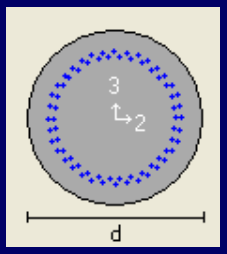
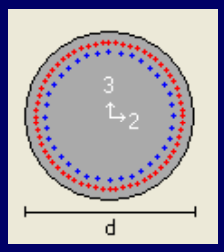
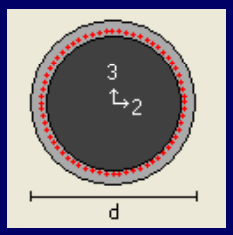
Design Table Application (controlling forces)









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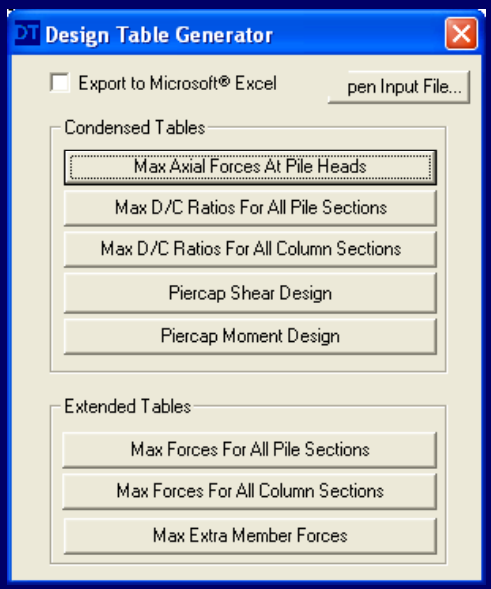
Design Tables (under development)



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Axial Forces at pile heads

AXIAL FORCES AT PILE HEADS
(USE TO COMPARE TO PILE DRIVE CAPACITY)
MAXIMUM COMPRESSION AND MAXIMUM TENSION FORCES

"STRENGTH CASES"

PIER	PILE	MAX TENSION	COMB	AASHTO	D/C	MAX COMPRESSION	COMB	AASHTO	D/C
1	1	n/a	n/a	n/a	n/a	-753.46	2	STRENGTH-I	0.42
1	2	n/a	n/a	n/a	n/a	-747.84	21	STRENGTH-V	0.48
1	3	n/a	n/a	n/a	n/a	-752.73	37	STRENGTH-V	0.52
1	4	n/a	n/a	n/a	n/a	-752.76	37	STRENGTH-V	0.47
1	5	n/a	n/a	n/a	n/a	-752.20	35	STRENGTH-V	0.41
1	6	n/a	n/a	n/a	n/a	-743.90	1	STRENGTH-I	0.46
1	7	n/a	n/a	n/a	n/a	-740.50	1	STRENGTH-I	0.44
1	8	n/a	n/a	n/a	n/a	-743.76	1	STRENGTH-I	0.41
1	9	n/a	n/a	n/a	n/a	-738.27	1	STRENGTH-I	0.50
1	10	n/a	n/a	n/a	n/a	-758.53	41	STRENGTH-V	0.40
1	11	n/a	n/a	n/a	n/a	-751.10	25	STRENGTH-V	0.48
1	12	n/a	n/a	n/a	n/a	-747.82	25	STRENGTH-V	0.52
1	13	n/a	n/a	n/a	n/a	-748.10	29	STRENGTH-V	0.49

"SERVICE CASES"

PIER	PILE	MAX TENSION	COMB	AASHTO	D/C	MAX COMPRESSION	COMB	AASHTO	D/C
1	1	n/a	n/a	n/a	n/a	-594.63	99	SERVICE-I	0.12
1	2	n/a	n/a	n/a	n/a	-593.68	85	SERVICE-I	0.14
1	3	n/a	n/a	n/a	n/a	-596.40	85	SERVICE-I	0.11
1	4	n/a	n/a	n/a	n/a	-597.49	101	SERVICE-I	0.15

"EXTREME EVENT II CASES"

PIER	PILE	MAX TENSION	COMB	AASHTO	D/C	MAX COMPRESSION	COMB	AASHTO	D/C
1	1	n/a	n/a	n/a	n/a	-932.30	84	EXTREME-II	0.60
1	2	n/a	n/a	n/a	n/a	-846.37	69	EXTREME-II	0.74
1	3	n/a	n/a	n/a	n/a	-831.16	73	EXTREME-II	0.70
1	4	n/a	n/a	n/a	n/a	-872.56	74	EXTREME-II	0.71

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AXIAL FORCES AT PILE HEADS

(USE TO COMPARE TO PILE DRIVE CAPACITY)

MAXIMUM COMPRESSION AND MAXIMUM TENSION FORCES

"STRENGTH CASES"

PIER	PILE	MAX TENSION	COMB	AASHTO	D/C	MAX COMPRESSION	COMB	AASHTO	D/C
1	1	n/a	n/a	n/a	n/a	-753.46	2	STRENGTH-I	0.42
1	2	n/a	n/a	n/a	n/a	-747.84	21	STRENGTH-V	0.48
1	3	n/a	n/a	n/a	n/a	-752.73	37	STRENGTH-V	0.52
1	4	n/a	n/a	n/a	n/a	-752.76	37	STRENGTH-V	0.47
1	5	n/a	n/a	n/a	n/a	-752.20	35	STRENGTH-V	0.41
1	6	n/a	n/a	n/a	n/a	-743.90	1	STRENGTH-I	0.46
1	7	n/a	n/a	n/a	n/a	-740.50	1	STRENGTH-I	0.44
1	8	n/a	n/a	n/a	n/a	-743.76	1	STRENGTH-I	0.41
1	9	n/a	n/a	n/a	n/a	-738.27	1	STRENGTH-I	0.50
1	10	n/a	n/a	n/a	n/a	-758.53	41	STRENGTH-V	0.40
1	11	n/a	n/a	n/a	n/a	-751.10	25	STRENGTH-V	0.48
1	12	n/a	n/a	n/a	n/a	-747.82	25	STRENGTH-V	0.52
1	13	n/a	n/a	n/a	n/a	-748.10	29	STRENGTH-V	0.49

"SERVICE CASES"

PIER	PILE	MAX TENSION	COMB	AASHTO	D/C	MAX COMPRESSION	COMB	AASHTO	D/C
1	1	n/a	n/a	n/a	n/a	-594.63	99	SERVICE-I	0.12
1	2	n/a	n/a	n/a	n/a	-593.68	85	SERVICE-I	0.14
1	3	n/a	n/a	n/a	n/a	-596.40	85	SERVICE-I	0.11
1	4	n/a	n/a	n/a	n/a	-597.49	101	SERVICE-I	0.15

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Max demand / capacity for each pile cross-section and display of all concurrent forces.

Maximum Demand Capacity Ratios For All Pile Cross Section Properties

Pier No.	Pile No.	ELEM NO.	PROP NO.	NODE NO.	LC	AASHTO CASE	i/j	FAX	F22	F33	M22	M33	T	D/C
1	11	52	1	532	55	STRENGTH-III	J	-744.44	-6.62	-5.73	-73.59	2127.17	2.30	0.30
1	7	112	1	345	74	EXTREME-II	J	-897.27	-6.62	-5.73	-73.59	3196.20	5.57	0.98
1	4	235	1	235	85	SERVICE-I	J	-512.83	-6.62	-5.73	-73.59	1127.17	4.67	0.68
1	2	322	2	401	50	STRENGTH-III	J	-755.43	-5.65	-4.76	-30.73	2235.76	3.54	0.46
1	8	457	2	567	69	EXTREME-II	J	-994.16	-5.65	-4.76	-30.73	3648.97	2.42	1.05
1	9	214	2	198	99	SERVICE-I	J	-523.43	-5.65	-4.76	-30.73	1077.23	1.53	0.54
1	12	531	3	678	68	STRENGTH-V	J	-796.18	-2.04	-1.16	27.69	2653.65	5.27	0.39
1	3	155	3	157	82	EXTREME-II	J	-912.24	-2.04	-1.16	27.69	3763.42	12.52	1.03
1	1	365	3	427	103	SERVICE-I	J	-479.18	-2.04	-1.16	27.69	1385.65	4.87	0.49
1	13	61	4	634	46	STRENGTH-III	J	-812.48	-0.60	0.28	31.47	2456.38	3.97	0.60
1	5	502	4	593	80	EXTREME-II	J	-856.64	-0.60	0.28	31.47	3873.18	5.34	0.86
1	7	374	4	436	92	SERVICE-I	J	-499.48	-0.60	0.28	31.47	1637.22	1.75	0.55

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1					**PIER CAP SHEAR DESIGN**										
2					**Maximum Shear Forces at Left and Right of Bearings and at Column Faces**										
3															
4	**"Strength Cases"**														
5															
6	**BEARING**	**ROW**	**LOC.**	**PROP NO.**	**NODE NO.**	**LC**	**AASHTO CASE**	**i OR j**	**F22**	**F33**	**FAX**	**M22**	**M33**	**T**	**D/C**
7															
8	1	1	LEFT	16	495	24	STRENGTH-V	J	-14.86	0.00	0.00	0.00	23.76	0.00	0.00
9	1	1	RIGHT	15	495	2	STRENGTH-I	I	-705.94	0.00	0.00	0.00	22.84	0.00	0.00
10	2	1	LEFT	12	499	2	STRENGTH-I	J	1070.11	0.00	-41.07	-0.01	-1245.06	0.00	0.00
11	2	1	RIGHT	12	499	35	STRENGTH-V	I	389.97	0.00	-42.73	0.00	-864.70	0.00	0.05
12	3	1	LEFT	12	502	2	STRENGTH-I	J	335.84	0.00	-41.07	0.00	-4779.52	0.00	0.32
13	3	1	RIGHT	12	502	2	STRENGTH-I	I	-354.27	0.00	-41.07	0.00	-4779.51	0.00	0.32
14	4	1	LEFT	12	505	31	STRENGTH-V	J	-404.26	0.00	-42.72	0.00	-723.93	0.00	0.04
15	4	1	RIGHT	12	505	1	STRENGTH-I	I	-1001.87	0.00	-38.43	0.00	-1176.35	0.00	0.08
16	5	1	LEFT	21	520	2	STRENGTH-I	J	10.73	0.00	0.00	0.00	4.04	0.00	0.00
17	5	1	RIGHT	22	520	1	STRENGTH-I	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18															
19	**"Service Cases"**														
20															
21	**BEARING**	**ROW**	**LOC.**	**PROP NO.**	**NODE NO.**	**LC**	**AASHTO CASE**	**i OR j**	**F22**	**F33**	**FAX**	**M22**	**M33**	**T**	**D/C**
22															
23	1	1	LEFT	16	495	85	SERVICE-I	J	12.71	0.00	0.00	0.00	19.24	0.00	0.00
24	1	1	RIGHT	15	495	99	SERVICE-I	I	-509.87	0.00	7.82	0.00	18.93	0.00	0.00
25	2	1	LEFT	12	499	99	SERVICE-I	J	798.23	0.00	-41.52	0.00	-661.99	0.00	0.04
26	2	1	RIGHT	12	499	99	SERVICE-I	I	309.27	0.00	-33.71	0.00	-662.42	0.00	0.04
27	3	1	LEFT	12	502	99	SERVICE-I	J	257.97	0.00	-33.71	0.00	-3454.74	0.00	0.23
28	3	1	RIGHT	12	502	95	SERVICE-I	I	-268.57	0.00	-33.71	0.00	-3454.62	0.00	0.23
29	4	1	LEFT	12	505	95	SERVICE-I	J	-319.87	0.00	-33.71	0.00	-557.98	0.00	0.03
30	4	1	RIGHT	12	505	93	SERVICE-I	I	-758.17	0.00	-40.01	0.00	-623.30	0.00	0.04
31	5	1	LEFT	21	520	92	SERVICE-I	J	5.62	0.00	0.00	0.00	4.08	0.00	0.00
32	5	1	RIGHT	22	520	85	SERVICE-I	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Contact Information:

- Bridge Software Institute (BSI) 352-392-9537 (ext 1514) Cary Peterson
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- BSI@CE.UFL.EDU
- WWW://BSI-WEB.CE.UFL.EDU