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Project	Date	
2008-66: Knik Arm Bridge Foundations	1/31/09	
Subject	Design	Checked
Report on Drivability & 48" Dia. Pile Design	PED	WWH

This pile design review and drivability submittal is for the use of National Constructors Group as an aid in their evaluation and review of the bridge foundation type presented on the PND Inc. Knik Arm Bridge Crossing Concept drawings dated 5/20/07. To calculate the pile capacity and associated drivability we used geotechnical data presented by Shannon & Wilson Inc. in their report titled Preliminary Geotechnical Report Knik Arm Bridge Project dated 12-2003.

In our review of the proposed PP48x1.5 pipe pile to be installed on 6:12 batters over deep water with 13.5 fps currents and a 29 ft tidal range we have studied the following key issues.

1. Pile type selection of Spin Fin Piles.
2. Corrosion resistance of the steel.
3. Depth of penetration needed to reach sufficient geo-capacity.
4. Drivability of the Spin Fin piles.
5. Recommended hammer for driving long 6:12 batter pile.
6. Ice Loading Conditions.
7. Seismic Loading Conditions.

Selection of Spin Fin Piles for the Foundation Type

We believe the driving will be similar to non-fin pipe pile because during driving the fins can rotate with the 7:1 pitch. When this happens the friction is on the steel fins only and the soil cores through and past the fins. Supplemental fin resistance is the effective end bearing of the fin steel area and the friction in between the fins. After the fins are connected to the structure and fixed against torsion the perimeter of the fins create a box area that provides soil to soil shear resistance.

One problem with Spin Fin pile is that they may disturb the soils above because the fins plow the ground as they are driven. In the literature PND Inc. uses a SPT blow count based empirical formula for the upper side friction/adhesion on the shaft and end bearing on their effective steel area, which is the plan projection of the fin bottom to the top [or vise versa] times the N value based bearing capacity.

Based on our experience and review of papers on the testing and calculating of Spin Fin pile capacity their correlation to test results appear good but inaccurate as to actual load transfer distribution. The empirical static calculation over estimates the end bearing benefit of the fins and under estimates the frictional resistance of the piles. We do not believe the fins provide nearly full end bearing on the donut area. End bearing is limited to the frictional capacity of the soil plug between the fins. The same can be said for the pipe pile itself. End bearing capacity is the lower of either the inside friction or the bottom bearing of the core/plug soils.

The plowing action of the fins appears to reduce the lateral coefficient in sands and other cohesion less soils from K=0.8 to K=0.5. In clays we have experience the alpha factor [α] is reduced measurably. The formulas for friction and adhesion vary by method, and we chose to use the API-RP2A method for this job because it is conservative and easier to understand.

For sands and cohesion less soils: fs=σv'*K*tan(δ)
For clays and cohesive soils: fa= α * Su

K is the lateral coefficient, Su is the undrained shear strength and δ is the soil pile friction angle.

The primary benefit of Spin Fin pile is to shorten the length of tension piles. Non-fin pile resist uplift with outside friction, the pile dead load and the weight of the soil plug. Spin Fin pile reduce the outside friction but more than offset that, with the upward bearing on the top of the fin steel and friction between the fins and around the fins if rotationally restrained.

In compression loading with the large deeply driven pile proposed there is so much inside friction of the pipe pile combined with the outside friction that the benefit of adding fins to the pile is in question. Based on our static capacity calculation for the sand profile at B-A10 the 1700 kip required geo-tension capacity is met at elevation -160 ft for both a straight sided and Spin Fin pile. The geo-compression capacity requirement of 3500 kips is satisfied at this level by both pile. [See pg. 19/95] The fins provide only 300-400 kip or 10% more capacity.

Over on the East Bluff the soil profile is nearly all clay from B-1A eastward toward the bluff. At boring B-1A the profile is all clay and the calculated capacities at elevation -264 ft were 3067 to 3363 kip compression and 3072 to 3363 kip tension. [See pg. 21/95] Bents in this area may need supplemental pile to keep the lengths with-in reason. We made no attempt to reduce the API alpha for the Spin Fin pile in clay as it is our recommendation they not be considered for use in nearly all clay soils or in mixed profiles where the fins bear in clay. We see no benefit and only potential capacity problems for Spin Fin pile in clays.

The pile will need to have templates and guide sleeves to be driven in the deep fast flow waters. Fins add difficulty to pitching the pile and setting into the guide sleeves.

The current sawhorse bent batter pile configuration adds a lot of torque to the piles. This is a good reason to consider using the Spin Fin pile in granular cohesion less soil locations.

Corrosion Resistance of the Steel

Review of the literature on the subject indicates the normal rate of corrosion for silted, cold and dissolved oxygen rich seawater is on the order of 0.3 mm/yr [12 mil/yr] per year in the tidal zone. For axial load alone the pile needs 111 in^2 area to satisfy the design service loads of 1690 kip compression and 827 kip tension. At the above given rate the inside of the pile needs to be free of oxygen, as it will be if filled with concrete as currently planned and it will need supplemental cathotic protection. Since anodes get knocked off by ice and coatings are susceptible to abrasion that leaves impressed current as the likely best method. For a 75 yr life the 12 mils/yr cuts the pile down to 111 In^2 in 60 years so the remaining 15 years needs to be addressed. In Tomlinson's book he quotes Hedborg who said a rate of 0.88 mm/yr has been observed on a platform at Cook Inlet, Alaska.

Another solution is to reduce the outer wall thickness to the minimum allowed for hard sustained driving which is 7/8” {OD/100+0.25”, API-RP2A}. The area reduction reduces the pile impedance EA/c so for example the IHC S-500 reaches >300 bpf at 250 ft pile length vs. 270 ft length with a 1.5 inch wall pile. It would still need to be corrosion protected to a thickness needed to provide core concrete with good confinement. The core could be reinforced with a composite structural section such as a box beam or pipe insert that would be protected by the confined concrete for against corrosion. On steep batters a structural section is preferable to rebar cages. The embedded lower section of the pile will not corrode as much so it can be designed for 1/8” corrosion on the OD so a 1 inch wall will work, depending on the final design requirement. The piles have bending about both axis and surprisingly high torsion based on this study which all need consideration in conjunction with steel cost and corrosion resistance design.

Depth of penetration needed to reach sufficient geo-capacity

The piles near boring B-A10 will need to be driven to tip elevation -160 ft resulting in a total 267 ft pile length. The pile near B-A1 need to be driven to deeper than tip elevation -264 ft resulting in a pile length in excess of 383 ft. The solution for those bents is more piles with less loading.

Drivability of the Spin Fin piles

The APE D180 and D225 diesel hammers will drive the pile to 240 and 250 ft diagonal length before reaching refusal blow counts of 240 bpf for not more than one foot at the end of initial driving respectively. [Elev. -135 to -145 ft] After setup the maximum capacity the hammers can achieve is 3000 and 3475 kip respectively.

The IHC S500 and MHU 500T hydraulic hammers will drive the pile to 275 and 300 ft diagonal lengths before reaching refusal blowcounts >400 bpf at the end of initial driving respectively. [Elev.-165 to -185 ft] After setup the maximum capacity the hammers can achieve is 3000 and 4730 kip respectively. Therefore the MHU 500T which was used on both the Benicia and the Bay Bridges by Kiewit is the proper hammer size to consider for constructability. The D180 is available for rent and is used on Bridges in west Canada presently. However the loading requirement and penetration depths will need some reduction before that hammer can be considered a candidate for the whole job.

One way to supplement penetration with the D180 that we designed for Wakota Bridge in St Paul, Mn. and for the Arco Berthing facility in Pueget Sound is to install fixed jets terminating above the tip so as not to disturb the outside friction but to enable loosening of the pile core/plug soils. That will get the pile to tip. Then to prove capacity restrike testing can be done using the D180 with special fuel injection to get a bigger stroke out of the hammer for a blow or two, which is all the PDA tester needs. This way the smaller hammer can get the pile to tip and it can prove the high capacity is achieved upon setup.

We initially considered a Delmag D200, but upon review of the hammer data sheet we learned it is not rated for more than a 4:12 batter. This previously largest diesel hammer was designed to have a heavier ram but needed to be no longer than the D100 or D160 to be compatible with some of the offshore platform work in the Gulf of Mexico. This meant a larger ram diameter was needed and on occasion the additional heat expansion radially caused siezing in the cylinder. This is probably why it has a lower batter angle rating than the other similar hammers. Could be even more problematic in Alaska. The D180 is working fine on Frazier River Canada in -10^{o} F per Dave Yingling of APE who is the technical support for Kiewit on that project currently.

Recommended hammer for driving long 6:12 batter pile

Based on the current design loads and pile details we recommend the MHU 500T.

Ice Loading Conditions

We reviewed a lot of literature in deciding what to use for the compression strength of the ice. On the Cook Inlet pier project designed and built by BCG Construction Mr Fotinos indicated they used 300 psi. In the AASHTO 300 psi is used for ice where at breakup initial movement of the ice sheet as a whole or where large sheets of sound ice may strike the piles. The batter pile slope reduction factor of 0.75 reduces the 300 psi to 225 psi contact pressure. This is in line with reported measured ice forces in the Cook Inlet for 1 ft thick ice where the contact pressure were 120-255 psi on 3 ft diameter piles. Also at Port Mackenzie PND Inc. reported the batter pile put the ice into flexural failure mode vs. crushing mode with vertical piles. Their design load of 250 kips per pile for 3 ft trestle piles ratios up to the 388 kip/pile we get for the 4 ft pile in the same body of water.

Wind forces, vortex shedding and eddies can cause the ice to floe in the longitudinal direction for the bridge. To account for this we arbitrarily used 30% of the transverse forces based on our study on the subject.

By our structural analysis calculation in Robot 21 we calculate 18” of unrestrained longitudinal deflection unless the superstructure can be designed to resist the movement and can transfer the forces to the abutments.

Seismic Loading Conditions

The bridge is sandwiched between two faults on each side of the Knik Arm. Nearby Port Mackenzie trestle is reportedly designed for 1g initially, then they reduced the design to 0.38g because of the soft response [4-6% of pile diameter] of the Spin Fin pile when designed for a large end bearing load distribution. Considering most bridge criteria will not accept deflection of greater than ½” at service load levels we used 1 g 100% transverse and 30% longitudinal in our structural modeling for determination of pile loading for this study.

PP48x1.5 Drivability Analysis - Table of Contents

Geometric & Geotechnical Information:

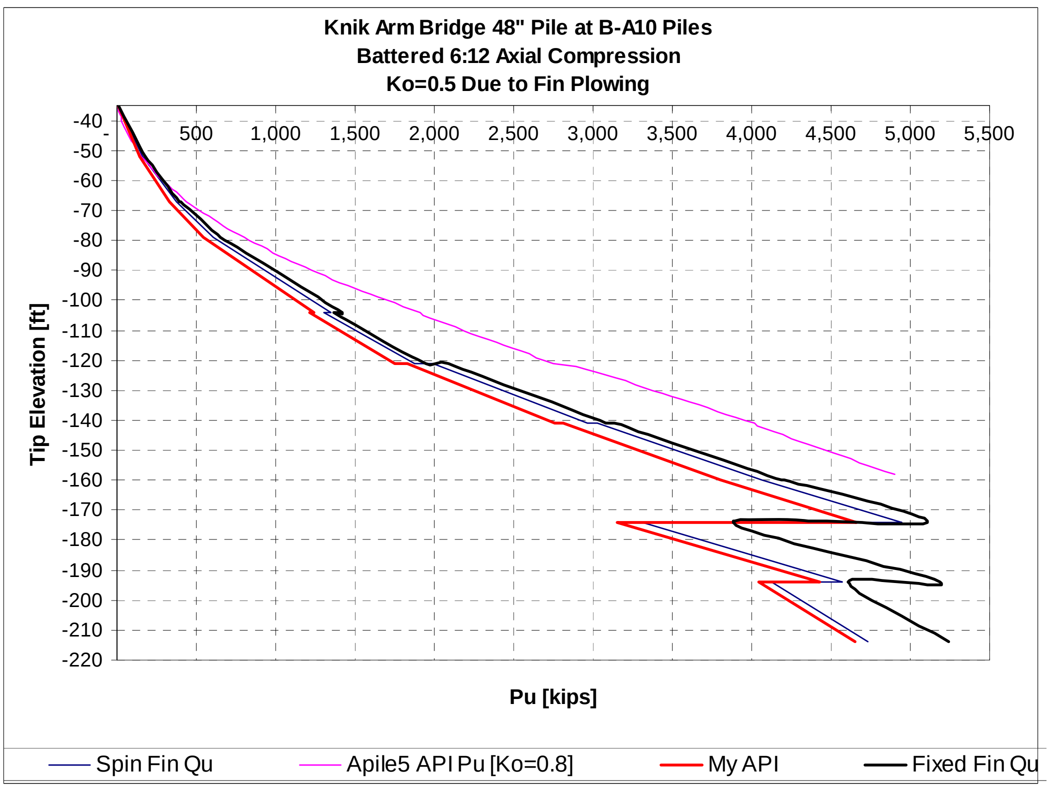
Spin Fin Pile Tests and Static Calculation Calibration for API method:

Boring B – A10 Soil Conditions

Required Geo-Capacity will be approximately 2.25*1556 = 3500 kips. At boring B-A10 the capacity with spin fin on PP48x1.5 is reached at tip elevation -145 to -155 ft. That corresponds to a total diagonal pile length of 250 ft to 260 ft. We evaluated operation of four hammers two diesel and two hydraulic.

The APE D180 and D225 diesel hammers will drive the pile to 240 and 250 ft diagonal lengths before reaching refusal blowcounts of 240 bpf for not more than one foot at the end of initial driving respectively. [Elev. -135 to -145 ft] After setup the maximum capacity the hammers can achieve is 3000 and 3475 kip respectively.

The IHC S500 and MHU 500T hydraulic hammers will drive the pile to 275 and 300 ft diagonal lengths before reaching refusal blowcounts >400 bpf at the end of initial driving respectively.
[Elev.-165 to -185 ft] After setup the maximum capacity the hammers can achieve is 3000 and 4730 kip respectively. Therefore the MHU 500T which was used on both the Benicia and the Bay Bridges by Kiewit is the proper hammer size to consider for constructability. The D180 is available for rent and is used on Bridges in west Canada presently. However the loading requirement and penetration depths will need some reduction before that hammer can be considered a candidate for the whole job.



When we calibrate our API method to the spin fin pile test results we found the Ko lateral coefficient of 0.5 does a better job of calibrating than the recommended Ko=0.8. We believe this is because the spin fin plows the soils and reduces friction on the shaft above the fins. It appears the fins increase the compression capacity of a non-fin pile by 200 – 350 kips. This is a relatively small percentage increase for high capacity pile, but can be a higher increase percentage wise with normal 400 to 600 kip pile capacity ranges.

Boring B – A10 Soil Conditions

APE D180-42 OED Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=435 k-ft. Wr= 39.65 k, Smax=10.68 ft variable stroke. At 6:12 Batter standard 0.80 efficiency for ram friction is reduced to [0.80-0.089]=0.71, Smax is reduced to 0.89*10.68 = 9.77 ft and the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. Near direct impact using steel striker plate & no hammer cushion per APE practice. **Total hammer hoisting weight is 69 tons**.

We had to change from a D200 by Pileco to the D180 by APE because the D200 maximum batter is 4:12. Per APE the 6:12 batter is in the operational range of their hammers. The D200 was designed with a larger diameter ram that is shorter but heavier. This ram can sometimes expand too much and sieze in the cylinder, so it is not suited for steeper batter driving.

Ben C. Gerwick, Inc. Jan 28 2009
D180-42 -PP48x1.5- B-A10, L300' GRLWEAP(TM) Version 2005

Gain/Loss 1 at Shaft and Toe 0.830 / 0.850

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	79.1	78.2	0.9	0.0	0.000	0.000	9.77	0.0
126.0	160.5	78.9	81.6	0.0	0.000	0.000	9.77	0.0
150.0	240.3	131.5	108.8	1.7	21.044	-12.225	7.21	211.6
155.0	295.1	152.3	142.8	2.1	21.374	-11.862	7.32	206.8
160.0	354.2	177.4	176.8	2.6	21.515	-11.170	7.36	202.4
170.0	507.2	242.0	265.2	4.9	22.281	-9.960	7.56	189.1
175.0	595.3	281.7	313.6	6.5	22.543	-9.399	7.67	184.0
185.0	835.1	376.1	459.0	11.2	22.951	-7.963	7.83	178.5
195.0	1109.5	492.4	617.1	17.9	23.505	-6.470	8.07	177.5
205.0	1405.9	630.7	775.2	28.7	23.658	-5.000	8.13	174.1
210.0	1544.8	705.0	839.8	34.2	23.822	-4.445	8.20	175.3
220.0	1897.4	864.6	1032.7	51.8	24.071	-3.210	8.31	177.2
230.0	2347.9	1061.8	1286.0	80.9	24.309	-1.913	8.42	179.0
240.0	2866.5	1296.6	1569.9	147.4	24.519	-1.920	8.51	180.3
250.0	3395.5	1545.9	1849.6	433.7	24.694	-2.419	8.59	181.4
260.0	3976.5	1809.9	2166.6	9999.0	24.836	-2.609	8.65	182.1
270.0	4569.3	2105.1	2464.1	9999.0	24.979	-2.568	8.71	182.7
285.0	3636.3	2712.3	924.0	9999.0	25.017	-2.745	8.71	181.4
300.0	4360.9	3436.9	924.0	9999.0	25.231	-2.723	8.79	181.6

Refusal occurred; no driving time output possible

Gain/Loss 2 at Shaft and Toe 1.000 / 1.000

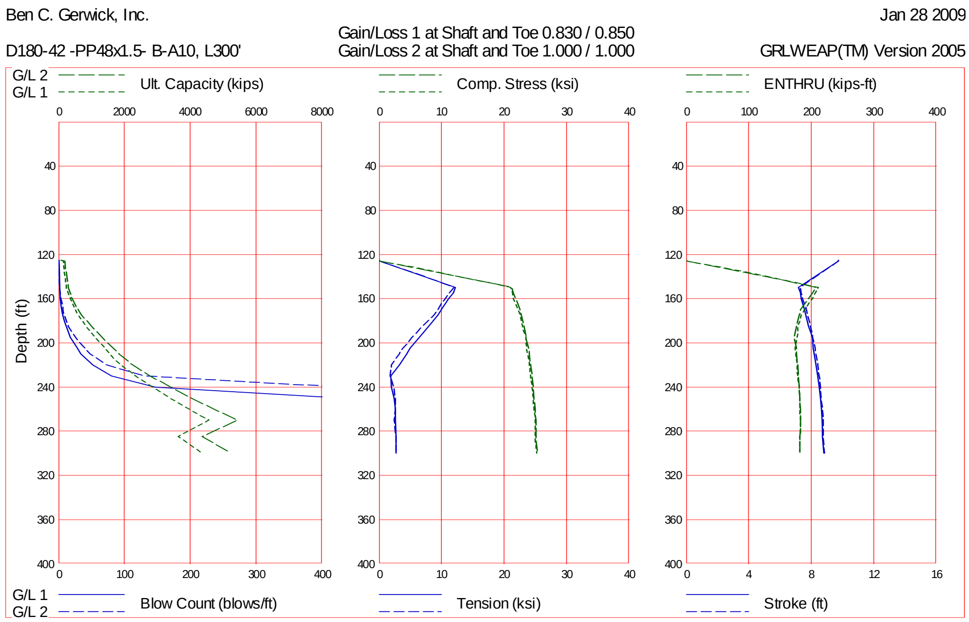
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	95.3	94.3	1.0	0.0	0.000	0.000	9.77	0.0
126.0	191.0	95.0	96.0	0.0	0.000	0.000	9.77	0.0
150.0	286.4	158.4	128.0	2.0	21.317	-11.966	7.30	207.4
155.0	351.5	183.5	168.0	2.6	21.512	-11.227	7.36	202.5
160.0	421.7	213.7	208.0	3.5	21.886	-10.615	7.45	195.3
170.0	603.6	291.6	312.0	6.7	22.585	-9.401	7.68	183.1
175.0	708.4	339.4	369.0	9.0	22.778	-8.771	7.76	180.5
185.0	993.1	453.1	540.0	14.7	23.244	-7.029	7.95	176.9
195.0	1319.3	593.3	726.0	25.7	23.546	-5.304	8.08	173.7
205.0	1671.9	759.9	912.0	40.2	23.923	-3.819	8.25	176.1
210.0	1837.4	849.4	988.0	48.5	24.024	-3.228	8.30	176.8
220.0	2256.7	1041.7	1215.0	73.4	24.285	-2.022	8.41	178.7
230.0	2792.3	1279.3	1513.0	132.0	24.493	-1.730	8.50	180.1
240.0	3409.1	1562.1	1847.0	446.4	24.674	-2.386	8.58	181.3
250.0	4038.6	1862.6	2176.0	9999.0	24.846	-2.635	8.65	182.3
260.0	4729.6	2180.6	2549.0	9999.0	24.988	-2.586	8.72	182.9
270.0	5435.3	2536.3	2899.0	9999.0	25.075	-2.398	8.75	182.9
285.0	4354.9	3267.9	1087.0	9999.0	25.159	-2.750	8.78	182.0
300.0	5227.9	4140.9	1087.0	9999.0	25.364	-2.764	8.85	182.0

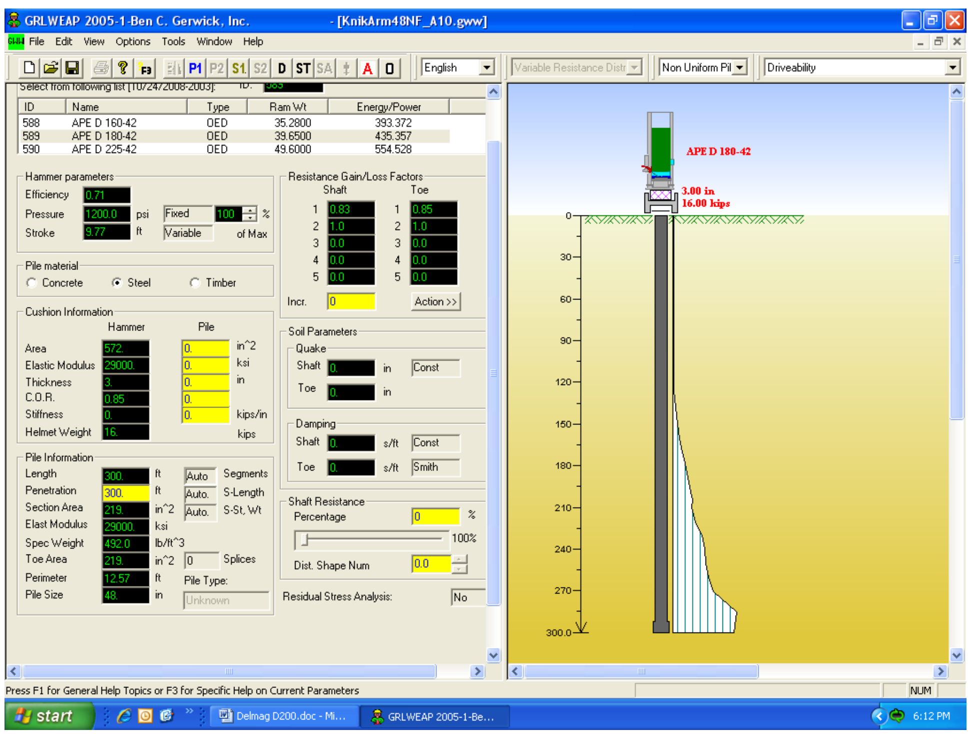
Refusal occurred; no driving time output possible

D180 Refusal is 20 bpi for 1 ft or less ---→ Qbor = 3000 kips

Boring B – A10 Soil Conditions

APE D180-42 OED Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=435 k-ft. Wr= 39.65 k, Smax=10.68 ft variable stroke. At 6:12 Batter standard 0.80 efficiency for ram friction is reduced to [0.80-0.089]=0.71, Smax is reduced to 0.89*10.68 = 9.77 ft and the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. Near direct impact using steel striker plate & no hammer cushion per APE practice. **Total hammer hoisting weight is 69 tons**.





Boring B – A10 Soil Conditions

APE D225-42 OED Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=555 k-ft. Wr= 49.6 k, Smax=10.68 ft variable stroke. At 6:12 Batter standard 0.80 efficiency for ram friction is reduced to [0.80-0.089]=0.71, Smax is reduced to 0.89*11.18 = 9.95 ft and the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. Near direct impact using steel striker plate & no hammer cushion per APE practice. **Total hammer hoisting weight is 76.4 tons**.

Ben C. Gerwick, Inc. Jan 28 2009
D225-42 -PP48x1.5- B-A10, L300' GRLWEAP(TM) Version 2005

Gain/Loss 1 at Shaft and Toe 0.830 / 0.850

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	79.1	78.2	0.9	0.0	0.000	0.000	9.95	0.0
126.0	160.5	78.9	81.6	0.0	0.000	0.000	9.95	0.0
150.0	240.3	131.5	108.8	1.4	20.576	-11.544	6.79	274.5
155.0	295.1	152.3	142.8	1.7	21.205	-11.379	6.95	268.4
160.0	354.2	177.4	176.8	2.0	21.444	-10.825	7.01	262.1
170.0	507.2	242.0	265.2	3.5	22.122	-9.316	7.11	243.2
175.0	595.3	281.7	313.6	4.6	22.649	-8.723	7.29	238.9
185.0	835.1	376.1	459.0	8.2	23.061	-7.112	7.41	226.9
195.0	1109.5	492.4	617.1	12.4	23.631	-5.722	7.62	222.9
205.0	1405.9	630.7	775.2	18.3	24.142	-4.361	7.81	221.1
210.0	1544.8	705.0	839.8	21.2	24.352	-3.820	7.88	222.0
220.0	1897.4	864.6	1032.7	31.4	24.708	-2.586	8.02	224.9
230.0	2347.9	1061.8	1286.0	51.8	25.108	-1.307	8.18	228.5
240.0	2866.5	1296.6	1569.9	86.6	25.307	-1.974	8.25	229.6
250.0	3395.5	1545.9	1849.6	160.7	25.569	-2.570	8.35	231.6
260.0	3976.5	1809.9	2166.6	681.0	25.777	-2.987	8.43	232.7
270.0	4569.3	2105.1	2464.1	9999.0	25.978	-3.152	8.51	233.9
285.0	3636.3	2712.3	924.0	1455.2	26.078	-3.105	8.54	232.5
300.0	4360.9	3436.9	924.0	9999.0	26.389	-2.687	8.64	233.3

Refusal occurred; no driving time output possible

Gain/Loss 2 at Shaft and Toe 1.000 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	95.3	94.3	1.0	0.0	0.000	0.000	9.95	0.0
126.0	191.0	95.0	96.0	0.0	0.000	0.000	9.95	0.0
150.0	286.4	158.4	128.0	1.6	21.147	-11.463	6.93	269.3
155.0	351.5	183.5	168.0	2.0	21.416	-10.874	7.01	262.0
160.0	421.7	213.7	208.0	2.6	21.784	-10.165	7.07	255.0
170.0	603.6	291.6	312.0	4.8	22.519	-8.627	7.23	235.9
175.0	708.4	339.4	369.0	6.1	22.827	-7.934	7.33	230.2
185.0	993.1	453.1	540.0	10.5	23.396	-6.306	7.53	223.7
195.0	1319.3	593.3	726.0	16.6	24.039	-4.673	7.77	221.8
205.0	1671.9	759.9	912.0	24.3	24.505	-3.192	7.95	223.2
210.0	1837.4	849.4	988.0	29.2	24.665	-2.611	8.00	224.4
220.0	2256.7	1041.7	1215.0	46.5	25.107	-1.433	8.18	228.7
230.0	2792.3	1279.3	1513.0	80.0	25.267	-1.819	8.23	229.3
240.0	3409.1	1562.1	1847.0	162.9	25.547	-2.517	8.34	231.4
250.0	4038.6	1862.6	2176.0	906.2	25.766	-3.029	8.43	232.8
260.0	4729.6	2180.6	2549.0	9999.0	25.993	-3.246	8.51	234.4
270.0	5435.3	2536.3	2899.0	9999.0	26.173	-3.149	8.58	235.2
285.0	4354.9	3267.9	1087.0	9999.0	26.293	-3.014	8.62	233.8
300.0	5227.9	4140.9	1087.0	9999.0	26.599	-2.754	8.71	234.1

Refusal occurred; no driving time output possible

D225 Refusal is 20 bpi for 1 ft or less ---→ Qbor = 3475 kips

Boring B – A10 Soil Conditions

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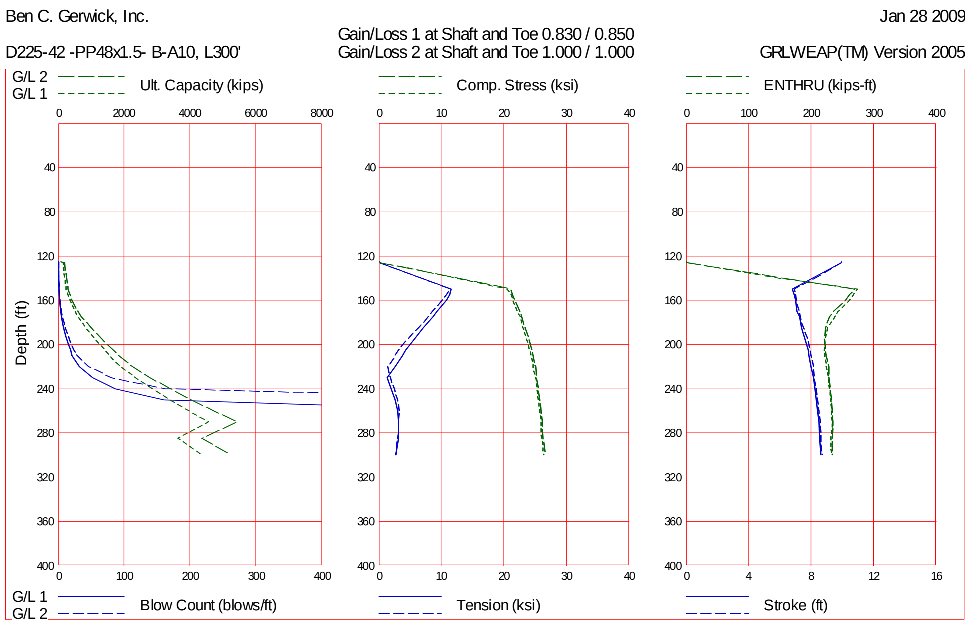
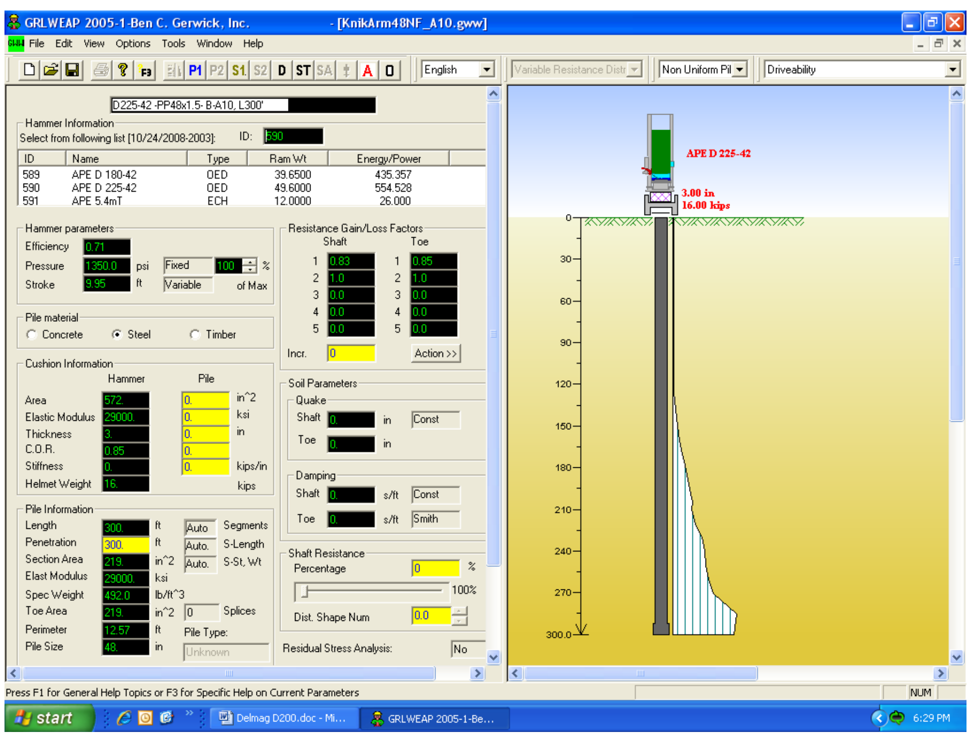




Boring B – A10 Soil Conditions

IHC S-500 ECH Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=366 k-ft. Wr= 55.3 k, S=6.62 ft fixed. At 6:12 Batter standard 0.95 efficiency for ram friction is reduced to [0.95-0.089]*0.89=0.77, the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. **Total hammer hoisting weight is 66 tons.**

Ben C. Gerwick, Inc. Jan 28 2009
IHC S-500 -PP48x1.5- B-A10, L300' GRLWEAP(TM) Version 2005

Gain/Loss 1 at Shaft and Toe 0.830 / 0.850

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	79.1	78.2	0.9	0.0	0.000	0.000	6.62	0.0
126.0	160.5	78.9	81.6	0.0	0.000	0.000	6.62	0.0
150.0	240.3	131.5	108.8	0.0	0.000	0.000	6.62	0.0
155.0	295.1	152.3	142.8	5.2	27.511	-19.025	6.62	276.9
160.0	354.2	177.4	176.8	5.9	27.511	-18.062	6.62	276.9
170.0	507.2	242.0	265.2	7.0	27.511	-16.112	6.62	276.9
175.0	595.3	281.7	313.6	7.2	27.511	-15.085	6.62	276.9
185.0	835.1	376.1	459.0	10.1	27.511	-12.477	6.62	276.9
195.0	1109.5	492.4	617.1	14.2	27.511	-9.866	6.62	276.9
205.0	1405.9	630.7	775.2	18.7	27.511	-7.482	6.62	276.9
210.0	1544.8	705.0	839.8	20.5	27.511	-6.614	6.62	276.9
220.0	1897.4	864.6	1032.7	25.9	27.511	-4.665	6.62	276.9
230.0	2347.9	1061.8	1286.0	35.5	27.511	-3.272	6.62	276.9
240.0	2866.5	1296.6	1569.9	52.3	27.511	-3.913	6.62	276.9
250.0	3395.5	1545.9	1849.6	78.9	27.511	-4.379	6.62	276.9
260.0	3976.5	1809.9	2166.6	138.2	27.511	-4.536	6.62	276.8
270.0	4569.3	2105.1	2464.1	377.3	27.511	-4.586	6.62	276.8
285.0	3636.3	2712.3	924.0	129.2	27.530	-2.941	6.62	276.8
300.0	4360.9	3436.9	924.0	1286.7	27.507	-3.539	6.62	276.6

Total Number of Blows: 20326

Driving Time (min):	677	508	406	338	290	254	225	203	184	169
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

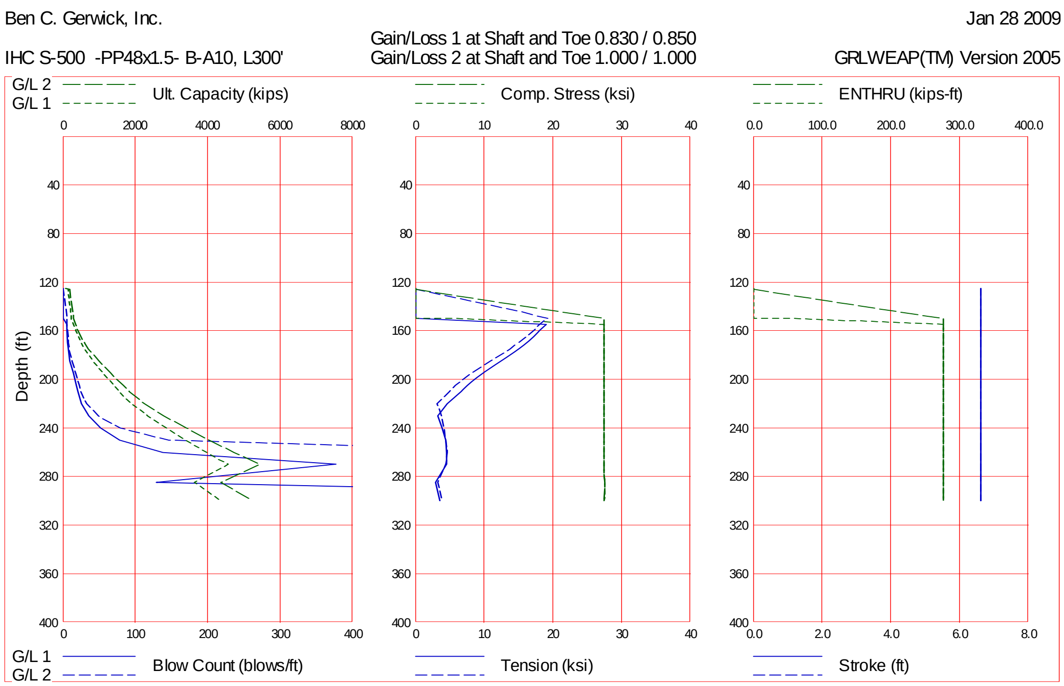
Gain/Loss 2 at Shaft and Toe 1.000 / 1.000

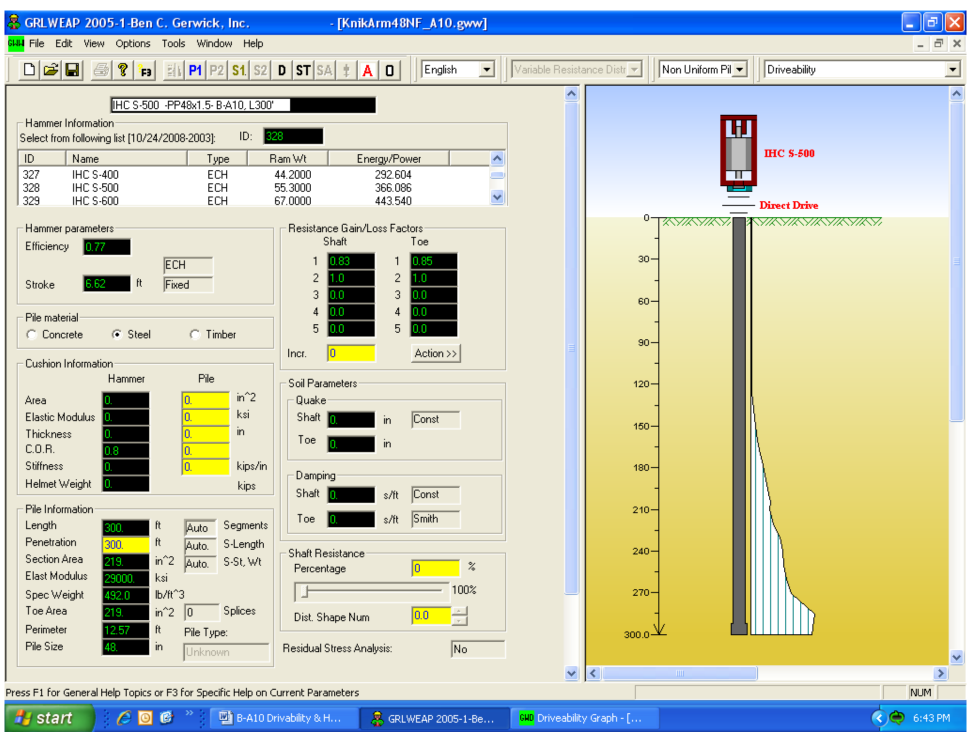
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	95.3	94.3	1.0	0.0	0.000	0.000	6.62	0.0
126.0	191.0	95.0	96.0	0.0	0.000	0.000	6.62	0.0
150.0	286.4	158.4	128.0	5.1	27.511	-19.219	6.62	276.9
155.0	351.5	183.5	168.0	5.9	27.511	-18.133	6.62	276.9
160.0	421.7	213.7	208.0	6.7	27.511	-17.192	6.62	276.9
170.0	603.6	291.6	312.0	7.3	27.511	-14.962	6.62	276.9
175.0	708.4	339.4	369.0	8.5	27.511	-13.761	6.62	276.9
185.0	993.1	453.1	540.0	12.3	27.511	-10.889	6.62	276.9
195.0	1319.3	593.3	726.0	17.6	27.511	-8.142	6.62	276.9
205.0	1671.9	759.9	912.0	22.3	27.511	-5.840	6.62	276.9
210.0	1837.4	849.4	988.0	24.8	27.511	-4.952	6.62	276.9
220.0	2256.7	1041.7	1215.0	33.1	27.511	-3.197	6.62	276.9
230.0	2792.3	1279.3	1513.0	49.2	27.511	-3.770	6.62	276.9
240.0	3409.1	1562.1	1847.0	79.3	27.511	-4.238	6.62	276.8
250.0	4038.6	1862.6	2176.0	146.2	27.511	-4.413	6.62	276.8
260.0	4729.6	2180.6	2549.0	621.4	27.511	-4.633	6.62	276.8
270.0	5435.3	2536.3	2899.0	9999.0	27.511	-4.469	6.62	276.8
285.0	4354.9	3267.9	1087.0	9999.0	27.533	-3.264	6.62	276.8
300.0	5227.9	4140.9	1087.0	9999.0	27.509	-3.851	6.62	276.5

Refusal occurred; no driving time output possible

Boring B – A10 Soil Conditions

IHC S-500 ECH Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=366 k-ft. Wr= 55.3 k, S=6.62 ft fixed. At 6:12 Batter standard 0.95 efficiency for ram friction is reduced to [0.95-0.089]*0.89=0.77, the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. **Total hammer hoisting weight is 66 tons.**





Boring B – A10 Soil Conditions

Menck MHU 500T ECH Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=406 k-ft. Wr= 66 k, S=6.15 ft fixed. At 6:12 Batter standard 0.95 efficiency for ram friction is reduced to [0.95-0.089]*0.89=0.77, the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. **Total hammer hoisting weight is 88.2 tons**.

Ben C. Gerwick, Inc. Jan 28 2009
MHU 500T-PP48x1.5- B-A10, L300' GRLWEAP(TM) Version 2005

Gain/Loss 1 at Shaft and Toe 0.830 / 0.850

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	79.1	78.2	0.9	0.0	0.000	0.000	6.15	0.0
126.0	160.5	78.9	81.6	0.0	0.000	0.000	6.15	0.0
150.0	240.3	131.5	108.8	0.0	0.000	0.000	6.15	0.0
155.0	295.1	152.3	142.8	4.7	27.063	-19.195	6.15	307.4
160.0	354.2	177.4	176.8	5.2	27.055	-18.222	6.15	307.4
170.0	507.2	242.0	265.2	6.6	27.058	-16.257	6.15	307.4
175.0	595.3	281.7	313.6	7.0	27.040	-15.142	6.15	307.4
185.0	835.1	376.1	459.0	8.8	27.027	-12.425	6.15	307.4
195.0	1109.5	492.4	617.1	12.3	27.007	-9.820	6.15	307.3
205.0	1405.9	630.7	775.2	16.2	26.965	-7.463	6.15	307.3
210.0	1544.8	705.0	839.8	17.8	26.950	-6.517	6.15	307.3
220.0	1897.4	864.6	1032.7	22.6	26.902	-4.512	6.15	307.3
230.0	2347.9	1061.8	1286.0	30.9	26.835	-3.151	6.15	307.3
240.0	2866.5	1296.6	1569.9	45.4	26.770	-3.741	6.15	307.3
250.0	3395.5	1545.9	1849.6	69.2	26.705	-3.896	6.15	307.3
260.0	3976.5	1809.9	2166.6	116.1	26.641	-4.071	6.15	307.3
270.0	4569.3	2105.1	2464.1	270.3	26.577	-4.274	6.15	307.3
285.0	3636.3	2712.3	924.0	102.4	26.481	-2.967	6.15	307.3
300.0	4360.9	3436.9	924.0	505.8	26.397	-2.904	6.15	307.0

Total Number of Blows: 12179

Driving Time (min):	405	304	243	202	173	152	135	121	110	101
@Blow Rate (b/min):	30	40	50	60	70	80	90	100	110	120

Driving Time for continuously running hammer; any wait times not included

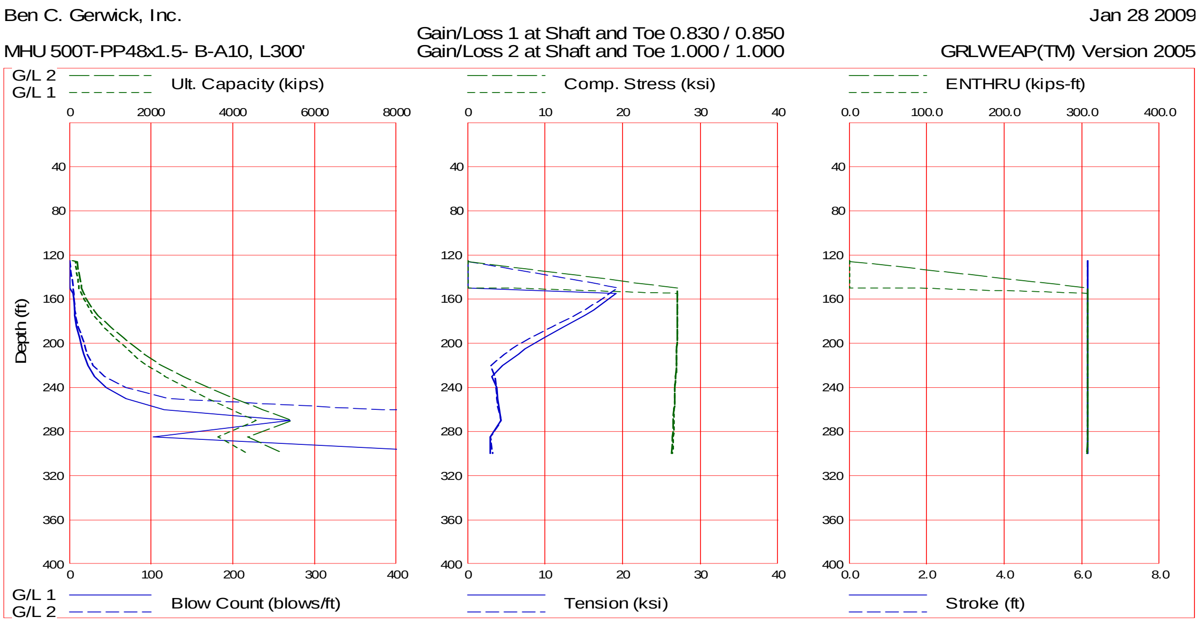
Gain/Loss 2 at Shaft and Toe 1.000 / 1.000

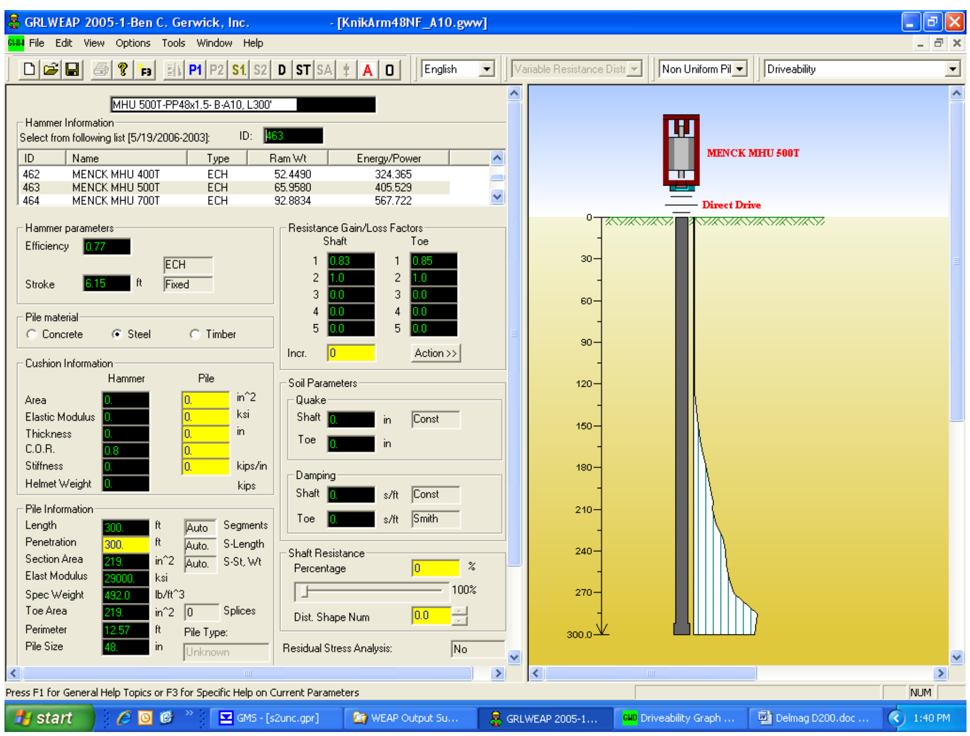
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
125.0	95.3	94.3	1.0	0.0	0.000	0.000	6.15	0.0
126.0	191.0	95.0	96.0	0.0	0.000	0.000	6.15	0.0
150.0	286.4	158.4	128.0	4.5	27.078	-19.365	6.15	307.4
155.0	351.5	183.5	168.0	5.2	27.069	-18.276	6.15	307.4
160.0	421.7	213.7	208.0	5.9	27.062	-17.324	6.15	307.4
170.0	603.6	291.6	312.0	7.0	27.065	-15.055	6.15	307.4
175.0	708.4	339.4	369.0	7.4	27.045	-13.811	6.15	307.4
185.0	993.1	453.1	540.0	10.7	27.033	-10.889	6.15	307.3
195.0	1319.3	593.3	726.0	15.3	27.013	-8.108	6.15	307.3
205.0	1671.9	759.9	912.0	19.4	26.970	-5.735	6.15	307.3
210.0	1837.4	849.4	988.0	21.6	26.952	-4.772	6.15	307.3
220.0	2256.7	1041.7	1215.0	28.9	26.908	-3.087	6.15	307.3
230.0	2792.3	1279.3	1513.0	42.7	26.836	-3.609	6.15	307.3
240.0	3409.1	1562.1	1847.0	69.5	26.757	-3.670	6.15	307.3
250.0	4038.6	1862.6	2176.0	122.0	26.679	-3.794	6.15	307.3
260.0	4729.6	2180.6	2549.0	383.6	26.602	-4.045	6.15	307.3
270.0	5435.3	2536.3	2899.0	9999.0	26.524	-4.284	6.15	307.3
285.0	4354.9	3267.9	1087.0	720.2	26.409	-2.978	6.15	307.3
300.0	5227.9	4140.9	1087.0	9999.0	26.307	-3.277	6.15	307.0

Refusal occurred; no driving time output possible

Boring B – A10 Soil Conditions

Menck MHU 500T ECH Driving PP48x1.5 L300, D175 Spin Fin Pile, Rated E=406 k-ft. Wr= 66 k, S=6.15 ft fixed. At 6:12 Batter standard 0.95 efficiency for ram friction is reduced to [0.95-0.089]*0.89=0.77, the pile and hammer gravity values are reduced by the cosine of the batter angle to 28.77 g. **Total hammer hoisting weight is 88.2 tons.**





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Input  File: C:\PROGRAM FILES\ENSOFT\APILEP5\EXAMPLES\KNIKARM48NF_A10.GWI
Hammer File: C:\Program Files\PDI\GRLWEAP 2005\HAMMER2003.GW
Hammer File Version:  2003 (10/24/2008)

                       Input File Contents
    IHC S-500  -PP48x1.5- B-A10, L300'
OUT OSG HAM STR FUL PEL  N SPL N-U P-D %SK ISM  0 PHI RSA ITR H-D MXT     DEx
-100   0 328   0   1   0  0   0   1   3   0   1  0   0   0   0   0   0   0.000
   Pile g  Hammer g  Toe Area Pile Size           Pile Type
   28.770    28.770   219.000   48.000              Unknown
     W Cp      A Cp      E Cp      T Cp       CoR      ROut      StCp
    0.000     0.000       0.0     0.000     0.800     0.010       0.0
     A Cu      E Cu      T Cu       CoR      ROut      StCu
    0.000       0.0     0.000     0.000     0.000       0.0
     LPle      APle      EPle      WPle      Peri      Strg       CoR      ROut
  300.000   219.000 29000.000   492.000    12.570    50.000     1.000     0.010
  292.000   219.000 29000.000   492.000    12.570    50.000
  292.000   309.000 29000.000   492.000    12.570    50.000
  300.000   309.000 29000.000   492.000    12.570    50.000
Manufac  Hmr Name  HmrType No Seg-s
IHC      S-500           3       9
   Ram Wt     Ram L   Ram Dia   MaxStrk   RtdStrk    Efficy
    55.30    324.70     27.60      6.62      6.62      0.95
   No. Assmbly Segs
                 2
 <----  Assembly Masses ----><----Assembly Stiffnesses---->
   34.180    34.180     0.000  170878.0  170878.0       0.0
 Non-Uni Ram Weights,   Stiffn.
        1     1.667  136306.0
        2     1.667  136306.0
        3     1.667  136306.0
        4    14.238  899162.0
        5    14.238  899162.0
        6    14.238  899162.0
        7     2.528  257862.0
        8     2.528  257862.0
        9     2.528  257862.0
   Stroke    Effic.  Pressure  R-Weight   T-Delay Exp-Coeff   Eps-Str  Total-AW
   6.6200    0.7700 1350.0000    0.0000    0.0000    0.0000    0.0000    0.0000
       Qs        Qt        Js        Jt        Qx        Jx      Rati      Dept
    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
 Research Soil Model: Atoe, Plug,  Gap, Q-fac
    0.000     0.000     0.000     0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
    0.000     0.000     0.000     0.000
 Res. Distribution
   Dpth    Rskn    Rtoe      Qs      Qt      Js      Jt    SU F    LimD    SU T
   0.00    0.06    1.00    0.10    0.00    0.20    0.00    1.00    0.00    1.00
 125.00    0.06    1.00    0.10    0.00    0.20    0.00    1.00    0.00    6.60
 126.00    0.06   96.00    0.10    0.60    0.20    0.15    1.00    0.00    6.60
 150.00    0.36  128.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 155.00    0.44  168.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 160.00    0.52  208.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 170.00    0.72  312.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 175.00    0.80  369.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 185.00    1.01  540.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 195.00    1.22  726.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 205.00    1.43  912.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 210.00    1.42  988.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 220.00    1.64 1215.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 230.00    2.14 1513.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 240.00    2.36 1847.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 250.00    2.42 2176.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 260.00    2.64 2549.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 270.00    3.02 2899.00    0.10    0.48    0.20    0.15    1.00    0.00    1.00
 285.00    4.74 1087.00    0.10    0.85    0.20    0.15    1.00    0.00    1.00
 300.00    4.52 1087.00    0.10    0.85    0.20    0.15    1.00    0.00    1.00
```

MHU 500T
W_r = 66 k
E_r = 406 k-FT

IHC S-500
W_r = 55.3 k
E_r = 366 k-FT

Table of Efficiency Reductions for Battered Pile Driving

Instructions:

- If the hammer has internal ram velocity monitoring, no friction losses or stroke reductions should be used. Because the measured impact velocity is used to control the nominal energy delivered to the pile, losses are internally corrected by the hammer operating system.
- For other hammer types, use the standard efficiency and subtract from it the Friction Loss for appropriate friction factor (0.1 well greased) to yield a new, reduced efficiency.
- For hammers with fixed strokes, i.e., External Combustion Hammers (those without internal ram velocity monitoring) multiply the reduced efficiency with Stroke Reduction to yield the efficiency that may be used as an input in **Options**, Hammer Parameters.
- The pile and hammer gravity values should also be multiplied by the cosine of the batter angle (the same as the Stroke Reduction) to better model the static weight of the pile and hammer in the direction of the pile's axis.

				Friction Losses for Friction Factors		
Batter X : 12	Batter 1 : Y	Angle Degree	Stroke Reduction	0.1	0.2	0.3
1 : 12	1 : 12	4.76	1.00	0.008	0.017	0.025
	1 : 8	7.13	0.99	0.012	0.024	0.037
2 : 12	1 : 6	9.46	0.99	0.016	0.033	0.049
	1 : 5	11.31	0.98	0.020	0.039	0.059
2.5 : 12		11.77	0.98	0.020	0.041	0.061
3 : 12	1 : 4	14.04	0.97	0.024	0.049	0.073
[illegible] : 12		16.26	0.96	0.028	0.056	0.084
4 : 12	1 : 3	18.43	0.95	0.032	0.063	0.095
5 : 12		22.62	0.92	0.039	0.077	0.115
6 : 12	1 : 2	26.56	0.89	0.045	0.089	0.134
8 : 12		33.69	0.83	0.056	0.111	0.167
9 : 12		36.87	0.8	0.060	0.120	0.180
10 : 12		39.81	0.77	0.064	0.128	0.192
11 : 12		42.51	0.74	0.068	0.135	0.203
12 : 12	1 : 1	45.00	0.71	0.071	0.141	0.212

MONITOR (DIRECT)

11' VERT STROKE

180 ON FRASER RIVER w/
└ TEMP -10°F OK.

N = 20 bpi @ 1"
– N = 15 bpi @ 3"
BRENT ROBERTS

3 IN WORLD ↔

ECH = MENCK OR IHC HYDRO HAMMERS

STD e, Δe

OVERRIDE TO EFFICIENCY IS $(0.95 - 0.089) \times 0.89 = 0.77$

20' THICK

PILE & HAMMER: $g = 32.17 \times \cos 26.56° = 28.77\,g$

$S = 0.89\,S_{max} =$

DAVE [illegible]

The flexibility of the MHU design allows several configurations. All configurations share common basic design features described in this folder but vary in their depth rating. The “S” hammer series (S designates Standard) is built for shallow water applications up to 400 m (1,300 ft) of water. The “T” hammer series (T meaning Deep) is equipped for 2,000 m (6,500 ft) water depth. The “U” hammer series (U is for Ultra-deep) is outfitted for 3,000 m (10,000 ft) and beyond.

MENCK’s unique patented submersible electric-hydraulic power pack (MUP) is available for all MHU-T and MHU-U hammers up to 1,000 kJ (MHU 900T and MHU 810U) of energy.

MHU hammer																
S hammer	150S	220S	300S	440S	550S	660S	800S	1000S	1200S	1500S	1700S	1900S	2100S	2400S	2700S	3000S
T hammer	135T	200T	270T	400T	500T	600T	720T	900T								
U hammer			240U	360U	450U	540U	650U	810U								
Operational data																
Minimum energy kJ	15	20	30	40	50	60	80	100	110	150	170	190	210	240	270	300
Maximum energy kJ	150	230	305	440	550	660	800	1000	1200	1530	1730	1930	2140	2430	2750	3050
Recom. oil flow l/min	380	550	700	1000	1150	1250	1600	2000	2400	3000	3200	3200	3600	4200	4500	5100
Blow rate bl/min	38	38	40	38	38	32	38	38	38	38	35	32	32	32	32	32
Hammer weight t	21.1	25.4	30.8	44.2	54.2	67	79.6	104.6	119.2	134	145	157.6	215	240	255	280
Hammer length m	7.5	8.5	9.6	10.7	11.8	11.2	12.5	13.2	14.3	15.5	16.4	17.4	15.4	16.5	17.2	18.1
Standard configuration																
Pile sleeve	48″	1.6 m	1.6 m	60″	72″	72″	84″	96″	96″	102″	102″	102″	108″	108″	108″	108″
Total weight above water t	32.7	44.8	52.3	74	87.3	107	139.2	175	203.3	195	214	231.1	330	380	400	450
Total weight submerged t	24.5	35.3	41.5	59.5	70.5	86.1	112	140	163.4	155	172	187.7	270	300	330	365

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APE D225-42 Single Acting Diesel Impact Hammer

D225-42 With a 2.5 m Bottom Drive.

MODEL D225-42 (22.5 metric ton ram)

SPECIFICATIONS

Stroke at maximum rated energy	135 in (343 cm)
Maximum rated energy (Setting 4)	558,135 ft-lbs (757 kNm)
Setting 3	507,902 ft-lbs (689 kNm)
Setting 2	435,345 ft-lbs (590 kNm)
Minimum rated energy (Setting 1)	362,787 ft-lbs (491 kNm)

(Variable throttle allows for lower minimum energy and infinite fuel settings.)

Maximum obtainable stroke	202 in (381 cm)
Maximum obtainable energy	834,473 ft-lbs (1,131 kNm)
Speed (blows per minute)	34-53

WEIGHTS

Ram	49,612 lbs (22,500 kg)
Hammer weight (includes trip device)	112,820 lbs (51,165 kg)
Typical operating (weight w/ 98"/2.5 m offshore)	152,820 lbs (69,306 kg)

Optional Variable Throttle Control.

CAPACITIES

Fuel tank ***(runs on diesel or bio-diesel)***	95 gal (360 liters)
Oil tank	26 gal (99 liters)

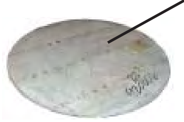
CONSUMPTION

Diesel or Bio-diesel fuel	18 gal/hr (68 liters/hr)
Lubrication	2 gal/hr (7.6 liters/hr)
Grease	8 to 10 pumps every 45 minutes of operation time.

25" STRIKER PLATE

Weight	1,036 lbs (470 kg)
Diameter	25 in (57.15 cm)
Area	471 sq-in (696 sq-cm)
Thickness	8 inches (20.32 cm)

Cushion Material.



CUSHION MATERIAL

Type/Qty	**Micarta**/5 ea
Diameter	25 in (57.15 cm)
Thickness	1in (25.4 mm)

Type/Qty	**Aluminum**/4ea
Thickness	1/2 in (12.7 mm)
Diameter	25 in (57.15 cm)
Total combined thickness	3 inches (5.08)
Area	490 in (1,246 cm)
Elastic-modulus	285 ksi (1,965 mpa)
Coeff. of restitution	.8

TYPICAL OFFSHORE LEADER

Standard offshore for 98"/2.5m piles and under	42,000lbs (92,610 kg)

Standard Offshore.

MINIMUM BOX LEAD SIZE/OPERATING LENGTH

Minimum box leader size	10 in x 60 in (25.4 cm x 152 cm)
Operating length in offshore	432 in (11m)

Corporate Offices
7032 South 196th
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(253) 872-8710 Fax

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e-mail: ape@apevibro.com

Note: All specifications are subject to change without notice

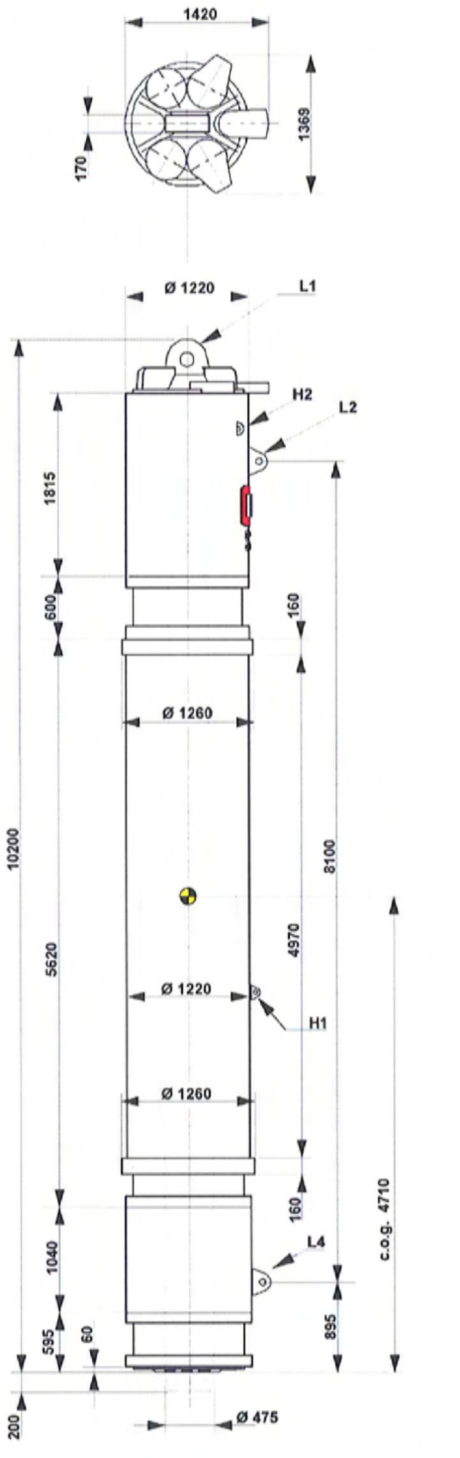
IHC Hydrohammer B.V.

Data sheet Hydrohammer® S-500

Equipment	Manual
sheet no.	: 1.1.0120
revision	: 10
date	: December 2003
sheet	: 1/1

APPLICATION: **Steel pile driving. On shore and underwater.**

Code no. 85.31.00.01



Main dimensions

Operating data

Max. net energy/blow	500	kNm
Min. net energy/blow	20	kNm
Blow rate (max energy)	45	Blows/min

Weights

Ram	25	tons
Hammer (incl. ram, in air)	55	tons
Hammer (incl. ram, in salt water) (Only if fully submerged)	45,0	tons

Hydraulic data

Operating pressure	250-300	bar
Max. pressure	350	bar
Max. oil flow	1400	l / min

Gas filling pressure

Vertical pile driving only! Values will vary for:
- pile driving under different angles with the vertical,
- pile driving underwater depending on water depth.

Supply accumulator *(Nitrogen)*	130-160	bar
Return accumulator *(Nitrogen)*	3 - 5	bar
Cap *(Nitrogen or Air)*	15-22	bar

Safety setting

Cap	40	bar

Hose connections

Oil supply 2x2" (P)	M68x2	male
Oil return 2x2" (R)	M68x2	male
Air or Nitrogen to cap (CA)	M42x2	male

Working Load Limit (WLL) and hole diameter

L1 *(green pin shackle)* 250 tons ∅145 mm
Shackle for L1 supplied with the hammer
L2/L4 *(green pin shackle)* 55 tons ∅73 mm
H1 12 tons ∅40 mm
For connection of the load carrying cable of the hose bundle.
H2 6.5 tons ∅27 mm
For connection of the load carrying cable of the control cable.

©IHC Hydrohammer B.V., P.O. Box 26, 2960 AA Kinderdijk, The Netherlands Phone +31.78 6910302 Fax +31.78 6910304
Subject to modifications e-mail: info@ihchh.com Web: www.ihchh.com

APE D180-42 Single Acting Diesel Impact Hammer

D180-42 driving 48" piles with a 54" offshore.

MODEL D180-42 (18.0 metric ton ram)

SPECIFICATIONS

Stroke at maximum rated energy	135 in (343 cm)
Maximum rated energy (Setting 4)	454,054 ft-lbs (615,615 Nm)
Setting 3	407,286 ft-lbs (552,207 Nm)
Setting 2	350,530 ft-lbs (475,255 Nm)
Minimum rated energy (Setting 1)	291,049 ft-lbs (394,610 Nm)

(Variable throttle allows for lower minimum energy and infinite fuel settings.)

Maximum obtainable stroke	201 in (381 cm)
Maximum obtainable energy	666,395 ft-lbs (195,567 Nm)
Speed (blows per minute)	34-53

WEIGHTS

Ram	39,690 lbs (18,000 kg)
Anvil	10,223 lbs (4,642 kg)
Anvil cross sectional area	837.85 sq-in (2,128 sq-cm)
Hammer weight (includes hydraulic trip device)	92,000 lbs (11,286 kg)
Typical operating (weight with 10"x68" offshore)	138,000 lbs (62,595 kg)

CAPACITIES

Fuel tank ***(runs on diesel or bio-diesel)***	63.4 gal (240 liters)
Oil tank	10.3 gal (40 liters)

Optional Variable Throttle Control.

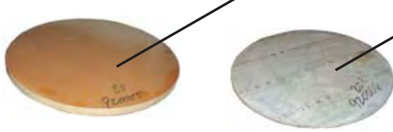
CONSUMPTION

Diesel or Bio-diesel fuel	14 gal/hr (30 liters/hr)
Lubrication	1.18 gal/hr (2.9 liters/hr)
Grease	8 to 10 pumps every 45 minutes of operation time.

STRIKER PLATE

Weight	1,036 lbs (470 kg)
Diameter	25 in (57.15 cm)
Area	471 sq-in (696 sq-cm)
Thickness	8 inches (20.32 cm)

Cushion Material.



CUSHION MATERIAL

Type/Qty	**Micarta**/2 ea
Diameter	25 in (57.15 cm)
Thickness	1in (25.4 mm)

Type/Qty	**Aluminum**/3 ea
Thickness	1/2 in (12.7 mm)
Diameter	25 in (57.15 cm)
Total combined thickness	5 inches (5.08)
Area	490 in (1,246 cm)
Elastic-modulus	285 ksi (1,965 mpa)
Coeff. of restitution	

Standard Offshore.

OFFSHORE LEADER

Offshore for 98"/2.5 meter piles and under	42,000lbs (19,050 kg)

MINIMUM BOX LEAD SIZE/OPERATING LENGTH

Minimum box leader size	10 in x 54 in (25.4 cm x 137 cm)
Operating length for offshore leader	433 in (11 m)

AMERICAN PILEDRIVING EQUIPMENT, INC. APE

Corporate Offices
7032 South 196th
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(800) 248-8498 & (253) 872-0141
(253) 872-8710 Fax

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www.apevibro.com
e-mail: ape@apevibro.com

Note: All specifications are subject to change without notice 1/07.

BCG Inc.

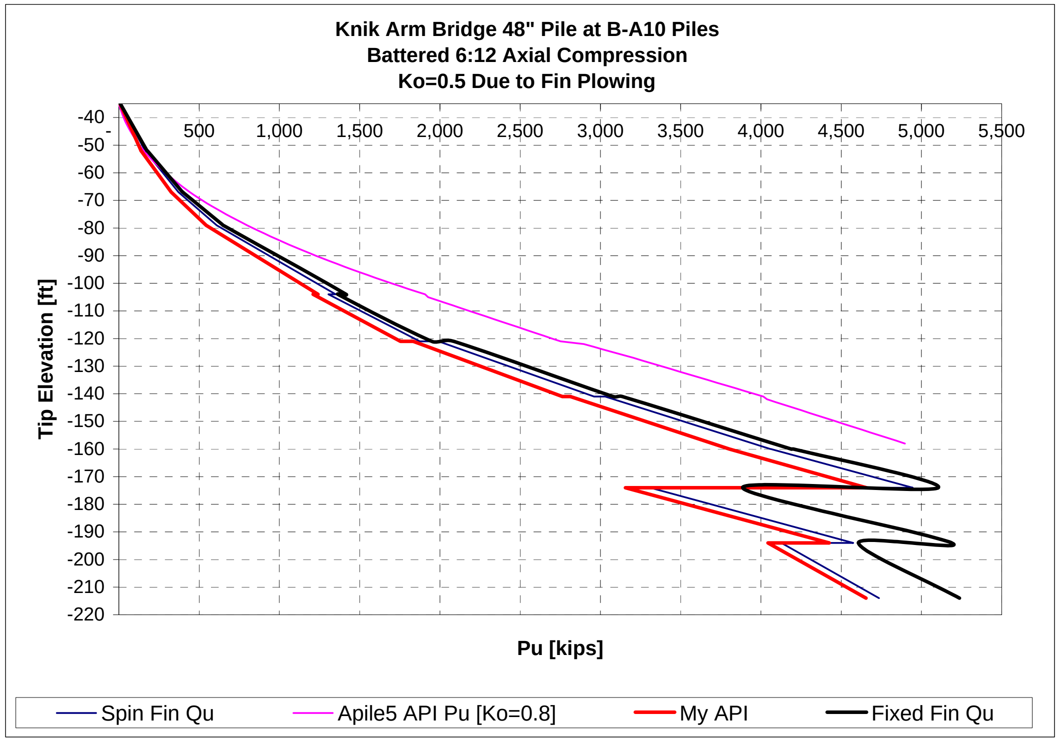
Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A10

PED
1/30/2009

79 ft top 0 0

Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	Plugged Fin Bearing Qfc kip	PND Fin Formula Po kip	WEAP ANALYSIS OD qs ksf	Torsion Restraint Fins Qb kip	Non-Torsion Restraint Fins Qb kip
-34	0	113	126	-	0	0.04	-	-
-52	18	131	146	344	25	0.18	80	67
-52	18	131	146	344		0.20	82	68
-67	33	146	163	630	269	0.36	184	159
-67	33	146	163	630		0.37	186	159
-79	45	158	177	921	456	0.54	304	265
-79	45	158	177	921		0.54	304	265
-104	70	183	205	1,527	1050	0.90	668	604
-104	70	183	205	1,309		0.84	648	590
-121	87	200	224	1,663	778	1.07	929	854
-121	87	200	224	2,217		1.25	986	891
-141	107	220	246	2,772	3047	1.56	1,460	1,341
-141	107	220	246	3,118		1.47	1,468	1,360
-160	126	239	267	3,711	1816	1.75	1,966	1,838
-160	126	239	267	3,711		1.86	1,982	1,840
-174	140	253	283	4,147	3656	2.08	2,412	2,254
-174	140	253	283	892		4.77	1,663	1,087
-194	160	273	305	892	3509	4.52	1,695	1,081
-194	160	273	305	571		2.32	1,160	680
-214	180	293	328	571	2541	2.17	1,178	677

Batter Correction
1 H
2 V
2.24 D
1.12 D/V



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BCG Inc.

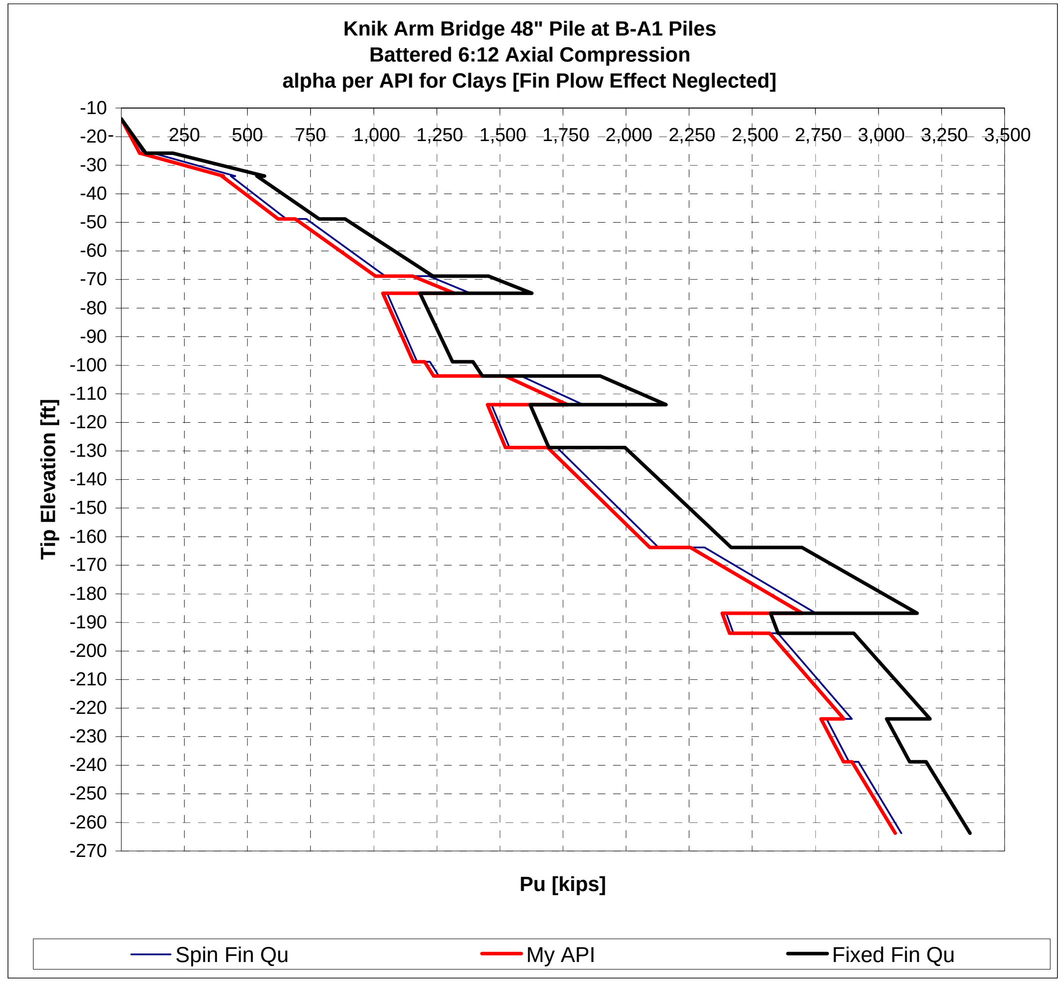
Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A1

PED
1/30/2009

79 ft top 0 0

Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	Plugged Fin Bearing Qfc kip	PND Fin Formula Po kip	WEAP ANALYSIS OD qs ksf	Torsion Restraint Fins Qb kip	Non-Torsion Restraint Fins Qb kip
-13.8	0	92.8	104	-	0	0.02	-	-
-25.8	12	104.8	117	229	10	0.12	44	35
-25.8	12	104.8	117	238		1.77	150	71
-33.8	20	112.8	126	238	129	1.52	342	226
-33.8	20	112.8	126	190		1.15	318	215
-48.8	35	127.8	143	190	332	0.97	361	231
-48.8	35	127.8	143	247		1.37	456	302
-68.8	55	147.8	165	247	796	1.13	486	297
-68.8	55	147.8	165	371		2.01	688	453
-74.8	61	153.8	172	371	522	1.96	695	451
-74.8	61	153.8	172	133		0.42	286	156
-98.8	85	177.8	199	133	2370	0.36	294	155
-98.8	85	177.8	199	171		0.52	371	200
-103.8	90	182.8	204	171	1262	0.50	373	200
-103.8	90	182.8	204	409		1.86	805	491
-113.8	100	192.8	216	409	2548	1.76	818	489
-113.8	100	192.8	216	143		0.36	318	165
-128.8	115	207.8	232	143	2470	0.34	321	165
-128.8	115	207.8	232	283		0.95	603	333
-163.8	150	242.8	271	283	2098	0.82	618	331
-163.8	150	242.8	271	418		1.48	879	494
-186.8	173	265.8	297	418	2438	1.37	893	491
-186.8	173	265.8	297	152		0.30	350	174
-193.8	180	272.8	305	152	2541	0.29	351	174
-193.8	180	272.8	305	285		0.76	632	331
-223.8	210	302.8	339	285	2984	0.70	639	330
-223.8	210	302.8	339	209		0.44	478	240
-238.8	225	317.8	355	209	3206	0.42	480	240
-238.8	225	317.8	355	238		0.51	542	274
-263.8	250	342.8	383	238	3575	0.49	545	273

Batter Correction
1 H
2 V
2.24 D
1.12 D/V



BCG Inc.

Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A10

PED
1/30/2009

79 ft top 0 0

Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	gamma pcf	N bpf	Su ksf	phi deg	0.67 delta deg	tan[delta] rad	Ko	sigma.v psf	C/p'	alpha	fr psf	Batter Included Dpile 4 ft Qs kip	fr psi	Nq	qb ksf
-34	0	113	126	51.6		0	32	21.4	0.393	0.50	-	-	-	36	-	0.3	35	0
-52	18	131	146	51.6	8	0	32	21.4	0.393	0.50	929	-	-	182	46	1.3	35	33
-52	18	131	146	51.6		0	34	22.8	0.420	0.50	929	-	-	195	46	1.4	35	33
-67	33	146	163	51.6	35	0	34	22.8	0.420	0.50	1,703	-	-	358	121	2.5	35	60
-67	33	146	163	65.6		0	35	23.5	0.434	0.50	1,703	-	-	369	121	2.6	35	60
-79	45	158	177	65.6	40	0	35	23.5	0.434	0.50	2,490	-	-	540	213	3.8	35	87
-79	45	158	177	65.6		0	35	23.5	0.434	0.50	2,490	-	-	540	213	3.8	35	87
-104	70	183	205	65.6	55	0	35	23.5	0.434	0.50	4,130	-	-	896	527	6.2	35	145
-104	70	183	205	65.6		0	33	22.1	0.406	0.50	4,130	-	-	839	527	5.8	30	124
-121	87	200	224	65.6	32	0	33	22.1	0.406	0.50	5,245	-	-	1,065	782	7.4	30	157
-121	87	200	224	65.6		0	38	25.5	0.476	0.50	5,245	-	-	1,249	782	8.7	40	210
-141	107	220	246	65.6	100	0	38	25.5	0.476	0.50	6,557	-	-	1,561	1,220	10.8	40	262
-141	107	220	246	65.6		0	36	24.1	0.448	0.50	6,557	-	-	1,468	1,220	10.2	45	295
-160	126	239	267	65.6	50	0	36	24.1	0.448	0.50	7,804	-	-	1,747	1,687	12.1	45	351
-160	126	239	267	65.6		0	38	25.5	0.476	0.50	7,804	-	-	1,858	1,687	12.9	45	351
-174	140	253	283	65.6	90	0	38	25.5	0.476	0.50	8,722	-	-	2,076	2,095	14.4	45	392
-174	140	253	283	67.6		9.38	0	0.0	0.000	0.80	8,722	1.075	0.509	4,773	2,095	33.1	40	84
-194	160	273	305	67.6	75	9.38	0	0.0	0.000	0.80	10,074	0.931	0.482	4,522	3,366	31.4	40	84
-194	160	273	305	67.6		6.00	0	0.0	0.000	0.80	10,074	0.596	0.386	2,315	3,366	16.1	40	54
-214	180	293	328	67.6	48	6.00	0	0.0	0.000	0.80	11,426	0.525	0.362	2,174	3,977	15.1	40	54

Batter Correction

1	H
2	V
2.24	D
1.12	D/V

Fin & Pile Geometry

OD=	48	in	Ap=	219	In^2	Ac=	11.04	ft^2	7	V
t=	1.5	in	Afin=	90	In^2	Acf=	10.57	ft^2	1	H
w.fin=	9	in	Acomb=	309	In^2	Afsp=	17.8	ft^2	8.13	deg
t.fin=	1	in	DL=	97	k	Ao=	11.19	ft^2		
n.fin=	10	ea				Asf=	138	ft^2		
L.fin=	8	ft								

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BCG Inc.

Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A10

PED
1/30/2009

79 ft top	0	0																
Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	Bottom of Pile Steel As Qbs kip	Plugged Core Bearing Qbc.p kip	Qbc.eff kip	Pile with out Fins Comp. Qu= Qs+Qbc kip	Pile with out Fins Tension Tu= Qs+ DL kip	Fin Steel Bearing Qfsb kip	Kch 1.2 Fin Friction Qfs kip	Qfu Fin Steel Qfs+Qfsb kip	Spinning Fin Pile Comp. Capacity Pu kip	Spinning Fin Pile Tension Capacity Tu kip	Less 1.5 Net Qfso kip	Df Qfb.eff kip	Qfso+Qfb.eff kip	Torsion Restrained Fin Pile Capacity Pu kip	Torsion Restrained Fin Pile Capacity Tu kip
-34	0	113	126	-	-	-	**0**	*97*	-	-	-	-	*97*	-			0	*97*
-52	18	131	146	49	359	43	**139**	*158*	20	4	**24**	163	*182*	13	24	**36**	175	*194*
-52	18	131	146	49	359	43	**139**	*158*	20	4	**24**	163	*182*	14	24	**38**	177	*196*
-67	33	146	163	91	658	114	**326**	*246*	37	8	**45**	371	*290*	25	45	**70**	396	*316*
-67	33	146	163	91	658	114	**326**	*246*	37	8	**45**	371	*291*	27	45	**72**	398	*317*
-79	45	158	177	133	963	199	**544**	*347*	54	12	**66**	610	*413*	39	66	**105**	649	*452*
-79	45	158	177	133	963	199	**544**	*347*	54	12	**66**	610	*413*	39	66	**105**	649	*452*
-104	70	183	205	220	1,597	494	**1,241**	*682*	90	19	**110**	1,351	*792*	65	110	**174**	1,416	*856*
-104	70	183	205	189	1,368	494	**1,210**	*682*	77	18	**95**	1,305	*777*	59	95	**154**	1,364	*836*
-121	87	200	224	239	1,738	733	**1,754**	*951*	98	23	**121**	1,875	*1072*	75	121	**196**	1,950	*1147*
-121	87	200	224	319	2,317	733	**1,834**	*951*	131	27	**158**	1,991	*1108*	95	158	**253**	2,086	*1203*
-141	107	220	246	399	2,897	1,144	**2,763**	*1406*	164	33	**197**	2,961	*1603*	119	197	**316**	3,079	*1722*
-141	107	220	246	449	3,259	1,144	**2,813**	*1406*	184	31	**216**	3,029	*1622*	108	216	**324**	3,137	*1730*
-160	126	239	267	534	3,878	1,581	**3,802**	*1888*	219	37	**257**	4,059	*2145*	128	257	**385**	4,187	*2273*
-160	126	239	267	534	3,878	1,581	**3,802**	*1888*	219	40	**259**	4,061	*2147*	141	259	**400**	4,203	*2289*
-174	140	253	283	597	4,335	1,964	**4,656**	*2308*	245	44	**290**	4,946	*2598*	158	290	**448**	5,104	*2756*
-174	140	253	283	128	932	932	**3,155**	*2308*	53	102	**155**	3,310	*2463*	576	155	**731**	3,886	*3039*
-194	160	273	305	128	932	932	**4,426**	*3595*	53	97	**149**	4,575	*3745*	614	149	**763**	5,189	*4359*
-194	160	273	305	82	596	596	**4,044**	*3595*	34	50	**83**	4,127	*3679*	480	83	**564**	4,608	*4159*
-214	180	293	328	82	596	596	**4,655**	*4223*	34	46	**80**	4,735	*4303*	502	80	**582**	5,237	*4805*

Batter Correction

1 H
2 V
2.24 D
1.12 D/V

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BCG Inc.

Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A1

PED
1/30/2009

79 ft top 0 0

Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	gamma pcf	N bpf	Su ksf	phi deg	0.67 delta deg	tan[delta] rad	Ko	sigma.v psf	C/p'	alpha	fr psf	Batter Included Dpile 4 ft Qs kip	fr psi	Nq	qb ksf
-13.8	0	92.8	104	51.6		0	32	21.4	0.393	0.50	-	-	-	24	-	0.2	35	0
-25.8	12	104.8	117	51.6	8	0	32	21.4	0.393	0.50	619	-	-	122	20	0.8	35	22
-25.8	12	104.8	117	65.6		2.5	0	0.0	0.000	0.50	619	4.037	0.709	1,772	20	12.3	9	23
-33.8	20	112.8	126	65.6	35	2.5	0	0.0	0.000	0.50	1,144	2.185	0.608	1,520	191	10.6	9	23
-33.8	20	112.8	126	65.6		2	0	0.0	0.000	0.50	1,144	1.748	0.575	1,150	191	8.0	9	18
-48.8	35	127.8	143	65.6	40	2	0	0.0	0.000	0.50	2,128	0.940	0.485	969	396	6.7	9	18
-48.8	35	127.8	143	65.6		2.6	0	0.0	0.000	0.50	2,128	1.222	0.526	1,367	396	9.5	9	23
-68.8	55	147.8	165	65.6	55	2.6	0	0.0	0.000	0.50	3,440	0.756	0.435	1,130	713	7.8	9	23
-68.8	55	147.8	165	65.6		3.9	0	0.0	0.000	0.50	3,440	1.134	0.516	2,012	713	14.0	9	35
-74.8	61	153.8	172	65.6	32	3.9	0	0.0	0.000	0.50	3,834	1.017	0.502	1,958	878	13.6	9	35
-74.8	61	153.8	172	65.6		1.4	0	0.0	0.000	0.50	3,834	0.365	0.302	423	878	2.9	9	13
-98.8	85	177.8	199	65.6	100	1.4	0	0.0	0.000	0.50	5,408	0.259	0.254	356	998	2.5	9	13
-98.8	85	177.8	199	65.6		1.8	0	0.0	0.000	0.50	5,408	0.333	0.288	519	998	3.6	9	16
-103.8	90	182.8	204	65.6	50	1.8	0	0.0	0.000	0.50	5,736	0.314	0.280	504	1,034	3.5	9	16
-103.8	90	182.8	204	65.6		4.3	0	0.0	0.000	0.50	5,736	0.750	0.433	1,862	1,034	12.9	9	39
-113.8	100	192.8	216	65.6	90	4.3	0	0.0	0.000	0.50	6,392	0.673	0.410	1,763	1,282	12.2	9	39
-113.8	100	192.8	216	67.6		1.50	0	0.0	0.000	0.80	6,392	0.235	0.242	363	1,282	2.5	9	14
-128.8	115	207.8	232	67.6	75	1.50	0	0.0	0.000	0.80	7,406	0.203	0.225	338	1,353	2.3	9	14
-128.8	115	207.8	232	67.6		2.98	0	0.0	0.000	0.80	7,406	0.402	0.317	945	1,353	6.6	9	27
-163.8	150	242.8	271	67.6	48	2.98	0	0.0	0.000	0.80	9,772	0.305	0.276	823	1,757	5.7	9	27
-163.8	150	242.8	271	67.6		4.40	0	0.0	0.000	0.80	9,772	0.450	0.336	1,476	1,757	10.3	9	40
-186.8	173	265.8	297	67.6	48	4.40	0	0.0	0.000	0.80	11,327	0.388	0.312	1,371	2,200	9.5	9	40
-186.8	173	265.8	297	67.6		1.60	0	0.0	0.000	0.80	11,327	0.141	0.188	301	2,200	2.1	9	14
-193.8	180	272.8	305	67.6	48	1.60	0	0.0	0.000	0.80	11,800	0.136	0.184	295	2,229	2.0	9	14
-193.8	180	272.8	305	67.6		3.00	0	0.0	0.000	0.80	11,800	0.254	0.252	756	2,229	5.3	9	27
-223.8	210	302.8	339	67.6	48	3.00	0	0.0	0.000	0.80	13,828	0.217	0.233	699	2,524	4.9	9	27
-223.8	210	302.8	339	67.6		2.20	0	0.0	0.000	0.80	13,828	0.159	0.199	439	2,524	3.0	9	20
-238.8	225	317.8	355	67.6	48	2.20	0	0.0	0.000	0.80	14,842	0.148	0.193	424	2,613	2.9	9	20
-238.8	225	317.8	355	67.6		2.50	0	0.0	0.000	0.80	14,842	0.168	0.205	513	2,613	3.6	9	23
-263.8	250	342.8	383	67.6	48	2.50	0	0.0	0.000	0.80	16,532	0.151	0.194	486	2,784	3.4	9	23

Batter Correction		Fin & Pile Geometry							
1	H	OD=	48 in	Ap=	219 In^2	Ac=	11.04 ft^2	7	V
2	V	t=	1.5 in	Afin=	90 In^2	Acf=	10.57 ft^2	1	H
2.24	D	w.fin=	9 in	Acomb=	309 In^2	Afsp=	17.8 ft^2	8.13	deg
1.12	D/V	t.fin=	1 in	DL=	80 k	Ao=	11.19 ft^2		
		n.fin=	10 ea			Asf=	138 ft^2		
		L.fin=	8 ft						

P:\2008\2008-66\calc\PED Drivability Analysis\Pile Dsn SprdShts\Spin Fin Piles.xls

BCG Inc.

Job 2008-66
Knik Arm Bridge Piles
PP48x1.5 at B-A1

PED
1/30/2009

79 ft top 0 0

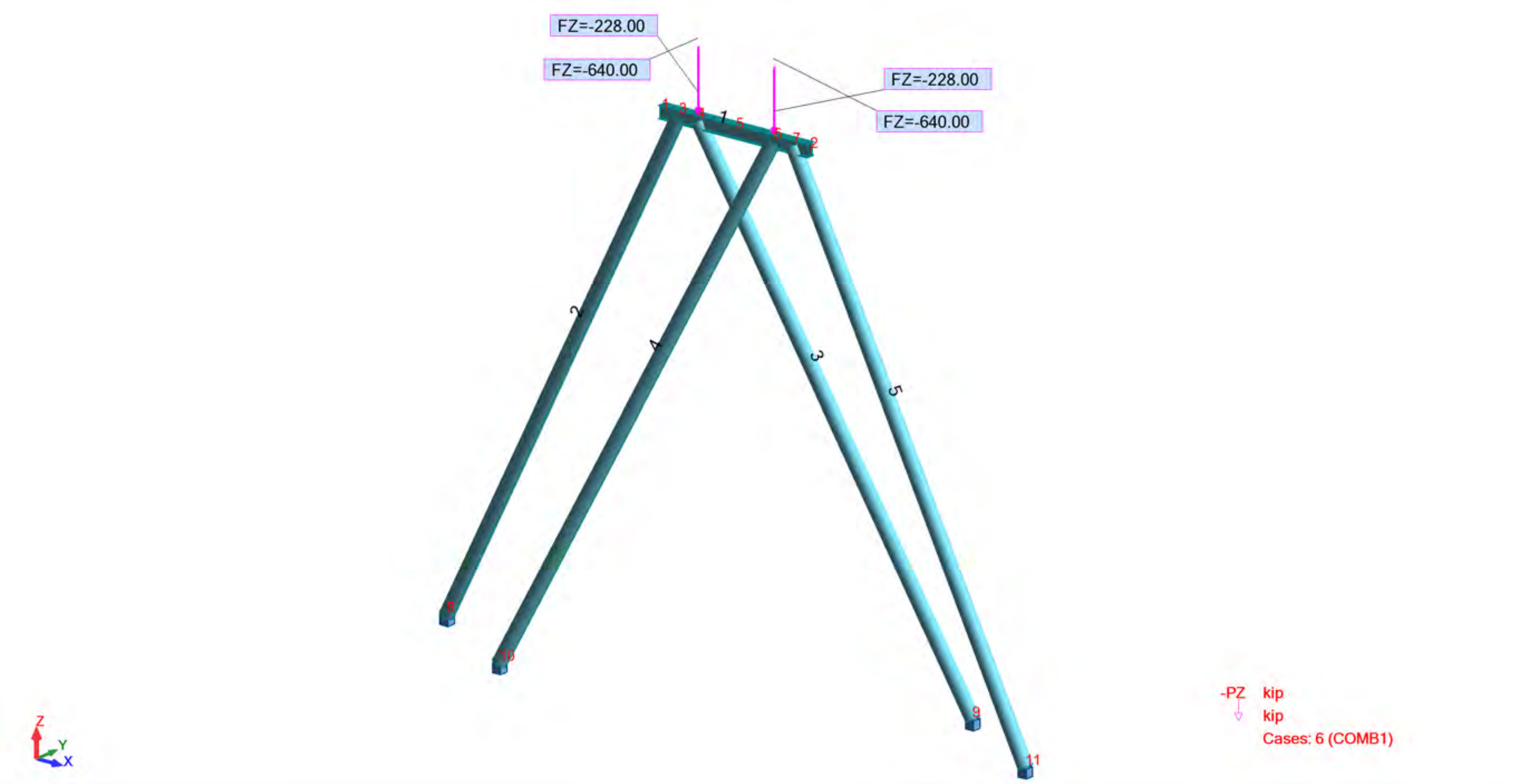
Elev ft	vert embed depth ft	vert pile length ft	diagonal pile length	Bottom of Pile Steel As Qbs kip	Plugged Core Bearing Qbc.p kip	Qbc.eff kip	Pile with out Fins Comp. Qu= Qs+Qbc kip	Pile with out Fins Tension Tu= Qs+ DL kip	Fin Steel Bearing Qfsb kip	Kch 1.2 Fin Friction Qfs kip	Qfu Fin Steel Qfs+Qfsb kip	Spinning Fin Pile Comp. Capacity Pu kip	Spinning Fin Pile Tension Capacity Tu kip	Less 1.5 Net Qfso kip	Df Qfb.eff kip	Qfso+Qfb.eff kip	Torsion Restrained Fin Pile Capacity Pu kip	Torsion Restrained Fin Pile Capacity Tu kip
-13.8	0	92.8	104	-	-	-	**0**	*80*	-	-	-	-	*80*	-			0	*80*
-25.8	12	104.8	117	33	239	19	**73**	*110*	14	3	**16**	89	*126*	8	16	**24**	97	*135*
-25.8	12	104.8	117	34	249	19	**74**	*110*	14	38	**52**	126	*162*	78	52	**130**	204	*241*
-33.8	20	112.8	126	34	249	179	**405**	*288*	14	33	**47**	451	*334*	116	47	**163**	568	*451*
-33.8	20	112.8	126	27	199	179	**398**	*288*	11	25	**36**	434	*324*	103	36	**139**	537	*427*
-48.8	35	127.8	143	27	199	199	**622**	*505*	11	21	**32**	654	*537*	130	32	**162**	784	*667*
-48.8	35	127.8	143	36	258	258	**690**	*505*	15	29	**44**	734	*548*	153	44	**197**	887	*702*
-68.8	55	147.8	165	36	258	258	**1,007**	*839*	15	24	**39**	1,046	*878*	189	39	**228**	1,235	*1067*
-68.8	55	147.8	165	53	388	388	**1,154**	*839*	22	43	**65**	1,219	*904*	236	65	**301**	1,455	*1139*
-74.8	61	153.8	172	53	388	388	**1,319**	*1009*	22	42	**64**	1,383	*1073*	244	64	**308**	1,627	*1316*
-74.8	61	153.8	172	19	139	139	**1,037**	*1009*	8	9	**17**	1,054	*1026*	130	17	**147**	1,183	*1156*
-98.8	85	177.8	199	19	139	139	**1,157**	*1149*	8	8	**15**	1,172	*1164*	140	15	**155**	1,312	*1304*
-98.8	85	177.8	199	25	179	179	**1,202**	*1149*	10	11	**21**	1,223	*1170*	171	21	**192**	1,394	*1341*
-103.8	90	182.8	204	25	179	179	**1,237**	*1189*	10	11	**21**	1,258	*1209*	173	21	**194**	1,431	*1382*
-103.8	90	182.8	204	59	427	427	**1,520**	*1189*	24	40	**64**	1,584	*1253*	314	64	**378**	1,898	*1566*
-113.8	100	192.8	216	59	427	427	**1,768**	*1445*	24	38	**62**	1,830	*1506*	328	62	**390**	2,158	*1835*
-113.8	100	192.8	216	21	149	149	**1,451**	*1445*	8	8	**16**	1,467	*1461*	153	16	**169**	1,620	*1613*
-128.8	115	207.8	232	21	149	149	**1,522**	*1528*	8	7	**16**	1,538	*1544*	156	16	**172**	1,694	*1700*
-128.8	115	207.8	232	41	296	296	**1,690**	*1528*	17	20	**37**	1,727	*1565*	269	37	**306**	1,996	*1835*
-163.8	150	242.8	271	41	296	296	**2,094**	*1962*	17	18	**34**	2,129	*1996*	288	34	**322**	2,417	*2284*
-163.8	150	242.8	271	60	437	437	**2,255**	*1962*	25	32	**56**	2,311	*2018*	386	56	**442**	2,697	*2404*
-186.8	173	265.8	297	60	437	437	**2,698**	*2424*	25	29	**54**	2,752	*2478*	401	54	**456**	3,154	*2880*
-186.8	173	265.8	297	22	159	159	**2,381**	*2424*	9	6	**15**	2,397	*2440*	176	15	**191**	2,573	*2615*
-193.8	180	272.8	305	22	159	159	**2,410**	*2459*	9	6	**15**	2,426	*2474*	177	15	**192**	2,602	*2651*
-193.8	180	272.8	305	41	298	298	**2,569**	*2459*	17	16	**33**	2,602	*2492*	301	33	**334**	2,902	*2793*
-223.8	210	302.8	339	41	298	298	**2,863**	*2779*	17	15	**32**	2,895	*2810*	309	32	**341**	3,204	*3120*
-223.8	210	302.8	339	30	219	219	**2,773**	*2779*	12	9	**22**	2,794	*2800*	238	22	**260**	3,032	*3038*
-238.8	225	317.8	355	30	219	219	**2,862**	*2880*	12	9	**21**	2,883	*2902*	240	21	**262**	3,124	*3142*
-238.8	225	317.8	355	34	249	249	**2,896**	*2880*	14	11	**25**	2,921	*2905*	268	25	**293**	3,189	*3173*
-263.8	250	342.8	383	34	249	249	**3,067**	*3072*	14	10	**24**	3,091	*3096*	272	24	**297**	3,363	*3369*

Batter Correction
1 H
2 V
2.24 D
1.12 D/V

P:\2008\2008-66\calc\PED Drivability Analysis\Pile Dsn SprdShts\Spin Fin Piles.xls

Robot 21 - Trial Version
Author: **Patrick E. Durnal**
Address: Ben C. Gerwick, Inc OAK
File: Knik Arm Bridge
Project: 2008-66

Structure - Cases: 6 (COMB1)



Date : 29/01/09
Page : **1**

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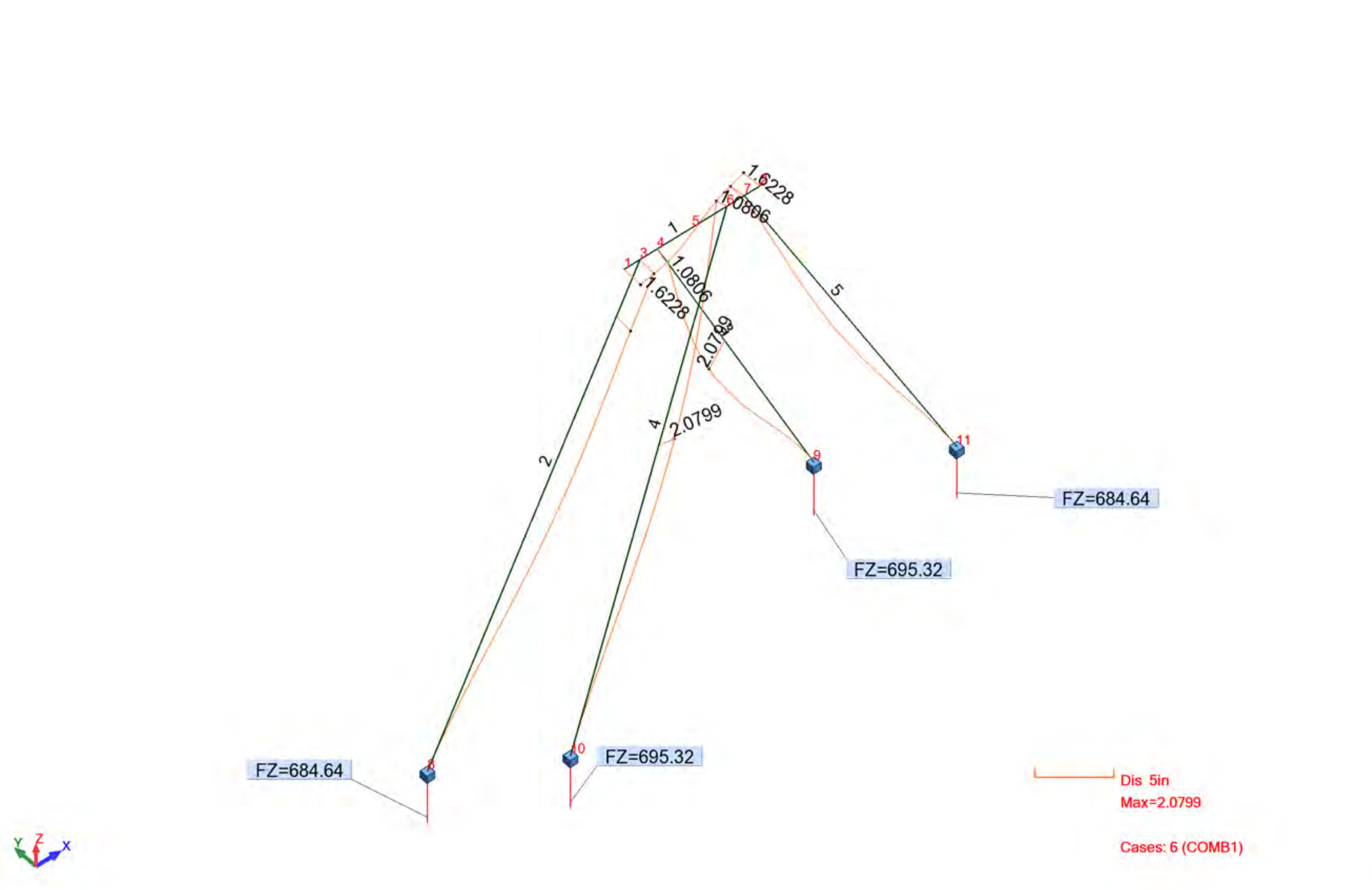
Structure - Exact deformation(s),Reaction forces(kip), Cases: 6 (COMB1)



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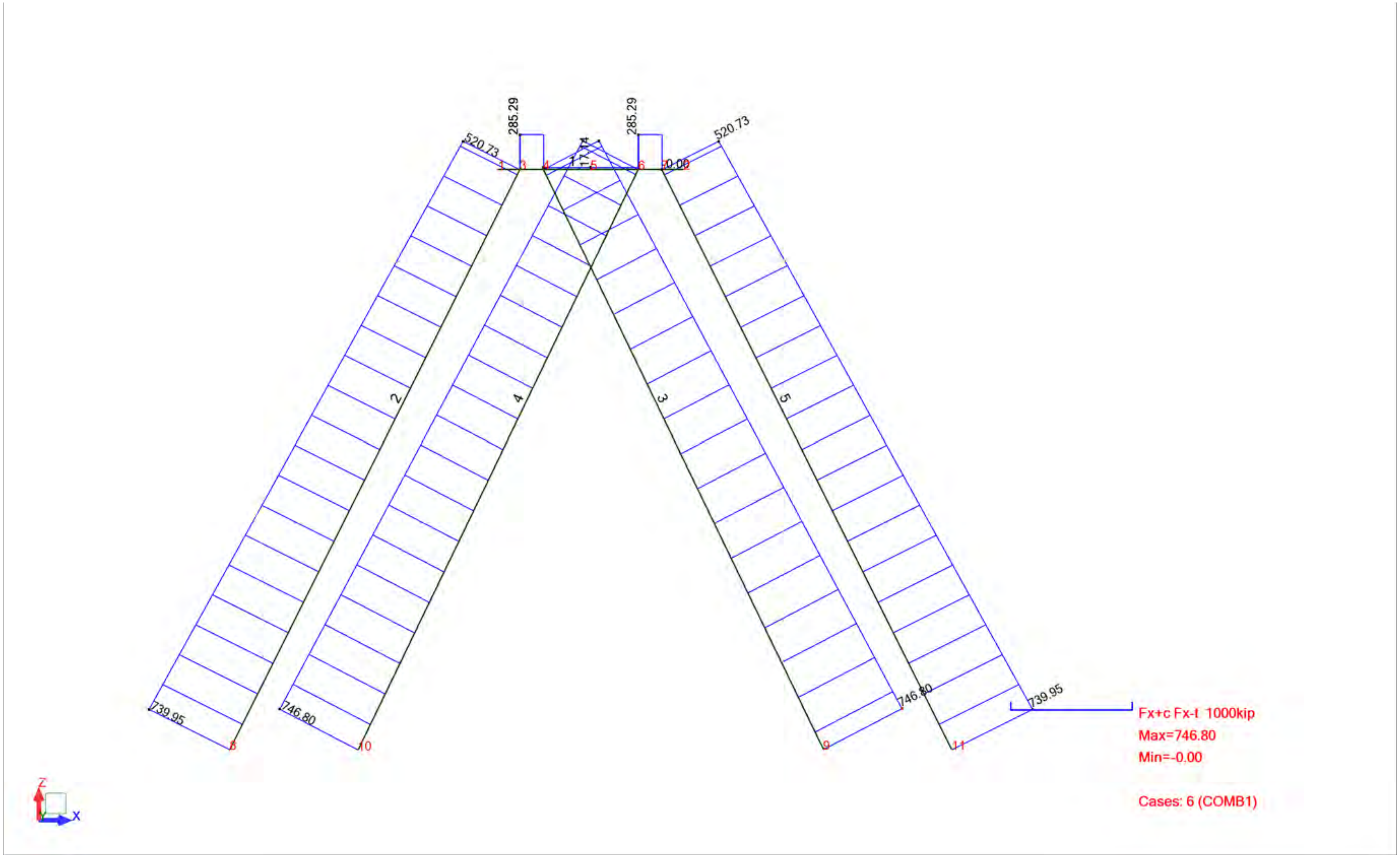
Structure - FX, Cases: 6 (COMB1)



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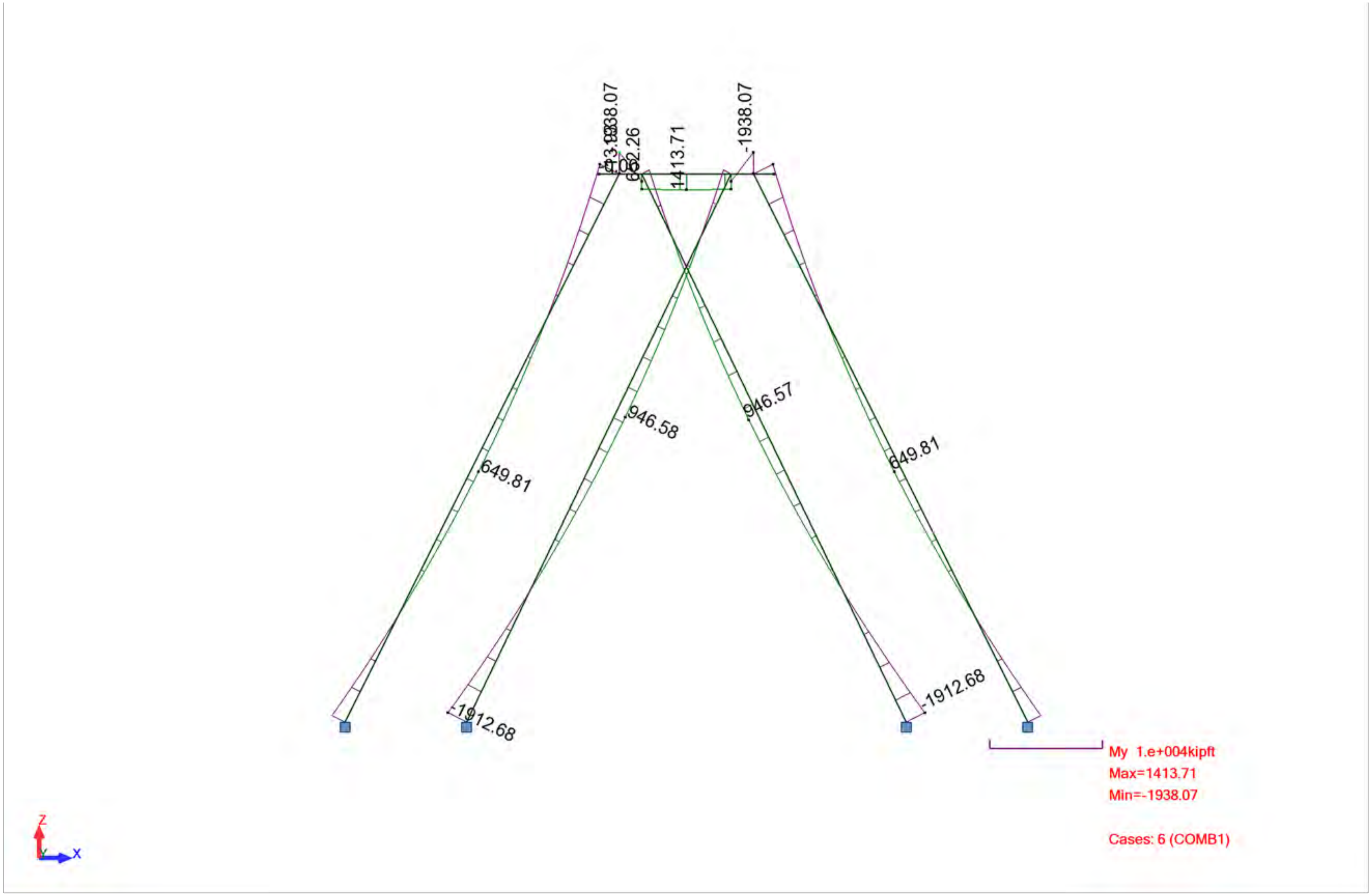
Project: 2008-66

Structure - MY, Cases: 6 (COMB1)



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Robot 21 - Trial Version
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Address: Ben C. Gerwick, Inc OAK
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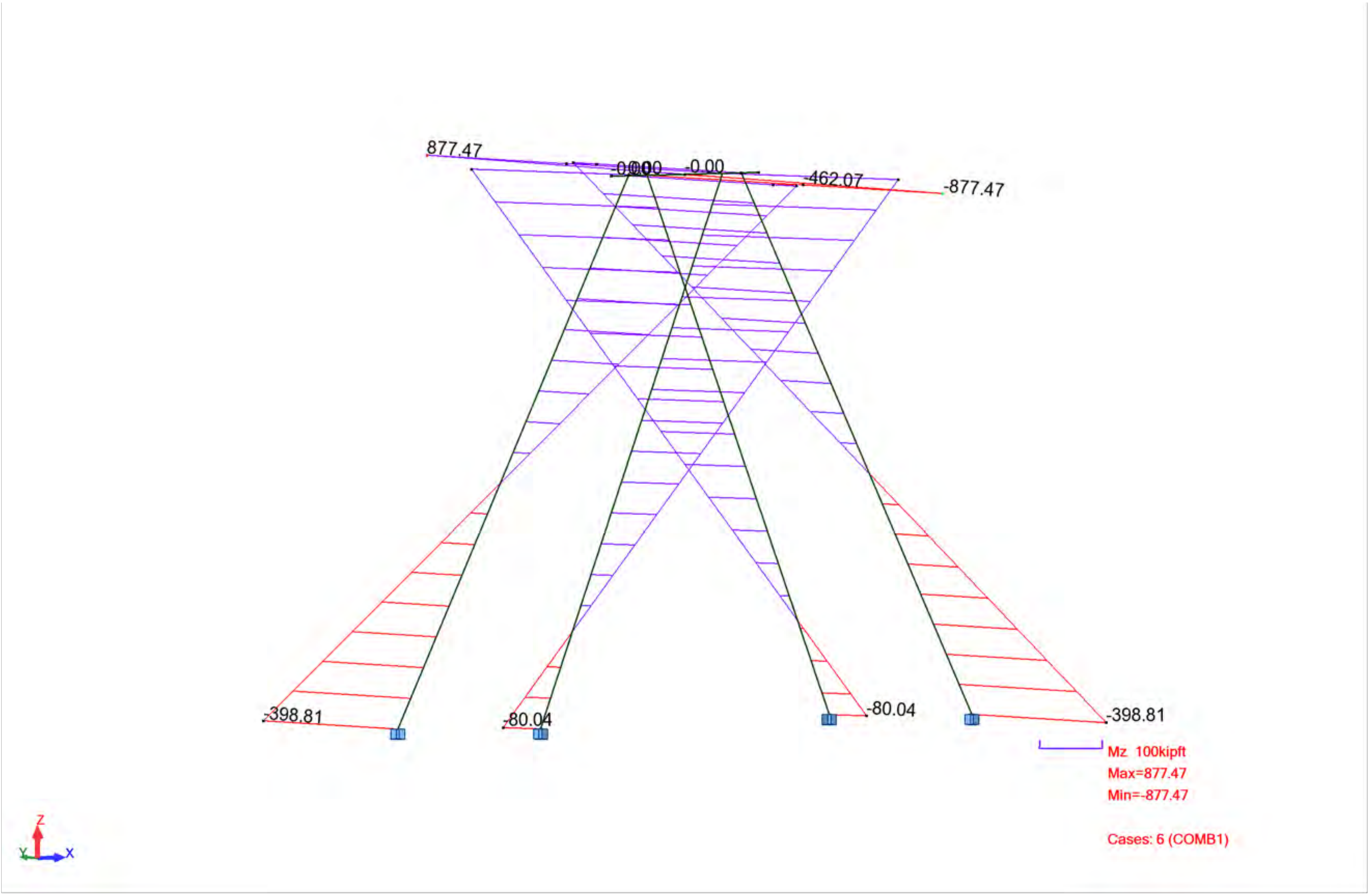
Structure - MZ, Cases: 6 (COMB1)



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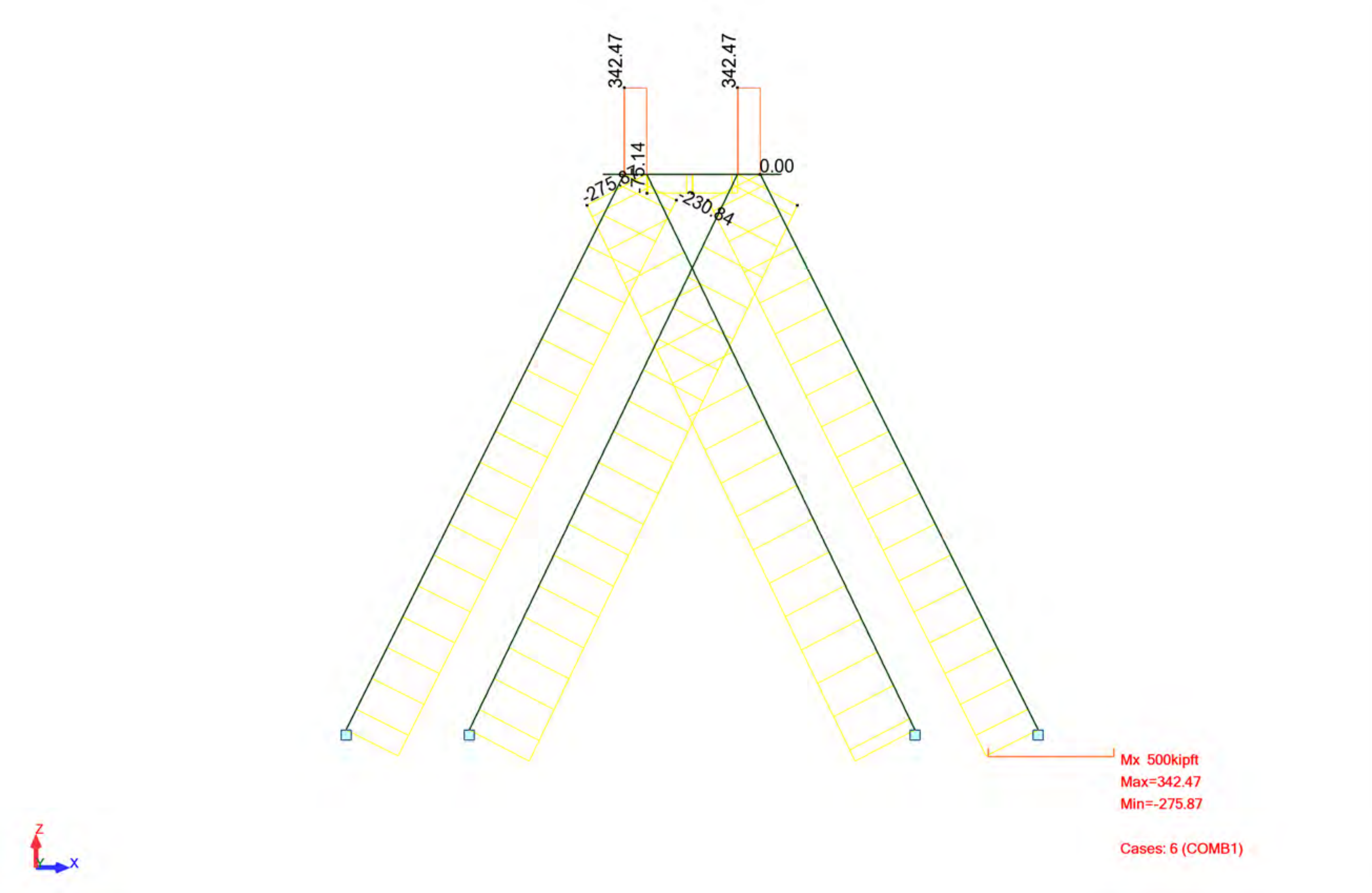
Structure - MX, Cases: 6 (COMB1)



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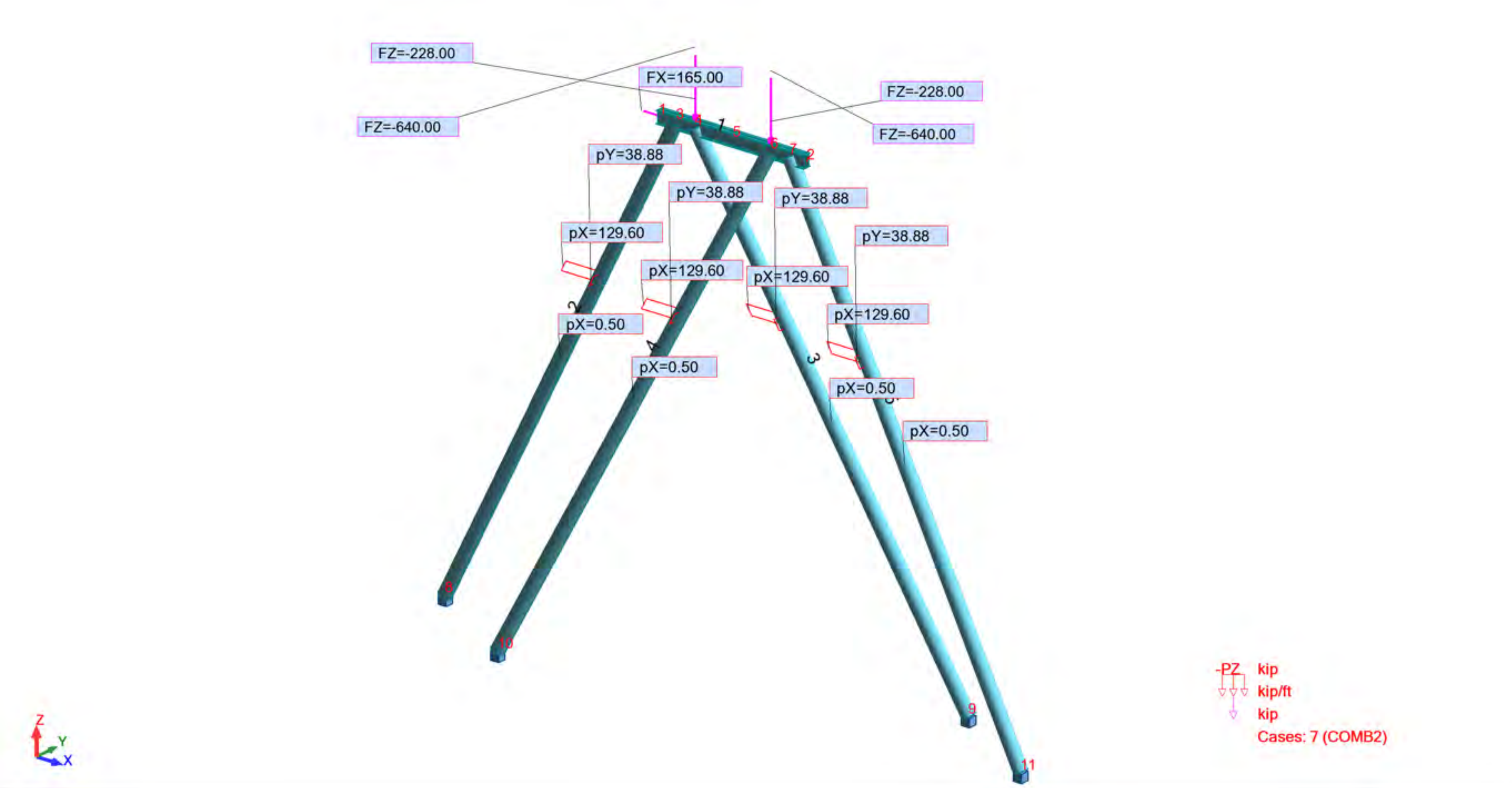
Structure - Cases: 7 (COMB2)



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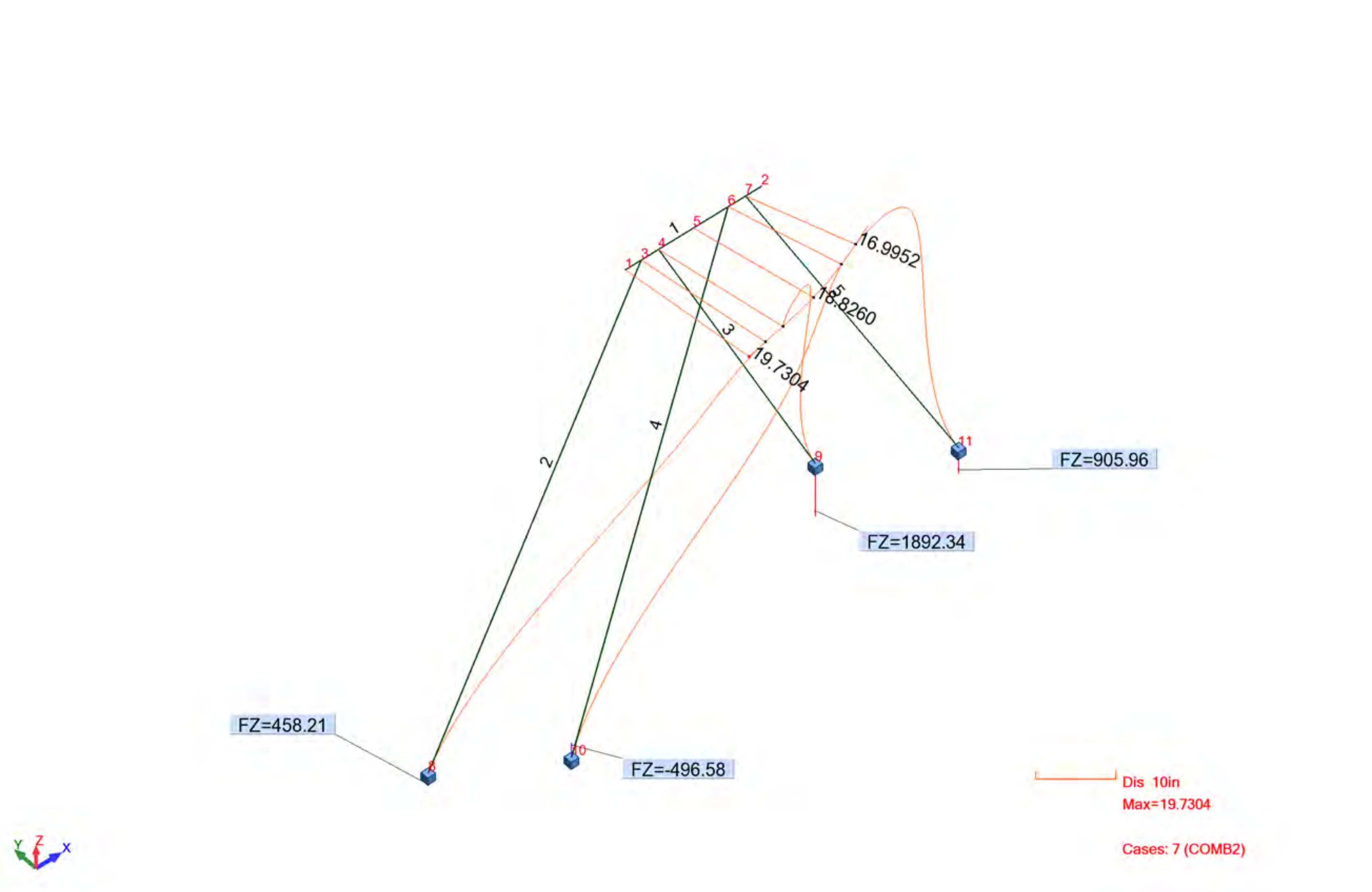
Project: 2008-66

Structure - Exact deformation(s),Reaction forces(kip), Cases: 7 (COMB2)



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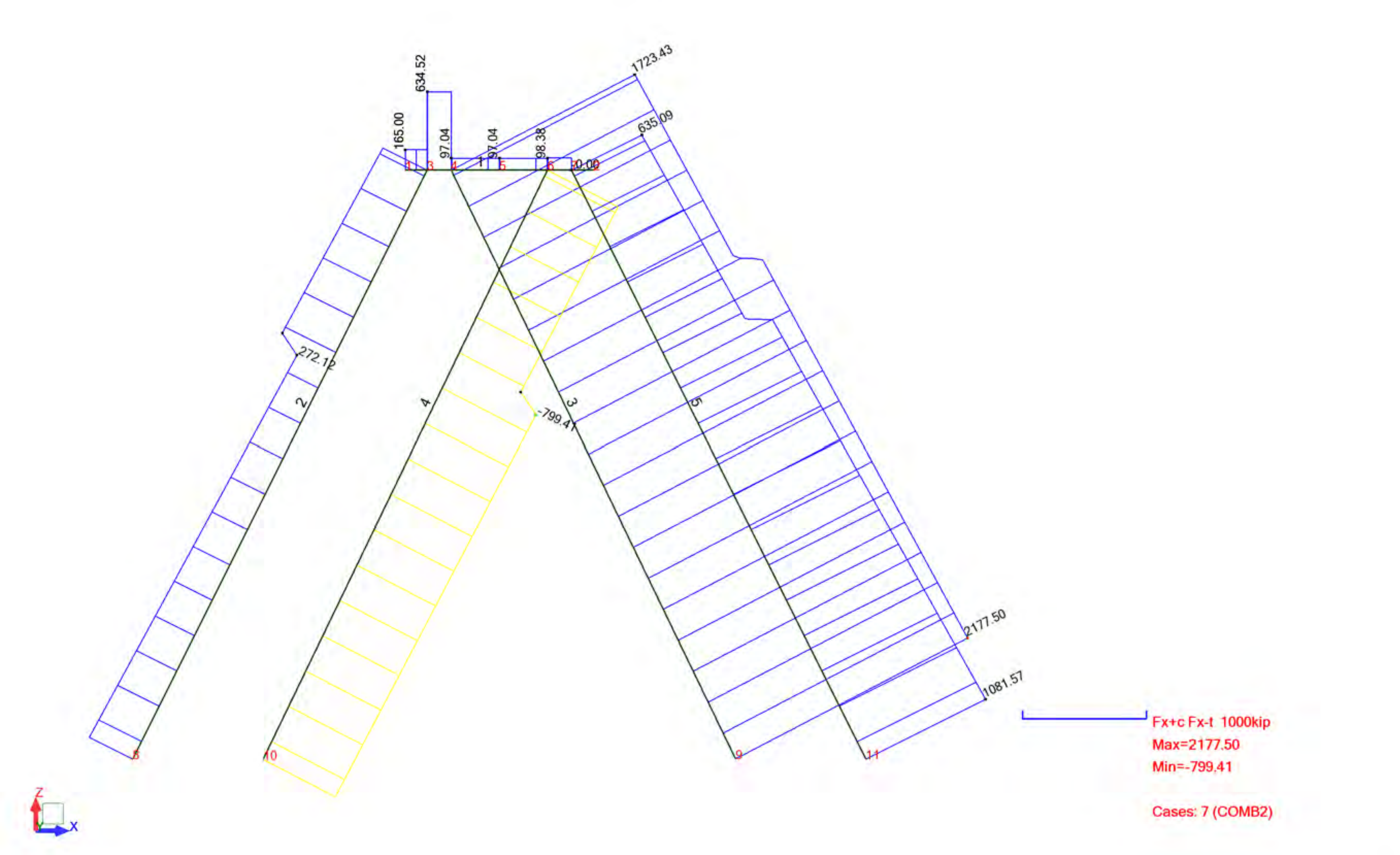
Project: 2008-66

Structure - FX, Cases: 7 (COMB2)



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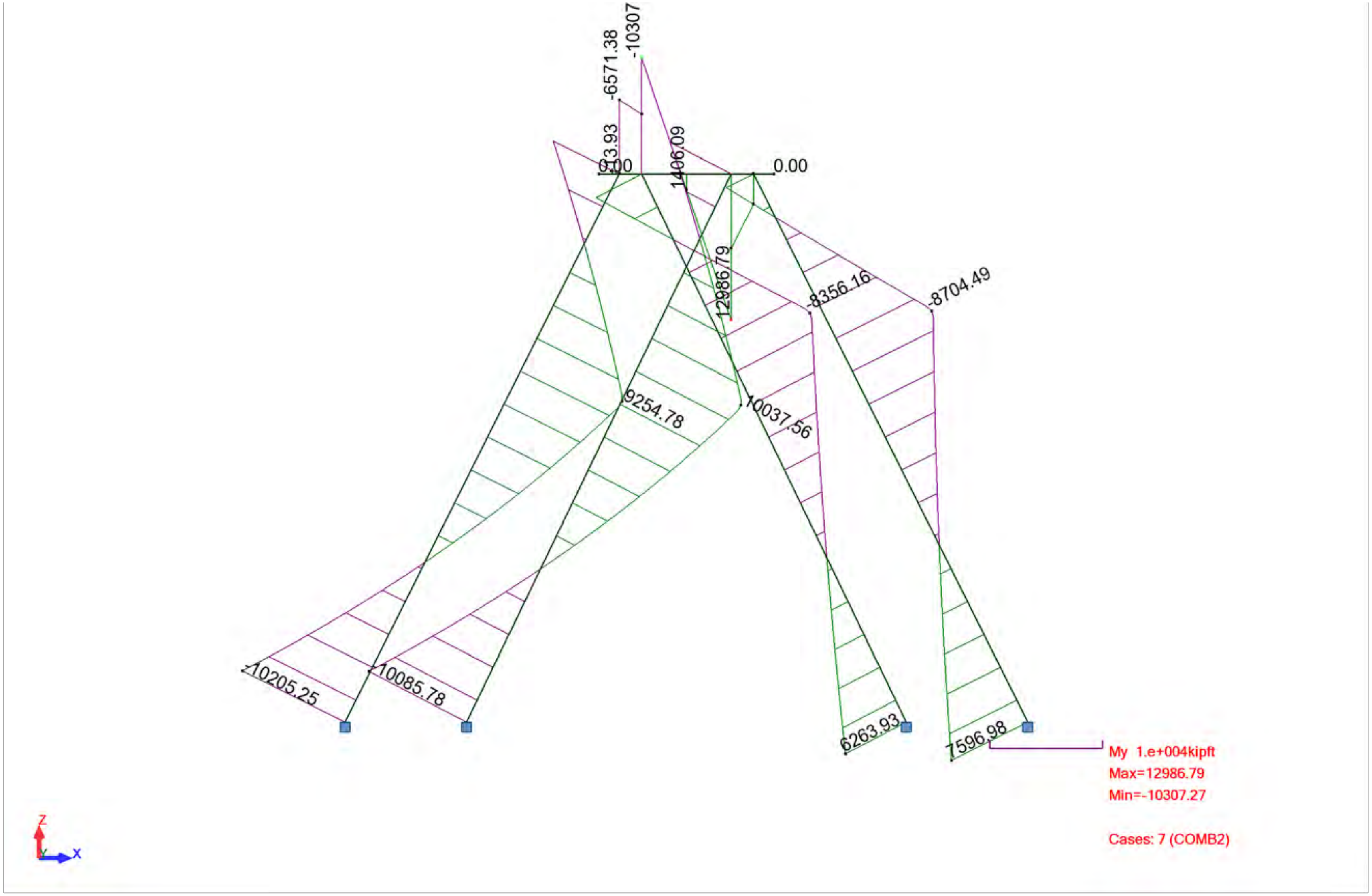
Project: 2008-66

Structure - MY, Cases: 7 (COMB2)



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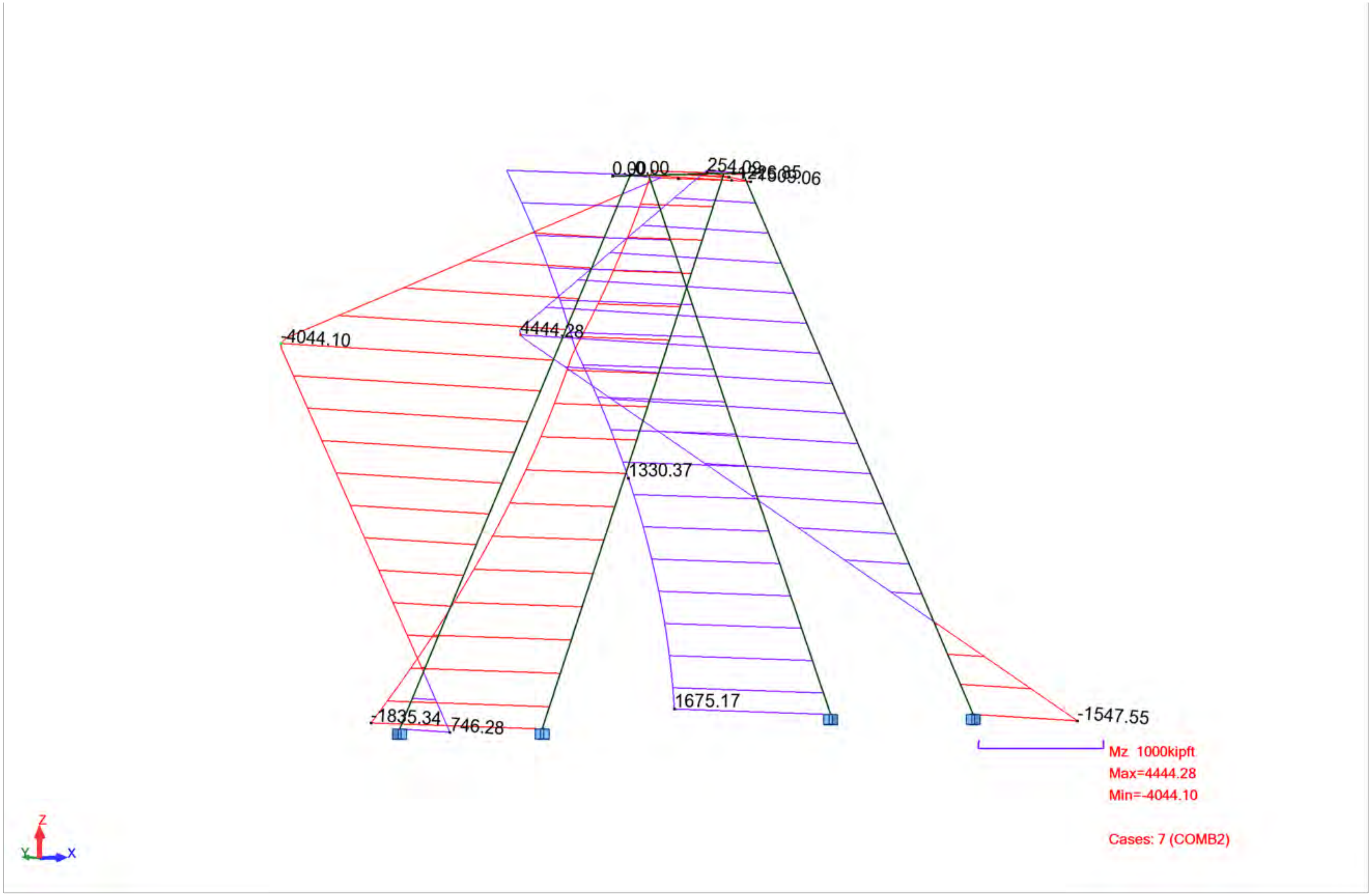
Structure - MZ, Cases: 7 (COMB2)



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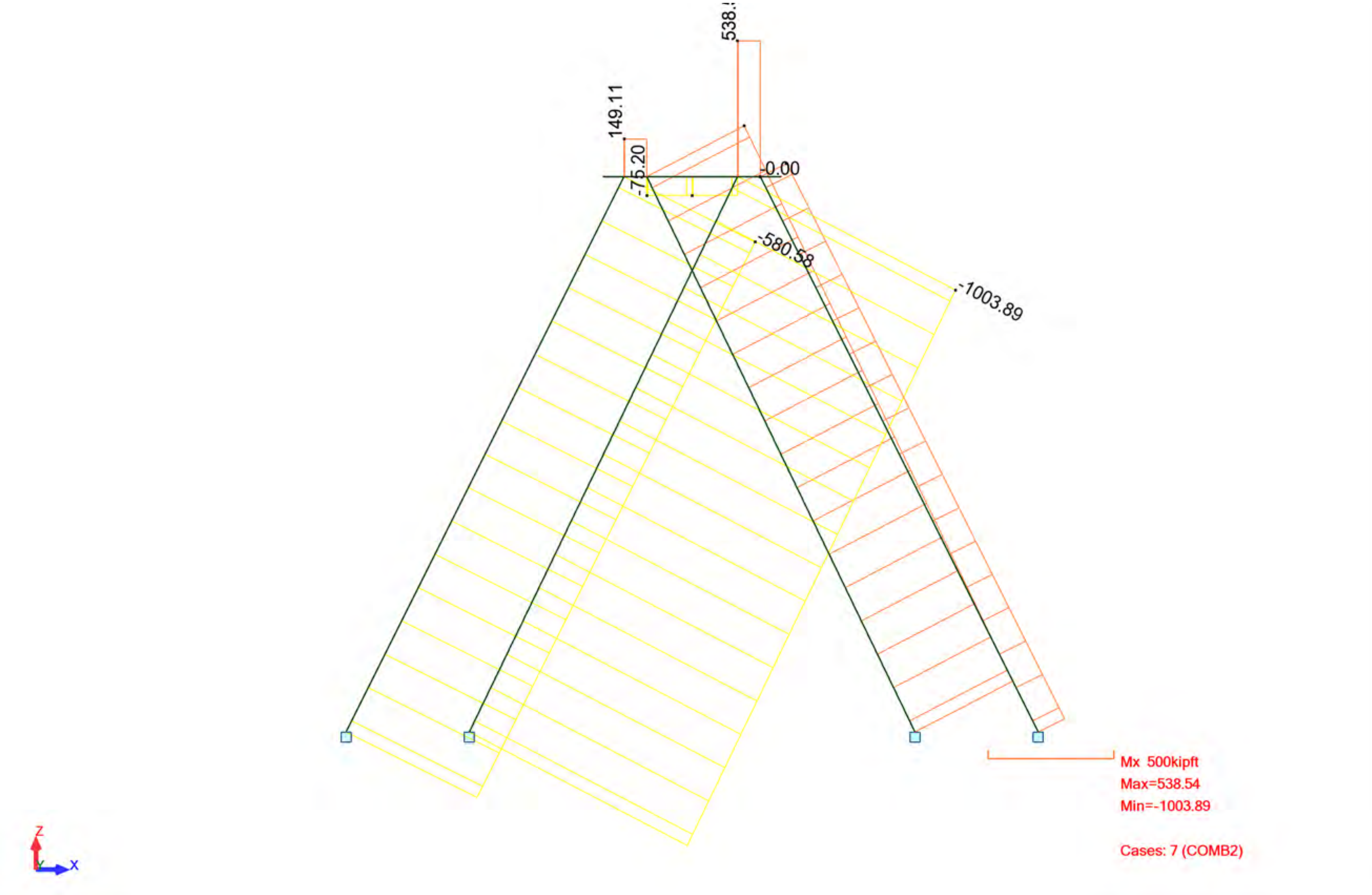

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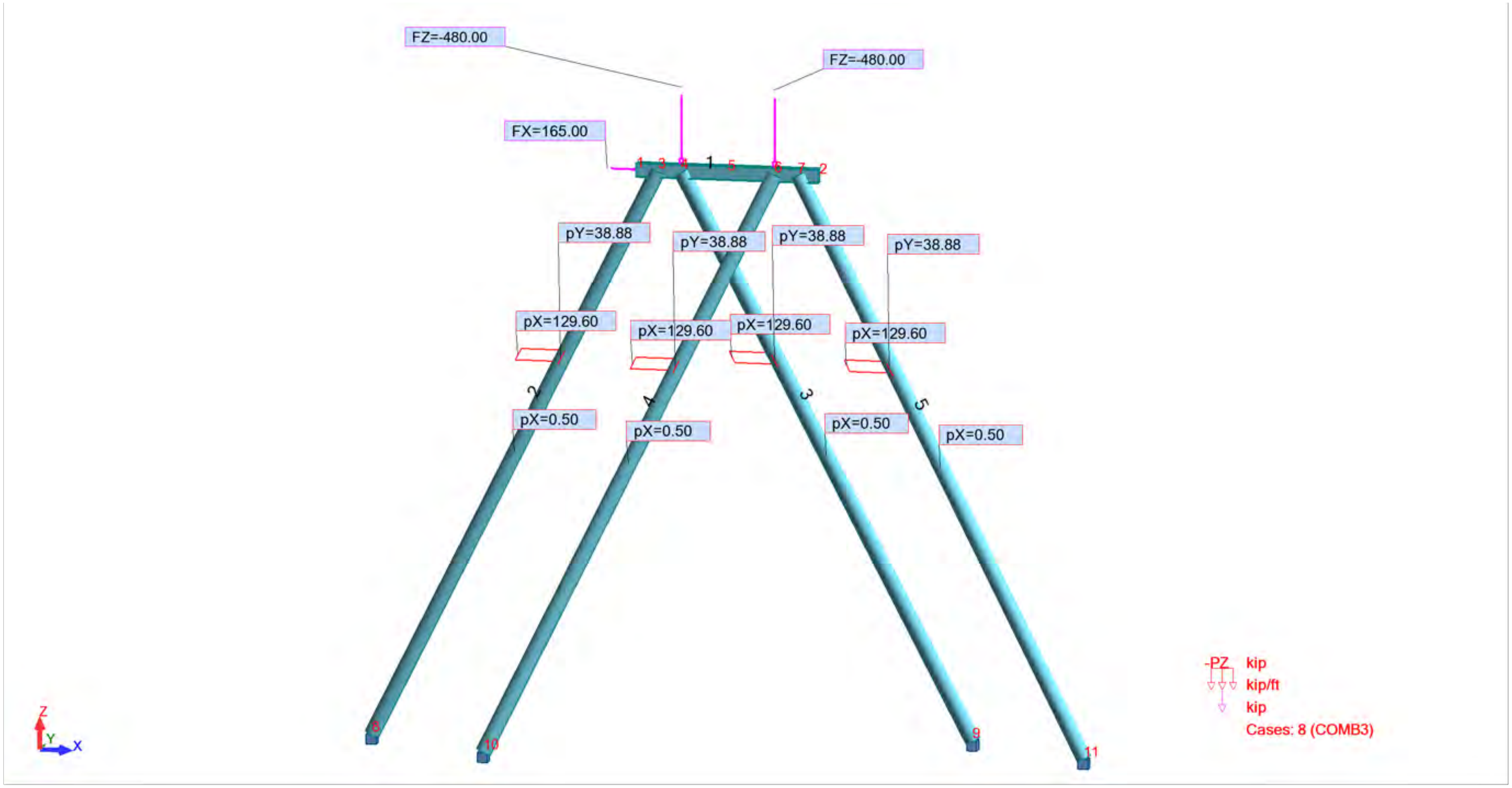
Structure - Cases: 8 (COMB3)



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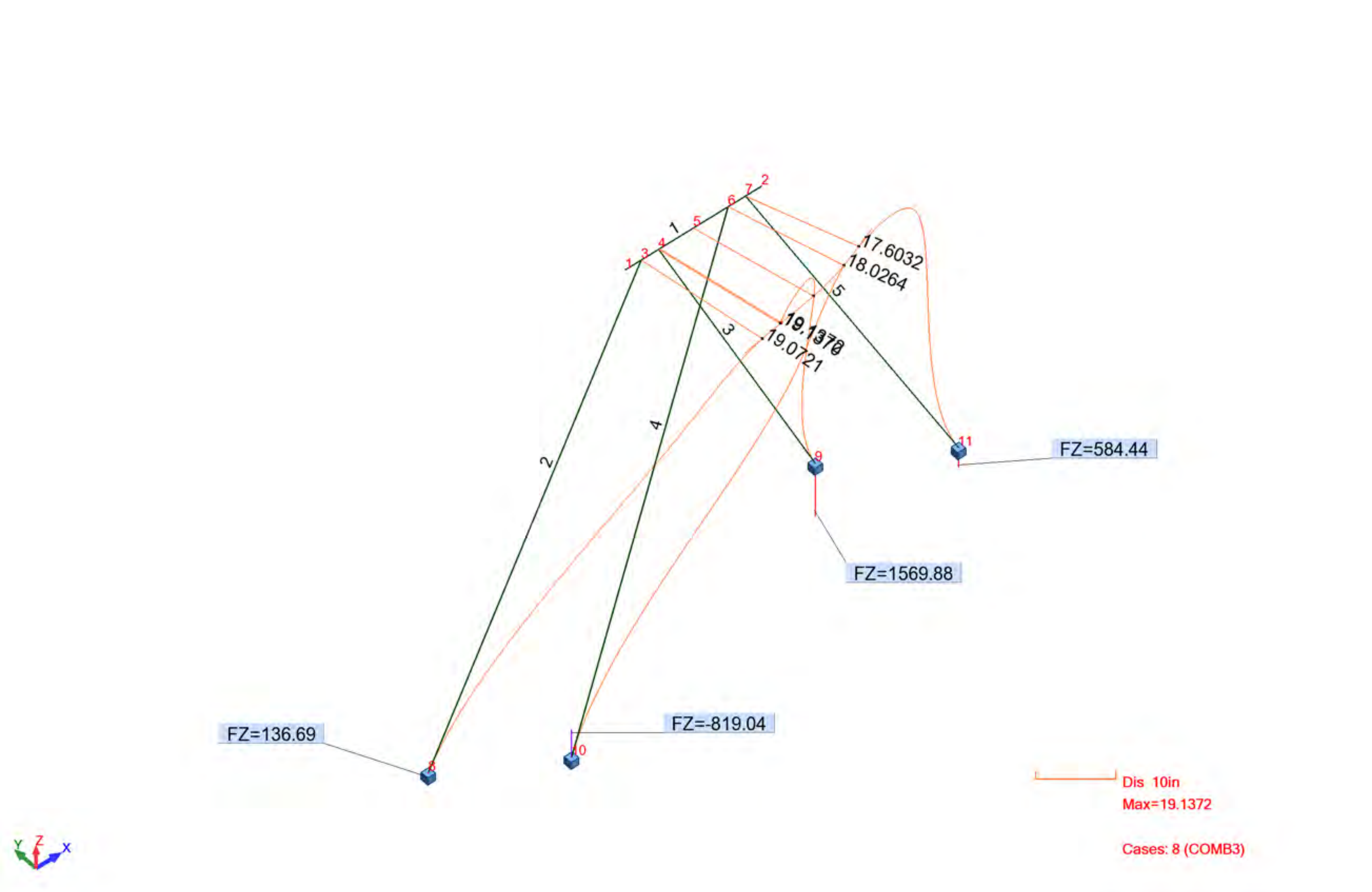
Structure - Exact deformation(s),Reaction forces(kip), Cases: 8 (COMB3)



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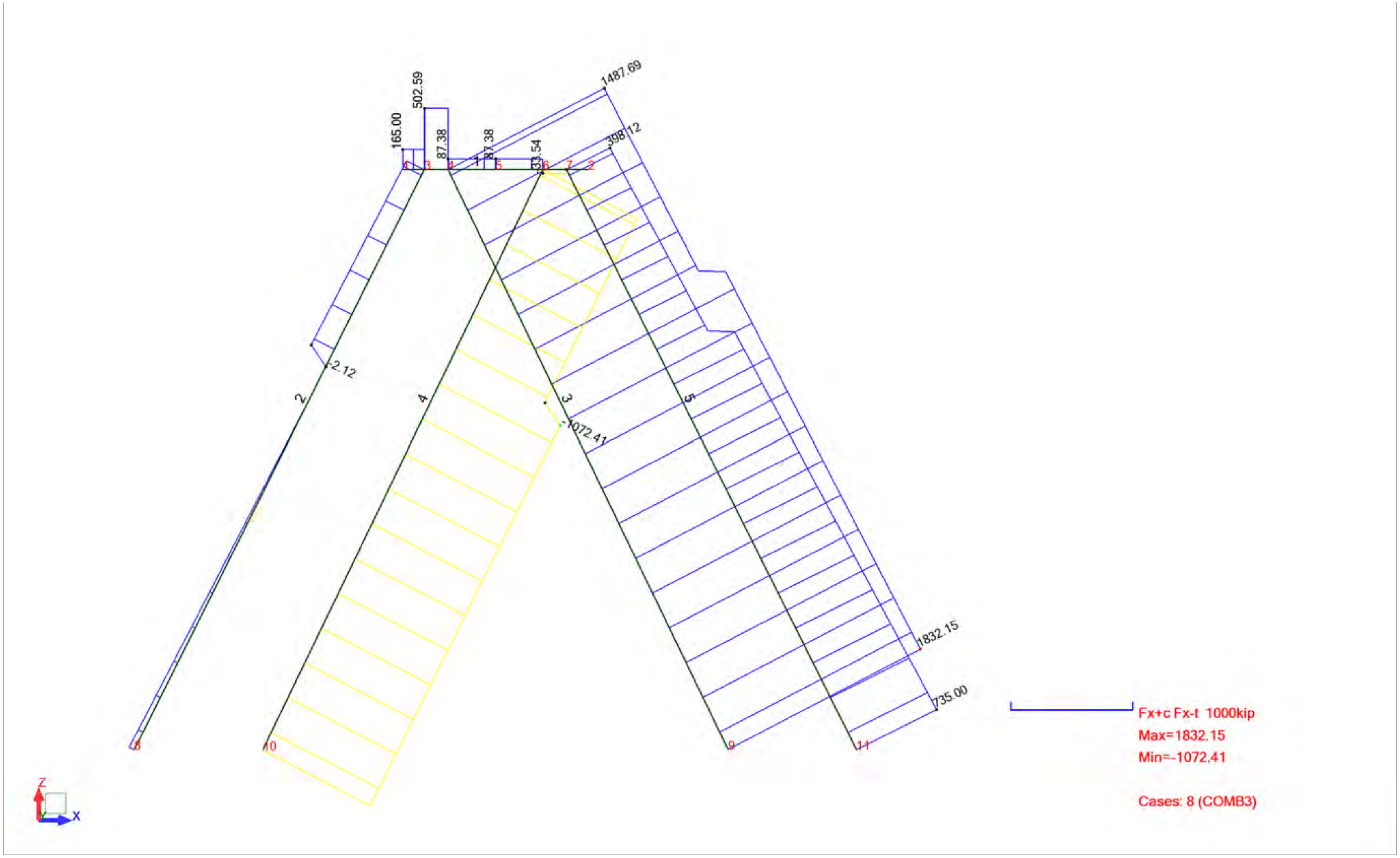
Structure - FX, Cases: 8 (COMB3)



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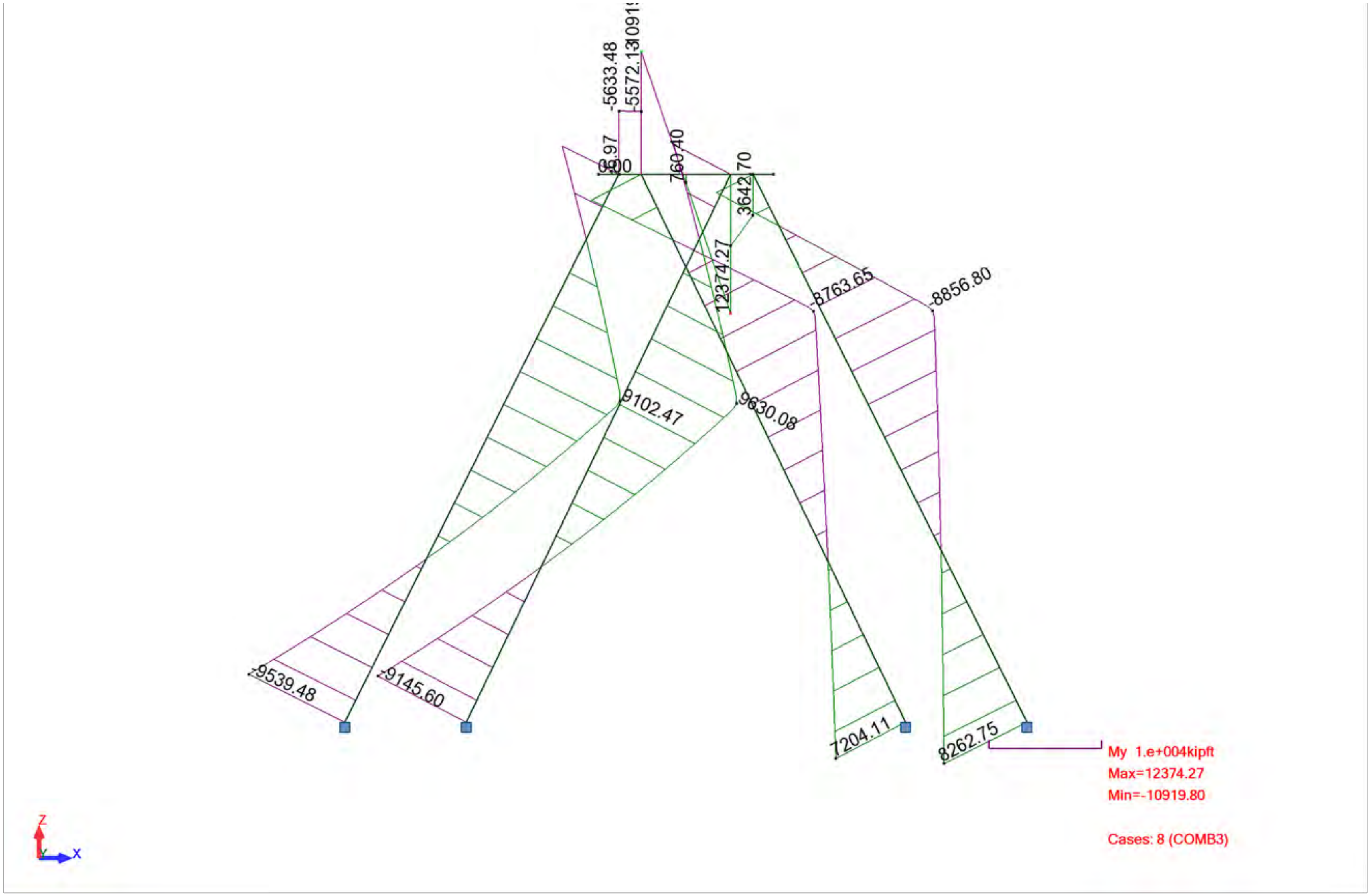
Structure - MY, Cases: 8 (COMB3)



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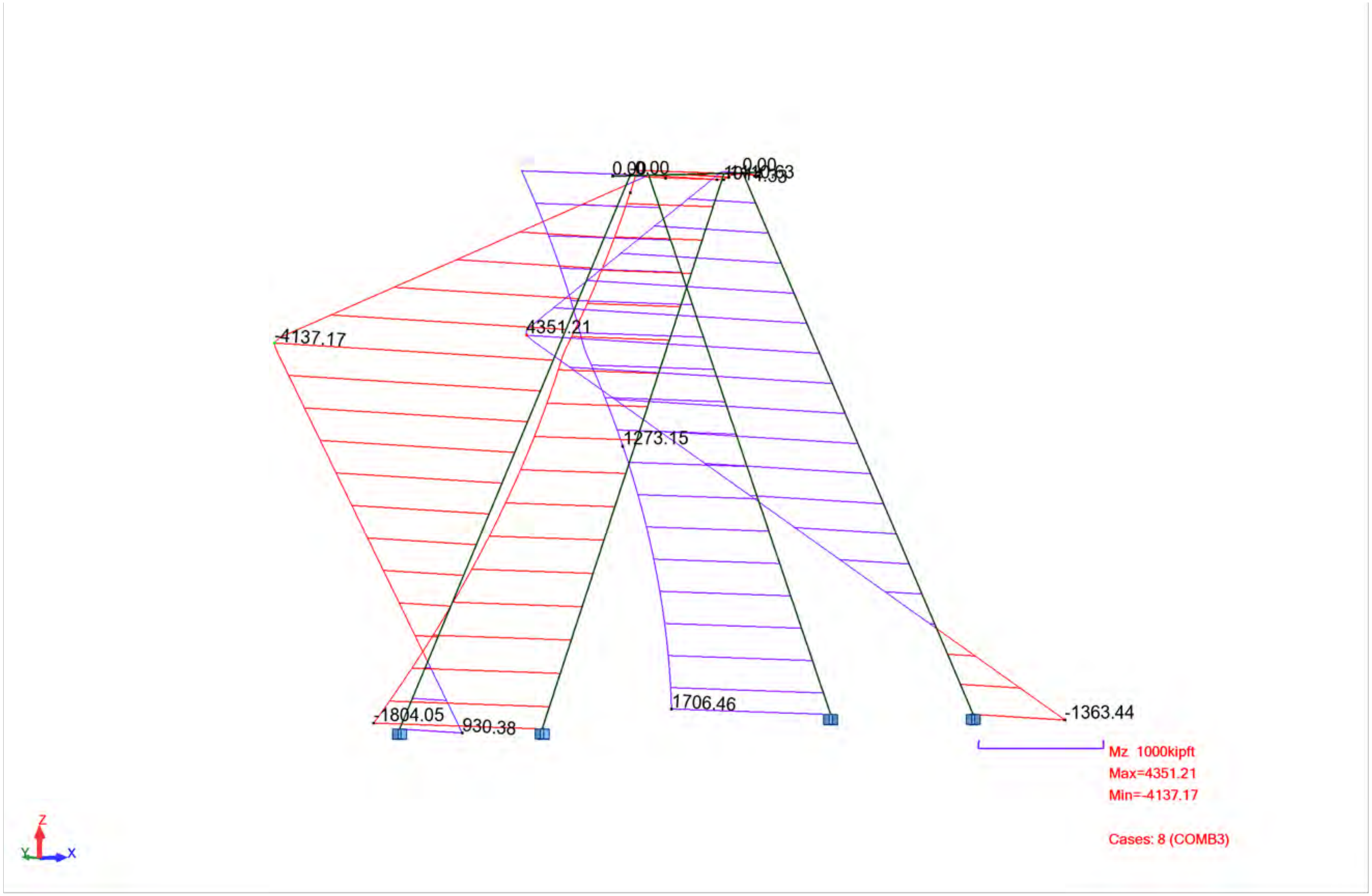
Structure - MZ, Cases: 8 (COMB3)



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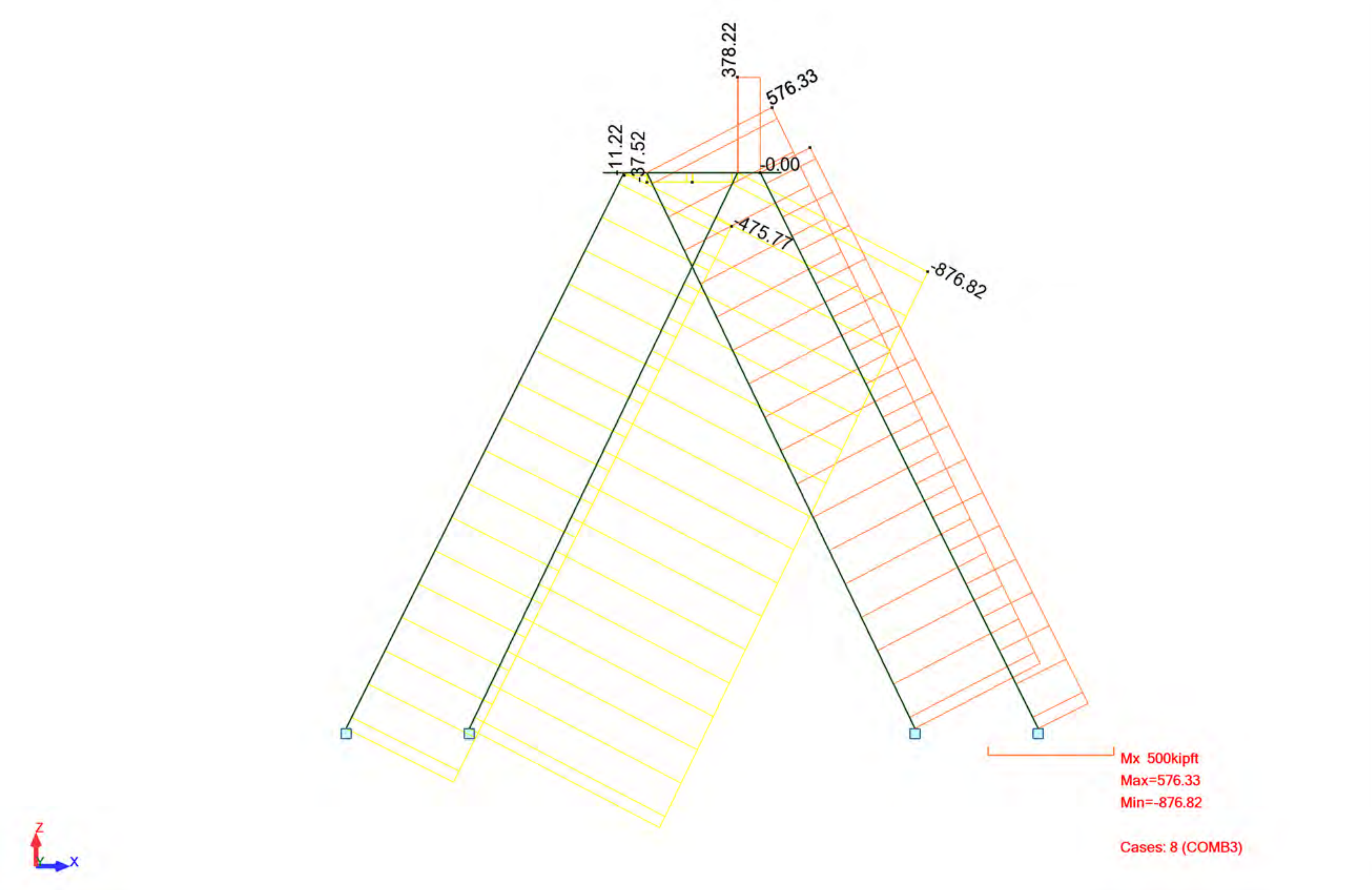
Structure - MX, Cases: 8 (COMB3)



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Robot 21 - Trial Version
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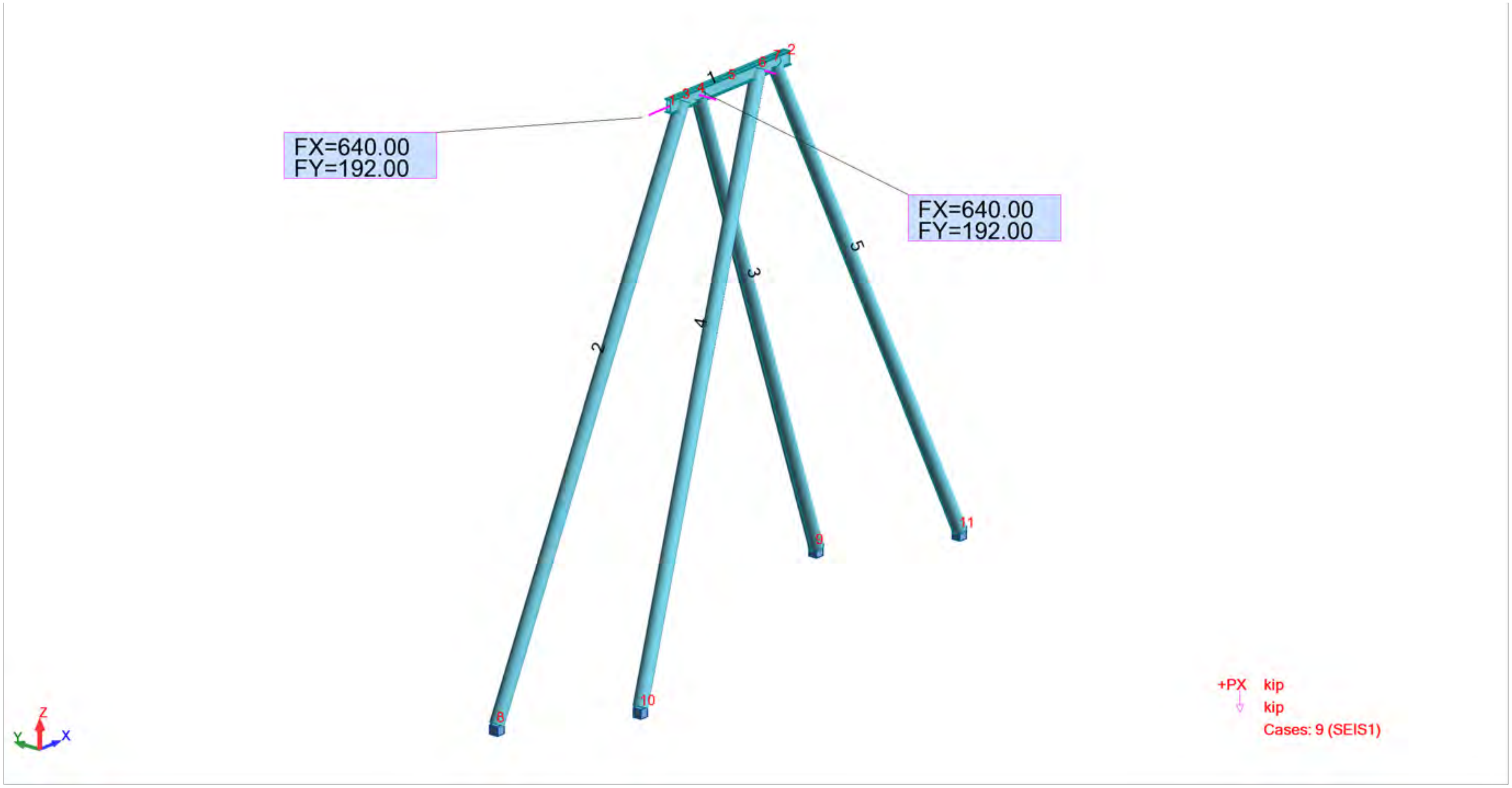
Address: Ben C. Gerwick, Inc OAK Project: 2008-66

Structure - Cases: 9 (SEIS1)



Robot 21 - Trial Version
Author: **Patrick E. Durnal**
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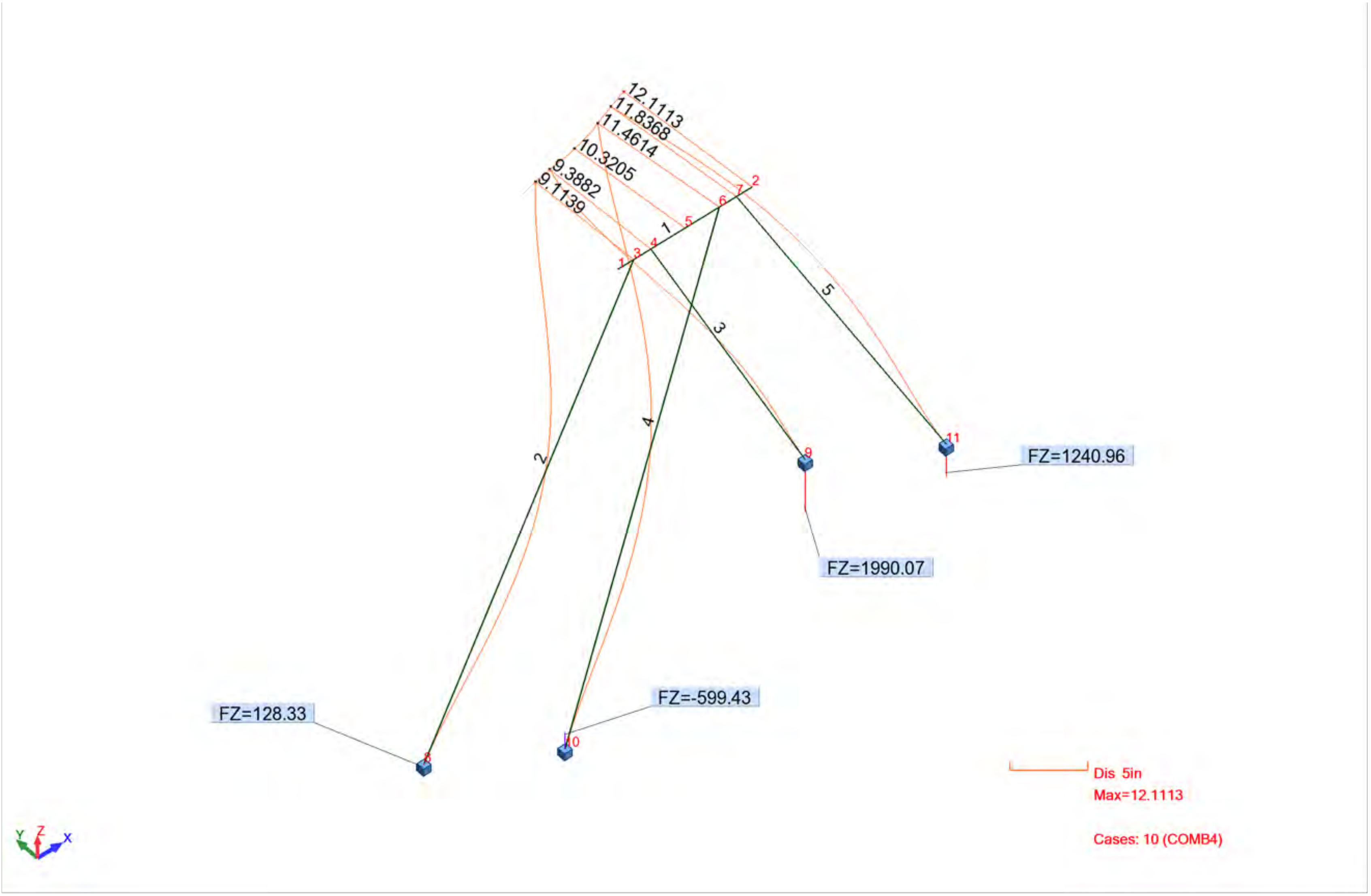
File: Knik Arm Bridge
Project: 2008-66

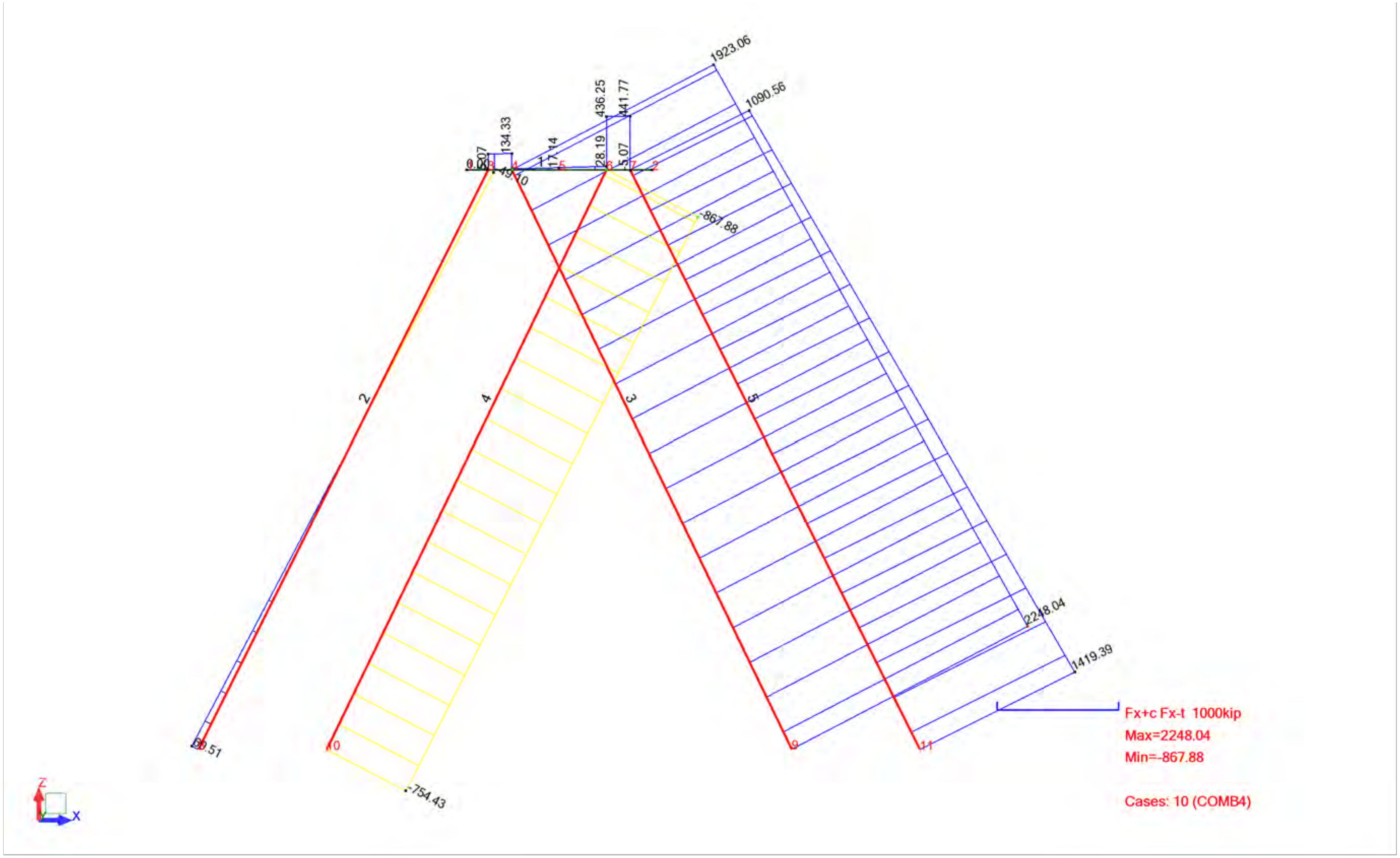
Structure - Exact deformation(s),Reaction forces(kip), Cases: 10 (COMB4)



Date : 30/01/09 Page : **1**

Robot 21 - Trial Version
Author: **Patrick E. Durnal** File: Knik Arm Bridge
Address: Ben C. Gerwick, Inc OAK Project: 2008-66

Structure - FX, Cases: 10 (COMB4)



Date : 29/01/09 Page : **1**

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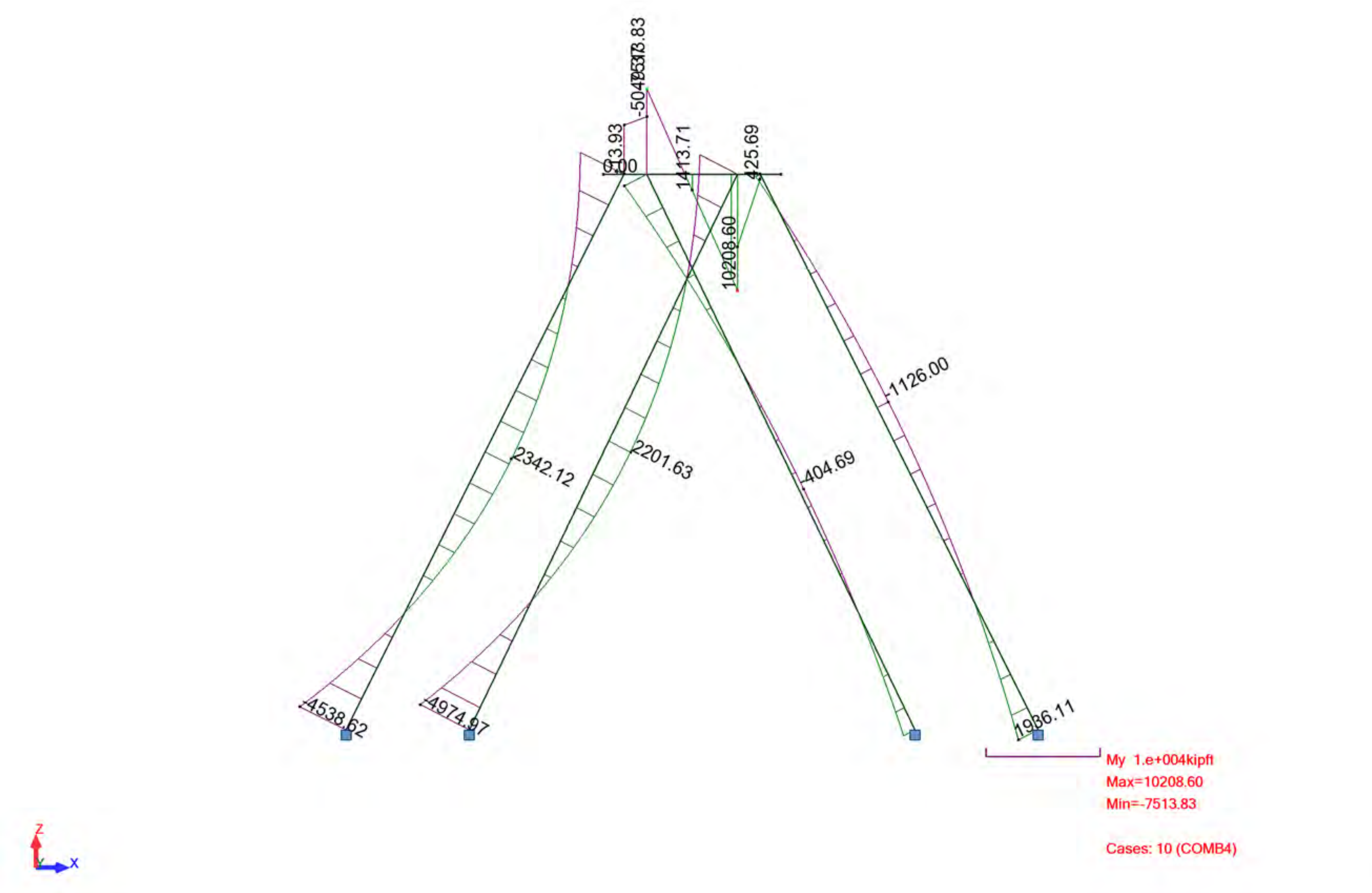
Project: 2008-66

Structure - MY, Cases: 10 (COMB4)



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Structure - MZ, Cases: 10 (COMB4)