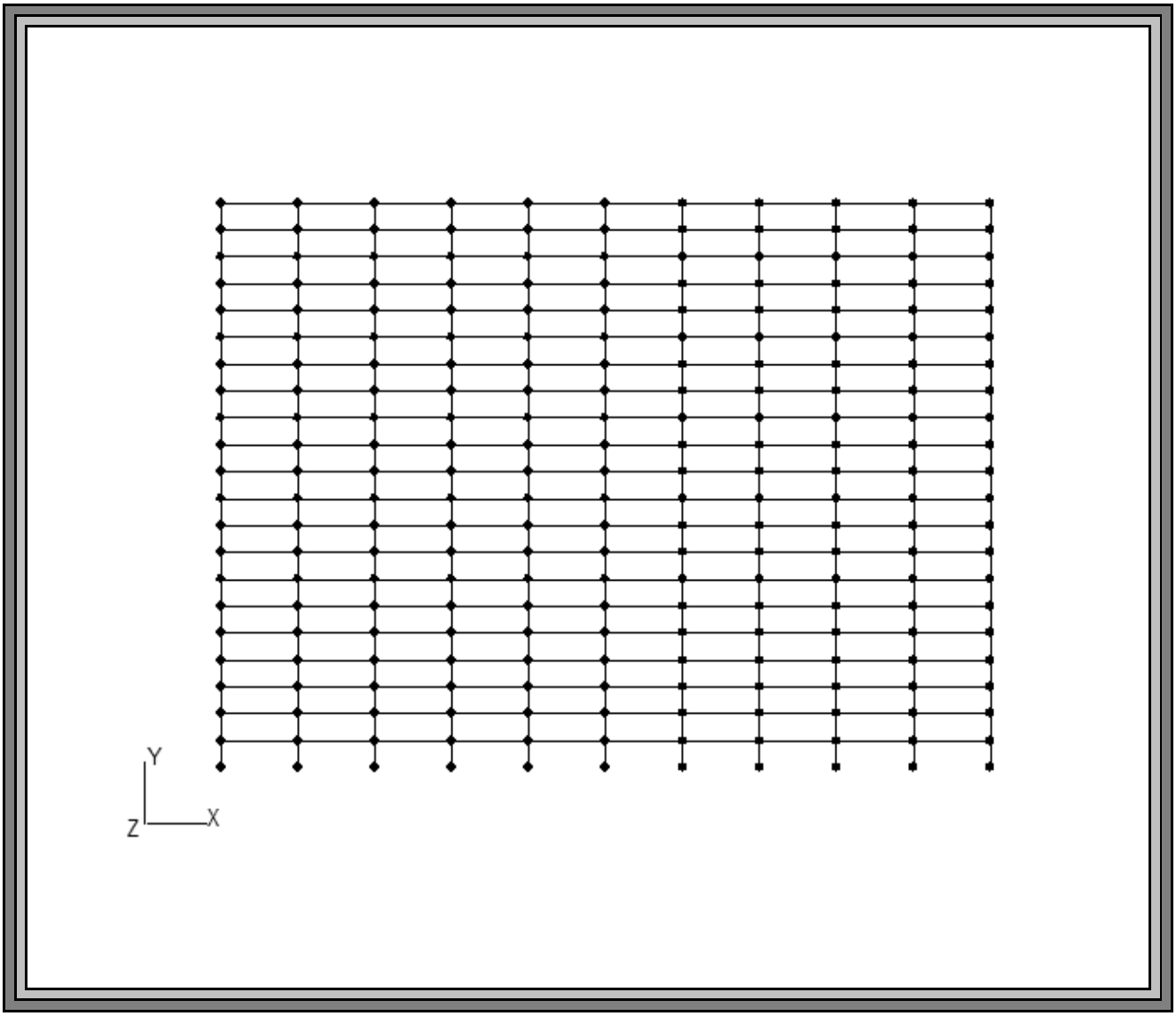
June 2007

Summary of a
Comparison of Static Analysis Analysis Results Between
GTSTRUDL 29 and ZZZ-P for a
Structure with Initial Rigid Body Instabilities

This is a brief summary of a comparison of static analysis results between GTSTRUDL 29 and another popular structural analysis program hereinafter referred to as ZZZ-P for the following structure:



Summary of Results

1. The structure shown on the previous page was initially modeled and analyzed by ZZZ-P. The ZZZ-P input file was then used to develop a GTSTRUDL command file for the purpose of performing a static analysis. Various results computed by GTSTRUDL and by ZZZ-P for the static analysis are compared herein.

2. The structure model was determined to have initial rigid body instabilities. Although ZZZ-P detected the initial instabilities, ZZZ-P proceeds as follows:

   a. ZZZ-P reports that it detected "instabilities" in the model, and then outputs warning messages such as:

      ### - AN INSTABILITY WAS DETECTED AS A NEGATIVE ON THE DIAGONAL DURING THE SOLUTION
      ●●●●●●●●
      ### - A SMALL POSITIVE NUMBER IS ADDED IN SUBSTITUTION FOR THE NEGATIVE VALUE

   b. The ZZZ-P warning messages appear to say that if the governing equations (i.e., the Stiffness Equatins) that are assembled for structure models contain initial rigid body instabilities, and during the equation solving procedures when such an instability is detected, the equations are automatically changed by ZZZ-P so that the solution can proceed, and analysis results are subsequently output.

      For example, if ZZZ-P detects a negative number, or a zero value, or a sufficiently small positive number on the diagonal of the reduced stiffness equations during its equation solving, ZZZ-P changes such values to a small positive number, and then continues the solution processing.

3. GTSTRUDL detects the initial rigid body instabilities in the model of the structure. GTSTRUDL then outputs information regarding the conditions existing during its equation solving that resulted in a determination that instabilities exist, and then terminates the equation solving. It should be noted that except for various *trivial* cases, such a determination by any structural analysis program during the equation solving ***cannot*** identify the rigid body instabilities. Rather, GTSTRUDL includes an alternate analytical procedure that the engineer may use to compute and identify the locations of the non-trivial instabilities. The engineer must then correct such instabilities (which can ONLY be corrected by the engineer, and can never, nor should be, corrected by a computer program) prior to a subsequent correct analysis.

4. Following the correction by the engineer of the rigid body instabilities in the model, GTSTRUDL was used to perform the static analysis on the initially stable model.

5. Static analysis results computed by GTSTRUDL for the model corrected by the engineer were then compared to the analysis results computed by ZZZ-P for the unstable model where the equations were changed by ZZZ-P. The comparison results are shown in Table 1, and are described as follows:

   Table 1 compares support joint reactions for support joints 1 to 11. Differences in the reaction forces range in absolute value from around 0.16% to 35,400%, where the average percent difference in the reaction force values is 668%. !!! The reaction forces as computed by ZZZ-P are incorrect when compared to the reaction forces computed by GTSTRUDL for the model where the initial rigid body instabilities were corrected by the engineer.

6. Conclusions:

1. ZZZ-P's procedure of changing negative numbers, and zero values, and sufficiently small positive numbers on the diagonal of the reduced stiffness equations during its equation solving is not correct since there is no solution for a structure with initial rigid body instabilities (i.e., the governing equations are not solvable for those cases where such negative or zero values are encountered during the solution process). Changing negative, zero, or very small positive numbers to small positive numbers DOES NOT fix initial rigid body instabilities. Rather, such changes create a new system of governing equations that, in general, have no relationship to the corrections that must be made in order to correct the modeling errors that caused the initial rigid body instabilities.

2. After such changes are made by ZZZ-P, ZZZ-P continues to solve the modified equations and outputs joint displacement, support joint reaction, and member end force analysis results. Unfortunately, such results should have no relationship to the correct results that would be obtained by analyzing a model where the initial rigid body instabilities are first corrected by the engineer prior to the analysis equation solving.

3. During the linear elastic solution of the governing equations of structural behavior (i.e., the stiffness equations), if conditions are encountered that indicate rigid body instabilities exist in the model, the solution process must terminate and issue appropriate warning messages to the engineer. The engineer must then correct the model by removing the rigid body instabilities prior to the next attempt to perform an analysis of the structure model.

   No other approach is correct.

Table 1: Comparison of Support Joint Reactions

Plane Frame: Stable and Initial Rigid Body Instabilities

Support Joint Reaction Components

GTSTRUDL Support Joint Reaction Components						**ZZZ-P Support Joint Reaction Components**						**Absolute Value % Difference**			
[Initial Rigid Body Instabilities						***[ZZZ-P Changes Diagonal***						**[(GTSTRUDL - ZZZ-P)/GTSTRUDL]x100**			
Corrected by the Engineer]						***Values from - to +]***									
JOINT	LOAD	X FORCE	Y FORCE	Z MOMENT		JOINT	LOAD	FORCE-X	FORCE-Y	MOM-Z		JOINT	LOAD	X FORCE	Y FORCE	Z MOMENT
1	1	1.291	124.341	-2.838	-----	1	1	1.65	80.56	-3.94		1	1	27.81%	35.21%	38.83%
	2	1.897	103.932	-4.169	-----		2	2.22	65.14	-5.15			2	17.03%	37.32%	23.53%
	3	-5.608	-17.135	21.085	-----		3	-5.62	-16.64	21.12			3	0.21%	2.89%	0.17%
	101	3.187	228.273	-7.007	-----		101	3.87	145.7	-9.08			101	21.43%	36.17%	29.58%
	102	-2.421	211.138	14.078	-----		102	-1.75	129.05	12.04			102	27.72%	38.88%	14.48%
2	1	0.498	149.520	-1.351	-----	2	1	1.21	118.37	-3.1		2	1	142.97%	20.83%	129.46%
	2	0.732	140.926	-1.984	-----		2	1.37	112.13	-3.56			2	87.16%	20.43%	79.44%
	3	-6.874	-3.010	22.497	-----		3	-6.89	-2.16	22.55			3	0.23%	28.24%	0.24%
	101	1.230	290.446	-3.335	-----		101	2.57	230.5	-6.66			101	108.94%	20.64%	99.70%
	102	-5.644	287.436	19.162	-----		102	-4.32	228.34	15.89			102	23.46%	20.56%	17.08%
3	1	0.299	157.335	-0.853	-----	3	1	1.38	175.71	-3.18		3	1	361.54%	11.68%	272.80%
	2	0.439	152.408	-1.253	-----		2	1.43	168.2	-3.41			2	225.74%	10.36%	172.15%
	3	-6.482	-1.197	21.350	-----		3	-6.5	-0.51	21.41			3	0.28%	57.39%	0.28%
	101	0.737	309.743	-2.106	-----		101	2.81	343.91	-6.59			101	281.28%	11.03%	212.92%
	102	-5.745	308.546	19.244	-----		102	-3.7	343.41	14.82			102	35.60%	11.30%	22.99%
4	1	0.162	159.854	-0.489	-----	4	1	0.16	266.71	-0.44		4	1	1.23%	66.85%	10.02%
	2	0.238	156.109	-0.719	-----		2	0.24	253.63	-0.7			2	0.84%	62.47%	2.64%
	3	-6.246	-0.620	20.583	-----		3	-6.27	-0.19	20.65			3	0.38%	69.35%	0.33%
	101	0.401	315.963	-1.208	-----		101	0.39	520.34	-1.14			101	2.74%	64.68%	5.63%
	102	-5.846	315.343	19.375	-----		102	-5.87	520.15	19.51			102	0.41%	64.95%	0.70%
5	1	0.063	159.957	-0.209	-----	5	1	-0.99	178.05	2.12		5	1	1471.43%	11.31%	914.35%
	2	0.092	156.260	-0.307	-----		2	-0.86	171.27	1.78			2	834.78%	9.61%	479.80%
	3	-6.054	-0.455	19.966	-----		3	-6.08	-0.33	20.03			3	0.43%	27.47%	0.32%
	101	0.154	316.218	-0.517	-----		101	-1.85	349.32	3.9			101	1101.30%	10.47%	654.35%
	102	-5.899	315.763	19.449	-----		102	-7.92	348.99	23.94			102	34.26%	10.52%	23.09%
6	1	-0.009	158.173	0.004	-----	6	1	-0.55	129.95	1.42		6	1	6011.11%	17.84%	35400.00%
	2	-0.014	153.639	0.006	-----		2	-0.47	127.11	1.2			2	3257.14%	17.27%	19900.00%
	3	-5.896	-0.231	19.464	-----		3	-5.93	-0.89	19.54			3	0.58%	285.28%	0.39%
	101	-0.023	311.812	0.010	-----		101	-1.02	257.06	2.62			101	4334.78%	17.56%	26100.00%
	102	-5.920	311.582	19.473	-----		102	-6.94	256.17	22.15			102	17.23%	17.78%	13.75%
7	1	-0.011	156.894	0.083	-----	7	1	-0.11	130.17	0.57		7	1	900.00%	17.03%	586.75%
	2	-0.017	151.760	0.121	-----		2	-0.07	129.64	0.49			2	311.76%	14.58%	304.96%
	3	-5.773	-0.122	19.055	-----		3	-5.79	-2.5	19.1			3	0.29%	1949.18%	0.24%
	101	-0.028	308.654	0.204	-----		101	-0.18	259.81	1.05			101	542.86%	15.82%	414.71%
	102	-5.801	308.532	19.259	-----		102	-5.97	257.31	20.15			102	2.91%	16.60%	4.63%
8	1	-0.114	164.899	0.375	-----	8	1	-0.14	157.12	0.68		8	1	22.81%	4.72%	81.33%
	2	-0.168	163.520	0.551	-----		2	-0.2	158.68	0.83			2	19.05%	2.96%	50.64%
	3	-5.633	-1.729	18.630	-----		3	-5.62	-4.48	18.6			3	0.23%	159.11%	0.16%
	101	-0.282	328.419	0.926	-----		101	-0.34	315.8	1.51			101	20.57%	3.84%	63.07%
	102	-5.915	326.690	19.556	-----		102	-5.96	311.32	20.11			102	0.76%	4.70%	2.83%
9	1	-0.331	159.722	0.907	-----	9	1	-0.46	157.43	1.41		9	1	38.97%	1.43%	55.46%
	2	-0.486	155.914	1.333	-----		2	-0.63	154.53	1.83			2	29.63%	0.89%	37.28%
	3	-5.459	0.419	18.142	-----		3	-5.42	-0.48	18.05			3	0.71%	14.56%	0.51%
	101	-0.817	315.636	2.241	-----		101	-1.09	311.96	3.24			101	33.41%	1.16%	44.58%
	102	-6.275	316.055	20.382	-----		102	-6.51	311.48	21.29			102	3.75%	1.45%	4.45%
10	1	-0.534	148.976	1.423	-----	10	1	-0.71	147.27	2.01		10	1	32.96%	1.15%	41.25%
	2	-0.784	140.127	2.091	-----		2	-0.97	137.89	2.68			2	23.72%	1.60%	28.17%
	3	-5.288	4.278	17.627	-----		3	-5.24	5.28	17.51			3	0.91%	23.42%	0.66%
	101	-1.318	289.104	3.515	-----		101	-1.67	285.16	4.69			101	26.71%	1.36%	33.43%
	102	-6.605	293.382	21.142	-----		102	-6.91	290.44	22.2			102	4.62%	1.00%	5.00%
11	1	-1.313	121.940	2.888	-----	11	1	-1.44	120.27	3.4		11	1	9.67%	1.37%	17.73%
	2	-1.929	100.404	4.244	-----		2	-2.06	96.78	4.75			2	6.79%	3.61%	11.92%
	3	-3.689	19.801	14.614	-----		3	-3.65	22.9	14.52			3	1.06%	15.65%	0.64%
	101	-3.241	222.344	7.132	-----		101	-3.5	217.05	8.15			101	7.99%	2.38%	14.27%
	102	-6.930	242.145	21.746	-----		102	-7.15	239.94	22.66			102	3.17%	0.91%	4.20%

GTSTRUDL Model:

ACTIVE UNITS WEIGHT KIP LENGTH FEET

TOTAL LENGTH, WEIGHT AND VOLUME FOR SPECIFIED MEMBERS

LENGTH = 4.3050E+03 WEIGHT = 1.6616E+03 VOLUME = 3.3906E+03

ZZZ-P Model:

PROFILE	**LENGTH(FEET)**	**WEIGHT(KIPS)**
PRISMATIC STEEL	**4305.00**	**1661.605**
	TOTAL =	**1661.605**

TOTAL VOLUME OF PRISMATIC STEEL SECTIONS = 3390.62 CUBIC FEET