APPENDIX E

STRUCTURE ANALYSIS

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Task #6 – Wind Load Evaluation

6.1. Scope – An evaluation of the Herbert, Rowland & Grubic, Inc., (HRG) calculations from the 2002 Bridge Inspection Report of the Kinzua Viaduct will be made ascertaining appropriateness of analysis methodology, code compliance and completeness of evaluation.

Summary and Conclusions

An evaluation of HRG's analysis of the Kinzua Viaduct for the 2002 Bridge Inspection Report was conducted. The analysis was found to be complete and accurate.

Analysis and rating calculations were performed using Working Stress or Allowable Stress methodology in accordance with the following specifications:

1) American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, Fifteenth Edition, 1996.

2) AASHTO Manual for Condition Evaluation of Bridges, Second Edition, 1994 as revised by the 1995, 1996, 1998 and 2000 Interim Revisions

3) American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, 2002

Note that references to the AREA code in the 2002 Inspection Report should reference the AREMA code listed above. However, all calculations presented in the inspection report are correct and consistent with the AREMA specifications.

Superstructure ratings were performed using the Pennsylvania Department of Transportation's (PennDOT's) Bridge Analysis and Rating (BAR-7) computer program that performs structural and rating analyses in accordance with AASHTO specifications. Inventory Ratings in accordance with AASHTO Specifications are equivalent to Normal Ratings as outlined in the AREMA code, with an allowable bending stress equal to 0.55*Fy for both specifications. Analysis runs were performed for as-built and existing (including section losses) conditions of the riveted built-up girders of the viaduct for both the long (61.0') spans between towers and the short (38.5') tower spans. Dead loads included the self-weight of the riveted girder along with the tributary weight of attachments, decking, and rails calculated accurately from existing viaduct structure drawings.

AREMA design live loads include the Cooper E series loads. New bridges are to be designed for the Cooper E80 (1136 kip) live load. The HRG analyses include ratings for the Cooper E72 load, current loads used by the Knox Kane Railroad that would use the viaduct for tourist/passenger services, and the Cooper E35 load that is the Cooper E load most closely matching the weight and configuration of the Knox Kane Steam Engine. Impact was incorporated in accordance with AREMA Chapter 15 Sections 1.3.5 and 7.3.3.3.

The superstructure ratings were satisfactory for the Knox Kane and Cooper E35 live loads using a yield stress (Fy) equal to 26 ksi as recommended in the AASHTO Manual for Condition Evaluation of Bridges for bridges built prior to 1905 (Section 6.6.2.1). Material tests indicate that the steel used for the viaduct actually has a yield stress equal to 33 ksi.

The substructure was evaluated by modeling bent 20 of the viaduct as a plane frame using STAAD Pro 2001 structural analysis software. Bents 19 through 22 of the viaduct are similar, and are the highest and most critical bents for the structure. The bent frame was modeled with various support conditions to simulate the as-built structure, as well as the existing structure condition in which expansion rollers under the east columns are frozen and the bottom struts are deteriorated. Dead load and live load (Cooper E35) reactions from the BAR-7 superstructure analysis were applied to the top of the plane frame model. Section properties and weights, including all lacing and attachments, for columns and struts were accurately calculated from existing plans for input into the STAAD model.

Wind loads are applied to the bent frame model in accordance with AREMA Sections 1.3.7 and 1.3.8 for loaded and unloaded bridges, respectively. A wind pressure equal to 30 psf is applied to the loaded bridge (with live load), and a wind pressure equal to 50 psf is applied to the unloaded bridge (without live load) based on a 100 MPH wind speed. Additionally, the loaded bridge has a 300 lb/ft load applied to the train. Note that AREMA Section 7.3.3.5 allows a reduction in the design wind loads for rating calculations, but the reduced loads were not used for the 2002 inspection report.

The bent frame model was analyzed for AASHTO Service Load cases 1 through 6, slightly modified to incorporate wind load requirements outlined in AREMA. The yield stress of the bent frame members was found to be 33 ksi from material tests. Ratings for the bent members are based on the AREMA Maximum Rating allowable stress, K, equal to 0.8 Fy (26.4 ksi) (similar to an AASHTO Operating Rating value), and are calculated using AREMA combined stress equations (Section 7.3.4.3). Several bent members were found to have inadequate rating values resulting in repair recommendations as outlined in the 2002 Inspection Report.

Overall, the analysis methods used by HRG in the 2002 Bridge Inspection Report for the Kinzua Viaduct were deemed adequate. Applied loads, allowable stresses, and rating calculations were found to be in compliance with relevant codes, and the analyses performed accurately depict the structural condition of the viaduct.

6.2. Scope – The undamaged structure will be analyzed based on wind speed, wind direction and gust factor determined under Task 5 (Meteorological Interpretation). An elastic analysis will be performed. This evaluation will initially assume complete integrity of the existing anchor bolt system to accurately predict theoretical uplift forces that could fully be expected with an intact structure. A comparison of these forces against material strengths derived in Task 4 (Evaluation of Existing Anchor Bolts) will also be made.

Procedure

A walk-through of the bridge site following the collapse revealed that the towers fell essentially intact, making it evident that the failure of the structure was initiated at the column to concrete pedestal connections. Therefore, the structure was analyzed to try to determine the forces experienced by the anchor system at the time of the collapse. Each bent column was attached to its concrete pedestal using two 1-1/4" diameter heavy upset threaded rods. The threaded rods were the original anchors from the initial wrought iron construction of the viaduct in 1882. As part of the reconstruction of the viaduct in 1900, the original wrought iron anchor rods were extended by coupling standard tap bolts to the existing anchors using a threaded sleeve.

The plane-frame STAAD model of bent 20 from the 2002 Bridge Inspection Report of the Kinzua Viaduct was reproduced using STAAD Pro 2002 software. Section properties used in the model are calculated in the 2002 Report. The orientation of the collapsed towers indicated that the first towers to fall were towers 10 and 11 (bents 19 through 22). Bents 19 through 22 are the highest, most critical bents on the structure, and they are identical in construction. Therefore, modeling bent 20 for the event wind load analysis was considered acceptable.

The following analysis runs were made:

1) **File 'Kinzorig'** – The as-built structure, with full member stiffness; all members connected; wind pressure from the left based on 73, 80, 90, 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with roller

bearing (no friction) on the left (east side) and pin bearing on the right (west side).

2) **File 'Kinzu100'** – The as-built structure, with full member stiffness; all members connected; wind pressure from the left based on 73, 80, 90 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with frozen roller bearing (modeled as a 95 kip/in spring per the 2002 Inspection Report) on the left (east side) and a pin bearing on the right (west side).
3) **File 'Kin100RL'** – The as-built structure, with full member stiffness; bottom strut released; wind pressure from the left based on 73, 80, 90, 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with frozen roller bearing (modeled as a 95 kip/in spring per the 2002 Inspection Report) on the left (east side) and a pin bearing on the right (west side).

The direction of the fallen trees and orientation of the collapsed towers indicated that the windstorm that caused the failure had approached the structure from the east. Therefore, all bent analyses were run assuming wind on the left (east) side.

A site visit following the collapse, as well as notes from the 2002 Inspection Report revealed that all of the roller bearings under the east columns had rusted and 'frozen' prior to the collapse. Therefore, STAAD models for the event wind load assumed the roller bearings to be frozen. Additionally, the bottom struts on most of the towers were severely rusted with heavy section losses at the strut to column connections. Many bottom struts experienced 100% section loss. Therefore, analysis runs were also performed assuming that the bottom strut was released from the columns.

A damage assessment of the site along with meteorological data recorded at the time of the event indicated that the windstorm causing the collapse was equivalent to an F-1 tornado based on the Fujita Tornado Damage Scale (see attached F-scale criteria). AREMA Chapter 15, Section 1.3.8 specifies a design wind pressure of 50 psf for new bridges when unloaded (without live load). The 50 psf pressure is based on a 100 mph wind speed. No adjustments for varying design wind speeds are specified in AREMA. Therefore, ASCE-7 (2002) was used to determine wind pressures on the structure for various wind speeds. The upper and lower wind speed limits for an F-1 tornado are 112 mph and 73 mph, respectively. Therefore, wind event analyses were run for 73 mph, 80 mph, 90 mph, 100 mph, and 112 mph wind speeds.

Summary of Results

Table 1. Tensile Capacity of Original Wrought Iron Anchor System

Nominal Heavy Upset Threaded Rod Diameter	Tensile Capacity of 1½" Dia. Steel Anchor Bolts added in 1900 (Based on Tensile Area at Threads)[1]	Tensile Capacity of 2- ¼" O.D. Wrought Iron Coupling added in 1900 (Based on Tensile Area at Threads)[2]	Tensile Capacity of Original 1882 Wrought Iron Anchor Rod (Based on Tensile Area at 1½" Dia. Threads)[3]	Tensile Capacity of Original 1882 Wrought Iron Anchor Rod (Based on Nominal Area of 1¼" Dia. Tie Rod)[3]	Tensile Capacity of Original 1882 Anchor Rod (Based on Nominal Area of 1¼" Dia. Tie Rod, Assuming 20% Section Loss)[3]
1 ¼"	84.3 kips	99.3 kips	87.1 kips	76.1 kips	60.9 kips

[1] Tensile capacity is based on a Tensile Strength of 60 ksi determined from material tests conducted by the Center for Advanced Technology for Large Structural Systems (ATLSS) at Lehigh University, Bethlehem, Pennsylvania.
[2] Tensile capacity is based on a Tensile Strength of 55 ksi determined from material tests conducted by ATLSS at Lehigh University, Bethlehem, Pennsylvania.
[3] Tensile capacity is based on a Tensile Strength of 62 ksi determined from material tests conducted by ATLSS at Lehigh University, Bethlehem, Pennsylvania.

Note: Post-collapse site investigations and material tests indicate that corrosion loss was significant in the original 1882 heavy upset threaded rod anchors. Fractographic examination of fractured original 1882 anchor rods showed that the fracture resulted from tensile overload and was fully ductile fracture. Coupling fractures show evidence of fatigue fracture with secondary fractures occurring by overload, presumably during the collapse. It appears that at least some of the couplings were completely fractured by fatigue at the time of the collapse. It is assumed that 3 out of 4 couplings at the expansion rollers under the windward columns of each tower had failed prior to the collapse of the viaduct, and that the original anchor rods experienced 20% section loss. Therefore, the uplift capacity for each tower at the time of collapse is assumed to be:

$$Capacity = 62\ ksi \times \pi \times (1.25")^2 / 4 \times 0.80 \times 0.25 \times 4\ bolts = 60.9\ kips/tower \quad (30.4\ kips/bent)$$

Table 2. Wind Speed vs. Wind Pressure

Specification	Design Wind Speed (MPH)	Design Pressure (psf)	Wind Speed (MPH)	Wind Pressure[1] (psf)
AREMA, 2002	Not Specified (100 MPH assumed)	50	--	--
ASCE-7, 2002	90 MPH at location of viaduct	35.87	73	23.60
			80	28.34
			90	35.87
			100	44.29
			112	55.55

[1] AREMA does not specify a method to adjust wind pressure with wind speed. ASCE-7 specifies to calculate the wind pressure according to the equation:

$p = 0.00256 K_z K_{zt} V^2 I$ where: K_z = velocity pressure exposure coefficient (ASCE Sec. 6.5.6.6)
= 1.73 assuming Exposure D @ 300' (ASCE Table 6-3)
K_{zt} = topographic factor (ASCE Sec. 6.5.7.2)
= 1.0 assuming Exposure D
V = Wind Speed in MPH
I = Importance Factor (ASCE Sec. 6.5.5)
= use 1.0 for evaluation

Table 3. STAAD Results

Analysis Run	Wind Speed[1] (MPH)	Wind Pressure[1] (psf)	Total Lateral Wind Force (kips)	West Base Compression / Shear[2] (kips)	East Base Tension / Shear[2] (kips)	Tensile Force per Anchor Rod (kips)	Tensile Stress per Rod[3] (ksi)
'Kinzorig'	73	23.60	54.89	208.19 (-54.87)	27.71 (0.00)	Compression	--
	80	28.34	65.95	226.39 (-65.93)	9.54 (0.00)	Compression	--
	83.4 (at uplift inception)	30.82	71.71	235.85 (-71.68)	0.00 (0.00)	0.00	0.00
	90	35.87	83.44	255.17 (-83.40)	-19.20 (0.00)	9.60	7.82
	93.6 (at assumed capacity at collapse)[4]	38.82	90.32	266.48 (-90.27)	-30.40 (0.00)	15.20	12.39
	100	44.29	103.01	287.36 (-102.95)	-51.34 (0.00)	25.67	20.92
	112	55.55	129.26	330.56 (-129.18)	-94.45 (0.00)	47.22	38.49
	126.3 (at full bolt capacity)[5]	70.64	164.36	388.30 (-164.24)	-152.15 (0.00)	76.08	62.00

Table 3. STAAD Results (cont'd.)

Analysis Run	Wind Speed[1] (MPH)	Wind Pressure[1] (psf)	Total Lateral Wind Force (kips)	West Base Compression / Shear[2] (kips)	East Base Tension / Shear[2] (kips)	Tensile Force per Anchor Rod (kips)	Tensile Stress per Rod[3] (ksi)
'Kinzu100'	73	23.60	54.89	208.18 (-52.71)	27.70 (-2.17)	Compression	--
	80	28.34	65.95	226.38 (-62.34)	9.53 (-3.60)	Compression	--
	83.4 (at uplift inception)	30.82	71.71	235.84 (-67.34)	0.00 (-4.34)	0.00	0.00
	90	35.87	83.44	255.15 (-77.56)	-19.21 (-5.86)	9.60	7.83
	93.6 (at assumed capacity at collapse)[4]	38.82	90.32	266.46 (-83.54)	-30.40 (-6.75)	15.20	12.39
	100	44.29	103.01	287.34 (-94.58)	-51.36 (-8.38)	25.68	20.93
	112	55.55	129.26	330.52 (-117.43)	-94.49 (-11.77)	47.24	38.50
	126.3 (at full bolt capacity)[5]	70.64	164.36	388.25 (-147.96)	-152.15 (-16.31)	76.08	62.00

Table 3. STAAD Results (cont'd.)

Analysis Run	Wind Speed[1] (MPH)	Wind Pressure[1] (psf)	Total Lateral Wind Force (kips)	West Base Compression / Shear[2] (kips)	East Base Tension / Shear[2] (kips)	Tensile Force per Anchor Rod (kips)	Tensile Stress per Rod[3] (ksi)
'Kin100RL'	73	23.60	54.89	206.46 (-46.32)	25.98 (-8.57)	Compression	--
	80	28.34	65.95	224.65 (-51.91)	7.80 (-14.04)	Compression	--
	82.8 (at uplift inception)	30.36	70.65	232.37 (-54.29)	0.00 (-16.36)	0.00	0.00
	90	35.87	83.44	253.41 (-60.75)	-20.96 (-22.69)	10.48	8.54
	93.0 (at assumed capacity at collapse)[4]	38.32	89.16	262.80 (-63.64)	-30.40 (-25.52)	15.20	12.39
	100	44.29	103.01	285.57 (-70.64)	-53.13 (-32.37)	26.56	21.65
	112	55.55	129.26	328.73 (-83.91)	-96.28 (-45.35)	48.14	39.23
	125.8 (at full bolt capacity)[5]	70.14	163.19	384.50 (-101.06)	-152.15 (-62.13)	76.08	62.00

[1] STAAD analyses were run for a base wind pressure of 50 psf. Wind pressures at various velocities were run as separate load combinations with a load factor applied to the wind loading equal to the pressure at a given wind speed divided by the base pressure times a Dynamic Load Factor = 1.1 (i.e. at 73 mph, the load factor applied to the wind load was (23.60 psf x 1.1) / 50 psf = 0.519). Several iterations were performed for each of the three STAAD runs to determine the load factor at inception of uplift on the windward column, and to determine the load factor at the point where the anchor bolts were

stressed to their ultimate capacity at time of collapse (including losses) and at initial construction (without losses). Wind pressure and speed were then back calculated as shown below.

[2] Number in parenthesis is the shear force at the base concurrent with the compressive (positive) / tensile (negative) force.

[3] Number given is the stress on the nominal area of the tie rod for the heavy upset threaded rod anchors.

[4] At the time of the collapse, it is assumed that 20% section loss had occurred in the tie rods of the heavy upset threaded anchor rods, and that 3 of 4 couplings had failed on the windward side of each tower resulting in an uplift capacity of (62 ksi x 1.227 in^2 x 0.8 =) 60.9 kips/tower (30.4 kips/bent).

[5] Full bolt uplift capacity for windward columns of tower at time of construction = 62 ksi x 1.227 in^2 x 4 bolts = 304.30 kips/tower (152.15 kips/bent).

- Calculation of wind pressure and speed at inception of uplift and at full anchor bolt capacity for the original viaduct construction case ('Kinzorig' analysis), and for the case where the expansion bearing under the east column is frozen ('Kinzu100' analysis):

1) Load Factor @ Uplift = 0.678 Pressure, p = 0.678 x 50 psf / 1.1 = 30.82 psf

Therefore, Velocity @ Uplift, $V_{up} = \sqrt{p/(0.00256 K_z K_{zt} I)} = \sqrt{30.82\,psf/(0.00256\times1.73\times1.0\times1.0)} = 83.4\,mph$

2) Load Factor @ Full Bolt Capacity (with losses, at collapse) = 0.854 Pressure, p = 0.854 x 50 psf / 1.1 = 38.82 psf

Velocity @ Collapse, $V_{Full} = \sqrt{38.82\,psf/(0.00256\times1.73\times1.0\times1.0)} = 93.6\,mph$

3) Load Factor @ Full Bolt Capacity (without losses) = 1.554 Pressure, p = 1.554 x 50 psf / 1.1 = 70.64 psf

Velocity @ Full Bolt Capacity, $V_{Full} = \sqrt{70.64\,psf/(0.00256\times1.73\times1.0\times1.0)} = 126.3\,mph$

- Calculation of wind pressure and speed at inception of uplift and at full anchor bolt capacity for the viaduct when the expansion bearing under the east column is frozen, and the bottom strut is removed ('Kin100RL'):

1) Load Factor @ Uplift = 0.668 Pressure, p = 0.668 x 50 psf / 1.1 = 30.36 psf

Therefore, Velocity @ Uplift, $V_{up} = \sqrt{30.36\,psf / (0.00256 \times 1.73 \times 1.0 \times 1.0)} = 82.8\,mph$

2) Load Factor @ Full Bolt Capacity (with losses, at collapse) = 0.843 Pressure, p = 0.843 x 50 psf / 1.1 = 38.32 psf

Velocity @ Collapse, $V_{Full} = \sqrt{38.32\,psf / (0.00256 \times 1.73 \times 1.0 \times 1.0)} = 93.0\,mph$

3) Load Factor @ Full Bolt Capacity (without losses) = 1.543 Pressure, p = 1.543 x 50 psf / 1.1 = 70.14 psf

Velocity @ Full Bolt Capacity, $V_{Full} = \sqrt{70.14\,psf / (0.00256 \times 1.73 \times 1.0 \times 1.0)} = 125.8\,mph$

KINZUA VIADUCT

THEORETICAL ANCHOR BOLT CAPACITY DURING THE JULY 21, 2003 EVENT

ANCHOR BOLT FAILURE TABULATION **				
MODE	**DESCRIPTION**	**EAST SIDE EXPANSION BEARING**	**WEST SIDE FIXED BEARING**	**TOTAL BOTH SIDES**
1	Failure of bolt screwed into coupler	1	0	1
2	Coupler Failed	28	0	28
3A	Wrought Iron Anchor Rod Failed Above Masonry	5	20	25
3B	Wrought Iron Anchor Rod Failed Below Masonry	3	22	25
4	Failure of Washer Plates	5	0	5
-	Not Accessible	2	2	4
	Total Number of Bolts	44	44	**88**
	Total Number of Bolts Observed	42	42	**84**

****Per the August 18, 2003 report prepared by HRG/REI Joint Venture, 369 East Park Drive, Harrisburg, PA 17111 as prepared for PA Department of Conservation and Natural Resources**

East side, expansion bearing anchor system capacity:

- Observed failure modes accounted for by the couplers (Modes 2 & 3A) = $\frac{28+5}{42}$ = 78.6%
- Observed failure modes other than the couplers (Modes 1, 3B & 4) = $\frac{1+3+5}{42}$ = 21.4%

All collars (couplers) observed at the side exhibit full depth radial cracking (fractures).

Based on the anchor bolt report prepared by Lehigh University the coupling fractures show evidence of fatigue fracture with secondary fractures occurring by overload presumably during the collapse. It appears that at least some of the couplings were completely fractured at the time of the collapse.

Therefore, our wind load structural analysis assumes that 3 out of 4 anchor bolt assemblies are not capable of resisting uplift forces due to wind loading.

KINZUA VIADUCT
BOARD OF INQUIRY INVESTIGATION
WIND ANALYSIS

Type Analysis – Plane Frame using STAAD Pro 2003

Bent Analyzed - #20 (19, 21 and 22 similar) height = 277.48' c-c steel

Models Analyzed – Final analysis investigated three conditions:

- **File 'Kinzorig'** – The as-built structure, with full member stiffness; all members connected; wind pressure from the left based on 73, 80, 90, 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with roller bearing (no friction) on the left (east side) and pin bearing on the right (west side).
- **File 'Kinzu100'** – The as-built structure, with full member stiffness; all members connected; wind pressure from the left based on 73, 80, 90, 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with frozen roller bearing (modeled as a 95 kip/in spring per the 2002 Inspection Report) on the left (east side) and a pin bearing on the right (west side).
- **File 'Kin100RL'** – The as-built structure, with full member stiffness; bottom strut released; wind pressure from the left based on 73, 80, 90, 100, and 112 mph wind per ASCE-7 (2002) Section 6.5; and with frozen roller bearing (modeled as a 95 kip/in spring per the 2002 Inspection Report) on the left (east side) and a pin bearing on the right (west side).

The spring constant for the bearing is 95kip/inch (per 2002 Bridge Inspection Report by Herbert, Rowland, and Grubic, Inc. (HRG)).

Bent Sections – Built-up riveted steel with lacing bars and angles, from plans

- Columns (24" x 37") A = 40.72 in^2 and I = 12336 in^4 (lower 2 stories)
- Columns (24" x 37") A = 35.44 in^2 and I = 10825 in^4 (upper 3 stories)
- Header or Cap Beam (depth = 105.5") A = 96.6 in^2 and I = 121188 in^4
- Strut 1 (depth = 48" o-o) A = 12.36 in^2 and I = 5450 in^4
- Strut 2 (depth = 72" o-o) A = 16.16 in^2 and I = 16527 in^4
- Strut 3 (depth = 84" o-o) A = 23.52 in^2 and I = 32199 in^4
- Strut 4 (depth = 96" o-o) A = 23.52 in^2 and I = 43407 in^4
- Strut 5 (depth = 30" o-o) A = 11.44 in^2 and I = 2198 in^4

Note: Section properties are calculated in the 2002 Bridge Inspection Report by HRG.

Steel - Fy = 33,000 psi used from material testing

KINZUA VIADUCT
BOARD OF INQUIRY INVESTIGATION
WIND ANALYSIS

Dead Loads – from Superstructure, includes;

- Girder, rails, ties, walkways, steel diaphragms and braces – acting as a continuous span for application of the load at the top. Point load/girder is 50 k from BAR7 run.

Note: Dead loads are calculated in the 2002 Bridge Inspection Report by HRG.

Dead Loads – from Substructure, includes:

- Self weight of columns and struts – by STAAD
- Additional weight for lacing, connections, x-bracing and miscellaneous members per the 2002 Bridge Inspection Report by HRG.

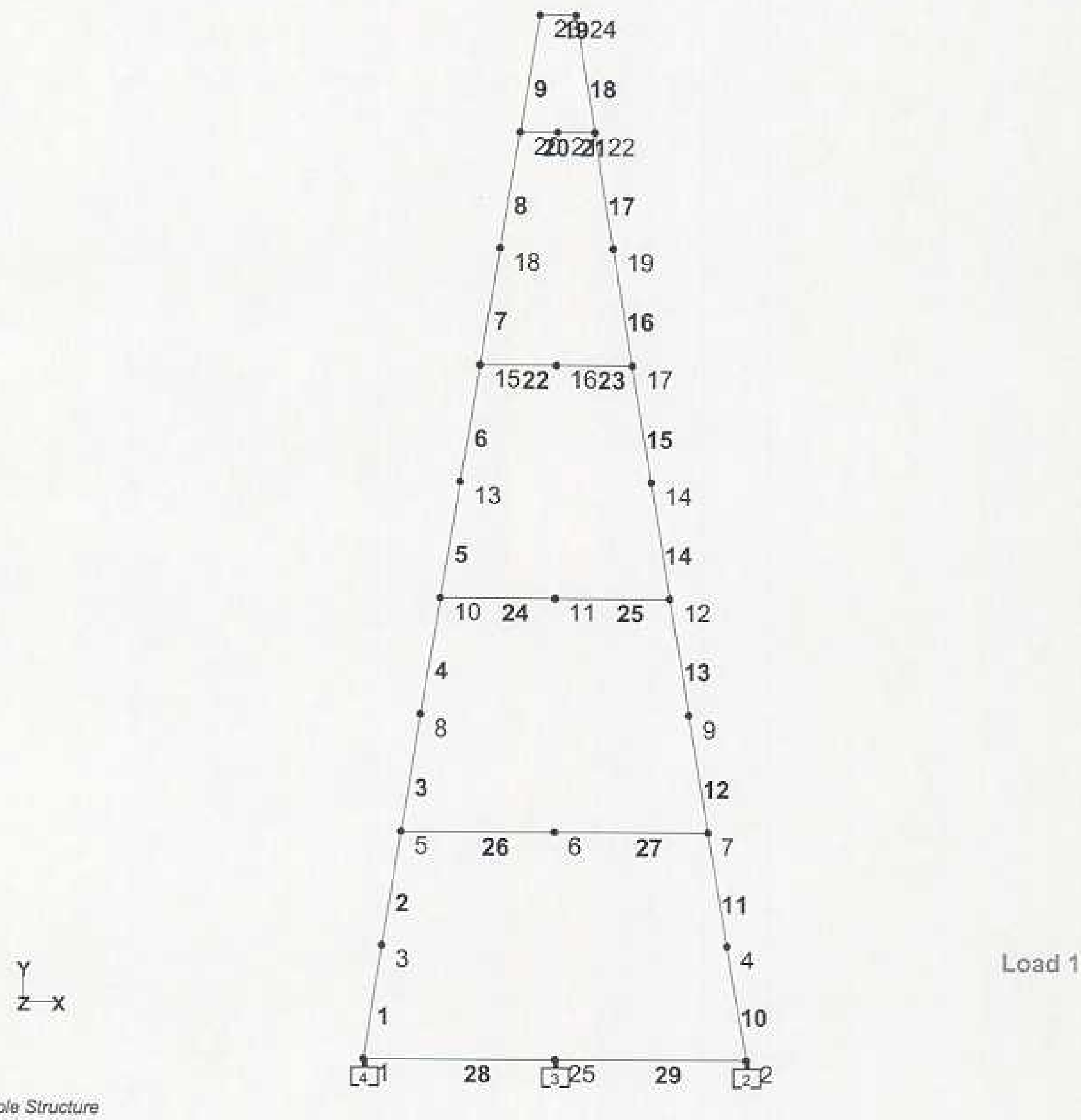
Wind Load on Substructure – Considered as follows:

- AREMA: 50 psf on unloaded structure, Chapter 15, Section 1.3.8 (design spec)
- AREMA does not specify any adjustment for wind speeds other than the design wind speed. Therefore, wind pressures for various wind speeds for the analysis of the collapse are calculated using ASCE-7 (2002), Section 6.5, Importance Category III, Exposure D at 300'.

Application of Wind Loads – Loads applied to exposed face of both column legs and to one-half of the x-bracing. The wind pressure on the columns applied as a uniform load, while the x-bracing load applied as a concentrated load at the applicable node. The wind from the superstructure applied as a concentrated load at the center of the cap beam.

Load Combination – 0.9 DL + W

Software licensed to Gannett Fleming, Inc.	Job No 042420	Sheet No 1	Rev
	Part 1620H		
Job Title Kinzua Viaduct Collapse (Wind Analysis)	Ref		
	By VDL	Date 25-Aug-03	Chd
Client DCNR	File Kinzorig.std	Date/Time 08-Oct-2003 14:36	



Job Information

	Engineer	Checked	Approved
Name:	VDL		
Date:	25-Aug-03		

Structure Type	PLANE FRAME

Number of Nodes	25	Highest Node	25
Number of Elements	29	Highest Beam	29

Number of Basic Load Cases	2
Number of Combination Load Cases	9

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	3	FULL WIND ON STRUCTURE (50 PSF)
Combination	8	0.9DL + W
Combination	13	0.9DL + W (73 MPH)
Combination	14	0.9DL + W (80 MPH)
Combination	15	0.9DL + W (LIFT OFF)
Combination	16	0.9DL + W (90 MPH)
Combination	17	0.9DL + W (CAPACITY AT COLLAPSE)
Combination	18	0.9DL + W (100 MPH)
Combination	19	0.9DL + W (112 MPH)
Combination	20	0.9DL + W (FULL BOLT CAPACITY)

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****************************************************
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*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    OCT  8, 2003                  *
*           Time=    14:36: 9                      *
*                                                  *
*      USER ID: Gannett Fleming, Inc.              *
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 1. STAAD PLANE KINZUA VIADUCT COLLAPSE, WIND ANALYSIS
 2. START JOB INFORMATION
 3. JOB NAME KINZUA VIADUCT COLLAPSE (WIND ANALYSIS)
 4. *
 5. *'KINZORIG' - AS-BUILT STRUCTURE, WITH FULL MEMBER STIFFNESS
 6. *ALL MEMBERS CONNECTED; WIND PRESSURE FROM THE LEFT BASED ON
 7. *73, 80, 90, AND 112 MPH WIND PER ASCE-7 (2002) SECTION 6.5
 8. *AND WITH ROLLER BEARING (NO FRICTION) ON THE LEFT (EAST)SIDE
 9. *AND PIN BEARING ON THE RIGHT (WEST) SIDE
10. *
11. JOB CLIENT DCNR
12. JOB NO 042420
13. JOB PART 1620H
14. ENGINEER NAME VDL
15. ENGINEER DATE 25-AUG-03
16. END JOB INFORMATION
17. INPUT WIDTH 79
18. UNIT FEET KIP
19. JOINT COORDINATES
20. 1 0 0 0; 2 102.06 0 0; 3 5.03 30.16 0; 4 97.03 30.16 0; 5 10.05 60.32 0
21. 6 51.03 60.32 0; 7 92.01 60.32 0; 8 15.22 91.32 0; 9 86.84 91.32 0
22. 10 20.39 122.32 0; 11 51.03 122.32 0; 12 81.67 122.32 0; 13 25.56 153.32 0
23. 14 76.51 153.32 0; 15 30.72 184.32 0; 16 51.03 184.32 0; 17 71.34 184.32 0
24. 18 35.89 215.32 0; 19 66.18 215.32 0; 20 41.05 246.32 0; 21 51.03 246.32 0
25. 22 61.01 246.32 0; 23 46.25 277.48 0; 24 55.81 277.48 0; 25 51.03 0 0
26. MEMBER INCIDENCES
27. 1 1 3; 2 3 5; 3 5 8; 4 8 10; 5 10 13; 6 13 15; 7 15 18; 8 18 20; 9 20 23
28. 10 2 4; 11 4 7; 12 7 9; 13 9 12; 14 12 14; 15 14 17; 16 17 19; 17 19 22
29. 18 22 24; 19 23 24; 20 20 21; 21 21 22; 22 15 16; 23 16 17; 24 10 11; 25 11 12
30. 26 5 6; 27 6 7; 28 1 25; 29 25 2
31. UNIT INCHES KIP
32. MEMBER PROPERTY AMERICAN
33. 1 TO 4 10 TO 13 PRIS AX 40.72 IZ 12336
34. 5 TO 9 14 TO 18 PRIS AX 35.44 IZ 10825
35. 26 27 PRIS AX 23.52 IZ 43407
36. 24 25 PRIS AX 23.52 IZ 32199
37. 22 23 PRIS AX 16.16 IZ 16527
38. 20 21 PRIS AX 12.36 IZ 5450
39. 19 PRIS AX 96.6 IZ 121188
40. 28 29 PRIS AX 11.44 IZ 2198
41. DEFINE MATERIAL START
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42. ISOTROPIC STEEL
43. E 29000
44. POISSON 0.3
45. DENSITY 0.000283
46. ALPHA 6.5E-006
47. DAMP 0.03
48. END DEFINE MATERIAL
49. CONSTANTS
50. MATERIAL STEEL MEMB 1 TO 29
51. PRINT MEMBER INFORMATION
```

MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (INCH)	BETA (DEG)	RELEASES
1	1	3	366.919	0.00	
2	3	5	366.899	0.00	
3	5	8	377.138	0.00	
4	8	10	377.138	0.00	
5	10	13	377.138	0.00	
6	13	15	377.118	0.00	
7	15	18	377.138	0.00	
8	18	20	377.118	0.00	
9	20	23	379.091	0.00	
10	2	4	366.919	0.00	
11	4	7	366.899	0.00	
12	7	9	377.138	0.00	
13	9	12	377.138	0.00	
14	12	14	377.118	0.00	
15	14	17	377.138	0.00	
16	17	19	377.118	0.00	
17	19	22	377.138	0.00	
18	22	24	379.091	0.00	
19	23	24	114.720	0.00	
20	20	21	119.760	0.00	
21	21	22	119.760	0.00	
22	15	16	243.720	0.00	
23	16	17	243.720	0.00	
24	10	11	367.680	0.00	
25	11	12	367.680	0.00	
26	5	6	491.760	0.00	
27	6	7	491.760	0.00	
28	1	25	612.360	0.00	
29	25	2	612.360	0.00	

************ END OF DATA FROM INTERNAL STORAGE ************

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52. SUPPORTS
53. 2 FIXED BUT MZ
54. 25 FIXED BUT MZ KFX 1
55. 1 FIXED BUT FX MZ
56. UNIT FEET KIP
57. LOAD 1 DEAD LOAD
58. SELFWEIGHT Y -1
59. JOINT LOAD
60. 23 24 FY -50
61. MEMBER LOAD
62. 1 TO 18 UNI GY -0.1
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63. 19 UNI GY -0.05
64. 20 21 UNI GY -0.045
65. 22 23 UNI GY -0.055
66. 24 25 UNI GY -0.06
67. 26 27 UNI GY -0.06
68. 28 29 UNI GY -0.04
69. LOAD 3 FULL WIND ON STRUCTURE (50 PSF)
70. JOINT LOAD
71. 23 FX 22.3
72. 3 5 8 10 13 15 18 20 FX 1.7
73. 4 7 9 12 14 17 19 22 FX 1.7
74. MEMBER LOAD
75. 1 TO 18 UNI GX 0.1
76. LOAD COMB 8 0.9DL + W
77. 1 0.9 3 1.0
78. LOAD COMB 13 0.9DL + W (73 MPH)
79. 1 0.9 3 0.519
80. LOAD COMB 14 0.9DL + W (80 MPH)
81. 1 0.9 3 0.6236
82. LOAD COMB 15 0.9DL + W (LIFT OFF)
83. 1 0.9 3 0.678
84. LOAD COMB 16 0.9DL + W (90 MPH)
85. 1 0.9 3 0.789
86. LOAD COMB 17 0.9DL + W (CAPACITY AT COLLAPSE)
87. 1 0.9 3 0.854
88. LOAD COMB 18 0.9DL + W (100 MPH)
89. 1 0.9 3 0.974
90. LOAD COMB 19 0.9DL + W (112 MPH)
91. 1 0.9 3 1.2222
92. LOAD COMB 20 0.9DL + W (FULL BOLT CAPACITY)
93. 1 0.9 3 1.554
94. PERFORM ANALYSIS
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        P R O B L E M   S T A T I S T I C S
        -----------------------------------

NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    25/    29/     3
ORIGINAL/FINAL BAND-WIDTH=    24/     3/     12 DOF
TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     71
SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =    12.1/ 15120.3 MB,  EXMEM = 2165.7 MB
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95. PRINT SUPPORT REACTION LIST 1 2 25
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SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = PLANE

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
1	1	0.00	130.96	0.00	0.00	0.00	0.00
	3	0.00	-173.72	0.00	0.00	0.00	0.00
	8	0.00	-55.85	0.00	0.00	0.00	0.00
	13	0.00	27.71	0.00	0.00	0.00	0.00
	14	0.00	9.54	0.00	0.00	0.00	0.00
	15	0.00	0.09	0.00	0.00	0.00	0.00
	16	0.00	-19.20	0.00	0.00	0.00	0.00
	17	0.00	-30.49	0.00	0.00	0.00	0.00
	18	0.00	-51.34	0.00	0.00	0.00	0.00
	19	0.00	-94.45	0.00	0.00	0.00	0.00
	20	0.00	-152.09	0.00	0.00	0.00	0.00
2	1	-0.04	130.96	0.00	0.00	0.00	0.00
	3	-105.66	174.02	0.00	0.00	0.00	0.00
	8	-105.70	291.89	0.00	0.00	0.00	0.00
	13	-54.87	208.19	0.00	0.00	0.00	0.00
	14	-65.93	226.39	0.00	0.00	0.00	0.00
	15	-71.68	235.85	0.00	0.00	0.00	0.00
	16	-83.40	255.17	0.00	0.00	0.00	0.00
	17	-90.27	266.48	0.00	0.00	0.00	0.00
	18	-102.95	287.36	0.00	0.00	0.00	0.00
	19	-129.18	330.56	0.00	0.00	0.00	0.00
	20	-164.24	388.30	0.00	0.00	0.00	0.00
25	1	0.04	4.39	0.00	0.00	0.00	0.00
	3	-0.10	-0.30	0.00	0.00	0.00	0.00
	8	-0.06	3.65	0.00	0.00	0.00	0.00
	13	-0.02	3.80	0.00	0.00	0.00	0.00
	14	-0.03	3.76	0.00	0.00	0.00	0.00
	15	-0.03	3.75	0.00	0.00	0.00	0.00
	16	-0.04	3.71	0.00	0.00	0.00	0.00
	17	-0.05	3.69	0.00	0.00	0.00	0.00
	18	-0.06	3.66	0.00	0.00	0.00	0.00
	19	-0.08	3.58	0.00	0.00	0.00	0.00
	20	-0.12	3.48	0.00	0.00	0.00	0.00

************** END OF LATEST ANALYSIS RESULT **************

96. PERFORM ANALYSIS PRINT MODE SHAPES

97. PRINT MEMBER FORCES LIST 1 TO 29

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
1	1	1	130.84	0.49	0.00	0.00	0.00	-10.85
		3	-123.65	0.70	0.00	0.00	0.00	7.64
	3	1	-174.89	24.12	0.00	0.00	0.00	266.82
		3	174.39	-21.10	0.00	0.00	0.00	424.60
	8	1	-57.14	24.57	0.00	0.00	0.00	257.05
		3	63.10	-20.47	0.00	0.00	0.00	431.47
	13	1	26.98	12.96	0.00	0.00	0.00	128.71
		3	-20.78	-10.32	0.00	0.00	0.00	227.24
	14	1	8.69	15.49	0.00	0.00	0.00	156.62
		3	-2.54	-12.53	0.00	0.00	0.00	271.65
	15	1	-0.82	16.80	0.00	0.00	0.00	171.14
		3	6.95	-13.67	0.00	0.00	0.00	294.75
	16	1	-20.24	19.48	0.00	0.00	0.00	200.75
		3	26.31	-16.02	0.00	0.00	0.00	341.88
	17	1	-31.60	21.04	0.00	0.00	0.00	218.10
		3	37.64	-17.39	0.00	0.00	0.00	369.48
	18	1	-52.59	23.94	0.00	0.00	0.00	250.11
		3	58.57	-19.92	0.00	0.00	0.00	420.43
	19	1	-96.00	29.92	0.00	0.00	0.00	316.34
		3	101.85	-25.16	0.00	0.00	0.00	525.81
	20	1	-154.03	37.93	0.00	0.00	0.00	404.87
		3	159.71	-32.16	0.00	0.00	0.00	666.69
2	1	3	123.65	-0.74	0.00	0.00	0.00	-7.64
		5	-116.46	1.94	0.00	0.00	0.00	-33.41
	3	3	-174.10	19.48	0.00	0.00	0.00	-424.60
		5	173.60	-16.47	0.00	0.00	0.00	974.21
	8	3	-62.82	18.81	0.00	0.00	0.00	-431.47
		5	68.78	-14.72	0.00	0.00	0.00	944.14
	13	3	20.93	9.44	0.00	0.00	0.00	-227.24
		5	-14.72	-6.80	0.00	0.00	0.00	475.54
	14	3	2.71	11.48	0.00	0.00	0.00	-271.65
		5	3.44	-8.52	0.00	0.00	0.00	577.44
	15	3	-6.76	12.54	0.00	0.00	0.00	-294.75
		5	12.88	-9.42	0.00	0.00	0.00	630.44
	16	3	-26.08	14.70	0.00	0.00	0.00	-341.88
		5	32.15	-11.25	0.00	0.00	0.00	738.58
	17	3	-37.40	15.97	0.00	0.00	0.00	-369.48
		5	43.44	-12.32	0.00	0.00	0.00	801.90
	18	3	-58.29	18.31	0.00	0.00	0.00	-420.43
		5	64.27	-14.29	0.00	0.00	0.00	918.81
	19	3	-101.50	23.14	0.00	0.00	0.00	-525.81
		5	107.36	-18.38	0.00	0.00	0.00	1160.61
	20	3	-159.27	29.61	0.00	0.00	0.00	-666.69
		5	164.96	-23.84	0.00	0.00	0.00	1483.85

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
3	1	5	110.25	0.51	0.00	0.00	0.00	-12.89
		8	-102.86	0.72	0.00	0.00	0.00	9.69
	3	5	-137.30	21.19	0.00	0.00	0.00	517.26
		8	136.78	-18.09	0.00	0.00	0.00	100.11
	8	5	-38.07	21.66	0.00	0.00	0.00	505.67
		8	44.20	-17.45	0.00	0.00	0.00	108.84
	13	5	27.97	11.46	0.00	0.00	0.00	256.86
		8	-21.59	-8.74	0.00	0.00	0.00	60.68
	14	5	13.60	13.68	0.00	0.00	0.00	310.97
		8	-7.28	-10.64	0.00	0.00	0.00	71.15
	15	5	6.14	14.83	0.00	0.00	0.00	339.11
		8	0.16	-11.62	0.00	0.00	0.00	76.60
	16	5	-9.10	17.19	0.00	0.00	0.00	396.52
		8	15.34	-13.63	0.00	0.00	0.00	87.71
	17	5	-18.03	18.56	0.00	0.00	0.00	430.14
		8	24.23	-14.81	0.00	0.00	0.00	94.22
	18	5	-34.50	21.11	0.00	0.00	0.00	492.22
		8	40.65	-16.98	0.00	0.00	0.00	106.23
	19	5	-68.58	26.37	0.00	0.00	0.00	620.60
		8	74.60	-21.47	0.00	0.00	0.00	131.08
	20	5	-114.14	33.40	0.00	0.00	0.00	792.23
		8	119.98	-27.47	0.00	0.00	0.00	164.30
4	1	8	102.86	-0.72	0.00	0.00	0.00	-9.69
		10	-95.47	1.95	0.00	0.00	0.00	-32.22
	3	8	-136.50	16.42	0.00	0.00	0.00	-100.11
		10	135.98	-13.32	0.00	0.00	0.00	567.36
	8	8	-43.93	15.77	0.00	0.00	0.00	-108.84
		10	50.06	-11.56	0.00	0.00	0.00	538.37
	13	8	21.73	7.87	0.00	0.00	0.00	-60.68
		10	-15.35	-5.16	0.00	0.00	0.00	265.46
	14	8	7.45	9.59	0.00	0.00	0.00	-71.15
		10	-1.13	-6.55	0.00	0.00	0.00	324.81
	15	8	0.03	10.49	0.00	0.00	0.00	-76.60
		10	6.27	-7.27	0.00	0.00	0.00	355.67
	16	8	-15.12	12.31	0.00	0.00	0.00	-87.71
		10	21.36	-8.75	0.00	0.00	0.00	418.65
	17	8	-24.00	13.37	0.00	0.00	0.00	-94.22
		10	30.20	-9.62	0.00	0.00	0.00	455.53
	18	8	-40.38	15.34	0.00	0.00	0.00	-106.23
		10	46.52	-11.22	0.00	0.00	0.00	523.61
	19	8	-74.26	19.42	0.00	0.00	0.00	-131.08
		10	80.27	-14.52	0.00	0.00	0.00	664.43
	20	8	-119.55	24.87	0.00	0.00	0.00	-164.30
		10	125.39	-18.94	0.00	0.00	0.00	852.69
5	1	10	90.66	0.90	0.00	0.00	0.00	3.01
		13	-83.83	0.24	0.00	0.00	0.00	7.31

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	3	10	-104.54	16.70	0.00	0.00	0.00	401.21
		13	104.02	-13.60	0.00	0.00	0.00	74.80
	8	10	-22.94	17.50	0.00	0.00	0.00	403.92
		13	28.57	-13.38	0.00	0.00	0.00	81.37
	13	10	27.34	9.47	0.00	0.00	0.00	210.94
		13	-21.46	-6.84	0.00	0.00	0.00	45.40
	14	10	16.41	11.22	0.00	0.00	0.00	252.90
		13	-10.58	-8.26	0.00	0.00	0.00	53.22
	15	10	10.72	12.13	0.00	0.00	0.00	274.73
		13	-4.92	-9.00	0.00	0.00	0.00	57.29
	16	10	-0.88	13.98	0.00	0.00	0.00	319.26
		13	6.62	-10.51	0.00	0.00	0.00	65.59
	17	10	-7.68	15.07	0.00	0.00	0.00	345.34
		13	13.39	-11.39	0.00	0.00	0.00	70.45
	18	10	-20.22	17.07	0.00	0.00	0.00	393.48
		13	25.87	-13.03	0.00	0.00	0.00	79.43
	19	10	-46.17	21.21	0.00	0.00	0.00	493.06
		13	51.69	-16.40	0.00	0.00	0.00	97.99
	20	10	-80.86	26.75	0.00	0.00	0.00	626.18
		13	86.20	-20.91	0.00	0.00	0.00	122.81
6	1	13	83.83	-0.27	0.00	0.00	0.00	-7.31
		15	-77.00	1.40	0.00	0.00	0.00	-18.97
	3	13	-103.74	11.95	0.00	0.00	0.00	-74.80
		15	103.22	-8.85	0.00	0.00	0.00	401.68
	8	13	-28.29	11.71	0.00	0.00	0.00	-81.37
		15	33.92	-7.59	0.00	0.00	0.00	384.61
	13	13	21.61	5.96	0.00	0.00	0.00	-45.40
		15	-15.73	-3.33	0.00	0.00	0.00	191.40
	14	13	10.76	7.21	0.00	0.00	0.00	-53.22
		15	-4.93	-4.26	0.00	0.00	0.00	233.41
	15	13	5.11	7.86	0.00	0.00	0.00	-57.29
		15	0.68	-4.74	0.00	0.00	0.00	255.27
	16	13	-6.40	9.19	0.00	0.00	0.00	-65.59
		15	12.14	-5.72	0.00	0.00	0.00	299.85
	17	13	-13.14	9.97	0.00	0.00	0.00	-70.45
		15	18.85	-6.29	0.00	0.00	0.00	325.96
	18	13	-25.59	11.40	0.00	0.00	0.00	-79.43
		15	31.24	-7.36	0.00	0.00	0.00	374.16
	19	13	-51.34	14.37	0.00	0.00	0.00	-97.99
		15	56.86	-9.55	0.00	0.00	0.00	473.86
	20	13	-85.76	18.33	0.00	0.00	0.00	-122.81
		15	91.11	-12.49	0.00	0.00	0.00	607.14
7	1	15	74.32	1.12	0.00	0.00	0.00	9.72
		18	-67.49	0.02	0.00	0.00	0.00	7.60
	3	15	-71.19	12.45	0.00	0.00	0.00	252.09
		18	70.67	-9.35	0.00	0.00	0.00	90.58

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	8	15	-4.30	13.46	0.00	0.00	0.00	260.84
		18	9.93	-9.34	0.00	0.00	0.00	97.41
	13	15	29.94	7.47	0.00	0.00	0.00	139.58
		18	-24.06	-4.84	0.00	0.00	0.00	53.84
	14	15	22.50	8.77	0.00	0.00	0.00	165.95
		18	-16.67	-5.82	0.00	0.00	0.00	63.32
	15	15	18.62	9.45	0.00	0.00	0.00	179.67
		18	-12.83	-6.32	0.00	0.00	0.00	68.25
	16	15	10.72	10.83	0.00	0.00	0.00	207.65
		18	-4.98	-7.36	0.00	0.00	0.00	78.30
	17	15	6.10	11.64	0.00	0.00	0.00	224.03
		18	-0.39	-7.97	0.00	0.00	0.00	84.19
	18	15	-2.45	13.14	0.00	0.00	0.00	254.28
		18	8.09	-9.09	0.00	0.00	0.00	95.06
	19	15	-20.12	16.23	0.00	0.00	0.00	316.85
		18	25.63	-11.41	0.00	0.00	0.00	117.54
	20	15	-43.74	20.36	0.00	0.00	0.00	400.49
		18	49.08	-14.52	0.00	0.00	0.00	147.59
8	1	18	67.49	-0.04	0.00	0.00	0.00	-7.60
		20	-60.66	1.18	0.00	0.00	0.00	-11.52
	3	18	-70.39	7.70	0.00	0.00	0.00	-90.58
		20	69.87	-4.60	0.00	0.00	0.00	283.79
	8	18	-9.65	7.66	0.00	0.00	0.00	-97.41
		20	15.28	-3.54	0.00	0.00	0.00	273.43
	13	18	24.21	3.96	0.00	0.00	0.00	-53.84
		20	-18.33	-1.33	0.00	0.00	0.00	136.92
	14	18	16.85	4.76	0.00	0.00	0.00	-63.32
		20	-11.02	-1.81	0.00	0.00	0.00	166.61
	15	18	13.02	5.18	0.00	0.00	0.00	-68.25
		20	-7.22	-2.06	0.00	0.00	0.00	182.04
	16	18	5.21	6.04	0.00	0.00	0.00	-78.30
		20	0.54	-2.57	0.00	0.00	0.00	213.55
	17	18	0.63	6.54	0.00	0.00	0.00	-84.19
		20	5.08	-2.87	0.00	0.00	0.00	231.99
	18	18	-7.82	7.46	0.00	0.00	0.00	-95.06
		20	13.46	-3.42	0.00	0.00	0.00	266.05
	19	18	-25.29	9.37	0.00	0.00	0.00	-117.54
		20	30.80	-4.56	0.00	0.00	0.00	336.48
	20	18	-48.64	11.93	0.00	0.00	0.00	-147.59
		20	53.99	-6.09	0.00	0.00	0.00	430.65
9	1	20	59.44	0.85	0.00	0.00	0.00	7.87
		23	-52.58	0.30	0.00	0.00	0.00	0.82
	3	20	-39.36	7.94	0.00	0.00	0.00	22.23
		23	38.84	-4.83	0.00	0.00	0.00	179.45
	8	20	14.14	8.71	0.00	0.00	0.00	29.31
		23	-8.48	-4.56	0.00	0.00	0.00	180.19

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	13	20	33.07	4.88	0.00	0.00	0.00	18.62
		23	-27.16	-2.24	0.00	0.00	0.00	93.87
	14	20	28.95	5.72	0.00	0.00	0.00	20.94
		23	-23.10	-2.74	0.00	0.00	0.00	112.64
	15	20	26.81	6.15	0.00	0.00	0.00	22.15
		23	-20.98	-3.00	0.00	0.00	0.00	122.41
	16	20	22.44	7.03	0.00	0.00	0.00	24.62
		23	-16.67	-3.54	0.00	0.00	0.00	142.32
	17	20	19.88	7.55	0.00	0.00	0.00	26.06
		23	-14.15	-3.85	0.00	0.00	0.00	153.99
	18	20	15.16	8.50	0.00	0.00	0.00	28.73
		23	-9.49	-4.43	0.00	0.00	0.00	175.52
	19	20	5.39	10.47	0.00	0.00	0.00	34.24
		23	0.15	-5.63	0.00	0.00	0.00	220.06
	20	20	-7.67	13.11	0.00	0.00	0.00	41.62
		23	13.04	-7.23	0.00	0.00	0.00	279.61
10	1	2	130.84	0.49	0.00	0.00	0.00	-10.85
		4	-123.65	0.70	0.00	0.00	0.00	7.64
	3	2	175.00	-24.75	0.00	0.00	0.00	-277.14
		4	-174.49	21.73	0.00	0.00	0.00	-433.49
	8	2	292.75	-24.30	0.00	0.00	0.00	-286.91
		4	-285.78	22.37	0.00	0.00	0.00	-426.61
	13	2	208.58	-12.40	0.00	0.00	0.00	-153.60
		4	-201.85	11.91	0.00	0.00	0.00	-218.10
	14	2	226.88	-14.99	0.00	0.00	0.00	-182.59
		4	-220.10	14.19	0.00	0.00	0.00	-263.44
	15	2	236.40	-16.33	0.00	0.00	0.00	-197.67
		4	-229.59	15.37	0.00	0.00	0.00	-287.02
	16	2	255.83	-19.08	0.00	0.00	0.00	-228.43
		4	-248.96	17.78	0.00	0.00	0.00	-335.14
	17	2	267.20	-20.69	0.00	0.00	0.00	-246.44
		4	-260.30	19.19	0.00	0.00	0.00	-363.32
	18	2	288.20	-23.66	0.00	0.00	0.00	-279.70
		4	-281.24	21.80	0.00	0.00	0.00	-415.34
	19	2	331.63	-29.80	0.00	0.00	0.00	-348.49
		4	-324.55	27.20	0.00	0.00	0.00	-522.93
	20	2	389.70	-38.01	0.00	0.00	0.00	-440.44
		4	-382.45	34.41	0.00	0.00	0.00	-666.76
11	1	4	123.65	-0.74	0.00	0.00	0.00	-7.64
		7	-116.46	1.94	0.00	0.00	0.00	-33.39
	3	4	174.21	-20.11	0.00	0.00	0.00	433.49
		7	-173.70	17.10	0.00	0.00	0.00	-1002.31
	8	4	285.49	-20.78	0.00	0.00	0.00	426.61
		7	-278.52	18.84	0.00	0.00	0.00	-1032.36
	13	4	201.70	-11.11	0.00	0.00	0.00	218.10
		7	-194.97	10.62	0.00	0.00	0.00	-550.25

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	14	4	219.92	-13.21	0.00	0.00	0.00	263.44
		7	-213.14	12.41	0.00	0.00	0.00	-655.09
	15	4	229.40	-14.31	0.00	0.00	0.00	287.02
		7	-222.59	13.34	0.00	0.00	0.00	-709.62
	16	4	248.73	-16.54	0.00	0.00	0.00	335.14
		7	-241.87	15.24	0.00	0.00	0.00	-820.87
	17	4	260.06	-17.85	0.00	0.00	0.00	363.32
		7	-253.16	16.35	0.00	0.00	0.00	-886.02
	18	4	280.96	-20.26	0.00	0.00	0.00	415.34
		7	-274.01	18.40	0.00	0.00	0.00	-1006.30
	19	4	324.20	-25.25	0.00	0.00	0.00	522.93
		7	-317.12	22.64	0.00	0.00	0.00	-1255.07
	20	4	382.00	-31.92	0.00	0.00	0.00	666.76
		7	-374.75	28.31	0.00	0.00	0.00	-1587.64
12	1	7	110.25	0.51	0.00	0.00	0.00	-12.90
		9	-102.86	0.72	0.00	0.00	0.00	9.72
	3	7	137.26	-20.95	0.00	0.00	0.00	-505.95
		9	-136.74	17.85	0.00	0.00	0.00	-103.66
	8	7	236.48	-20.48	0.00	0.00	0.00	-517.56
		9	-229.32	18.49	0.00	0.00	0.00	-94.91
	13	7	170.46	-10.41	0.00	0.00	0.00	-274.19
		9	-163.54	9.91	0.00	0.00	0.00	-45.05
	14	7	184.82	-12.60	0.00	0.00	0.00	-327.12
		9	-177.85	11.77	0.00	0.00	0.00	-55.90
	15	7	192.28	-13.74	0.00	0.00	0.00	-354.64
		9	-185.29	12.75	0.00	0.00	0.00	-61.54
	16	7	207.52	-16.06	0.00	0.00	0.00	-410.80
		9	-200.46	14.73	0.00	0.00	0.00	-73.04
	17	7	216.44	-17.43	0.00	0.00	0.00	-443.69
		9	-209.35	15.89	0.00	0.00	0.00	-79.78
	18	7	232.91	-19.94	0.00	0.00	0.00	-504.40
		9	-225.76	18.03	0.00	0.00	0.00	-92.22
	19	7	266.98	-25.14	0.00	0.00	0.00	-629.98
		9	-259.70	22.46	0.00	0.00	0.00	-117.95
	20	7	312.52	-32.09	0.00	0.00	0.00	-797.85
		9	-305.07	28.38	0.00	0.00	0.00	-152.34
13	1	9	102.86	-0.72	0.00	0.00	0.00	-9.72
		12	-95.48	1.95	0.00	0.00	0.00	-32.18
	3	9	136.46	-16.17	0.00	0.00	0.00	103.66
		12	-135.94	13.07	0.00	0.00	0.00	-563.14
	8	9	229.04	-16.82	0.00	0.00	0.00	94.91
		12	-221.87	14.82	0.00	0.00	0.00	-592.10
	13	9	163.40	-9.04	0.00	0.00	0.00	45.05
		12	-156.48	8.54	0.00	0.00	0.00	-321.23
	14	9	177.67	-10.73	0.00	0.00	0.00	55.90
		12	-170.70	9.90	0.00	0.00	0.00	-380.14

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	15	9	185.10	-11.61	0.00	0.00	0.00	61.54
		12	-178.10	10.62	0.00	0.00	0.00	-410.77
	16	9	200.24	-13.40	0.00	0.00	0.00	73.04
		12	-193.19	12.07	0.00	0.00	0.00	-473.28
	17	9	209.11	-14.45	0.00	0.00	0.00	79.78
		12	-202.02	12.92	0.00	0.00	0.00	-509.89
	18	9	225.49	-16.40	0.00	0.00	0.00	92.22
		12	-218.34	14.48	0.00	0.00	0.00	-577.46
	19	9	259.36	-20.41	0.00	0.00	0.00	117.95
		12	-252.08	17.73	0.00	0.00	0.00	-717.24
	20	9	304.63	-25.77	0.00	0.00	0.00	152.34
		12	-297.18	22.07	0.00	0.00	0.00	-904.09
14	1	12	90.65	0.87	0.00	0.00	0.00	2.54
		14	-83.82	0.27	0.00	0.00	0.00	6.86
	3	12	104.54	-16.76	0.00	0.00	0.00	-403.09
		14	-104.02	13.66	0.00	0.00	0.00	-74.85
	8	12	186.12	-15.98	0.00	0.00	0.00	-400.81
		14	-179.46	13.90	0.00	0.00	0.00	-68.68
	13	12	135.84	-7.92	0.00	0.00	0.00	-206.92
		14	-129.42	7.33	0.00	0.00	0.00	-32.67
	14	12	146.77	-9.67	0.00	0.00	0.00	-249.09
		14	-140.31	8.76	0.00	0.00	0.00	-40.50
	15	12	152.46	-10.58	0.00	0.00	0.00	-271.01
		14	-145.96	9.50	0.00	0.00	0.00	-44.57
	16	12	164.07	-12.44	0.00	0.00	0.00	-315.76
		14	-157.51	11.02	0.00	0.00	0.00	-52.88
	17	12	170.86	-13.53	0.00	0.00	0.00	-341.96
		14	-164.27	11.91	0.00	0.00	0.00	-57.75
	18	12	183.40	-15.54	0.00	0.00	0.00	-390.33
		14	-176.75	13.55	0.00	0.00	0.00	-66.73
	19	12	209.35	-19.70	0.00	0.00	0.00	-490.38
		14	-202.57	16.94	0.00	0.00	0.00	-85.31
	20	12	244.04	-25.26	0.00	0.00	0.00	-624.12
		14	-237.09	21.47	0.00	0.00	0.00	-110.15
15	1	14	83.82	-0.24	0.00	0.00	0.00	-6.86
		17	-76.99	1.38	0.00	0.00	0.00	-18.68
	3	14	103.75	-11.95	0.00	0.00	0.00	74.85
		17	-103.23	8.85	0.00	0.00	0.00	-401.67
	8	14	179.18	-12.17	0.00	0.00	0.00	68.68
		17	-172.52	10.09	0.00	0.00	0.00	-418.48
	13	14	129.28	-6.42	0.00	0.00	0.00	32.67
		17	-122.87	5.84	0.00	0.00	0.00	-225.28
	14	14	140.13	-7.67	0.00	0.00	0.00	40.50
		17	-133.66	6.76	0.00	0.00	0.00	-267.29
	15	14	145.78	-8.32	0.00	0.00	0.00	44.57
		17	-139.28	7.24	0.00	0.00	0.00	-289.14

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	16	14	157.29	-9.65	0.00	0.00	0.00	52.88
		17	-150.74	8.23	0.00	0.00	0.00	-333.73
	17	14	164.04	-10.42	0.00	0.00	0.00	57.75
		17	-157.45	8.80	0.00	0.00	0.00	-359.84
	18	14	176.49	-11.86	0.00	0.00	0.00	66.73
		17	-169.83	9.86	0.00	0.00	0.00	-408.04
	19	14	202.24	-14.82	0.00	0.00	0.00	85.31
		17	-195.46	12.06	0.00	0.00	0.00	-507.73
	20	14	236.66	-18.79	0.00	0.00	0.00	110.15
		17	-229.71	15.00	0.00	0.00	0.00	-641.01
16	1	17	74.31	1.09	0.00	0.00	0.00	9.30
		19	-67.48	0.04	0.00	0.00	0.00	7.22
	3	17	71.19	-12.48	0.00	0.00	0.00	-252.35
		19	-70.67	9.38	0.00	0.00	0.00	-91.03
	8	17	138.06	-11.49	0.00	0.00	0.00	-243.97
		19	-131.40	9.41	0.00	0.00	0.00	-84.52
	13	17	103.82	-5.49	0.00	0.00	0.00	-122.59
		19	-97.41	4.90	0.00	0.00	0.00	-40.74
	14	17	111.27	-6.80	0.00	0.00	0.00	-148.99
		19	-104.80	5.89	0.00	0.00	0.00	-50.26
	15	17	115.14	-7.47	0.00	0.00	0.00	-162.72
		19	-108.64	6.40	0.00	0.00	0.00	-55.21
	16	17	123.04	-8.86	0.00	0.00	0.00	-190.73
		19	-116.49	7.44	0.00	0.00	0.00	-65.32
	17	17	127.67	-9.67	0.00	0.00	0.00	-207.13
		19	-121.08	8.05	0.00	0.00	0.00	-71.23
	18	17	136.21	-11.17	0.00	0.00	0.00	-237.41
		19	-129.56	9.17	0.00	0.00	0.00	-82.16
	19	17	153.88	-14.26	0.00	0.00	0.00	-300.04
		19	-147.10	11.50	0.00	0.00	0.00	-104.75
	20	17	177.50	-18.40	0.00	0.00	0.00	-383.77
		19	-170.55	14.61	0.00	0.00	0.00	-134.95
17	1	19	67.48	-0.02	0.00	0.00	0.00	-7.22
		22	-60.64	1.16	0.00	0.00	0.00	-11.35
	3	19	70.39	-7.68	0.00	0.00	0.00	91.03
		22	-69.88	4.58	0.00	0.00	0.00	-283.59
	8	19	131.12	-7.70	0.00	0.00	0.00	84.52
		22	-124.46	5.62	0.00	0.00	0.00	-293.80
	13	19	97.26	-4.00	0.00	0.00	0.00	40.74
		22	-90.85	3.42	0.00	0.00	0.00	-157.40
	14	19	104.63	-4.81	0.00	0.00	0.00	50.26
		22	-98.15	3.90	0.00	0.00	0.00	-187.06
	15	19	108.45	-5.22	0.00	0.00	0.00	55.21
		22	-101.96	4.15	0.00	0.00	0.00	-202.49
	16	19	116.27	-6.08	0.00	0.00	0.00	65.32
		22	-109.71	4.66	0.00	0.00	0.00	-233.97

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	17	19	120.84	-6.58	0.00	0.00	0.00	71.23
		22	-114.25	4.95	0.00	0.00	0.00	-252.40
	18	19	129.29	-7.50	0.00	0.00	0.00	82.16
		22	-122.64	5.50	0.00	0.00	0.00	-286.43
	19	19	146.76	-9.40	0.00	0.00	0.00	104.75
		22	-139.98	6.64	0.00	0.00	0.00	-356.82
	20	19	170.12	-11.95	0.00	0.00	0.00	134.95
		22	-163.17	8.16	0.00	0.00	0.00	-450.91
18	1	22	59.44	0.85	0.00	0.00	0.00	7.82
		24	-52.57	0.30	0.00	0.00	0.00	0.84
	3	22	39.36	-7.93	0.00	0.00	0.00	-22.23
		24	-38.84	4.82	0.00	0.00	0.00	-179.21
	8	22	92.85	-7.17	0.00	0.00	0.00	-15.19
		24	-86.15	5.09	0.00	0.00	0.00	-178.46
	13	22	73.92	-3.36	0.00	0.00	0.00	-4.50
		24	-67.47	2.77	0.00	0.00	0.00	-92.26
	14	22	78.04	-4.19	0.00	0.00	0.00	-6.82
		24	-71.53	3.27	0.00	0.00	0.00	-111.00
	15	22	80.18	-4.62	0.00	0.00	0.00	-8.03
		24	-73.65	3.54	0.00	0.00	0.00	-120.75
	16	22	84.55	-5.50	0.00	0.00	0.00	-10.50
		24	-77.96	4.07	0.00	0.00	0.00	-140.64
	17	22	87.11	-6.01	0.00	0.00	0.00	-11.95
		24	-80.48	4.38	0.00	0.00	0.00	-152.29
	18	22	91.83	-6.97	0.00	0.00	0.00	-14.61
		24	-85.14	4.96	0.00	0.00	0.00	-173.80
	19	22	101.60	-8.94	0.00	0.00	0.00	-20.13
		24	-94.78	6.16	0.00	0.00	0.00	-218.28
	20	22	114.66	-11.57	0.00	0.00	0.00	-27.51
		24	-107.67	7.76	0.00	0.00	0.00	-277.74
19	1	23	8.95	1.81	0.00	0.00	0.00	-0.82
		24	-8.95	1.80	0.00	0.00	0.00	0.84
	3	23	11.15	-37.52	0.00	0.00	0.00	-179.45
		24	-11.15	37.52	0.00	0.00	0.00	-179.21
	8	23	19.20	-35.89	0.00	0.00	0.00	-180.19
		24	-19.20	39.14	0.00	0.00	0.00	-178.46
	13	23	13.84	-17.84	0.00	0.00	0.00	-93.87
		24	-13.84	21.10	0.00	0.00	0.00	-92.26
	14	23	15.00	-21.77	0.00	0.00	0.00	-112.64
		24	-15.00	25.02	0.00	0.00	0.00	-111.00
	15	23	15.61	-23.81	0.00	0.00	0.00	-122.41
		24	-15.61	27.06	0.00	0.00	0.00	-120.75
	16	23	16.85	-27.97	0.00	0.00	0.00	-142.32
		24	-16.85	31.23	0.00	0.00	0.00	-140.64
	17	23	17.57	-30.41	0.00	0.00	0.00	-153.99
		24	-17.57	33.66	0.00	0.00	0.00	-152.29

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	18	23	18.91	-34.91	0.00	0.00	0.00	-175.52
		24	-18.91	38.17	0.00	0.00	0.00	-173.80
	19	23	21.68	-44.23	0.00	0.00	0.00	-220.06
		24	-21.68	47.48	0.00	0.00	0.00	-218.28
	20	23	25.37	-56.67	0.00	0.00	0.00	-279.61
		24	-25.37	59.93	0.00	0.00	0.00	-277.74
20	1	20	2.17	0.87	0.00	0.00	0.00	3.65
		21	-2.17	-0.01	0.00	0.00	0.00	0.74
	3	20	0.00	-30.65	0.00	0.00	0.00	-306.02
		21	0.00	30.65	0.00	0.00	0.00	0.10
	8	20	1.96	-29.87	0.00	0.00	0.00	-302.73
		21	-1.96	30.65	0.00	0.00	0.00	0.77
	13	20	1.96	-15.12	0.00	0.00	0.00	-155.54
		21	-1.96	15.90	0.00	0.00	0.00	0.72
	14	20	1.96	-18.33	0.00	0.00	0.00	-187.55
		21	-1.96	19.11	0.00	0.00	0.00	0.73
	15	20	1.96	-20.00	0.00	0.00	0.00	-204.19
		21	-1.96	20.78	0.00	0.00	0.00	0.73
	16	20	1.96	-23.40	0.00	0.00	0.00	-238.16
		21	-1.96	24.18	0.00	0.00	0.00	0.75
	17	20	1.96	-25.39	0.00	0.00	0.00	-258.05
		21	-1.96	26.17	0.00	0.00	0.00	0.75
	18	20	1.96	-29.07	0.00	0.00	0.00	-294.78
		21	-1.96	29.85	0.00	0.00	0.00	0.76
	19	20	1.96	-36.68	0.00	0.00	0.00	-370.73
		21	-1.96	37.46	0.00	0.00	0.00	0.79
	20	20	1.96	-46.85	0.00	0.00	0.00	-472.27
		21	-1.96	47.63	0.00	0.00	0.00	0.82
21	1	21	2.17	0.01	0.00	0.00	0.00	-0.74
		22	-2.17	0.86	0.00	0.00	0.00	-3.53
	3	21	0.00	-30.65	0.00	0.00	0.00	-0.10
		22	0.00	30.65	0.00	0.00	0.00	-305.82
	8	21	1.96	-30.65	0.00	0.00	0.00	-0.77
		22	-1.96	31.43	0.00	0.00	0.00	-308.99
	13	21	1.96	-15.90	0.00	0.00	0.00	-0.72
		22	-1.96	16.68	0.00	0.00	0.00	-161.89
	14	21	1.96	-19.11	0.00	0.00	0.00	-0.73
		22	-1.96	19.89	0.00	0.00	0.00	-193.88
	15	21	1.96	-20.78	0.00	0.00	0.00	-0.73
		22	-1.96	21.56	0.00	0.00	0.00	-210.52
	16	21	1.96	-24.18	0.00	0.00	0.00	-0.75
		22	-1.96	24.96	0.00	0.00	0.00	-244.47
	17	21	1.96	-26.17	0.00	0.00	0.00	-0.75
		22	-1.96	26.95	0.00	0.00	0.00	-264.34
	18	21	1.96	-29.85	0.00	0.00	0.00	-0.76
		22	-1.96	30.63	0.00	0.00	0.00	-301.04

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	19	21	1.96	-37.46	0.00	0.00	0.00	-0.79
		22	-1.96	38.24	0.00	0.00	0.00	-376.95
	20	21	1.96	-47.63	0.00	0.00	0.00	-0.82
		22	-1.96	48.41	0.00	0.00	0.00	-478.42
22	1	15	2.91	2.23	0.00	0.00	0.00	9.25
		16	-2.91	0.00	0.00	0.00	0.00	13.35
	3	15	0.01	-32.20	0.00	0.00	0.00	-653.77
		16	-0.01	32.20	0.00	0.00	0.00	-0.13
	8	15	2.63	-30.19	0.00	0.00	0.00	-645.45
		16	-2.63	32.20	0.00	0.00	0.00	11.89
	13	15	2.62	-14.70	0.00	0.00	0.00	-330.98
		16	-2.62	16.71	0.00	0.00	0.00	11.95
	14	15	2.63	-18.07	0.00	0.00	0.00	-399.37
		16	-2.63	20.08	0.00	0.00	0.00	11.94
	15	15	2.63	-19.82	0.00	0.00	0.00	-434.93
		16	-2.63	21.83	0.00	0.00	0.00	11.93
	16	15	2.63	-23.40	0.00	0.00	0.00	-507.50
		16	-2.63	25.41	0.00	0.00	0.00	11.92
	17	15	2.63	-25.49	0.00	0.00	0.00	-550.00
		16	-2.63	27.50	0.00	0.00	0.00	11.91
	18	15	2.63	-29.35	0.00	0.00	0.00	-628.45
		16	-2.63	31.36	0.00	0.00	0.00	11.89
	19	15	2.63	-37.34	0.00	0.00	0.00	-790.71
		16	-2.63	39.35	0.00	0.00	0.00	11.86
	20	15	2.64	-48.03	0.00	0.00	0.00	-1007.63
		16	-2.64	50.03	0.00	0.00	0.00	11.82
23	1	16	2.91	0.00	0.00	0.00	0.00	-13.35
		17	-2.91	2.23	0.00	0.00	0.00	-9.37
	3	16	0.01	-32.20	0.00	0.00	0.00	0.13
		17	-0.01	32.20	0.00	0.00	0.00	-654.02
	8	16	2.63	-32.20	0.00	0.00	0.00	-11.89
		17	-2.63	34.21	0.00	0.00	0.00	-662.45
	13	16	2.62	-16.71	0.00	0.00	0.00	-11.95
		17	-2.62	18.72	0.00	0.00	0.00	-347.87
	14	16	2.63	-20.08	0.00	0.00	0.00	-11.94
		17	-2.63	22.09	0.00	0.00	0.00	-416.28
	15	16	2.63	-21.83	0.00	0.00	0.00	-11.93
		17	-2.63	23.84	0.00	0.00	0.00	-451.86
	16	16	2.63	-25.41	0.00	0.00	0.00	-11.92
		17	-2.63	27.41	0.00	0.00	0.00	-524.46
	17	16	2.63	-27.50	0.00	0.00	0.00	-11.91
		17	-2.63	29.51	0.00	0.00	0.00	-566.97
	18	16	2.63	-31.36	0.00	0.00	0.00	-11.89
		17	-2.63	33.37	0.00	0.00	0.00	-645.45
	19	16	2.63	-39.35	0.00	0.00	0.00	-11.86
		17	-2.63	41.36	0.00	0.00	0.00	-807.78

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	20	16	2.64	-50.03	0.00	0.00	0.00	-11.82
		17	-2.64	52.04	0.00	0.00	0.00	-1024.78
24	1	10	3.60	4.28	0.00	0.00	0.00	29.21
		11	-3.60	0.01	0.00	0.00	0.00	36.23
	3	10	-0.14	-31.57	0.00	0.00	0.00	-968.57
		11	0.14	31.57	0.00	0.00	0.00	1.17
	8	10	3.10	-27.72	0.00	0.00	0.00	-942.28
		11	-3.10	31.58	0.00	0.00	0.00	33.77
	13	10	3.17	-12.54	0.00	0.00	0.00	-476.40
		11	-3.17	16.39	0.00	0.00	0.00	33.21
	14	10	3.15	-15.84	0.00	0.00	0.00	-577.71
		11	-3.15	19.70	0.00	0.00	0.00	33.34
	15	10	3.15	-17.56	0.00	0.00	0.00	-630.40
		11	-3.15	21.41	0.00	0.00	0.00	33.40
	16	10	3.13	-21.06	0.00	0.00	0.00	-737.91
		11	-3.13	24.92	0.00	0.00	0.00	33.53
	17	10	3.12	-23.11	0.00	0.00	0.00	-800.87
		11	-3.12	26.97	0.00	0.00	0.00	33.60
	18	10	3.10	-26.90	0.00	0.00	0.00	-917.10
		11	-3.10	30.76	0.00	0.00	0.00	33.74
	19	10	3.07	-34.74	0.00	0.00	0.00	-1157.50
		11	-3.07	38.60	0.00	0.00	0.00	34.03
	20	10	3.02	-45.21	0.00	0.00	0.00	-1478.87
		11	-3.02	49.07	0.00	0.00	0.00	34.42
25	1	11	3.60	-0.01	0.00	0.00	0.00	-36.23
		12	-3.60	4.29	0.00	0.00	0.00	-29.64
	3	11	-0.14	-31.57	0.00	0.00	0.00	-1.17
		12	0.14	31.57	0.00	0.00	0.00	-966.23
	8	11	3.10	-31.58	0.00	0.00	0.00	-33.77
		12	-3.10	35.44	0.00	0.00	0.00	-992.92
	13	11	3.17	-16.39	0.00	0.00	0.00	-33.21
		12	-3.17	20.25	0.00	0.00	0.00	-528.16
	14	11	3.15	-19.70	0.00	0.00	0.00	-33.34
		12	-3.15	23.55	0.00	0.00	0.00	-629.22
	15	11	3.15	-21.41	0.00	0.00	0.00	-33.40
		12	-3.15	25.27	0.00	0.00	0.00	-681.79
	16	11	3.13	-24.92	0.00	0.00	0.00	-33.53
		12	-3.13	28.77	0.00	0.00	0.00	-789.04
	17	11	3.12	-26.97	0.00	0.00	0.00	-33.60
		12	-3.12	30.83	0.00	0.00	0.00	-851.84
	18	11	3.10	-30.76	0.00	0.00	0.00	-33.74
		12	-3.10	34.62	0.00	0.00	0.00	-967.79
	19	11	3.07	-38.60	0.00	0.00	0.00	-34.03
		12	-3.07	42.45	0.00	0.00	0.00	-1207.61
	20	11	3.02	-49.07	0.00	0.00	0.00	-34.42
		12	-3.02	52.93	0.00	0.00	0.00	-1528.21

MEMBER END FORCES STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
26	1	5	3.41	5.73	0.00	0.00	0.00	46.30
		6	-3.41	0.00	0.00	0.00	0.00	71.16
	3	5	0.44	-36.60	0.00	0.00	0.00	-1491.47
		6	-0.44	36.60	0.00	0.00	0.00	-8.39
	8	5	3.51	-31.44	0.00	0.00	0.00	-1449.80
		6	-3.51	36.60	0.00	0.00	0.00	55.65
	13	5	3.30	-13.84	0.00	0.00	0.00	-732.40
		6	-3.30	19.00	0.00	0.00	0.00	59.68
	14	5	3.34	-17.66	0.00	0.00	0.00	-888.41
		6	-3.34	22.82	0.00	0.00	0.00	58.81
	15	5	3.37	-19.66	0.00	0.00	0.00	-969.55
		6	-3.37	24.81	0.00	0.00	0.00	58.35
	16	5	3.42	-23.72	0.00	0.00	0.00	-1135.10
		6	-3.42	28.88	0.00	0.00	0.00	57.42
	17	5	3.45	-26.10	0.00	0.00	0.00	-1232.05
		6	-3.45	31.26	0.00	0.00	0.00	56.87
	18	5	3.50	-30.49	0.00	0.00	0.00	-1411.02
		6	-3.50	35.65	0.00	0.00	0.00	55.87
	19	5	3.61	-39.57	0.00	0.00	0.00	-1781.21
		6	-3.61	44.73	0.00	0.00	0.00	53.78
	20	5	3.76	-51.72	0.00	0.00	0.00	-2276.08
		6	-3.76	56.88	0.00	0.00	0.00	51.00
27	1	6	3.41	0.00	0.00	0.00	0.00	-71.16
		7	-3.41	5.73	0.00	0.00	0.00	-46.29
	3	6	0.44	-36.60	0.00	0.00	0.00	8.39
		7	-0.44	36.60	0.00	0.00	0.00	-1508.26
	8	6	3.51	-36.60	0.00	0.00	0.00	-55.65
		7	-3.51	41.76	0.00	0.00	0.00	-1549.92
	13	6	3.30	-19.00	0.00	0.00	0.00	-59.68
		7	-3.30	24.15	0.00	0.00	0.00	-824.44
	14	6	3.34	-22.82	0.00	0.00	0.00	-58.81
		7	-3.34	27.98	0.00	0.00	0.00	-982.21
	15	6	3.37	-24.81	0.00	0.00	0.00	-58.35
		7	-3.37	29.97	0.00	0.00	0.00	-1064.26
	16	6	3.42	-28.88	0.00	0.00	0.00	-57.42
		7	-3.42	34.04	0.00	0.00	0.00	-1231.67
	17	6	3.45	-31.26	0.00	0.00	0.00	-56.87
		7	-3.45	36.42	0.00	0.00	0.00	-1329.71
	18	6	3.50	-35.65	0.00	0.00	0.00	-55.87
		7	-3.50	40.81	0.00	0.00	0.00	-1510.70
	19	6	3.61	-44.73	0.00	0.00	0.00	-53.78
		7	-3.61	49.89	0.00	0.00	0.00	-1885.05
	20	6	3.76	-56.88	0.00	0.00	0.00	-51.00
		7	-3.76	62.03	0.00	0.00	0.00	-2385.49
28	1	1	-21.04	1.83	0.00	0.00	0.00	10.85
		25	21.04	2.20	0.00	0.00	0.00	-20.24

MEMBER END FORCES   STRUCTURE TYPE = PLANE

ALL UNITS ARE -- KIP FEET

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	3	1	52.56	-5.18	0.00	0.00	0.00	-266.82
		25	-52.56	5.18	0.00	0.00	0.00	2.58
	8	1	33.63	-3.53	0.00	0.00	0.00	-257.05
		25	-33.63	7.15	0.00	0.00	0.00	-15.64
	13	1	8.35	-1.04	0.00	0.00	0.00	-128.71
		25	-8.35	4.66	0.00	0.00	0.00	-16.88
	14	1	13.85	-1.58	0.00	0.00	0.00	-156.62
		25	-13.85	5.21	0.00	0.00	0.00	-16.61
	15	1	16.71	-1.87	0.00	0.00	0.00	-171.14
		25	-16.71	5.49	0.00	0.00	0.00	-16.47
	16	1	22.54	-2.44	0.00	0.00	0.00	-200.75
		25	-22.54	6.06	0.00	0.00	0.00	-16.18
	17	1	25.96	-2.78	0.00	0.00	0.00	-218.10
		25	-25.96	6.40	0.00	0.00	0.00	-16.01
	18	1	32.26	-3.40	0.00	0.00	0.00	-250.11
		25	-32.26	7.02	0.00	0.00	0.00	-15.70
	19	1	45.31	-4.68	0.00	0.00	0.00	-316.34
		25	-45.31	8.30	0.00	0.00	0.00	-15.06
	20	1	62.75	-6.40	0.00	0.00	0.00	-404.87
		25	-62.75	10.02	0.00	0.00	0.00	-14.21
29	1	25	-21.00	2.20	0.00	0.00	0.00	20.24
		2	21.00	1.83	0.00	0.00	0.00	-10.85
	3	25	52.47	-5.48	0.00	0.00	0.00	-2.58
		2	-52.47	5.48	0.00	0.00	0.00	-277.14
	8	25	33.57	-3.51	0.00	0.00	0.00	15.64
		2	-33.57	7.13	0.00	0.00	0.00	-286.91
	13	25	8.33	-0.87	0.00	0.00	0.00	16.88
		2	-8.33	4.49	0.00	0.00	0.00	-153.60
	14	25	13.82	-1.44	0.00	0.00	0.00	16.61
		2	-13.82	5.06	0.00	0.00	0.00	-182.59
	15	25	16.67	-1.74	0.00	0.00	0.00	16.47
		2	-16.67	5.36	0.00	0.00	0.00	-197.67
	16	25	22.50	-2.35	0.00	0.00	0.00	16.18
		2	-22.50	5.97	0.00	0.00	0.00	-228.43
	17	25	25.91	-2.70	0.00	0.00	0.00	16.01
		2	-25.91	6.33	0.00	0.00	0.00	-246.44
	18	25	32.20	-3.36	0.00	0.00	0.00	15.70
		2	-32.20	6.98	0.00	0.00	0.00	-279.70
	19	25	45.23	-4.72	0.00	0.00	0.00	15.06
		2	-45.23	8.34	0.00	0.00	0.00	-348.49
	20	25	62.63	-6.54	0.00	0.00	0.00	14.21
		2	-62.63	10.16	0.00	0.00	0.00	-440.44

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************** END OF LATEST ANALYSIS RESULT **************

98. FINISH

     *********** END OF THE STAAD.Pro RUN ***********

       **** DATE= OCT  8,2003   TIME= 14:36:10 ****

 ************************************************************
 *     For questions on STAAD.Pro, please contact :        *
 *  By Email - North America  : support@reiusa.com         *
 *  By Email - International  : support@reiworld.com       *
 *  Tel. (USA) : 714-974-2500 ; Fax (USA) : 714-974-4771   *
 ************************************************************
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Job Information

	Engineer	Checked	Approved
Name:	VDL		
Date:	25-Aug-03		

Structure Type	PLANE FRAME

Number of Nodes	25	Highest Node	25
Number of Elements	29	Highest Beam	29

Number of Basic Load Cases	2
Number of Combination Load Cases	9

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	3	FULL WIND ON STRUCTURE (50 PSF)
Combination	8	0.9DL + W
Combination	13	0.9DL + W (73 MPH)
Combination	14	0.9DL + W (80 MPH)
Combination	15	0.9DL + W (LIFT OFF)
Combination	16	0.9DL + W (90 MPH)
Combination	17	0.9DL + W (CAPACITY AT COLLAPSE)
Combination	18	0.9DL + W (100 MPH)
Combination	19	0.9DL + W (112 MPH)
Combination	20	0.9DL + W (FULL BOLT CAPACITY)

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****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2003    Bld 1002.US           *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    OCT  8, 2003                  *
*           Time=    14:38:12                      *
*                                                  *
*      USER ID: Gannett Fleming, Inc.              *
****************************************************
```

```
 1. STAAD PLANE KINZUA VIADUCT COLLAPSE, WIND ANALYSIS
 2. START JOB INFORMATION
 3. JOB NAME KINZUA VIADUCT COLLAPSE (WIND ANALYSIS)
 4. *
 5. *'KINZU100' - AS-BUILT STRUCTURE, WITH FULL MEMBER STIFFNESS
 6. *ALL MEMBERS CONNECTED; WIND PRESSURE FROM THE LEFT BASED ON
 7. *73, 80, 90, 100, AND 112 MPH WIND PER ASCE-7 (2002)SECTION 6.5
 8. *AND WITH FROZEN ROLLER BEARING (MODELED AS A 95 KIP/IN SPRING
 9. *PER THE 2002 INSPECTION REPORT) ON THE LEFT (EAST) SIDE AND A
10. *PIN BEARING ON THE RIGHT (WEST) SIDE
11. *
12. JOB CLIENT DCNR
13. JOB NO 042420
14. JOB PART 1620H
15. ENGINEER NAME VDL
16. ENGINEER DATE 25-AUG-03
17. END JOB INFORMATION
18. INPUT WIDTH 79
19. UNIT FEET KIP
20. JOINT COORDINATES
21. 1 0 0 0; 2 102.06 0 0; 3 5.03 30.16 0; 4 97.03 30.16 0; 5 10.05 60.32 0
22. 6 51.03 60.32 0; 7 92.01 60.32 0; 8 15.22 91.32 0; 9 86.84 91.32 0
23. 10 20.39 122.32 0; 11 51.03 122.32 0; 12 81.67 122.32 0; 13 25.56 153.32 0
24. 14 76.51 153.32 0; 15 30.72 184.32 0; 16 51.03 184.32 0; 17 71.34 184.32 0
25. 18 35.89 215.32 0; 19 66.18 215.32 0; 20 41.05 246.32 0; 21 51.03 246.32 0
26. 22 61.01 246.32 0; 23 46.25 277.48 0; 24 55.81 277.48 0; 25 51.03 0 0
27. MEMBER INCIDENCES
28. 1 1 3; 2 3 5; 3 5 8; 4 8 10; 5 10 13; 6 13 15; 7 15 18; 8 18 20; 9 20 23
29. 10 2 4; 11 4 7; 12 7 9; 13 9 12; 14 12 14; 15 14 17; 16 17 19; 17 19 22
30. 18 22 24; 19 23 24; 20 20 21; 21 21 22; 22 15 16; 23 16 17; 24 10 11; 25 11 12
31. 26 5 6; 27 6 7; 28 1 25; 29 25 2
32. UNIT INCHES KIP
33. MEMBER PROPERTY AMERICAN
34. 1 TO 4 10 TO 13 PRIS AX 40.72 IZ 12336
35. 5 TO 9 14 TO 18 PRIS AX 35.44 IZ 10825
36. 26 27 PRIS AX 23.52 IZ 43407
37. 24 25 PRIS AX 23.52 IZ 32199
38. 22 23 PRIS AX 16.16 IZ 16527
39. 20 21 PRIS AX 12.36 IZ 5450
40. 19 PRIS AX 96.6 IZ 121188
41. 28 29 PRIS AX 11.44 IZ 2198
```

```
42. DEFINE MATERIAL START
43. ISOTROPIC STEEL
44. E 29000
45. POISSON 0.3
46. DENSITY 0.000283
47. ALPHA 6.5E-006
48. DAMP 0.03
49. END DEFINE MATERIAL
50. CONSTANTS
51. MATERIAL STEEL MEMB 1 TO 29
52. PRINT MEMBER INFORMATION
```

MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (INCH)	BETA (DEG)	RELEASES
1	1	3	366.919	0.00	
2	3	5	366.899	0.00	
3	5	8	377.138	0.00	
4	8	10	377.138	0.00	
5	10	13	377.138	0.00	
6	13	15	377.118	0.00	
7	15	18	377.138	0.00	
8	18	20	377.118	0.00	
9	20	23	379.091	0.00	
10	2	4	366.919	0.00	
11	4	7	366.899	0.00	
12	7	9	377.138	0.00	
13	9	12	377.138	0.00	
14	12	14	377.118	0.00	
15	14	17	377.138	0.00	
16	17	19	377.118	0.00	
17	19	22	377.138	0.00	
18	22	24	379.091	0.00	
19	23	24	114.720	0.00	
20	20	21	119.760	0.00	
21	21	22	119.760	0.00	
22	15	16	243.720	0.00	
23	16	17	243.720	0.00	
24	10	11	367.680	0.00	
25	11	12	367.680	0.00	
26	5	6	491.760	0.00	
27	6	7	491.760	0.00	
28	1	25	612.360	0.00	
29	25	2	612.360	0.00	

************ END OF DATA FROM INTERNAL STORAGE ************

53. SUPPORTS
54. 2 FIXED BUT MZ
55. 25 FIXED BUT MZ KFX 1
56. 1 FIXED BUT MZ KFX 95
57. UNIT FEET KIP
58. LOAD 1 DEAD LOAD
59. SELFWEIGHT Y -1
60. JOINT LOAD
61. 23 24 FY -50
62. MEMBER LOAD
63. 1 TO 18 UNI GY -0.1

```
64. 19 UNI GY -0.05
65. 20 21 UNI GY -0.045
66. 22 23 UNI GY -0.055
67. 24 25 UNI GY -0.06
68. 26 27 UNI GY -0.06
69. 28 29 UNI GY -0.04
70. LOAD 3 FULL WIND ON STRUCTURE (50 PSF)
71. JOINT LOAD
72. 23 FX 22.3
73. 3 5 8 10 13 15 18 20 FX 1.7
74. 4 7 9 12 14 17 19 22 FX 1.7
75. MEMBER LOAD
76. 1 TO 18 UNI GX 0.1
77. LOAD COMB 8 0.9DL + W
78. 1 0.9 3 1.0
79. LOAD COMB 13 0.9DL + W (73 MPH)
80. 1 0.9 3 0.519
81. LOAD COMB 14 0.9DL + W (80 MPH)
82. 1 0.9 3 0.6236
83. LOAD COMB 15 0.9DL + W (LIFT OFF)
84. 1 0.9 3 0.678
85. LOAD COMB 16 0.9DL + W (90 MPH)
86. 1 0.9 3 0.789
87. LOAD COMB 17 0.9DL + W (CAPACITY AT COLLAPSE)
88. 1 0.9 3 0.854
89. LOAD COMB 18 0.9DL + W (100 MPH)
90. 1 0.9 3 0.974
91. LOAD COMB 19 0.9DL + W (112 MPH)
92. 1 0.9 3 1.2222
93. LOAD COMB 20 0.9DL + W (FULL BOLT CAPACITY)
94. 1 0.9 3 1.554
95. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     25/     29/      3
 ORIGINAL/FINAL BAND-WIDTH=     24/      3/      12 DOF
 TOTAL PRIMARY LOAD CASES =      2, TOTAL DEGREES OF FREEDOM =      71
 SIZE OF STIFFNESS MATRIX =          1 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.1/ 15104.7 MB,  EXMEM = 2165.6 MB


96. PRINT SUPPORT REACTION LIST 1 2 25
```

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = PLANE

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
1	1	5.47	130.98	0.00	0.00	0.00	0.00
	3	-13.66	-173.76	0.00	0.00	0.00	0.00
	8	-8.74	-55.88	0.00	0.00	0.00	0.00
	13	-2.17	27.70	0.00	0.00	0.00	0.00
	14	-3.60	9.53	0.00	0.00	0.00	0.00
	15	-4.34	0.07	0.00	0.00	0.00	0.00
	16	-5.86	-19.21	0.00	0.00	0.00	0.00
	17	-6.75	-30.51	0.00	0.00	0.00	0.00
	18	-8.38	-51.36	0.00	0.00	0.00	0.00
	19	-11.77	-94.49	0.00	0.00	0.00	0.00
	20	-16.31	-152.14	0.00	0.00	0.00	0.00
2	1	-5.50	130.98	0.00	0.00	0.00	0.00
	3	-92.03	173.98	0.00	0.00	0.00	0.00
	8	-96.98	291.86	0.00	0.00	0.00	0.00
	13	-52.71	208.18	0.00	0.00	0.00	0.00
	14	-62.34	226.38	0.00	0.00	0.00	0.00
	15	-67.34	235.84	0.00	0.00	0.00	0.00
	16	-77.56	255.15	0.00	0.00	0.00	0.00
	17	-83.54	266.46	0.00	0.00	0.00	0.00
	18	-94.58	287.34	0.00	0.00	0.00	0.00
	19	-117.43	330.52	0.00	0.00	0.00	0.00
	20	-147.96	388.25	0.00	0.00	0.00	0.00
25	1	0.03	4.36	0.00	0.00	0.00	0.00
	3	-0.07	-0.23	0.00	0.00	0.00	0.00
	8	-0.05	3.70	0.00	0.00	0.00	0.00
	13	-0.01	3.81	0.00	0.00	0.00	0.00
	14	-0.02	3.78	0.00	0.00	0.00	0.00
	15	-0.02	3.77	0.00	0.00	0.00	0.00
	16	-0.03	3.75	0.00	0.00	0.00	0.00
	17	-0.04	3.73	0.00	0.00	0.00	0.00
	18	-0.04	3.71	0.00	0.00	0.00	0.00
	19	-0.06	3.65	0.00	0.00	0.00	0.00
	20	-0.09	3.57	0.00	0.00	0.00	0.00

************** END OF LATEST ANALYSIS RESULT **************

97. PERFORM ANALYSIS PRINT MODE SHAPES

98. FINISH

```
************ END OF THE STAAD.Pro RUN ***********

**** DATE= OCT  8,2003   TIME= 14:38:13 ****

********************************************************
*     For questions on STAAD.Pro, please contact :     *
*  By Email - North America  : support@reiusa.com      *
*  By Email - International  : support@reiworld.com    *
*  Tel. (USA) : 714-974-2500 ; Fax (USA) : 714-974-4771 *
********************************************************
```

Job Information

	Engineer	Checked	Approved
Name:	VDL		
Date:	25-Aug-03		

Structure Type	PLANE FRAME

Number of Nodes	25	Highest Node	25
Number of Elements	29	Highest Beam	29

Number of Basic Load Cases	2
Number of Combination Load Cases	9

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	3	FULL WIND ON STRUCTURE (50 PSF)
Combination	8	0.9DL + W
Combination	13	0.9DL + W (73 MPH)
Combination	14	0.9DL + W (80 MPH)
Combination	15	0.9DL + W (LIFT OFF)
Combination	16	0.9DL + W (90 MPH)
Combination	17	0.9DL + W (CAPACITY AT COLLAPSE)
Combination	18	0.9DL + W (100 MPH)
Combination	19	0.9DL + W (112 MPH)
Combination	20	0.9DL + W (FULL BOLT CAPACITY)

```
**************************************************
*                                                *
*           STAAD.Pro                            *
*           Version  2003    Bld 1002.US         *
*           Proprietary Program of               *
*           Research Engineers, Intl.            *
*           Date=    OCT  8, 2003                *
*           Time=    14:48:51                    *
*                                                *
*      USER ID: Gannett Fleming, Inc.            *
**************************************************
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```
STAAD PLANE KINZUA VIADUCT COLLAPSE, WIND ANALYSIS
START JOB INFORMATION
JOB NAME KINZUA VIADUCT COLLAPSE (WIND ANALYSIS)
*
*'KIN100RL' - AS-BUILT STRUCTURE, WITH FULL MEMBER STIFFNESS
*BOTTOM STRUT RELEASED; WIND PRESSURE FROM THE LEFT BASED ON
*73, 80, 90, 100, AND 112 MPH WIND PER ASCE-7 (2002) SECTION 6.5
*AND WITH FROZEN ROLLER BEARING (MODELED AS A 95 KIP/IN SPRING PER
*THE 2002 INSPECTION REPORT) ON THE LEFT (EAST) SIDE AND A PIN
*BEARING ON THE RIGHT (WEST) SIDE.
*
JOB CLIENT DCNR
JOB NO 042420
JOB PART 1620H
ENGINEER NAME VDL
ENGINEER DATE 25-AUG-03
END JOB INFORMATION
INPUT WIDTH 79
UNIT FEET KIP
JOINT COORDINATES
1 0 0 0; 2 102.06 0 0; 3 5.03 30.16 0; 4 97.03 30.16 0; 5 10.05 60.32 0
6 51.03 60.32 0; 7 92.01 60.32 0; 8 15.22 91.32 0; 9 86.84 91.32 0
10 20.39 122.32 0; 11 51.03 122.32 0; 12 81.67 122.32 0; 13 25.56 153.32 0
14 76.51 153.32 0; 15 30.72 184.32 0; 16 51.03 184.32 0; 17 71.34 184.32 0
18 35.89 215.32 0; 19 66.18 215.32 0; 20 41.05 246.32 0; 21 51.03 246.32 0
22 61.01 246.32 0; 23 46.25 277.48 0; 24 55.81 277.48 0; 25 51.03 0 0
MEMBER INCIDENCES
1 1 3; 2 3 5; 3 5 8; 4 8 10; 5 10 13; 6 13 15; 7 15 18; 8 18 20; 9 20 23
10 2 4; 11 4 7; 12 7 9; 13 9 12; 14 12 14; 15 14 17; 16 17 19; 17 19 22
18 22 24; 19 23 24; 20 20 21; 21 21 22; 22 15 16; 23 16 17; 24 10 11; 25 11 12
26 5 6; 27 6 7; 28 1 25; 29 25 2
UNIT INCHES KIP
MEMBER PROPERTY AMERICAN
1 TO 4 10 TO 13 PRIS AX 40.72 IZ 12336
5 TO 9 14 TO 18 PRIS AX 35.44 IZ 10825
26 27 PRIS AX 23.52 IZ 43407
24 25 PRIS AX 23.52 IZ 32199
22 23 PRIS AX 16.16 IZ 16527
20 21 PRIS AX 12.36 IZ 5450
19 PRIS AX 96.6 IZ 121188
28 29 PRIS AX 11.44 IZ 2198
```

```
42. DEFINE MATERIAL START
43. ISOTROPIC STEEL
44. E 29000
45. POISSON 0.3
46. DENSITY 0.000283
47. ALPHA 6.5E-006
48. DAMP 0.03
49. END DEFINE MATERIAL
50. CONSTANTS
51. MATERIAL STEEL MEMB 1 TO 29
52. MEMBER RELEASE
53. 28 START FX FY MZ
54. 29 END FX FY MZ
55. PRINT MEMBER INFORMATION
```

MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (INCH)	BETA (DEG)	RELEASES
1	1	3	366.919	0.00	
2	3	5	366.899	0.00	
3	5	8	377.138	0.00	
4	8	10	377.138	0.00	
5	10	13	377.138	0.00	
6	13	15	377.118	0.00	
7	15	18	377.138	0.00	
8	18	20	377.118	0.00	
9	20	23	379.091	0.00	
10	2	4	366.919	0.00	
11	4	7	366.899	0.00	
12	7	9	377.138	0.00	
13	9	12	377.138	0.00	
14	12	14	377.118	0.00	
15	14	17	377.138	0.00	
16	17	19	377.118	0.00	
17	19	22	377.138	0.00	
18	22	24	379.091	0.00	
19	23	24	114.720	0.00	
20	20	21	119.760	0.00	
21	21	22	119.760	0.00	
22	15	16	243.720	0.00	
23	16	17	243.720	0.00	
24	10	11	367.680	0.00	
25	11	12	367.680	0.00	
26	5	6	491.760	0.00	
27	6	7	491.760	0.00	
28	1	25	612.360	0.00	110001000000
29	25	2	612.360	0.00	000000110001

************ END OF DATA FROM INTERNAL STORAGE ************

56. SUPPORTS
57. 2 FIXED BUT MZ
58. 25 FIXED BUT MZ KFX 1
59. 1 FIXED BUT MZ KFX 95
60. UNIT FEET KIP
61. LOAD 1 DEAD LOAD
62. SELFWEIGHT Y -1
63. JOINT LOAD
64. 23 24 FY -50
65. MEMBER LOAD
66. 1 TO 18 UNI GY -0.1

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67. 19 UNI GY -0.05
68. 20 21 UNI GY -0.045
69. 22 23 UNI GY -0.055
70. 24 25 UNI GY -0.06
71. 26 27 UNI GY -0.06
72. 28 29 UNI GY -0.04
73. LOAD 3 FULL WIND ON STRUCTURE (50 PSF)
74. JOINT LOAD
75. 23 FX 22.3
76. 3 5 8 10 13 15 18 20 FX 1.7
77. 4 7 9 12 14 17 19 22 FX 1.7
78. MEMBER LOAD
79. 1 TO 18 UNI GX 0.1
80. LOAD COMB 8 0.9DL + W
81. 1 0.9 3 1.0
82. LOAD COMB 13 0.9DL + W (73 MPH)
83. 1 0.9 3 0.519
84. LOAD COMB 14 0.9DL + W (80 MPH)
85. 1 0.9 3 0.6236
86. LOAD COMB 15 0.9DL + W (LIFT OFF)
87. 1 0.9 3 0.668
88. LOAD COMB 16 0.9DL + W (90 MPH)
89. 1 0.9 3 0.789
90. LOAD COMB 17 0.9DL + W (CAPACITY AT COLLAPSE)
91. 1 0.9 3 0.843
92. LOAD COMB 18 0.9DL + W (100 MPH)
93. 1 0.9 3 0.974
94. LOAD COMB 19 0.9DL + W (112 MPH)
95. 1 0.9 3 1.2222
96. LOAD COMB 20 0.9DL + W (FULL BOLT CAPACITY)
97. 1 0.9 3 1.543
98. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     25/    29/     3
 ORIGINAL/FINAL BAND-WIDTH=    24/     3/     12 DOF
 TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     71
 SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =    12.1/ 15055.7 MB,  EXMEM = 2165.4 MB


ZERO STIFFNESS IN DIRECTION 6 AT JOINT      25 EQN.NO.       7
      LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
      THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
      EFFECTIVELY RELEASED IN THIS DIRECTION.


99. PRINT SUPPORT REACTION LIST 1 2 25
```

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = PLANE

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
1	1	20.64	129.13	0.00	0.00	0.00	0.00
	3	-52.31	-173.87	0.00	0.00	0.00	0.00
	8	-33.73	-57.65	0.00	0.00	0.00	0.00
	13	-8.57	25.98	0.00	0.00	0.00	0.00
	14	-14.04	7.80	0.00	0.00	0.00	0.00
	15	-16.36	0.08	0.00	0.00	0.00	0.00
	16	-22.69	-20.96	0.00	0.00	0.00	0.00
	17	-25.52	-30.35	0.00	0.00	0.00	0.00
	18	-32.37	-53.13	0.00	0.00	0.00	0.00
	19	-45.35	-96.28	0.00	0.00	0.00	0.00
	20	-62.13	-152.06	0.00	0.00	0.00	0.00
2	1	-20.64	129.14	0.00	0.00	0.00	0.00
	3	-53.45	173.87	0.00	0.00	0.00	0.00
	8	-72.03	290.09	0.00	0.00	0.00	0.00
	13	-46.32	206.46	0.00	0.00	0.00	0.00
	14	-51.91	224.65	0.00	0.00	0.00	0.00
	15	-54.29	232.37	0.00	0.00	0.00	0.00
	16	-60.75	253.41	0.00	0.00	0.00	0.00
	17	-63.64	262.80	0.00	0.00	0.00	0.00
	18	-70.64	285.57	0.00	0.00	0.00	0.00
	19	-83.91	328.73	0.00	0.00	0.00	0.00
	20	-101.06	384.50	0.00	0.00	0.00	0.00
25	1	0.00	8.05	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00
	8	0.00	7.24	0.00	0.00	0.00	0.00
	13	0.00	7.24	0.00	0.00	0.00	0.00
	14	0.00	7.24	0.00	0.00	0.00	0.00
	15	0.00	7.24	0.00	0.00	0.00	0.00
	16	0.00	7.24	0.00	0.00	0.00	0.00
	17	0.00	7.24	0.00	0.00	0.00	0.00
	18	0.00	7.24	0.00	0.00	0.00	0.00
	19	0.00	7.24	0.00	0.00	0.00	0.00
	20	0.00	7.24	0.00	0.00	0.00	0.00

************** END OF LATEST ANALYSIS RESULT **************

100. PERFORM ANALYSIS PRINT MODE SHAPES
ZERO STIFFNESS IN DIRECTION 6 AT JOINT 25 EQN.NO. 7
LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
EFFECTIVELY RELEASED IN THIS DIRECTION.

```
101. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= OCT  8,2003   TIME= 14:48:52 ****

     ************************************************************
     *     For questions on STAAD.Pro, please contact :         *
     *  By Email - North America  : support@reiusa.com          *
     *  By Email - International  : support@reiworld.com        *
     *  Tel. (USA) : 714-974-2500 ; Fax (USA) : 714-974-4771    *
     ************************************************************
```

Job Information

	Engineer	Checked	Approved
Name:	VDL		
Date:	25-Aug-03		

Structure Type	PLANE FRAME

Number of Nodes	25	Highest Node	25
Number of Elements	29	Highest Beam	29

Number of Basic Load Cases	1
Number of Combination Load Cases	0

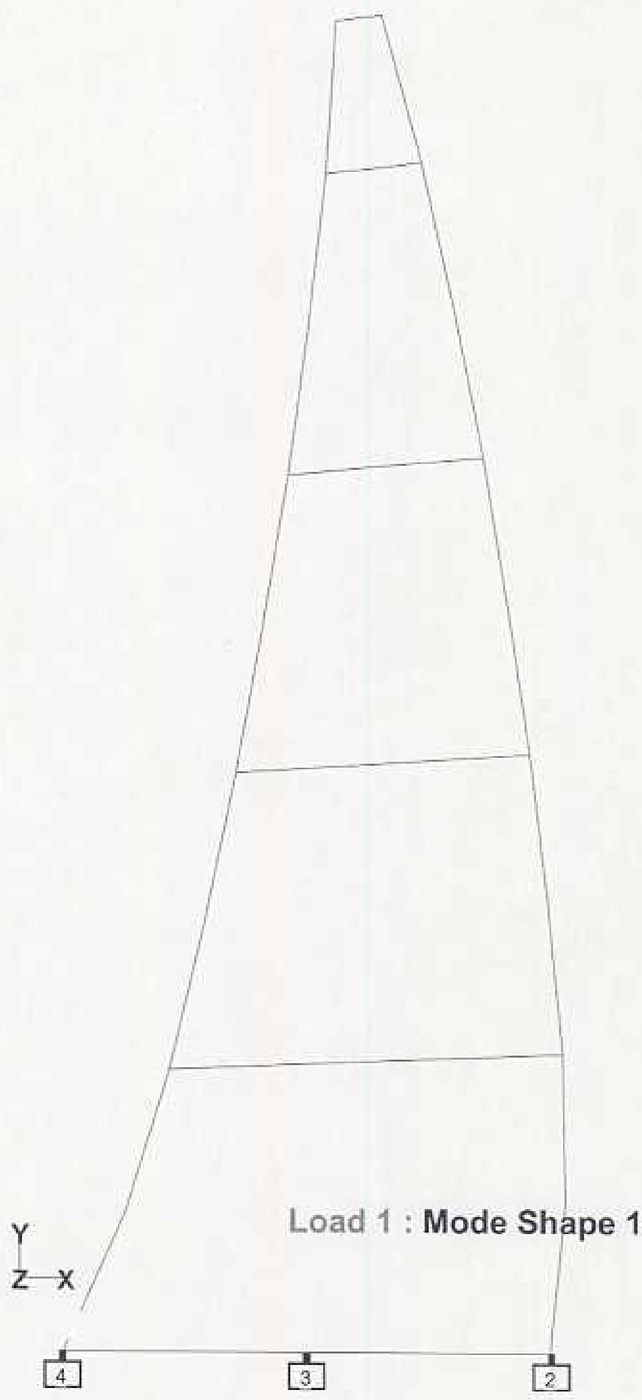
Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD

Software licensed to Gannett Fleming, Inc.	Job No 042420	Sheet No 2	Rev
	Part 1620H		
Job Title Kinzua Viaduct Collapse (Wind Analysis)	Ref		
	By VDL	Date 25-Aug-03	Chd
Client DCNR	File NatFreq.std	Date/Time 25-Sep-2003 07:50	



Mode Shape for Fundamental Frequency

```
**************************************************
*                                                *
*          STAAD.Pro                             *
*          Version  2003    Bld 1002.US          *
*          Proprietary Program of                *
*          Research Engineers,  Intl.            *
*          Date=    SEP 25, 2003                 *
*          Time=      8:52:17                    *
*                                                *
*     USER ID: Gannett Fleming, Inc.             *
**************************************************
```

```
 1. STAAD PLANE KINZUA VIADUCT COLLAPSE, WIND ANALYSIS
 2. START JOB INFORMATION
 3. JOB NAME KINZUA VIADUCT COLLAPSE (WIND ANALYSIS)
 4. JOB CLIENT DCNR
 5. JOB NO 042420
 6. JOB PART 1620H
 7. ENGINEER NAME VDL
 8. ENGINEER DATE 25-AUG-03
 9. END JOB INFORMATION
10. INPUT WIDTH 79
11. UNIT FEET KIP
12. JOINT COORDINATES
13. 1 0 0 0; 2 102.06 0 0; 3 5.03 30.16 0; 4 97.03 30.16 0; 5 10.05 60.32 0
14. 6 51.03 60.32 0; 7 92.01 60.32 0; 8 15.22 91.32 0; 9 86.84 91.32 0
15. 10 20.39 122.32 0; 11 51.03 122.32 0; 12 81.67 122.32 0; 13 25.56 153.32 0
16. 14 76.51 153.32 0; 15 30.72 184.32 0; 16 51.03 184.32 0; 17 71.34 184.32 0
17. 18 35.89 215.32 0; 19 66.18 215.32 0; 20 41.05 246.32 0; 21 51.03 246.32 0
18. 22 61.01 246.32 0; 23 46.25 277.48 0; 24 55.81 277.48 0; 25 51.03 0 0
19. MEMBER INCIDENCES
20. 1 1 3; 2 3 5; 3 5 8; 4 8 10; 5 10 13; 6 13 15; 7 15 18; 8 18 20; 9 20 23
21. 10 2 4; 11 4 7; 12 7 9; 13 9 12; 14 12 14; 15 14 17; 16 17 19; 17 19 22
22. 18 22 24; 19 23 24; 20 20 21; 21 21 22; 22 15 16; 23 16 17; 24 10 11; 25 11 12
23. 26 5 6; 27 6 7; 28 1 25; 29 25 2
24. UNIT INCHES KIP
25. MEMBER PROPERTY AMERICAN
26. 1 TO 4 10 TO 13 PRIS AX 40.72 IZ 12336
27. 5 TO 9 14 TO 18 PRIS AX 35.44 IZ 10825
28. 26 27 PRIS AX 23.52 IZ 43407
29. 24 25 PRIS AX 23.52 IZ 32199
30. 22 23 PRIS AX 16.16 IZ 16527
31. 20 21 PRIS AX 12.36 IZ 5450
32. 19 PRIS AX 96.6 IZ 121188
33. 28 29 PRIS AX 11.44 IZ 2198
34. DEFINE MATERIAL START
35. ISOTROPIC STEEL
36. E 29000
37. POISSON 0.3
38. DENSITY 0.000283
39. ALPHA 6.5E-006
40. DAMP 0.03
41. END DEFINE MATERIAL
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42. CONSTANTS
43. MATERIAL STEEL MEMB 1 TO 29
44. PRINT MEMBER INFORMATION
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MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (INCH)	BETA (DEG)	RELEASES
1	1	3	366.919	0.00	
2	3	5	366.899	0.00	
3	5	8	377.138	0.00	
4	8	10	377.138	0.00	
5	10	13	377.138	0.00	
6	13	15	377.118	0.00	
7	15	18	377.138	0.00	
8	18	20	377.118	0.00	
9	20	23	379.091	0.00	
10	2	4	366.919	0.00	
11	4	7	366.899	0.00	
12	7	9	377.138	0.00	
13	9	12	377.138	0.00	
14	12	14	377.118	0.00	
15	14	17	377.138	0.00	
16	17	19	377.118	0.00	
17	19	22	377.138	0.00	
18	22	24	379.091	0.00	
19	23	24	114.720	0.00	
20	20	21	119.760	0.00	
21	21	22	119.760	0.00	
22	15	16	243.720	0.00	
23	16	17	243.720	0.00	
24	10	11	367.680	0.00	
25	11	12	367.680	0.00	
26	5	6	491.760	0.00	
27	6	7	491.760	0.00	
28	1	25	612.360	0.00	
29	25	2	612.360	0.00	

************ END OF DATA FROM INTERNAL STORAGE ************

45. CUT OFF MODE SHAPE 10
46. SUPPORTS
47. 2 FIXED BUT MZ
48. 25 FIXED BUT MZ KFX 1
49. 1 FIXED BUT FX MZ
50. UNIT FEET KIP
51. LOAD 1 DEAD LOAD
52. SELFWEIGHT X -1.8
53. JOINT LOAD
54. 23 24 FX -50
55. MEMBER LOAD

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56. 1 TO 18 UNI GY -0.1
57. 19 UNI GY -0.05
58. 20 21 UNI GY -0.045
59. 22 23 UNI GY -0.055
60. 24 25 UNI GY -0.06
61. 26 27 UNI GY -0.06
62. 28 29 UNI GY -0.04
63. SPECTRUM CQC X 1. ACC SCALE 32.2 DAMP .03
64. 0.001 2.5
65. 0.33 2.5
66. 0.5 1.905
67. 0.75 1.454
68. 1. 1.2
69. 1.25 1.034
70. 1.5 0.992
71. 2. 0.756
72. 3. 0.577
73. 5. 0.41
74. PERFORM ANALYSIS PRINT MODE SHAPES


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     25/    29/     3
ORIGINAL/FINAL BAND-WIDTH=    24/     3/     12 DOF
TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      71
SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =    12.1/ 21126.5 MB,  EXMEM = 2174.6 MB


NUMBER OF MODES REQUESTED                =    10
NUMBER OF EXISTING MASSES IN THE MODEL =    46
NUMBER OF MODES THAT WILL BE USED        =    10
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CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	0.857	1.16702	2.451E-16
2	1.336	0.74860	6.052E-16
3	2.641	0.37863	2.064E-16
4	4.275	0.23391	3.876E-14
5	6.678	0.14974	5.113E-12
6	9.177	0.10897	3.993E-10
7	10.346	0.09665	1.986E-11
8	11.221	0.08912	2.338E-10
9	11.779	0.08490	1.225E-10
10	13.067	0.07653	1.859E-09

The following Frequencies are estimates that were calculated. These are for information only and will not be used. Remaining values are either above the cut off mode/freq values or are of low accuracy. To use these frequencies, rerun with a higher cutoff mode (or mode + freq) value.

CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
11	13.597	0.07354	3.742E-09
12	15.058	0.06641	5.707E-08
13	16.024	0.06241	2.975E-08
14	18.085	0.05529	1.528E-08
15	20.981	0.04766	9.465E-07
16	23.829	0.04197	1.280E-06

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	1	0.02586	0.00000	0.00000	0.000E+00	0.000E+00	-1.308E-03
2	1	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-1.348E-03
3	1	0.51231	-0.07304	0.00000	0.000E+00	0.000E+00	-1.196E-03
4	1	0.50191	0.07561	0.00000	0.000E+00	0.000E+00	-1.237E-03
5	1	0.77328	-0.10840	0.00000	0.000E+00	0.000E+00	-8.003E-05
6	1	0.77336	0.00346	0.00000	0.000E+00	0.000E+00	3.799E-04
7	1	0.77319	0.11269	0.00000	0.000E+00	0.000E+00	-9.069E-05
8	1	0.90029	-0.12285	0.00000	0.000E+00	0.000E+00	-4.253E-04
9	1	0.90139	0.12734	0.00000	0.000E+00	0.000E+00	-4.232E-04
10	1	0.97709	-0.12894	0.00000	0.000E+00	0.000E+00	1.550E-04
11	1	0.97719	0.00202	0.00000	0.000E+00	0.000E+00	4.570E-04
12	1	0.97711	0.13326	0.00000	0.000E+00	0.000E+00	1.565E-04
13	1	1.00000	-0.12661	0.00000	0.000E+00	0.000E+00	-1.312E-04
14	1	0.99992	0.13091	0.00000	0.000E+00	0.000E+00	-1.315E-04
15	1	0.98552	-0.11808	0.00000	0.000E+00	0.000E+00	3.180E-04
16	1	0.98555	0.00217	0.00000	0.000E+00	0.000E+00	5.810E-04
17	1	0.98551	0.12238	0.00000	0.000E+00	0.000E+00	3.178E-04
18	1	0.91799	-0.10228	0.00000	0.000E+00	0.000E+00	1.561E-04
19	1	0.91808	0.10662	0.00000	0.000E+00	0.000E+00	1.561E-04
20	1	0.80421	-0.07882	0.00000	0.000E+00	0.000E+00	5.317E-04
21	1	0.80422	0.00214	0.00000	0.000E+00	0.000E+00	7.482E-04
22	1	0.80422	0.08311	0.00000	0.000E+00	0.000E+00	5.318E-04
23	1	0.58712	-0.03982	0.00000	0.000E+00	0.000E+00	7.295E-04
24	1	0.58712	0.04412	0.00000	0.000E+00	0.000E+00	7.295E-04
25	1	0.01292	0.00000	0.00000	0.000E+00	0.000E+00	6.640E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	2	-0.01027	0.00000	0.00000	0.000E+00	0.000E+00	-1.874E-03
2	2	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-1.858E-03
3	2	0.67466	-0.12785	0.00000	0.000E+00	0.000E+00	-1.647E-03
4	2	0.67883	0.12683	0.00000	0.000E+00	0.000E+00	-1.631E-03
5	2	0.99959	-0.19558	0.00000	0.000E+00	0.000E+00	5.579E-05
6	2	1.00000	-0.00138	0.00000	0.000E+00	0.000E+00	5.650E-04
7	2	0.99963	0.19387	0.00000	0.000E+00	0.000E+00	6.006E-05
8	2	0.99154	-0.21003	0.00000	0.000E+00	0.000E+00	9.512E-05
9	2	0.99113	0.20825	0.00000	0.000E+00	0.000E+00	9.419E-05
10	2	0.86830	-0.20531	0.00000	0.000E+00	0.000E+00	5.812E-04
11	2	0.86848	-0.00085	0.00000	0.000E+00	0.000E+00	5.435E-04
12	2	0.86829	0.20359	0.00000	0.000E+00	0.000E+00	5.810E-04
13	2	0.52855	-0.16671	0.00000	0.000E+00	0.000E+00	1.115E-03
14	2	0.52835	0.16506	0.00000	0.000E+00	0.000E+00	1.115E-03
15	2	0.13724	-0.11963	0.00000	0.000E+00	0.000E+00	8.072E-04
16	2	0.13725	-0.00087	0.00000	0.000E+00	0.000E+00	3.273E-04
17	2	0.13724	0.11789	0.00000	0.000E+00	0.000E+00	8.072E-04

18	2	-0.33388	-0.05627	0.00000	0.000E+00	0.000E+00	1.434E-03
19	2	-0.33409	0.05464	0.00000	0.000E+00	0.000E+00	1.434E-03
20	2	-0.73857	-0.00407	0.00000	0.000E+00	0.000E+00	4.797E-04
21	2	-0.73859	-0.00085	0.00000	0.000E+00	0.000E+00	-1.995E-04
22	2	-0.73857	0.00235	0.00000	0.000E+00	0.000E+00	4.793E-04
23	2	-0.86950	0.00811	0.00000	0.000E+00	0.000E+00	-1.487E-04
24	2	-0.86950	-0.00983	0.00000	0.000E+00	0.000E+00	-1.487E-04
25	2	-0.00514	0.00000	0.00000	0.000E+00	0.000E+00	9.331E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	3	-0.02817	0.00000	0.00000	0.000E+00	0.000E+00	1.687E-03
2	3	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	1.727E-03
3	3	-0.62384	0.09439	0.00000	0.000E+00	0.000E+00	1.287E-03
4	3	-0.61175	-0.09710	0.00000	0.000E+00	0.000E+00	1.332E-03
5	3	-0.81182	0.12083	0.00000	0.000E+00	0.000E+00	-3.543E-04
6	3	-0.81300	-0.00403	0.00000	0.000E+00	0.000E+00	-2.019E-04
7	3	-0.81171	-0.12556	0.00000	0.000E+00	0.000E+00	-3.410E-04
8	3	-0.31698	0.03313	0.00000	0.000E+00	0.000E+00	-1.887E-03
9	3	-0.31840	-0.03815	0.00000	0.000E+00	0.000E+00	-1.890E-03
10	3	0.23196	-0.06351	0.00000	0.000E+00	0.000E+00	-5.287E-04
11	3	0.23214	-0.00225	0.00000	0.000E+00	0.000E+00	5.141E-04
12	3	0.23193	0.05870	0.00000	0.000E+00	0.000E+00	-5.305E-04
13	3	0.73773	-0.15906	0.00000	0.000E+00	0.000E+00	-1.550E-03
14	3	0.73778	0.15408	0.00000	0.000E+00	0.000E+00	-1.550E-03
15	3	0.99963	-0.21394	0.00000	0.000E+00	0.000E+00	5.104E-04
16	3	1.00000	-0.00250	0.00000	0.000E+00	0.000E+00	1.046E-03
17	3	0.99963	0.20901	0.00000	0.000E+00	0.000E+00	5.109E-04
18	3	0.68000	-0.17527	0.00000	0.000E+00	0.000E+00	1.206E-03
19	3	0.67971	0.17039	0.00000	0.000E+00	0.000E+00	1.206E-03
20	3	0.18325	-0.10727	0.00000	0.000E+00	0.000E+00	1.211E-03
21	3	0.18327	-0.00249	0.00000	0.000E+00	0.000E+00	7.070E-04
22	3	0.18325	0.10227	0.00000	0.000E+00	0.000E+00	1.210E-03
23	3	-0.26475	-0.04315	0.00000	0.000E+00	0.000E+00	7.171E-04
24	3	-0.26475	0.03815	0.00000	0.000E+00	0.000E+00	7.171E-04
25	3	-0.01410	0.00000	0.00000	0.000E+00	0.000E+00	-8.536E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	4	0.00466	0.00000	0.00000	0.000E+00	0.000E+00	-1.585E-03
2	4	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-1.590E-03
3	4	0.52588	-0.09648	0.00000	0.000E+00	0.000E+00	-9.097E-04
4	4	0.52359	0.09690	0.00000	0.000E+00	0.000E+00	-9.172E-04
5	4	0.54445	-0.10935	0.00000	0.000E+00	0.000E+00	7.235E-04
6	4	0.54660	0.00077	0.00000	0.000E+00	0.000E+00	-2.625E-05
7	4	0.54442	0.11015	0.00000	0.000E+00	0.000E+00	7.206E-04
8	4	-0.34624	0.03118	0.00000	0.000E+00	0.000E+00	2.981E-03
9	4	-0.34588	-0.03031	0.00000	0.000E+00	0.000E+00	2.981E-03

10	4	-0.99779	0.13204	0.00000	0.000E+00	0.000E+00	-2.292E-04
11	4	-1.00000	0.00036	0.00000	0.000E+00	0.000E+00	-4.226E-04
12	4	-0.99778	-0.13121	0.00000	0.000E+00	0.000E+00	-2.285E-04
13	4	-0.26163	0.00226	0.00000	0.000E+00	0.000E+00	-2.976E-03
14	4	-0.26177	-0.00168	0.00000	0.000E+00	0.000E+00	-2.976E-03
15	4	0.55766	-0.14093	0.00000	0.000E+00	0.000E+00	-4.284E-04
16	4	0.55820	0.00042	0.00000	0.000E+00	0.000E+00	1.084E-03
17	4	0.55765	0.14180	0.00000	0.000E+00	0.000E+00	-4.281E-04
18	4	0.77994	-0.19397	0.00000	0.000E+00	0.000E+00	-1.670E-04
19	4	0.77966	0.19473	0.00000	0.000E+00	0.000E+00	-1.670E-04
20	4	0.50076	-0.16367	0.00000	0.000E+00	0.000E+00	1.513E-03
21	4	0.50087	0.00037	0.00000	0.000E+00	0.000E+00	1.298E-03
22	4	0.50075	0.16438	0.00000	0.000E+00	0.000E+00	1.513E-03
23	4	-0.15284	-0.06915	0.00000	0.000E+00	0.000E+00	1.223E-03
24	4	-0.15284	0.06986	0.00000	0.000E+00	0.000E+00	1.223E-03
25	4	0.00234	0.00000	0.00000	0.000E+00	0.000E+00	7.939E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	5	-0.04277	0.00000	0.00000	0.000E+00	0.000E+00	4.731E-04
2	5	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	4.823E-04
3	5	-0.17639	0.00810	0.00000	0.000E+00	0.000E+00	6.685E-05
4	5	-0.14476	-0.01038	0.00000	0.000E+00	0.000E+00	1.394E-04
5	5	-0.09845	-0.01878	0.00000	0.000E+00	0.000E+00	-3.167E-04
6	5	-0.09914	-0.01075	0.00000	0.000E+00	0.000E+00	1.908E-04
7	5	-0.09790	0.01096	0.00000	0.000E+00	0.000E+00	-2.649E-04
8	5	0.23840	-0.09041	0.00000	0.000E+00	0.000E+00	-8.773E-04
9	5	0.23091	0.08092	0.00000	0.000E+00	0.000E+00	-8.856E-04
10	5	0.29224	-0.11487	0.00000	0.000E+00	0.000E+00	6.347E-04
11	5	0.29374	-0.00326	0.00000	0.000E+00	0.000E+00	1.368E-04
12	5	0.29206	0.10632	0.00000	0.000E+00	0.000E+00	6.230E-04
13	5	-0.42345	-0.01098	0.00000	0.000E+00	0.000E+00	2.005E-03
14	5	-0.42203	0.00267	0.00000	0.000E+00	0.000E+00	2.007E-03
15	5	-0.67945	0.01704	0.00000	0.000E+00	0.000E+00	-8.595E-04
16	5	-0.68108	-0.00471	0.00000	0.000E+00	0.000E+00	2.966E-04
17	5	-0.67946	-0.02587	0.00000	0.000E+00	0.000E+00	-8.551E-04
18	5	0.54225	-0.20658	0.00000	0.000E+00	0.000E+00	-3.673E-03
19	5	0.54095	0.19700	0.00000	0.000E+00	0.000E+00	-3.673E-03
20	5	0.99944	-0.30248	0.00000	0.000E+00	0.000E+00	1.959E-03
21	5	1.00000	-0.00460	0.00000	0.000E+00	0.000E+00	2.751E-03
22	5	0.99941	0.29318	0.00000	0.000E+00	0.000E+00	1.957E-03
23	5	-0.12985	-0.14079	0.00000	0.000E+00	0.000E+00	2.394E-03
24	5	-0.12985	0.13146	0.00000	0.000E+00	0.000E+00	2.394E-03
25	5	-0.02169	0.00000	0.00000	0.000E+00	0.000E+00	-2.388E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	6	0.13920	0.00000	0.00000	0.000E+00	0.000E+00	-3.430E-03

2	6	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	3.492E-03
3	6	1.00000	-0.14003	0.00000	0.000E+00	0.000E+00	4.627E-04
4	6	-0.91652	-0.14726	0.00000	0.000E+00	0.000E+00	-1.376E-04
5	6	-0.00724	0.02891	0.00000	0.000E+00	0.000E+00	2.799E-03
6	6	-0.01720	0.76037	0.00000	0.000E+00	0.000E+00	-5.341E-05
7	6	-0.02653	0.00456	0.00000	0.000E+00	0.000E+00	-2.734E-03
8	6	-0.73943	0.15048	0.00000	0.000E+00	0.000E+00	-2.628E-04
9	6	0.71213	0.12918	0.00000	0.000E+00	0.000E+00	1.414E-04
10	6	0.00199	0.02764	0.00000	0.000E+00	0.000E+00	-1.822E-03
11	6	0.01184	-0.31971	0.00000	0.000E+00	0.000E+00	-1.034E-05
12	6	0.02145	0.01687	0.00000	0.000E+00	0.000E+00	1.776E-03
13	6	0.44545	-0.04601	0.00000	0.000E+00	0.000E+00	2.135E-04
14	6	-0.44249	-0.05726	0.00000	0.000E+00	0.000E+00	-1.052E-04
15	6	-0.00429	0.02803	0.00000	0.000E+00	0.000E+00	1.018E-03
16	6	-0.01031	0.15028	0.00000	0.000E+00	0.000E+00	-2.747E-05
17	6	-0.01624	0.01590	0.00000	0.000E+00	0.000E+00	-1.058E-03
18	6	-0.20936	0.06158	0.00000	0.000E+00	0.000E+00	-1.996E-04
19	6	0.22418	0.05813	0.00000	0.000E+00	0.000E+00	1.092E-04
20	6	0.00695	0.02506	0.00000	0.000E+00	0.000E+00	-3.123E-04
21	6	0.01137	0.00541	0.00000	0.000E+00	0.000E+00	-6.530E-06
22	6	0.01576	0.02580	0.00000	0.000E+00	0.000E+00	3.569E-04
23	6	-0.00280	0.02530	0.00000	0.000E+00	0.000E+00	-3.846E-06
24	6	-0.00297	0.02387	0.00000	0.000E+00	0.000E+00	-1.916E-05
25	6	0.07156	0.00000	0.00000	0.000E+00	0.000E+00	-1.550E-05

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	7	-0.12617	0.00000	0.00000	0.000E+00	0.000E+00	2.775E-03
2	7	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-2.500E-03
3	7	-0.78694	0.10815	0.00000	0.000E+00	0.000E+00	-6.601E-04
4	7	0.63554	0.10194	0.00000	0.000E+00	0.000E+00	2.782E-04
5	7	-0.01894	-0.01947	0.00000	0.000E+00	0.000E+00	-1.026E-03
6	7	0.02433	-0.26544	0.00000	0.000E+00	0.000E+00	8.228E-05
7	7	0.06647	0.00484	0.00000	0.000E+00	0.000E+00	8.451E-04
8	7	-0.15313	0.00091	0.00000	0.000E+00	0.000E+00	6.404E-04
9	7	0.22310	0.02747	0.00000	0.000E+00	0.000E+00	-4.532E-04
10	7	0.00734	-0.02716	0.00000	0.000E+00	0.000E+00	-1.752E-03
11	7	-0.01798	-0.37178	0.00000	0.000E+00	0.000E+00	-1.104E-05
12	7	-0.04283	-0.01967	0.00000	0.000E+00	0.000E+00	1.857E-03
13	7	0.97407	-0.18492	0.00000	0.000E+00	0.000E+00	-3.551E-04
14	7	-1.00000	-0.17827	0.00000	0.000E+00	0.000E+00	2.008E-04
15	7	0.01618	-0.02411	0.00000	0.000E+00	0.000E+00	3.108E-03
16	7	0.01407	0.36625	0.00000	0.000E+00	0.000E+00	3.794E-05
17	7	0.01179	-0.01111	0.00000	0.000E+00	0.000E+00	-3.100E-03
18	7	-0.90907	0.13105	0.00000	0.000E+00	0.000E+00	-3.092E-04
19	7	0.90478	0.13581	0.00000	0.000E+00	0.000E+00	4.232E-04
20	7	-0.03181	-0.01162	0.00000	0.000E+00	0.000E+00	-1.479E-03
21	7	-0.01230	-0.10014	0.00000	0.000E+00	0.000E+00	-1.095E-06
22	7	0.00725	-0.01317	0.00000	0.000E+00	0.000E+00	1.444E-03
23	7	0.00264	-0.01733	0.00000	0.000E+00	0.000E+00	3.934E-05
24	7	0.00191	-0.01653	0.00000	0.000E+00	0.000E+00	-2.735E-05
25	7	-0.06538	0.00000	0.00000	0.000E+00	0.000E+00	-6.872E-05

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	8	-0.16273	0.00000	0.00000	0.000E+00	0.000E+00	3.657E-03
2	8	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	4.342E-03
3	8	-0.94692	0.13436	0.00000	0.000E+00	0.000E+00	-1.376E-03
4	8	-1.00000	-0.17744	0.00000	0.000E+00	0.000E+00	-1.095E-03
5	8	0.22534	-0.05402	0.00000	0.000E+00	0.000E+00	-1.357E-03
6	8	0.23504	0.04699	0.00000	0.000E+00	0.000E+00	9.065E-04
7	8	0.23189	0.01403	0.00000	0.000E+00	0.000E+00	-1.854E-03
8	8	0.52663	-0.10733	0.00000	0.000E+00	0.000E+00	1.044E-03
9	8	0.74044	0.09469	0.00000	0.000E+00	0.000E+00	1.089E-03
10	8	-0.21957	0.01261	0.00000	0.000E+00	0.000E+00	7.593E-04
11	8	-0.21841	-0.05838	0.00000	0.000E+00	0.000E+00	-6.174E-04
12	8	-0.21057	-0.06532	0.00000	0.000E+00	0.000E+00	1.074E-03
13	8	-0.37250	0.04225	0.00000	0.000E+00	0.000E+00	-8.663E-04
14	8	-0.31985	-0.09387	0.00000	0.000E+00	0.000E+00	-1.047E-03
15	8	0.20768	-0.04883	0.00000	0.000E+00	0.000E+00	-7.274E-04
16	8	0.20551	-0.06813	0.00000	0.000E+00	0.000E+00	3.214E-04
17	8	0.20057	-0.01776	0.00000	0.000E+00	0.000E+00	-1.760E-04
18	8	0.24367	-0.05389	0.00000	0.000E+00	0.000E+00	9.313E-04
19	8	-0.02201	-0.05861	0.00000	0.000E+00	0.000E+00	9.042E-04
20	8	-0.17813	0.01674	0.00000	0.000E+00	0.000E+00	1.155E-04
21	8	-0.18156	-0.02280	0.00000	0.000E+00	0.000E+00	-6.076E-04
22	8	-0.18441	-0.08874	0.00000	0.000E+00	0.000E+00	-3.273E-04
23	8	0.01173	-0.00902	0.00000	0.000E+00	0.000E+00	-4.731E-04
24	8	0.01183	-0.06221	0.00000	0.000E+00	0.000E+00	-4.631E-04
25	8	-0.08489	0.00000	0.00000	0.000E+00	0.000E+00	-2.000E-03

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	9	-0.11864	0.00000	0.00000	0.000E+00	0.000E+00	1.700E-03
2	9	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-2.962E-03
3	9	-0.49827	0.05440	0.00000	0.000E+00	0.000E+00	-6.609E-04
4	9	0.70601	0.10987	0.00000	0.000E+00	0.000E+00	6.821E-04
5	9	-0.09510	-0.01957	0.00000	0.000E+00	0.000E+00	7.275E-04
6	9	-0.01577	0.13125	0.00000	0.000E+00	0.000E+00	-8.492E-05
7	9	0.06450	-0.00232	0.00000	0.000E+00	0.000E+00	-2.825E-04
8	9	-0.97492	0.11569	0.00000	0.000E+00	0.000E+00	1.502E-04
9	9	0.78768	0.10562	0.00000	0.000E+00	0.000E+00	-3.421E-04
10	9	-0.00262	-0.05382	0.00000	0.000E+00	0.000E+00	-2.099E-03
11	9	0.02278	-0.42518	0.00000	0.000E+00	0.000E+00	1.242E-04
12	9	0.04742	-0.02736	0.00000	0.000E+00	0.000E+00	1.818E-03
13	9	0.27429	-0.10949	0.00000	0.000E+00	0.000E+00	7.992E-04
14	9	-0.14460	-0.06872	0.00000	0.000E+00	0.000E+00	-5.783E-04
15	9	0.00949	-0.07472	0.00000	0.000E+00	0.000E+00	-1.220E-03
16	9	-0.02961	-0.23750	0.00000	0.000E+00	0.000E+00	-2.847E-05
17	9	-0.06826	-0.06511	0.00000	0.000E+00	0.000E+00	1.452E-03

18	9	0.93964	-0.23164	0.00000	0.000E+00	0.000E+00	-1.988E-04
19	9	-1.00000	-0.22415	0.00000	0.000E+00	0.000E+00	-9.834E-05
20	9	0.05298	-0.08760	0.00000	0.000E+00	0.000E+00	1.658E-03
21	9	0.02982	0.02404	0.00000	0.000E+00	0.000E+00	1.551E-04
22	9	0.00655	-0.06248	0.00000	0.000E+00	0.000E+00	-1.649E-03
23	9	-0.00079	-0.07797	0.00000	0.000E+00	0.000E+00	9.137E-05
24	9	0.00002	-0.06316	0.00000	0.000E+00	0.000E+00	1.664E-04
25	9	-0.06217	0.00000	0.00000	0.000E+00	0.000E+00	3.157E-04

MODE SHAPES

JOINT	MODE	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	10	0.02677	0.00000	0.00000	0.000E+00	0.000E+00	1.444E-03
2	10	0.00000	0.00000	0.00000	0.000E+00	0.000E+00	-1.401E-03
3	10	-0.31075	0.08856	0.00000	0.000E+00	0.000E+00	-3.539E-04
4	10	0.31750	0.08505	0.00000	0.000E+00	0.000E+00	4.267E-04
5	10	-0.06734	0.08097	0.00000	0.000E+00	0.000E+00	8.393E-04
6	10	-0.00536	0.34586	0.00000	0.000E+00	0.000E+00	-3.093E-06
7	10	0.05701	0.07456	0.00000	0.000E+00	0.000E+00	-6.660E-04
8	10	-0.67347	0.20764	0.00000	0.000E+00	0.000E+00	-3.079E-04
9	10	0.69642	0.20681	0.00000	0.000E+00	0.000E+00	2.740E-04
10	10	-0.06648	0.13325	0.00000	0.000E+00	0.000E+00	4.542E-04
11	10	0.00152	0.22579	0.00000	0.000E+00	0.000E+00	-2.182E-05
12	10	0.06945	0.12930	0.00000	0.000E+00	0.000E+00	-3.991E-04
13	10	-1.00000	0.30819	0.00000	0.000E+00	0.000E+00	2.119E-05
14	10	0.96524	0.29755	0.00000	0.000E+00	0.000E+00	-3.200E-05
15	10	-0.05498	0.17120	0.00000	0.000E+00	0.000E+00	-5.804E-04
16	10	0.00542	0.10588	0.00000	0.000E+00	0.000E+00	7.926E-06
17	10	0.06572	0.16769	0.00000	0.000E+00	0.000E+00	5.055E-04
18	10	-0.65659	0.28050	0.00000	0.000E+00	0.000E+00	3.931E-04
19	10	0.67754	0.27907	0.00000	0.000E+00	0.000E+00	-3.188E-04
20	10	-0.02676	0.18375	0.00000	0.000E+00	0.000E+00	-1.197E-03
21	10	-0.00880	0.10867	0.00000	0.000E+00	0.000E+00	-4.665E-05
22	10	0.00921	0.17644	0.00000	0.000E+00	0.000E+00	1.201E-03
23	10	0.00044	0.18049	0.00000	0.000E+00	0.000E+00	-1.083E-05
24	10	-0.00012	0.17614	0.00000	0.000E+00	0.000E+00	-6.491E-05
25	10	0.01419	0.00000	0.00000	0.000E+00	0.000E+00	-1.081E-05

RESPONSE LOAD CASE 1

CQC MODAL COMBINATION METHOD USED.

DYNAMIC WEIGHT X Y Z	2.631959E+02	6.540866E+01	0.000000E+00	KIP
MISSING WEIGHT X Y Z	-8.816248E+00	-6.025187E+01	0.000000E+00	KIP
MODAL WEIGHT X Y Z	2.543796E+02	5.156788E+00	0.000000E+00	KIP

MODE	ACCELERATION-G	DAMPING
1	1.08998	0.03000
2	1.45771	0.03000
3	2.33169	0.03000
4	2.50202	0.03000
5	2.50202	0.03000
6	2.50202	0.03000
7	2.50202	0.03000
8	2.50202	0.03000
9	2.50202	0.03000
10	2.50202	0.03000

	MASS PARTICIPATION FACTORS IN PERCENT						BASE SHEAR IN KIP		
MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	91.18	0.00	0.00	91.184	0.000	0.000	261.59	0.00	0.00
2	2.13	0.00	0.00	93.313	0.000	0.000	8.17	0.00	0.00
3	2.57	0.00	0.00	95.880	0.001	0.000	15.75	0.00	0.00
4	0.01	0.00	0.00	95.891	0.001	0.000	0.07	0.00	0.00
5	0.23	0.00	0.00	96.125	0.004	0.000	1.54	0.00	0.00
6	0.02	0.28	0.00	96.141	0.285	0.000	0.10	0.00	0.00
7	0.02	0.05	0.00	96.157	0.337	0.000	0.11	0.00	0.00
8	0.49	0.18	0.00	96.649	0.513	0.000	3.24	0.00	0.00
9	0.00	0.48	0.00	96.650	0.994	0.000	0.01	0.00	0.00
10	0.00	6.89	0.00	96.650	7.884	0.000	0.00	0.00	0.00
					TOTAL SRSS	SHEAR	262.21	0.00	0.00
					TOTAL 10PCT	SHEAR	262.21	0.00	0.00
					TOTAL ABS	SHEAR	290.58	0.00	0.00
					TOTAL CQC	SHEAR	262.35	0.00	0.00

75. FINISH

```
      *********** END OF THE STAAD.Pro RUN ***********

        **** DATE= SEP 25,2003   TIME=  8:52:18 ****

*******************************************************
*     For questions on STAAD.Pro, please contact :    *
*  By Email - North America  : support@reiusa.com     *
*  By Email - International  : support@reiworld.com   *
*  Tel. (USA) : 714-974-2500 ; Fax (USA) : 714-974-4771 *
*******************************************************
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STRUCTURAL DYNAMICS

Natural Period:

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = 0.86\,cps \quad \therefore T = 1.17\ sec$$

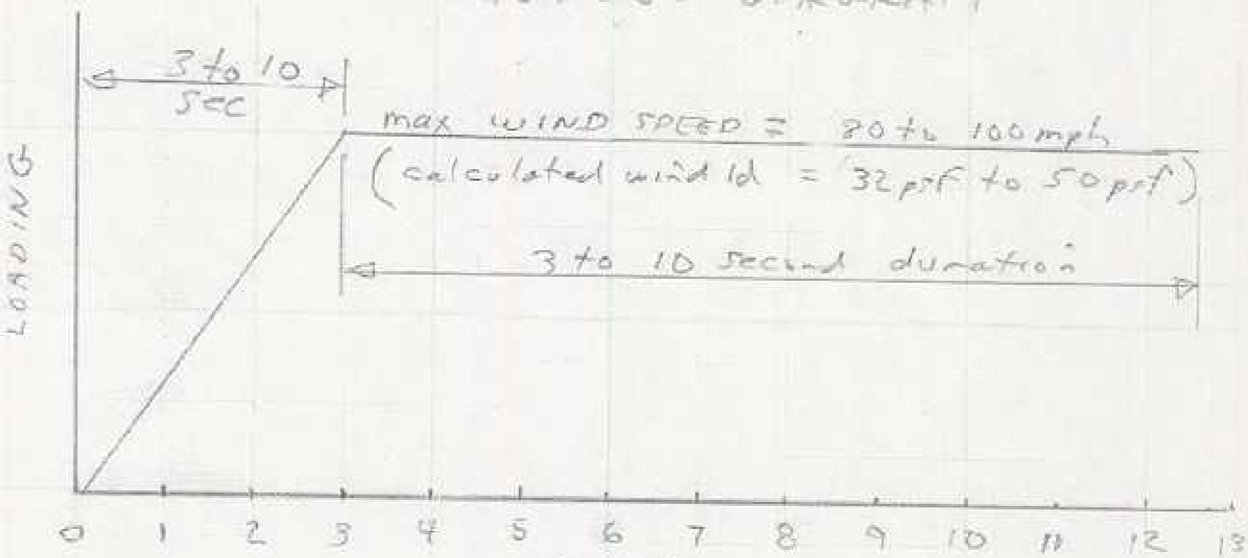
(see STAAD output)

RESPONSE TO DYNAMIC WIND LOADING:

DLF = Dynamic Load Factor = ratio of dynamic forces to static forces

Ref: Figure 2.9, page 48, "STRUCTURAL DYNAMICS" by John M. Biggs

WIND LOADING DIAGRAM



Above Loading is based on input from Dr Paul Markowski of PSU using the 3 sec value for the acceleration time (t_r)

$t_r / T = 3/1.17 = 2.56$ USE FIGURE 2.9

$$\therefore DLF = 1.1$$

CALCULATE CRITICAL NATURAL PERIOD

$\frac{t_r}{T} < .75$ required for large DLF response (based on Fig 2.9)

$\therefore T > \frac{t_r}{.75} = 4\ sec$ or larger

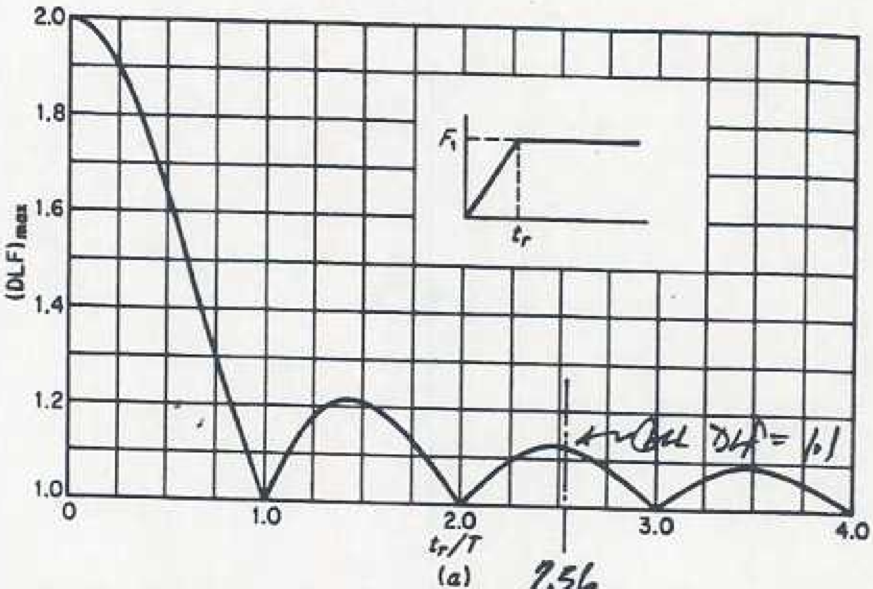
Note: Natural Period is not close to the 4 sec

Gannett Fleming

SUBJECT Kimzua Viaduct
Wind Analysis
BY RLR DATE 9/03 CHKD BY VDL DATE 9/03

SHEET NO. OF
JOB NO.

STRUCTURAL DYNAMICS



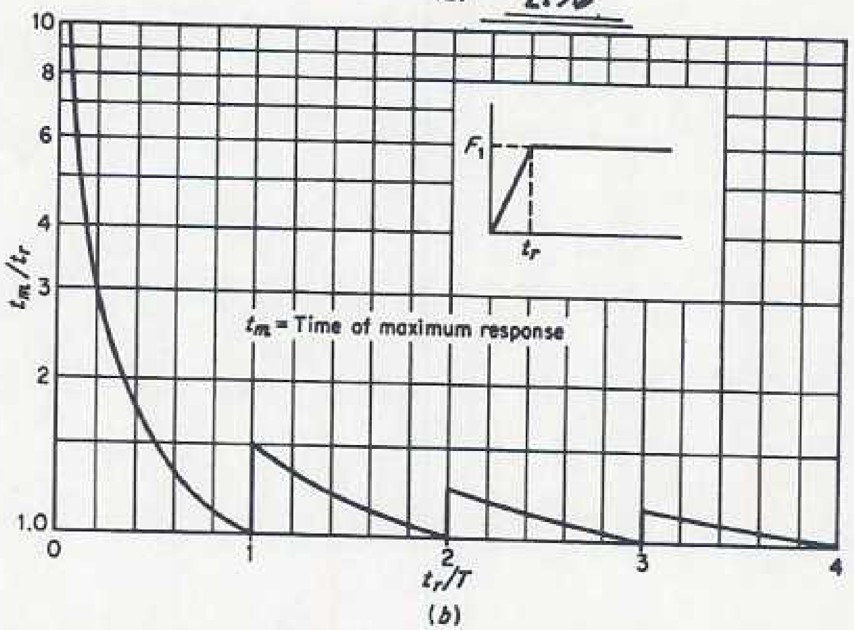


FIGURE 2.9 Maximum response of one-degree elastic systems (undamped) subjected to constant force with finite rise time. (*U.S. Army Corps of Engineers.*[10])

INTRODUCTION TO STRUCTURAL DYNAMICS

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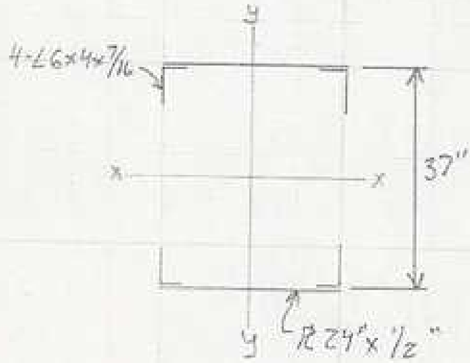
Lower Column Section Capacity



$A_s = 40.72 \text{ in}^2$

$I_x = 12{,}336 \text{ in}^4$

$I_y = 3{,}117 \text{ in}^4$

} See 2002 Bridge Inspection Report for Calculations

AREMA, Minimum F_u

Tensile Capacity $= A_s F_u = 40.72 \text{ in}^2 \times 50 \text{ ksi} = 2036$ kips

$= \quad '' \quad \times 57 \text{ ksi} = 2321$ kips

Actual F_u from material testing

Compressive Capacity

Effective Length Factor, $K_x = 1.2$ $\quad L_x = 61.15'$

$K_y = 0.8$ $\quad L_y = 30.58'$

Critical Buckling Stress (Global); $F_E = \dfrac{\pi^2 E I}{A (KL)^2}$

$\therefore F_{E_x} = \dfrac{\pi^2 (29{,}000 \text{ ksi})(12{,}336 \text{ in}^4)}{40.72 \text{ in}^2 (1.2 \times 61.15' \times 12''/')^2} = 111.8 \text{ ksi} > F_u$

$F_{E_y} = \dfrac{\pi^2 (29{,}000 \text{ ksi})(3{,}117 \text{ in}^4)}{40.72 \text{ in}^2 (0.8 \times 30.58' \times 12''/')^2} = 254.2 \text{ ksi} > F_u$

$\therefore$ Compression Capacity Based on Euler Buckling $= 111.8 \times 40.72 = 4552$ kips

Critical Buckling Stress (Local), $F_{cr} = \dfrac{12{,}000}{(b/t)^2}$ (Steel Structures, Gaylord, Gaylord & Stallmeyer, 1992)

$\therefore F_{cr} = \dfrac{12{,}000}{(6''/(7/16''))^2} = 63.8 \text{ ksi} > F_u$

$\therefore$ Compressive Capacity Based on Local Buckling $= 63.8 \text{ ksi} \times 40.72 \text{ in}^2$

$= 2598$ kips

Use Tensile/Compressive Capacity $= A_s F_u = 2321$ kips

Wind Event Capacity/Demand Ratios for Lower Column Section

Column Capacity = 2321 kips (Tension & Compression)

	Bot. of West Col. Compression		Bott. of East Col. Tension
Case A (83 mph, @ uplift)	236.40 kip	(STAAD Load 15)	0 kip
Case B (94 mph, Reduced Anchor Capacity)	267.20 kip	(STAAD Load 17)	31.60 kip
Case C (126 mph, Full Anchor Bolt Capacity)	389.70 kip	(STAAD Load 20)	154.03 kip
	↑ STAAD Member 10 ↓		↑ STAAD Member 1 ↓

	Capacity/Demand (Compression)	Capacity/Demand (Tension)
Case A	2321/236.4 = 9.8	2321/0 = ∞
Case B	2321/267.20 = 8.7	2321/31.60 = 73.4
Case C	2321/389.70 = 5.9	2321/154.03 = 15.1

Gannett Fleming

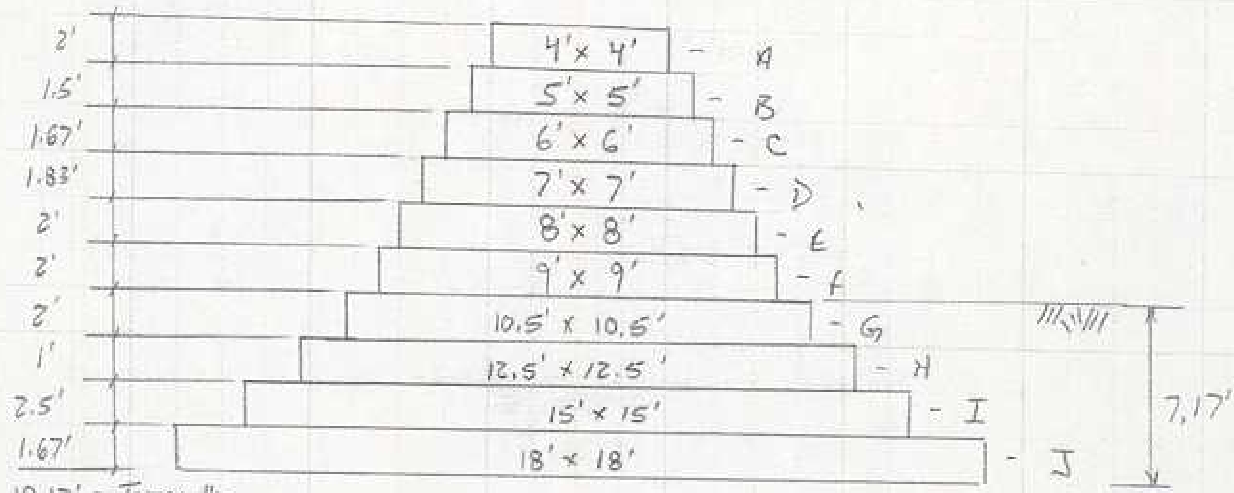
SUBJECT: Board of Inquiry Investigation
Kinzua Viaduct Collapse

BY: YPL DATE: 10/03 CHKD. BY: RLR DATE: 10/03

SHEET NO. ___ OF ___

JOB NO. 42420
16204

WEIGHT OF SANDSTONE MASONRY TOWER LEG (PIER 19 WEST PEDESTAL)



VOLUME, SECTION					
A =	4^2	×	2'	=	32.0 FT^3
B =	5^2	×	1.5'	=	37.5 "
C =	6^2	×	1.67'	=	60.1 "
D =	7^2	×	1.83'	=	89.7 "
E =	8^2	×	2'	=	128.0 "
F =	9^2	×	2'	=	162.0 "
G =	10.5^2	×	2'	=	220.5 "
H =	12.5^2	×	1'	=	156.2 "
I =	15^2	×	2.5'	=	562.5 "
J =	18^2	×	1.67'	=	541.1 "

TOTAL CONCRETE VOLUME = 1989.6 FT^3

TOTAL CONCRETE WEIGHT = 1989.6 FT^3 × 0.140 K/FT^3 = 278.5 KIPS

ENGAGED SOIL VOLUME = $(18^2 \times 5.5) - (15^2 \times 2.5 + 12.5^2 \times 1 + 10.5^2 \times 2)$
= 842.8 FT^3

ENGAGED SOIL WT. = 842.8 FT^3 × 0.11 K/FT^3 = 92.7 K

WEIGHT OF CONC. + SOIL = 371.2 KIPS

* EFFECTIVE WEIGHT BASED ON 0.9 W = 334.1 KIP

* NOTE: BENT 20 & 21 HAVE STRAP FOOTINGS

The Fujita Tornado Damage Scale

The Fujita Tornado Scale, usually referred to as the F-Scale, classifies tornadoes based on the resulting damage. This scale was developed by Dr. T. Theodore Fujita (University of Chicago) in 1971.

F-SCALE	WINDS	TYPE OF DAMAGE	FREQUENCY
F0	40-72 mph 64-116 km/h	MINIMAL DAMAGE: Some damage to chimneys, TV antennas, roof shingles, trees, and windows.	29%
F1	73-112 mph 117-180 km/h	MODERATE DAMAGE: Automobiles overturned, carports destroyed, trees uprooted.	40%
F2	113-157 mph 181-253 km/h	MAJOR DAMAGE: Roofs blown off homes, sheds and outbuildings demolished, mobile homes overturned.	24%
F3	158-206 mph 254-332 km/h	SEVERE DAMAGE: Exterior walls and roofs blown off homes. Metal buildings collapsed or are severely damaged. Forests and farmland flattened.	6%
F4	207-260 mph 333-418 km/h	DEVASTATING DAMAGE: Few walls, if any, standing in well-built homes. Large steel and concrete missiles thrown far distances.	2%
F5	261-318 mph 419-512 km/h	INCREDIBLE DAMAGE: Homes leveled with all debris removed. Schools, motels, and other larger structures have considerable damage with exterior walls and roofs gone. Top stories demolished.	less than 1%

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