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APPENDIX A
Nomenclature

General Nomenclature

| | |
|------------------------------------|--|
| A | Area under a strain/distance curve, in. ² |
| A _{column} | Area of column web affected by an applied load, in. ² |
| A _{stiff} | Area of a stiffener cross section, in. ² |
| A _{stiffeners} | Total area of all stiffener cross sections used in a column connection, in. ² |
| A _{tot} | Total column/stiffener area affected by an applied load, in. ² |
| E | Modulus of elasticity, ksi |
| F _{yf} | Yield stress of flange material, ksi |
| F _{ys} | Yield stress of stiffener material, ksi |
| F _{yw} | Yield stress of web material, ksi |
| N | Length of bearing, in. |
| P | Total applied load, kips |
| P _{applied} | Applied load, kips |
| P _{column} | Force in column, kips |
| P _s | Force in stiffener, kips |
| (P _s) _{allow} | Allowable stiffener load based on yield of material, kips |
| P _{stiff} | Force in stiffener, kips |
| P _{tot} | Total applied load, kips |
| P _w | Force in column web, kips |
| R _n | Nominal resistance, kips |
| b _f | Flange width, in. |
| c | Length of the effective load distribution along the column web, in. |
| d | Depth of column section, in. |
| h | Clear distance between flanges less the fillet or corner radius, in. |
| k | Distance from outer face of flange to web toe of fillet, in. |
| k ₁ | Distance from the web center line to flange toe of fillet, in. |
| l _e | Distance along the length of column affected by the applied load, in. |
| t _b | Thickness of beam flange or connection plate delivering the concentrated force, in. |

| | |
|--------|--------------------------|
| t_f | Flange thickness, in. |
| t_s | Stiffener thickness, in. |
| t_w | Web thickness, in. |
| w_s | Stiffener width, in. |
| ϕ | Resistance factor |

APPENDIX B
TEST 1 Result

B.1 Experimental Data

| AVERAGE STRAIN GAGE READINGS | | | | | |
|---|--------------|---------------|--------------|-----------------|-----------------|
| BOTTOM FLANGE - LEFT STIFF. (micro-strain) | | | | | |
| LOAD | Inner | Middle | Outer | at 0.25" | at 2.75" |
| 0 | 1E+30 | 1E+30 | 1E+30 | 0.001 | 0.001 |
| 0 | -9.61538 | -12.499999 | -8.65384 | 1.923077 | 2.884615 |
| 5.2 | 12.98077 | 4.326925 | 19.71154 | 5.769231 | -40.3846 |
| 10.2 | 34.61539 | 24.999995 | 41.34618 | 13.46154 | -62.5 |
| 15.2 | 53.84614 | 44.23076 | 59.13462 | 25.96154 | -71.1538 |
| 20.1 | 76.92306 | 67.307695 | 82.69228 | 44.23077 | -66.3462 |
| 25.2 | 100.9615 | 91.826925 | 105.7692 | 62.5 | -60.5769 |
| 30.2 | 120.6731 | 112.98076 | 128.3654 | 82.6923 | -52.8846 |
| 35.2 | 143.75 | 138.46153 | 152.8846 | 101.9231 | -42.3077 |
| 40.2 | 167.3077 | 162.49998 | 176.9231 | 124.0385 | -29.8077 |
| 45.18 | 188.9423 | 185.09612 | 200 | 145.1923 | -17.3077 |
| 50.1 | 212.0192 | 210.09614 | 222.5961 | 167.3077 | -2.88462 |
| 55.13 | 235.0962 | 235.09613 | 245.6731 | 189.4231 | 10.57692 |
| 60.05 | 255.7693 | 259.1346 | 270.1923 | 211.5384 | 27.88461 |
| 65.1 | 282.6923 | 287.0192 | 298.0769 | 236.5384 | 49.03846 |
| 70.06 | 307.2116 | 313.46155 | 325 | 260.5769 | 65.38461 |
| 75.03 | 333.1731 | 340.3846 | 351.4423 | 285.5769 | 84.61538 |
| 80.16 | 360.577 | 368.74995 | 377.8846 | 310.5769 | 103.8461 |
| 85.14 | 386.0577 | 395.1923 | 404.3269 | 336.5384 | 125 |
| 90.15 | 408.1731 | 418.74995 | 427.8846 | 360.5769 | 141.3462 |
| 95.16 | 437.0192 | 448.0769 | 456.7308 | 386.5384 | 164.4231 |
| 99.9 | 460.0961 | 471.63455 | 479.8077 | 410.5769 | 180.7692 |
| 105.11 | 485.5769 | 499.03845 | 507.2115 | 438.4615 | 204.8077 |
| 110.01 | 511.5385 | 525.48075 | 533.6538 | 464.4231 | 226.9231 |
| 115.22 | 537.5 | 551.4423 | 559.6153 | 491.3461 | 245.1923 |
| 120.12 | 561.5385 | 576.92305 | 585.0961 | 518.2692 | 268.2692 |
| 125.09 | 587.9808 | 603.36535 | 611.5384 | 546.1538 | 291.3461 |
| 130.07 | 615.8654 | 631.24995 | 637.0192 | 574.0384 | 311.5384 |
| 135.04 | 640.3846 | 656.24995 | 662.0192 | 602.8846 | 334.6154 |
| 140.02 | 669.2308 | 684.61535 | 688.9423 | 630.7692 | 357.6923 |
| 154.94 | 744.2307 | 759.1345 | 758.6538 | 712.5 | 424.0384 |
| 155.17 | 750.4808 | 763.94225 | 762.0192 | 722.1153 | 429.8077 |
| 160.07 | 775 | 788.46145 | 787.5 | 750 | 451.9231 |
| 165.05 | 803.3653 | 816.3461 | 814.423 | 779.8076 | 475.9615 |
| 170.02 | 827.4038 | 840.3846 | 838.4615 | 807.6923 | 499.0384 |
| 175.23 | 853.3653 | 865.8653 | 864.9038 | 725 | 525.9615 |
| 180.05 | 876.4423 | 893.26915 | 880.2884 | 764.4231 | 557.6923 |
| 185.18 | 900.9615 | 919.2307 | 908.6538 | 799.0384 | 588.4615 |
| 190.11 | 923.5577 | 944.7115 | 941.3459 | 848.0768 | 620.1923 |
| 195.05 | 947.5961 | 972.1153 | 969.7117 | 884.6153 | 648.0768 |

| | | | | | |
|--------|----------|-----------|----------|----------|----------|
| 199.9 | 970.1922 | 999.03815 | 996.6345 | 913.4614 | 675.9615 |
| 205 | 997.5961 | 1030.2885 | 1025.961 | 949.9999 | 708.6538 |
| 210.05 | 1021.634 | 1056.25 | 1052.404 | 985.5768 | 730.7692 |
| 215.18 | 1048.077 | 1085.577 | 1081.731 | 999.9999 | 753.8461 |
| 220.42 | 1074.039 | 1112.019 | 1108.654 | 1039.423 | 775.9615 |
| 225.36 | 1080.289 | 1117.3075 | 1113.462 | 1047.115 | 782.6923 |
| 229.13 | 1119.231 | 1160.096 | 1158.654 | 1084.615 | 831.7307 |
| 235 | 1152.885 | 1195.673 | 1149.039 | 1129.808 | 854.8076 |
| 240.17 | 1177.885 | 1223.077 | 1171.154 | 1162.5 | 882.6922 |
| 245.08 | 1194.712 | 1241.827 | 1193.269 | 1225 | 902.8845 |
| 250.2 | 1228.365 | 1277.404 | 1226.443 | 1280.769 | 939.423 |
| 255.02 | 1252.885 | 1303.3655 | 1243.269 | 1327.885 | 965.3845 |
| 268 | 1318.27 | 1370.673 | 1296.635 | 1411.538 | 1033.654 |

| AVERAGE STRAIN GAGE READINGS | | | | | |
|--|--------------|---------------|--------------|-----------------|-----------------|
| BOTTOM FLANGE - RIGHT STIFF. (micro-strain) | | | | | |
| LOAD | Inner | Middle | Outer | at 0.25" | at 2.75" |
| 0 | 1E+30 | 1E+30 | 5E+29 | 0.001 | 0.001 |
| 0 | -5.28846 | -6.73077 | -6.25 | 0.961538 | 1.923077 |
| 5.2 | 23.07692 | 23.55769 | 24.03846 | 22.11538 | 5.769231 |
| 10.2 | 52.40384 | 53.84615 | 53.36538 | 38.46154 | 3.846154 |
| 15.2 | 79.32694 | 81.73078 | 80.76925 | 55.76923 | 8.653846 |
| 20.1 | 106.25 | 109.1346 | 107.6923 | 76.92308 | 23.07692 |
| 25.2 | 133.1731 | 137.5 | 135.5769 | 98.07691 | 35.57692 |
| 30.2 | 157.2115 | 161.5384 | 159.1346 | 117.3077 | 49.03846 |
| 35.2 | 183.1731 | 187.5 | 184.1346 | 138.4615 | 63.46154 |
| 40.2 | 209.1346 | 213.9423 | 209.1346 | 159.6154 | 78.84615 |
| 45.18 | 233.6539 | 238.9423 | 232.2115 | 179.8077 | 95.1923 |
| 50.1 | 258.6539 | 263.9423 | 257.6923 | 201.9231 | 112.5 |
| 55.13 | 283.6539 | 288.4615 | 281.7308 | 223.0769 | 129.8077 |
| 60.05 | 307.2115 | 313.4615 | 307.2116 | 244.2308 | 150 |
| 65.1 | 333.1731 | 338.4615 | 332.6923 | 266.3461 | 173.0769 |
| 70.06 | 359.1346 | 365.3846 | 359.1346 | 289.4231 | 192.3077 |
| 75.03 | 384.6154 | 390.8654 | 383.1731 | 311.5384 | 214.4231 |
| 80.16 | 411.5385 | 417.7885 | 409.6154 | 335.5769 | 234.6154 |
| 85.14 | 436.0577 | 442.3077 | 432.6923 | 358.6538 | 256.7308 |
| 90.15 | 460.5769 | 467.3077 | 455.7693 | 381.7308 | 275.9615 |
| 95.16 | 486.5385 | 493.2692 | 480.2885 | 405.7692 | 298.0769 |
| 99.9 | 511.0577 | 517.3077 | 501.9231 | 427.8846 | 316.3461 |
| 105.11 | 536.5385 | 541.8269 | 525 | 452.8846 | 339.423 |
| 110.01 | 561.5384 | 565.8654 | 547.5961 | 476.9231 | 361.5384 |
| 115.22 | 587.5 | 590.8654 | 569.7115 | 501.9231 | 382.6923 |
| 120.12 | 611.5385 | 613.4616 | 590.3846 | 525.9615 | 405.7692 |

| | | | | | |
|--------|----------|----------|----------|----------|----------|
| 125.09 | 637.0192 | 637.9808 | 611.0577 | 550.9615 | 428.8461 |
| 130.07 | 662.9808 | 662.5 | 633.6538 | 575.9615 | 450 |
| 135.04 | 686.5384 | 685.0961 | 653.3653 | 600.9615 | 473.0769 |
| 140.02 | 712.0192 | 709.1346 | 675.4808 | 625.9615 | 497.1154 |
| 154.94 | 782.6923 | 775.4808 | 736.0576 | 698.0768 | 567.3076 |
| 155.17 | 789.423 | 781.2499 | 739.9038 | 707.6923 | 575.3076 |
| 160.07 | 812.5 | 802.8846 | 760.5769 | 731.7307 | 600 |
| 165.05 | 837.9807 | 826.4423 | 781.25 | 757.6923 | 625 |
| 170.02 | 864.423 | 851.4422 | 804.8076 | 785.5768 | 655.7692 |
| 175.23 | 889.4231 | 874.0384 | 824.5192 | 813.4615 | 680.7692 |
| 180.05 | 908.6538 | 892.3077 | 840.3845 | 838.4615 | 703.8461 |
| 185.18 | 931.25 | 913.4613 | 860.0961 | 864.423 | 728.8461 |
| 190.11 | 951.923 | 933.173 | 882.6924 | 887.4999 | 753.8461 |
| 195.05 | 975.9613 | 956.25 | 904.8077 | 913.4614 | 778.8461 |
| 199.9 | 996.1538 | 974.519 | 921.1539 | 937.4999 | 797.1153 |
| 205 | 1017.308 | 995.6728 | 936.0576 | 963.4614 | 821.1538 |
| 210.05 | 1037.981 | 1014.904 | 956.2499 | 986.5384 | 842.3076 |
| 215.18 | 1058.173 | 1033.654 | 975.0002 | 1009.615 | 832.6923 |
| 220.42 | 1079.808 | 1053.846 | 999.5192 | 1034.615 | 830.7692 |
| 225.36 | 1082.212 | 1055.288 | 1006.731 | 1043.269 | 835.5768 |
| 229.13 | 1109.616 | 1083.173 | 1036.538 | 1072.115 | 979.8076 |
| 235 | 1129.808 | 1102.885 | 1063.461 | 1094.231 | 1100.961 |
| 240.17 | 1141.827 | 1122.116 | 1077.885 | 1107.692 | 1305.769 |
| 245.08 | 1147.115 | 1130.288 | 1084.135 | 1115.385 | 1425.961 |
| 250.2 | 1167.789 | 1155.289 | 1112.019 | 1137.5 | 1538.461 |
| 255.02 | 1183.173 | 1184.135 | 1140.866 | 1151.923 | 1544.231 |
| 268 | 1231.25 | 1241.827 | 1175.481 | 1192.308 | 1600.961 |

| AVERAGE STRAIN GAGE READINGS | | | | | |
|--|--------------|---------------|--------------|-----------------|-----------------|
| TOP FLANGE - LEFT STIFF. (micro-strain) | | | | | |
| LOAD | Inner | Middle | Outer | at 0.25" | at 2.75" |
| 0 | 1E+30 | 1E+30 | 1E+30 | 0.001 | 0.001 |
| 0 | -16.3462 | -12.980767 | -15.8654 | 0.961538 | 0.961538 |
| 5.2 | 2.40385 | 6.25 | 2.884615 | 13.46154 | -6.73077 |
| 10.2 | 24.51923 | 26.92308 | 22.59616 | 22.11538 | -24.0385 |
| 15.2 | 43.75 | 47.596127 | 42.30771 | 34.61538 | -28.8462 |
| 20.1 | 65.86539 | 71.153854 | 66.34616 | 51.92308 | -20.1923 |
| 25.2 | 89.90385 | 94.71152 | 90.38462 | 70.1923 | -8.65385 |
| 30.2 | 110.0961 | 115.86537 | 111.5385 | 87.49999 | 2.884615 |
| 35.2 | 132.2116 | 139.42308 | 136.0577 | 107.6923 | 16.34615 |
| 40.2 | 155.7692 | 162.98077 | 160.0962 | 127.8846 | 32.69231 |
| 45.18 | 176.9231 | 186.05765 | 183.1731 | 148.0769 | 50 |
| 50.1 | 199.5193 | 209.1346 | 205.2885 | 169.2308 | 68.26923 |

| | | | | | |
|--------|----------|-----------|----------|----------|----------|
| 55.13 | 223.0769 | 233.6538 | 228.8461 | 190.3846 | 88.46153 |
| 60.05 | 244.2308 | 255.7692 | 250.9616 | 211.5384 | 108.6538 |
| 65.1 | 268.2692 | 281.24995 | 276.9231 | 234.6154 | 131.7308 |
| 70.06 | 294.2307 | 307.21155 | 302.4038 | 257.6923 | 155.7692 |
| 75.03 | 318.75 | 335.5769 | 330.2885 | 278.8461 | 179.8077 |
| 80.16 | 344.2308 | 361.05765 | 356.7307 | 302.8846 | 202.8846 |
| 85.14 | 367.7885 | 386.05765 | 381.25 | 326.923 | 228.8461 |
| 90.15 | 390.3846 | 410.5769 | 406.25 | 349.0384 | 251.9231 |
| 95.16 | 417.7885 | 438.94225 | 434.6154 | 373.0769 | 277.8846 |
| 99.9 | 439.4231 | 462.0192 | 458.1731 | 394.2308 | 300.9615 |
| 105.11 | 463.4615 | 487.0192 | 481.7308 | 420.1923 | 328.8461 |
| 110.01 | 488.4615 | 513.46155 | 509.1346 | 443.2692 | 355.7692 |
| 115.22 | 512.0193 | 538.46155 | 533.6539 | 467.3077 | 380.7692 |
| 120.12 | 535.0961 | 562.98075 | 558.6538 | 491.3461 | 408.6538 |
| 125.09 | 562.9808 | 592.7884 | 587.9808 | 517.3077 | 435.5769 |
| 130.07 | 587.5 | 619.2307 | 614.4231 | 542.3076 | 462.5 |
| 135.04 | 610.5769 | 642.7884 | 638.9423 | 566.3461 | 490.3846 |
| 140.02 | 636.5385 | 670.19225 | 663.4615 | 592.3076 | 518.2692 |
| 154.94 | 706.7307 | 743.26915 | 735.5769 | 661.5384 | 595.1923 |
| 155.17 | 712.0192 | 746.15375 | 737.4999 | 670.1923 | 604.8076 |
| 160.07 | 735.0962 | 769.71145 | 761.0576 | 696.1538 | 632.6923 |
| 165.05 | 762.5 | 798.55765 | 787.4999 | 723.0768 | 663.4615 |
| 170.02 | 786.5384 | 822.1153 | 808.6538 | 750 | 692.3076 |
| 175.23 | 811.5384 | 846.63455 | 831.25 | 777.8845 | 777.8845 |
| 180.05 | 834.6154 | 872.59605 | 854.8076 | 806.7307 | 806.7307 |
| 185.18 | 859.1345 | 898.5576 | 882.2115 | 832.6923 | 832.6923 |
| 190.11 | 886.0577 | 930.28835 | 912.9807 | 859.6153 | 859.6153 |
| 195.05 | 911.5384 | 958.6536 | 937.0192 | 886.5384 | 886.5384 |
| 199.9 | 938.4615 | 990.8654 | 970.673 | 917.3076 | 917.3076 |
| 205 | 966.3459 | 1021.1536 | 999.5192 | 944.2307 | 944.2307 |
| 210.05 | 994.7115 | 1053.846 | 942.3076 | 975.9614 | 975.9614 |
| 215.18 | 1023.077 | 1084.615 | 958.1733 | 1005.769 | 1005.769 |
| 220.42 | 1050.962 | 1113.4615 | 892.7886 | 1036.538 | 1036.538 |
| 225.36 | 1057.693 | 1120.673 | 884.1343 | 1046.154 | 1046.154 |
| 229.13 | 1092.308 | 1160.096 | 916.8269 | 1077.885 | 1077.885 |
| 235 | 1114.904 | 1189.9035 | 938.4614 | 1103.846 | 1103.846 |
| 240.17 | 1133.173 | 1219.2305 | 1216.346 | 1124.038 | 1124.038 |
| 245.08 | 1153.366 | 1247.596 | 1275.481 | 1139.423 | 1139.423 |
| 250.2 | 1187.981 | 1274.519 | 1339.423 | 1173.077 | 1173.077 |
| 255.02 | 1210.096 | 1299.519 | 1404.327 | 1192.308 | 1192.308 |
| 268 | 1263.942 | 1367.7885 | 1497.596 | 1243.269 | 1243.269 |

| AVERAGE STRAIN GAGE READINGS | | | | | |
|---|--------------|---------------|--------------|-----------------|-----------------|
| TOP FLANGE - RIGHT STIFF. (micro-strain) | | | | | |
| LOAD | Inner | Middle | Outer | at 0.25" | at 2.75" |
| 0 | 1E+30 | 1E+30 | 1E+30 | 0.001 | 0.001 |
| 0 | -14.9038 | -7.21154 | -5.28846 | 0.961538 | 0.961538 |
| 5.2 | 11.0577 | 22.11539 | 24.51923 | 12.5 | -28.8462 |
| 10.2 | 39.90384 | 52.40387 | 56.24998 | 26.92308 | -32.6923 |
| 15.2 | 65.86539 | 80.28844 | 84.6154 | 45.19231 | -25 |
| 20.1 | 92.78846 | 108.6539 | 113.4615 | 66.34615 | -7.69231 |
| 25.2 | 120.1923 | 137.0192 | 142.3077 | 88.46153 | 12.5 |
| 30.2 | 142.3077 | 162.0192 | 167.3077 | 110.5769 | 30.76923 |
| 35.2 | 167.7885 | 187.9807 | 192.7885 | 131.7308 | 50.96154 |
| 40.2 | 192.7885 | 214.4231 | 219.2308 | 154.8077 | 72.11538 |
| 45.18 | 215.3846 | 239.4231 | 242.7885 | 177.8846 | 93.26922 |
| 50.1 | 239.4231 | 264.4231 | 268.2692 | 200.9615 | 116.3462 |
| 55.13 | 263.4616 | 290.3846 | 292.3077 | 224.0384 | 139.4231 |
| 60.05 | 286.0577 | 315.3846 | 316.3461 | 247.1154 | 162.5 |
| 65.1 | 312.0192 | 340.3846 | 341.3462 | 271.1538 | 187.5 |
| 70.06 | 338.4616 | 366.8269 | 366.3462 | 296.1538 | 212.5 |
| 75.03 | 364.9039 | 392.3077 | 390.8654 | 319.2308 | 237.5 |
| 80.16 | 390.8654 | 420.1923 | 416.8269 | 345.1923 | 264.4231 |
| 85.14 | 414.9038 | 443.2692 | 438.9423 | 369.2308 | 289.4231 |
| 90.15 | 438.9423 | 467.7885 | 462.0192 | 394.2308 | 315.3846 |
| 95.16 | 465.8654 | 493.75 | 486.0577 | 419.2308 | 341.3461 |
| 99.9 | 488.4615 | 517.3077 | 507.6923 | 443.2692 | 366.3461 |
| 105.11 | 511.5384 | 540.8654 | 530.2885 | 469.2307 | 392.3077 |
| 110.01 | 535.5769 | 564.9038 | 552.4038 | 493.2692 | 418.2692 |
| 115.22 | 558.6538 | 589.4231 | 578.3654 | 520.1923 | 450 |
| 120.12 | 581.7308 | 611.5385 | 598.5576 | 545.1923 | 475.9615 |
| 125.09 | 607.6923 | 635.5769 | 620.1923 | 571.1538 | 501.9231 |
| 130.07 | 632.2115 | 659.6154 | 642.7884 | 597.1154 | 528.8461 |
| 135.04 | 654.8076 | 681.7308 | 662.5 | 623.0768 | 554.8076 |
| 140.02 | 680.2884 | 706.25 | 686.0577 | 649.0384 | 583.6538 |
| 154.94 | 749.5192 | 773.0768 | 748.0768 | 722.1153 | 660.5768 |
| 155.17 | 755.2885 | 777.4038 | 751.4423 | 731.7307 | 671.1538 |
| 160.07 | 777.8846 | 799.0384 | 771.1538 | 757.6923 | 697.1153 |
| 165.05 | 801.4423 | 821.1538 | 791.3461 | 783.6538 | 726.9231 |
| 170.02 | 829.3269 | 849.0384 | 817.3077 | 813.4615 | 764.4231 |
| 175.23 | 851.923 | 869.7115 | 837.0192 | 840.3845 | 792.3076 |
| 180.05 | 867.3076 | 887.0192 | 850 | 866.3461 | 821.1538 |
| 185.18 | 888.4615 | 908.6538 | 872.5961 | 889.423 | 850.9615 |
| 190.11 | 907.2115 | 929.8076 | 897.5961 | 911.5384 | 890.3845 |
| 195.05 | 930.7692 | 952.4038 | 921.1538 | 935.5768 | 920.1922 |
| 199.9 | 949.5192 | 969.7115 | 937.9807 | 959.6153 | 960.5768 |

| | | | | | |
|--------|----------|----------|----------|----------|----------|
| 205 | 970.1923 | 988.9422 | 953.8461 | 983.6538 | 985.5768 |
| 210.05 | 987.0192 | 1006.731 | 972.1153 | 1005.769 | 1025 |
| 215.18 | 1007.212 | 1022.597 | 988.4615 | 1030.769 | 1054.808 |
| 220.42 | 1027.885 | 1040.866 | 1007.212 | 1055.769 | 1086.538 |
| 225.36 | 1031.731 | 1042.308 | 1009.615 | 1065.385 | 1102.885 |
| 229.13 | 1060.577 | 1069.231 | 1035.577 | 1096.154 | 1124.038 |
| 235 | 1083.173 | 1088.943 | 1057.693 | 1125 | 1116.346 |
| 240.17 | 1101.923 | 1104.327 | 1074.519 | 1149.038 | 1137.5 |
| 245.08 | 1111.539 | 1112.019 | 1082.212 | 1162.5 | 1133.654 |
| 250.2 | 1128.366 | 1150.481 | 1085.577 | 1225.961 | 1166.346 |
| 255.02 | 1166.347 | 1176.923 | 1112.02 | 1247.115 | 1192.308 |
| 268 | 1247.116 | 1219.712 | 1148.077 | 1324.038 | 1211.538 |

B.2 ABAQUS Input Data File

```
*HEADING
      W16X45 COLUMN WITH 2 3/4X3X14-7/8" STIFFENERS
      S8R ELEMENTS          6/19/96
      LOAD = 150 kips      Test 1
*NODE
**BOTTOM FLANGE NODES
1,1.0,0.5,0.2825
25,17.0,0.5,0.2825
26,1.0,2.2588,0.2825
50,17.0,2.2588,0.2825
51,1.0,4.0175,0.2825
75,17.0,4.0175,0.2825
76,1.0,5.7763,0.2825
100,17.0,5.7763,0.2825
101,1.0,7.535,0.2825
125,17.0,7.535,0.2825
**WEB NODES
126,1.0,4.0175,4.315
150,17.0,4.0175,4.315
151,1.0,4.0175,8.3475
175,17.0,4.0175,8.3475
176,1.0,4.0175,12.38
200,17.0,4.0175,12.38
201,1.0,4.0175,16.413
225,17.0,4.0175,16.413
**TOP FLANGE NODES
226,1.0,0.5,16.413
250,17.0,0.5,16.413
251,1.0,2.2588,16.413
275,17.0,2.2588,16.413
276,1.0,5.7763,16.413
300,17.0,5.7763,16.413
301,1.0,7.535,16.413
325,17.0,7.535,16.413
**STIFFENER NODES
401,9.0,7.0175,0.2825
425,9.0,7.0175,16.413
426,9.0,5.5175,0.2825
450,9.0,5.5175,16.413
451,9.0,4.0175,0.2825
475,9.0,4.0175,16.413
476,9.0,2.5175,0.2825
500,9.0,2.5175,16.413
501,9.0,1.0175,0.2825
525,9.0,1.0175,16.413
**FLANGE INTERMEDIATE NODES
13,9.0,0.5,0.2825
38,9.0,2.2588,0.2825
63,9.0,4.0175,0.2825
88,9.0,5.7763,0.2825
113,9.0,7.535,0.2825
238,9.0,0.5,16.4125
```

263,9.0,2.2588,16.413
 288,9.0,5.7763,16.413
 313,9.0,7.535,16.413
 **WEB INTERMEDIATE NODES
 138,9.0,4.0175,4.315
 163,9.0,4.0175,8.3475
 188,9.0,4.0175,12.38
 213,9.0,4.0175,16.413
 **SUPPLEMENTAL NODES
 1001,1.0,1.0175,0.2825
 1025,17.0,1.0175,0.2825
 1026,1.0,2.5175,0.2825
 1050,17.0,2.5175,0.2825
 1051,1.0,5.5175,0.2825
 1075,17.0,5.5175,0.2825
 1076,1.0,7.0175,0.2825
 1100,17.0,7.0175,0.2825
 **
 2001,1.0,1.0175,16.413
 2025,17.0,1.0175,16.413
 2026,1.0,2.5175,16.413
 2050,17.0,2.5175,16.413
 2051,1.0,5.5175,16.413
 2075,17.0,5.5175,16.413
 2076,1.0,7.0175,16.413
 2100,17.0,7.0175,16.413
 **INTERMEDIATE NODES
 1013,9.0,1.0175,0.2825
 1038,9.0,2.5175,0.2825
 1063,9.0,5.5175,0.2825
 1088,9.0,7.0175,0.2825
 2013,9.0,1.0175,16.413
 2038,9.0,2.5175,16.413
 2063,9.0,5.5175,16.413
 2088,9.0,7.0175,16.413
 *NGEN,NSET=BOTFLG
 1,13
 26,38
 51,63
 76,88
 101,113
 1001,1013
 1026,1038
 1051,1063
 1076,1088
 *NGEN,NSET=NBOTFLG
 13,25
 38,50
 63,75
 88,100
 113,125
 1013,1025
 1038,1050
 1063,1075

```

1088,1100
**WEB INTERMEDIATE NODES
*NGEN,NSET=NWEB
138,150
163,175
188,200
213,225
*NGEN,NSET=WEB
126,138
151,163
176,188
201,213
**TOP FLANGE INTERMEDIATE NODES
*NGEN,NSET=TOPFLG
226,238
251,263
276,288
301,313
2001,2013
2026,2038
2051,2063
2076,2088
*NGEN,NSET=NTOPFLG
238,250
263,275
288,300
313,325
2013,2025
2038,2050
2063,2075
2088,2100
**NODES FOR STIFFENER 1
*NGEN,NSET=LSTIFF
401,425
426,450
451,475
**NODES FOR STIFFENER 2
*NGEN,NSET=RSTIFF
451,475
476,500
501,525
**NODES TO BE LOADED
*NSET,NSET=NLOAD
425,525
*NSET,NSET=SLOAD
450,475,500
**NODES FIXED AT WALL
*NSET,NSET=NFIXED
NBOFLG,BOTFLG,401,426,451,476,501
**GENERATE ELEMENTS
*ELEMENT, TYPE=S8R
1,1,3,28,26,2,1003,27,1001
13,26,28,53,51,27,1028,52,1026
25,51,53,78,76,52,1053,77,1051

```

```

37,76,78,103,101,77,1078,102,1076
49,51,53,153,151,52,128,152,126
61,151,153,203,201,152,178,202,176
73,226,228,253,251,227,2003,252,2001
85,251,253,203,201,252,2028,202,2026
97,201,203,278,276,202,2053,277,2051
109,276,278,303,301,277,2078,302,2076
121,401,403,453,451,402,428,452,426
133,451,453,503,501,452,478,502,476
*ELGEN,ELSET=EBOTFLG
1,12,2,1,1
13,12,2,1,1
25,12,2,1,1
37,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=EBOTFLG
0.565
*ELGEN,ELSET=EWEB
49,12,2,1,1
61,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=EWEB
0.345
*ELGEN,ELSET=ETOPFLG
73,12,2,1,1
85,12,2,1,1
97,12,2,1,1
109,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=ETOPFLG
0.565
*ELGEN,ELSET=ESTIFF
121,12,2,1,1
133,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=ESTIFF
0.75
*ELSET,ELSET=EOUTPUT,GENERATE
121,145,1
*NSET,NSET=DEFLECT
LSTIFF,RSTIFF
**TIE STIFFENER NODES TO FLANGE NODES
*MPC
TIE,1088,401
TIE,1063,426
TIE,63,451
TIE,1038,476
TIE,1013,501
TIE,2088,425
TIE,2063,450
TIE,213,475
TIE,2038,500
TIE,2013,525
*MATERIAL,NAME=STEEL
*ELASTIC
29000.0,0.3
*BOUNDARY
NFIXED,1,3

```

```
*STEP
*STATIC
*CLOAD
NLOAD,3,18.75
SLOAD,3,37.5
*EL PRINT,ELSET=EOUTPUT,SUMMARY=NO,POSITION=NODES
S11
*END STEP
```


APPENDIX C
TEST 2 Results

C.1 Experimental Data

| Load (kips) | Micro-strain: Stiffener R | | |
|----------------|---------------------------|----------|----------|
| | 0.75 in. | 1.5 in. | 2.25 in. |
| 0 | 3.5 | 3.5 | 3.5 |
| 5.35 | 41.34616 | 45.19231 | 49.51923 |
| 10.5 | 80.76923 | 86.05769 | 93.26922 |
| 15.18 | 112.9808 | 119.7115 | 128.3654 |
| 20.5 | 152.4039 | 161.0577 | 171.6346 |
| 25.2 | 187.9808 | 198.5577 | 211.5385 |
| 30.2 | 225.9616 | 238.9423 | 255.2885 |
| 35.1 | 262.9808 | 278.8461 | 298.5577 |
| 40 | 300.4808 | 319.7115 | 341.3462 |
| 45.1 | 338.9423 | 360.0961 | 385.0961 |
| 50 | 376.4423 | 400.4808 | 428.3654 |
| 55 | 413.9423 | 441.3461 | 472.1154 |
| 60 | 452.4038 | 481.7308 | 515.3846 |
| 64.95 | 490.8654 | 523.5577 | 559.6154 |
| 70.1 | 531.25 | 566.8269 | 606.7307 |
| 75.13 | 570.1923 | 608.6539 | 650.4808 |
| 80 | 607.6922 | 649.0384 | 693.75 |
| 85.1 | 647.1154 | 690.8654 | 737.9808 |
| 90 | 684.6154 | 731.25 | 781.25 |
| 95.1 | 723.0769 | 772.5961 | 825.9615 |
| 100 | 762.0192 | 813.4615 | 869.2307 |
| 105 | 800 | 854.3269 | 913.4615 |
| 110 | 838.9422 | 897.1153 | 958.6538 |
| 115.16 | 879.3269 | 939.423 | 1004.807 |
| 122.8 | 938.4615 | 1003.365 | 1073.077 |
| 125 | 956.2499 | 1022.596 | 1093.269 |
| 130 | 995.1923 | 1064.423 | 1138.462 |
| 135 | 1034.135 | 1106.731 | 1183.654 |
| 140.1 | 1074.52 | 1148.558 | 1229.808 |
| 145 | 1112.981 | 1191.346 | 1275.481 |
| 150.2 | 1155.288 | 1237.019 | 1325.962 |
| 155.2 | 1195.192 | 1281.25 | 1373.077 |
| 165.5 | 1276.443 | 1368.269 | 1467.308 |
| 170.1 | 1312.981 | 1408.173 | 1510.577 |
| 175 | 1347.116 | 1444.712 | 1549.519 |
| 180 | 1390.866 | 1492.308 | 1600.481 |
| 186.3 | 1440.385 | 1544.712 | 1657.212 |
| 190.3 | 1472.596 | 1578.846 | 1693.27 |
| 195 | 1510.096 | 1619.231 | 1737.019 |
| 201 | 1557.211 | 1669.712 | 1790.866 |

| Load (kips) | Micro-strain: Stiffener L | | |
|----------------|---------------------------|----------|----------|
| | 0.75 in. | 1.5 in. | 2.25 in. |
| 0 | 8.5 | 9.5 | 10.5 |
| 5.35 | 37.5 | 38.46154 | 39.42308 |
| 10.5 | 77.40385 | 81.73077 | 84.61538 |
| 15.18 | 112.9808 | 120.6731 | 126.4423 |
| 20.5 | 155.7692 | 166.3462 | 174.5192 |
| 25.2 | 190.8654 | 203.8461 | 213.9423 |
| 30.2 | 228.8461 | 243.75 | 254.3269 |
| 35.1 | 265.3846 | 282.6923 | 295.1923 |
| 40 | 302.8846 | 322.1154 | 335.5769 |
| 45.1 | 341.3461 | 362.0192 | 376.9231 |
| 50 | 378.3654 | 401.4423 | 416.8269 |
| 55 | 416.3462 | 440.3846 | 457.2115 |
| 60 | 454.3269 | 480.2884 | 497.5962 |
| 64.95 | 491.8269 | 519.7116 | 538.4616 |
| 70.1 | 532.2115 | 562.0192 | 581.7307 |
| 75.13 | 570.673 | 602.4038 | 623.0769 |
| 80 | 608.6538 | 641.8269 | 663.4615 |
| 85.1 | 646.6346 | 681.7308 | 704.8077 |
| 90 | 684.6154 | 721.6346 | 745.1923 |
| 95.1 | 723.0769 | 762.0192 | 787.0192 |
| 100 | 760.5769 | 801.4423 | 826.923 |
| 105 | 798.5576 | 841.3461 | 868.2692 |
| 110 | 837.5 | 881.7307 | 909.1346 |
| 115.16 | 876.923 | 923.0769 | 950.9615 |
| 122.8 | 935.0961 | 983.6538 | 1013.461 |
| 125 | 952.4038 | 1001.442 | 1031.731 |
| 130 | 990.8653 | 1042.308 | 1072.596 |
| 135 | 1028.846 | 1081.731 | 1113.462 |
| 140.1 | 1068.269 | 1122.596 | 1155.289 |
| 145 | 1104.808 | 1161.058 | 1193.75 |
| 150.2 | 1144.231 | 1200.961 | 1232.212 |
| 155.2 | 1181.731 | 1239.423 | 1271.635 |
| 165.5 | 1259.616 | 1319.712 | 1353.366 |
| 170.1 | 1294.231 | 1355.288 | 1389.423 |
| 175 | 1326.923 | 1389.423 | 1423.077 |
| 180 | 1369.712 | 1433.654 | 1468.269 |
| 186.3 | 1418.269 | 1484.135 | 1520.192 |
| 190.3 | 1449.039 | 1515.866 | 1552.404 |
| 195 | 1485.577 | 1553.366 | 1589.423 |
| 201 | 1531.731 | 1601.442 | 1638.462 |

| | | | |
|--------|----------|----------|----------|
| 204.5 | 1584.135 | 1699.039 | 1822.596 |
| 210.06 | 1627.885 | 1746.635 | 1873.558 |
| 215.42 | 1670.673 | 1792.308 | 1922.596 |
| 220.1 | 1707.693 | 1832.212 | 1965.866 |
| 225.05 | 1747.116 | 1874.52 | 2012.019 |
| 230.12 | 1787.019 | 1918.269 | 2060.096 |
| 235.2 | 1827.404 | 1961.539 | 2107.692 |
| 240 | 1866.346 | 2004.808 | 2159.135 |
| 245 | 1907.692 | 2051.442 | 2212.981 |
| 250.5 | 1952.885 | 2100.962 | 2270.192 |
| 255.1 | 2011.539 | 2130.769 | 2460.096 |
| 260 | 1991.346 | 2169.712 | 2723.558 |
| 0 | -72.5962 | -3.36538 | 359.1346 |

| | | | |
|--------|----------|----------|----------|
| 204.5 | 1557.693 | 1628.366 | 1665.385 |
| 210.06 | 1600.481 | 1672.116 | 1709.135 |
| 215.42 | 1641.827 | 1715.865 | 1753.366 |
| 220.1 | 1678.365 | 1752.885 | 1791.827 |
| 225.05 | 1716.827 | 1792.788 | 1831.25 |
| 230.12 | 1756.25 | 1833.654 | 1873.077 |
| 235.2 | 1796.154 | 1875 | 1916.827 |
| 240 | 1834.616 | 1915.385 | 1957.693 |
| 245 | 1875.962 | 1959.615 | 2003.846 |
| 250.5 | 1920.673 | 2007.212 | 2053.846 |
| 255.1 | 1958.173 | 2041.346 | 2085.096 |
| 260 | 1982.212 | 2048.558 | 2110.577 |
| 0 | -26.4423 | -59.6154 | -70.6731 |

| Load (kips) | Micro-strain: Web R | | | | | | |
|----------------|---------------------|----------|----------|----------|----------|----------|----------|
| | 1 in. | 2 in. | 3 in. | 4 in. | 5 in. | 6 in. | 7in. |
| 0 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| 5.35 | 11.53846 | 3.846156 | -0.48077 | -1.92308 | -1.92308 | -1.92308 | -1.92308 |
| 10.5 | 27.88462 | 11.53846 | 2.403845 | -1.44231 | -3.36538 | -2.88462 | -3.84616 |
| 15.18 | 45.19231 | 19.71154 | 4.80769 | -0.96154 | -4.32692 | -4.8077 | -5.76923 |
| 20.5 | 68.75 | 31.73077 | 10.09616 | 0.961535 | -4.32693 | -5.28846 | -7.69231 |
| 25.2 | 89.90384 | 42.78846 | 15.38462 | 2.403845 | -3.84616 | -5.76923 | -8.65385 |
| 30.2 | 112.9808 | 54.80769 | 20.67308 | 4.32692 | -3.84616 | -6.73077 | -11.0577 |
| 35.1 | 136.0577 | 67.30769 | 25.96153 | 6.25 | -3.84616 | -8.17308 | -12.9808 |
| 40 | 160.577 | 80.76925 | 32.69231 | 9.615385 | -3.36539 | -8.65385 | -14.4231 |
| 45.1 | 185.577 | 94.23075 | 38.46154 | 11.53847 | -3.36539 | -9.61539 | -16.3462 |
| 50 | 211.0577 | 108.6539 | 45.19231 | 15.38461 | -2.40385 | -9.61538 | -17.7885 |
| 55 | 236.5384 | 122.5962 | 51.4423 | 17.30769 | -1.92308 | -11.5385 | -20.1923 |
| 60 | 262.9808 | 137.0193 | 58.65384 | 20.67308 | -0.96154 | -11.5385 | -21.6346 |
| 64.95 | 288.9423 | 151.9231 | 65.8654 | 23.55769 | -0.48077 | -12.5 | -23.0769 |
| 70.1 | 317.3077 | 167.7885 | 73.07691 | 26.92308 | 0.48077 | -12.5 | -25 |
| 75.13 | 343.75 | 182.2115 | 80.28845 | 29.8077 | 0.48077 | -13.9423 | -26.9231 |
| 80 | 370.6731 | 197.1154 | 87.50001 | 33.17308 | 1.923075 | -13.9423 | -28.3654 |
| 85.1 | 397.1154 | 212.0192 | 94.71155 | 36.05769 | 2.403845 | -14.9038 | -30.2885 |
| 90 | 423.5577 | 226.9231 | 101.4423 | 39.42308 | 2.88461 | -14.4231 | -31.7308 |
| 95.1 | 449.5193 | 240.8654 | 108.1731 | 42.30769 | 3.84615 | -15.8654 | -34.1346 |
| 100 | 476.4423 | 255.7692 | 115.3846 | 45.1923 | 4.80769 | -16.3462 | -35.5769 |
| 105 | 502.8846 | 270.6731 | 122.1154 | 48.55768 | 5.28846 | -16.8269 | -37.0192 |
| 110 | 530.2885 | 286.0577 | 129.8077 | 51.44232 | 6.25 | -17.3077 | -38.4615 |
| 115.16 | 557.6923 | 300.9616 | 137.5 | 54.32691 | 6.730765 | -17.7885 | -40.8654 |
| 122.8 | 598.5577 | 324.0385 | 148.5577 | 60.09614 | 8.653845 | -18.75 | -42.7885 |
| 125 | 611.0577 | 330.7692 | 151.4423 | 61.05771 | 8.17308 | -19.2308 | -44.2307 |
| 130 | 637.9807 | 346.6346 | 159.6154 | 64.90387 | 9.61538 | -19.7115 | -45.6731 |
| 135 | 665.3846 | 361.5384 | 166.3462 | 67.30768 | 9.615385 | -20.6731 | -47.5962 |
| 140.1 | 693.2692 | 377.4038 | 174.0385 | 71.15384 | 11.05769 | -21.1538 | -49.0385 |

| | | | | | | | |
|--------|----------|----------|----------|----------|----------|----------|----------|
| 145 | 719.7116 | 392.3077 | 181.25 | 74.03848 | 12.01923 | -21.6346 | -50.4808 |
| 150.2 | 748.5577 | 408.6539 | 188.9423 | 77.88462 | 12.5 | -22.1154 | -52.4039 |
| 155.2 | 775.4807 | 423.5577 | 196.1539 | 80.76921 | 12.98077 | -22.5962 | -54.3269 |
| 165.5 | 831.25 | 454.8077 | 211.5385 | 87.98076 | 15.38462 | -24.0385 | -57.6923 |
| 170.1 | 857.2115 | 470.1923 | 218.75 | 90.86539 | 15.86538 | -24.5192 | -59.6154 |
| 175 | 880.7692 | 483.6539 | 225.4808 | 94.71155 | 17.78846 | -25 | -60.5769 |
| 180 | 912.4999 | 500.9615 | 233.6539 | 98.07691 | 18.26923 | -25.4808 | -62.9808 |
| 186.3 | 947.5961 | 521.1538 | 243.75 | 102.8846 | 19.71153 | -25.4808 | -64.9039 |
| 190.3 | 970.1922 | 533.6538 | 250 | 105.2885 | 20.19231 | -26.4423 | -65.8654 |
| 195 | 997.596 | 550 | 258.1731 | 109.1346 | 21.15384 | -26.4423 | -67.3077 |
| 201 | 1031.731 | 569.2308 | 267.3077 | 113.9423 | 22.59615 | -26.9231 | -69.7115 |
| 204.5 | 1051.923 | 580.7692 | 273.0769 | 116.3461 | 23.55769 | -27.4038 | -71.1538 |
| 210.06 | 1084.615 | 599.5192 | 282.6923 | 121.1538 | 25 | -27.8846 | -72.5962 |
| 215.42 | 1116.346 | 617.7884 | 291.3462 | 125 | 26.44229 | -28.8462 | -74.5192 |
| 220.1 | 1144.231 | 634.1346 | 300 | 128.8462 | 27.88461 | -28.8462 | -75.9616 |
| 225.05 | 1174.039 | 651.4422 | 308.1731 | 133.1731 | 28.36536 | -29.3269 | -77.8846 |
| 230.12 | 1204.808 | 669.7115 | 317.7885 | 137.9808 | 29.80768 | -29.3269 | -79.3269 |
| 235.2 | 1236.058 | 687.5 | 326.4423 | 142.3077 | 31.73077 | -29.8077 | -81.25 |
| 240 | 1266.827 | 705.2884 | 335.5769 | 146.6346 | 33.17307 | -29.8077 | -82.2115 |
| 245 | 1298.558 | 723.5577 | 344.7116 | 150.9615 | 34.61539 | -30.2885 | -84.1346 |
| 250.5 | 1333.654 | 744.7115 | 355.2885 | 155.7692 | 37.01922 | -30.7692 | -86.0577 |
| 255.1 | 1370.673 | 765.8653 | 365.8654 | 161.0577 | 38.46153 | -31.25 | -88.4615 |
| 260 | 1423.077 | 795.673 | 380.2885 | 167.7885 | 39.90384 | -31.25 | -90.8654 |
| 0 | 66.82692 | 37.98077 | 18.26923 | 8.653846 | 2.884615 | 0 | -3.36538 |

| Load (kips) | Micro-strain: Web L | | | | | | |
|----------------|---------------------|----------|----------|----------|----------|----------|----------|
| | 1 in. | 2 in. | 3 in. | 4 in. | 5 in. | 6 in. | 7 in. |
| 0 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
| 5.35 | 51.44231 | 32.21154 | 17.78846 | 8.653845 | 3.84615 | 0 | -2.40385 |
| 10.5 | 95.67306 | 60.09616 | 33.17308 | 15.86539 | 7.21154 | 0.480765 | -3.84616 |
| 15.18 | 130.2885 | 80.76923 | 44.23077 | 21.15384 | 8.653845 | 0 | -6.73077 |
| 20.5 | 168.2693 | 103.3654 | 56.73077 | 26.44231 | 10.57693 | 0.48077 | -8.17308 |
| 25.2 | 200.4808 | 122.5962 | 66.82692 | 31.73077 | 12.98077 | 0 | -9.13462 |
| 30.2 | 234.6154 | 142.3077 | 77.40384 | 36.05769 | 14.90385 | 0 | -10.5769 |
| 35.1 | 266.8269 | 161.0577 | 87.5 | 40.38462 | 16.34615 | -0.48077 | -12.9808 |
| 40 | 298.5577 | 179.3269 | 96.63461 | 44.71154 | 17.78846 | -0.48077 | -14.4231 |
| 45.1 | 330.2884 | 197.1154 | 106.25 | 49.03846 | 19.23077 | -0.48077 | -16.3462 |
| 50 | 361.0577 | 214.9038 | 115.3846 | 53.36538 | 20.67308 | -0.96154 | -17.7885 |
| 55 | 391.3462 | 231.25 | 124.0385 | 56.25 | 21.63462 | -1.44231 | -20.6731 |
| 60 | 421.6346 | 249.0385 | 133.1731 | 60.57692 | 23.07692 | -1.92308 | -22.5962 |
| 64.95 | 451.9231 | 266.3462 | 142.3077 | 63.9423 | 24.03846 | -2.40385 | -23.5577 |
| 70.1 | 483.6539 | 284.6154 | 151.4424 | 68.26923 | 25.96154 | -2.88462 | -25.9615 |
| 75.13 | 514.4231 | 300.9615 | 160.0962 | 72.11538 | 26.44231 | -2.88462 | -27.8846 |
| 80 | 543.75 | 318.2692 | 169.2308 | 75.96153 | 28.36538 | -3.36538 | -29.3269 |
| 85.1 | 574.0385 | 335.0962 | 177.4038 | 79.32693 | 29.80769 | -3.84615 | -30.2885 |

| | | | | | | | |
|--------|----------|----------|----------|----------|----------|----------|----------|
| 90 | 603.8462 | 352.4039 | 186.5385 | 83.65383 | 30.76923 | -3.84616 | -32.2115 |
| 95.1 | 635.0961 | 369.7115 | 195.1923 | 87.50001 | 31.73077 | -4.32693 | -34.6154 |
| 100 | 664.4231 | 386.5385 | 204.3269 | 91.34615 | 33.17307 | -4.80769 | -36.0577 |
| 105 | 694.7115 | 403.3654 | 212.9808 | 94.71153 | 34.13461 | -5.28847 | -37.9808 |
| 110 | 724.9999 | 420.6731 | 221.6346 | 99.03848 | 36.05769 | -5.28847 | -39.4231 |
| 115.16 | 755.7692 | 438.4615 | 230.7692 | 102.8846 | 37.01923 | -5.76923 | -41.3462 |
| 122.8 | 801.923 | 463.9423 | 244.2308 | 108.6538 | 38.94231 | -6.25 | -43.75 |
| 125 | 814.9038 | 471.1539 | 248.0769 | 109.6154 | 39.42307 | -6.25 | -44.7115 |
| 130 | 844.7115 | 488.4615 | 257.2115 | 113.4616 | 40.86538 | -6.25 | -46.1538 |
| 135 | 874.5192 | 504.8077 | 265.3846 | 116.8269 | 41.82692 | -7.21154 | -48.0769 |
| 140.1 | 904.8076 | 522.1154 | 273.5577 | 120.6731 | 43.26923 | -7.21154 | -50 |
| 145 | 933.173 | 538.4616 | 281.7308 | 124.0385 | 44.23077 | -8.17308 | -51.9231 |
| 150.2 | 964.423 | 555.7692 | 290.8654 | 128.3654 | 45.67307 | -8.17308 | -53.3654 |
| 155.2 | 994.2309 | 573.0769 | 300 | 131.7308 | 46.15384 | -9.13462 | -55.2885 |
| 165.5 | 1055.289 | 606.7307 | 317.3077 | 139.4231 | 49.03846 | -9.13462 | -58.6539 |
| 170.1 | 1082.212 | 622.1154 | 324.5192 | 142.7885 | 50 | -10.0962 | -60.0961 |
| 175 | 1106.731 | 635.5768 | 331.7308 | 145.1923 | 50.96154 | -10.0962 | -61.0577 |
| 180 | 1139.423 | 653.8462 | 340.8654 | 149.5193 | 52.40384 | -10.5769 | -63.9423 |
| 186.3 | 1175.962 | 674.5192 | 351.9231 | 153.8462 | 53.84615 | -11.0577 | -65.8654 |
| 190.3 | 1199.039 | 687.5 | 357.6923 | 156.25 | 54.32692 | -11.5385 | -67.3077 |
| 195 | 1225.481 | 701.923 | 365.8654 | 159.6154 | 55.28846 | -11.5385 | -68.2692 |
| 201 | 1260.096 | 721.1538 | 375 | 163.4616 | 56.25 | -12.0192 | -70.6731 |
| 204.5 | 1278.366 | 730.7692 | 379.8077 | 165.3847 | 57.21154 | -12.9808 | -71.6346 |
| 210.06 | 1309.135 | 748.0769 | 388.4616 | 169.2308 | 58.17307 | -13.4615 | -73.5577 |
| 215.42 | 1338.462 | 764.423 | 396.6346 | 172.1154 | 58.65385 | -13.9423 | -75.4808 |
| 220.1 | 1364.423 | 778.3653 | 403.3654 | 175 | 59.61538 | -14.4231 | -77.4039 |
| 225.05 | 1390.865 | 793.2692 | 410.0962 | 177.8846 | 60.09615 | -14.9039 | -78.8462 |
| 230.12 | 1417.788 | 807.6923 | 417.3077 | 180.2885 | 60.57692 | -15.8654 | -80.7692 |
| 235.2 | 1444.231 | 822.1153 | 424.5192 | 183.1731 | 61.05769 | -16.3462 | -82.6923 |
| 240 | 1471.635 | 836.5384 | 431.25 | 186.0577 | 62.01923 | -16.8269 | -84.1346 |
| 245 | 1499.038 | 850.9615 | 438.4615 | 188.9423 | 62.5 | -18.2692 | -86.5385 |
| 250.5 | 1528.846 | 867.3077 | 446.6346 | 191.3462 | 63.46153 | -18.75 | -87.9808 |
| 255.1 | 1562.5 | 885.0961 | 455.2885 | 195.1923 | 64.42308 | -19.2308 | -90.3846 |
| 260 | 1614.423 | 912.9809 | 469.2308 | 200.4808 | 65.86538 | -20.1923 | -93.2693 |
| 0 | 83.17308 | 44.23077 | 23.55769 | 11.05769 | 5.28846 | 0 | -2.40385 |

C.2 ABAQUS Input Data File

```
*NODE
      W8X48 COLUMN WITH 2 3/8X3X7-1/8" STIFFENERS
      S8R ELEMENTS          6/19/96
      LOAD = 150 kips      Test 2
**BOTTOM FLANGE NODES
1,1.0,0.5,0.3425
25,19.0,0.5,0.3425
26,1.0,2.5275,0.3425
50,19.0,2.5275,0.3425
51,1.0,4.555,0.3425
75,19.0,4.555,0.3425
76,1.0,6.5825,0.3425
100,19.0,6.5825,0.3425
101,1.0,8.61,0.3425
125,19.0,8.61,0.3425
**WEB NODES
126,1.0,4.555,2.4675
150,19.0,4.555,2.4675
151,1.0,4.555,4.5825
175,19.0,4.555,4.5825
176,1.0,4.555,6.7175
200,19.0,4.555,6.7175
201,1.0,4.555,8.8425
225,19.0,4.555,8.8425
**TOP FLANGE NODES
226,1.0,0.5,8.8425
250,19.0,0.5,8.8425
251,1.0,2.5275,8.8425
275,19.0,2.5275,8.8425
276,1.0,6.5875,8.8425
300,19.0,6.5875,8.8425
301,1.0,8.61,8.8425
325,19.0,8.61,8.8425
**STIFFENER NODES
401,10.0,7.555,0.3425
425,10.0,7.555,8.8425
426,10.0,6.055,0.3425
450,10.0,6.055,8.8425
451,10.0,4.555,0.3425
475,10.0,4.555,8.8425
476,10.0,3.055,0.3425
500,10.0,3.055,8.8425
501,10.0,1.555,0.3425
525,10.0,1.555,8.8425
**FLANGE INTERMEDIATE NODES
13,10.0,0.5,0.3425
38,10.0,2.5275,0.3425
63,10.0,4.555,0.3425
88,10.0,6.5825,0.3425
113,10.0,8.61,0.3425
238,10.0,0.5,8.8425
263,10.0,2.5275,8.8425
```

288,10.0,6.5825,8.8425
 313,10.0,8.61,8.8425
 **WEB INTERMEDIATE NODES
 138,10.0,4.555,2.4675
 163,10.0,4.555,4.5925
 188,10.0,4.555,6.7175
 213,10.0,4.555,8.8425
 **SUPPLEMENTAL NODES
 1001,1.0,1.555,0.3425
 1025,19.0,1.555,0.3425
 1026,1.0,3.055,0.3425
 1050,19.0,3.055,0.3425
 1051,1.0,6.055,0.3425
 1075,19.0,6.055,0.3425
 1076,1.0,7.555,0.3425
 1100,19.0,7.555,0.3425
 **
 2001,1.0,1.555,8.8425
 2025,19.0,1.555,8.8425
 2026,1.0,3.055,8.8425
 2050,19.0,3.055,8.8425
 2051,1.0,6.055,8.8425
 2075,19.0,6.055,8.8425
 2076,1.0,7.555,8.8425
 2100,19.0,7.555,8.8425
 **INTERMEDIATE NODES
 1013,10.0,1.555,0.3425
 1038,10.0,3.055,0.3425
 1063,10.0,6.055,0.3425
 1088,10.0,7.555,0.3425
 2013,10.0,1.555,8.8425
 2038,10.0,3.055,8.8425
 2063,10.0,6.055,8.8425
 2088,10.0,7.555,8.8425
 *NGEN,NSET=BOTFLG
 1,13
 26,38
 51,63
 76,88
 101,113
 1001,1013
 1026,1038
 1051,1063
 1076,1088
 *NGEN,NSET=NBOTFLG
 13,25
 38,50
 63,75
 88,100
 113,125
 1013,1025
 1038,1050
 1063,1075
 1088,1100

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**WEB INTERMEDIATE NODES
*NGEN,NSET=NWEB
138,150
163,175
188,200
213,225
*NGEN,NSET=WEB
126,138
151,163
176,188
201,213
**TOP FLANGE INTERMEDIATE NODES
*NGEN,NSET=TOPFLG
226,238
251,263
276,288
301,313
2001,2013
2026,2038
2051,2063
2076,2088
*NGEN,NSET=NTOPFLG
238,250
263,275
288,300
313,325
2013,2025
2038,2050
2063,2075
2088,2100
**NODES FOR STIFFENER 1
*NGEN,NSET=LSTIFF
401,425
426,450
451,475
**NODES FOR STIFFENER 2
*NGEN,NSET=RSTIFF
451,475
476,500
501,525
**NODES TO BE LOADED
*NSET,NSET=NLOAD
425,525
*NSET,NSET=SLOAD
450,475,500
**NODES FIXED
*NSET,NSET=NFIXED
NBOTFLG,BOTFLG,401,426,451,476,501
**GENERATE ELEMENTS
*ELEMENT,TYPE=S8R
1,1,3,28,26,2,1003,27,1001
13,26,28,53,51,27,1028,52,1026
25,51,53,78,76,52,1053,77,1051
37,76,78,103,101,77,1078,102,1076

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49,51,53,153,151,52,128,152,126
61,151,153,203,201,152,178,202,176
73,226,228,253,251,227,2003,252,2001
85,251,253,203,201,252,2028,202,2026
97,201,203,278,276,202,2053,277,2051
109,276,278,303,301,277,2078,302,2076
121,401,403,453,451,402,428,452,426
133,451,453,503,501,452,478,502,476
*ELGEN,ELSET=EBOTFLG
1,12,2,1,1
13,12,2,1,1
25,12,2,1,1
37,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=EBOTFLG
0.685
*ELGEN,ELSET=EWEB
49,12,2,1,1
61,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=EWEB
0.4
*ELGEN,ELSET=ETOPFLG
73,12,2,1,1
85,12,2,1,1
97,12,2,1,1
109,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=ETOPFLG
0.685
*ELGEN,ELSET=ESTIFF
121,12,2,1,1
133,12,2,1,1
*SHELL SECTION,MATERIAL=STEEL,ELSET=ESTIFF
0.375
*ELSET,ELSET=EOUTPUT,GENERATE
121,145,1
*NSET,NSET=DEFLECT
LSTIFF,RSTIFF
**TIE NODES
*MPC
TIE,1088,401
TIE,1063,426
TIE,63,451
TIE,1038,476
TIE,1013,501
TIE,2088,425
TIE,2063,450
TIE,213,475
TIE,2038,500
TIE,2013,525
*MATERIAL,NAME=STEEL
*ELASTIC
29000.0,0.3
*BOUNDARY
NFIXED,1,3
*STEP

```

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*STATIC
*CLOAD
NLOAD,3,18.75
SLOAD,3,37.5
*EL PRINT,ELSET=EOUTPUT,SUMMARY=NO,POSITION=NODES
S11
*END STEP
```

VITA

Michelle L. Holland

Michelle L. Floyd was born on January 23, 1972 in Norfolk, VA. After graduating from high school in Newport News, she enrolled at Virginia Tech in 1990. She obtained a Bachelor of Science in Civil Engineering in December of 1994. In January 1995, she enrolled in Civil Engineering graduate program, Structures Division, at Virginia Tech in pursuit of a Master of Science Degree. In July of 1996 she began working as an Associate Engineer for Newport News Shipbuilding, Submarine Division and was married to R. Cameron Holland IV in September of that year.