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|  | |  | | --- | | **Simulation of Main Frame**  **Date: Tuesday, January 21, 2014 Designer: Solidworks**  **Study name: Puck study**  **Analysis type: Static** | | Table of Contents  [Description 1](#_Toc378105787)  [Assumptions 2](#_Toc378105788)  [Model Information 2](#_Toc378105789)  [Study Properties 5](#_Toc378105790)  [Units 5](#_Toc378105791)  [Material Properties 6](#_Toc378105792)  [Loads and Fixtures 7](#_Toc378105793)  [Connector Definitions 7](#_Toc378105794)  [Contact Information 7](#_Toc378105795)  [Mesh Information 8](#_Toc378105796)  [Sensor Details 8](#_Toc378105797)  [Resultant Forces 9](#_Toc378105798)  [Beams 10](#_Toc378105799)  [Study Results 13](#_Toc378105800)  [Conclusion 16](#_Toc378105801) | |
| Description Force analysis for the frame |

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| Assumptions |

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| Model Information  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  | | --- | |  |   ****Model name:** Main Frame**  ****Current Configuration:** Default<As Machined>** | | | | | ****Beam Bodies:**** | | | | | ****Document Name and Reference**** | ****Formulation**** | ****Properties**** | ****Document Path/Date Modified**** | | **Beam-1(Structural Member5[2])** | **Beam – Uniform C/S** | ****Section Standard-ansi inch/square tube/3 x 3 x 0.25****  ****Section Area: 1670.35in^2****  ****Length:1600.2mm****  ****Volume:0.0026729m^3****  ****Mass Density:7800kg/m^3****  ****Mass:20.8486kg****  ****Weight:204.316N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-2(Trim/Extend9[1])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1670.35in^2****  ****Length:1761.1mm****  ****Volume:0.00293589m^3****  ****Mass Density:7800kg/m^3****  ****Mass:22.8999kg****  ****Weight:224.419N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-3(Structural Member5[1])** | **Beam – Uniform C/S** | ****Section Standard-ansi inch/square tube/3 x 3 x 0.25****  ****Section Area: 1670.35in^2****  ****Length:1600.2mm****  ****Volume:0.0026729m^3****  ****Mass Density:7800kg/m^3****  ****Mass:20.8486kg****  ****Weight:204.316N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-4(Trim/Extend9[2])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1670.35in^2****  ****Length:1761.1mm****  ****Volume:0.00293589m^3****  ****Mass Density:7800kg/m^3****  ****Mass:22.8999kg****  ****Weight:224.419N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-5(Trim/Extend6)** | **Beam – Uniform C/S** | ****Section Standard-ansi inch/rectangular tube/3 x 2 x 0.25****  ****Section Area: 2638.09in^2****  ****Length:1458.43mm****  ****Volume:0.00383757m^3****  ****Mass Density:7800kg/m^3****  ****Mass:29.9331kg****  ****Weight:293.344N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-6(Trim/Extend7[1])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1025.19in^2****  ****Length:638.672mm****  ****Volume:0.000654745m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.10701kg****  ****Weight:50.0487N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-7(Trim/Extend7[2])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1025.19in^2****  ****Length:636.35mm****  ****Volume:0.000652364m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.08844kg****  ****Weight:49.8667N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-8(Trim/Extend7[3])** | **Beam – Uniform C/S** | ****Section Standard-ansi inch/square tube/2 x 2 x 0.25****  ****Section Area: 1025.19in^2****  ****Length:636.35mm****  ****Volume:0.000652364m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.08844kg****  ****Weight:49.8667N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-9(Trim/Extend7[4])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1025.19in^2****  ****Length:636.35mm****  ****Volume:0.000652364m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.08844kg****  ****Weight:49.8667N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-10(Trim/Extend7[5])** | **Beam – Uniform C/S** | ****Section Standard-ansi inch/square tube/2 x 2 x 0.25****  ****Section Area: 1025.19in^2****  ****Length:636.35mm****  ****Volume:0.000652364m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.08844kg****  ****Weight:49.8667N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | | **Beam-11(Trim/Extend7[6])** | **Beam – Uniform C/S** | ****Section Standard-****  ****Section Area: 1025.19in^2****  ****Length:638.672mm****  ****Volume:0.000654745m^3****  ****Mass Density:7800kg/m^3****  ****Mass:5.10701kg****  ****Weight:50.0487N**** | ****\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2\Main Frame.SLDPRT****  **Jan 21 11:22:21 2014** | |

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| Study Properties  |  |  | | --- | --- | | Study name | Puck study | | Analysis type | Static | | Mesh type | Beam Mesh | | Solver type | Direct sparse solver | | Inplane Effect: | Off | | Soft Spring: | Off | | Inertial Relief: | Off | | Incompatible bonding options | Automatic | | Large displacement | Off | | Compute free body forces | On | | Result folder | SolidWorks document (\\vtcfiles1.vtc.vsc.edu\shared\ELM\ELM4701\Bridge Tester\Design\Solidworks Models\Frame REV 2) | |

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| Units  |  |  | | --- | --- | | Unit system: | SI (MKS) | | Length/Displacement | mm | | Temperature | Kelvin | | Angular velocity | Rad/sec | | Pressure/Stress | N/m^2 | |

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| Material Properties  |  |  |  | | --- | --- | --- | | ****Model Reference**** | ****Properties**** | ****Components**** | |  | |  |  | | --- | --- | | ****Name:**** | **Plain Carbon Steel** | | ****Model type:**** | **Linear Elastic Isotropic** | | ****Default failure criterion:**** | **Unknown** | | ****Yield strength:**** | **2.20594e+008 N/m^2** | | ****Tensile strength:**** | **3.99826e+008 N/m^2** | | ****Elastic modulus:**** | **2.1e+011 N/m^2** | | ****Poisson's ratio:**** | **0.28** | | ****Mass density:**** | **7800 kg/m^3** | | ****Shear modulus:**** | **7.9e+010 N/m^2** | | ****Thermal expansion coefficient:**** | **1.3e-005 /Kelvin** | | **SolidBody 1(Structural Member5[2])(Main Frame),**  **SolidBody 2(Trim/Extend9[1])(Main Frame),**  **SolidBody 3(Structural Member5[1])(Main Frame),**  **SolidBody 4(Trim/Extend9[2])(Main Frame),**  **SolidBody 5(Trim/Extend6)(Main Frame),**  **SolidBody 6(Trim/Extend7[1])(Main Frame),**  **SolidBody 7(Trim/Extend7[2])(Main Frame),**  **SolidBody 8(Trim/Extend7[3])(Main Frame),**  **SolidBody 9(Trim/Extend7[4])(Main Frame),**  **SolidBody 10(Trim/Extend7[5])(Main Frame),**  **SolidBody 11(Trim/Extend7[6])(Main Frame)** | | **Curve Data:N/A** | | | |

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| **Loads and Fixtures**  | ****Fixture name**** | ****Fixture Image**** | ****Fixture Details**** | | --- | --- | --- | | **Fixed-1** |  | |  |  | | --- | --- | | Entities: | **2 Joint(s)** | | Type: | **Fixed Geometry** | |  | ****Load name**** | ****Load Image**** | ****Load Details**** | | --- | --- | --- | | **Force-1** |  | |  |  | | --- | --- | | Entities: | **1 Beam (s)** | | Reference: | **Face< 1 >** | | Values: | **---, ---, 20000 lbf** | | Moments: | **---, ---, --- lbf·in** | | Non uniform load options: | **Total Load Distribution** | | Type: | **Triangular distribution** | | |

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| Connector Definitions No Data |

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| Contact Information No Data |

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| Mesh Information  |  |  | | --- | --- | | Mesh type | Beam Mesh |  Mesh Information - Details  |  |  | | --- | --- | | Total Nodes | 268 | | Total Elements | 264 | | Time to complete mesh(hh;mm;ss): | 00:00:09 | | Computer name: | CARTER-PC | |  | | |

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| Sensor Details No Data |

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| Resultant ForcesReaction Forces  | Selection set | Units | Sum X | Sum Y | Sum Z | Resultant | | --- | --- | --- | --- | --- | --- | | Entire Model | N | 0 | 88633.7 | -4.14524e-016 | 88633.7 |  Reaction Moments  | Selection set | Units | Sum X | Sum Y | Sum Z | Resultant | | --- | --- | --- | --- | --- | --- | | Entire Model | N·m | 3.19467e-012 | -6.70176e-014 | -5.34103 | 5.34103 | |
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| BeamsBeam Forces  | Beam Name | Joints | Axial(N) | Shear1(N) | Shear2(N) | Moment1(N·m) | Moment2(N·m) | Torque(N·m) | | --- | --- | --- | --- | --- | --- | --- | --- | | Beam-1(Structural Member5[2]) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | 2 | 0 | 0 | 0 | 0 | 0 | 0 | | Beam-2(Trim/Extend9[1]) | 1 | 42561.8 | 965.517 | 4.37206e-014 | 1.71771e-012 | -346.962 | 4.2625e-014 | | 2 | -31003.7 | -3258.65 | -3.64445e-013 | -3.01189e-013 | -1077.88 | 6.58031e-014 | | 3 | 31003.7 | 3258.65 | 3.64444e-013 | 5.52674e-013 | -1170.74 | -6.58031e-014 | | Beam-3(Structural Member5[1]) | 1 | 0 | -3.27418e-011 | -7.64054e-025 | -4.09458e-027 | -4.54747e-012 | 7.75482e-026 | | 2 | 0 | -1.09139e-011 | -1.60589e-024 | 3.15039e-026 | 3.63798e-012 | 8.40105e-026 | | 3 | 28375.8 | 97.8906 | 9.56703e-015 | 1.55543e-013 | 389.662 | -8.53218e-014 | | 4 | 13992.2 | -200.722 | -2.77949e-013 | 6.71199e-014 | 143.502 | 3.77647e-014 | | Beam-4(Trim/Extend9[2]) | 1 | 46071.9 | -965.404 | -4.4136e-014 | 1.79594e-012 | 341.621 | -9.10418e-014 | | 2 | -32591.4 | 3429.93 | 3.23544e-014 | -5.29178e-013 | 1128.46 | 3.86643e-014 | | 3 | 32591.4 | -3429.77 | -3.23516e-014 | 5.06853e-013 | 1238.3 | -3.86668e-014 | | Beam-5(Trim/Extend6) | 1 | 2293.13 | 11558.1 | -3.20973e-013 | 2.99514e-014 | 1474.85 | -7.75688e-013 | | 2 | -2464.33 | 13480.5 | -1.15165e-014 | 6.85195e-014 | -1484.74 | -6.7714e-013 | | 3 | -20968.2 | 18257.3 | -1.04522e-013 | 3.18509e-013 | 463.763 | -3.05194e-013 | | 4 | -20536.3 | 20699.5 | 3.66557e-013 | 5.81943e-013 | 724.288 | 7.40162e-013 | | 5 | -2293.13 | -6555.37 | 3.20973e-013 | 5.20712e-014 | 1052.61 | 7.75688e-013 | | Beam-6(Trim/Extend7[1]) | 1 | -34291.5 | 0.00795712 | -1098.45 | -335.906 | -0.00243329 | 8.01942e-015 | | 2 | 34291.5 | -0.0105558 | 1098.38 | -365.623 | -0.00351378 | -8.02173e-015 | | Beam-7(Trim/Extend7[2]) | 1 | -21773.9 | 0.00866771 | -1023.49 | 292.419 | 0.00247644 | 4.80035e-015 | | 2 | 21773.9 | -0.00908159 | 1023.54 | 358.894 | 0.00318436 | -4.80279e-015 | | Beam-8(Trim/Extend7[3]) | 1 | -21635.5 | -0.000146031 | -245.346 | -119.231 | 7.09665e-005 | -2.67204e-014 | | 2 | 21635.5 | 0.000245133 | 245.351 | -36.8966 | 3.68638e-005 | 2.6721e-014 | | Beam-9(Trim/Extend7[4]) | 1 | 23025.2 | -0.00016668 | 280.038 | -123.5 | -7.35079e-005 | 6.73915e-015 | | 2 | -23025.2 | 0.000680693 | -280.043 | -54.7016 | -0.000132962 | -6.73845e-015 | | Beam-10(Trim/Extend7[5]) | 1 | 22921.5 | -0.000117528 | 974.698 | 277.714 | 3.34864e-005 | -2.00819e-014 | | 2 | -22921.5 | -0.000973837 | -974.702 | 342.535 | -0.000342231 | 2.00819e-014 | | Beam-11(Trim/Extend7[6]) | 1 | 32602.4 | -5.58563e-005 | 1057.18 | -323.629 | -1.7099e-005 | 3.12692e-014 | | 2 | -32602.4 | 0.00206963 | -1057.19 | -351.564 | -0.000688248 | -3.12688e-014 |  Beam Stresses  | Beam Name | Joints | Axial(N/m^2) | Bending Dir1(N/m^2) | Bending Dir2(N/m^2) | Torsional (N/m^2) | Worst Case(N/m^2) | | --- | --- | --- | --- | --- | --- | --- | | Beam-1(Structural Member5[2]) | 1 | 0 | 0 | 0 | 0 | 0 | | 2 | 0 | 0 | 0 | 0 | 0 | | Beam-2(Trim/Extend9[1]) | 1 | 2.54808e+007 | 4.98215e-008 | 1.00635e+007 | 9.22152e-010 | 3.55442e+007 | | 2 | 1.85612e+007 | 8.73587e-009 | -3.12635e+007 | 1.42359e-009 | 4.98247e+007 | | 3 | 1.85612e+007 | 1.60301e-008 | 3.3957e+007 | -1.42359e-009 | 5.25182e+007 | | Beam-3(Structural Member5[1]) | 1 | 0 | -1.18762e-022 | 1.31898e-007 | 1.67768e-021 | 1.31898e-007 | | 2 | 0 | -9.13759e-022 | 1.05518e-007 | 1.81749e-021 | 1.05518e-007 | | 3 | 1.69879e+007 | 4.51146e-009 | -1.1302e+007 | -1.84585e-009 | 2.82899e+007 | | 4 | 8.37679e+006 | 1.94679e-009 | -4.16221e+006 | 8.17003e-010 | 1.2539e+007 | | Beam-4(Trim/Extend9[2]) | 1 | 2.75822e+007 | 5.20905e-008 | -9.90858e+006 | -1.9696e-009 | 3.74907e+007 | | 2 | 1.95117e+007 | 1.53486e-008 | 3.27305e+007 | 8.36465e-010 | 5.22422e+007 | | 3 | 1.95117e+007 | 1.47011e-008 | -3.59164e+007 | -8.36519e-010 | 5.54282e+007 | | Beam-5(Trim/Extend6) | 1 | -869239 | -4.56963e-010 | 1.50538e+007 | -9.9718e-009 | 1.5923e+007 | | 2 | -934134 | 1.04539e-009 | 1.51547e+007 | -8.70493e-009 | 1.60888e+007 | | 3 | -7.94826e+006 | 4.85944e-009 | -4.73362e+006 | -3.9234e-009 | 1.26819e+007 | | 4 | -7.78454e+006 | 8.8786e-009 | -7.39278e+006 | 9.5151e-009 | 1.51773e+007 | | 5 | -869239 | 7.94441e-010 | -1.07439e+007 | 9.9718e-009 | 1.16132e+007 | | Beam-6(Trim/Extend7[1]) | 1 | -3.34489e+007 | -2.67532e+007 | 193.799 | 4.26858e-010 | 6.02023e+007 | | 2 | -3.34489e+007 | 2.912e+007 | -279.855 | -4.26981e-010 | 6.25692e+007 | | Beam-7(Trim/Extend7[2]) | 1 | 2.12389e+007 | -2.32897e+007 | 197.236 | 2.55513e-010 | 4.45288e+007 | | 2 | 2.12389e+007 | 2.8584e+007 | -253.618 | -2.55643e-010 | 4.98232e+007 | | Beam-8(Trim/Extend7[3]) | 1 | -2.11038e+007 | -9.4961e+006 | -5.65211 | -1.42227e-009 | 3.05999e+007 | | 2 | -2.11038e+007 | 2.93862e+006 | 2.93601 | 1.42231e-009 | 2.40425e+007 | | Beam-9(Trim/Extend7[4]) | 1 | -2.24594e+007 | 9.83616e+006 | -5.85452 | 3.58712e-010 | 3.22956e+007 | | 2 | -2.24594e+007 | -4.3567e+006 | 10.5897 | -3.58674e-010 | 2.68161e+007 | | Beam-10(Trim/Extend7[5]) | 1 | 2.23583e+007 | 2.21185e+007 | -2.66702 | -1.06892e-009 | 4.44768e+007 | | 2 | 2.23583e+007 | -2.72811e+007 | -27.2569 | 1.06892e-009 | 4.96394e+007 | | Beam-11(Trim/Extend7[6]) | 1 | -3.18013e+007 | 2.57754e+007 | -1.36184 | 1.6644e-009 | 5.75767e+007 | | 2 | -3.18013e+007 | -2.80003e+007 | 54.8154 | -1.66438e-009 | 5.98016e+007 | |

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| Study Results  | Name | Type | Min | Max | | --- | --- | --- | --- | | Stress1 | TXY: Shear in Y Dir. on YZ Plane | 0 ksi  Element: 1 | 9.0749 ksi  Element: 169 | | **Main Frame-Puck study-Stress-Stress1** | | | |  | Name | Type | Min | Max | | --- | --- | --- | --- | | Displacement1 | URES: Resultant Displacement | 0 mm  Node: 1 | 0.531664 mm  Node: 160 | | **Main Frame-Puck study-Displacement-Displacement1** | | | |  | Name | Type | | --- | --- | | Displacement1{1} | URES: Resultant Displacement | | **Main Frame-Puck study-Displacement-Displacement1{1}** | |  | Name | Type | | --- | --- | | Displacement2 | Deformed Shape | | **Main Frame-Puck study-Displacement-Displacement2** | |  |  | | --- | |  | | **Image-1** | |

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| Conclusion |