Supplementary Table 1. Analysis of Variance (ANOVA) for Shear Stress

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Seq SS** | **Contribution** | **Adj SS** | **Adj MS** |
| Model | 27 | 541.614 | 99.79% | 541.614 | 20.060 |
|   Linear | 6 | 511.677 | 94.28% | 511.677 | 85.279 |
|     H | 1 | 0.015 | 0.00% | 0.015 | 0.015 |
|     L1 | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L2 | 1 | 277.440 | 51.12% | 277.440 | 277.440 |
|     Adhesive Thickness | 1 | 101.682 | 18.73% | 101.682 | 101.682 |
|     Fx | 1 | 132.540 | 24.42% | 132.540 | 132.540 |
|     Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|   Square | 6 | 8.760 | 1.61% | 8.760 | 1.460 |
|     H\*H | 1 | 1.323 | 0.24% | 0.003 | 0.003 |
|     L1\*L1 | 1 | 0.190 | 0.04% | 0.003 | 0.003 |
|     L2\*L2 | 1 | 0.200 | 0.04% | 0.001 | 0.001 |
|     Adhesive Thickness\*Adhesive Thickness | 1 | 7.042 | 1.30% | 6.721 | 6.721 |
|     Fx\*Fx | 1 | 0.002 | 0.00% | 0.003 | 0.003 |
|     Fz\*Fz | 1 | 0.003 | 0.00% | 0.003 | 0.003 |
|   2-Way Interaction | 15 | 21.177 | 3.90% | 21.177 | 1.412 |
|     H\*L1 | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     H\*L2 | 1 | 0.005 | 0.00% | 0.005 | 0.005 |
|     H\*Adhesive Thickness | 1 | 0.003 | 0.00% | 0.003 | 0.003 |
|     H\*Fx | 1 | 0.005 | 0.00% | 0.005 | 0.005 |
|     H\*Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L1\*L2 | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L1\*Adhesive Thickness | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L1\*Fx | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L1\*Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     L2\*Adhesive Thickness | 1 | 8.000 | 1.47% | 8.000 | 8.000 |
|     L2\*Fx | 1 | 9.245 | 1.70% | 9.245 | 9.245 |
|     L2\*Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     Adhesive Thickness\*Fx | 1 | 3.920 | 0.72% | 3.920 | 3.920 |
|     Adhesive Thickness\*Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
|     Fx\*Fz | 1 | 0.000 | 0.00% | 0.000 | 0.000 |
| Error | 26 | 1.126 | 0.21% | 1.126 | 0.043 |
|   Lack-of-Fit | 21 | 1.126 | 0.21% | 1.126 | 0.054 |
|   Pure Error | 5 | 0.000 | 0.00% | 0.000 | 0.000 |
| Total | 53 | 542.740 | 100.00% |   |   |
| **Source** | **F-Value** | **P-Value** |
| Model | 463.26 | 0.000 |
|   Linear | 1969.44 | 0.000 |
|     H | 0.35 | 0.561 |
|     L1 | 0.00 | 1.000 |
|     L2 | 6407.20 | 0.000 |
|     Adhesive Thickness | 2348.24 | 0.000 |
|     Fx | 3060.88 | 0.000 |
|     Fz | 0.00 | 1.000 |
|   Square | 33.72 | 0.000 |
|     H\*H | 0.07 | 0.799 |
|     L1\*L1 | 0.07 | 0.799 |
|     L2\*L2 | 0.02 | 0.899 |
|     Adhesive Thickness\*Adhesive Thickness | 155.21 | 0.000 |
|     Fx\*Fx | 0.07 | 0.799 |
|     Fz\*Fz | 0.07 | 0.799 |
|   2-Way Interaction | 32.60 | 0.000 |
|     H\*L1 | 0.00 | 1.000 |
|     H\*L2 | 0.12 | 0.737 |
|     H\*Adhesive Thickness | 0.06 | 0.812 |
|     H\*Fx | 0.12 | 0.737 |
|     H\*Fz | 0.00 | 1.000 |
|     L1\*L2 | 0.00 | 1.000 |
|     L1\*Adhesive Thickness | 0.00 | 1.000 |
|     L1\*Fx | 0.00 | 1.000 |
|     L1\*Fz | 0.00 | 1.000 |
|     L2\*Adhesive Thickness | 184.75 | 0.000 |
|     L2\*Fx | 213.50 | 0.000 |
|     L2\*Fz | 0.00 | 1.000 |
|     Adhesive Thickness\*Fx | 90.53 | 0.000 |
|     Adhesive Thickness\*Fz | 0.00 | 1.000 |
|     Fx\*Fz | 0.00 | 1.000 |
| Error |   |   |
|   Lack-of-Fit | \* | \* |
|   Pure Error |   |   |
| Total |   |   |

Supplementary Table 2. Analysis of Variance (ANOVA) for Peel Stress

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Seq SS** | **Contribution** | **Adj SS** | **Adj MS** |
| Model | 27 | 13.3508 | 99.83% | 13.3508 | 0.49448 |
|   Linear | 6 | 12.8500 | 96.09% | 12.8500 | 2.14167 |
|     H | 1 | 0.0017 | 0.01% | 0.0017 | 0.00167 |
|     L1 | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L2 | 1 | 0.0067 | 0.05% | 0.0067 | 0.00667 |
|     Adhesive Thickness | 1 | 4.8600 | 36.34% | 4.8600 | 4.86000 |
|     Fx | 1 | 2.9400 | 21.98% | 2.9400 | 2.94000 |
|     Fz | 1 | 5.0417 | 37.70% | 5.0417 | 5.04167 |
|   Square | 6 | 0.3983 | 2.98% | 0.3983 | 0.06639 |
|     H\*H | 1 | 0.0333 | 0.25% | 0.0064 | 0.00643 |
|     L1\*L1 | 1 | 0.0031 | 0.02% | 0.0000 | 0.00000 |
|     L2\*L2 | 1 | 0.0352 | 0.26% | 0.0064 | 0.00643 |
|     Adhesive Thickness\*Adhesive Thickness | 1 | 0.3267 | 2.44% | 0.3150 | 0.31500 |
|     Fx\*Fx | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     Fz\*Fz | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|   2-Way Interaction | 15 | 0.1025 | 0.77% | 0.1025 | 0.00683 |
|     H\*L1 | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     H\*L2 | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     H\*Adhesive Thickness | 1 | 0.0025 | 0.02% | 0.0025 | 0.00250 |
|     H\*Fx | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     H\*Fz | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L1\*L2 | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L1\*Adhesive Thickness | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L1\*Fx | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L1\*Fz | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     L2\*Adhesive Thickness | 1 | 0.0050 | 0.04% | 0.0050 | 0.00500 |
|     L2\*Fx | 1 | 0.0050 | 0.04% | 0.0050 | 0.00500 |
|     L2\*Fz | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
|     Adhesive Thickness\*Fx | 1 | 0.0450 | 0.34% | 0.0450 | 0.04500 |
|     Adhesive Thickness\*Fz | 1 | 0.0450 | 0.34% | 0.0450 | 0.04500 |
|     Fx\*Fz | 1 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
| Error | 26 | 0.0225 | 0.17% | 0.0225 | 0.00087 |
|   Lack-of-Fit | 21 | 0.0225 | 0.17% | 0.0225 | 0.00107 |
|   Pure Error | 5 | 0.0000 | 0.00% | 0.0000 | 0.00000 |
| Total | 53 | 13.3733 | 100.00% |   |   |
| **Source** | **F-Value** | **P-Value** |
| Model | 571.39 | 0.000 |
|   Linear | 2474.81 | 0.000 |
|     H | 1.93 | 0.177 |
|     L1 | 0.00 | 1.000 |
|     L2 | 7.70 | 0.010 |
|     Adhesive Thickness | 5616.00 | 0.000 |
|     Fx | 3397.33 | 0.000 |
|     Fz | 5825.93 | 0.000 |
|   Square | 76.72 | 0.000 |
|     H\*H | 7.43 | 0.011 |
|     L1\*L1 | 0.00 | 1.000 |
|     L2\*L2 | 7.43 | 0.011 |
|     Adhesive Thickness\*Adhesive Thickness | 364.00 | 0.000 |
|     Fx\*Fx | 0.00 | 1.000 |
|     Fz\*Fz | 0.00 | 1.000 |
|   2-Way Interaction | 7.90 | 0.000 |
|     H\*L1 | 0.00 | 1.000 |
|     H\*L2 | 0.00 | 1.000 |
|     H\*Adhesive Thickness | 2.89 | 0.101 |
|     H\*Fx | 0.00 | 1.000 |
|     H\*Fz | 0.00 | 1.000 |
|     L1\*L2 | 0.00 | 1.000 |
|     L1\*Adhesive Thickness | 0.00 | 1.000 |
|     L1\*Fx | 0.00 | 1.000 |
|     L1\*Fz | 0.00 | 1.000 |
|     L2\*Adhesive Thickness | 5.78 | 0.024 |
|     L2\*Fx | 5.78 | 0.024 |
|     L2\*Fz | 0.00 | 1.000 |
|     Adhesive Thickness\*Fx | 52.00 | 0.000 |
|     Adhesive Thickness\*Fz | 52.00 | 0.000 |
|     Fx\*Fz | 0.00 | 1.000 |
| Error |   |   |
|   Lack-of-Fit | \* | \* |
|   Pure Error |   |   |
| Total |   |   |

Supplementary Table 3. Response Surface Regression: Coded Coefficients for Shear Stress as a Function of Joint Parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Term** | **Coef** | **SE Coef** | **95% CI** | **T-Value** | **P-Value** |
| Constant | 6.8000 | 0.0850 | (6.6254; 6.9746) | 80.04 | 0.000 |
| H | 0.0250 | 0.0425 | (-0.0623; 0.1123) | 0.59 | 0.561 |
| L1 | -0.0000 | 0.0425 | (-0.0873; 0.0873) | -0.00 | 1.000 |
| L2 | 3.4000 | 0.0425 | (3.3127; 3.4873) | 80.04 | 0.000 |
| Adhesive Thickness | -2.0583 | 0.0425 | (-2.1456; -1.9710) | -48.46 | 0.000 |
| Fx | 2.3500 | 0.0425 | (2.2627; 2.4373) | 55.33 | 0.000 |
| Fz | -0.0000 | 0.0425 | (-0.0873; 0.0873) | -0.00 | 1.000 |
| H\*H | -0.0167 | 0.0649 | (-0.1500; 0.1167) | -0.26 | 0.799 |
| L1\*L1 | -0.0167 | 0.0649 | (-0.1500; 0.1167) | -0.26 | 0.799 |
| L2\*L2 | 0.0083 | 0.0649 | (-0.1250; 0.1417) | 0.13 | 0.899 |
| Adhesive Thickness\*Adhesive Thickness | 0.8083 | 0.0649 | (0.6750; 0.9417) | 12.46 | 0.000 |
| Fx\*Fx | -0.0167 | 0.0649 | (-0.1500; 0.1167) | -0.26 | 0.799 |
| Fz\*Fz | -0.0167 | 0.0649 | (-0.1500; 0.1167) | -0.26 | 0.799 |
| H\*L1 | -0.0000 | 0.0736 | (-0.1512; 0.1512) | -0.00 | 1.000 |
| H\*L2 | 0.0250 | 0.0736 | (-0.1262; 0.1762) | 0.34 | 0.737 |
| H\*Adhesive Thickness | -0.0125 | 0.0520 | (-0.1194; 0.0944) | -0.24 | 0.812 |
| H\*Fx | 0.0250 | 0.0736 | (-0.1262; 0.1762) | 0.34 | 0.737 |
| H\*Fz | 0.0000 | 0.0736 | (-0.1512; 0.1512) | 0.00 | 1.000 |
| L1\*L2 | 0.0000 | 0.0736 | (-0.1512; 0.1512) | 0.00 | 1.000 |
| L1\*Adhesive Thickness | -0.0000 | 0.0736 | (-0.1512; 0.1512) | -0.00 | 1.000 |
| L1\*Fx | -0.0000 | 0.0520 | (-0.1069; 0.1069) | -0.00 | 1.000 |
| L1\*Fz | -0.0000 | 0.0736 | (-0.1512; 0.1512) | -0.00 | 1.000 |
| L2\*Adhesive Thickness | -1.0000 | 0.0736 | (-1.1512; -0.8488) | -13.59 | 0.000 |
| L2\*Fx | 1.0750 | 0.0736 | (0.9238; 1.2262) | 14.61 | 0.000 |
| L2\*Fz | -0.0000 | 0.0520 | (-0.1069; 0.1069) | -0.00 | 1.000 |
| Adhesive Thickness\*Fx | -0.7000 | 0.0736 | (-0.8512; -0.5488) | -9.51 | 0.000 |
| Adhesive Thickness\*Fz | 0.0000 | 0.0736 | (-0.1512; 0.1512) | 0.00 | 1.000 |
| Fx\*Fz | 0.0000 | 0.0736 | (-0.1512; 0.1512) | 0.00 | 1.000 |
| **Term** | **VIF** |
| Constant |   |
| H | 1.00 |
| L1 | 1.00 |
| L2 | 1.00 |
| Adhesive Thickness | 1.00 |
| Fx | 1.00 |
| Fz | 1.00 |
| H\*H | 1.30 |
| L1\*L1 | 1.30 |
| L2\*L2 | 1.30 |
| Adhesive Thickness\*Adhesive Thickness | 1.30 |
| Fx\*Fx | 1.30 |
| Fz\*Fz | 1.30 |
| H\*L1 | 1.00 |
| H\*L2 | 1.00 |
| H\*Adhesive Thickness | 1.00 |
| H\*Fx | 1.00 |
| H\*Fz | 1.00 |
| L1\*L2 | 1.00 |
| L1\*Adhesive Thickness | 1.00 |
| L1\*Fx | 1.00 |
| L1\*Fz | 1.00 |
| L2\*Adhesive Thickness | 1.00 |
| L2\*Fx | 1.00 |
| L2\*Fz | 1.00 |
| Adhesive Thickness\*Fx | 1.00 |
| Adhesive Thickness\*Fz | 1.00 |
| Fx\*Fz | 1.00 |

Supplementary Table 4. Response Surface Regression: Coded Coefficients for Peel Stress as a Function of Joint Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Term** | **Coef** | **SE Coef** | **95% CI** | **T-Value** |
| Constant | 2.4000 | 0.0120 | (2.3753; 2.4247) | 199.84 |
| H | 0.00833 | 0.00600 | (-0.00401; 0.02068) | 1.39 |
| L1 | 0.00000 | 0.00600 | (-0.01234; 0.01234) | 0.00 |
| L2 | -0.01667 | 0.00600 | (-0.02901; -0.00432) | -2.78 |
| Adhesive Thickness | -0.45000 | 0.00600 | (-0.46234; -0.43766) | -74.94 |
| Fx | 0.35000 | 0.00600 | (0.33766; 0.36234) | 58.29 |
| Fz | 0.45833 | 0.00600 | (0.44599; 0.47068) | 76.33 |
| H\*H | -0.02500 | 0.00917 | (-0.04385; -0.00615) | -2.73 |
| L1\*L1 | 0.00000 | 0.00917 | (-0.01885; 0.01885) | 0.00 |
| L2\*L2 | -0.02500 | 0.00917 | (-0.04385; -0.00615) | -2.73 |
| Adhesive Thickness\*Adhesive Thickness | 0.17500 | 0.00917 | (0.15615; 0.19385) | 19.08 |
| Fx\*Fx | 0.00000 | 0.00917 | (-0.01885; 0.01885) | 0.00 |
| Fz\*Fz | -0.00000 | 0.00917 | (-0.01885; 0.01885) | -0.00 |
| H\*L1 | -0.0000 | 0.0104 | (-0.0214; 0.0214) | -0.00 |
| H\*L2 | 0.0000 | 0.0104 | (-0.0214; 0.0214) | 0.00 |
| H\*Adhesive Thickness | -0.01250 | 0.00735 | (-0.02762; 0.00262) | -1.70 |
| H\*Fx | 0.0000 | 0.0104 | (-0.0214; 0.0214) | 0.00 |
| H\*Fz | 0.0000 | 0.0104 | (-0.0214; 0.0214) | 0.00 |
| L1\*L2 | 0.0000 | 0.0104 | (-0.0214; 0.0214) | 0.00 |
| L1\*Adhesive Thickness | 0.0000 | 0.0104 | (-0.0214; 0.0214) | 0.00 |
| L1\*Fx | -0.00000 | 0.00735 | (-0.01512; 0.01512) | -0.00 |
| L1\*Fz | -0.0000 | 0.0104 | (-0.0214; 0.0214) | -0.00 |
| L2\*Adhesive Thickness | 0.0250 | 0.0104 | (0.0036; 0.0464) | 2.40 |
| L2\*Fx | 0.0250 | 0.0104 | (0.0036; 0.0464) | 2.40 |
| L2\*Fz | 0.00000 | 0.00735 | (-0.01512; 0.01512) | 0.00 |
| Adhesive Thickness\*Fx | -0.0750 | 0.0104 | (-0.0964; -0.0536) | -7.21 |
| Adhesive Thickness\*Fz | -0.0750 | 0.0104 | (-0.0964; -0.0536) | -7.21 |
| Fx\*Fz | -0.0000 | 0.0104 | (-0.0214; 0.0214) | -0.00 |
| **Term** | **P-Value** | **VIF** |
| Constant | 0.000 |   |
| H | 0.177 | 1.00 |
| L1 | 1.000 | 1.00 |
| L2 | 0.010 | 1.00 |
| Adhesive Thickness | 0.000 | 1.00 |
| Fx | 0.000 | 1.00 |
| Fz | 0.000 | 1.00 |
| H\*H | 0.011 | 1.30 |
| L1\*L1 | 1.000 | 1.30 |
| L2\*L2 | 0.011 | 1.30 |
| Adhesive Thickness\*Adhesive Thickness | 0.000 | 1.30 |
| Fx\*Fx | 1.000 | 1.30 |
| Fz\*Fz | 1.000 | 1.30 |
| H\*L1 | 1.000 | 1.00 |
| H\*L2 | 1.000 | 1.00 |
| H\*Adhesive Thickness | 0.101 | 1.00 |
| H\*Fx | 1.000 | 1.00 |
| H\*Fz | 1.000 | 1.00 |
| L1\*L2 | 1.000 | 1.00 |
| L1\*Adhesive Thickness | 1.000 | 1.00 |
| L1\*Fx | 1.000 | 1.00 |
| L1\*Fz | 1.000 | 1.00 |
| L2\*Adhesive Thickness | 0.024 | 1.00 |
| L2\*Fx | 0.024 | 1.00 |
| L2\*Fz | 1.000 | 1.00 |
| Adhesive Thickness\*Fx | 0.000 | 1.00 |
| Adhesive Thickness\*Fz | 0.000 | 1.00 |
| Fx\*Fz | 1.000 | 1.00 |

**Regression Equations for Shear and Peel Stresses**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Shear stress | = | -2.25 + 0.019 H + 0.0067 L1 + 0.1942 L2 - 10.92 Adhesive Thickness + 0.0600 Fx+ 0.0040 Fz - 0.000167 H\*H - 0.000167 L1\*L1 + 0.000083 L2\*L2+ 80.83 Adhesive Thickness\*Adhesive Thickness - 0.000027 Fx\*Fx- 0.000027 Fz\*Fz + 0.000000 H\*L1 + 0.000250 H\*L2 - 0.0125 H\*Adhesive Thickness+ 0.000100 H\*Fx - 0.000000 H\*Fz + 0.000000 L1\*L2- 0.0000 L1\*Adhesive Thickness - 0.000000 L1\*Fx - 0.000000 L1\*Fz- 1.0000 L2\*Adhesive Thickness + 0.004300 L2\*Fx - 0.000000 L2\*Fz- 0.2800 Adhesive Thickness\*Fx - 0.0000 Adhesive Thickness\*Fz - 0.000000 Fx\*Fz | **Eq.(1)** | Peel stress | = | -1.008 + 0.0433 H - 0.0000 L1 - 0.0042 L2 - 6.500 Adhesive Thickness+ 0.01800 Fx + 0.02433 Fz - 0.000250 H\*H + 0.000000 L1\*L1 - 0.000250 L2\*L2+ 17.500 Adhesive Thickness\*Adhesive Thickness + 0.000000 Fx\*Fx- 0.000000 Fz\*Fz + 0.000000 H\*L1 + 0.000000 H\*L2 - 0.01250 H\*Adhesive Thickness- 0.000000 H\*Fx + 0.000000 H\*Fz + 0.000000 L1\*L2 - 0.0000 L1\*Adhesive Thickness- 0.000000 L1\*Fx + 0.000000 L1\*Fz + 0.0250 L2\*Adhesive Thickness+ 0.000100 L2\*Fx - 0.000000 L2\*Fz - 0.03000 Adhesive Thickness\*Fx- 0.03000 Adhesive Thickness\*Fz + 0.000000 Fx\*Fz | **Eq. (2)** |

|  |  |
| --- | --- |
| Contour Plot of Shear stress vs L1; HContour Plot of Shear stress vs L2; HContour Plot of Shear stress vs Adhesive Thickness; HContour Plot of Shear stress vs Fx; HContour Plot of Shear stress vs Fz; HContour Plot of Shear stress vs L2; L1Contour Plot of Shear stress vs Adhesive Thickness; L1Contour Plot of Shear stress vs Fx; L1Contour Plot of Shear stress vs Fz; L1Contour Plot of Shear stress vs Adhesive Thickness; L2Contour Plot of Shear stress vs Fx; L2Contour Plot of Shear stress vs Fz; L2Contour Plot of Shear stress vs Fx; Adhesive ThicknessContour Plot of Shear stress vs Fz; Adhesive ThicknessContour Plot of Shear stress vs Fz; Fx | Contour Plot of Peel stress vs L1; HContour Plot of Peel stress vs L2; HContour Plot of Peel stress vs Adhesive Thickness; HContour Plot of Peel stress vs Fx; HContour Plot of Peel stress vs Fz; HContour Plot of Peel stress vs L2; L1Contour Plot of Peel stress vs Adhesive Thickness; L1Contour Plot of Peel stress vs Fx; L1Contour Plot of Peel stress vs Fz; L1Contour Plot of Peel stress vs Adhesive Thickness; L2Contour Plot of Peel stress vs Fx; L2Contour Plot of Peel stress vs Fz; L2Contour Plot of Peel stress vs Fx; Adhesive ThicknessContour Plot of Peel stress vs Fz; Adhesive ThicknessContour Plot of Peel stress vs Fz; Fx |
| (a) | (b) |

Supplementary Figure 1. Contour Plots of (a) Shear and (b) Peel stress