

# COMPFIRE

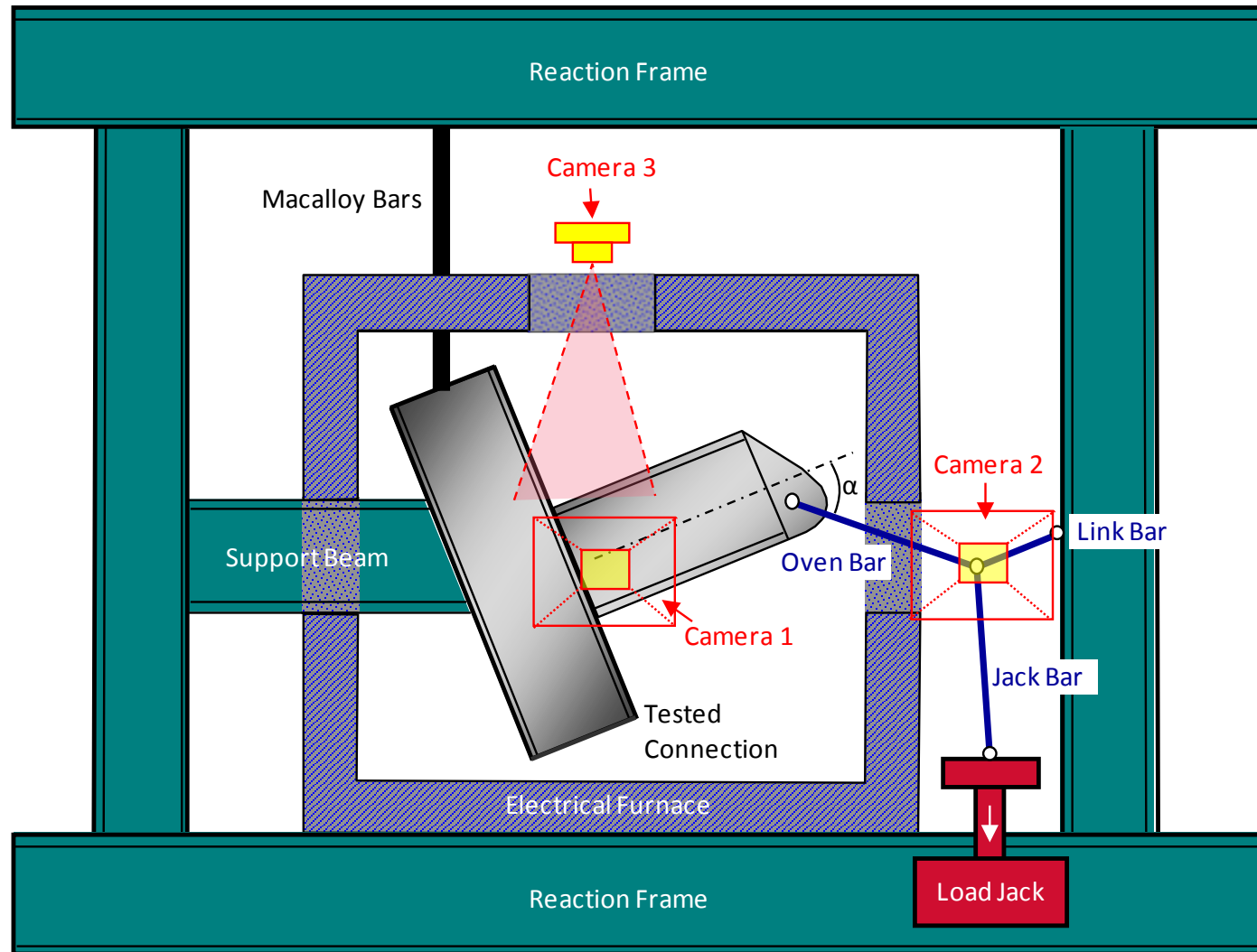
CCFT-UKPFC230\_20\_55\_03-03-2011

3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result

RFSR-CT-2009-0021

Design of joints to composite columns for improved fire robustness

[ftp://openspace.dec.uc.pt/](http://openspace.dec.uc.pt/)



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CCFT-UKPFC230\_20\_55\_03-03-2011

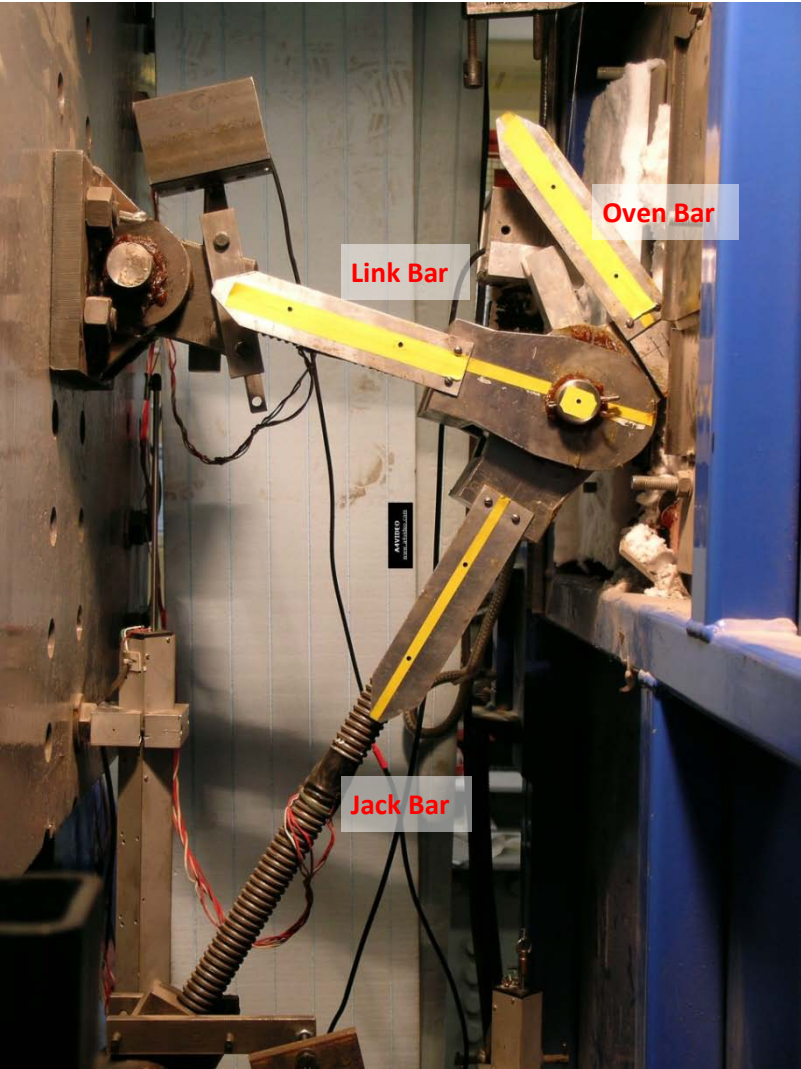
3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result



View of Camera 1



View of Camera 3



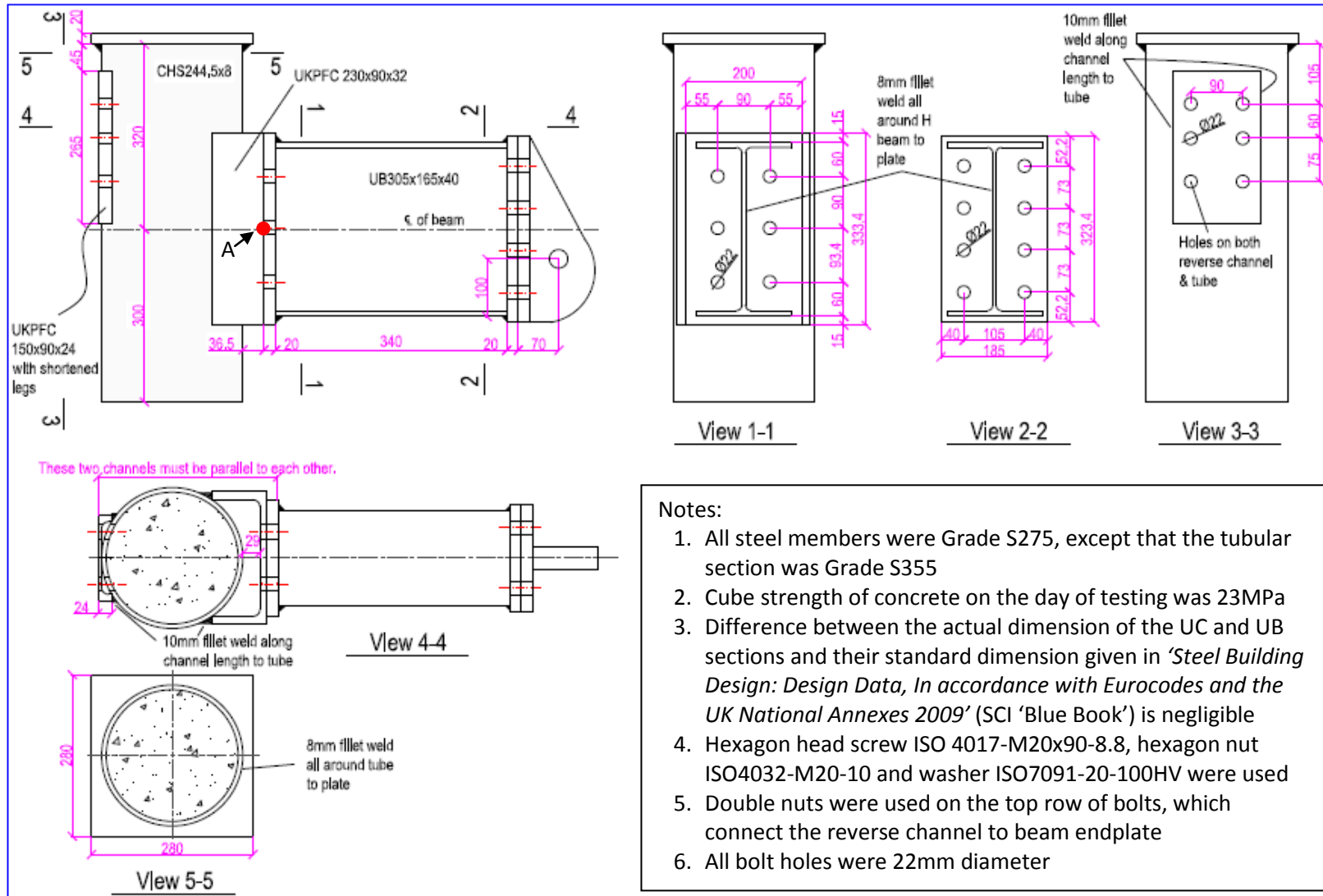
View of Camera 2



# COMPFIRE

CCFT-UKPFC230\_20\_55\_03-03-2011

3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result



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3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result

Nominal Temperature: 20°C

| Time     | Jack Displacement | Load Angle   | Beam Rotation | Column Rotation | Connection Rotation | Oven Bar Force | Tension | Shear | Moment* |
|----------|-------------------|--------------|---------------|-----------------|---------------------|----------------|---------|-------|---------|
| (minute) | (mm)              | $\alpha$ (°) | (°)           | (°)             | (°)                 | (kN)           | (kN)    | (kN)  | (kNm)   |
| 0        | -0.01             | 50.29        | 0.00          | 0.00            | 0.00                | 0.30           | 0.19    | 0.23  | 0.09    |
| 1        | 0.93              | 50.15        | 0.13          | 0.12            | 0.01                | 2.69           | 1.72    | 2.06  | 0.84    |
| 2        | 2.30              | 50.10        | 0.18          | 0.14            | 0.04                | 5.93           | 3.80    | 4.55  | 1.85    |
| 3        | 3.88              | 50.02        | 0.25          | 0.17            | 0.09                | 9.96           | 6.40    | 7.63  | 3.10    |
| 4        | 6.24              | 49.97        | 0.30          | 0.18            | 0.12                | 12.69          | 8.16    | 9.72  | 3.95    |
| 5        | 8.02              | 49.89        | 0.37          | 0.22            | 0.15                | 16.35          | 10.53   | 12.50 | 5.08    |
| 6        | 9.43              | 49.83        | 0.43          | 0.25            | 0.19                | 20.47          | 13.21   | 15.64 | 6.36    |
| 7        | 12.42             | 49.78        | 0.47          | 0.27            | 0.21                | 22.62          | 14.60   | 17.27 | 7.02    |
| 8        | 13.88             | 49.70        | 0.55          | 0.30            | 0.25                | 27.81          | 17.99   | 21.21 | 8.62    |
| 9        | 15.24             | 49.63        | 0.62          | 0.33            | 0.29                | 32.50          | 21.05   | 24.76 | 10.05   |
| 10       | 16.73             | 49.55        | 0.70          | 0.36            | 0.34                | 37.23          | 24.15   | 28.33 | 11.50   |
| 11       | 18.02             | 49.46        | 0.79          | 0.39            | 0.40                | 41.93          | 27.25   | 31.86 | 12.93   |
| 12       | 19.51             | 49.37        | 0.87          | 0.41            | 0.46                | 46.60          | 30.34   | 35.37 | 14.35   |
| 13       | 21.04             | 49.29        | 0.95          | 0.43            | 0.52                | 51.12          | 33.35   | 38.75 | 15.71   |
| 14       | 22.43             | 49.20        | 1.04          | 0.46            | 0.58                | 55.54          | 36.29   | 42.04 | 17.04   |
| 15       | 23.87             | 49.09        | 1.15          | 0.48            | 0.67                | 59.68          | 39.08   | 45.10 | 18.28   |
| 16       | 25.36             | 48.99        | 1.24          | 0.51            | 0.73                | 63.58          | 41.72   | 47.98 | 19.43   |
| 17       | 26.80             | 48.90        | 1.33          | 0.52            | 0.81                | 67.16          | 44.15   | 50.61 | 20.49   |
| 18       | 28.22             | 48.78        | 1.45          | 0.54            | 0.91                | 70.30          | 46.33   | 52.87 | 21.40   |
| 19       | 29.96             | 48.66        | 1.56          | 0.56            | 1.01                | 73.17          | 48.33   | 54.94 | 22.22   |
| 20       | 31.54             | 48.55        | 1.68          | 0.57            | 1.11                | 75.95          | 50.28   | 56.93 | 23.02   |
| 21       | 33.16             | 48.43        | 1.79          | 0.59            | 1.20                | 78.79          | 52.28   | 58.94 | 23.82   |

# COMPFIRE

CCFT-UKPFC230\_20\_55\_03-03-2011

3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result

|    |       |       |      |      |      |        |        |        |       |
|----|-------|-------|------|------|------|--------|--------|--------|-------|
| 22 | 34.60 | 48.31 | 1.91 | 0.60 | 1.31 | 81.39  | 54.14  | 60.78  | 24.55 |
| 23 | 36.15 | 48.19 | 2.03 | 0.61 | 1.41 | 83.90  | 55.94  | 62.53  | 25.25 |
| 24 | 37.60 | 48.07 | 2.15 | 0.63 | 1.52 | 86.28  | 57.66  | 64.19  | 25.90 |
| 25 | 39.08 | 47.94 | 2.27 | 0.65 | 1.63 | 88.21  | 59.09  | 65.49  | 26.41 |
| 26 | 40.74 | 47.82 | 2.38 | 0.66 | 1.73 | 90.86  | 61.01  | 67.34  | 27.15 |
| 27 | 42.39 | 47.70 | 2.51 | 0.67 | 1.84 | 93.23  | 62.75  | 68.95  | 27.78 |
| 28 | 43.90 | 47.57 | 2.63 | 0.67 | 1.96 | 95.48  | 64.42  | 70.47  | 28.38 |
| 29 | 45.48 | 47.43 | 2.77 | 0.69 | 2.08 | 97.72  | 66.10  | 71.97  | 28.97 |
| 30 | 46.96 | 47.31 | 2.89 | 0.70 | 2.18 | 100.02 | 67.82  | 73.52  | 29.58 |
| 31 | 48.51 | 47.18 | 3.01 | 0.72 | 2.30 | 102.25 | 69.50  | 75.00  | 30.15 |
| 32 | 50.06 | 47.05 | 3.14 | 0.73 | 2.41 | 104.53 | 71.22  | 76.52  | 30.75 |
| 33 | 51.53 | 46.92 | 3.27 | 0.73 | 2.54 | 106.67 | 72.86  | 77.92  | 31.30 |
| 34 | 53.11 | 46.79 | 3.40 | 0.75 | 2.65 | 108.90 | 74.57  | 79.36  | 31.86 |
| 35 | 54.58 | 46.66 | 3.53 | 0.75 | 2.78 | 111.12 | 76.27  | 80.81  | 32.42 |
| 36 | 56.33 | 46.53 | 3.65 | 0.76 | 2.89 | 113.54 | 78.11  | 82.40  | 33.04 |
| 37 | 58.00 | 46.39 | 3.79 | 0.78 | 3.01 | 115.90 | 79.94  | 83.92  | 33.63 |
| 38 | 59.38 | 46.26 | 3.92 | 0.80 | 3.12 | 117.98 | 81.58  | 85.24  | 34.14 |
| 39 | 60.87 | 46.11 | 4.06 | 0.81 | 3.24 | 120.34 | 83.42  | 86.73  | 34.72 |
| 40 | 62.40 | 45.98 | 4.20 | 0.83 | 3.37 | 122.90 | 85.41  | 88.37  | 35.35 |
| 41 | 64.07 | 45.85 | 4.32 | 0.84 | 3.48 | 125.38 | 87.33  | 89.96  | 35.97 |
| 42 | 65.57 | 45.71 | 4.46 | 0.86 | 3.60 | 127.76 | 89.21  | 91.45  | 36.54 |
| 43 | 66.93 | 45.56 | 4.60 | 0.87 | 3.73 | 130.33 | 91.25  | 93.06  | 37.16 |
| 44 | 68.41 | 45.43 | 4.74 | 0.88 | 3.86 | 132.76 | 93.17  | 94.57  | 37.74 |
| 45 | 69.92 | 45.29 | 4.88 | 0.90 | 3.98 | 135.14 | 95.08  | 96.03  | 38.30 |
| 46 | 71.41 | 45.15 | 5.01 | 0.91 | 4.10 | 137.55 | 97.00  | 97.52  | 38.87 |
| 47 | 72.88 | 45.02 | 5.14 | 0.93 | 4.21 | 140.09 | 99.02  | 99.09  | 39.47 |
| 48 | 74.61 | 44.87 | 5.29 | 0.95 | 4.34 | 142.69 | 101.13 | 100.67 | 40.07 |

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CCFT-UKPFC230\_20\_55\_03-03-2011

3 March 2011 Reverse Channel Connection (UKPFC 230x90x32) to Circular Concrete-Filled Tube Test Result

|    |        |       |      |      |      |        |        |        |       |
|----|--------|-------|------|------|------|--------|--------|--------|-------|
| 49 | 76.08  | 44.73 | 5.43 | 0.96 | 4.47 | 145.22 | 103.17 | 102.20 | 40.66 |
| 50 | 77.69  | 44.59 | 5.57 | 0.99 | 4.58 | 147.96 | 105.37 | 103.87 | 41.29 |
| 51 | 79.29  | 44.45 | 5.71 | 1.00 | 4.71 | 150.69 | 107.57 | 105.52 | 41.92 |
| 52 | 80.81  | 44.31 | 5.84 | 1.02 | 4.83 | 153.19 | 109.62 | 107.01 | 42.49 |
| 53 | 82.37  | 44.17 | 5.99 | 1.04 | 4.95 | 155.89 | 111.82 | 108.62 | 43.10 |
| 54 | 83.84  | 44.03 | 6.12 | 1.06 | 5.06 | 158.40 | 113.88 | 110.10 | 43.66 |
| 55 | 85.33  | 43.89 | 6.26 | 1.08 | 5.18 | 161.05 | 116.07 | 111.65 | 44.24 |
| 56 | 87.01  | 43.74 | 6.41 | 1.11 | 5.31 | 163.58 | 118.19 | 113.10 | 44.78 |
| 57 | 88.43  | 43.61 | 6.54 | 1.15 | 5.40 | 166.05 | 120.23 | 114.53 | 45.32 |
| 58 | 89.83  | 43.46 | 6.69 | 1.17 | 5.52 | 168.55 | 122.34 | 115.94 | 45.85 |
| 59 | 91.33  | 43.32 | 6.84 | 1.21 | 5.63 | 170.10 | 123.76 | 116.70 | 46.12 |
| 60 | 92.71  | 43.18 | 6.98 | 1.26 | 5.72 | 172.68 | 125.92 | 118.16 | 46.66 |
| 61 | 94.22  | 43.04 | 7.12 | 1.32 | 5.80 | 174.14 | 127.28 | 118.85 | 46.90 |
| 62 | 95.58  | 42.90 | 7.27 | 1.39 | 5.88 | 176.43 | 129.25 | 120.09 | 47.36 |
| 63 | 97.08  | 42.77 | 7.40 | 1.50 | 5.90 | 176.98 | 129.92 | 120.19 | 47.37 |
| 64 | 98.49  | 42.64 | 7.53 | 1.59 | 5.94 | 178.46 | 131.28 | 120.89 | 47.61 |
| 65 | 100.09 | 42.50 | 7.67 | 1.69 | 5.98 | 179.63 | 132.43 | 121.36 | 47.76 |
| 66 | 101.37 | 42.37 | 7.81 | 1.79 | 6.02 | 180.60 | 133.44 | 121.70 | 47.87 |
| 67 | 102.79 | 42.24 | 7.94 | 1.88 | 6.06 | 182.39 | 135.03 | 122.61 | 48.19 |
| 68 | 104.07 | 42.10 | 8.07 | 1.96 | 6.12 | 184.10 | 136.59 | 123.44 | 48.48 |
| 69 | 105.56 | 41.96 | 8.22 | 2.03 | 6.19 | 186.21 | 138.48 | 124.49 | 48.86 |
| 70 | 106.83 | 41.82 | 8.36 | 2.09 | 6.27 | 188.29 | 140.31 | 125.55 | 49.25 |
| 71 | 108.20 | 41.68 | 8.51 | 2.15 | 6.36 | 190.51 | 142.29 | 126.68 | 49.65 |
| 72 | 109.59 | 41.54 | 8.65 | 2.21 | 6.44 | 192.59 | 144.15 | 127.71 | 50.02 |
| 73 | 111.19 | 41.40 | 8.79 | 2.26 | 6.53 | 194.75 | 146.09 | 128.78 | 50.40 |
| 74 | 112.47 | 41.24 | 8.95 | 2.34 | 6.61 | 196.86 | 148.03 | 129.78 | 50.75 |
| 75 | 113.91 | 41.10 | 9.09 | 2.39 | 6.70 | 198.92 | 149.89 | 130.77 | 51.10 |

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|    |        |       |       |      |      |        |        |        |       |
|----|--------|-------|-------|------|------|--------|--------|--------|-------|
| 76 | 115.15 | 40.96 | 9.23  | 2.46 | 6.78 | 200.95 | 151.75 | 131.73 | 51.43 |
| 77 | 116.53 | 40.82 | 9.38  | 2.52 | 6.86 | 203.19 | 153.77 | 132.82 | 51.82 |
| 78 | 117.90 | 40.67 | 9.53  | 2.57 | 6.96 | 205.49 | 155.86 | 133.93 | 52.21 |
| 79 | 119.20 | 40.52 | 9.68  | 2.61 | 7.07 | 207.66 | 157.86 | 134.92 | 52.55 |
| 80 | 120.52 | 40.38 | 9.83  | 2.67 | 7.16 | 210.10 | 160.05 | 136.11 | 52.97 |
| 81 | 121.97 | 40.22 | 9.98  | 2.72 | 7.27 | 212.54 | 162.28 | 137.25 | 53.37 |
| 82 | 123.42 | 40.08 | 10.13 | 2.77 | 7.36 | 214.93 | 164.46 | 138.38 | 53.77 |
| 83 | 124.83 | 39.92 | 10.28 | 2.82 | 7.47 | 215.88 | 165.56 | 138.54 | 53.78 |
| 84 | 126.39 | 39.77 | 10.44 | 2.87 | 7.57 | 218.80 | 168.17 | 139.96 | 54.29 |
| 85 | 127.82 | 39.62 | 10.59 | 2.91 | 7.68 | 221.33 | 170.49 | 141.14 | 54.70 |
| 86 | 129.35 | 39.46 | 10.75 | 2.97 | 7.78 | 223.80 | 172.78 | 142.25 | 55.08 |
| 87 | 130.84 | 39.31 | 10.90 | 3.02 | 7.88 | 226.53 | 175.27 | 143.52 | 55.52 |
| 88 | 132.29 | 39.16 | 11.06 | 3.06 | 8.00 | 228.99 | 177.57 | 144.59 | 55.89 |
| 89 | 133.79 | 39.00 | 11.22 | 3.11 | 8.11 | 231.13 | 179.63 | 145.44 | 56.16 |
| 90 | 135.20 | 38.84 | 11.38 | 3.15 | 8.22 | 233.89 | 182.17 | 146.69 | 56.59 |
| 91 | 136.70 | 38.68 | 11.54 | 3.21 | 8.33 | 236.43 | 184.56 | 147.78 | 56.96 |
| 92 | 138.19 | 38.36 | 11.86 | 3.26 | 8.60 | 238.65 | 187.12 | 148.12 | 56.98 |
| 93 | 139.74 | 38.18 | 12.04 | 3.30 | 8.74 | 239.50 | 188.27 | 148.03 | 56.88 |
| 94 | 141.30 | 38.19 | 12.04 | 3.34 | 8.70 | 243.95 | 191.74 | 150.82 | 57.96 |
| 95 | 142.87 | 38.03 | 12.20 | 3.37 | 8.83 | 246.40 | 194.09 | 151.79 | 58.27 |
| 96 | 144.31 | 37.86 | 12.37 | 3.43 | 8.94 | 247.92 | 195.74 | 152.15 | 58.35 |
| 97 | 145.85 | 37.71 | 12.52 | 3.47 | 9.05 | 252.62 | 199.85 | 154.51 | 59.20 |
| 98 | 147.46 | 37.54 | 12.70 | 3.52 | 9.18 | 254.35 | 201.70 | 154.96 | 59.31 |

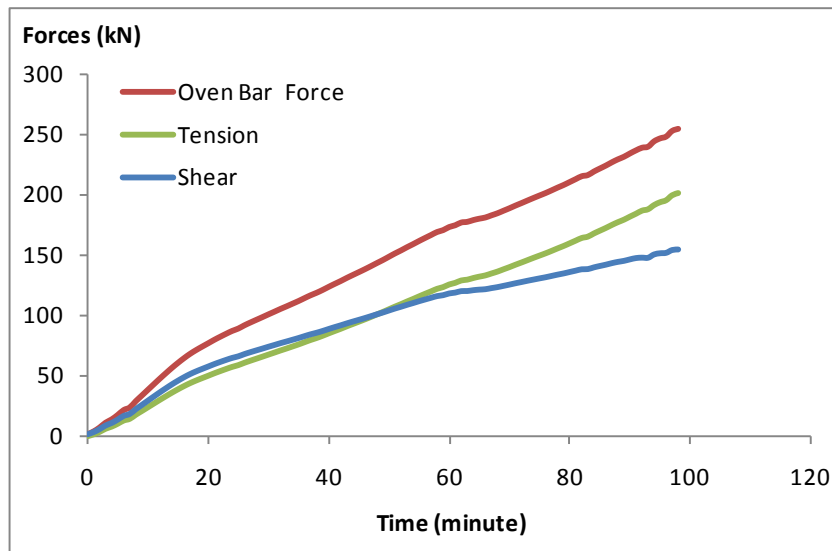
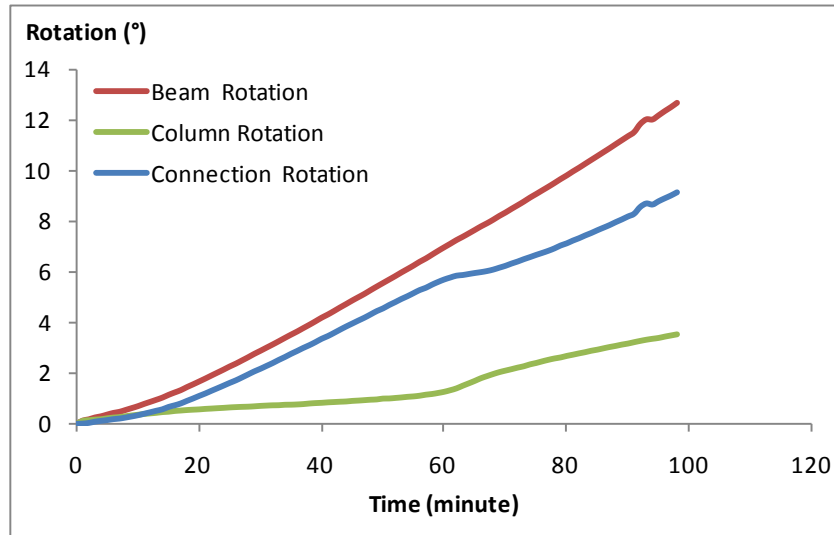
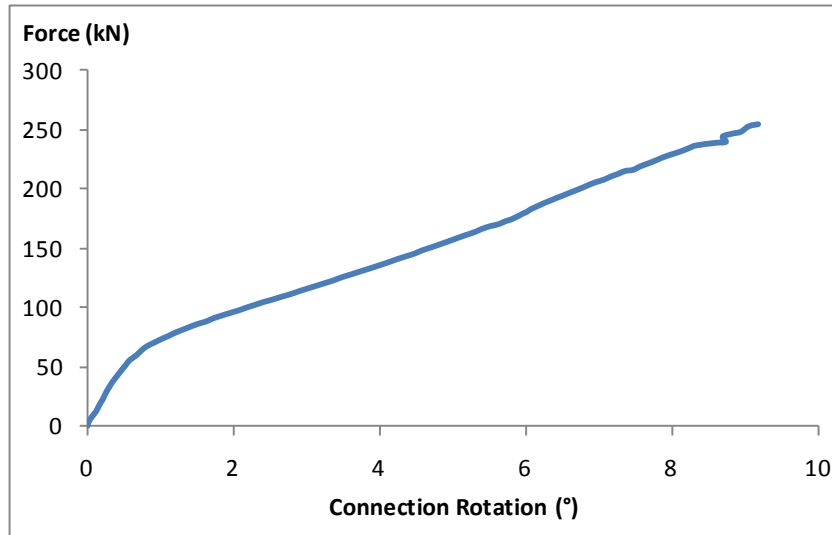
\* Moment about Point A on the specimen drawing



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The specimen did not fail – the test was stopped when the applied load level nearly reached the capacity of the test rig.



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Design of joints to composite columns for improved fire robustness

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## Photographs after Test





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