List of Figures

4.1 Panel dimensions 20
4.2 Layout of reinforcement and tendons for **DT** steel panel 20
4.3 Layout of reinforcement and tendons for **ST** steel panel 21
4.4 Layout of reinforcement and tendons for **DT** FRP panel 21
4.5 Layout of reinforcement and tendons for **ST** FRP panel 21
4.6 Cross-section details and prestressing forces for **DT** Steel panel 22
4.7 Cross-section details and prestressing forces for **DT** FRP panel 22
4.8 Cross-section details and prestressing forces for **ST** Steel panel 23
4.9 Cross-section details and prestressing forces for **ST** FRP panel 23
4.10 Glue anchor system 27
4.11 Steel sleeve/ aluminium wedges anchor system 28
4.12 Steel sleeve/ wedges anchor system 29
4.13 Test set-up for **DT** panels 30
4.14 Test set-up for **ST** panels 31
4.15 Three loading configurations on panels 32

5.1 ADINA meshing 34

6.1 Load to centre displacement behaviour until cracking for the central loading test 40
6.2 Load to intermediate displacement behaviour until cracking for the central loading test 41
6.3 Load to centre displacement behaviour until cracking for the intermediate loading test 42
6.4 Load to intermediate displacement behaviour until cracking for the intermediate loading test 43
6.5 Load to centre displacement behaviour until cracking for the shear loading test 44
6.6 Load to intermediate displacement behaviour until cracking for the shear loading test 45
6.7 Load to centre displacement behaviour until failure for the central loading test 46
6.8 Load to intermediate displacement behaviour until failure for the central loading test 47
6.9 ADINA cracking at failure 47

6.10 Analytical and experimental load-deflection behaviour until failure of the **DT** Steel panel . . . 48
6.11 Analytical and experimental load-deflection behaviour until failure of the **DT** FRP panel . . . 49
6.12 Analytical and experimental load-deflection behaviour until failure of the **ST** Steel panel . . . 49
6.13 Analytical and experimental load-deflection behaviour until failure of the **ST** FRP panel . . . 50

A.1 Stem 1 strain gages position for the **DT** Steel Panel . . . 60
A.2 Stem 2 strain gages position for the **DT** Steel Panel . . . 61
A.3 Slab reinforcement strain gages position for the **DT** Steel Panel . . . 62
A.4 Horizontal elongation at mid-span until cracking for the central loading test 63
A.5 Strain in the slab at mid-span until cracking for the central loading test . . 63
A.6 Strain in a tendon at 600 mm from mid-span until cracking for the central loading test . . . 64
A.7 Strain in a tendon at 1500 mm active side from mid-span until cracking for the central loading test . . . 64
A.8 Strain in n°6 stirrup on active side until cracking for the central loading test 65
A.9 Strain in n°6 stirrup on passive side until cracking for the central loading test 65
A.10 Strain in n°4 stirrup on passive side until cracking for the central loading test 66
A.11 Strain in n°7 stirrup on passive side until cracking for the central loading test 66
A.12 Strain in n°14 stirrup on passive side until cracking for the central loading test . . . 67
A.13 Strain in slab bar at 1875 mm from passive side until cracking for the central loading test . . . 67
A.14 Strain in slab transversal bar at 1555 mm from passive side until cracking for the central loading test . . . 68
A.15 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the central loading test . . . 68
A.16 Strain in slab bar n°8 at mid-span until cracking for the central loading test 69
A.17 Horizontal elongation at mid-span until cracking for the shear loading test 70
A.18 Strain in the slab at mid-span until cracking for the shear loading test . . . 70
A.19 Strain in a tendon at 600 mm from mid-span until cracking for the shear loading test . . . 71
A.20 Strain in a tendon at 1500 mm active side from mid-span until cracking for the shear loading test . . . 71
A.21 Strain in n°6 stirrup on active side until cracking for the shear loading test 72
A.22 Strain in n°6 stirrup on passive side until cracking for the shear loading test 72
A.23 Strain in n°4 stirrup on passive side until cracking for the shear loading test 73
A.24 Strain in n°7 stirrup on passive side until cracking for the shear loading test 73
A.25 Strain in n°14 stirrup on passive side until cracking for the shear loading test 74
A.26 Strain in slab bar at 1875 mm from passive side until cracking for the shear loading test . . . 74

A.27 Strain in slab transversal bar at 1555 mm from passive side until cracking for the shear loading test . . . 75
A.28 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the shear loading test . . . 75
A.29 Strain in slab bar n°8 at mid-span until cracking for the shear loading test 76
A.30 Horizontal elongation at mid-span until cracking for the intermediate loading test . . . 77
A.31 Strain in the slab at mid-span until cracking for the intermediate loading test 77
A.32 Strain in a tendon at 600 mm from mid-span until cracking for the intermediate loading test . . . 78
A.33 Strain in a tendon at 1500 mm active side from mid-span until cracking for the intermediate loading test . . . 78
A.34 Strain in n°6 stirrup on active side until cracking for the intermediate loading test . . . 79
A.35 Strain in n°6 stirrup on passive side until cracking for the intermediate loading test . . . 79
A.36 Strain in n°4 stirrup on passive side until cracking for the intermediate loading test . . . 80
A.37 Strain in n°7 stirrup on passive side until cracking for the intermediate loading test . . . 80
A.38 Strain in n°14 stirrup on passive side until cracking for the intermediate loading test . . . 81
A.39 Strain in slab bar at 1875 mm from passive side until cracking for the intermediate loading test . . . 81
A.40 Strain in slab transversal bar at 1555 mm from passive side until cracking for the intermediate loading test . . . 82
A.41 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the intermediate loading test . . . 82
A.42 Strain in slab bar n°8 at mid-span until cracking for the intermediate loading test . . . 83
A.43 Horizontal elongation at mid-span at failure for the central loading test . . 84
A.44 Strain in the slab at mid-span at failure for the central loading test 84
A.45 Strain on tendon at 600 mm from mid-span at failure for the central loading test . . . 85
A.46 Strain on tendon at 1500 mm active side from mid-span at failure for the central loading test . . . 85
A.47 Strain in n°6 stirrup on active side at failure for the central loading test . . 86
A.48 Strain in n°6 stirrup on passive side at failure for the central loading test . 86
A.49 Strain in n°4 stirrup on passive side at failure for the central loading test . 87
A.50 Strain in n°7 stirrup on passive side at failure for the central loading test . 87
A.51 Strain in n°14 stirrup on passive side at failure for the central loading test 88
A.52 Strain in slab bar at 1875 mm from passive side at failure for the central loading test . . . 88
A.53 Strain in slab transversal bar at 1555 mm from passive side at failure for the central loading test . . . 89

A.54 Strain in slab longitudinal bar at 1555 mm from passive side at failure for the central loading test 89
A.55 Strain in slab bar n°8 at mid-span at failure for the central loading test . . 90
A.56 Stem 1 strain gages position for the **DT** FRP Panel 91
A.57 Stem 2 strain gages position for the **DT** FRP Panel 92
A.58 Slab reinforcement strain gages position for the **DT** FRP Panel 93
A.59 Horizontal elongation at mid-span until cracking for the intermediate loading test 94
A.60 Strain in the slab at mid-span until cracking for the intermediate loading test 94
A.61 Strain in bottom tendon at mid-span until cracking for the intermediate loading test 95
A.62 Strain in bottom tendon at passive support until cracking for the intermediate loading test 95
A.63 Strain in n°6 stirrup on active side until cracking for the intermediate loading test 96
A.64 Strain in n°14 stirrup on active side stem 1 until cracking for the intermediate loading test 96
A.65 Strain in n°14 stirrup on active side stem 2 until cracking for the intermediate loading test 97
A.66 Strain in slab bar at 1875 mm from active side until cracking for the intermediate loading test 97
A.67 Strain in slab transversal bar at 1555 mm from active side until cracking for the intermediate loading test 98
A.68 Strain in slab longitudinal bar at 1555 mm from active side until cracking for the intermediate loading test 98
A.69 Strain in slab bar n°8 at mid-span until cracking for the intermediate loading test 99
A.70 Horizontal elongation at mid-span until cracking for the central loading test 100
A.71 Strain in the slab at mid-span until cracking for the central loading test . . 100
A.72 Strain in bottom tendon at mid-span until cracking for the central loading test 101
A.73 Strain in bottom tendon at passive support until cracking for the central loading test 101
A.74 Strain in n°6 stirrup on active side until cracking for the central loading test 102
A.75 Strain in n°14 stirrup on active side stem 1 until cracking for the central loading test 102
A.76 Strain in n°14 stirrup on active side stem 2 until cracking for the central loading test 103
A.77 Strain in slab bar at 1875 mm from active side until cracking for the central loading test 103
A.78 Strain in slab transversal bar at 1555 mm from active side until cracking for the central loading test 104
A.79 Strain in slab longitudinal bar at 1555 mm from active side until cracking for the central loading test 104
A.80 Strain in slab bar n°8 at mid-span until cracking for the central loading test 105

A.81 Horizontal elongation at mid-span until cracking for the shear loading test 106
A.82 Strain in the slab at mid-span until cracking for the shear loading test . . . 106
A.83 Strain in bottom tendon at mid-span until cracking for the shear loading test 107
A.84 Strain in nº6 stirrup on active side until cracking for the shear loading test 107
A.85 Strain in nº6 stirrup on passive side until cracking for the shear loading test 108
A.86 Strain in nº4 stirrup on passive side until cracking for the shear loading test 108
A.87 Strain in nº7 stirrup on passive side until cracking for the shear loading test 109
A.88 Strain in nº14 stirrup on active side stem 1 until cracking for the shear loading test 109
A.89 Strain in nº14 stirrup on active side stem 2 until cracking for the shear loading test 110
A.90 Strain in slab bar at 1875 mm from active side until cracking for the shear loading test 110
A.91 Strain in slab longitudinal bar at 1555 mm from active side until cracking for the shear loading test 111
A.92 Strain in slab bar nº8 at mid-span until cracking for the shear loading test 111
A.93 Horizontal elongation at mid-span at failure for the central loading test . . 112
A.94 Strain in the slab at mid-span at failure for the central loading test 112
A.95 Strain in bottom tendon at mid-span at failure for the central loading test 113
A.96 Strain in nº6 stirrup on active side at failure for the central loading test . . 113
A.97 Strain in nº6 stirrup on passive side at failure for the central loading test . 114
A.98 Strain in nº4 stirrup on passive side at failure for the central loading test . 114
A.99 Strain in nº7 stirrup on passive side at failure for the central loading test . 115
A.100 Strain in nº14 stirrup on active side stem 1 at failure for the central loading test 115
A.101 Strain in nº14 stirrup on active side stem 2 at failure for the central loading test 116
A.102 Strain in slab bar at 1875 mm from active side at failure for the central loading test 116
A.103 Strain in slab longitudinal bar at 1555 mm from active side at failure for the central loading test 117
A.104 Strain in slab bar nº8 at mid-span at failure for the central loading test . . 117
A.105 Stem strain gages position for the **ST** FRP Panel 118
A.106 LVDT's position for the **ST** FRP Panel 119
A.107 Strain in the slab at mid-span until cracking for the central loading test . . 120
A.108 Strain on the top slab at mid-span until cracking for the central loading test 120
A.109 Strain on the stem at mid-span until cracking for the central loading test . 121
A.110 Strain on tendons at mid-span until cracking for the central loading test . . 121
A.111 Strain on concrete at the same level as the tendons at mid-span until cracking for the central loading test 122
A.112 Strain on stem 2 tendons at passive side until cracking for the central loading test 122
A.113 Strain on tendon at 1500 mm from active side until cracking for the central loading test 123
A.114 Strain in nº6 stirrup on passive side until cracking for the central loading test 123

A.115 Strain in nº4 stirrup on active side until cracking for the central loading test 124
A.116 Strain in nº6 stirrup on active side until cracking for the central loading test 124
A.117 Strain in nº7 stirrup on active side until cracking for the central loading test 125
A.118 Strain in 45º strain gages on concrete at active support until cracking for the central loading test 125
A.119 Strain in nº14 stirrup on passive side until cracking for the central loading test 126
A.120 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the central loading test 126
A.121 Strain in the slab at mid-span until cracking for the shear loading test . . . 127
A.122 Strain on the top slab at mid-span until cracking for the shear loading test 127
A.123 Strain on the stem at mid-span until cracking for the shear loading test . . 128
A.124 Strain on tendons at mid-span until cracking for the shear loading test . . 128
A.125 Strain on concrete at the same level as the tendons at mid-span until cracking for the shear loading test 129
A.126 Strain in nº6 stirrup on passive side until cracking for the shear loading test 129
A.127 Strain in nº4 stirrup on active side until cracking for the shear loading test 130
A.128 Strain in nº6 stirrup on active side until cracking for the shear loading test 130
A.129 Strain in nº7 stirrup on active side until cracking for the shear loading test 131
A.130 Strain in 45º strain gages on concrete at active support until cracking for the shear loading test 131
A.131 Strain in nº14 stirrup on passive side until cracking for the shear loading test 132
A.132 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the shear loading test 132
A.133 Strain in the slab at mid-span until cracking for the intermediate loading test 133
A.134 Strain on the top slab at mid-span until cracking for the intermediate loading test 133
A.135 Strain on the stem at mid-span until cracking for the intermediate loading test 134
A.136 Strain on tendons at mid-span until cracking for the intermediate loading test 134
A.137 Strain on concrete at the same level as the tendons at mid-span until cracking for the intermediate loading test 135
A.138 Strain on tendon at 1500 mm from active side until cracking for the intermediate loading test 135
A.139 Strain in nº6 stirrup on passive side until cracking for the intermediate loading test 136
A.140 Strain in nº4 stirrup on active side until cracking for the intermediate loading test 136
A.141 Strain in nº6 stirrup on active side until cracking for the intermediate loading test 137
A.142 Strain in nº7 stirrup on active side until cracking for the intermediate loading test 137
A.143 Strain in 45º strain gages on concrete at active support until cracking for the intermediate loading test 138

A.144 Strain in nº14 stirrup on passive side until cracking for the intermediate loading test . . . 138
A.145 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the intermediate loading test . . . 139
A.146 Strain in the slab at mid-span at failure for the central loading test . . . 140
A.147 Strain on the top slab at mid-span at failure for the central loading test . . 140
A.148 Strain on the stem at mid-span at failure for the central loading test . . . 141
A.149 Strain on tendons at mid-span at failure for the central loading test . . . 141
A.150 Strain on concrete at the same level as the tendons at mid-span at failure for the central loading test . . . 142
A.151 Strain in nº6 stirrup on passive side at failure for the central loading test . 142
A.152 Strain in nº4 stirrup on active side at failure for the central loading test . . 143
A.153 Strain in nº6 stirrup on active side at failure for the central loading test . . 143
A.154 Strain in nº7 stirrup on active side at failure for the central loading test . . 144
A.155 Strain in 45º strain gages on concrete at active support at failure for the central loading test . . . 144
A.156 Strain in nº14 stirrup on passive side at failure for the central loading test 145
A.157 Strain in slab longitudinal bar at 1555 mm from passive side at failure for the central loading test . . . 145
A.158 Stem strain gages position for the **ST** Steel Panel . . . 146
A.159 LVDT's position for the **ST** Steel Panel . . . 147
A.160 Strain in the slab at mid-span until cracking for the central loading test . . 148
A.161 Strain on the top slab at mid-span until cracking for the central loading test 148
A.162 Strain on the stem at mid-span until cracking for the central loading test . 149
A.163 Strain on tendons at mid-span until cracking for the central loading test . . 149
A.164 Strain on concrete at the same level as the tendons at mid-span until cracking for the central loading test . . . 150
A.165 Strain on stem 2 tendons at passive side until cracking for the central loading test . . . 150
A.166 Strain on tendon at 1500 mm from active side until cracking for the central loading test . . . 151
A.167 Strain in nº6 stirrup on active side until cracking for the central loading test 151
A.168 Strain in nº4 stirrup on passive side until cracking for the central loading test 152
A.169 Strain in nº6 stirrup on passive side until cracking for the central loading test 152
A.170 Strain in nº7 stirrup on passive side until cracking for the central loading test 153
A.171 Strain in 45º strain gages on concrete at passive support until cracking for the central loading test . . . 153
A.172 Strain in nº14 stirrup on active side until cracking for the central loading test 154
A.173 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the central loading test . . . 154
A.174 Strain in the slab at mid-span until cracking for the shear loading test . . . 155
A.175 Strain on the top slab at mid-span until cracking for the shear loading test 156
A.176 Strain on the stem at mid-span until cracking for the shear loading test . . 156
A.177 Strain on tendons at mid-span until cracking for the shear loading test . . 157

A.178 Strain on concrete at the same level as the tendons at mid-span until cracking for the shear loading test . . . 157
A.179 Strain on stem 2 tendons at passive side until cracking for the shear loading test . . . 158
A.180 Strain on tendon at 1500 mm from active side until cracking for the shear loading test . . . 158
A.181 Strain in n°6 stirrup on active side until cracking for the shear loading test 159
A.182 Strain in n°4 stirrup on passive side until cracking for the shear loading test 159
A.183 Strain in n°6 stirrup on passive side until cracking for the shear loading test 160
A.184 Strain in n°7 stirrup on passive side until cracking for the shear loading test 160
A.185 Strain in 45° strain gages on concrete at passive support until cracking for the shear loading test . . . 161
A.186 Strain in n°14 stirrup on active side until cracking for the shear loading test 161
A.187 Strain in slab longitudinal bar at 1555 mm from passive side until cracking for the shear loading test . . . 162
A.188 Strain in the slab at mid-span at failure for the central loading test . . . 163
A.189 Strain on the top slab at mid-span at failure for the central loading test . . 163
A.190 Strain on the stem at mid-span at failure for the central loading test . . . 164
A.191 Strain on tendons at mid-span at failure for the central loading test . . . 164
A.192 Strain on concrete at the same level as the tendons at mid-span at failure for the central loading test . . . 165
A.193 Strain on stem 2 tendons at passive side at failure for the central loading test 165
A.194 Strain on tendon at 1500 mm from active side at failure for the central loading test . . . 166
A.195 Strain in n°6 stirrup on active side at failure for the central loading test . . 166
A.196 Strain in n°4 stirrup on passive side at failure for the central loading test . 167
A.197 Strain in n°6 stirrup on passive side at failure for the central loading test . 167
A.198 Strain in n°7 stirrup on passive side at failure for the central loading test . 168
A.199 Strain in 45° strain gages on concrete at passive at failure cracking for the central loading test . . . 168
A.200 Strain in n°14 stirrup on active side at failure for the central loading test . 169
A.201 Strain in slab longitudinal bar at 1555 mm from passive side at failure for the central loading test . . . 169