**Novel hybrid machine learning models for failure mode identification and shear strength prediction of rectangular hollow RC columns subjected to compressive and lateral loads**

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**1. Results of shear strength prediction**

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**Fig. S-1.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 50.

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**Fig. S-2.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 100.

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**Fig. S-3.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 150.

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**Fig. S-4.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 200.

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**Fig. S-5.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 250.

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**Fig. S-6.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 300.

**Table S-1** Performance of MFO-AB models on the training set

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pop** | **Tr.atio** | **R2** | **Score** | **A10** | **Score** | **RMSE** | **Score** | **MAE** | **Score** | **Total** |
| 50 | 0.55 | 0.987 | 45 | 0.409 | 34 | 70.126 | 46 | 52.952 | 46 | 171 |
|  | 0.60 | 0.984 | 34 | 0.403 | 30 | 76.702 | 35 | 56.795 | 42 | 141 |
|  | 0.65 | 0.985 | 40 | 0.41 | 36 | 73.003 | 41 | 57.07 | 41 | 158 |
|  | 0.70 | 0.976 | 5 | 0.333 | 3 | 88.287 | 19 | 68.844 | 19 | 46 |
|  | 0.75 | 0.983 | 32 | 0.378 | 15 | 79.096 | 32 | 60.653 | 32 | 111 |
|  | 0.80 | 0.977 | 7 | 0.365 | 10 | 96.286 | 6 | 75.644 | 6 | 29 |
|  | 0.85 | 0.978 | 13 | 0.402 | 28 | 90.456 | 14 | 72.539 | 8 | 63 |
|  | 0.90 | 0.977 | 7 | 0.398 | 23 | 90.623 | 13 | 72.1 | 12 | 55 |
| 100 | 0.55 | 0.987 | 45 | 0.394 | 21 | 70.701 | 44 | 52.185 | 48 | 158 |
|  | 0.60 | 0.984 | 34 | 0.431 | 43 | 76.211 | 36 | 57.689 | 39 | 152 |
|  | 0.65 | 0.985 | 40 | 0.385 | 19 | 73.068 | 40 | 57.189 | 40 | 139 |
|  | 0.70 | 0.981 | 23 | 0.31 | 2 | 78.527 | 33 | 61.746 | 29 | 87 |
|  | 0.75 | 0.98 | 20 | 0.344 | 4 | 84.675 | 23 | 62.818 | 26 | 73 |
|  | 0.80 | 0.976 | 5 | 0.396 | 22 | 97.223 | 4 | 76.202 | 3 | 34 |
|  | 0.85 | 0.975 | 3 | 0.363 | 8 | 97.023 | 5 | 75.87 | 5 | 21 |
|  | 0.90 | 0.977 | 7 | 0.37 | 12 | 91.78 | 10 | 71.956 | 13 | 42 |
| 150 | 0.55 | 0.988 | 48 | 0.409 | 34 | 69.148 | 48 | 52.983 | 45 | 175 |
|  | 0.60 | 0.984 | 34 | 0.417 | 39 | 76.96 | 34 | 57.777 | 38 | 145 |
|  | 0.65 | 0.984 | 34 | 0.436 | 45 | 75.357 | 37 | 57.8 | 37 | 153 |
|  | 0.70 | 0.981 | 23 | 0.405 | 32 | 79.382 | 31 | 63.445 | 25 | 111 |
|  | 0.75 | 0.982 | 29 | 0.378 | 15 | 79.729 | 30 | 62.651 | 27 | 101 |
|  | 0.80 | 0.981 | 23 | 0.427 | 42 | 87.773 | 21 | 70.074 | 17 | 103 |
|  | 0.85 | 0.978 | 13 | 0.431 | 43 | 92.257 | 8 | 72.323 | 11 | 75 |
|  | 0.90 | 0.977 | 7 | 0.398 | 23 | 90.982 | 12 | 71.491 | 14 | 56 |
| 200 | 0.55 | 0.981 | 23 | 0.348 | 6 | 85.943 | 22 | 66.223 | 21 | 72 |
|  | 0.60 | 0.987 | 45 | 0.5 | 48 | 69.863 | 47 | 52.317 | 47 | 187 |
|  | 0.65 | 0.98 | 20 | 0.372 | 13 | 83.746 | 24 | 64.188 | 22 | 79 |
|  | 0.70 | 0.984 | 34 | 0.405 | 32 | 72.566 | 42 | 57.981 | 36 | 144 |
|  | 0.75 | 0.982 | 29 | 0.422 | 40 | 80.781 | 27 | 63.805 | 24 | 120 |
|  | 0.80 | 0.974 | 1 | 0.375 | 14 | 101.852 | 1 | 77.96 | 1 | 17 |
|  | 0.85 | 0.979 | 18 | 0.412 | 38 | 89.133 | 17 | 70.036 | 18 | 91 |
|  | 0.90 | 0.978 | 13 | 0.398 | 23 | 89.398 | 16 | 70.921 | 15 | 67 |
| 250 | 0.55 | 0.98 | 20 | 0.424 | 41 | 88.168 | 20 | 59.17 | 33 | 114 |
|  | 0.60 | 0.986 | 44 | 0.403 | 30 | 72.085 | 43 | 55.454 | 44 | 161 |
|  | 0.65 | 0.984 | 34 | 0.436 | 45 | 75.273 | 38 | 58.513 | 34 | 151 |
|  | 0.70 | 0.981 | 23 | 0.381 | 17 | 80.034 | 28 | 62.09 | 28 | 96 |
|  | 0.75 | 0.985 | 40 | 0.389 | 20 | 73.078 | 39 | 58.298 | 35 | 134 |
|  | 0.80 | 0.979 | 18 | 0.365 | 10 | 91.477 | 11 | 72.679 | 7 | 46 |
|  | 0.85 | 0.974 | 1 | 0.363 | 8 | 99.956 | 3 | 76.143 | 4 | 16 |
|  | **0.90** | 0.978 | 13 | 0.361 | 7 | 88.557 | 18 | 70.516 | 16 | 54 |
| 300 | 0.55 | 0.983 | 32 | 0.439 | 47 | 81.524 | 26 | 60.839 | 31 | 136 |
|  | 0.60 | 0.978 | 13 | 0.292 | 1 | 89.47 | 15 | 67.203 | 20 | 49 |
|  | 0.65 | 0.982 | 29 | 0.41 | 36 | 79.821 | 29 | 60.922 | 30 | 124 |
|  | 0.70 | 0.985 | 40 | 0.381 | 17 | 70.241 | 45 | 55.487 | 43 | 145 |
|  | 0.75 | 0.981 | 23 | 0.4 | 27 | 82.176 | 25 | 63.868 | 23 | 98 |
|  | 0.80 | 0.975 | 3 | 0.344 | 4 | 100.356 | 2 | 77.55 | 2 | 11 |
|  | 0.85 | 0.977 | 7 | 0.402 | 28 | 94.418 | 7 | 72.519 | 9 | 51 |
|  | 0.90 | 0.977 | 7 | 0.398 | 23 | 91.916 | 9 | 72.341 | 10 | 49 |

**Table S-2** Performance of MFO-AB models on the test set

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pop** | **Tr.atio** | **R2** | **Score** | **A10** | **Score** | **RMSE** | **Score** | **MAE** | **Score** | **Total** |
| 50 | 0.55 | 0.394 | 23 | 0.2 | 16 | 534.093 | 25 | 235.775 | 26 | 90 |
|  | 0.60 | 0.386 | 20 | 0.163 | 8 | 563.275 | 22 | 254.094 | 15 | 65 |
|  | 0.65 | 0.364 | 12 | 0.209 | 17 | 601.924 | 13 | 261.272 | 11 | 53 |
|  | 0.70 | 0.345 | 6 | 0.162 | 7 | 646.98 | 4 | 299.193 | 2 | 19 |
|  | 0.75 | 0.343 | 4 | 0.194 | 15 | 637.805 | 9 | 251.605 | 17 | 45 |
|  | **0.80** | **0.916** | **47** | **0.36** | **46** | **212.269** | **48** | **120.163** | **45** | **186** |
|  | 0.85 | 0.913 | 37 | 0.263 | 38 | 242.169 | 39 | 148.985 | 39 | 153 |
|  | 0.90 | 0.912 | 32 | 0.231 | 26 | 281.647 | 33 | 176.224 | 36 | 127 |
| 100 | 0.55 | 0.434 | 28 | 0.255 | 31 | 515.996 | 28 | 212.943 | 29 | 116 |
|  | 0.60 | 0.384 | 19 | 0.143 | 3 | 563.957 | 21 | 260.252 | 14 | 57 |
|  | 0.65 | 0.404 | 24 | 0.233 | 30 | 582.614 | 17 | 236.859 | 25 | 96 |
|  | 0.70 | 0.334 | 1 | 0.135 | 2 | 652.819 | 1 | 300.991 | 1 | 5 |
|  | 0.75 | 0.367 | 14 | 0.29 | 41 | 626.229 | 12 | 247.233 | 22 | 89 |
|  | 0.80 | 0.916 | 47 | 0.32 | 44 | 212.279 | 47 | 120.043 | 47 | 185 |
|  | 0.85 | 0.913 | 37 | 0.211 | 20 | 243.149 | 37 | 150.489 | 38 | 132 |
|  | 0.90 | 0.911 | 31 | 0.231 | 26 | 282.735 | 31 | 176.87 | 32 | 120 |
| 150 | 0.55 | 0.437 | 30 | 0.255 | 31 | 514.456 | 30 | 207.588 | 30 | 121 |
|  | 0.60 | 0.383 | 18 | 0.143 | 3 | 564.351 | 20 | 261.922 | 10 | 51 |
|  | 0.65 | 0.41 | 25 | 0.256 | 34 | 579.975 | 18 | 239.068 | 23 | 100 |
|  | 0.70 | 0.35 | 9 | 0.189 | 13 | 644.564 | 6 | 292.507 | 4 | 32 |
|  | 0.75 | 0.352 | 11 | 0.258 | 35 | 633.228 | 11 | 251.047 | 20 | 77 |
|  | 0.80 | 0.915 | 42 | 0.36 | 46 | 213.416 | 44 | 122.014 | 44 | 176 |
|  | 0.85 | 0.913 | 37 | 0.211 | 20 | 242.873 | 38 | 151.225 | 37 | 132 |
|  | 0.90 | 0.912 | 32 | 0.231 | 26 | 280.924 | 36 | 176.298 | 35 | 129 |
| 200 | 0.55 | 0.42 | 27 | 0.182 | 10 | 522.455 | 27 | 228.247 | 27 | 91 |
|  | 0.60 | 0.389 | 21 | 0.184 | 11 | 561.761 | 23 | 251.039 | 21 | 76 |
|  | 0.65 | 0.367 | 14 | 0.186 | 12 | 600.823 | 15 | 269.024 | 7 | 48 |
|  | 0.70 | 0.345 | 6 | 0.189 | 13 | 647.141 | 3 | 292.265 | 5 | 27 |
|  | 0.75 | 0.351 | 10 | 0.258 | 35 | 633.792 | 10 | 251.556 | 18 | 73 |
|  | 0.80 | 0.915 | 42 | 0.28 | 40 | 213.524 | 43 | 123.486 | 43 | 168 |
|  | 0.85 | 0.915 | 42 | 0.211 | 20 | 239.853 | 42 | 145.286 | 41 | 145 |
|  | 0.90 | 0.912 | 32 | 0.308 | 42 | 281.964 | 32 | 176.948 | 31 | 137 |
| 250 | 0.55 | 0.435 | 29 | 0.255 | 31 | 515.489 | 29 | 223.339 | 28 | 117 |
|  | 0.60 | 0.381 | 17 | 0.143 | 3 | 565.451 | 19 | 261.004 | 12 | 51 |
|  | 0.65 | 0.369 | 16 | 0.209 | 17 | 599.655 | 16 | 260.479 | 13 | 62 |
|  | 0.70 | 0.349 | 8 | 0.216 | 23 | 645.019 | 5 | 297.519 | 3 | 39 |
|  | 0.75 | 0.34 | 2 | 0.226 | 25 | 639.164 | 7 | 251.088 | 19 | 53 |
|  | 0.80 | 0.915 | 42 | 0.4 | 48 | 212.414 | 46 | 120.107 | 46 | 182 |
|  | 0.85 | 0.914 | 40 | 0.316 | 43 | 240.98 | 40 | 145.868 | 40 | 163 |
|  | 0.90 | 0.912 | 32 | 0.154 | 6 | 281.003 | 35 | 176.751 | 33 | 106 |
| 300 | 0.55 | 0.415 | 26 | 0.164 | 9 | 524.734 | 26 | 238.139 | 24 | 85 |
|  | 0.60 | 0.389 | 21 | 0.122 | 1 | 561.713 | 24 | 263.697 | 9 | 55 |
|  | 0.65 | 0.365 | 13 | 0.209 | 17 | 601.72 | 14 | 266.365 | 8 | 52 |
|  | 0.70 | 0.344 | 5 | 0.216 | 23 | 647.671 | 2 | 292.247 | 6 | 36 |
|  | 0.75 | 0.342 | 3 | 0.258 | 35 | 638.124 | 8 | 252.167 | 16 | 62 |
|  | 0.80 | 0.915 | 42 | 0.32 | 44 | 212.708 | 45 | 119.87 | 48 | 179 |
|  | 0.85 | 0.914 | 40 | 0.263 | 38 | 240.79 | 41 | 144.44 | 42 | 161 |
|  | 0.90 | 0.912 | 32 | 0.231 | 26 | 281.193 | 34 | 176.324 | 34 | 126 |

**2. Results of failure modes identification**

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**Fig. S-7.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 50.

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**Fig. S-8.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 100.

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A picture containing screenshot, text, colorfulness, graphics

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**Fig. S-9.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 150.

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A picture containing screenshot, colorfulness, graphics, graphic design

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**Fig. S-10.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 200.

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**Fig. S-11.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 250.

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**Fig. S-12.** Effect of training-test ratios on the MFO-AB model’s performance with population size of 300.

**Table S-3** Performance of MFO-AB models on the training set

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pop** | **Tr.atio** | **Acc** | **Score** | **Pre** | **Score** | **Re** | **Score** | **f1** | **Score** | **Total** |
| 50 | 0.55 | 0.72 | 1 | 0.728 | 1 | 0.72 | 1 | 0.723 | 1 | 4 |
|  | 0.60 | 0.817 | 11 | 0.818 | 9 | 0.817 | 11 | 0.816 | 11 | 42 |
|  | 0.65 | 0.831 | 15 | 0.84 | 15 | 0.831 | 15 | 0.83 | 15 | 60 |
|  | 0.70 | 0.852 | 27 | 0.855 | 25 | 0.852 | 27 | 0.852 | 28 | 107 |
|  | 0.75 | 0.847 | 25 | 0.855 | 27 | 0.847 | 25 | 0.848 | 24 | 101 |
|  | 0.80 | 0.911 | 47 | 0.913 | 47 | 0.911 | 47 | 0.912 | 47 | 188 |
|  | 0.85 | 0.845 | 23 | 0.852 | 22 | 0.845 | 23 | 0.846 | 23 | 91 |
|  | 0.90 | 0.86 | 30 | 0.875 | 33 | 0.86 | 30 | 0.863 | 31 | 124 |
| 100 | 0.55 | 0.79 | 5 | 0.799 | 5 | 0.79 | 5 | 0.792 | 5 | 20 |
|  | 0.60 | 0.761 | 2 | 0.778 | 2 | 0.761 | 2 | 0.765 | 2 | 8 |
|  | 0.65 | 0.873 | 33 | 0.872 | 32 | 0.873 | 33 | 0.872 | 33 | 131 |
|  | 0.70 | 0.875 | 36 | 0.879 | 36 | 0.875 | 36 | 0.876 | 36 | 144 |
|  | 0.75 | 0.803 | 9 | 0.816 | 8 | 0.803 | 9 | 0.806 | 9 | 35 |
|  | 0.80 | 0.836 | 16 | 0.84 | 16 | 0.836 | 16 | 0.836 | 16 | 64 |
|  | 0.85 | 0.845 | 23 | 0.855 | 24 | 0.845 | 23 | 0.848 | 25 | 95 |
|  | 0.90 | 0.89 | 41 | 0.9 | 44 | 0.89 | 41 | 0.891 | 41 | 167 |
| 150 | 0.55 | 0.78 | 4 | 0.786 | 4 | 0.78 | 4 | 0.782 | 4 | 16 |
|  | 0.60 | 0.844 | 22 | 0.847 | 19 | 0.844 | 22 | 0.845 | 22 | 85 |
|  | 0.65 | 0.856 | 29 | 0.857 | 29 | 0.856 | 29 | 0.856 | 29 | 116 |
|  | 0.70 | 0.844 | 19 | 0.848 | 20 | 0.844 | 19 | 0.843 | 19 | 77 |
|  | 0.75 | 0.818 | 13 | 0.827 | 10 | 0.818 | 13 | 0.817 | 12 | 48 |
|  | 0.80 | 0.89 | 42 | 0.897 | 42 | 0.89 | 42 | 0.891 | 42 | 168 |
|  | **0.85** | **0.839** | **17** | **0.843** | **17** | **0.839** | **17** | **0.84** | **17** | **68** |
|  | 0.90 | 0.799 | 8 | 0.837 | 13 | 0.799 | 8 | 0.805 | 8 | 37 |
| 200 | 0.55 | 0.86 | 31 | 0.868 | 31 | 0.86 | 31 | 0.86 | 30 | 123 |
|  | 0.60 | 0.862 | 32 | 0.864 | 30 | 0.862 | 32 | 0.863 | 32 | 126 |
|  | 0.65 | 0.881 | 38 | 0.889 | 39 | 0.881 | 38 | 0.883 | 38 | 153 |
|  | 0.70 | 0.844 | 19 | 0.846 | 18 | 0.844 | 19 | 0.845 | 20 | 76 |
|  | 0.75 | 0.818 | 13 | 0.836 | 12 | 0.818 | 13 | 0.82 | 13 | 51 |
|  | 0.80 | 0.89 | 42 | 0.895 | 41 | 0.89 | 42 | 0.891 | 43 | 168 |
|  | 0.85 | 0.897 | 44 | 0.9 | 45 | 0.897 | 44 | 0.898 | 45 | 178 |
|  | 0.90 | 0.817 | 12 | 0.838 | 14 | 0.817 | 12 | 0.821 | 14 | 52 |
| 250 | 0.55 | 0.92 | 48 | 0.929 | 48 | 0.92 | 48 | 0.92 | 48 | 192 |
|  | 0.60 | 0.798 | 6 | 0.805 | 6 | 0.798 | 6 | 0.8 | 7 | 25 |
|  | 0.65 | 0.873 | 33 | 0.877 | 35 | 0.873 | 33 | 0.873 | 34 | 135 |
|  | 0.70 | 0.852 | 27 | 0.855 | 26 | 0.852 | 27 | 0.852 | 27 | 107 |
|  | 0.75 | 0.839 | 18 | 0.856 | 28 | 0.839 | 18 | 0.842 | 18 | 82 |
|  | 0.80 | 0.897 | 45 | 0.9 | 43 | 0.897 | 45 | 0.898 | 44 | 177 |
|  | 0.85 | 0.903 | 46 | 0.905 | 46 | 0.903 | 46 | 0.904 | 46 | 184 |
|  | 0.90 | 0.884 | 39 | 0.887 | 38 | 0.884 | 39 | 0.885 | 40 | 156 |
| 300 | 0.55 | 0.88 | 37 | 0.889 | 40 | 0.88 | 37 | 0.88 | 37 | 151 |
|  | 0.60 | 0.798 | 6 | 0.811 | 7 | 0.798 | 6 | 0.799 | 6 | 25 |
|  | 0.65 | 0.873 | 33 | 0.875 | 34 | 0.873 | 33 | 0.874 | 35 | 135 |
|  | 0.70 | 0.844 | 19 | 0.85 | 21 | 0.844 | 19 | 0.845 | 21 | 80 |
|  | 0.75 | 0.847 | 25 | 0.852 | 23 | 0.847 | 25 | 0.849 | 26 | 99 |
|  | 0.80 | 0.815 | 10 | 0.828 | 11 | 0.815 | 10 | 0.815 | 10 | 41 |
|  | 0.85 | 0.768 | 3 | 0.78 | 3 | 0.768 | 3 | 0.772 | 3 | 12 |
|  | 0.90 | 0.884 | 39 | 0.884 | 37 | 0.884 | 39 | 0.884 | 39 | 154 |

**Table S-4** Performance of MFO-AB models on the test set

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pop** | **Tr.atio** | **Acc** | **Score** | **Pre** | **Score** | **Re** | **Score** | **f1** | **Score** | **Total** |
| 50 | 0.55 | 0.663 | 4 | 0.671 | 4 | 0.663 | 4 | 0.666 | 4 | 16 |
|  | 0.60 | 0.703 | 8 | 0.707 | 8 | 0.703 | 8 | 0.702 | 8 | 32 |
|  | 0.65 | 0.677 | 5 | 0.717 | 11 | 0.677 | 5 | 0.68 | 5 | 26 |
|  | 0.70 | 0.727 | 16 | 0.733 | 14 | 0.727 | 16 | 0.729 | 16 | 62 |
|  | 0.75 | 0.761 | 23 | 0.761 | 22 | 0.761 | 23 | 0.76 | 23 | 91 |
|  | 0.80 | 0.811 | 35 | 0.815 | 32 | 0.811 | 35 | 0.81 | 35 | 137 |
|  | 0.85 | 0.75 | 20 | 0.754 | 19 | 0.75 | 20 | 0.75 | 20 | 79 |
|  | 0.90 | 0.842 | 43 | 0.865 | 44 | 0.842 | 43 | 0.841 | 44 | 174 |
| 100 | 0.55 | 0.711 | 13 | 0.736 | 15 | 0.711 | 13 | 0.711 | 12 | 53 |
|  | 0.60 | 0.635 | 1 | 0.642 | 1 | 0.635 | 1 | 0.638 | 1 | 4 |
|  | 0.65 | 0.785 | 25 | 0.793 | 26 | 0.785 | 25 | 0.785 | 27 | 103 |
|  | 0.70 | 0.8 | 29 | 0.806 | 29 | 0.8 | 29 | 0.802 | 29 | 116 |
|  | 0.75 | 0.804 | 31 | 0.808 | 30 | 0.804 | 31 | 0.805 | 34 | 126 |
|  | 0.80 | 0.784 | 24 | 0.793 | 25 | 0.784 | 24 | 0.783 | 24 | 97 |
|  | 0.85 | 0.821 | 38 | 0.818 | 34 | 0.821 | 38 | 0.818 | 38 | 148 |
|  | 0.90 | 0.842 | 43 | 0.845 | 43 | 0.842 | 43 | 0.841 | 43 | 172 |
| 150 | 0.55 | 0.711 | 13 | 0.712 | 9 | 0.711 | 13 | 0.712 | 13 | 48 |
|  | 0.60 | 0.649 | 2 | 0.658 | 2 | 0.649 | 2 | 0.652 | 2 | 8 |
|  | 0.65 | 0.723 | 15 | 0.726 | 13 | 0.723 | 15 | 0.725 | 15 | 58 |
|  | 0.70 | 0.8 | 29 | 0.826 | 36 | 0.8 | 29 | 0.803 | 30 | 124 |
|  | 0.75 | 0.804 | 31 | 0.81 | 31 | 0.804 | 31 | 0.805 | 33 | 126 |
|  | 0.80 | 0.838 | 41 | 0.845 | 42 | 0.838 | 41 | 0.84 | 42 | 166 |
|  | **0.85** | **0.893** | **47** | **0.908** | **48** | **0.893** | **47** | **0.888** | **47** | **189** |
|  | 0.90 | 0.789 | 26 | 0.837 | 38 | 0.789 | 26 | 0.785 | 26 | 116 |
| 200 | 0.55 | 0.747 | 17 | 0.747 | 17 | 0.747 | 17 | 0.747 | 17 | 68 |
|  | 0.60 | 0.703 | 8 | 0.704 | 6 | 0.703 | 8 | 0.703 | 10 | 32 |
|  | 0.65 | 0.754 | 21 | 0.786 | 23 | 0.754 | 21 | 0.758 | 22 | 87 |
|  | 0.70 | 0.818 | 37 | 0.838 | 39 | 0.818 | 37 | 0.817 | 37 | 150 |
|  | 0.75 | 0.804 | 31 | 0.816 | 33 | 0.804 | 31 | 0.804 | 31 | 126 |
|  | 0.80 | 0.838 | 41 | 0.839 | 40 | 0.838 | 41 | 0.838 | 41 | 163 |
|  | 0.85 | 0.821 | 38 | 0.827 | 37 | 0.821 | 38 | 0.819 | 39 | 152 |
|  | 0.90 | 0.684 | 6 | 0.702 | 5 | 0.684 | 6 | 0.682 | 6 | 23 |
| 250 | 0.55 | 0.747 | 17 | 0.754 | 20 | 0.747 | 17 | 0.748 | 19 | 73 |
|  | 0.60 | 0.703 | 8 | 0.706 | 7 | 0.703 | 8 | 0.703 | 9 | 32 |
|  | 0.65 | 0.708 | 11 | 0.714 | 10 | 0.708 | 11 | 0.71 | 11 | 43 |
|  | 0.70 | 0.855 | 45 | 0.867 | 45 | 0.855 | 45 | 0.855 | 46 | 181 |
|  | 0.75 | 0.826 | 40 | 0.843 | 41 | 0.826 | 40 | 0.824 | 40 | 161 |
|  | 0.80 | 0.811 | 35 | 0.822 | 35 | 0.811 | 35 | 0.814 | 36 | 141 |
|  | 0.85 | 0.893 | 47 | 0.893 | 47 | 0.893 | 47 | 0.891 | 48 | 189 |
|  | 0.90 | 0.789 | 26 | 0.8 | 27 | 0.789 | 26 | 0.784 | 25 | 104 |
| 300 | 0.55 | 0.747 | 17 | 0.747 | 17 | 0.747 | 17 | 0.747 | 17 | 68 |
|  | 0.60 | 0.662 | 3 | 0.67 | 3 | 0.662 | 3 | 0.665 | 3 | 12 |
|  | 0.65 | 0.708 | 11 | 0.726 | 12 | 0.708 | 11 | 0.712 | 14 | 48 |
|  | 0.70 | 0.691 | 7 | 0.742 | 16 | 0.691 | 7 | 0.686 | 7 | 37 |
|  | 0.75 | 0.804 | 31 | 0.804 | 28 | 0.804 | 31 | 0.804 | 32 | 122 |
|  | 0.80 | 0.757 | 22 | 0.758 | 21 | 0.757 | 22 | 0.755 | 21 | 86 |
|  | 0.85 | 0.857 | 46 | 0.885 | 46 | 0.857 | 46 | 0.847 | 45 | 183 |
|  | 0.90 | 0.789 | 26 | 0.792 | 24 | 0.789 | 26 | 0.788 | 28 | 104 |

A screenshot of a computer

Description automatically generated with low confidenceA screenshot of a computer

Description automatically generated with low confidence

**Fig. S-13.** Performance of MFO-AGB models.