Supplementary Material: Critical evaluation of metaheuristic algorithms for weight minimization of truss structures

# Supplementary Tables

**Table S1:** Statistical evaluation of algorithms’ performance in the planar 18-bar truss problem.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 9639.770 | 77.545 | 9589.927 | 38.382 | 9569.174 | 0.418 | 9697.989 | 82.286 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 9569.286 | 9874.173 | 9569.157 | 9710.503 | 9568.743 | 9570.611 | 9575.560 | 9863.105 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 18.657 | 25.221 | 19.520 | 23.041 | 20.247 | 20.741 | 16.109 | 26.763 |
| 2 | 25.009 | 31.692 | 25.206 | 31.050 | 28.673 | 29.284 | 25.181 | 32.775 |
| 3 | 8.659 | 12.678 | 9.232 | 11.685 | 9.578 | 10.139 | 6.663 | 14.717 |
| 4 | 12.541 | 18.817 | 12.632 | 16.837 | 14.770 | 15.082 | 12.783 | 20.649 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 9568.718 | 0.002 | 9568.717 | 0.001 | 9568.742 | 0.017 | 9569.484 | 0.445 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 9568.716 | 9568.726 | 9568.716 | 9568.719 | 9568.722 | 9568.796 | 9568.916 | 9570.512 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 20.503 | 20.544 | 20.503 | 20.529 | 20.459 | 20.553 | 20.337 | 20.863 |
| 2 | 28.888 | 28.923 | 28.894 | 28.919 | 28.873 | 28.940 | 28.641 | 29.124 |
| 3 | 9.771 | 9.795 | 9.769 | 9.792 | 9.741 | 9.826 | 9.536 | 9.950 |
| 4 | 14.931 | 14.958 | 14.937 | 14.951 | 14.900 | 15.001 | 14.702 | 15.150 |

Table S2: Comparison of best designs obtained in the spatial 25-bar tower problem (The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3)).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Lee and Geem (HS) | Sonmez (ABC‑AP) | Li et al. (HPSO) | Li et al. (PSOPC) | Lamberti (CMLPSA) | Kaveh and Talatahari (HPSACO) |
| 1 | 0.047 | 0.011 | 0.010 | 0.010 | 0.0100 | 0.010 |
| 2 | 2.022 | 1.979 | 1.970 | 1.979 | 1.9870 | 2.054 |
| 3 | 2.950 | 3.003 | 3.016 | 3.011 | 2.9935 | 3.008 |
| 4 | 0.010 | 0.010 | 0.010 | 0.100 | 0.0100 | 0.010 |
| 5 | 0.014 | 0.010 | 0.010 | 0.100 | 0.0100 | 0.010 |
| 6 | 0.688 | 0.690 | 0.694 | 0.657 | 0.6840 | 0.679 |
| 7 | 1.657 | 1.679 | 1.681 | 1.678 | 1.6769 | 1.611 |
| 8 | 2.663 | 2.652 | 2.643 | 2.693 | 2.6621 | 2.678 |
| Weight [lb] | 544.365 | 545.206 | 545.238 | 547.965 | 545.163 | 544.991 |
| Penalty | 1.817E+04 | ‑ | ‑ | ‑ | 2.007E+03 | 7.686E+04 |
|  |  |  |  |  |  |  |
| Bar Group Areas [in2] | Talatahari et al. (MSPSO) | Kaveh et al. (HPSSO) | Degertekin and Hayalioglu (TLBO) | Degertekin (EHS) | Degertekin (SAHS) | Kaveh et al. (CSP) |
| 1 | 0.0100 | 0.0100 | 0.0100 | 0.010 | 0.010 | 0.010 |
| 2 | 1.9848 | 1.9907 | 2.0712 | 1.995 | 2.074 | 1.910 |
| 3 | 2.9956 | 2.9881 | 2.9570 | 2.980 | 2.961 | 2.798 |
| 4 | 0.0100 | 0.0100 | 0.0100 | 0.010 | 0.010 | 0.010 |
| 5 | 0.0100 | 0.0100 | 0.0100 | 0.010 | 0.010 | 0.010 |
| 6 | 0.6852 | 0.6824 | 0.6891 | 0.696 | 0.691 | 0.708 |
| 7 | 1.6778 | 1.6764 | 1.6209 | 1.679 | 1.617 | 1.836 |
| 8 | 2.6599 | 2.6656 | 2.6768 | 2.652 | 2.674 | 2.645 |
| Weight [lb] | 545.172 | 545.160 | 545.095 | 545.486 | 545.118 | 545.145 |
| Penalty | ‑ | 2.026E+03 | 5.692E+04 | ‑ | 6.161E+04 | 2.413E+04 |
|  |  |  |  |  |  |  |
| Bar Group Areas [in2] | Kaveh and Zakian (EBA) | Camp (BB-BC) | Kaveh and Talatahari (HBB-BC) | Camp and Farshchin (TLBO) | Kaveh and Talatahari (CSS) | This study (DE1, DE3) |
| 1 | 0.01000 | 0.010 | 0.010 | 0.0100 | 0.010 | 0.010 |
| 2 | 1.97889 | 2.092 | 1.993 | 1.9878 | 2.003 | 1.983 |
| 3 | 3.00472 | 2.964 | 3.056 | 2.9914 | 3.007 | 2.999 |
| 4 | 0.01000 | 0.010 | 0.010 | 0.0102 | 0.010 | 0.010 |
| 5 | 0.01000 | 0.010 | 0.010 | 0.0100 | 0.010 | 0.010 |
| 6 | 0.68880 | 0.689 | 0.665 | 0.6828 | 0.687 | 0.682 |
| 7 | 1.67834 | 1.601 | 1.642 | 1.6775 | 1.655 | 1.678 |
| 8 | 2.65270 | 2.686 | 2.679 | 2.6640 | 2.660 | 2.663 |
| Weight [lb] | 545.169 | 545.522 | 545.143 | 545.176 | 545.093 | 545.172 |
| Penalty | 2.000E+03 | 7.910E+04 | 4.538E+04 | 2.000E+03 | 2.820E+04 | ‑ |

**Table S3:** Statistical evaluation of algorithms' performance in the spatial 25-bar tower problem.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 579.010 | 30.052 | 561.842 | 9.975 | 664.259 | 123.391 | 570.909 | 21.898 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 550.675 | 703.142 | 549.279 | 585.425 | 545.426 | 1155.675 | 547.124 | 627.713 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 0.013 | 0.330 | 0.010 | 0.391 | 0.010 | 32.714 | 0.010 | 0.010 |
| 2 | 0.878 | 4.679 | 1.105 | 3.748 | 1.745 | 2.409 | 1.379 | 3.265 |
| 3 | 1.562 | 5.206 | 1.852 | 4.609 | 2.620 | 3.422 | 1.714 | 4.642 |
| 4 | 0.011 | 0.594 | 0.010 | 0.707 | 0.010 | 26.146 | 0.010 | 0.272 |
| 5 | 0.011 | 0.839 | 0.010 | 0.493 | 0.010 | 15.637 | 0.010 | 0.328 |
| 6 | 0.505 | 2.197 | 0.520 | 1.096 | 0.634 | 0.727 | 0.505 | 1.555 |
| 7 | 1.368 | 4.445 | 1.470 | 2.537 | 1.542 | 1.742 | 1.503 | 3.187 |
| 8 | 1.459 | 3.052 | 1.909 | 3.055 | 2.536 | 2.807 | 2.034 | 3.485 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 545.176 | 0.004 | 545.173 | 0.002 | 545.368 | 0.060 | 797.911 | 179.954 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 545.172 | 545.187 | 545.172 | 545.180 | 545.265 | 545.487 | 558.483 | 1129.935 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 0.010 | 0.012 | 0.010 | 0.010 | 0.010 | 0.038 | 0.010 | 30.699 |
| 2 | 1.972 | 1.997 | 1.980 | 1.996 | 1.954 | 2.025 | 1.652 | 2.638 |
| 3 | 2.979 | 3.016 | 2.979 | 3.005 | 2.942 | 3.047 | 2.093 | 3.519 |
| 4 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.015 | 0.010 | 24.862 |
| 5 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.021 | 0.010 | 22.527 |
| 6 | 0.678 | 0.690 | 0.678 | 0.689 | 0.657 | 0.707 | 0.492 | 0.985 |
| 7 | 1.675 | 1.680 | 1.676 | 1.679 | 1.665 | 1.697 | 1.558 | 1.972 |
| 8 | 2.651 | 2.671 | 2.657 | 2.671 | 2.636 | 2.704 | 2.479 | 3.061 |

**Table S4:** Comparison of best designs obtained in the planar 10-bar truss problem (load case I). The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Lee and Geem (HS) | Sonmez (ABC‑AP) | Li et al. (HPSO) | Perez and Behdinan (PSO) | Wu and Cheng (AMPDE) |
| 1 | 30.150 | 30.548 | 30.704 | 33.500 | 30.378 |
| 2 | 0.102 | 0.100 | 0.100 | 0.100 | 0.100 |
| 3 | 22.710 | 23.180 | 23.167 | 22.766 | 23.468 |
| 4 | 15.270 | 15.218 | 15.183 | 14.417 | 15.196 |
| 5 | 0.102 | 0.100 | 0.100 | 0.100 | 0.100 |
| 6 | 0.544 | 0.551 | 0.551 | 0.100 | 0.533 |
| 7 | 7.541 | 7.463 | 7.460 | 7.534 | 7.437 |
| 8 | 21.560 | 21.058 | 20.978 | 20.467 | 21.084 |
| 9 | 21.450 | 21.501 | 21.508 | 20.392 | 21.433 |
| 10 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 |
| Weight [lb] | 5058.336 | 5060.888 | 5060.906 | 5024.248 | 5060.234 |
| Penalty | 1.907E+03 | ‑ | 1.001E+03 | 2.696E+04 | 2.308E+03 |
|  |  |  |  |  |  |
| Bar Group Areas [in2] | Haftka and Grdal | Kaveh et al. (HPSSO) | Degertekin and Hayalioglu (TLBO) | Lamberti and Pappalettere (IHS) | Kaveh and Talatahari (HPSACO) |
| 1 | 30.520 | 30.53838 | 30.4286 | 30.5222 | 30.307 |
| 2 | 0.100 | 0.10000 | 0.1000 | 0.1000 | 0.100 |
| 3 | 23.200 | 23.15103 | 23.2436 | 23.2005 | 23.434 |
| 4 | 15.220 | 15.20566 | 15.3677 | 15.2232 | 15.505 |
| 5 | 0.100 | 0.10000 | 0.1000 | 0.1000 | 0.100 |
| 6 | 0.551 | 0.54890 | 0.5751 | 0.5513 | 0.524 |
| 7 | 7.457 | 7.46532 | 7.4404 | 7.4572 | 7.437 |
| 8 | 21.040 | 21.06437 | 20.9665 | 21.0367 | 21.079 |
| 9 | 21.530 | 21.52935 | 21.5330 | 21.5288 | 21.229 |
| 10 | 0.100 | 0.10000 | 0.1000 | 0.1000 | 0.100 |
| Weight [lb] | 5060.926 | 5060.864 | 5060.956 | 5060.930 | 5056.591 |
| Penalty | 1.108E+03 | ‑ | ‑ | 1.001E+03 | 1.992E+03 |
|  |  |  |  |  |  |
| Bar Group Areas [in2] | Renwei and Peng (MP) | Bureerat and Pholdee (ADEA) | Camp and Farshchin (TLBO) | Degertekin (SAHS) | This study (DE3) |
| 1 | 30.590 | 30.5139 | 30.6684 | 30.394 | 30.531 |
| 2 | 0.100 | 0.1000 | 0.1000 | 0.100 | 0.100 |
| 3 | 23.270 | 23.2052 | 23.1584 | 23.098 | 23.197 |
| 4 | 15.190 | 15.2084 | 15.2226 | 15.491 | 15.228 |
| 5 | 0.100 | 0.1000 | 0.1000 | 0.100 | 0.100 |
| 6 | 0.460 | 0.5318 | 0.5421 | 0.529 | 0.550 |
| 7 | 7.500 | 7.4585 | 7.4654 | 7.488 | 7.459 |
| 8 | 21.070 | 21.0512 | 21.0255 | 21.189 | 21.045 |
| 9 | 21.480 | 21.5391 | 21.4660 | 21.342 | 21.511 |
| 10 | 0.100 | 0.1000 | 0.1000 | 0.100 | 0.100 |
| Weight [lb] | 5062.781 | 5060.895 | 5060.975 | 5061.275 | 5060.855 |
| Penalty | ‑ | ‑ | ‑ | 1.031E+03 | ‑ |

**Table S5:** Statistical evaluation of algorithms’ performance in the planar 10-bar truss problem (load case I).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 5250.611 | 209.569 | 5149.860 | 117.664 | 5072.901 | 9.496 | 5415.715 | 276.013 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 5099.936 | 5743.367 | 5081.989 | 5628.621 | 5063.456 | 5101.853 | 5102.510 | 6289.445 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 25.302 | 32.996 | 27.742 | 33.973 | 28.432 | 34.570 | 18.658 | 35.000 |
| 2 | 0.103 | 3.647 | 0.100 | 2.825 | 0.100 | 0.100 | 0.100 | 4.665 |
| 3 | 19.928 | 31.358 | 20.017 | 29.624 | 21.722 | 25.355 | 14.003 | 35.000 |
| 4 | 11.676 | 18.960 | 12.885 | 17.863 | 13.601 | 18.928 | 8.369 | 31.558 |
| 5 | 0.100 | 0.396 | 0.101 | 0.195 | 0.100 | 0.100 | 0.100 | 1.686 |
| 6 | 0.100 | 4.605 | 0.102 | 2.696 | 0.100 | 0.615 | 0.100 | 7.535 |
| 7 | 7.203 | 18.098 | 7.275 | 15.487 | 7.273 | 8.676 | 7.379 | 20.032 |
| 8 | 16.206 | 26.276 | 16.562 | 25.992 | 19.527 | 21.574 | 14.516 | 34.983 |
| 9 | 16.483 | 25.187 | 16.843 | 24.534 | 19.945 | 22.681 | 12.122 | 34.989 |
| 10 | 0.101 | 5.006 | 0.100 | 4.452 | 0.100 | 0.100 | 0.100 | 11.835 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 5060.865 | 0.006 | 5060.863 | 0.011 | 5062.677 | 2.885 | 5080.998 | 8.929 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 5060.858 | 5060.881 | 5060.855 | 5060.915 | 5061.195 | 5077.710 | 5064.229 | 5097.011 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 30.474 | 30.558 | 30.487 | 30.595 | 30.283 | 31.006 | 27.846 | 33.546 |
| 2 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.104 | 0.100 | 0.102 |
| 3 | 23.155 | 23.224 | 23.109 | 23.278 | 22.556 | 24.135 | 20.860 | 26.871 |
| 4 | 15.203 | 15.242 | 15.199 | 15.261 | 14.865 | 15.504 | 12.378 | 17.948 |
| 5 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.103 | 0.100 | 0.111 |
| 6 | 0.545 | 0.558 | 0.537 | 0.563 | 0.106 | 0.603 | 0.100 | 0.906 |
| 7 | 7.454 | 7.462 | 7.447 | 7.460 | 7.426 | 8.510 | 7.114 | 8.583 |
| 8 | 21.019 | 21.058 | 20.975 | 21.053 | 20.803 | 21.368 | 19.595 | 23.634 |
| 9 | 21.483 | 21.550 | 21.506 | 21.585 | 20.864 | 21.760 | 20.167 | 22.876 |
| 10 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.105 | 0.100 | 0.100 |

**Table S6:** Comparison of best designs obtained in the planar 10-bar truss problem (load case II). The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Lee and Geem (HS) | Sonmez (ABC‑AP) | Li et al. (HPSO) | Kaveh et al. (HPSSO) | Kaveh and Talatahari (HPSACO) | Degertekin and Hayalioglu (TLBO) |
| 1 | 23.250 | 23.4692 | 23.353 | 23.52377 | 23.1940 | 23.5240 |
| 2 | 0.102 | 0.1005 | 0.100 | 0.10000 | 0.1000 | 0.1000 |
| 3 | 25.730 | 25.2393 | 25.502 | 25.36864 | 24.5850 | 25.4410 |
| 4 | 14.510 | 14.3540 | 14.250 | 14.37799 | 14.2210 | 14.4790 |
| 5 | 0.100 | 0.1001 | 0.100 | 0.10000 | 0.1000 | 0.1000 |
| 6 | 1.977 | 1.9701 | 1.972 | 1.96973 | 1.9690 | 1.9950 |
| 7 | 12.210 | 12.4128 | 12.363 | 12.36780 | 12.4890 | 12.3340 |
| 8 | 12.610 | 12.8925 | 12.894 | 12.79722 | 12.9250 | 12.6890 |
| 9 | 20.360 | 20.3343 | 20.356 | 20.32577 | 20.9520 | 20.3540 |
| 10 | 0.100 | 0.1000 | 0.101 | 0.10000 | 0.1010 | 0.1000 |
| Weight [lb] | 4669.365 | 4677.089 | 4677.349 | 4676.949 | 4675.797 | 4678.315 |
| Penalty | 5.561E+03 | ‑ | 1.025E+03 | ‑ | 3.871E+03 | ‑ |
|  |  |  |  |  |  |  |
| Bar Group Areas [in2] | Talatahari et al. (MSPSO) | Talatahari et al. (PSO) | Degertekin (SAHS) | Degertekin (EHS) | Bureerat and Pholdee (ADEA) | This study (DE3) |
| 1 | 23.4432 | 23.9324 | 23.5250 | 23.589 | 23.7697 | 23.515 |
| 2 | 0.1000 | 0.1000 | 0.1000 | 0.100 | 0.1001 | 0.100 |
| 3 | 25.3718 | 25.2478 | 25.4290 | 25.422 | 25.3328 | 25.293 |
| 4 | 14.1360 | 14.1791 | 14.4880 | 14.488 | 14.3954 | 14.385 |
| 5 | 0.1000 | 0.1000 | 0.1000 | 0.100 | 0.1004 | 0.100 |
| 6 | 1.9699 | 1.9701 | 1.9920 | 1.975 | 1.9714 | 1.970 |
| 7 | 12.4335 | 12.5097 | 12.3520 | 12.362 | 12.4120 | 12.389 |
| 8 | 13.0173 | 13.0379 | 12.6980 | 12.682 | 12.8414 | 12.831 |
| 9 | 20.2717 | 19.9002 | 20.3410 | 20.322 | 20.0824 | 20.325 |
| 10 | 0.1000 | 0.1000 | 0.1000 | 0.100 | 0.1000 | 0.100 |
| Weight [lb] | 4677.253 | 4677.974 | 4678.848 | 4679.015 | 4677.326 | 4676.932 |
| Penalty | ‑ | 1.022E+03 | ‑ | ‑ | 1.005E+03 | ‑ |

**Table S7:** Statistical evaluation of algorithms’ performance in the planar 10-bar truss problem (load case II).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 4894.657 | 90.345 | 4743.481 | 32.227 | 4694.085 | 10.994 | 4910.675 | 111.381 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 4735.553 | 5079.055 | 4692.920 | 4805.366 | 4680.118 | 4717.370 | 4710.823 | 5219.890 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 17.755 | 28.810 | 20.779 | 27.778 | 20.960 | 27.278 | 16.423 | 35.000 |
| 2 | 0.101 | 0.414 | 0.103 | 0.343 | 0.100 | 0.100 | 0.100 | 0.623 |
| 3 | 20.229 | 30.160 | 21.567 | 29.000 | 22.000 | 29.913 | 17.023 | 30.536 |
| 4 | 10.769 | 19.940 | 11.461 | 17.798 | 12.911 | 17.588 | 9.658 | 26.646 |
| 5 | 0.100 | 1.472 | 0.100 | 0.325 | 0.100 | 0.100 | 0.100 | 0.442 |
| 6 | 1.928 | 4.640 | 1.985 | 3.363 | 1.969 | 1.972 | 1.893 | 4.150 |
| 7 | 9.582 | 17.623 | 11.672 | 15.230 | 11.649 | 13.130 | 10.996 | 16.451 |
| 8 | 10.277 | 19.884 | 10.364 | 16.252 | 11.534 | 14.109 | 8.934 | 20.108 |
| 9 | 16.541 | 22.207 | 16.702 | 23.089 | 18.307 | 21.706 | 14.762 | 34.186 |
| 10 | 0.101 | 0.648 | 0.101 | 0.344 | 0.100 | 0.100 | 0.100 | 0.280 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 4676.946 | 0.008 | 4676.940 | 0.007 | 4679.069 | 0.749 | 4796.789 | 215.699 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 4676.937 | 4676.969 | 4676.932 | 4676.968 | 4677.916 | 4680.667 | 4682.242 | 5612.583 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 23.061 | 24.068 | 23.467 | 23.578 | 21.794 | 35.000 | 20.456 | 27.702 |
| 2 | 0.100 | 0.111 | 0.100 | 0.100 | 0.100 | 0.103 | 0.100 | 17.223 |
| 3 | 24.719 | 25.524 | 25.221 | 25.348 | 22.698 | 27.531 | 19.777 | 29.754 |
| 4 | 14.101 | 14.716 | 14.333 | 14.422 | 13.518 | 15.497 | 12.348 | 19.282 |
| 5 | 0.100 | 0.105 | 0.100 | 0.100 | 0.100 | 0.103 | 0.100 | 0.802 |
| 6 | 1.969 | 2.005 | 1.970 | 1.970 | 1.969 | 1.973 | 1.967 | 4.922 |
| 7 | 12.315 | 12.576 | 12.372 | 12.402 | 11.886 | 13.160 | 11.573 | 13.515 |
| 8 | 12.623 | 13.181 | 12.784 | 12.884 | 10.322 | 14.529 | 10.633 | 19.965 |
| 9 | 19.967 | 20.681 | 20.303 | 20.369 | 19.593 | 22.672 | 17.491 | 22.880 |
| 10 | 0.100 | 0.105 | 0.100 | 0.100 | 0.100 | 0.101 | 0.100 | 0.100 |

**Table S8:** Comparison of best designs obtained in the planar 17-bar truss problem. Note: The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Lee and Geem (HS) | Khot and Berke (OC) | Barakat and Ibrahim (SCEO) | Adeli and Kumar (GA) | This study (DE3) |
| 1 | 15.821 | 15.930 | 15.897700 | 16.02858206 | 15.911 |
| 2 | 0.108 | 0.100 | 0.100367 | 0.10695021 | 0.100 |
| 3 | 11.996 | 12.070 | 12.064600 | 12.18302437 | 12.053 |
| 4 | 0.100 | 0.100 | 0.100189 | 0.11005022 | 0.100 |
| 5 | 8.150 | 8.067 | 8.085990 | 8.41651683 | 8.076 |
| 6 | 5.507 | 5.562 | 5.562290 | 5.71486143 | 5.552 |
| 7 | 11.829 | 11.933 | 11.939700 | 11.33052266 | 11.963 |
| 8 | 0.100 | 0.100 | 0.100009 | 0.10540021 | 0.100 |
| 9 | 7.934 | 7.945 | 7.950370 | 7.30051460 | 7.958 |
| 10 | 0.100 | 0.100 | 0.100005 | 0.11470023 | 0.100 |
| 11 | 4.093 | 4.055 | 4.049050 | 4.04550809 | 4.057 |
| 12 | 0.100 | 0.100 | 0.100005 | 0.10075020 | 0.100 |
| 13 | 5.660 | 5.657 | 5.665820 | 5.61101122 | 5.651 |
| 14 | 4.061 | 4.000 | 3.988130 | 4.04550809 | 4.005 |
| 15 | 5.656 | 5.558 | 5.565300 | 5.15221030 | 5.565 |
| 16 | 0.100 | 0.100 | 0.100031 | 0.10695021 | 0.100 |
| 17 | 5.582 | 5.579 | 5.578710 | 5.28551057 | 5.571 |
| Weight [lb] | 2580.975 | 2581.923 | 2581.899 | 2543.573 | 2581.895 |
| Penalty | 1.439E+03 | ‑ | 1.000E+03 | 1.797E+04 | ‑ |

**Table S9:** Statistical evaluation of algorithms’ performance in the planar 17-bar truss problem.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 2864.364 | 132.409 | 2697.876 | 53.008 | 2597.112 | 31.927 | 3170.541 | 188.595 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 2678.314 | 3320.587 | 2612.075 | 2803.950 | 2582.851 | 2757.438 | 2906.426 | 3724.046 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 10.622 | 19.444 | 12.101 | 17.533 | 12.654 | 17.788 | 7.289 | 33.375 |
| 2 | 0.266 | 6.915 | 0.254 | 4.909 | 0.100 | 4.867 | 0.100 | 23.878 |
| 3 | 9.096 | 25.091 | 10.443 | 17.094 | 11.075 | 15.484 | 6.221 | 25.565 |
| 4 | 0.100 | 4.196 | 0.100 | 1.587 | 0.100 | 0.100 | 0.100 | 4.778 |
| 5 | 6.242 | 26.416 | 7.576 | 13.421 | 7.449 | 12.479 | 4.078 | 19.082 |
| 6 | 0.340 | 7.567 | 1.465 | 5.911 | 1.090 | 6.120 | 0.100 | 13.258 |
| 7 | 5.661 | 13.715 | 7.918 | 12.670 | 8.535 | 12.884 | 4.914 | 25.362 |
| 8 | 0.104 | 6.343 | 0.100 | 2.717 | 0.100 | 0.692 | 0.100 | 5.161 |
| 9 | 4.273 | 15.049 | 4.937 | 10.170 | 4.627 | 8.629 | 2.336 | 15.362 |
| 10 | 0.141 | 6.791 | 0.122 | 4.500 | 0.100 | 4.870 | 0.100 | 14.137 |
| 11 | 2.696 | 13.781 | 3.427 | 7.332 | 3.827 | 7.389 | 2.009 | 18.473 |
| 12 | 0.159 | 7.247 | 0.175 | 3.885 | 0.100 | 3.416 | 0.100 | 5.542 |
| 13 | 3.723 | 12.608 | 4.232 | 7.906 | 5.340 | 5.984 | 3.103 | 20.595 |
| 14 | 2.582 | 8.524 | 3.164 | 6.642 | 3.706 | 4.592 | 2.062 | 14.841 |
| 15 | 0.210 | 7.517 | 1.611 | 5.923 | 1.104 | 5.900 | 0.100 | 11.895 |
| 16 | 0.144 | 7.200 | 0.226 | 4.762 | 0.100 | 5.000 | 0.100 | 14.163 |
| 17 | 0.245 | 8.680 | 1.702 | 6.575 | 1.139 | 6.076 | 0.100 | 13.353 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 2581.992 | 0.047 | 2581.981 | 0.086 | 2584.694 | 4.388 | 2605.621 | 21.507 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 2581.919 | 2582.091 | 2581.895 | 2582.242 | 2582.511 | 2606.616 | 2586.249 | 2660.871 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 15.745 | 16.109 | 15.737 | 16.101 | 15.158 | 16.407 | 14.061 | 18.601 |
| 2 | 0.100 | 0.127 | 0.100 | 0.121 | 0.109 | 0.773 | 0.100 | 1.740 |
| 3 | 11.955 | 12.242 | 11.893 | 12.229 | 12.071 | 13.271 | 11.629 | 16.049 |
| 4 | 0.100 | 0.102 | 0.100 | 0.100 | 0.100 | 0.129 | 0.100 | 0.559 |
| 5 | 7.979 | 8.142 | 8.019 | 8.197 | 8.014 | 8.861 | 7.194 | 9.665 |
| 6 | 5.491 | 5.611 | 5.520 | 5.604 | 5.024 | 5.602 | 4.074 | 6.277 |
| 7 | 11.771 | 12.020 | 11.772 | 12.013 | 11.179 | 12.136 | 10.111 | 12.744 |
| 8 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.129 | 0.100 | 0.604 |
| 9 | 7.834 | 8.034 | 7.852 | 8.080 | 7.640 | 8.090 | 6.553 | 9.753 |
| 10 | 0.100 | 0.101 | 0.100 | 0.101 | 0.100 | 0.573 | 0.100 | 1.064 |
| 11 | 4.020 | 4.113 | 3.974 | 4.138 | 3.970 | 4.410 | 3.520 | 5.266 |
| 12 | 0.100 | 0.101 | 0.100 | 0.100 | 0.100 | 0.342 | 0.100 | 0.760 |
| 13 | 5.605 | 5.727 | 5.585 | 5.778 | 5.358 | 5.790 | 4.842 | 6.955 |
| 14 | 3.964 | 4.070 | 3.952 | 4.045 | 3.899 | 4.377 | 3.185 | 4.934 |
| 15 | 5.474 | 5.598 | 5.449 | 5.591 | 4.573 | 5.564 | 3.837 | 6.076 |
| 16 | 0.100 | 0.109 | 0.100 | 0.107 | 0.112 | 0.832 | 0.100 | 1.682 |
| 17 | 5.502 | 5.628 | 5.512 | 5.654 | 5.233 | 5.670 | 4.623 | 6.343 |

**Table S10:** Comparison of best designs obtained in the planar 200-bar truss problem (D=29). (\*) Certain bar group areas have been slightly increased to account for very small stress violations.

Note: The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Coster and Stander (\*) #1 | Coster and Stander (\*) #2 | Sonmez (ABC‑AP) | Lee and Geem (HS) | Lamberti (CMLPSA) |
| 1 | 0.149 | 0.148 | 0.10390 | 0.1253 | 0.1468 |
| 2 | 0.945 | 0.940 | 0.94630 | 1.0157 | 0.9400 |
| 3 | 0.100 | 0.100 | 0.10370 | 0.1069 | 0.1000 |
| 4 | 0.101 | 0.101 | 0.11260 | 0.1096 | 0.1000 |
| 5 | 1.945 | 1.940 | 1.95200 | 1.9369 | 1.9400 |
| 6 | 0.299 | 0.297 | 0.29300 | 0.2686 | 0.2962 |
| 7 | 0.100 | 0.100 | 0.10640 | 0.1042 | 0.1000 |
| 8 | 3.123 | 3.105 | 3.12490 | 2.9731 | 3.1042 |
| 9 | 0.100 | 0.100 | 0.10770 | 0.1309 | 0.1000 |
| 10 | 4.123 | 4.105 | 4.12860 | 4.1831 | 4.1042 |
| 11 | 0.400 | 0.404 | 0.42500 | 0.3967 | 0.4034 |
| 12 | 0.100 | 0.192 | 0.10460 | 0.4416 | 0.1912 |
| 13 | 5.394 | 5.429 | 5.48030 | 5.1873 | 5.4284 |
| 14 | 0.100 | 0.100 | 0.10600 | 0.1912 | 0.1000 |
| 15 | 6.394 | 6.429 | 6.48530 | 6.2410 | 6.4284 |
| 16 | 0.527 | 0.574 | 0.56000 | 0.6994 | 0.5734 |
| 17 | 0.435 | 0.133 | 0.18250 | 0.1158 | 0.1327 |
| 18 | 7.951 | 7.973 | 8.04450 | 7.7643 | 7.9717 |
| 19 | 0.100 | 0.100 | 0.10260 | 0.1000 | 0.1000 |
| 20 | 8.951 | 8.973 | 9.03340 | 8.8279 | 8.9717 |
| 21 | 0.859 | 0.705 | 0.78440 | 0.6986 | 0.7049 |
| 22 | 0.151 | 0.421 | 0.75060 | 1.5563 | 0.4196 |
| 23 | 10.998 | 10.867 | 11.30570 | 10.9806 | 10.8636 |
| 24 | 0.101 | 0.100 | 0.22080 | 0.1317 | 0.1000 |
| 25 | 11.998 | 11.867 | 12.27300 | 12.1492 | 11.8606 |
| 26 | 0.914 | 1.035 | 1.40550 | 1.6373 | 1.0339 |
| 27 | 6.662 | 6.684 | 5.16000 | 5.0032 | 6.6818 |
| 28 | 10.806 | 10.808 | 9.99300 | 9.3545 | 10.8113 |
| 29 | 13.826 | 13.845 | 14.70144 | 15.0919 | 13.8404 |
| Weight [lb] | 25452.332 | 25453.036 | 25533.881 | 25447.528 | 25445.960 |
| Penalty | ‑ | ‑ | 5.583E+05 | 4.232E+05 | 2.215E+04 |

**Table S10 (cont.):** Comparison of best designs obtained in the planar 200-bar truss problem (D=29). Note: The weight has been re-evaluated without rounding and may differ from the source. The penalty is evaluated using Eq. (3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bar Group Areas [in2] | Dede and Ayvaz (TLBO) | Kaveh et al. (CSP) | Bureerat and Pholdee (ADEA) | Kaveh and Khayatazad (RO) | This study (DE3) |
| 1 | 0.113546 | 0.148000 | 0.1020 | 0.382 | 0.141 |
| 2 | 0.948427 | 0.946000 | 1.1193 | 2.116 | 0.945 |
| 3 | 0.107798 | 0.101000 | 0.1000 | 0.102 | 0.106 |
| 4 | 0.100009 | 0.101000 | 0.1223 | 0.141 | 0.101 |
| 5 | 1.934462 | 1.946100 | 1.9622 | 3.662 | 1.940 |
| 6 | 0.288872 | 0.297900 | 0.2693 | 0.176 | 0.296 |
| 7 | 0.211586 | 0.101000 | 0.1719 | 0.121 | 0.105 |
| 8 | 3.090253 | 3.107200 | 3.0690 | 3.544 | 3.100 |
| 9 | 0.103114 | 0.101000 | 0.1004 | 0.108 | 0.100 |
| 10 | 4.090254 | 4.106200 | 4.1509 | 5.565 | 4.103 |
| 11 | 0.450150 | 0.404900 | 0.4317 | 0.542 | 0.406 |
| 12 | 0.100707 | 0.194400 | 0.2122 | 0.138 | 0.200 |
| 13 | 5.479848 | 5.429900 | 5.3974 | 5.139 | 5.408 |
| 14 | 0.101144 | 0.101000 | 0.1102 | 0.101 | 0.175 |
| 15 | 6.479849 | 6.429900 | 6.3959 | 8.742 | 6.406 |
| 16 | 0.532949 | 0.575500 | 0.6141 | 0.431 | 0.618 |
| 17 | 0.132492 | 0.134900 | 0.2666 | 0.998 | 0.115 |
| 18 | 7.944450 | 7.974700 | 7.9408 | 7.212 | 8.026 |
| 19 | 0.100486 | 0.101000 | 0.1471 | 0.152 | 0.174 |
| 20 | 8.944437 | 8.974700 | 8.9445 | 8.452 | 9.028 |
| 21 | 0.701077 | 0.706480 | 0.8141 | 0.835 | 0.752 |
| 22 | 1.377693 | 0.422500 | 1.1050 | 0.413 | 0.131 |
| 23 | 11.239401 | 10.868500 | 11.2893 | 10.146 | 10.914 |
| 24 | 0.228718 | 0.101000 | 0.1004 | 0.874 | 0.101 |
| 25 | 12.239392 | 11.868400 | 12.2891 | 11.384 | 11.912 |
| 26 | 1.684935 | 1.035999 | 1.4742 | 1.197 | 0.879 |
| 27 | 4.913586 | 6.685900 | 5.3417 | 5.747 | 6.894 |
| 28 | 9.718956 | 10.811100 | 9.8931 | 7.823 | 10.942 |
| 29 | 15.021916 | 13.846490 | 14.9127 | 13.655 | 13.696 |
| Weight [lb] | 25664.002 | 25467.954 | 25800.525 | 25193.328 | 25472.157 |
| Penalty | 2.001E+03 | ‑ | 3.045E+03 | 3.764E+06 | ‑ |

**Table S11:** Statistical evaluation of algorithms’ performance in the planar 200-bar truss problem (D=29).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 38407.986 | 3177.350 | 31660.817 | 1829.522 | 46746.891 | 5284.747 | 38567.350 | 5903.163 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 33898.883 | 48819.862 | 28686.276 | 35833.563 | 36831.022 | 60205.616 | 29609.413 | 51205.525 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 0.105 | 5.000 | 0.137 | 2.506 | 0.100 | 22.837 | 0.100 | 4.236 |
| 2 | 0.828 | 5.285 | 0.399 | 4.456 | 0.944 | 18.825 | 0.100 | 6.343 |
| 3 | 0.125 | 3.168 | 0.100 | 3.147 | 0.100 | 27.907 | 0.100 | 2.344 |
| 4 | 0.106 | 3.151 | 0.113 | 2.406 | 0.100 | 15.011 | 0.100 | 0.100 |
| 5 | 1.565 | 9.201 | 1.417 | 8.568 | 1.908 | 20.271 | 1.064 | 10.499 |
| 6 | 0.109 | 1.673 | 0.123 | 2.608 | 0.100 | 0.321 | 0.100 | 4.432 |
| 7 | 0.139 | 6.768 | 0.100 | 4.694 | 0.100 | 20.940 | 0.100 | 7.350 |
| 8 | 2.308 | 17.949 | 1.305 | 10.174 | 3.053 | 27.969 | 1.297 | 13.087 |
| 9 | 0.103 | 5.905 | 0.100 | 4.117 | 0.100 | 27.159 | 0.100 | 3.786 |
| 10 | 2.963 | 14.444 | 2.290 | 9.668 | 3.933 | 32.326 | 2.296 | 16.610 |
| 11 | 0.231 | 2.881 | 0.338 | 4.610 | 0.191 | 0.579 | 0.100 | 4.490 |
| 12 | 0.101 | 3.181 | 0.127 | 3.641 | 0.100 | 19.106 | 0.100 | 11.138 |
| 13 | 4.544 | 19.089 | 3.488 | 17.151 | 5.080 | 28.538 | 2.658 | 12.601 |
| 14 | 0.134 | 12.791 | 0.139 | 6.729 | 0.100 | 21.365 | 0.100 | 8.432 |
| 15 | 5.539 | 19.913 | 4.298 | 12.629 | 5.946 | 28.596 | 3.690 | 12.243 |
| 16 | 0.340 | 2.763 | 0.398 | 3.915 | 0.383 | 1.317 | 0.353 | 6.550 |
| 17 | 0.138 | 9.689 | 0.100 | 6.913 | 0.100 | 17.711 | 0.100 | 5.410 |
| 18 | 2.595 | 18.376 | 5.853 | 15.946 | 7.140 | 29.000 | 4.819 | 14.877 |
| 19 | 0.122 | 5.751 | 0.100 | 6.383 | 0.100 | 30.638 | 0.100 | 8.912 |
| 20 | 4.533 | 21.117 | 6.969 | 15.307 | 8.293 | 25.533 | 5.143 | 9.947 |
| 21 | 0.710 | 17.670 | 0.568 | 4.561 | 0.474 | 2.311 | 0.421 | 7.633 |
| 22 | 0.187 | 9.510 | 0.100 | 7.697 | 0.100 | 14.431 | 0.100 | 17.527 |
| 23 | 9.508 | 19.814 | 9.197 | 16.857 | 10.063 | 25.029 | 2.690 | 16.136 |
| 24 | 0.211 | 8.834 | 0.142 | 7.585 | 0.100 | 32.457 | 0.100 | 13.547 |
| 25 | 9.732 | 21.720 | 10.648 | 17.248 | 11.395 | 28.687 | 3.682 | 19.818 |
| 26 | 1.202 | 6.985 | 0.842 | 4.318 | 0.645 | 4.691 | 1.526 | 16.861 |
| 27 | 1.096 | 12.217 | 2.454 | 11.122 | 1.430 | 24.239 | 2.157 | 15.278 |
| 28 | 6.252 | 17.913 | 6.888 | 15.412 | 5.772 | 12.162 | 7.046 | 23.846 |
| 29 | 12.670 | 26.425 | 13.190 | 19.335 | 13.220 | 27.937 | 10.043 | 22.344 |

**Table S11 (cont.):** Statistical evaluation of algorithms’ performance in the planar 200-bar truss problem (D=29)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 25623.082 | 82.251 | 25599.307 | 82.321 | 26268.844 | 268.780 | 59606.144 | 7420.925 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 25498.544 | 25931.803 | 25472.157 | 25854.535 | 25794.837 | 26996.671 | 45355.255 | 71724.592 |
| Bar Group Areas [in2] | Min | Max | Min | Max | Min | Max | Min | Max |
| 1 | 0.103 | 0.161 | 0.101 | 0.153 | 0.101 | 0.124 | 0.100 | 17.082 |
| 2 | 0.930 | 1.051 | 0.923 | 1.007 | 0.919 | 0.949 | 0.899 | 30.177 |
| 3 | 0.100 | 0.205 | 0.100 | 0.218 | 0.102 | 0.162 | 0.100 | 27.855 |
| 4 | 0.100 | 0.114 | 0.100 | 0.108 | 0.101 | 0.104 | 0.100 | 20.786 |
| 5 | 1.924 | 2.003 | 1.923 | 1.969 | 1.919 | 2.035 | 2.086 | 23.209 |
| 6 | 0.284 | 0.319 | 0.286 | 0.325 | 0.274 | 0.306 | 0.100 | 2.557 |
| 7 | 0.100 | 0.239 | 0.100 | 0.258 | 0.104 | 0.222 | 0.100 | 19.283 |
| 8 | 3.079 | 3.154 | 3.080 | 3.136 | 3.022 | 3.105 | 3.038 | 26.372 |
| 9 | 0.100 | 0.146 | 0.100 | 0.160 | 0.100 | 0.336 | 0.100 | 30.031 |
| 10 | 4.078 | 4.154 | 4.066 | 4.158 | 4.021 | 4.102 | 3.935 | 23.863 |
| 11 | 0.402 | 0.467 | 0.404 | 0.468 | 0.387 | 0.480 | 0.182 | 1.402 |
| 12 | 0.100 | 0.272 | 0.100 | 0.300 | 0.103 | 0.363 | 0.100 | 17.303 |
| 13 | 5.394 | 5.501 | 5.367 | 5.497 | 5.248 | 5.437 | 5.022 | 29.232 |
| 14 | 0.100 | 0.283 | 0.100 | 0.176 | 0.101 | 0.417 | 0.100 | 29.014 |
| 15 | 6.403 | 6.503 | 6.367 | 6.494 | 6.248 | 6.439 | 5.804 | 30.423 |
| 16 | 0.539 | 0.647 | 0.538 | 0.644 | 0.528 | 0.755 | 0.246 | 1.317 |
| 17 | 0.144 | 0.634 | 0.114 | 0.628 | 0.117 | 1.385 | 0.100 | 19.830 |
| 18 | 7.972 | 8.125 | 7.952 | 8.190 | 7.787 | 8.245 | 6.723 | 30.718 |
| 19 | 0.100 | 0.335 | 0.100 | 0.299 | 0.102 | 1.126 | 0.100 | 26.813 |
| 20 | 8.967 | 9.129 | 8.952 | 9.194 | 8.796 | 9.121 | 7.724 | 28.573 |
| 21 | 0.730 | 1.069 | 0.701 | 1.054 | 0.676 | 1.544 | 0.450 | 2.263 |
| 22 | 0.139 | 1.491 | 0.131 | 1.616 | 0.291 | 3.414 | 0.100 | 28.204 |
| 23 | 10.982 | 11.759 | 10.836 | 11.715 | 11.686 | 12.440 | 8.068 | 31.174 |
| 24 | 0.102 | 0.611 | 0.101 | 0.490 | 0.269 | 0.999 | 0.100 | 28.724 |
| 25 | 11.971 | 12.778 | 11.839 | 12.712 | 12.686 | 13.431 | 9.117 | 25.817 |
| 26 | 0.934 | 1.786 | 0.879 | 1.873 | 1.534 | 3.100 | 0.879 | 6.952 |
| 27 | 4.250 | 6.652 | 4.249 | 6.894 | 2.887 | 4.524 | 1.410 | 22.740 |
| 28 | 9.118 | 10.862 | 9.164 | 10.942 | 7.629 | 9.413 | 6.680 | 19.231 |
| 29 | 13.831 | 15.662 | 13.696 | 15.594 | 15.287 | 17.886 | 11.890 | 25.437 |

**Table S12:** Paired two-tailed t-test assuming unequal variances in the planar 200-bar truss problem (D=29).

|  |  |
| --- | --- |
| Algorithm | Two-tailed *p*  vs DE3 |
| SGA | 2.188093E-19 |
| HGA | 2.670505E-17 |
| EPSO | 1.339338E-19 |
| ABC | 8.459864E-13 |
| DE1 | 6.638020E-01 |
| SaDE | 7.097802E-15 |
| DE3 | ‑ |
| SA | 3.194724E-21 |

**Table S13:** Statistical evaluation of algorithms’ performance in the planar 200-bar truss problem (D=200).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Algorithm | SGA | | HGA | | EPSO | | ABC | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 89251.554 | 4011.026 | 56052.104 | 3366.534 | 93121.230 | 7262.950 | 53100.837 | 4154.684 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 81536.173 | 98761.572 | 51288.261 | 66268.242 | 76458.330 | 108216.800 | 45063.780 | 61056.111 |
|  |  |  |  |  |  |  |  |  |
| Algorithm | DE1 | | DE3 | | SaDE | | SA | |
| Weight [lb] | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. | Average | St. Dev. |
| 23146.869 | 806.098 | 23772.779 | 969.853 | 27305.964 | 1630.410 | 113423.939 | 5498.141 |
| Best | Worst | Best | Worst | Best | Worst | Best | Worst |
| 21999.715 | 24835.715 | 22197.372 | 26540.742 | 24062.390 | 30034.465 | 103383.788 | 123181.031 |

**Table S14:** Best design for the planar 200-bar truss (D=200) obtained by DE1. Each cell corresponds to the (10·row+col)th design variable.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 |  | 0.127 | 0.230 | 1.397 | 0.313 | 1.047 | 0.234 | 0.269 | 1.127 | 0.103 |
| 1 | 0.128 | 0.810 | 0.327 | 0.133 | 1.080 | 0.101 | 0.481 | 0.716 | 0.141 | 0.504 |
| 2 | 0.418 | 0.398 | 0.361 | 0.174 | 0.186 | 0.121 | 2.348 | 0.610 | 0.479 | 2.126 |
| 3 | 0.160 | 0.102 | 1.814 | 0.101 | 0.250 | 2.078 | 0.600 | 0.180 | 2.024 | 0.214 |
| 4 | 0.100 | 0.246 | 0.414 | 2.095 | 0.780 | 0.411 | 3.716 | 0.102 | 0.935 | 2.126 |
| 5 | 1.022 | 0.105 | 3.800 | 0.130 | 0.827 | 1.919 | 0.106 | 0.247 | 0.256 | 0.374 |
| 6 | 0.479 | 0.371 | 0.395 | 0.102 | 2.973 | 0.465 | 0.976 | 4.760 | 0.568 | 0.128 |
| 7 | 3.126 | 0.106 | 0.796 | 4.807 | 1.058 | 0.472 | 2.909 | 0.580 | 0.387 | 0.469 |
| 8 | 0.647 | 2.911 | 1.364 | 0.130 | 6.821 | 0.166 | 0.164 | 3.943 | 0.399 | 0.115 |
| 9 | 7.146 | 0.187 | 1.321 | 2.800 | 0.104 | 0.464 | 0.387 | 0.362 | 0.328 | 0.221 |
| 10 | 0.217 | 0.102 | 3.721 | 0.516 | 1.631 | 7.839 | 0.202 | 0.217 | 4.943 | 0.103 |
| 11 | 0.345 | 8.162 | 1.459 | 0.270 | 3.789 | 0.806 | 0.127 | 0.186 | 0.514 | 3.429 |
| 12 | 1.727 | 0.475 | 10.695 | 0.147 | 0.249 | 5.801 | 0.261 | 0.287 | 10.830 | 0.833 |
| 13 | 1.039 | 3.937 | 0.104 | 0.195 | 0.215 | 0.234 | 0.208 | 0.401 | 0.355 | 0.121 |
| 14 | 4.265 | 0.861 | 1.920 | 11.361 | 0.162 | 0.150 | 6.765 | 0.351 | 0.391 | 11.771 |
| 15 | 1.257 | 1.307 | 4.956 | 1.094 | 0.102 | 0.100 | 0.601 | 3.409 | 2.386 | 0.128 |
| 16 | 13.827 | 0.277 | 0.607 | 7.314 | 0.526 | 0.117 | 14.051 | 0.319 | 1.776 | 4.228 |
| 17 | 0.106 | 1.196 | 1.329 | 0.918 | 0.814 | 1.370 | 1.235 | 1.812 | 4.307 | 0.919 |
| 18 | 3.029 | 14.832 | 0.510 | 0.224 | 8.314 | 0.428 | 1.000 | 15.160 | 2.457 | 1.232 |
| 19 | 5.225 | 2.706 | 1.492 | 2.120 | 3.147 | 5.776 | 18.294 | 5.420 | 7.273 | 18.403 |
| 20 | 6.671 |  |  |  |  |  |  |  |  |  |