Supplementary Materials: Frequency-Constrained Truss Optimization Using the Fruit Fly Optimization Algorithm with Memory

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Table S1. Optimized designs obtained for the planar 10-bar truss problem

Design Variable	Gomes (2011)	Kaveh and Javadi (2014)	Gonçalves, Lopez, and Miguel (2015)	Taheri and Jalili (2016)		Zuo, Bai, and Li (2014)	Present work		
							N=20; t_{max}=500		
	PSO	HRPSO	SGA	BBO	EBBO	Hybrid OC-GA	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
A1 (cm^2)	37.712	34.793	34.282	35.1206	35.5816	37.284	34.427	36.219	34.834
A2 (cm^2)	9.959	15.245	15.062	14.6163	14.5615	9.445	14.234	13.528	14.283
A3 (cm^2)	40.265	35.562	36.205	34.4259	34.1122	35.051	35.251	34.721	35.577
A4 (cm^2)	16.788	13.836	14.566	14.6571	14.4837	19.262	15.589	15.332	14.524
A5 (cm^2)	11.576	0.646	0.645	0.7147	0.645	2.783	0.645	0.653	0.645
A6 (cm^2)	3.955	4.583	4.554	4.7327	4.5901	5.450	4.553	4.636	4.588
A7 (cm^2)	25.308	25.535	24.12	23.4828	23.8959	19.041	21.955	22.122	23.763
A8 (cm^2)	21.613	22.3	23.172	24.5863	23.7897	27.939	25.026	26.035	24.235
A9 (cm^2)	11.576	11.614	12.08	14.8527	12.9001	14.950	13.395	12.940	12.146
A10 (cm^2)	11.186	13.072	12.641	10.6566	12.3566	10.361	12.144	11.271	12.442

Best Weight (kg)	537.98	524.88	524.70	527.66	524.64	535.73	524.96	525.41	524.57
Average weight (kg)	540.89	N/A	525.68	533.58	527.00	N/A	529.97	530.14	528.53
Standard deviation (kg)	6.84	2.25	0.64	4.11	2.63	N/A	3.679	3.662	3.389
Number of structural Analyses	N/A	21,000	21,000	19,600	18,000	8,000	7257	4867	5818
R	N/A	1.00	1.00	1.00	1.00	1.00	**0.73**	**0.49**	**0.58**
Runs	N/A	N/A	10	100	100	N/A	100	100	100

(PSO—Particle Swarm Optimization, HRPSO—Harmony Search and Ray Optimizer Enhanced Particle Swarm Optimization Algorithm, SGA—Search Group Algorithm, BBO—Biogeography-based Optimization, EBBO—Enhanced Biogeography-based Optimization, Hybrid OC-GA—Hybrid Optimality Criterion and Genetic Algorithm)

Table S2. Natural frequencies (Hz) of the optimal designs for the planar 10-bar truss

Frequency number	Gomes (2011)	Kaveh and Javadi (2014)	Gonçalves, Lopez, and Miguel (2015)	Taheri and Jalili (2016)		Zuo, Bai, and Li (2014)	Present work		
							N=20; t_{max}=500		
	PSO	HRPSO	SGA	BBO	EBBO	Hybrid OC-GA	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
1	7.000	7.000	7.000	7.001	7.000	7.001	7.0000	7.0004	7.0000
2	17.786	16.169	16.203	16.265	16.158	17.030	16.1366	16.1940	16.1896
3	20.000	20.002	20.000	20.047	20.000	20.156	20.0000	20.0047	20.0000
4	20.063	20.005	20.012	20.208	20.004	21.318	20.0001	20.0610	20.0001
5	27.776	28.1466	28.462	27.724	28.643	27.431	28.3933	27.9395	28.5477

(PSO—Particle Swarm Optimization, HRPSO—Harmony Search and Ray Optimizer Enhanced Particle Swarm Optimization Algorithm, SGA—Search Group Algorithm, BBO—Biogeography-based Optimization, EBBO—Enhanced Biogeography-based Optimization, Hybrid OC-GA—Hybrid Optimality Criterion and Genetic Algorithm)

Table S3. Optimized designs obtained for the 52-bar dome-like truss problem

Variable group	Elements	Gomes (2011)	Wei et al. (2011)	Miguel and Miguel (2012)		Farshchin, Camp, and Maniat (2016)		Present work		
								N=20; t_{max}=500		
		PSO	PGA	HS	FA	TLBO	MC-TLBO	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
Z_A (m)	N/A	5.534	5.885	4.7374	6.4330	6.003	5.953	6.026	5.714	6.046
R_B (m)	N/A	2.089	1.762	1.5643	2.2210	2.263	2.291	2.286	2.163	2.239
Z_B (m)	N/A	3.928	4.409	3.7413	3.9200	3.745	3.704	3.728	3.880	3.769
R_F (m)	N/A	4.026	3.441	3.4882	4.0300	3.985	3.966	3.989	4.036	3.999
Z_F (m)	N/A	2.458	3.187	2.6274	2.5200	2.500	2.500	2.500	2.509	2.504
A1 (cm^2)	1-4	0.370	1.000	1.0085	1.0050	1.000	1.000	1.000	1.001	1.000
A2 (cm^2)	5-8	4.191	2.142	1.4999	1.3820	1.121	1.096	1.181	1.115	1.147
A3 (cm^2)	9-16	1.512	1.486	1.3948	1.2300	1.211	1.225	1.231	1.374	1.272
A4 (cm^2)	17-20	1.562	1.402	1.3462	1.2660	1.449	1.456	1.463	1.690	1.375
A5 (cm^2)	21-28	1.915	1.911	1.6776	1.4480	1.416	1.417	1.438	1.505	1.453
A6 (cm^2)	29-36	1.132	1.011	1.3704	1.0000	1.000	1.000	1.000	1.053	1.001
A7 (cm^2)	37-44	1.823	1.469	1.4137	1.5730	1.543	1.620	1.455	1.512	1.541
A8 (cm^2)	45-52	1.090	2.141	1.9378	1.4150	1.403	1.330	1.464	1.321	1.366
Best Weight (kg)		228.381	236.046	214.94	197.53	193.185	193.185	193.830	198.029	193.453
Average weight (kg)		234.300	274.164	229.88	212.80	200.300	197.876	217.922	245.180	202.559
Standard deviation (kg)		5.22	37.462	12.4400	8.44	15.4816	5.7905	22.515	28.166	7.263
Number of structural Analyses		11,270	13,519	20,000	10,000	15,000	15,000	7,165	5,027	5,986
R		1.00	1.00	1.00	1.00	1.00	1.00	**0.72**	**0.50**	**0.60**
Runs		5	10	5	5	100	100	100	100	100
f_1		12.751	12.81	12.2222	11.3119	11.4613	11.5924	11.5886	12.511	10.9414
f_2		28.649	28.65	28.6577	28.6529	28.6480	28.6480	28.6481	28.6552	28.6537

(PSO— Particle Swarm Optimization, PGA—Parallel Genetic Algorithm, HS—Harmony Search, FA—Firefly Algorithm, TLBO—Teaching–Learning-based Optimization, MC-TLBO—Multiclass Teaching–learning-based Optimization)

Table S4. Natural frequencies (Hz) of the optimal designs for the 52-bar dome-like truss

Frequency number	Gomes (2011)	Wei et al. (2011)	Miguel and Miguel (2012)		Farshchin, Camp, and Maniat (2016)		Present work		
							N=20; t_{max}=500		
	PSO	PGA	HS	FA	TLBO	MC-TLBO	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
1	12.751	12.81	12.2222	11.3119	11.4613	11.5924	11.5886	12.511	10.9414
2	28.649	28.65	28.6577	28.6529	28.6480	28.6480	28.6481	28.6552	28.6537
3	28.649	28.65	28.6577	28.6529	28.6480	28.6481	28.6481	28.6552	28.6538
4	28.803	29.54	28.6618	28.8030	28.6480	28.6481	28.6545	28.6959	28.6538
5	29.230	30.24	30.0997	28.8030	28.6513	28.6642	28.6545	29.668	28.7036

(PSO— Particle Swarm Optimization, PGA—Parallel Genetic Algorithm, HS—Harmony Search, FA—Firefly Algorithm, TLBO—Teaching–Learning-based Optimization, MC-TLBO—Multiclass Teaching–learning-based Optimization)

Table S5. Optimized designs obtained for the 200-bar truss problem

Variable group	Kaveh and Ghazaan (2015)			Kaveh and Mahdavi (2015)		Khatibinia and Naseralavi (2014)		Tejani, Savsani, and Patel (2016)		Tejani et al. (2017)	Present work		
											N=20; t_{max}=700		
	PSO	ALC-PSO	HALC-PSO	CBO	2D-CBO	IGSA	OMGSA	SOS	SOS-ABF1&2	ISOS	p_s=1	p_s=0	$p_s=(1-t/t_{max})$
A1	2.4662	0.2750	0.3072	0.3268	0.4460	0.495	0.289	0.4781	0.3845	0.3072	0.3404	0.3527	0.2922
A2	0.1000	0.4264	0.4545	0.4502	0.4556	0.717	0.486	0.4481	0.8524	0.5075	0.5229	0.4817	0.4356
A3	0.1000	0.1000	0.1000	0.1000	0.1519	0.100	0.100	0.1049	0.1130	0.1001	0.1025	0.1156	0.1012
A4	0.1000	0.1000	0.1000	0.1000	0.1000	0.100	0.100	0.1045	0.1000	0.1000	0.1000	0.1055	0.1036
A5	0.1000	0.7000	0.5080	0.7125	0.4723	0.639	0.499	0.4875	0.5084	0.5893	0.6171	0.5601	0.5238
A6	2.8260	0.7948	0.8276	0.8029	0.7543	0.799	0.804	0.9353	0.8885	0.8328	0.8001	0.8232	0.8051
A7	0.1000	0.1003	0.1023	0.1028	0.1024	0.335	0.103	0.1200	0.1000	0.1431	0.1014	0.1000	0.1034
A8	4.6937	1.5402	1.4357	1.4877	1.4924	0.806	1.377	1.3236	1.2170	1.3600	1.2827	1.4045	1.3841
A9	0.1000	0.1000	0.1007	0.1000	0.1000	0.100	0.100	0.1015	0.1356	0.1039	0.1000	0.1021	0.1010
A10	1.7291	1.7544	1.5528	1.0998	1.6060	1.027	1.554	1.4827	1.5477	1.5114	1.3983	1.6082	1.6812
A11	1.8842	1.1213	1.1529	0.8766	1.2098	1.543	1.151	1.1384	1.0568	1.3568	1.1151	1.2621	1.1531
A12	0.1000	0.1000	0.1522	0.1229	0.1061	0.445	0.131	0.1020	0.4552	0.1024	0.1640	0.1018	0.1015
A13	3.7185	2.8381	2.9564	2.9058	3.0909	2.621	3.028	2.9943	3.4433	2.9024	2.9630	2.7981	3.2184
A14	0.1000	0.1000	0.1003	0.1000	0.7916	0.118	0.101	0.1562	0.1000	0.1000	0.1028	0.1160	0.1368
A15	2.3450	3.3936	3.2242	3.9952	3.6095	3.149	3.261	3.4330	3.6060	3.4120	3.9716	4.8216	3.0767
A16	0.9164	1.5849	1.5839	1.7175	1.4999	1.865	1.612	1.6816	1.4460	1.4819	1.4093	1.6508	1.4532
A17	0.1000	0.1000	0.2818	0.1000	0.1000	0.479	0.209	0.1026	0.1893	0.2587	0.1653	0.1905	0.2665
A18	7.1603	5.2642	5.0696	5.9423	5.2951	4.996	5.020	5.0739	5.1791	4.8291	5.2515	5.0206	5.6239
A19	30.0000	0.1000	0.1033	0.1102	0.1000	0.100	0.133	0.1068	0.2666	0.1499	0.1463	0.1048	0.1065
A20	6.1670	5.7884	5.4657	5.8959	4.5288	4.316	5.453	6.0176	5.8750	5.5090	5.7514	5.5562	6.2659
A21	3.1906	2.0218	2.0975	2.1858	2.2178	2.301	2.113	2.0340	2.5624	2.2221	1.8170	2.1435	2.0241
A22	0.2150	0.4600	0.6598	0.5249	0.7571	1.621	0.723	0.6595	0.7535	0.6113	0.2254	0.4288	0.3194
A23	18.1871	7.8414	7.6585	7.2676	7.7999	7.387	7.724	6.9003	7.9706	7.3398	9.5565	7.5593	7.4890
A24	0.1000	0.2983	0.1444	0.1278	0.3506	0.432	0.182	0.2020	0.3324	0.1559	0.1267	0.4030	0.2147
A25	30.0000	8.1844	8.0520	7.8865	7.8943	10.561	7.971	6.8356	7.3386	8.6301	7.6892	7.3962	7.6745
A26	2.0233	2.7756	2.7889	2.8407	2.8097	3.997	2.996	2.6644	3.0958	2.8245	2.1086	2.7792	2.5772

A27	16.0615	10.1639	10.4770	11.7849	10.4220	8.230	10.206	12.1430	9.1512	10.8653	21.6992	10.2994	10.7086
A28	30.0000	21.4137	21.3257	22.7014	21.2576	17.888	20.699	22.2484	20.7230	20.9142	20.1326	21.4649	22.6400
A29	30.0000	10.9083	10.5111	7.8840	11.9061	18.708	11.555	8.9378	12.1258	10.5305	11.5429	10.1628	9.0670
Best Weight (kg)	3987.80	2162.99	2156.73	2203.212	2189.08	2273.96	2158.64	2180.32	2207.89	2169.46	2301.99	2175.52	2167.37
Average weight (kg)	5027.78	2562.07	2157.14	2481.492	2308.443	2289.79	2167.53	2303.30	2405.35	2244.64	2984.67	2342.12	2224.54
Standard deviation (kg)	708.95	328.55	0.2413	250.8259	132.5148	6.593	1.586	83.59	128.16	43.481	307.424	198.791	41.341
Number of structural Analyses	30,000	20,000	13,000	10,400	10,400	15,000	15,000	10,000	10,000	10,000	11,094	7,075	8,229
R	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**0.79**	**0.51**	**0.59**
Runs	30	30	30	20	20	20	20	N/A	N/A	N/A	100	100	100

(PSO— Particle Swarm Optimization, ALC-PSO— Particle Swarm Optimization with an Aging Leader and Challengers Algorithm, HALC-PSO—Harmony Search-based Mechanism Enhanced ALC-PSO, CBO—Colliding Bodies Optimization, 2D-CBO—Two-dimensional Colliding Bodies Algorithm, IGSA—Improved Gravitational Search Algorithm, OMGSA—Orthogonal Multi-gravitational Search Algorithm, SOS—Symbiotic Organisms Search, SOS-ABF1&2—Symbiotic Organisms Search with Adaptive Benefit Factors, ISOS—Improved Symbiotic Organisms Search)

Table S6. Natural frequencies (Hz) of the optimal designs for the 200-bar truss

Frequency number	Kaveh and Ghazaan (2015)			Kaveh and Mahdavi (2015)		Khatibinia and Naseralavi (2014)		Tejani, Savsani, and Patel (2016)		Tejani et al. (2017)	Present work		
											N=20; t_{max}=700		
	PSO	ALC-PSO	HALC-PSO	CBO	2D-CBO	IGSA	OMGSA	SOS	SOS-ABF1&2	ISOS	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
1	5.065	5.000	5.000	5.0028	5.003	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
2	13.180	12.136	12.254	12.5291	13.392	13.989	12.118	13.431	13.306	12.448	12.733	12.805	12.122
3	16.097	15.210	15.044	15.1905	15.204	15.057	15.029	15.265	15.540	15.233	15.035	15.235	15.028
4	17.681	16.723	16.718	16.5745	17.099	16.955	16.639	17.029	17.265	16.727	16.898	16.828	16.691
5	18.105	21.101	21.461	20.9419	21.208	22.293	21.218	21.855	21.731	21.758	21.190	21.802	21.261

(PSO— Particle Swarm Optimization, ALC-PSO— Particle Swarm Optimization with an Aging Leader and Challengers Algorithm, HALC-PSO—Harmony Search-based Mechanism Enhanced ALC-PSO, CBO—Colliding Bodies Optimization, 2D-CBO—Two-dimensional Colliding Bodies Algorithm, IGSA—Improved Gravitational Search Algorithm, OMGSA—Orthogonal Multi-gravitational Search Algorithm, SOS—Symbiotic Organisms Search, SOS-ABF1&2—Symbiotic Organisms Search with Adaptive Benefit Factors, ISOS—Improved Symbiotic Organisms Search)

Table S7. Optimized designs obtained for the 600-bar truss problem

Elements no. (nodes)	Kaveh and Zolghadr (2014)	Kaveh and Ghazaan (2016)		Kaveh and Ilchi Ghazaan (2018)		Kaveh and Zolghadr (2017)			Present work		
									N=30; t_{max}=800		
	DPSO	ECBO	ECBO-Cascade	VPS	MDVC-UVPS	BB-BC	HS	CPA	p_s=1	p_s=0	$p_s=(1-t/t_{\max})$
A1 (1-2)	1.365	1.4305	1.0299	1.3155	1.2575	1.502	1.439	1.155	44.0947	1.2077	1.8880
A2 (1-3)	1.391	1.3941	1.3664	1.2299	1.3466	1.495	1.425	1.304	1.8823	1.4281	1.6031
A3 (1-10)	5.686	5.5293	5.1095	5.5506	4.9738	7.077	4.942	4.178	13.3067	7.3987	6.6601
A4 (1-11)	1.511	1.0469	1.3011	1.3867	1.4025	93.172	1.677	1.335	1.9297	4.8837	1.4479
A5 (2-3)	17.711	16.9642	17.0572	17.4275	17.3802	18.930	18.331	18.375	16.7921	16.0726	16.7551
A6 (2-11)	36.266	35.1892	34.0764	40.1430	37.9742	32.699	36.074	39.914	24.7287	42.0237	40.4109
A7 (3-4)	13.263	12.2171	13.0985	12.8848	13.0306	14.601	13.407	13.609	12.7721	13.7688	13.0118
A8 (3-11)	16.919	16.7152	15.5882	15.5413	15.9209	15.492	17.066	16.470	15.2371	15.2465	15.3172
A9 (3-12)	13.333	12.5999	12.6889	12.2428	11.9419	13.533	13.122	14.108	14.0382	10.8683	11.3082
A10 (4-5)	9.534	9.5118	10.3314	9.3776	9.1643	10.424	10.061	10.038	11.1031	10.1305	10.1541
A11 (4-12)	9.884	8.9977	8.5313	8.6684	8.4332	10.171	9.827	9.514	7.8247	8.2092	8.5335
A12 (4-13)	9.547	9.4397	9.8308	9.1659	9.2375	11.374	9.388	9.329	15.2774	8.4079	8.9893
A13 (5-16)	7.866	6.8864	7.0101	7.1664	7.2213	8.184	7.083	6.938	7.3826	6.5448	8.0169
A14 (5-13)	5.529	4.2057	5.2917	5.2170	5.2142	5.857	5.697	5.545	5.3032	5.3614	5.1845
A15 (5-14)	7.007	7.2651	6.2750	6.5346	6.7961	7.669	7.139	6.763	6.4980	7.8844	5.7815
A16 (6-7)	5.462	6.1693	5.4305	5.4741	5.2078	5.985	5.082	5.209	5.5785	4.9397	5.6054
A17 (6-14)	3.853	3.9768	3.6414	3.6545	3.4586	3.807	3.295	3.842	3.5491	3.8453	3.4149
A18 (6-15)	7.432	8.3127	7.2827	7.6034	7.6407	10.361	7.663	8.112	8.5014	7.8154	6.9259
A19 (7-8)	4.261	4.1451	4.4912	4.2251	4.369	4.824	4.100	4.252	4.4229	4.3408	3.9590
A20 (7-15)	2.253	2.4042	1.9275	1.9717	2.1237	2.506	1.882	2.227	2.1343	2.1956	2.3043
A21 (7-16)	4.337	4.3038	4.6958	4.5107	4.5774	5.363	4.725	4.582	5.5468	4.6117	4.3281
A22 (8-9)	4.028	3.2539	3.3595	3.5251	3.4564	5.353	3.860	3.336	3.7467	3.4430	3.9612
A23 (8-16)	1.954	1.8273	1.7067	1.9255	1.792	1.695	2.280	1.725	1.7934	1.9084	1.8602
A24 (8-17)	4.709	4.8805	4.8372	4.7628	4.8264	5.762	4.912	4.675	5.2833	4.5022	4.6756
A25 (9-17)	1.410	1.5276	2.0253	1.6854	1.7601	1.651	1.502	1.673	1.7313	1.5346	1.6429

Best Weight (kg)	6344.55	6171.51	6140.51	6120.01	6115.10	6394.64	6357.59	6336.85	6847.47	6142.46	6093.97.
Average weight (kg)	6674.71	6191.50	6175.33	6158.11	6119.95	6704.11	6631.48	6376.01	7354.44	6192.37	6116.94
Standard deviation (kg)	473.21	39.08	34.08	28.49	16.23	551.65	304.09	90.39	303.28	76.698	11.859
Number of structural Analyses	9,000	20,000	20,000	30,000	18,000	40,000	40,000	40,000	19,267	11,606	14,006
R	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**0.80**	**0.48**	**0.58**
Runs	10	5	5	30	30	10	10	10	30	30	30

(DPSO—Democratic Particle Swarm Optimization, ECBO—Enhanced Colliding Bodies Algorithm, ECBO-Cascade—Enhanced Colliding Bodies Optimization with Cascade Optimization Strategy, VPS—Vibrating Particles System Algorithm, MDUC-UVPS—Vibrating Particles System Algorithm Using Multi-design Variable Configuration Cascade Optimization and an Upper Bound Strategy, BB-BC—Big Bang–Big Crunch, HS- Harmony Search, CPA—Cyclical Parthenogenesis Algorithm)

Table S8. Natural frequencies (Hz) of the optimal designs for the 600-bar truss

Frequency number	Kaveh and Zolghadr (2014)	Kaveh and Ghazaan (2016)		Kaveh and Ilchi Ghazaan (2018)		Kaveh and Zolghadr (2017)			EFOA		
									N=30; t_{max}=800		
	DPSO	ECBO	ECBO-Cascade	VPS	MDVC-UVPS	BB-BC	HS	CPA	$p_s=1$	$p_s=0$	$p_s=(1-t/t_{\max})$
	5.000	5.002	5.001	5.000	5.000	5.001	5.000	5.000	5.000	5.000	5.002
2	5.000	5.003	5.001	5.000	5.000	5.001	5.000	5.000	5.000	5.000	5.002
3	7.000	7.001	7.001	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
4	7.000	7.001	7.001	7.000	7.000	7.000	7.001	7.000	7.000	7.000	7.000
5	7.000	7.002	7.002	7.000	7.000	7.000	7.001	7.000	7.000	7.000	7.000

(DPSO—Democratic Particle Swarm Optimization, ECBO—Enhanced Colliding Bodies Algorithm, ECBO-Cascade—Enhanced Colliding Bodies Optimization with Cascade Optimization Strategy, VPS—Vibrating Particles System Algorithm, MDUC-UVPS—Vibrating Particles System Algorithm Using Multi-design Variable Configuration Cascade Optimization and an Upper Bound Strategy, BB-BC—Big Bang–Big Crunch, HS- Harmony Search, CPA—Cyclical Parthenogenesis Algorithm)