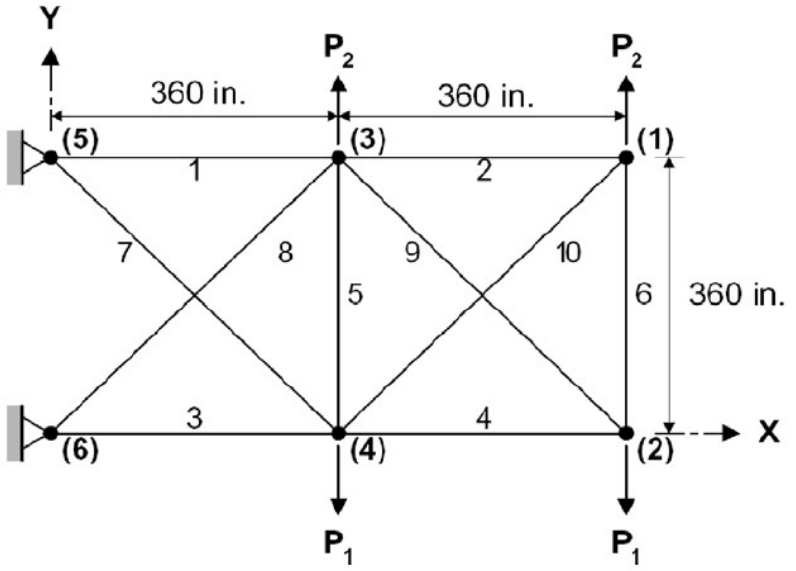
BMT: 10-bar planar truss structure

The 10-bar truss structure, shown in Fig. 2 [16], has previously been analyzed by many researchers, such as Schmit and Farshi [17], Rizzi [18], and Lee and Geem [16]. The material density is 0.1 lb/in^3 and the modulus of elasticity is 10,000 ksi. The members are subjected to the stress limits of ±25 ksi. All nodes in both vertical and horizontal directions are subjected to the displacement limits of ±2.0 in. There are 10 design variables in this example and the minimum permitted cross-sectional area of each member is 0.1 in^2. Two cases are considered: Case 1, $P_1 = 100$ kips and $P_2 = 0$; and Case 2, $P_1 = 150$ kips and $P_2 = 50$ kips.



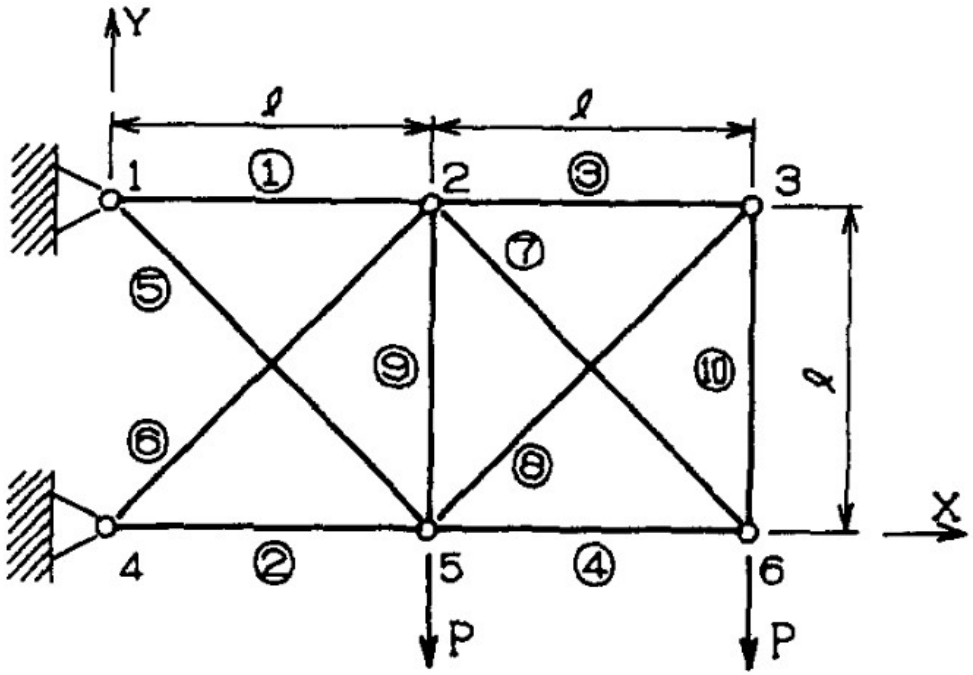
Comparison of optimal designs for the 10-bar planar truss (Case 1)

Variables		Optimal cross-sectional areas (in.^{2})		
		Schmit [17]	Rizzi [18]	Lee [16]
1	A_1	33.43	30.73	30.15
2	A_2	0.100	0.100	0.102
3	A_3	24.26	23.93	22.71
4	A_4	14.26	14.73	15.27
5	A_5	0.100	0.100	0.102
6	A_6	0.100	0.100	0.544
7	A_7	8.388	8.542	7.541
8	A_8	20.74	20.95	21.56
9	A_9	19.69	21.84	21.45
10	A_{10}	0.100	0.100	0.100
Weight (lb)		5089.0	5076.66	5057.88

Comparison of optimal designs for the 10-bar planar truss (Case 2)

Variables		Optimal cross-sectional areas (in.^{2})		
		Schmit [17]	Rizzi [18]	Lee [16]
1	A_1	24.29	23.53	23.25
2	A_2	0.100	0.100	0.102
3	A_3	23.35	25.29	25.73
4	A_4	13.66	14.37	14.51
5	A_5	0.100	0.100	0.100
6	A_6	1.969	1.970	1.977
7	A_7	12.67	12.39	12.21
8	A_8	12.54	12.83	12.61
9	A_9	21.97	20.33	20.36
10	A_{10}	0.100	0.100	0.100
Weight (lb)		4691.84	4676.92	4668.81

Optimal Weight Design Problem: 10 Bar Truss



$$\min \quad W(A) = \rho \sum_{i=1}^{10} l_i A_i$$

$$\text{s. t.} \quad G_i = \sigma_i \le b_i, (i = 1,2,..,10)$$

$$G_k = v_k \le b_k, (k = 2,3,5,6)$$

$$A_i^L \le A_i \le A_i^U, \quad (i = 1,2,..,10),$$

$$\sigma_i^L \le \sigma_i \le \sigma_i^U, \quad (i = 1,2,..,10),$$

$$v_k^L \le v_k \le v_k^U, \quad (k = 2,3,5,6),$$

where

$$\sigma_i = \epsilon_i E, (i = 1,2,..,10)$$

$$\begin{bmatrix} u_k \\ v_k \end{bmatrix} = \{F\}\,[K]^{-1}, (k = 2,3,5,6)$$

$11.5 \le A_1 \le 12.5$	$8.0 \le A_2 \le 9.0$
$0.1 \le A_3 \le 1.0$	$5.5 \le A_4 \le 6.5$
$5.5 \le A_5 \le 6.0$	$8.0 \le A_6 \le 9.0$
$8.0 \le A_7 \le 9.0$	$0.1 \le A_8 \le 1.0$
$0.1 \le A_9 \le 1.0$	$0.1 \le A_{10} \le 1.0$
$E = 10^7$	$\rho = 0.1$
$\lvert\sigma\rvert \le 25000$	$\lvert v_6\rvert \le 5.0$
$l_{1-4,9,10} = 360$	$P = 10^5$
$l_{5-8} = 360\sqrt{2}$	

Results: 10 Bar Truss

	improved GA	DCOC	Dual	DOC-FSD
A_1	12.131896	12.161173957	12.161173956	12.126576172
A_2	8.794619	8.707029023	8.707029026	8.827450732
A_3	0.100000	0.100000000	0.100000000	0.100000000
A_4	6.065801	6.040579884	6.040579884	6.046585281
A_5	5.100000	5.560164853	5.560164853	5.564322434
A_6	8.539911	8.573640198	8.573640196	8.497882192
A_7	8.575261	8.542669996	8.542669996	8.551162911
A_8	0.100000	0.100000000	0.100000000	0.100000000
A_9	0.100000	0.100000000	0.100000000	0.100000000
A_{10}	0.100000	0.100000000	0.100000000	0.100000000
W(lb)	2118.626	2139.105	2139.105	2139.198

	σ_i	f_i
l_1	166.2779	20215.11096
l_2	-2249.6584	-19784.88904
l_3	475.6522	47.56522
l_4	-1640.7454	-9952.43478
l_5	2713.3182	13837.92279
l_6	-1691.6275	-1446.34846
l_7	1641.3341	14074.86824
l_8	-672.6738	-67.26738
l_9	2626.7618	262.67618
l_{10}	475.6522	47.56522

node	u_k	v_k
1	0	0
2	0.606673	-1.817000
3	0.768973	-4.83595
4	0	0
5	-0.827898	-2.78003
6	-1.422710	-4.99826