MeshFree Benchmark Series
免網格分析軟體-基準測試

Verification of Modal Analysis
模態分析驗證

01 **Free Vibration of a Wedge**

問題定義

Determine the first fundamental frequency and vibration mode of a wedge which is constrained at the wide end (Fig. vm01).

單位: IPS

材料屬性

楊氏係數 E=3.e+7 psi.,泊松比 v=0, mass density = 7.28e-4lb - s2 /in4"

參考

Timoshenko, S., and Young, D.N., "Vibration Problems in Engineering", 3rd Edition, D. Van Nostrand Co., Inc., New York, 1955, pg. 392, Art. 62.
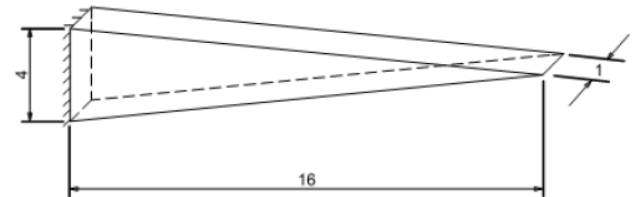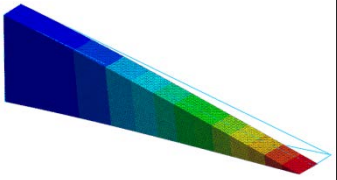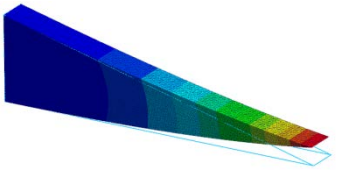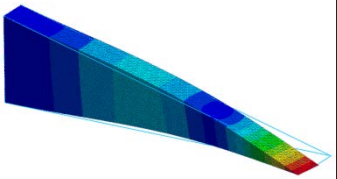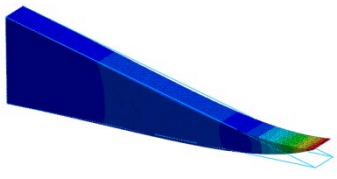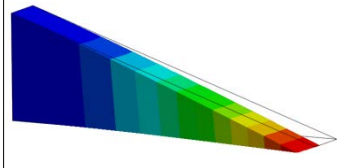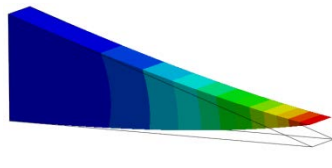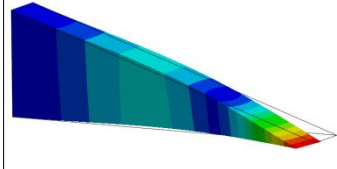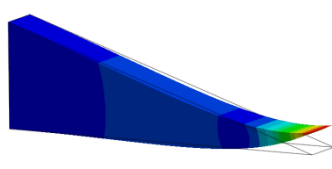
Fig. VM01

Fundamental Frequency(Hz)

	頻率(Hz)	誤差(%)		頻率(Hz)	誤差(%)
理論	259.16	-	理論	259.16	-
FEM 有限元素 分析軟體	255.66	-1.35%	MeshFree 免網格 分析軟體	255.61	-1.37%

02 In-Plane Vibration of a Cantilever Plate

問題定義

Find the fundamental frequency for in-plane vibration of a cantilevered plate (Fig. vm02).

To exclude out-of-plane vibration of the plate its surface is constrained in z-direction (Uz=0)

單位: IPS

材料屬性

楊氏係數 E=3e7 psi,泊松比 v=0.3, mass density = 7.28e-4lb - s2 /in4.

參考

Roark, R.J. and Young, W.C., Formula for Stress and Strain, (New York:McGraw-Hill Book 6, 1982) pp. 576-578.
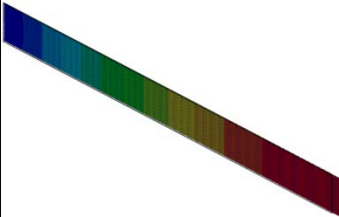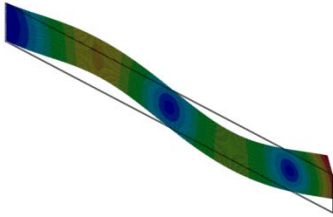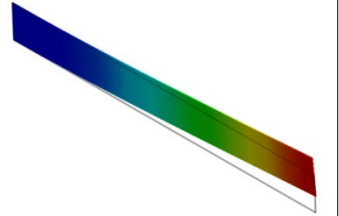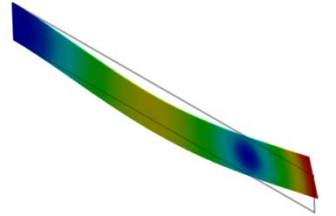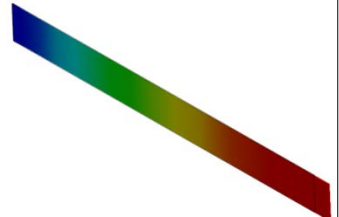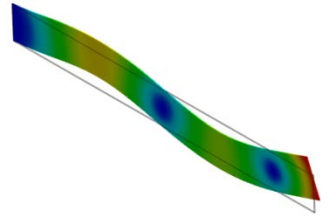
Fig. VM02

Fundamental Frequency(Hz)

	頻率(Hz)	誤差(%)		頻率(Hz)	誤差(%)
理論	101.33	-	理論	101.33	-
FEM 有限元素 分析軟體	100.39	-0.93%	MeshFree 免網格 分析軟體	100.39	-0.93%

03 **Cylindrical Shell**

問題定義

Find fundamental frequency of a cantilever cylindrical shell (Fig. vm03).

單位: IPS

材料屬性

楊氏係數 E=3e7 psi,泊松比 v=0.3, mass density = 7.28e-4lb - s2 /in4.

參考

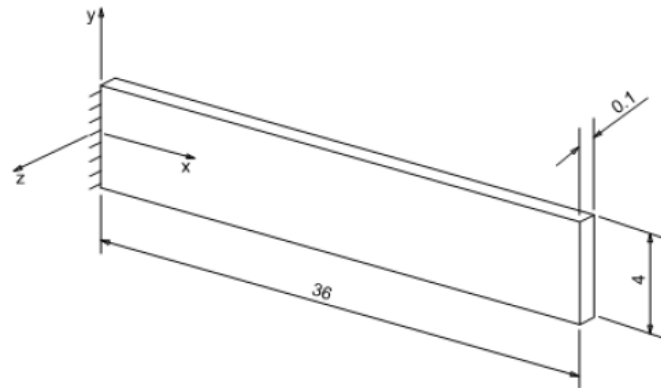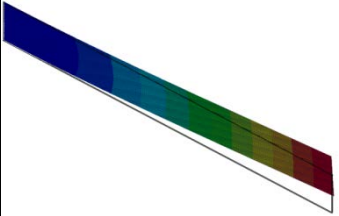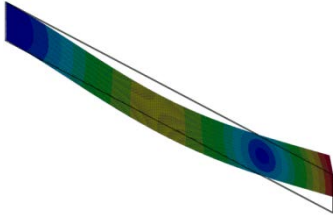Roark, R.J. and Young, W.C., Formula for Stress and Strain, NY: McGraw-Hill Co. 1982, p.576.
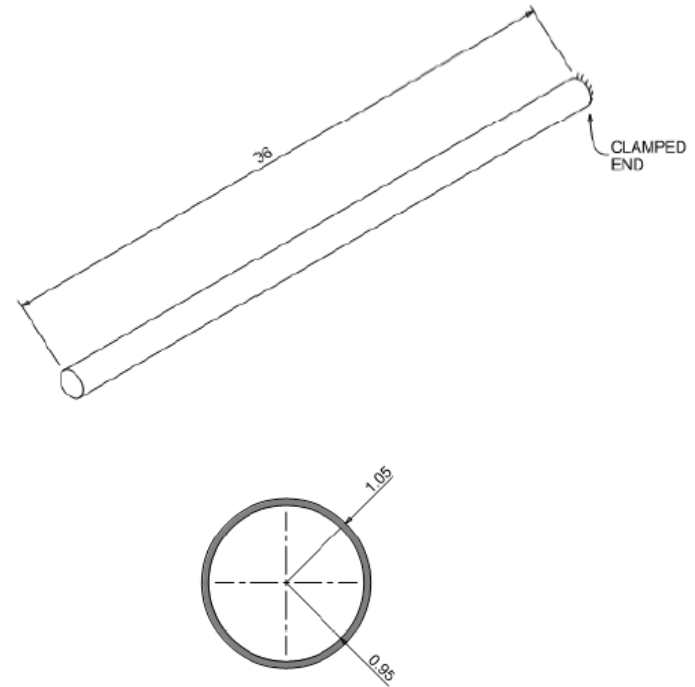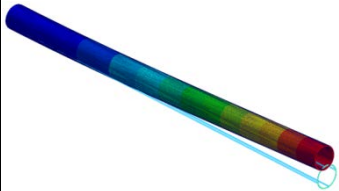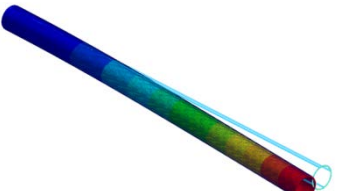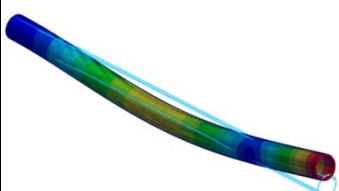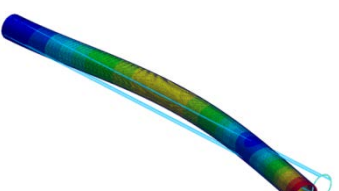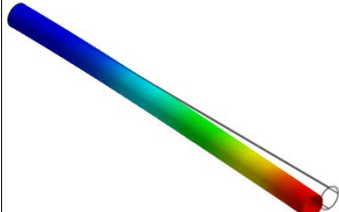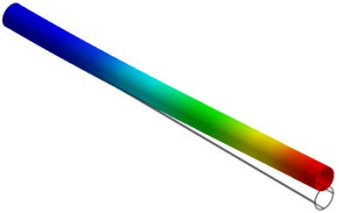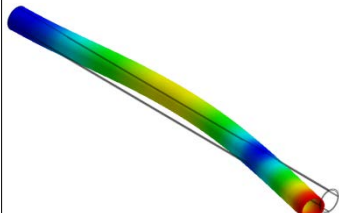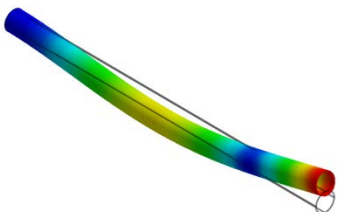
Fig. VM03

Fundamental Frequency(Hz)

	頻率(Hz)	誤差(%)		頻率(Hz)	誤差(%)
理論	62.05	-	理論	62.05	-
FEM 有限元素 分析軟體	61.78	-0.44%	MeshFree 免網格 分析軟體	61.68	-0.60%

04 **Free Thin Square Plate**

問題定義
Determine the first fourteen modal frequencies for a free thin square plate (Fig. vm04)

單位: SI

材料屬性
楊氏係數 E=2e11,泊松比 v=0.3, mass density =8e3 kg/m3

參考
[1] The Standard NAFEMS Benchmarks TNSB, Rev. 3, 5 October , 1990

[2] *iguchi S. Biegeschwingungen and Klangfiguren der Vierseitig freien rechtteckigen Platte .*
Ing – Archiv, Bd 21, p.5-6, 1953

THICKNESS = 0.05m

10m

10m
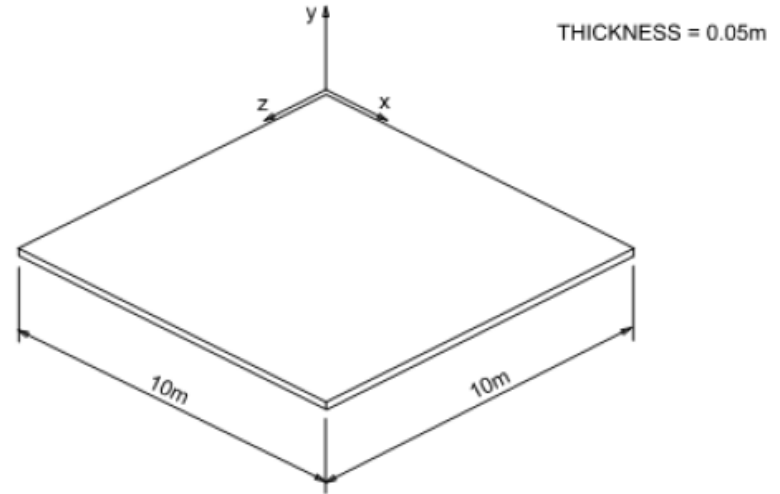
Fig. VM04

Fundamental Frequency(Hz)

柔性模態	1	2	3	4	5	6	7	8
Ref. (Hz) 誤差(%)	1.622 -	2.360 -	2.922 -	4.190 -	4.190 -	7.356 -	7.356 -	7.668 -
FEM 2D (Hz) 誤差(%)	1.620 -0.12%	2.359 -0.04%	2.922 0%	4.185 -0.12%	4.185 -0.12%	7.357 0.01%	7.357 0.01%	7.656 -0.16%
FEM 3D (Hz) 誤差(%)	1.619 -0.18%	2.359 -0.04%	2.922 0%	4.183 -0.17%	4.183 -0.17%	7.354 -0.03%	7.354 -0.03%	7.652 -0.21%
MeshFree (Hz) 誤差(%)	1.619 -0.18%	2.359 -0.04%	2.921 -0.03%	4.183 -0.17%	4.183 -0.17%	7.351 -0.07%	7.351 -0.07%	7.651 -0.22%

柔性模態	9	10	11	12	13	14	-	-
Ref. (Hz) 誤差(%)	NA	NA	NA	NA	NA	NA	-	-
FEM 2D (Hz) 誤差(%)	8.331	9.287	12.677	12.677	14.104	14.748	-	-
FEM 3D (Hz) 誤差(%)	8.327	9.282	12.669	12.669	14.092	14.736	-	-
MeshFree (Hz) 誤差(%)	8.323	9.279	12.665	12.665	14.083	14.727	-	-

Fundamental Frequency(Hz)

	柔性模態振形			柔性模態振形	
	Mode 1	Mode 2		Mode 1	Mode 2
FEM 有限元素 分析軟體			MeshFree 免網格 分析軟體		
	Mode 3	Mode 4		Mode 3	Mode 4

05 **Cantilevered Beam**

問題定義

Normal mode dynamic analysis of a cantilevered beam (shown below). Left end fully constrained, back face has slider constraint to remove 3rd dimension.

單位: SI

材料屬性

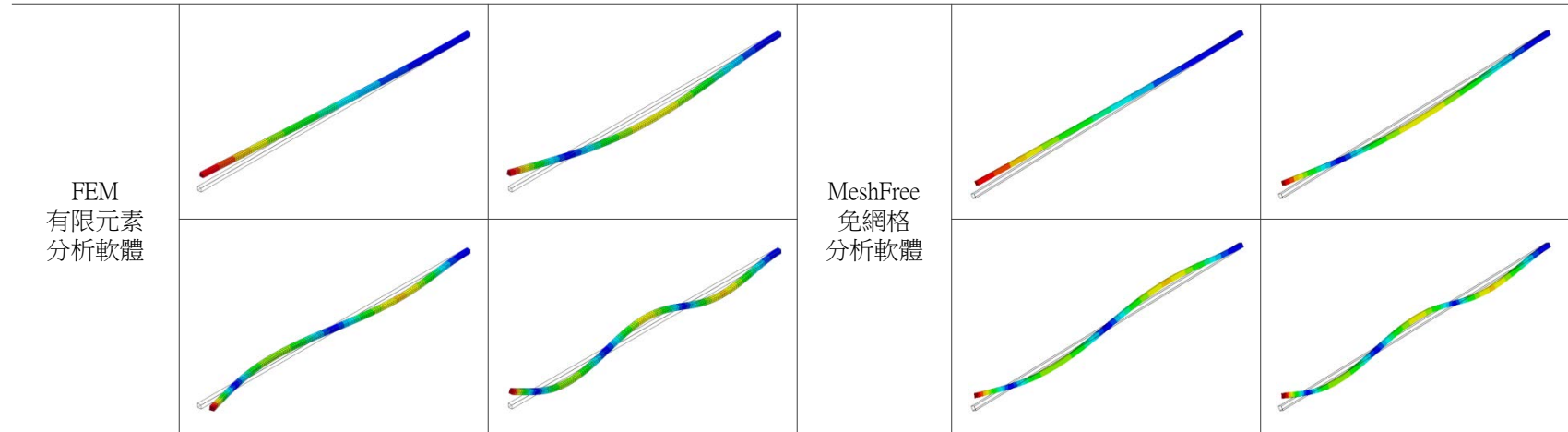楊氏係數 E=2e11, 泊松比 v=0.3, mass density □ = 8.e3 kg/m3.

參考

NAFEMS Finite Element Methods & Standards, Abbassian, F., Dawswell, D. J., and Knowles, N. C. Selected Benchmarks for Natural Frequency Analysis Test No. 71. Glasgow: NAFEMS, Nov., 1987.

0.125 m

10.0 m

0.125 m

Fig. VM05

Fundamental Frequency(Hz)

柔性模態	1	2	3	4	5	6
Ref. (Hz) 誤差(%)	1.001	6.327	17.720	34.720	57.390	85.730
FEM 1D (Hz) 誤差(%)	1.504 50.25%	6.603 4.36%	18.467 4.22%	36.129 4.06%	59.603 3.86%	88.828 3.61%
FEM 3D (Hz) 誤差(%)	1.010 0.90%	6.329 0.03%	17.706 -0.08%	34.654 -0.19%	57.196 -0.34%	85.277 -0.53%
MeshFree (Hz) 誤差(%)	1.010 0.90%	6.326 -0.02%	17.691 -0.16%	34.608 -0.32%	57.084 -0.53%	85.045 -0.80%

FEM 有限元素 分析軟體		MeshFree 免網格 分析軟體	

06 **Circular Ring**

問題定義

Normal mode dynamic analysis of a cantilevered beam (shown below). Left end fully constrained, back face has slider constraint to remove 3rd dimension.

單位: SI

材料屬性

楊氏係數 E=2e11 N/m2 ,泊松比 v=0.3, mass density = 8000 kg/m3.

參考

NAFEMS Finite Element Methods & Standards, Abbassian, F., Dawswell, D. J., and Knowles, N. C. Selected Benchmarks for Natural Frequency Analysis Test No. 71. Glasgow: NAFEMS, Nov., 1987. .
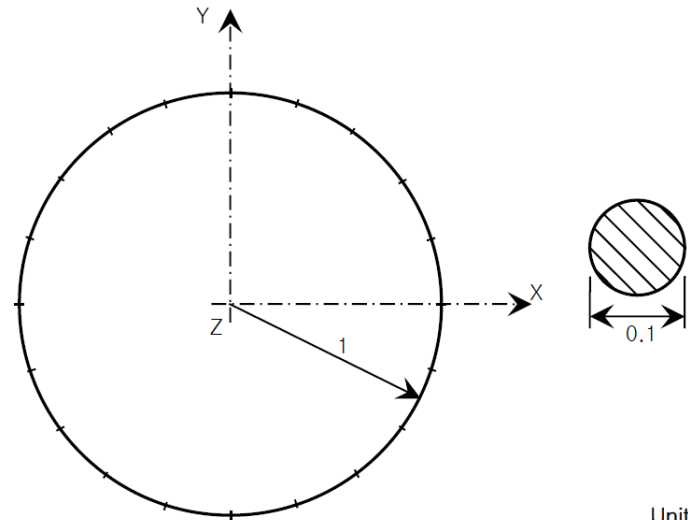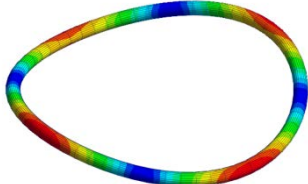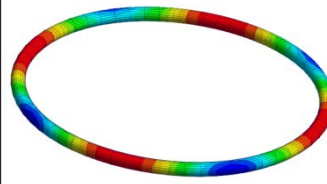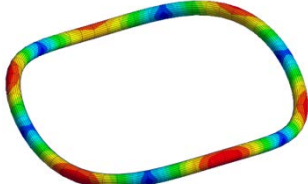

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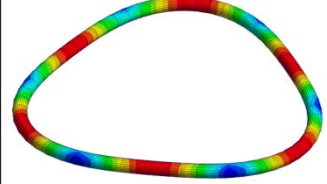
Fig. VM06

Fundamental Frequency(Hz)

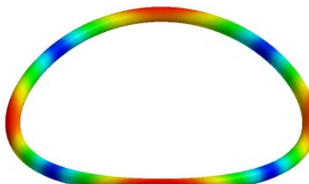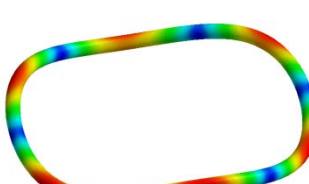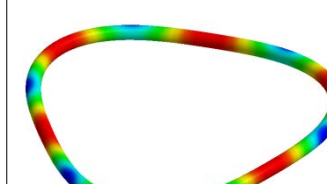| 柔性模態	7,8 Out of Plane	9,10 In Plane	11,12 Out of Plane	13,14 In Plane	15 Out of Plane	16 In Plane
Ref. (Hz)	51.85	53.38	148.8	151	287	289.5
NAFEMS (Hz) 誤差(%)	52.29 0.85%	53.97 1.11%	149.7 0.60%	152.4 0.93%	288.3 -0.45%	288.3 -0.41%
FEM 1D (Hz) 誤差(%)	51.705 -0.28%	53.224 -0.29%	147.45 -0.91%	149.64 -0.90%	282.13 -1.70%	284.62 -1.69%
FEM 3D (Hz) 誤差(%)	51.507 -0.66%	53.296 -0.16%	147.86 -0.63%	150.98 -0.01%	285.70 -0.45%	290.13 0.22%
MeshFree (Hz) 誤差(%)	51.487 -0.70%	53.149 -0.43%	146.78 -1.36%	149.49 -1.00%	280.80 -2.16%	280.80 -3.01%

Fundamental Frequency(Hz)

	柔性模態振形			柔性模態振形	
	Mode 7,8	Mode 9,10		Mode 7,8	Mode 9,10
FEM 有限元素 分析軟體			MeshFree 免網格 分析軟體		
	Mode 11,12	Mode 13,14		Mode 11,12	Mode 13,14

問題定義

Normal mode dynamic analysis of a fixed right triangular plate, with 6-inch length and 0.034-inch thickness (fig. VM07).

單位: IPS

材料屬性

楊氏係數 E=6.5e6 lb/in2 ,泊松比 v=0.3541,

Weight density= 0.06414 lb/in3, mass density = 1.66128e-4 lb-s2/in4

參考

"ASME Pressure Vessel and Piping 1972 Computer Programs Verification.", I.S. Tuba and W.B. Wright, ASME publication, I-24, Problem 2
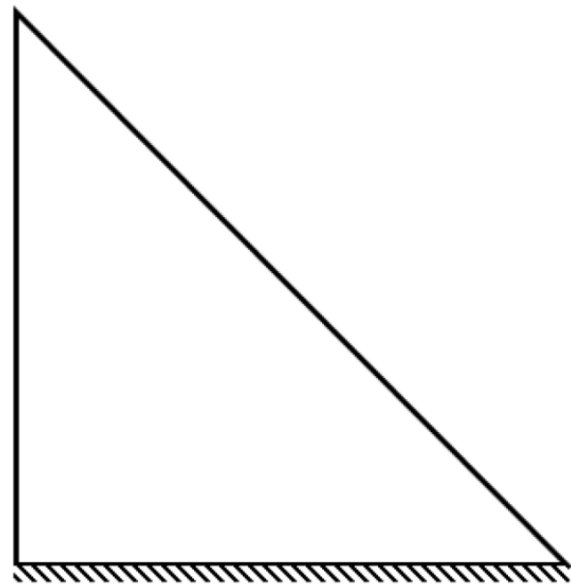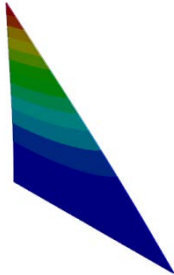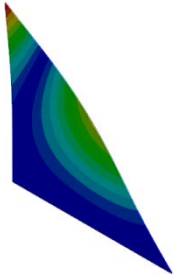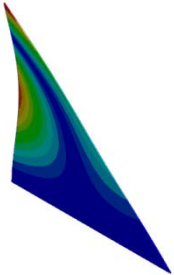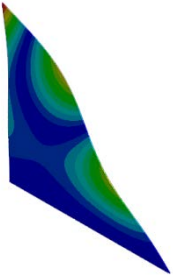

Fig. VM07

Maximum Principle Stress

模態	1		2		3		4	
結果	頻率(Hz)	誤差(%)	頻率(Hz)	誤差(%)	頻率(Hz)	誤差(%)	頻率(Hz)	誤差(%)
理論	55.9	-	210.9	-	293.5	-		
FEM 有限元素 分析軟體	56.04	0.25%	211.80	0.43%	293.82	0.11%	505.13	-
MeshFree 免網格 分析軟體	55.95	0.10%	211.39	0.23%	293.12	-0.13%	505.11	-0.00%