

圖 1.1 具應力奇異點厚板示意圖

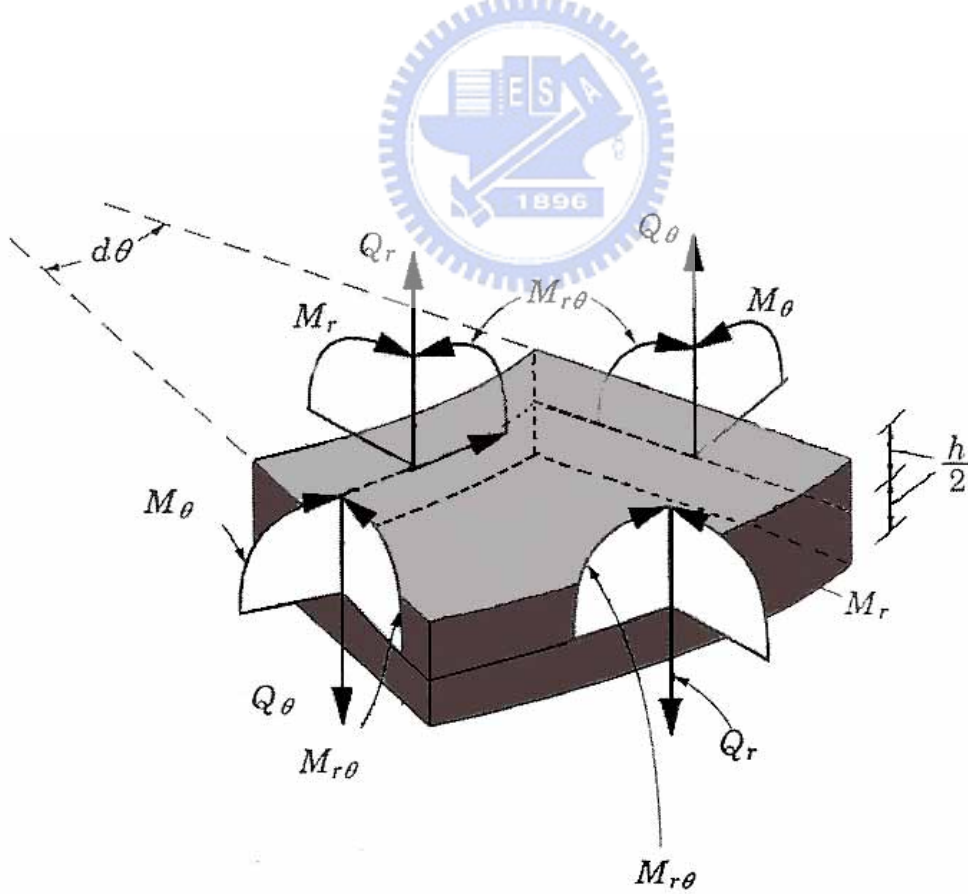


圖 2.1 板上內力之示意圖(修改 Reddy, 1999)

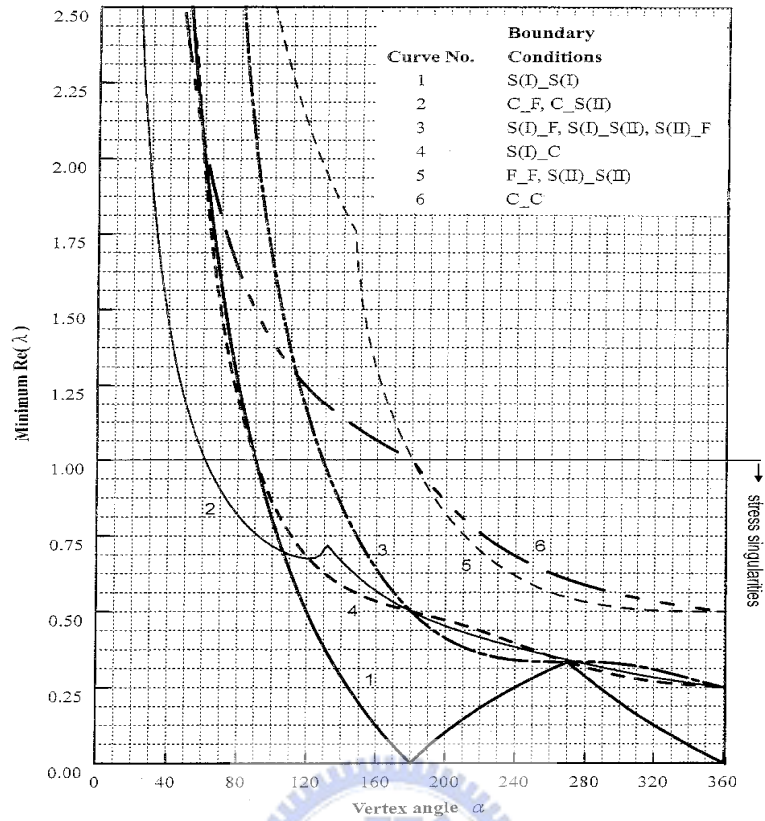


圖 2.2 最小實部 λ 值與扇形角之關係(節錄 Huang, 2003)

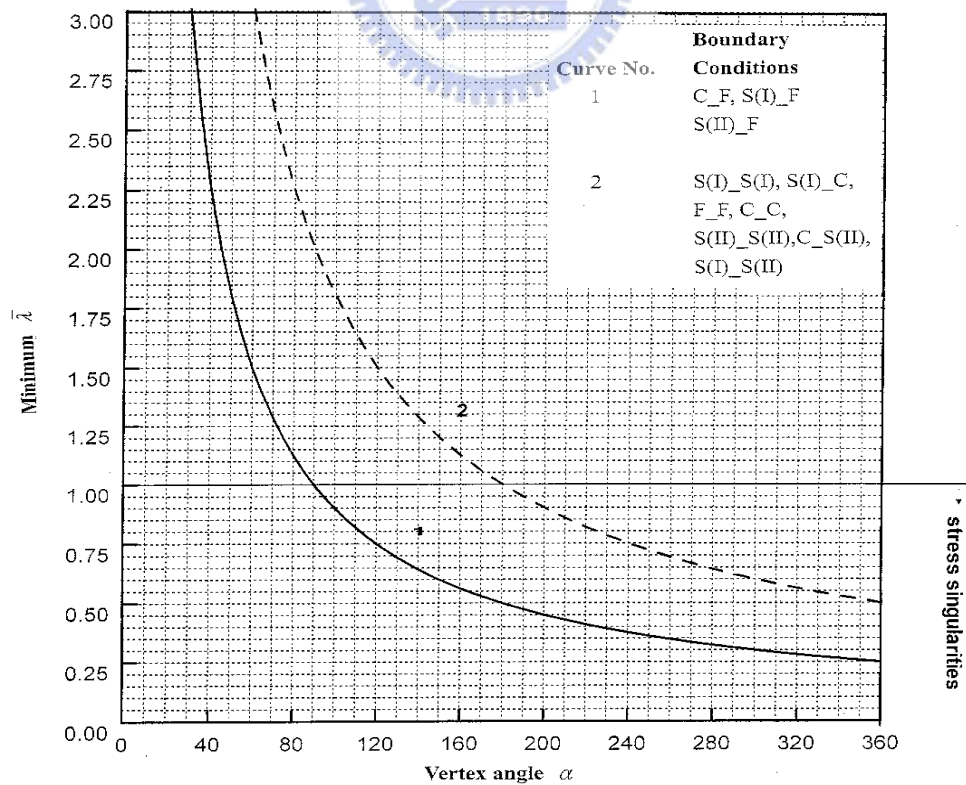


圖 2.3 最小 λ 值與扇形角之關係(節錄 Huang, 2003)

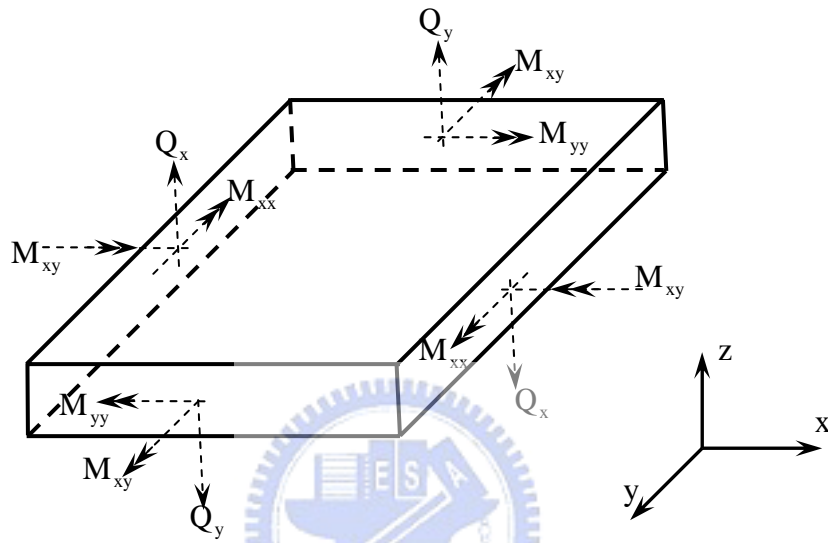


圖 3.1 板上之剪力與彎矩示意圖

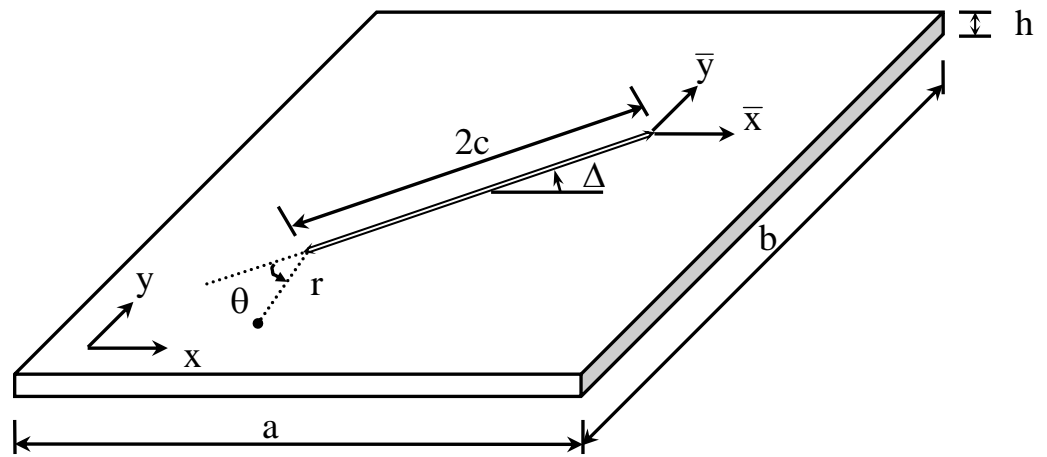


圖 4.1 方形板裂縫與座標系統示意圖

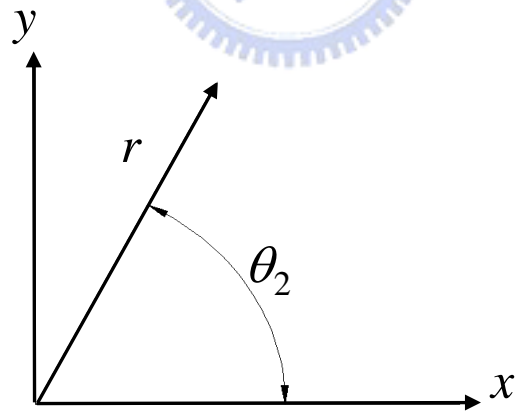
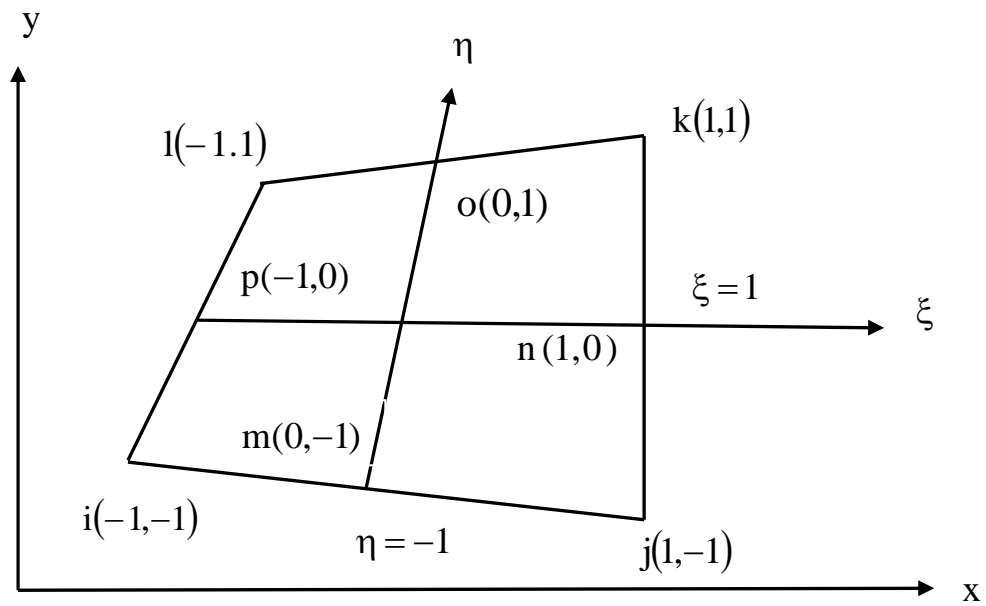


圖 4.2 極座標與卡式座標轉換示意圖



其中形狀函數(shape function)如下

$$N_i(\xi, \eta) = \frac{1}{4}(1 - \xi)(1 - \eta)(-\xi - \eta - 1)$$

$$N_j(\xi, \eta) = \frac{1}{4}(1 + \xi)(1 - \eta)(\xi - \eta - 1)$$

$$N_k(\xi, \eta) = \frac{1}{4}(1 + \xi)(1 + \eta)(\xi + \eta - 1)$$

$$N_l(\xi, \eta) = \frac{1}{4}(1 - \xi)(1 + \eta)(-\xi + \eta - 1)$$

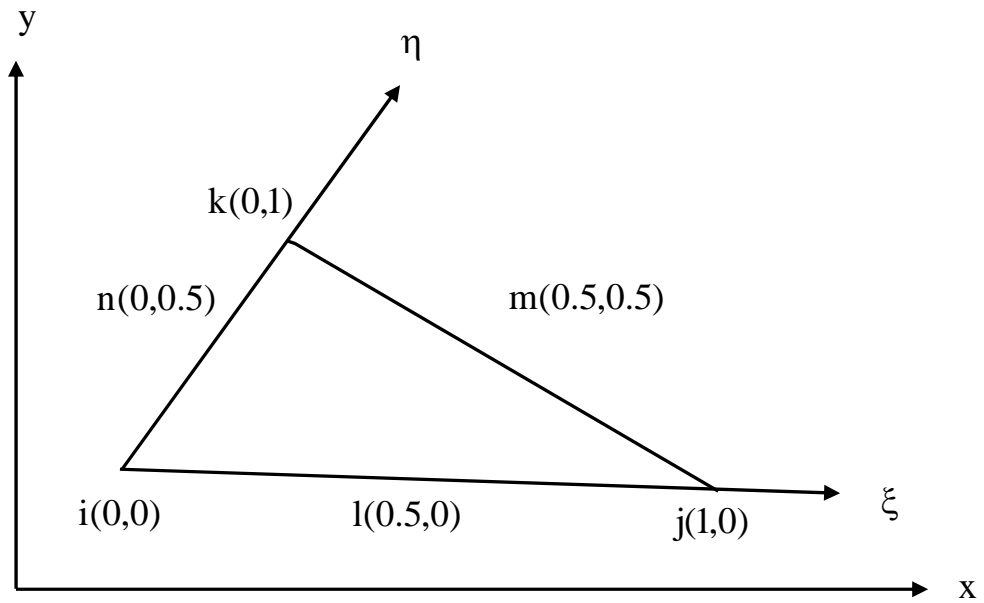
$$N_m(\xi, \eta) = \frac{1}{2}(1 - \eta)(1 - \xi^2)$$

$$N_n(\xi, \eta) = \frac{1}{2}(1 + \xi)(1 - \eta^2)$$

$$N_o(\xi, \eta) = \frac{1}{2}(1 + \eta)(1 - \xi^2)$$

$$N_p(\xi, \eta) = \frac{1}{2}(1 - \xi)(1 - \eta^2)$$

圖 4.3 四邊形元素示意圖及其形狀函數定義



其中形狀函數(shape function)如下

$$N_i(\xi, \eta) = (1 - \xi - \eta)(1 - 2\xi - 2\eta)$$

$$N_j(\xi, \eta) = \xi(2\xi - 1)$$

$$N_k(\xi, \eta) = \eta(2\eta - 1)$$

$$N_l(\xi, \eta) = 4\xi(1 - \xi - \eta)$$

$$N_m(\xi, \eta) = 4\xi\eta$$

$$N_n(\xi, \eta) = 4\eta(1 - \xi - \eta)$$

圖 4.4 三角形元素示意圖及其形狀函數定義

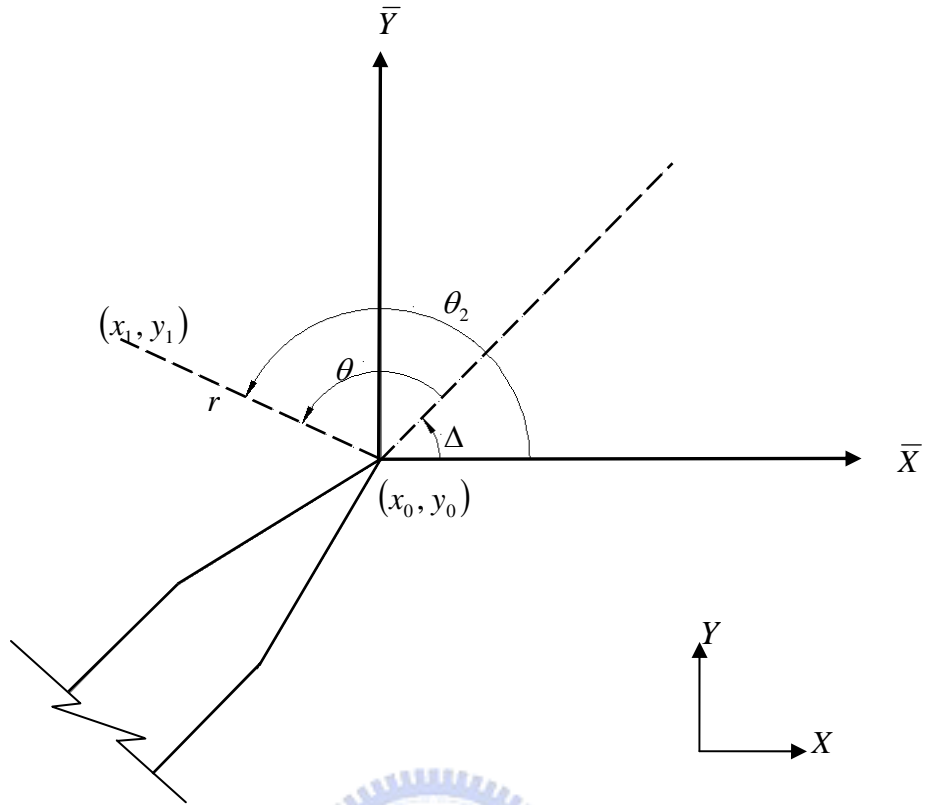


圖 4.5 裂縫尖端之座標轉換示意圖

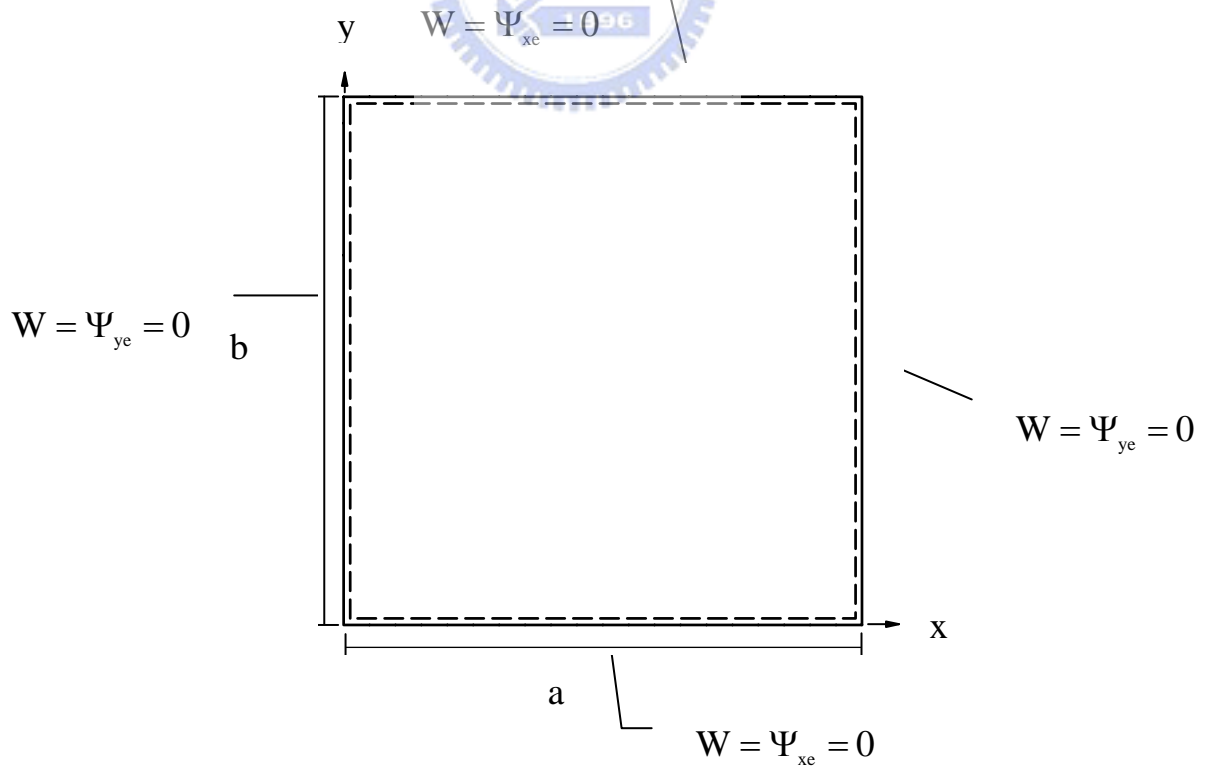


圖 4.6 一階剪力變形理論 (FSDT) 簡支承邊界條件

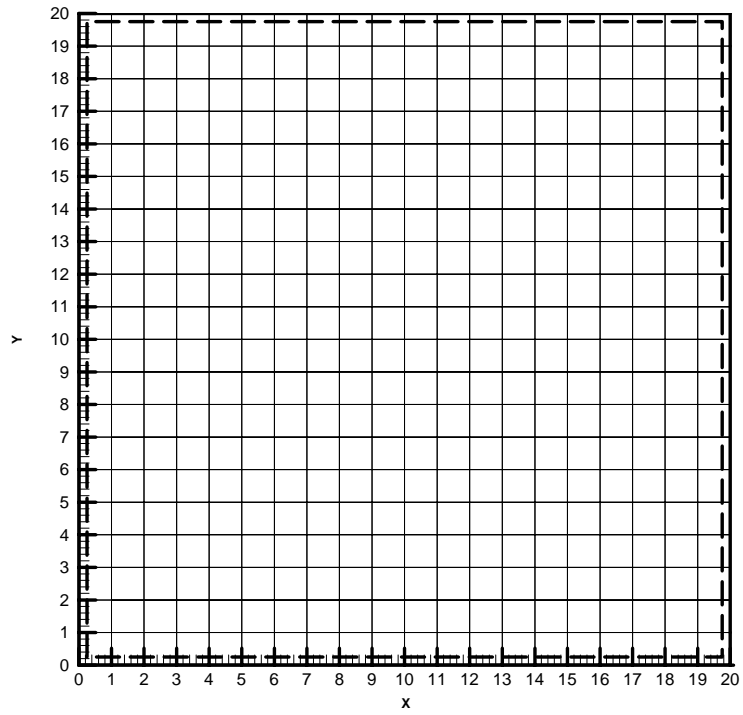


圖 4.7 sq1(a) 網格切割圖

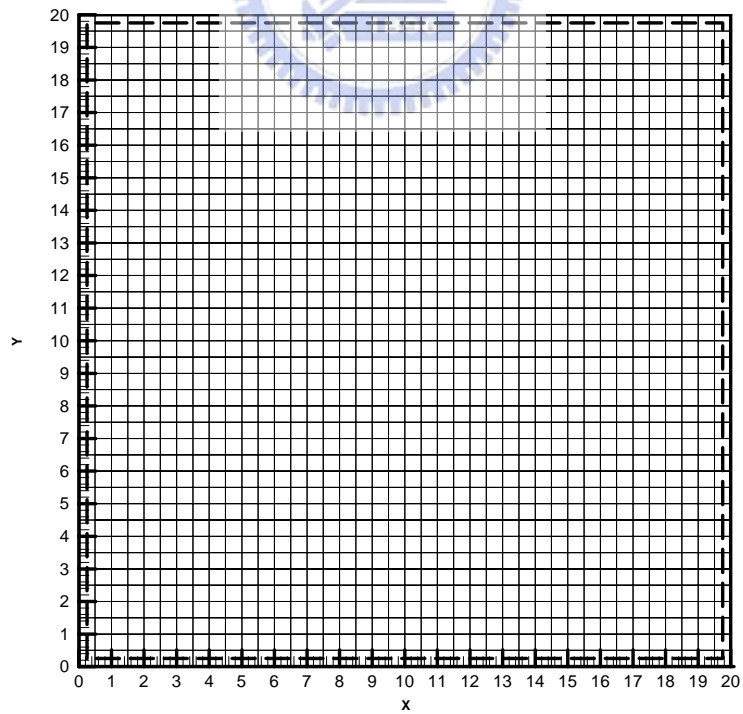


圖 4.8 sq1(b) 網格切割圖

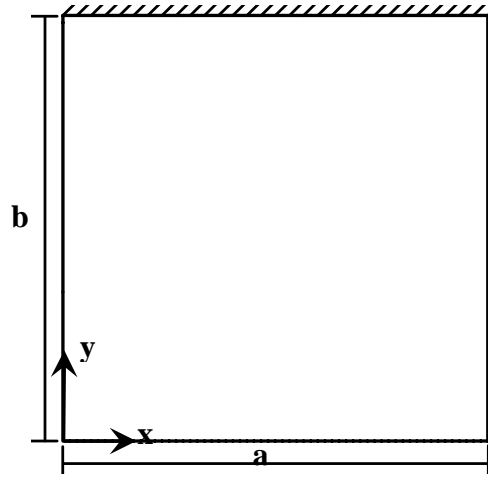
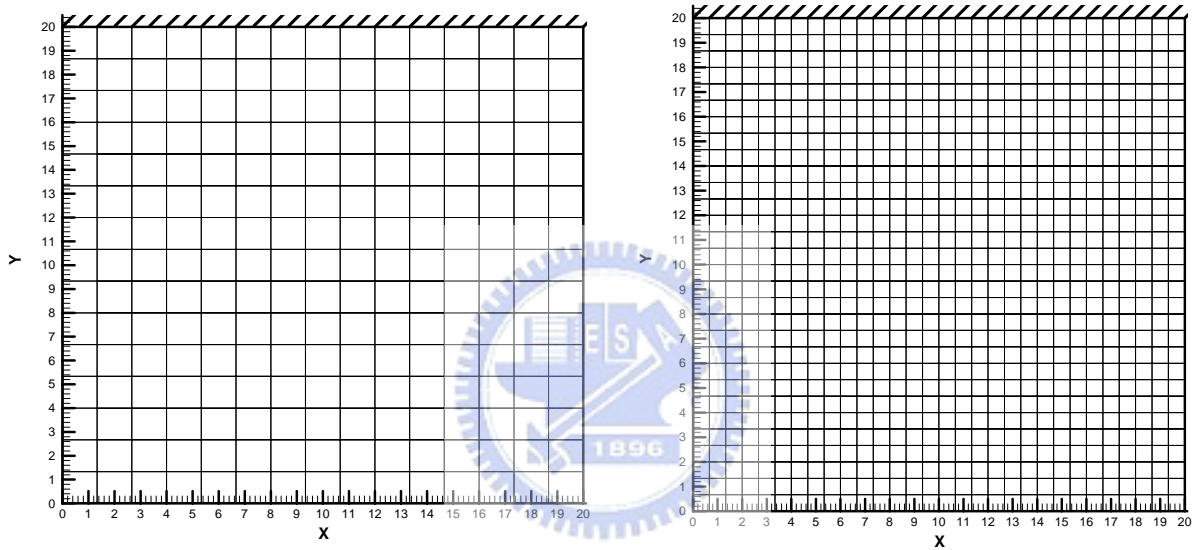
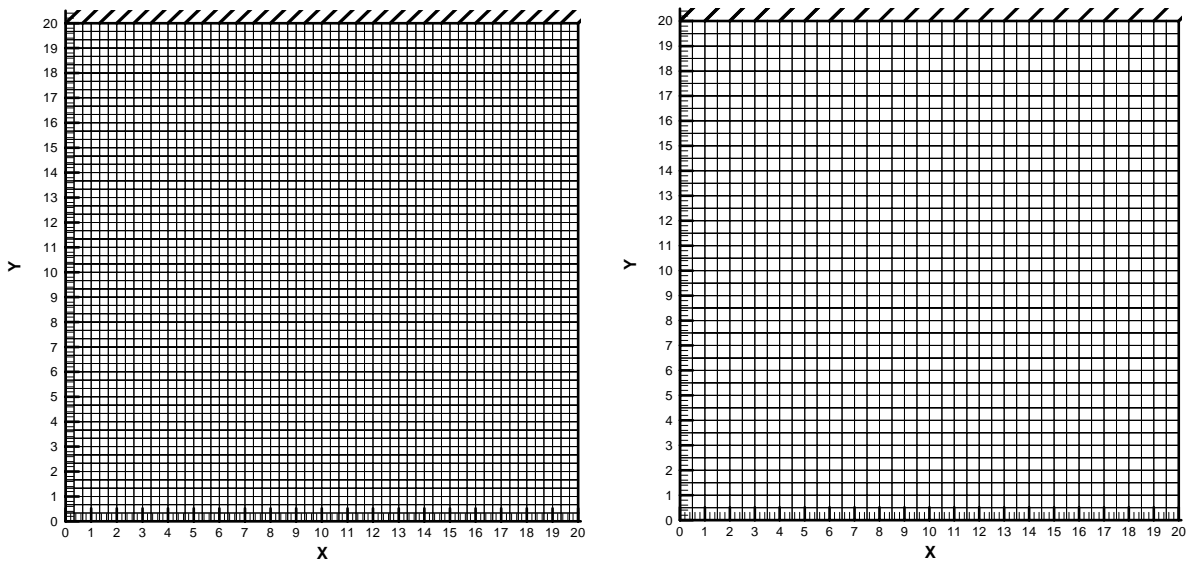


圖 4.9 四周邊界為 FFCF 之懸臂板示意圖



Sq2(a)

Sq2(b)



Sq2(c)

Sq2(d)

圖 4.10 分析 FFCF 板所切割之網格圖

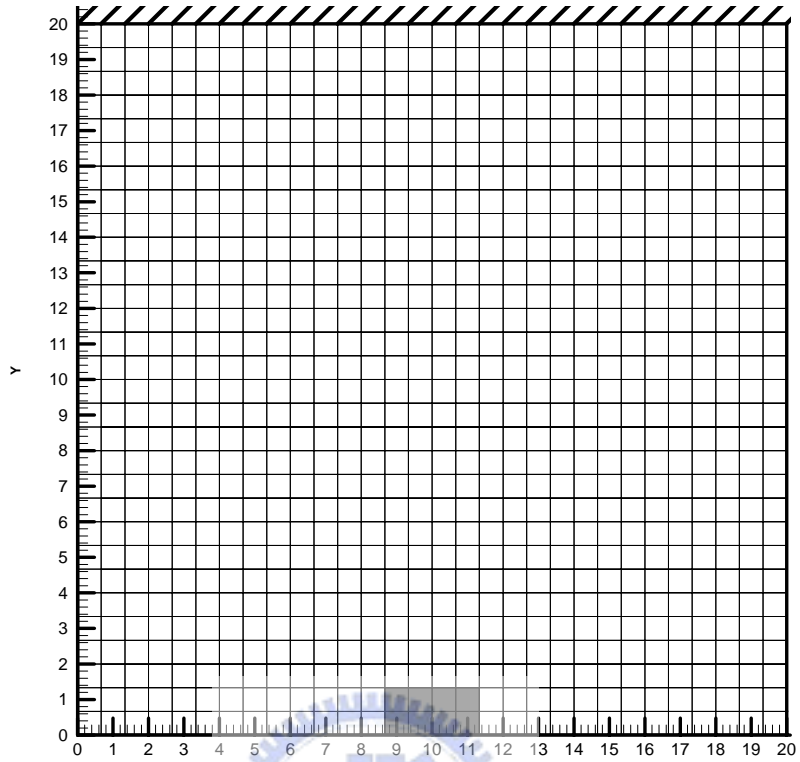


圖 4.11 sq3 網格切割圖

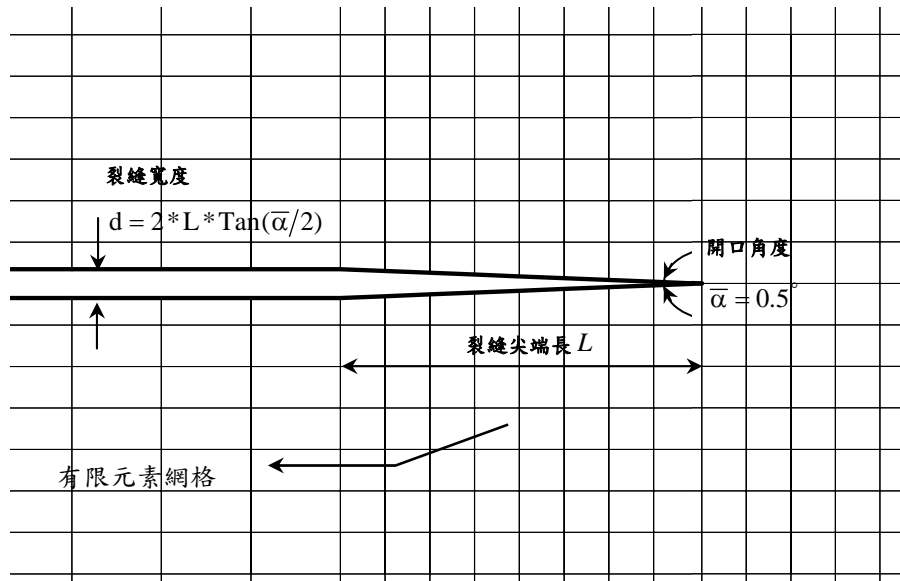
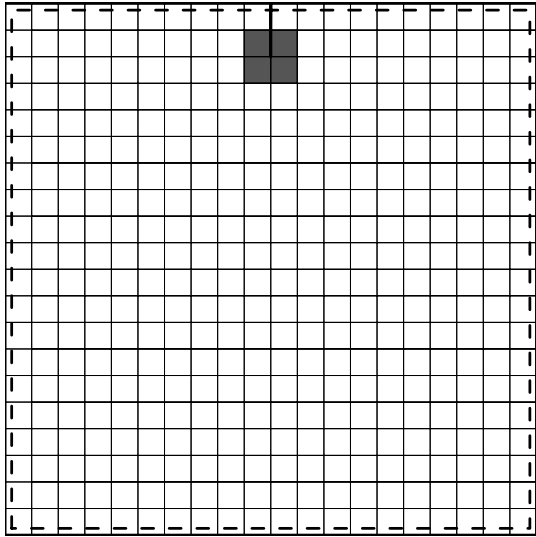
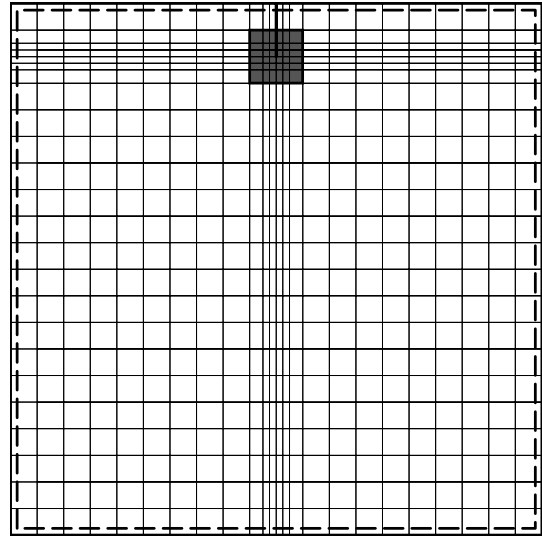


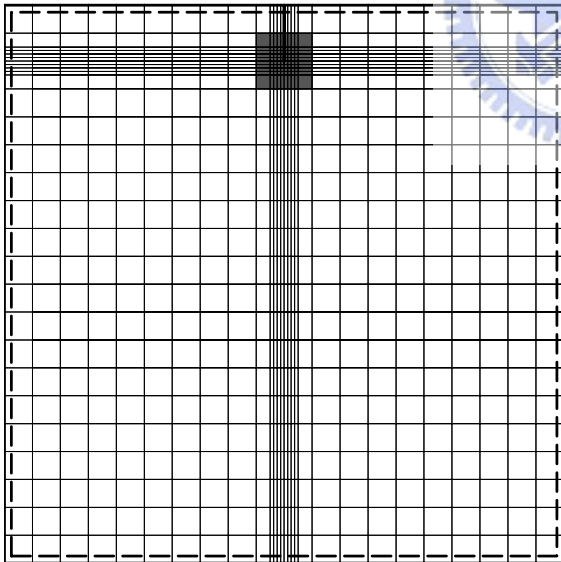
圖 4.12 裂縫與裂縫尖端示意圖



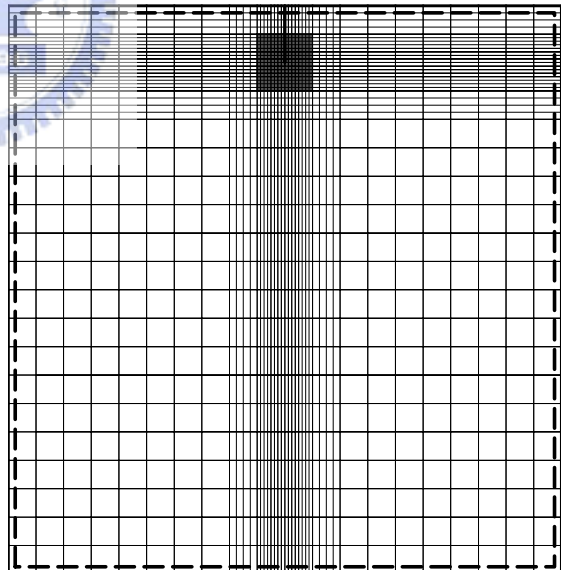
sq4(a)



sq4(b)

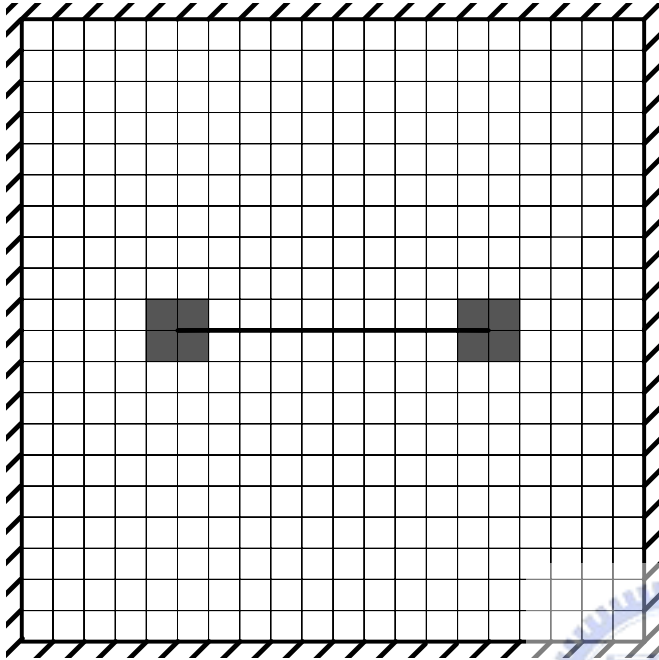


sq4(c)

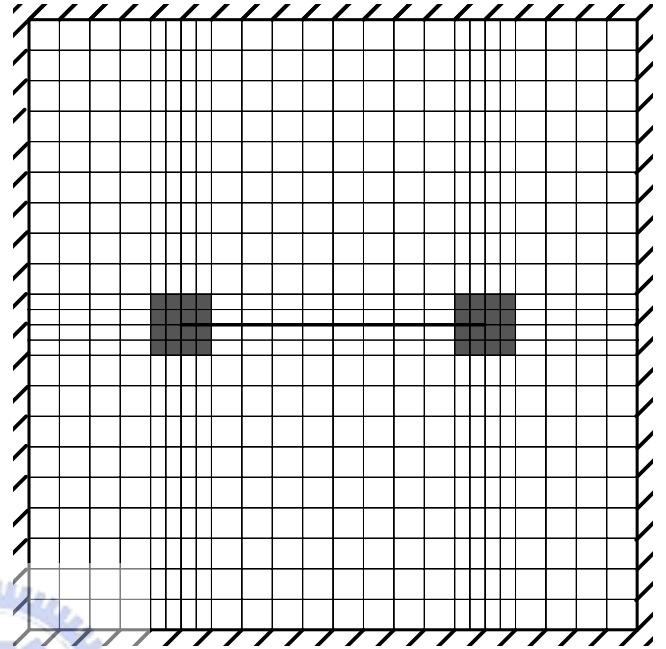


sq4(d)

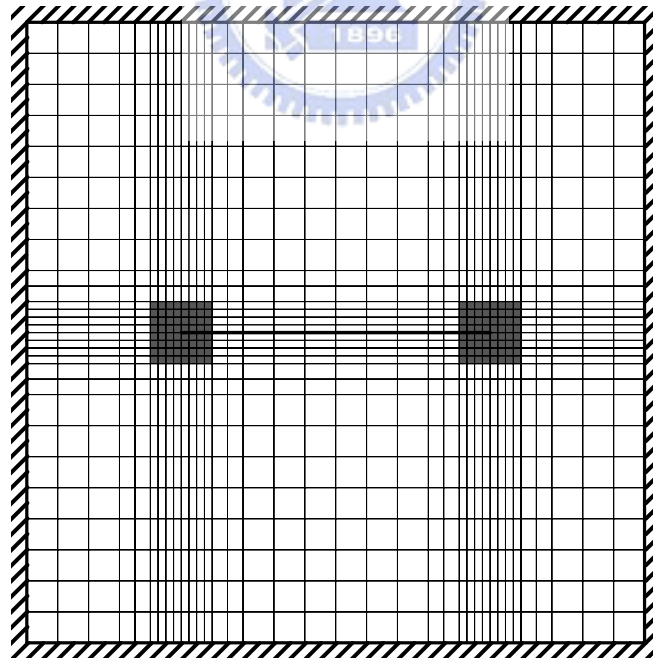
圖 4.13 分析具邊界裂縫簡支板之網格切割圖



sq5(a)



sq5(b)



sq5(c)

圖 4.14 四端邊界為 CCCC 之裂縫厚板有限元素網格分析模型

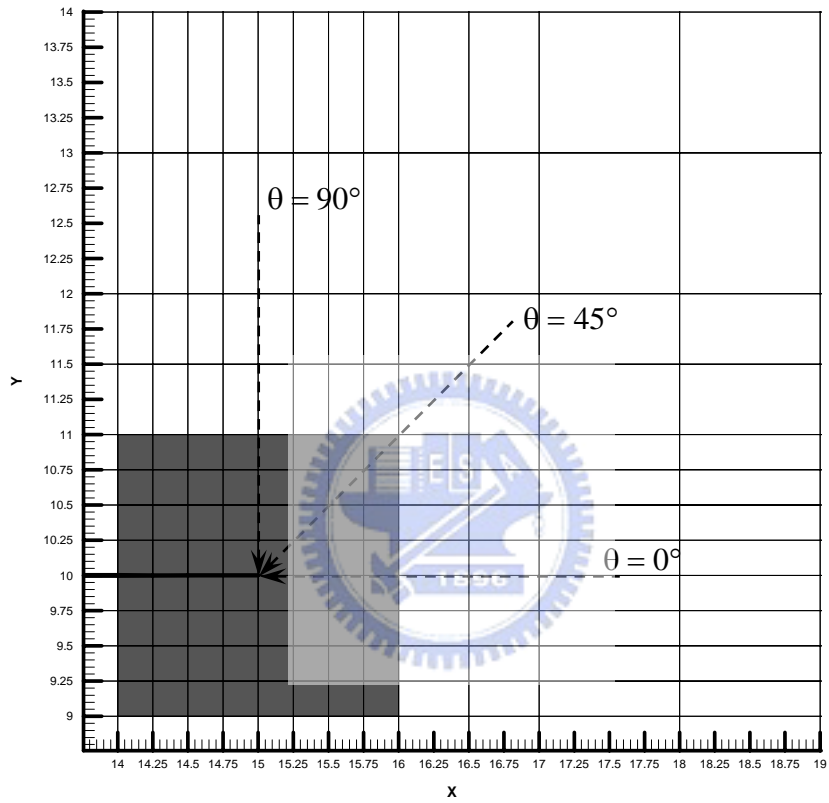
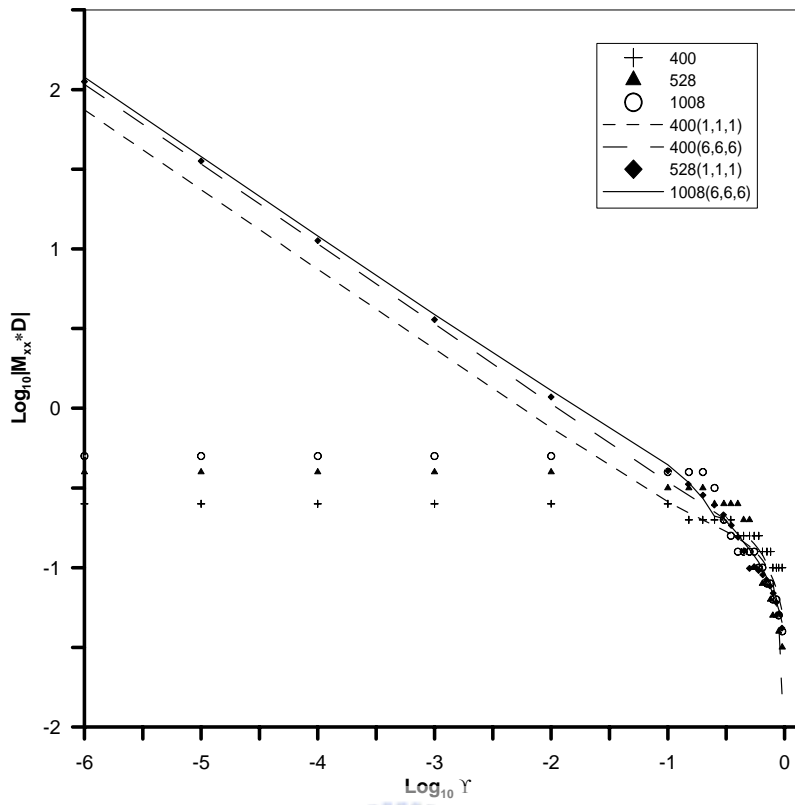
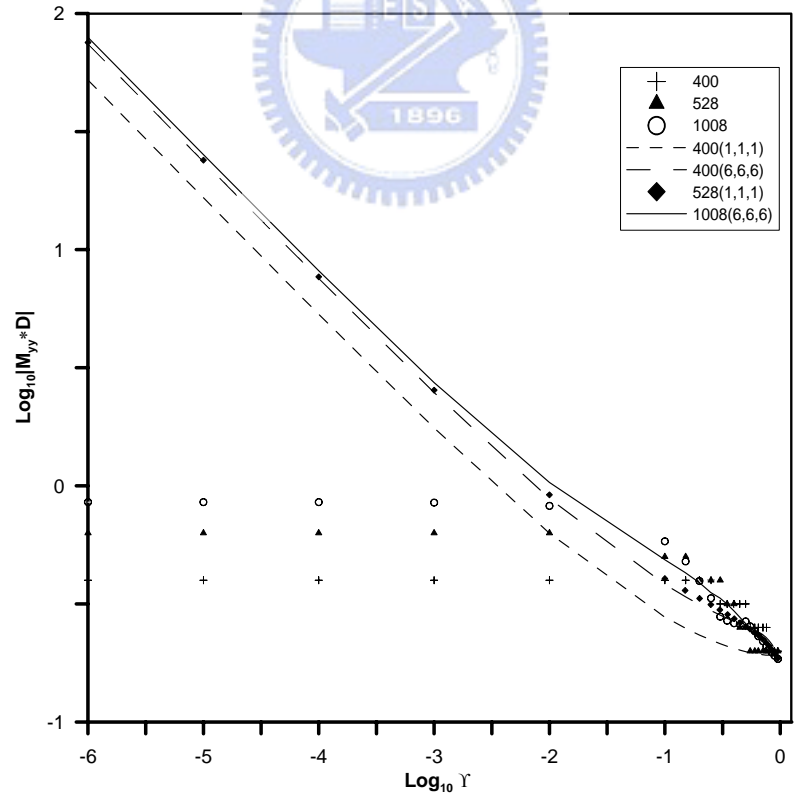


圖 4.15 $\Delta = 0^\circ$, 奇異點(Corner A)在 $\theta = (0^\circ, 45^\circ, 90^\circ)$ 之計算內力方向



(a)



(b)

圖 4.16(續上頁)

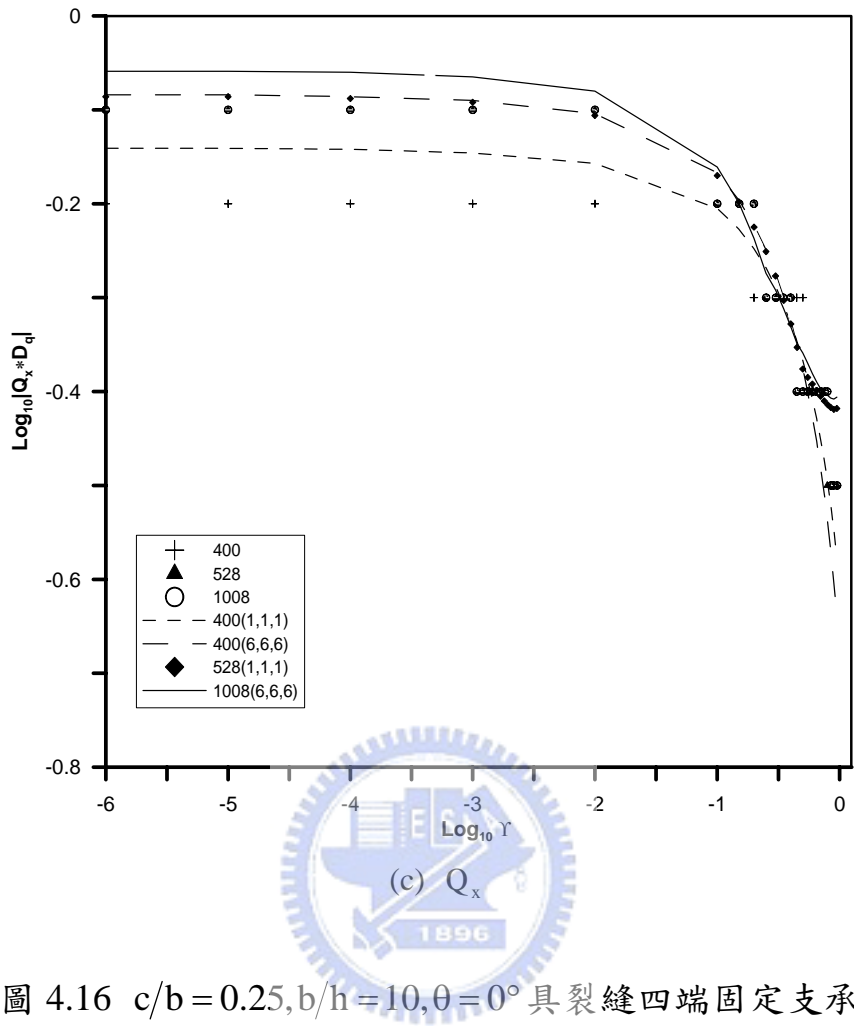
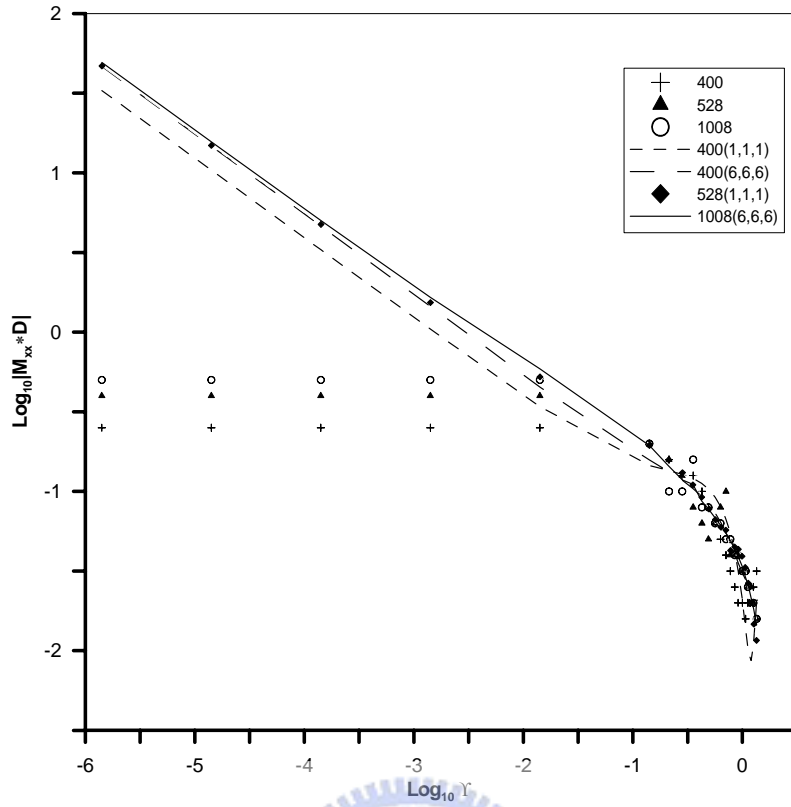
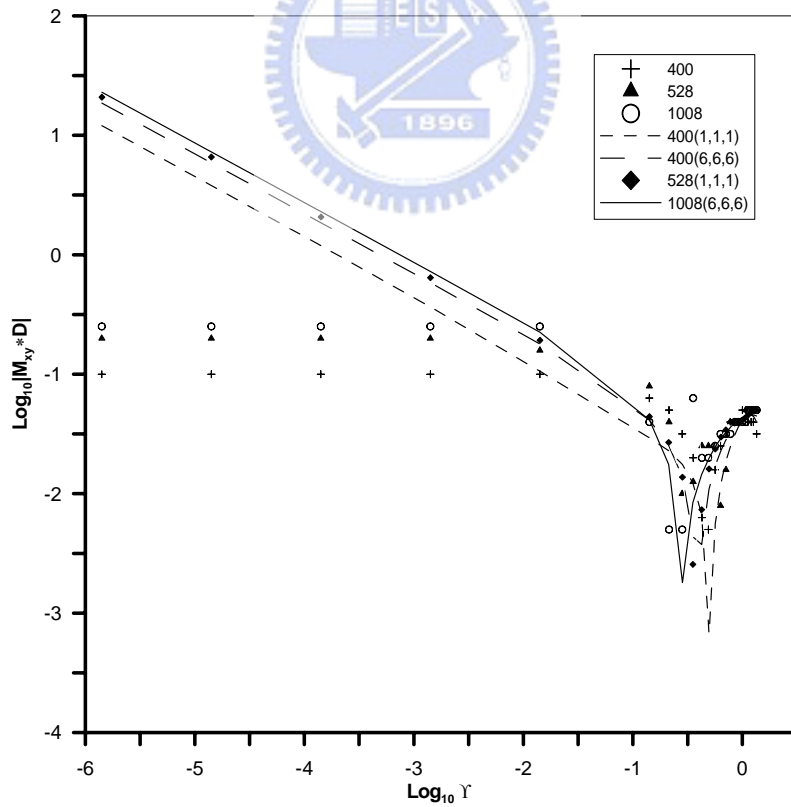


圖 4.16 $c/b = 0.25, b/h = 10, \theta = 0^\circ$ 具裂縫四端固定支承

(CCCC)板受均佈載重之裂縫處內力收斂性分析

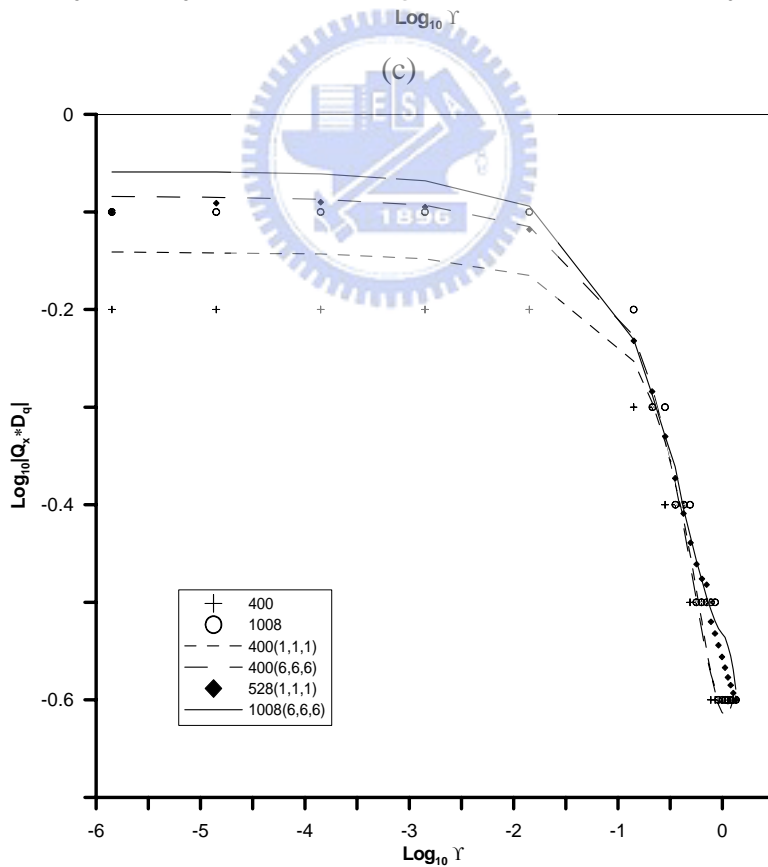
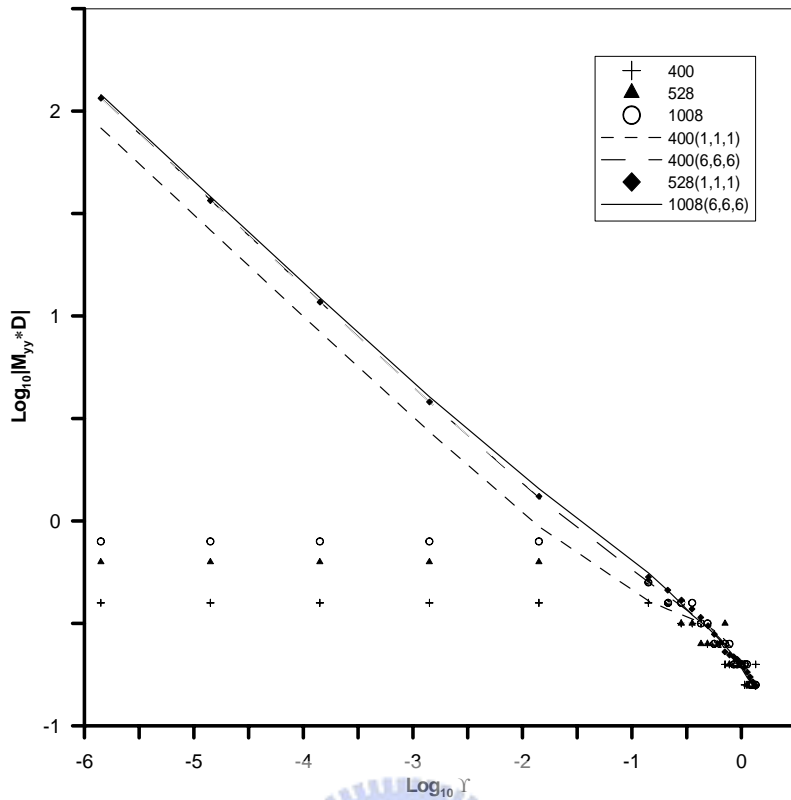


(a)



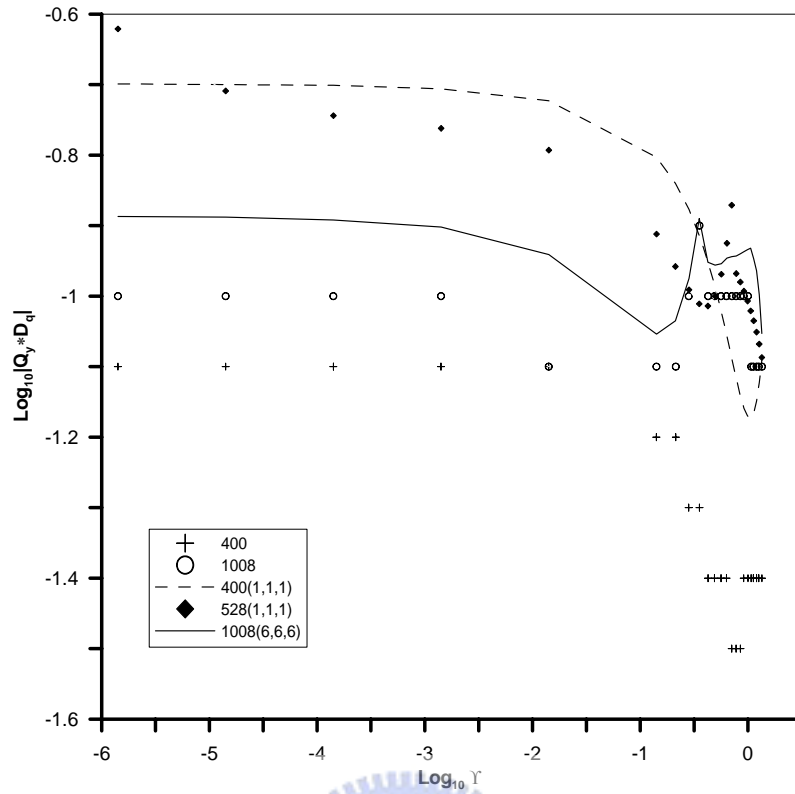
(b)

圖 4.17(續上頁)



(d)

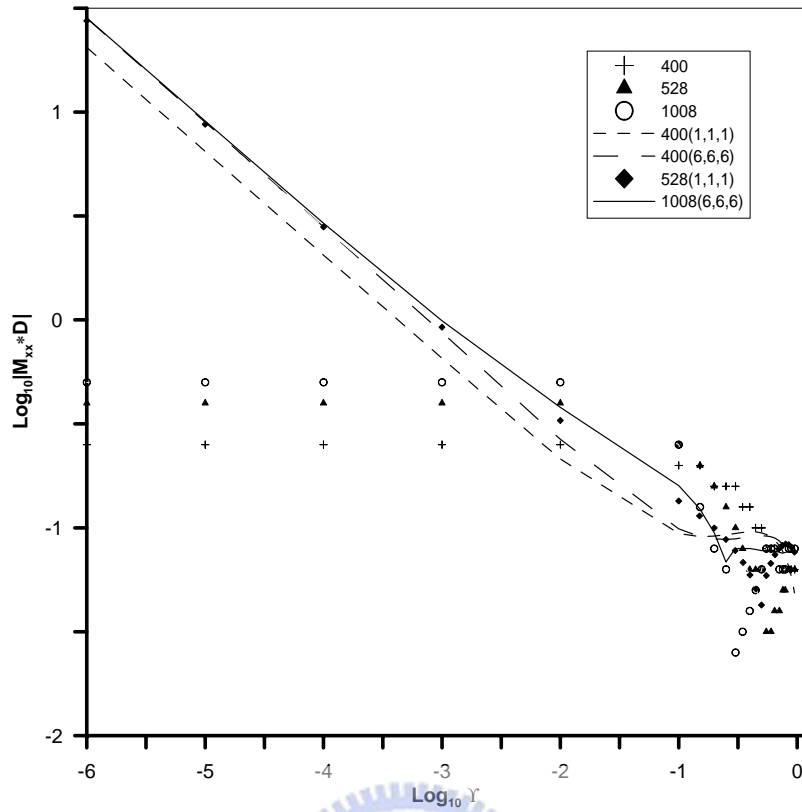
圖 4.17(續上頁)



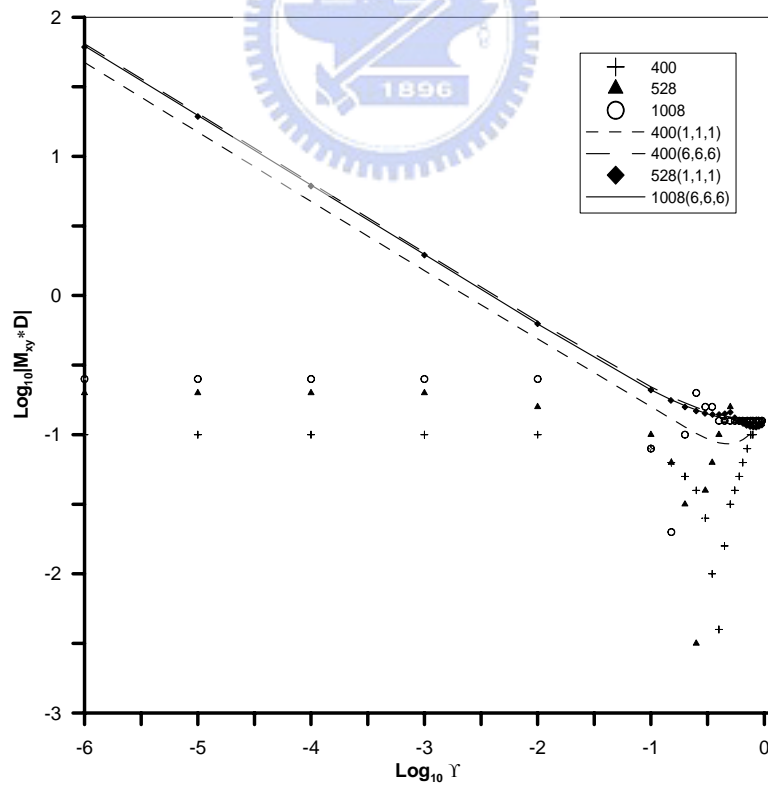
(e)

圖 4.17 $c/b = 0.25, b/h = 10, \theta = 45^\circ$ 具裂縫四端固定支承

(CCCC)板受均佈載重之裂縫處內力收斂性分析

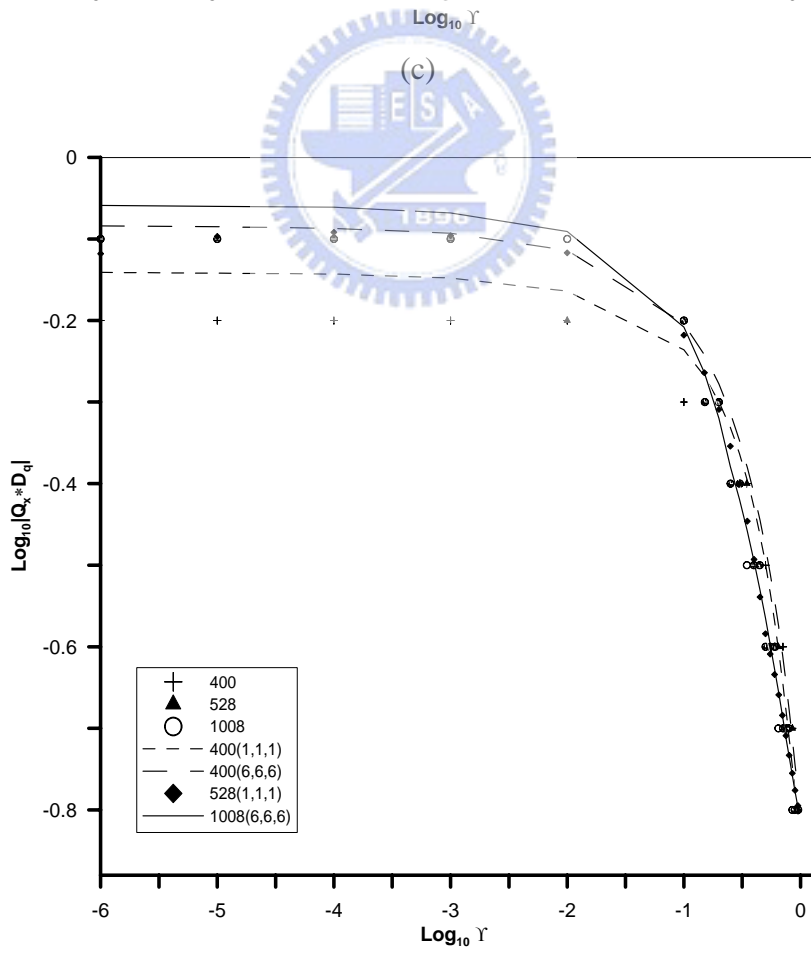
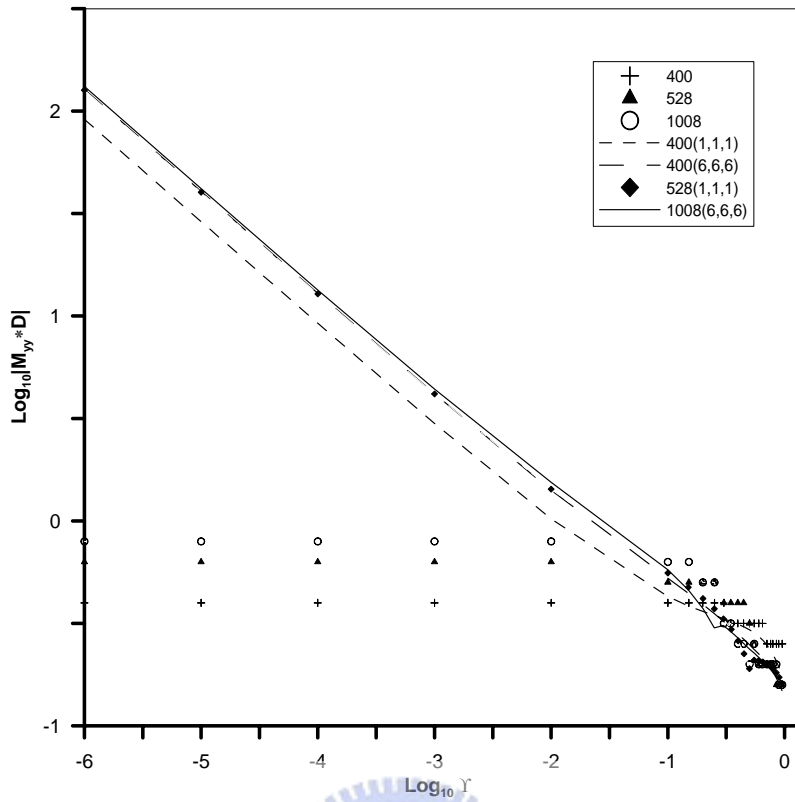


(a)

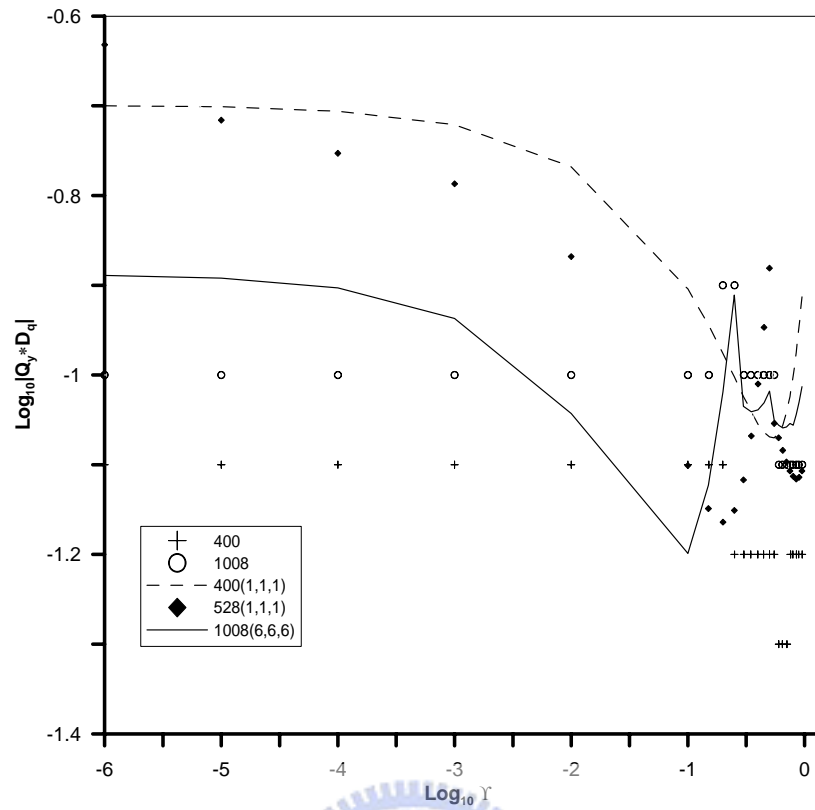


(b)

圖 4.18(續上頁)



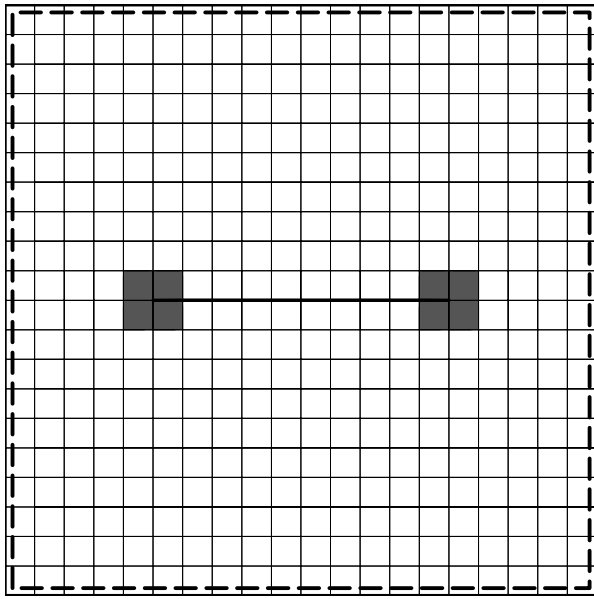
(d)
圖 4.18(續上頁)



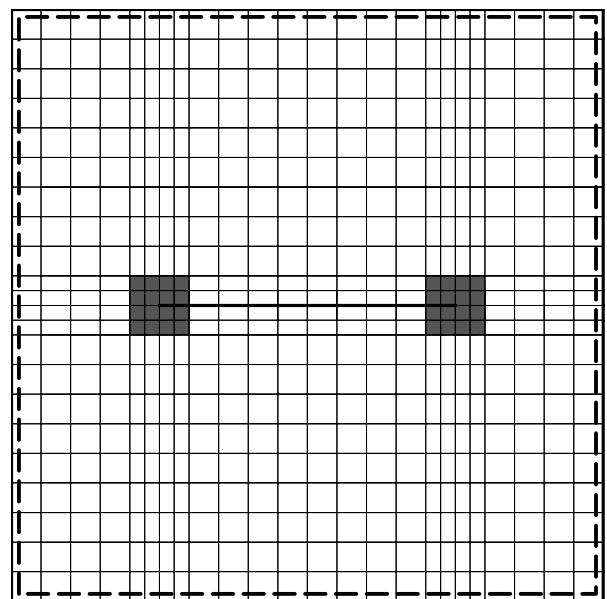
(e)

圖 4.18 $c/b=0.25, b/h=10, \theta=90^\circ$ 具裂縫四端固定支承

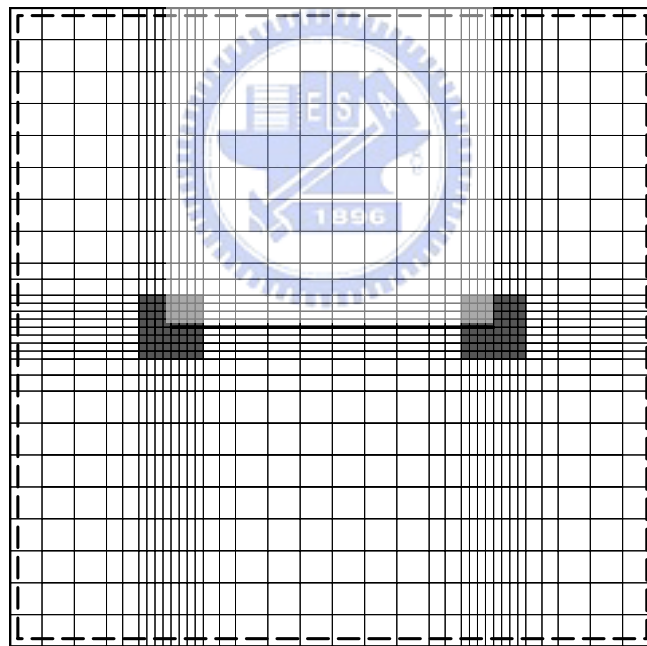
(CCCC)板受均佈載重之裂縫處內力收斂性分析



sq6(a)

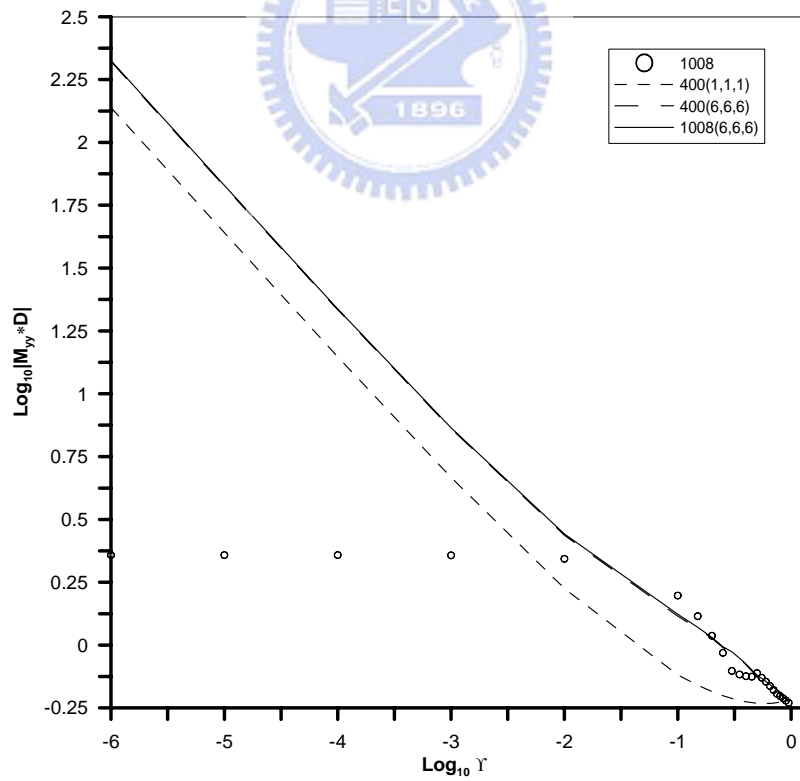
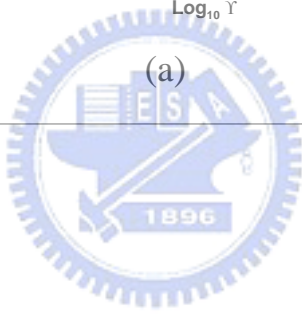
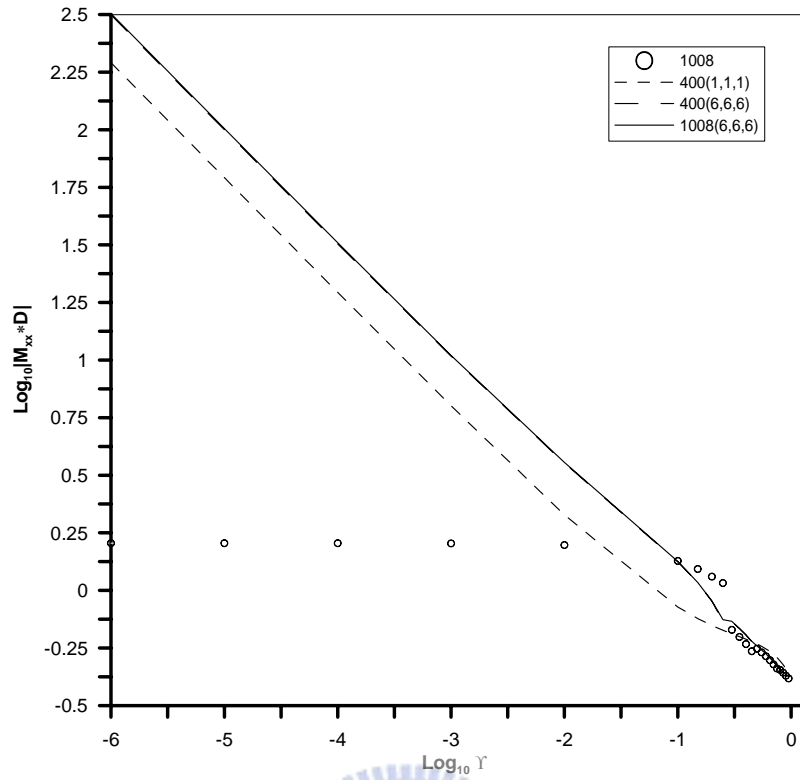


sq6(b)

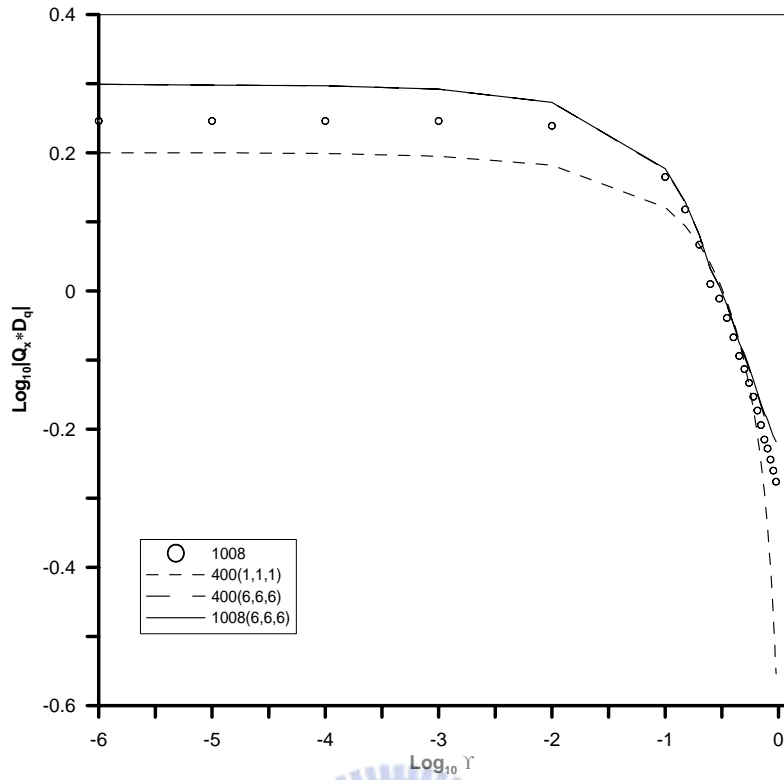


sq6(c)

圖 4.19 四端邊界為 SSSS 之裂縫厚板有限元素網格分析模型

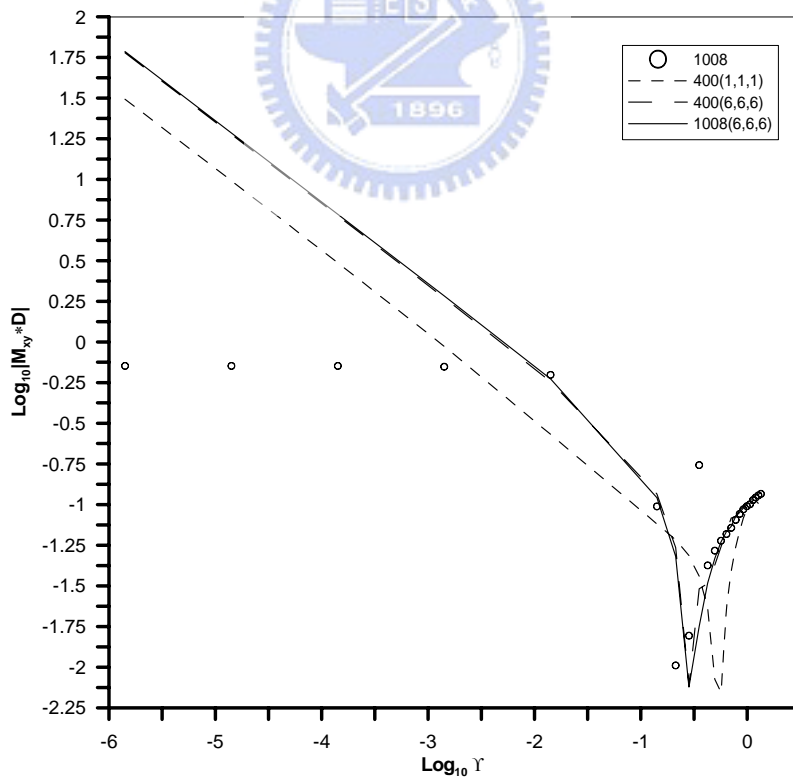
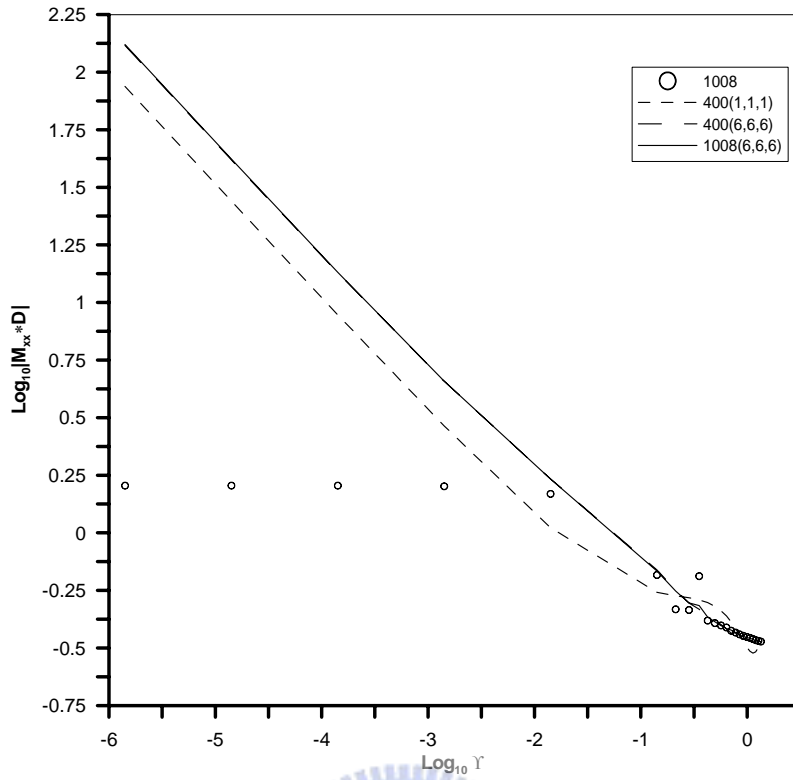


(b)
圖 4.20(續上頁)

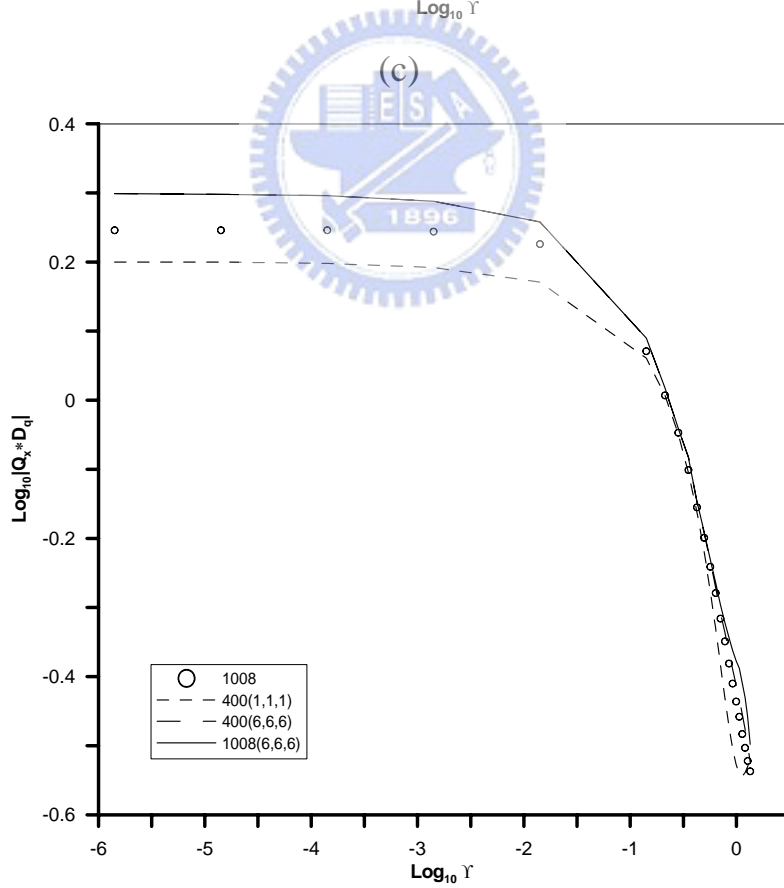
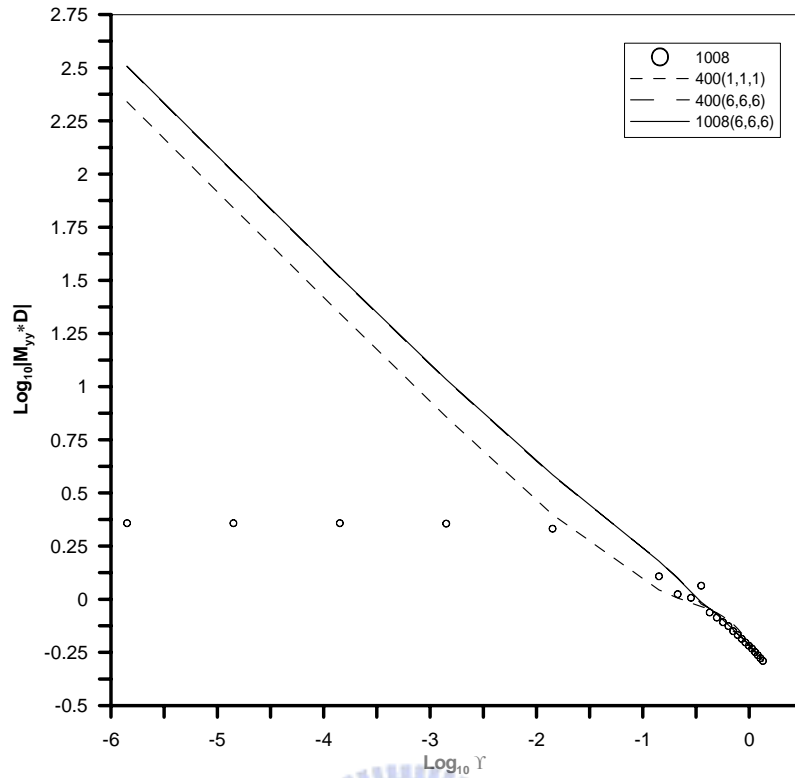


(c)

圖 4.20 $c/b = 0.25, b/h = 10, \theta = 0^\circ$ 具裂縫四端簡支承
(SSSS)板受均佈載重之裂縫處內力收斂性分析



(b)
圖 4.21(續上頁)



(d)
圖 4.21(續上頁)

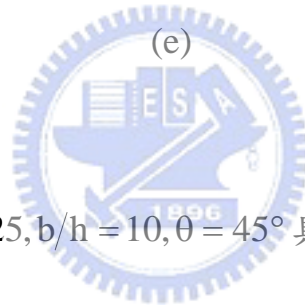
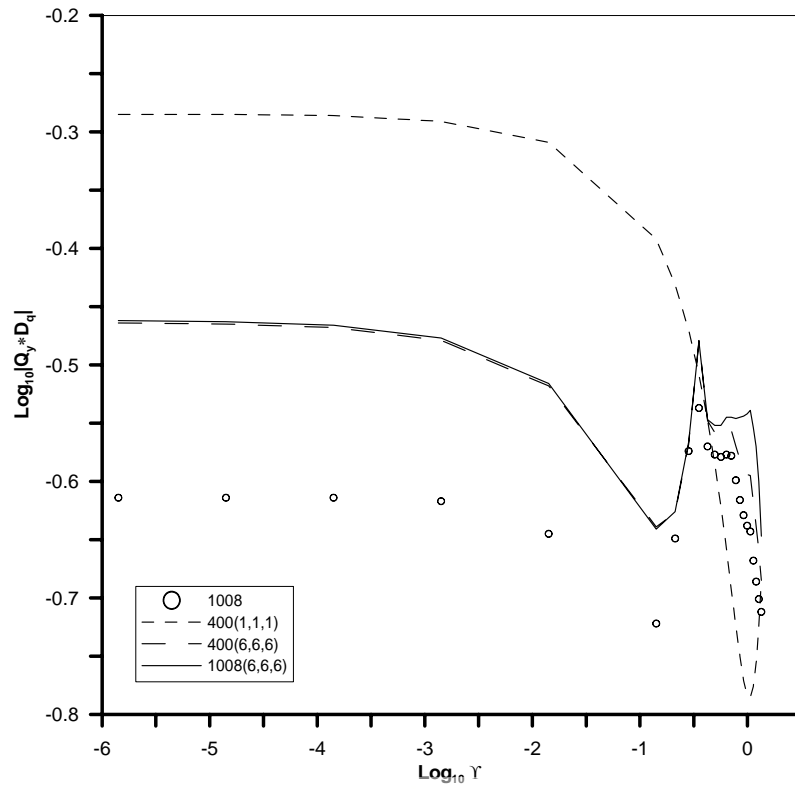
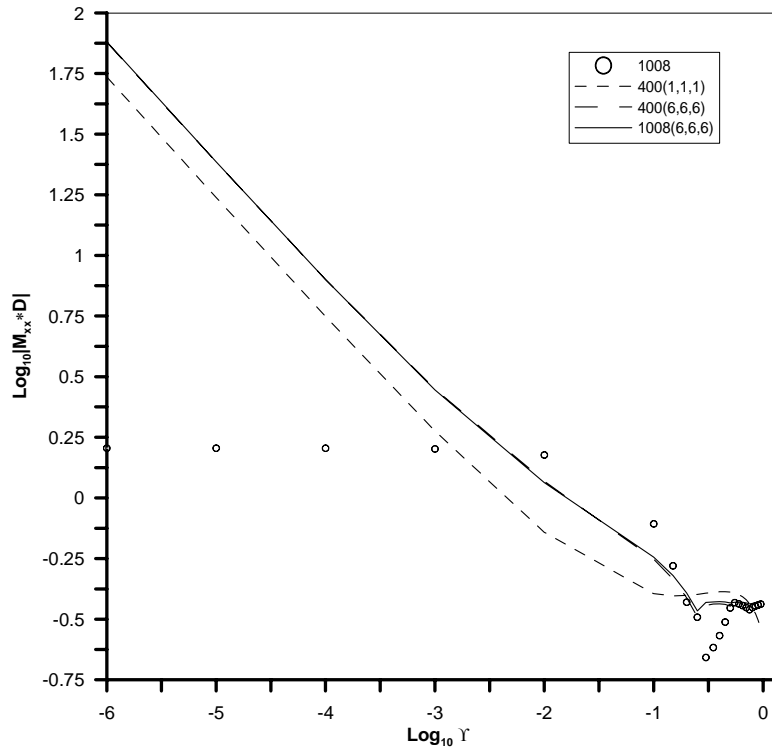
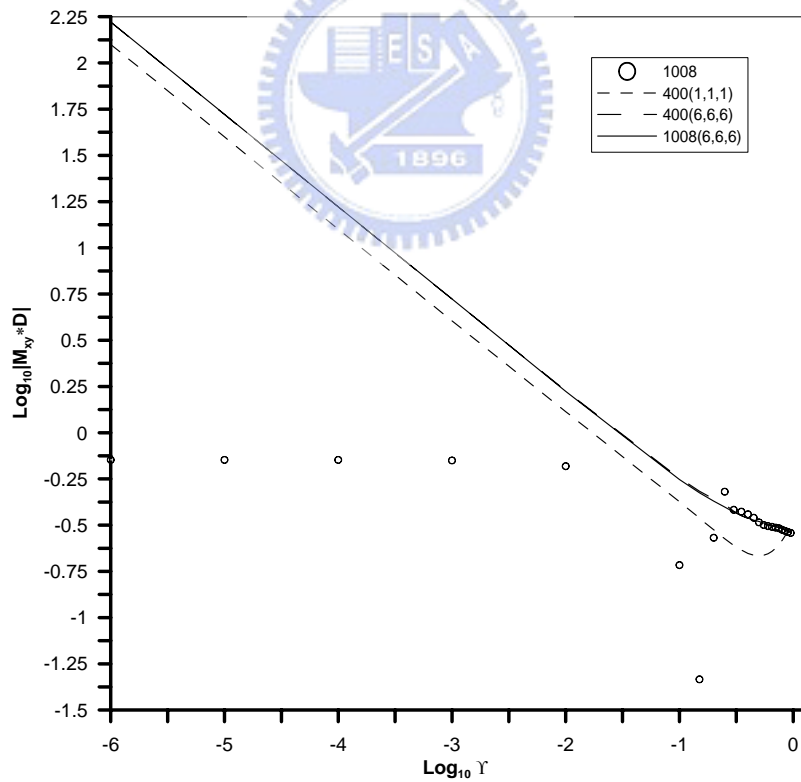


圖 4.21 $c/b = 0.25, b/h = 10, \theta = 45^\circ$ 具裂縫四端簡支承

(SSSS)板受均佈載重之裂縫處內力收斂性分析

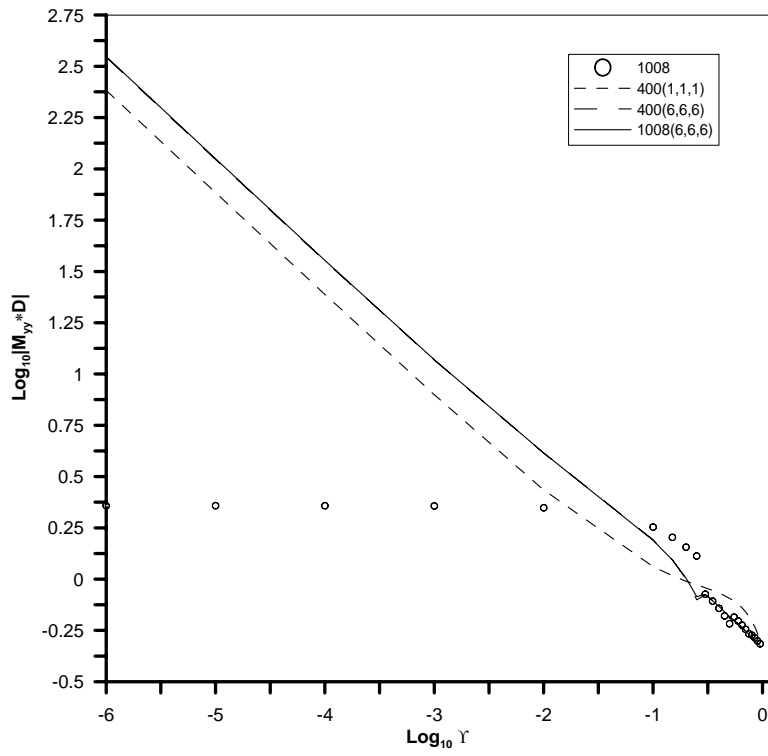


(a)

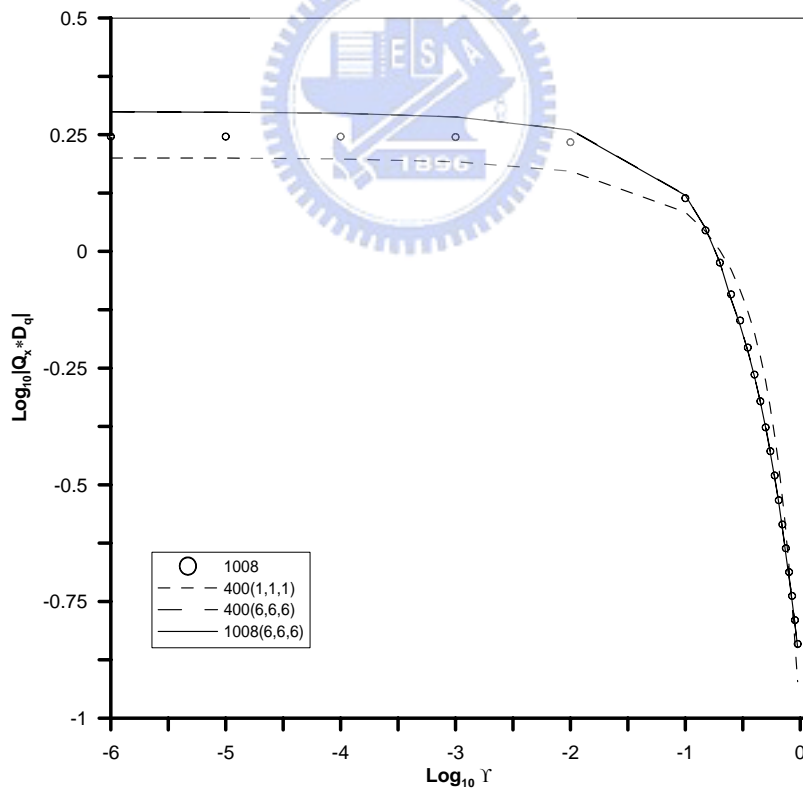


(b)

圖 4.22(續上頁)



(c)



(d)

圖 4.22(續上頁)

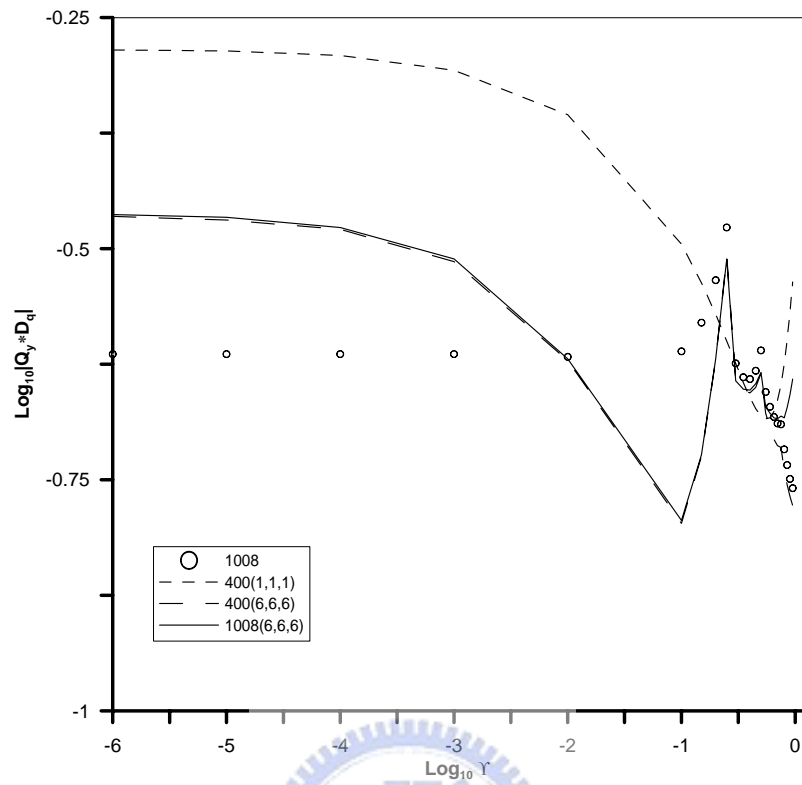
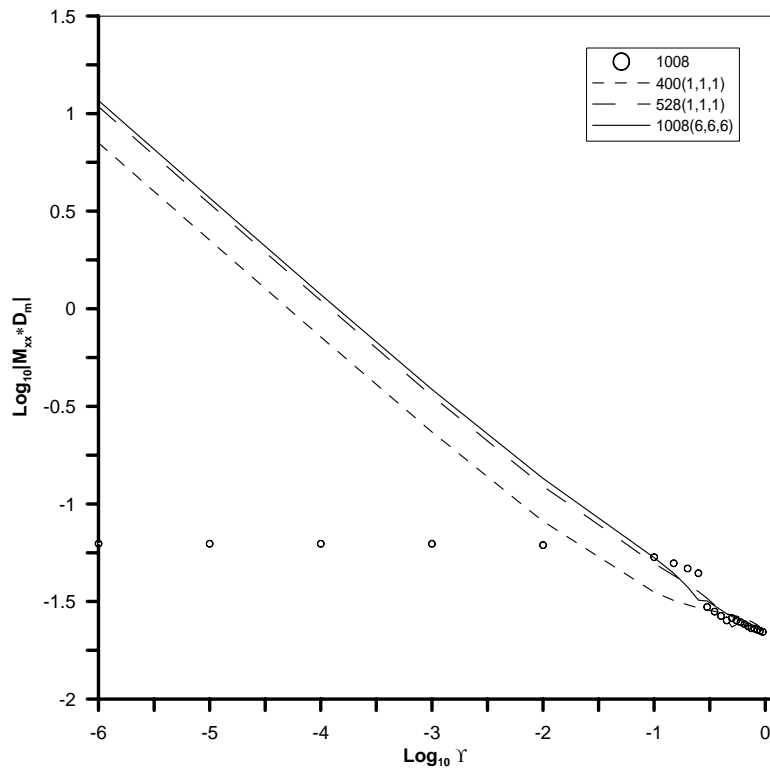
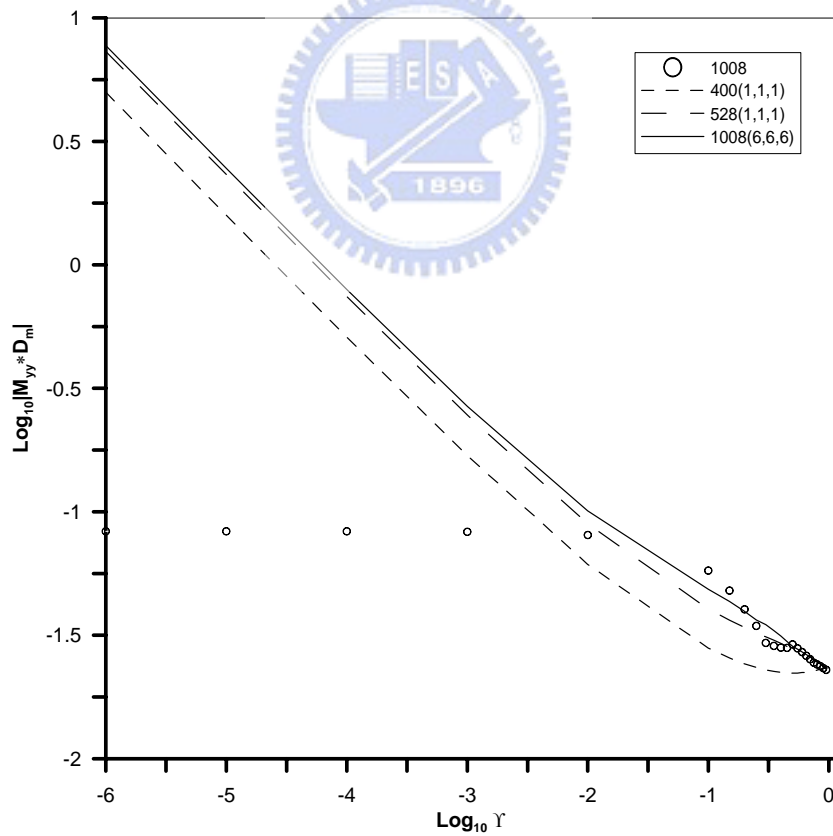


圖 4.22 $c/b = 0.25, b/h = 10, \theta = 90^\circ$ 具裂縫四端簡支承

(SSSS)板受均佈載重之裂縫處內力收斂性分析

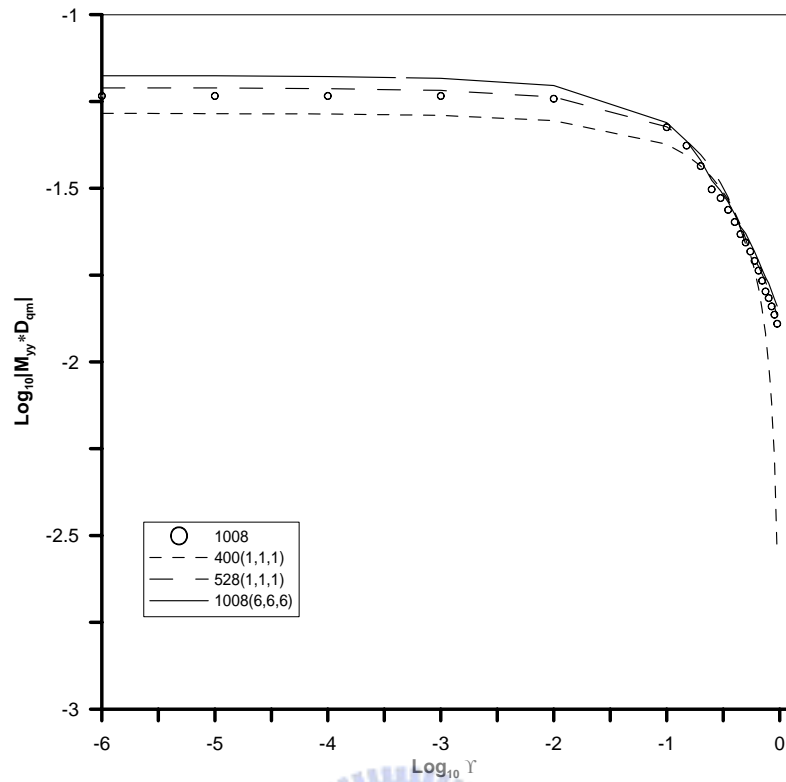


(a)



(b)

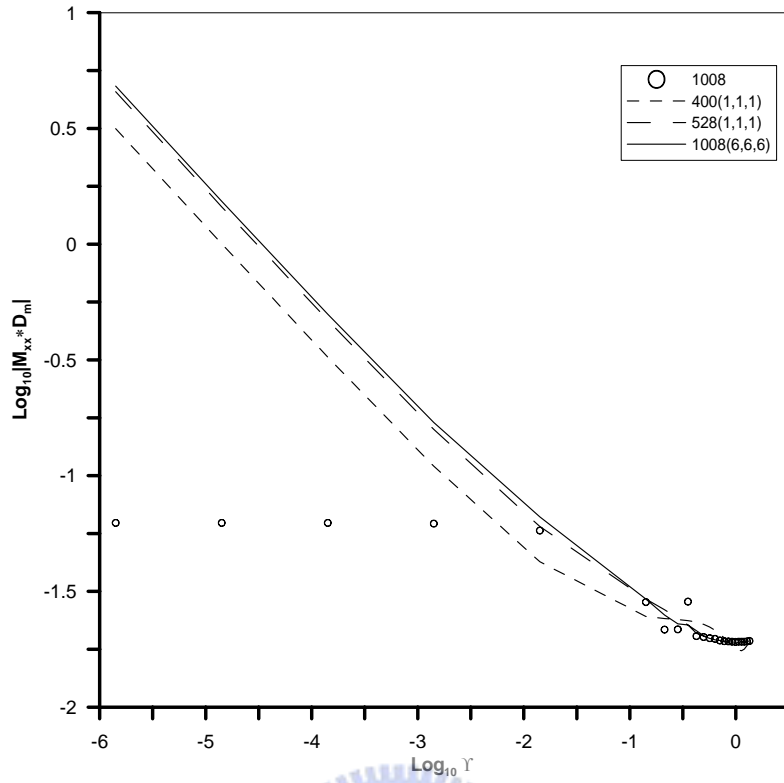
圖 4.23(續上頁)



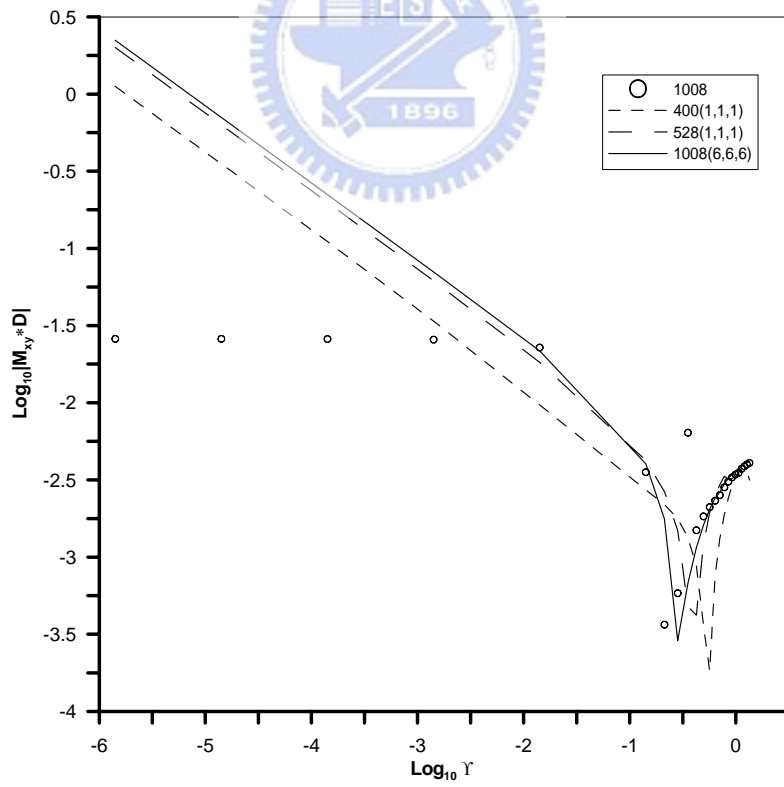
(c)

圖 4.23 $c/b = 0.25, b/h = 10, \theta = 0^\circ$ 具裂縫四端簡支承

(SSSS)板受板端彎矩之裂縫處內力收斂性分析

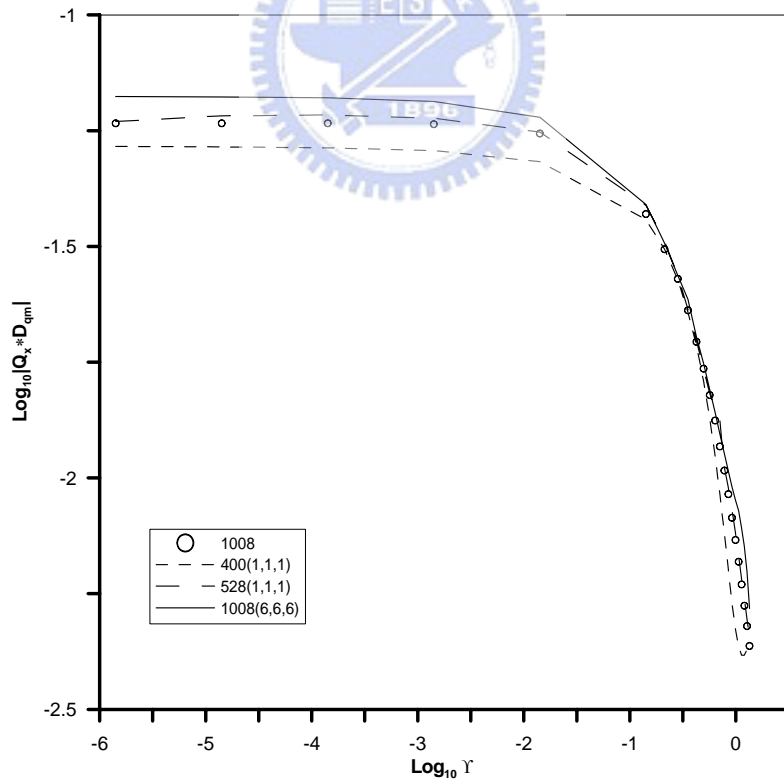
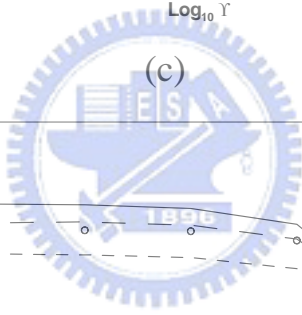
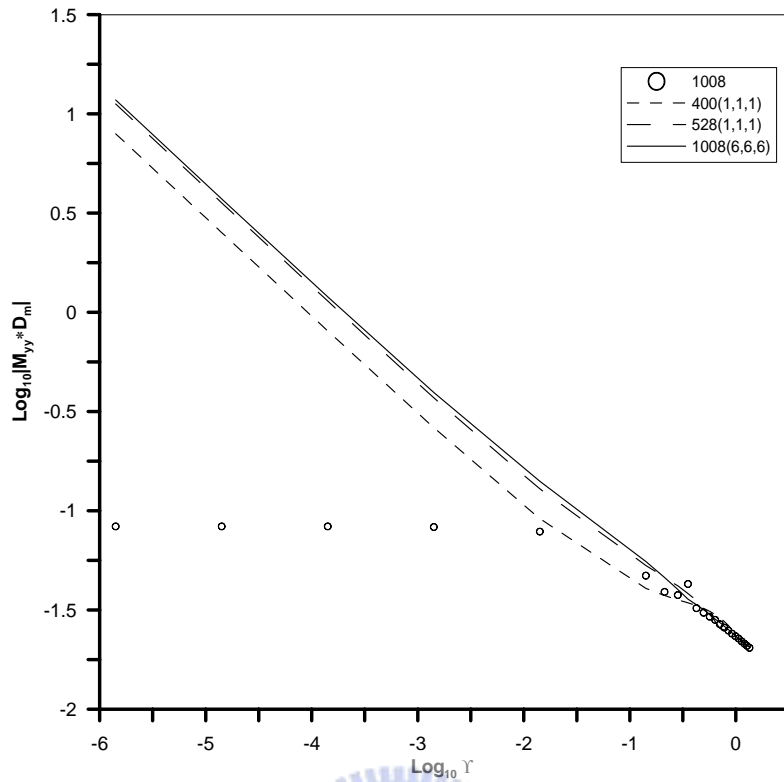


(a)

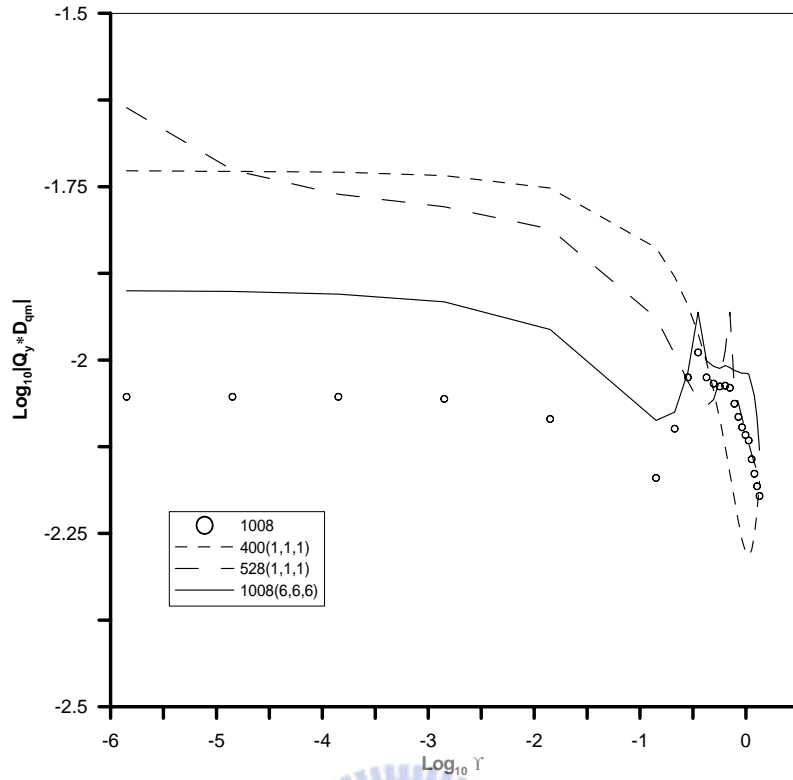


(b)

圖 4.24(續上頁)



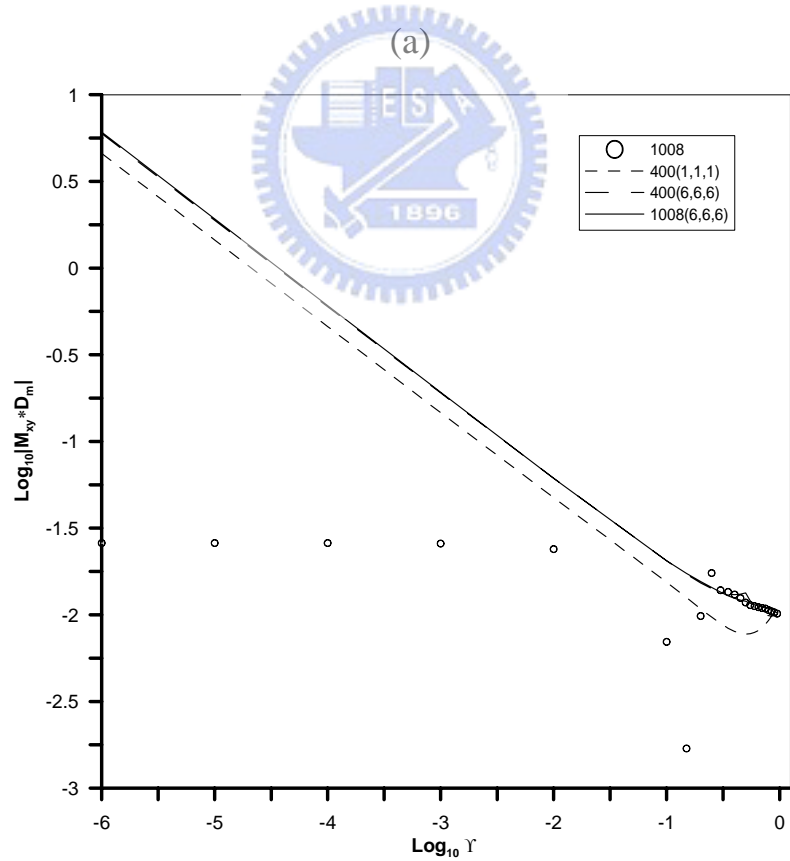
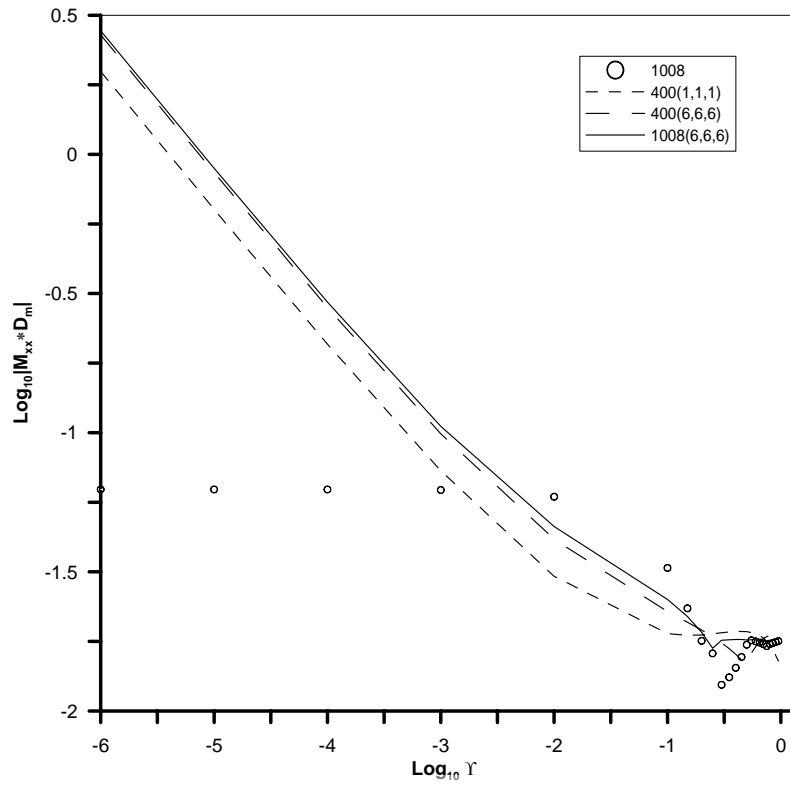
(d)
圖 4.24(續上頁)



(e)

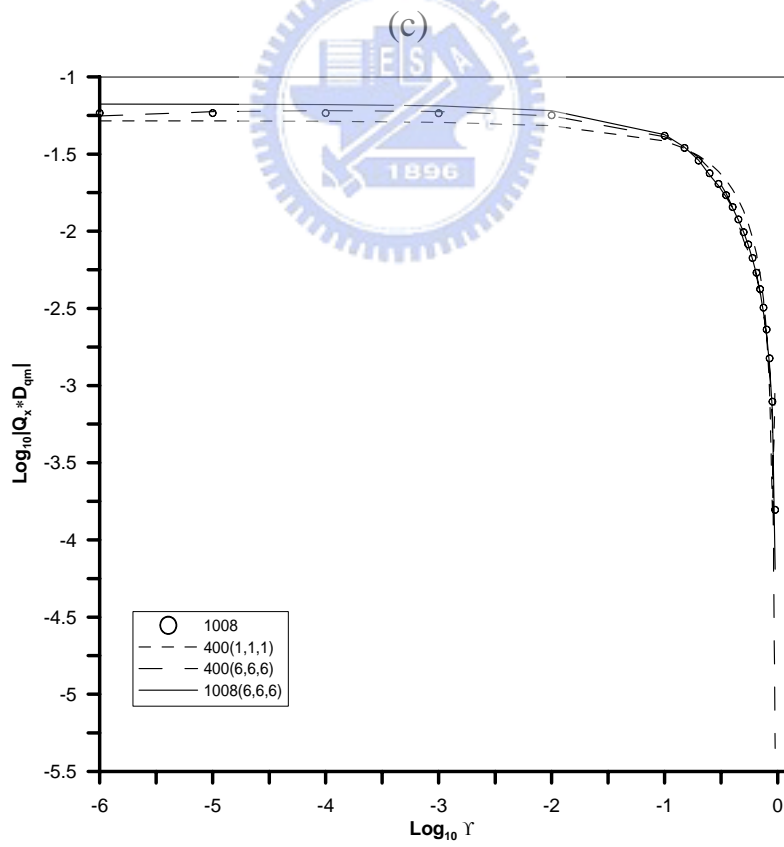
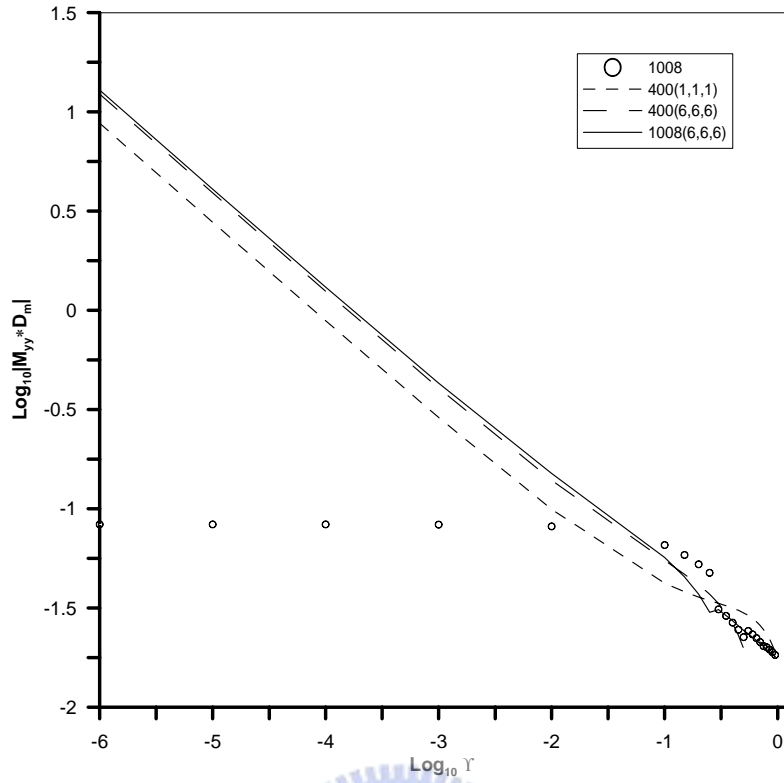
圖 4.24 $c/b = 0.25, b/h = 10, \theta = 45^\circ$ 具裂縫四端簡支承

(SSSS)板受板端彎矩之裂縫處內力收斂性分析

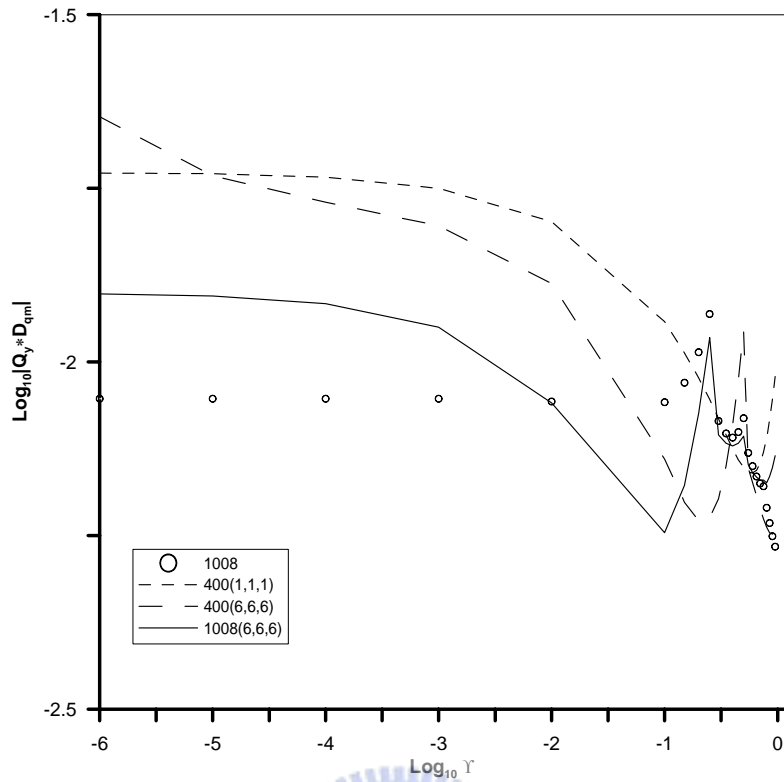


(b)

圖 4.25(續上頁)



(d)
圖 4.25(續上頁)



(e)

圖 4.25 $c/b = 0.25, b/h = 10, \theta = 90^\circ$ 具裂縫四端簡支承

(SSSS)板受板端彎矩之裂縫處內力收斂性分析

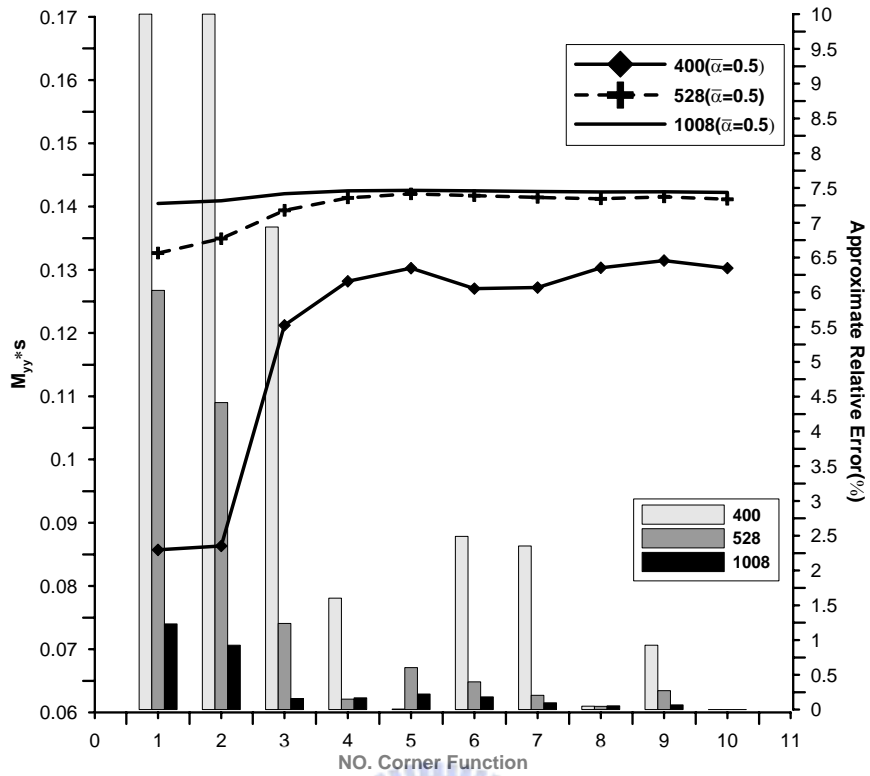


圖 4.26(a) $c/b=0.25$ 網格與角函數個數應力強度無因次收斂性分析

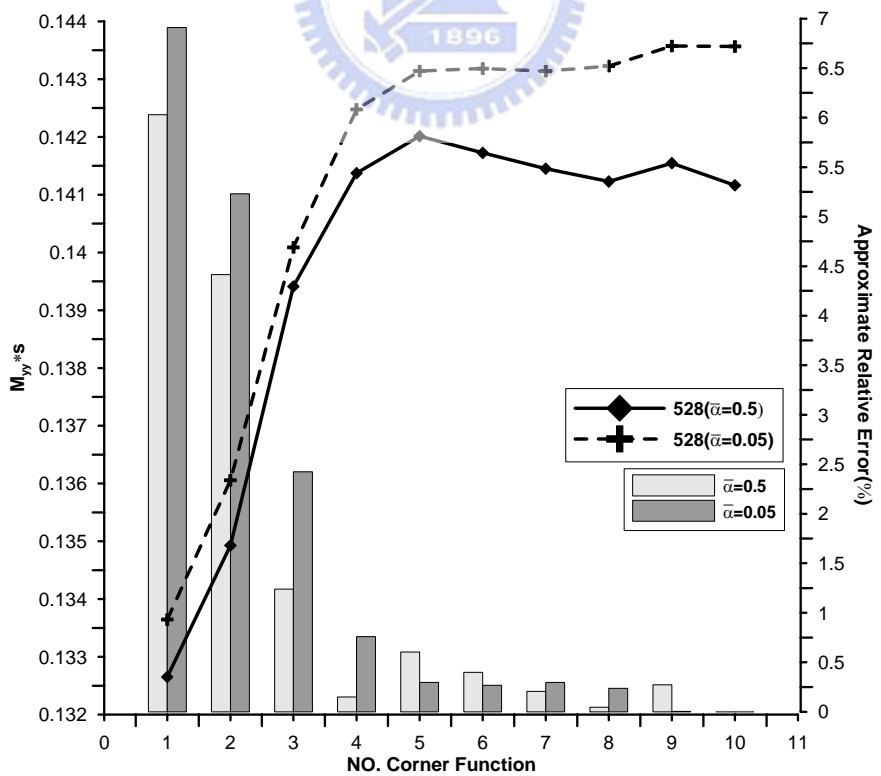


圖 4.26(b) 不同裂縫開口角度與角函數個數應力強度無因次收斂性分析

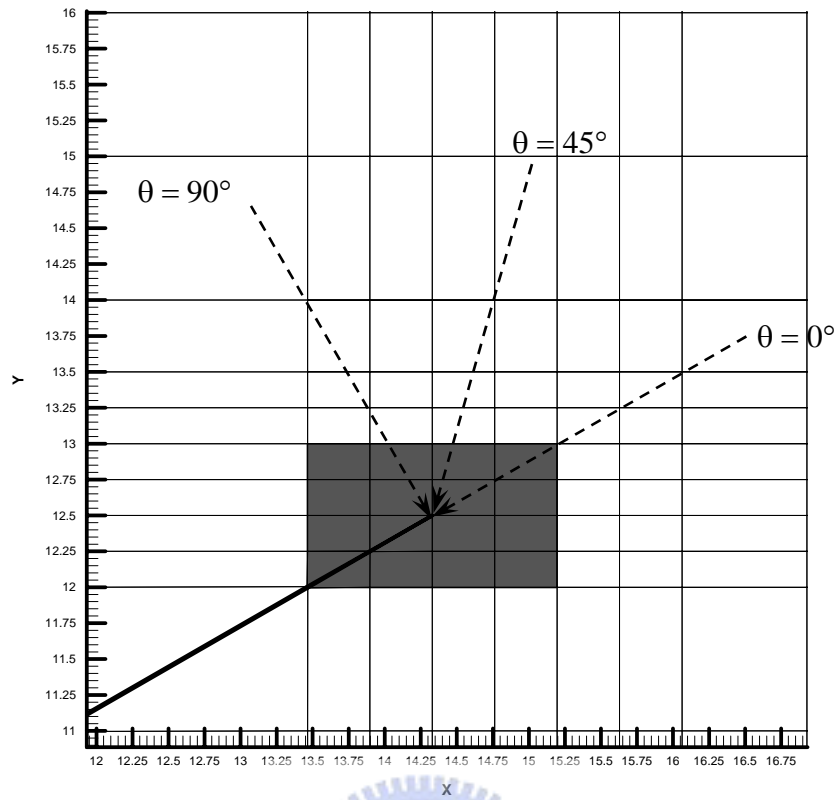


圖 4.27(a) $\Delta = 30^\circ$ ，奇異點(Corner A)在 $\theta = (0^\circ, 45^\circ, 90^\circ)$ 之計算內力方向

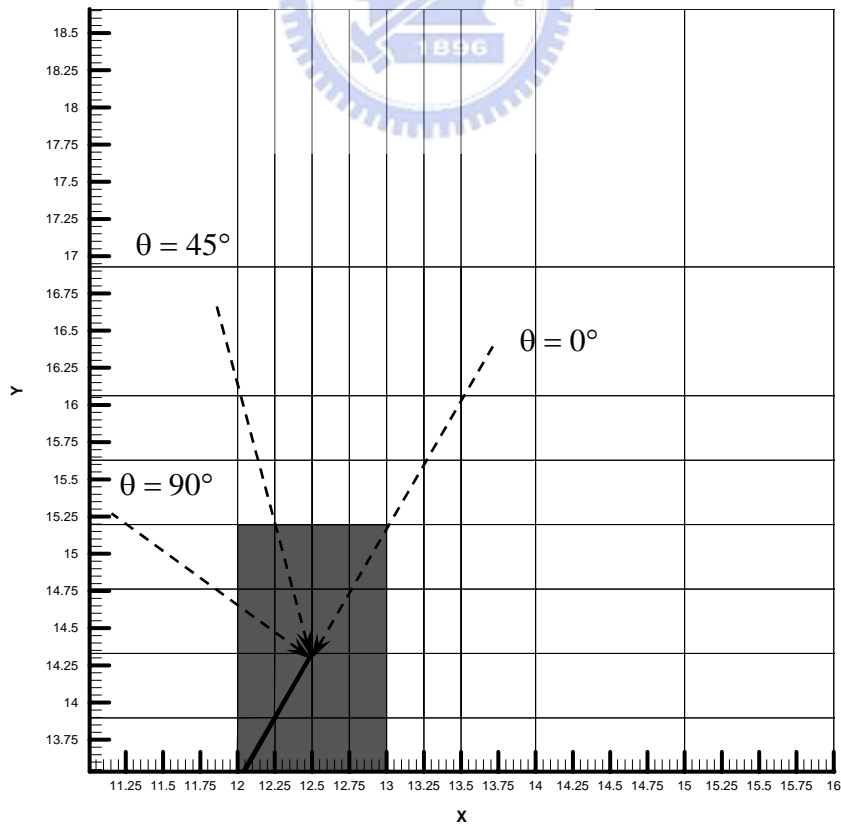


圖 4.27(b) $\Delta = 60^\circ$ ，奇異點(Corner A)在 $\theta = (0^\circ, 45^\circ, 90^\circ)$ 之計算內力方向

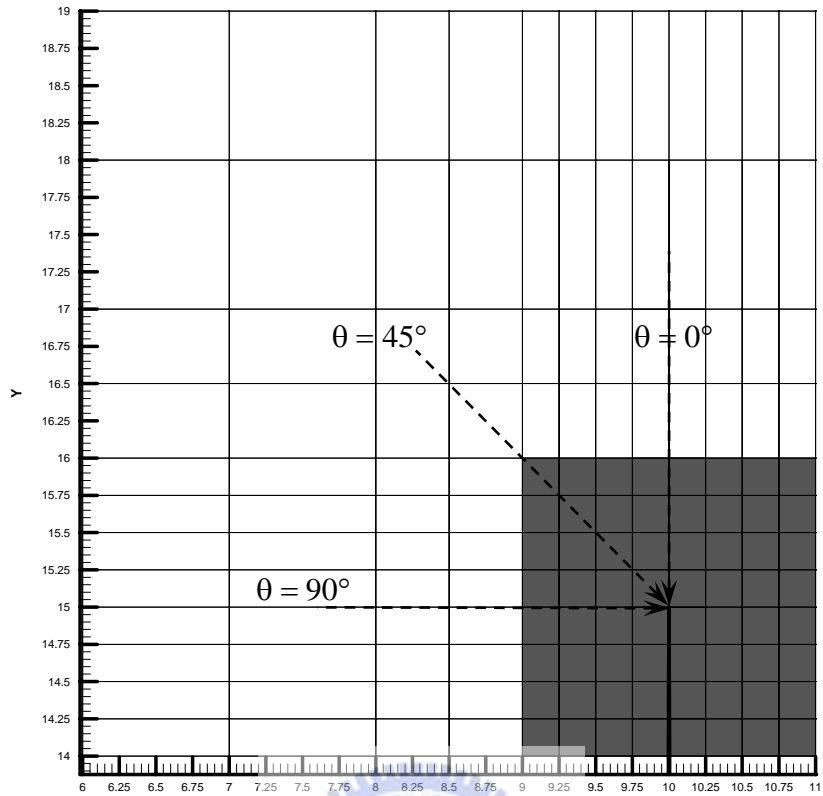


圖 4.27(c) $\Delta = 90^\circ$, 奇異點(Corner A)在 $\theta = (0^\circ, 45^\circ, 90^\circ)$ 之計算內力方向

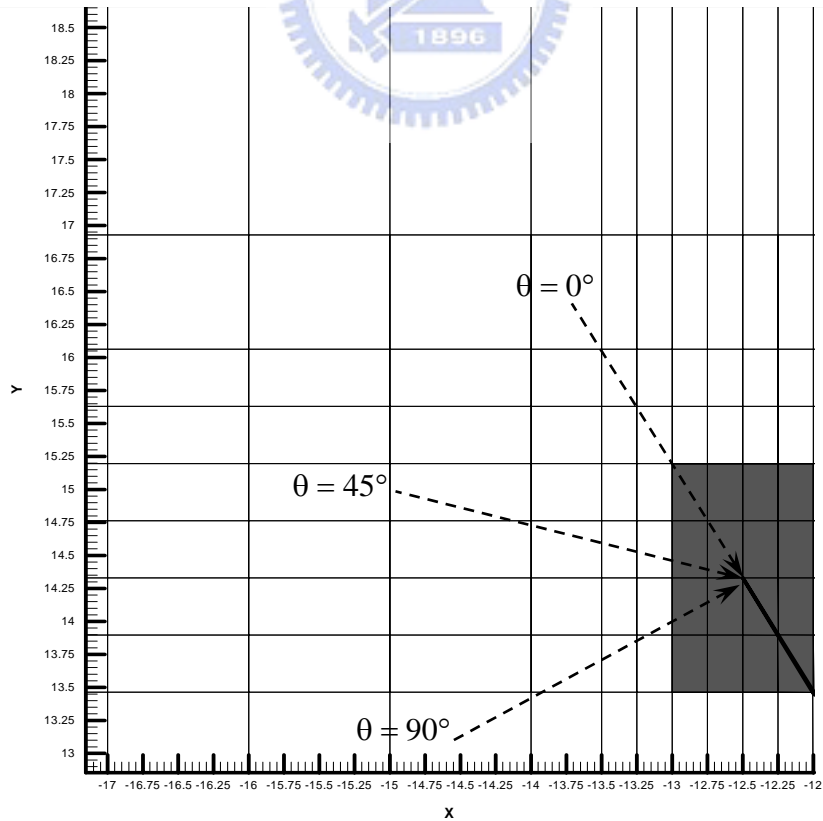


圖 4.27(d) $\Delta = 120^\circ$, 奇異點(Corner A) $\theta = (0^\circ, 45^\circ, 90^\circ)$ 之計算內力方向

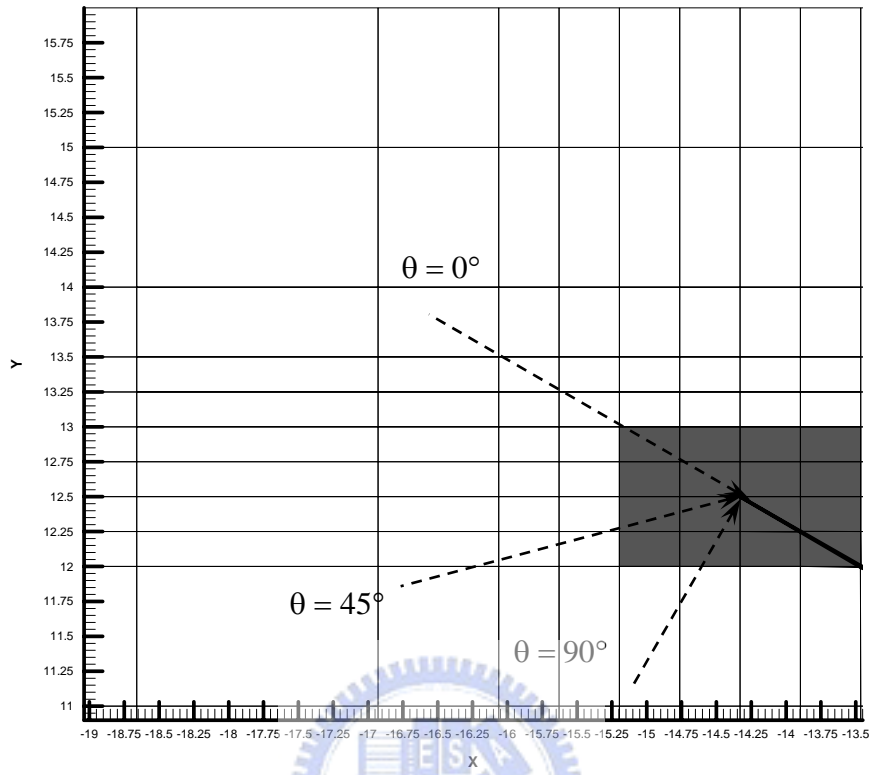
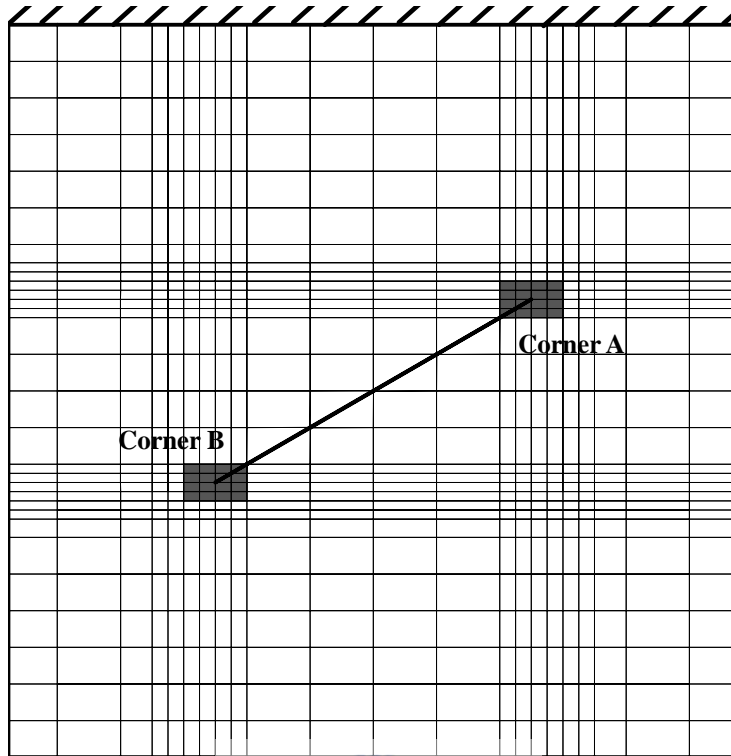
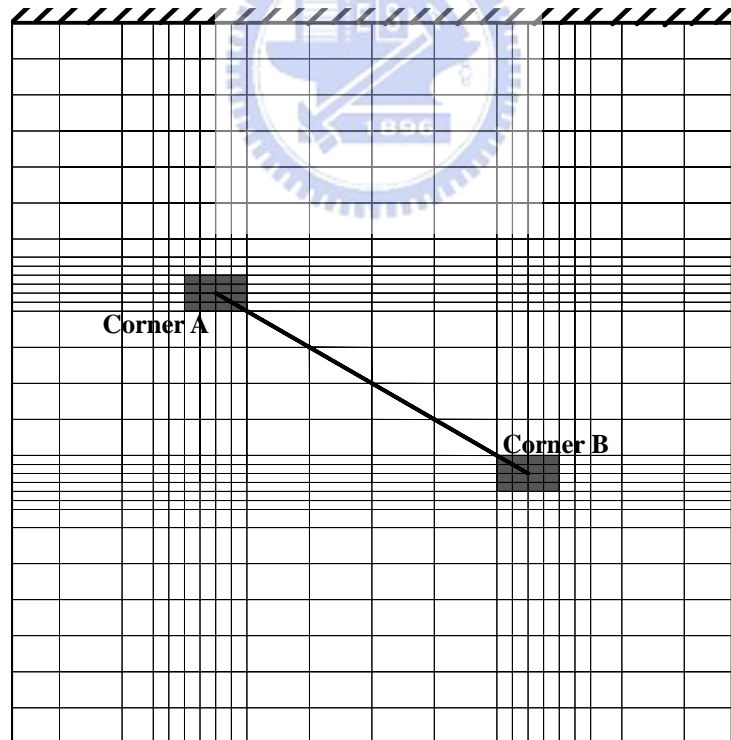


圖 4.27(e) $\Delta = 150^\circ$, 奇異點(Corner A)在 $\theta = (0^\circ, 45^\circ, 90^\circ)$ 計算內力方向



sq7(a)



sq7(b)

圖 4.28 裂縫尖端 Corner A 分別旋轉 30 度(a)及 150 度(b)之懸臂裂縫厚板有限元素網格分析模型

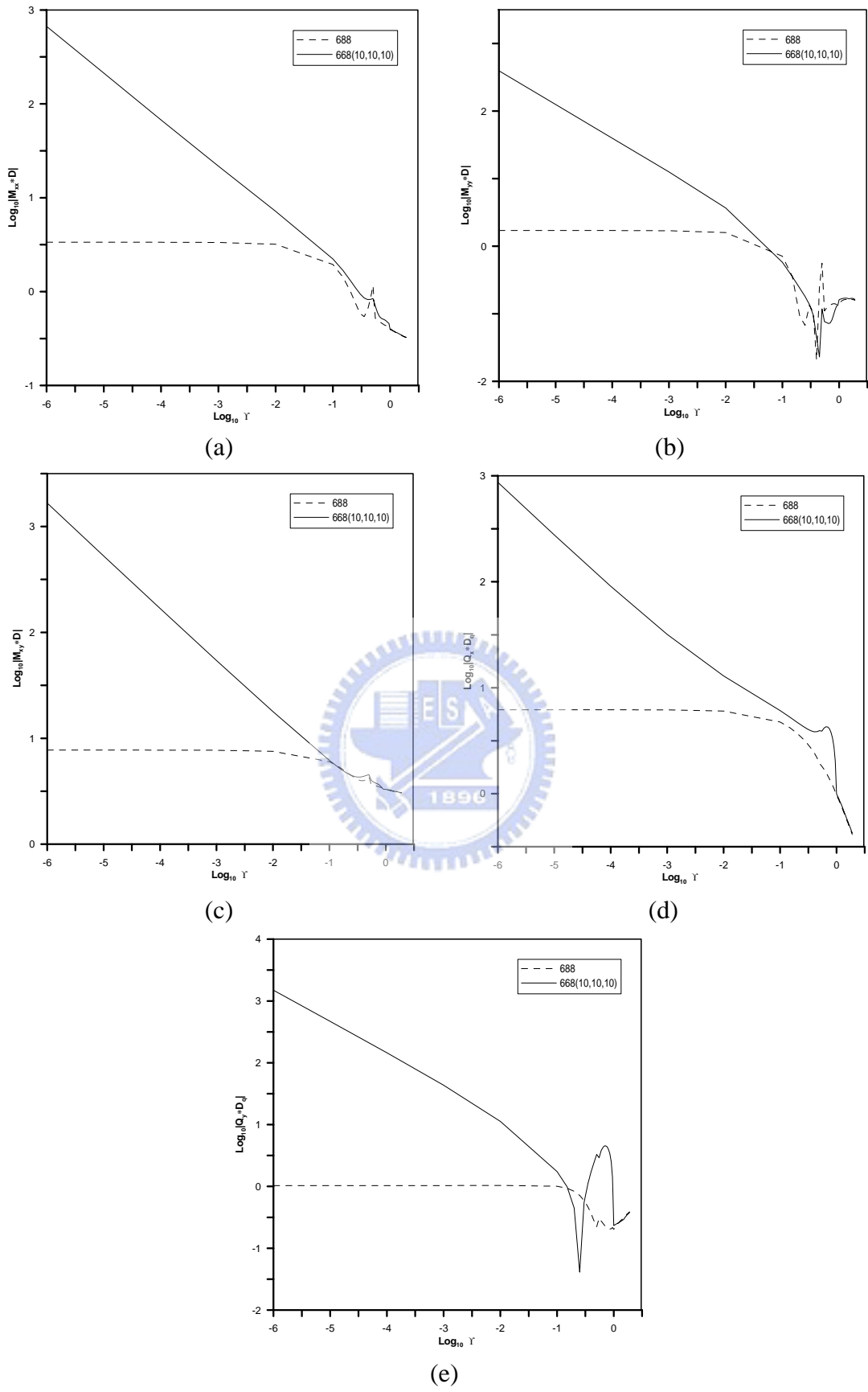


圖 4.29 $\Delta = 30^\circ, c/b = 0.25, b/h = 10, \theta = 0^\circ$ 懸臂板受均載時裂縫處內力分佈

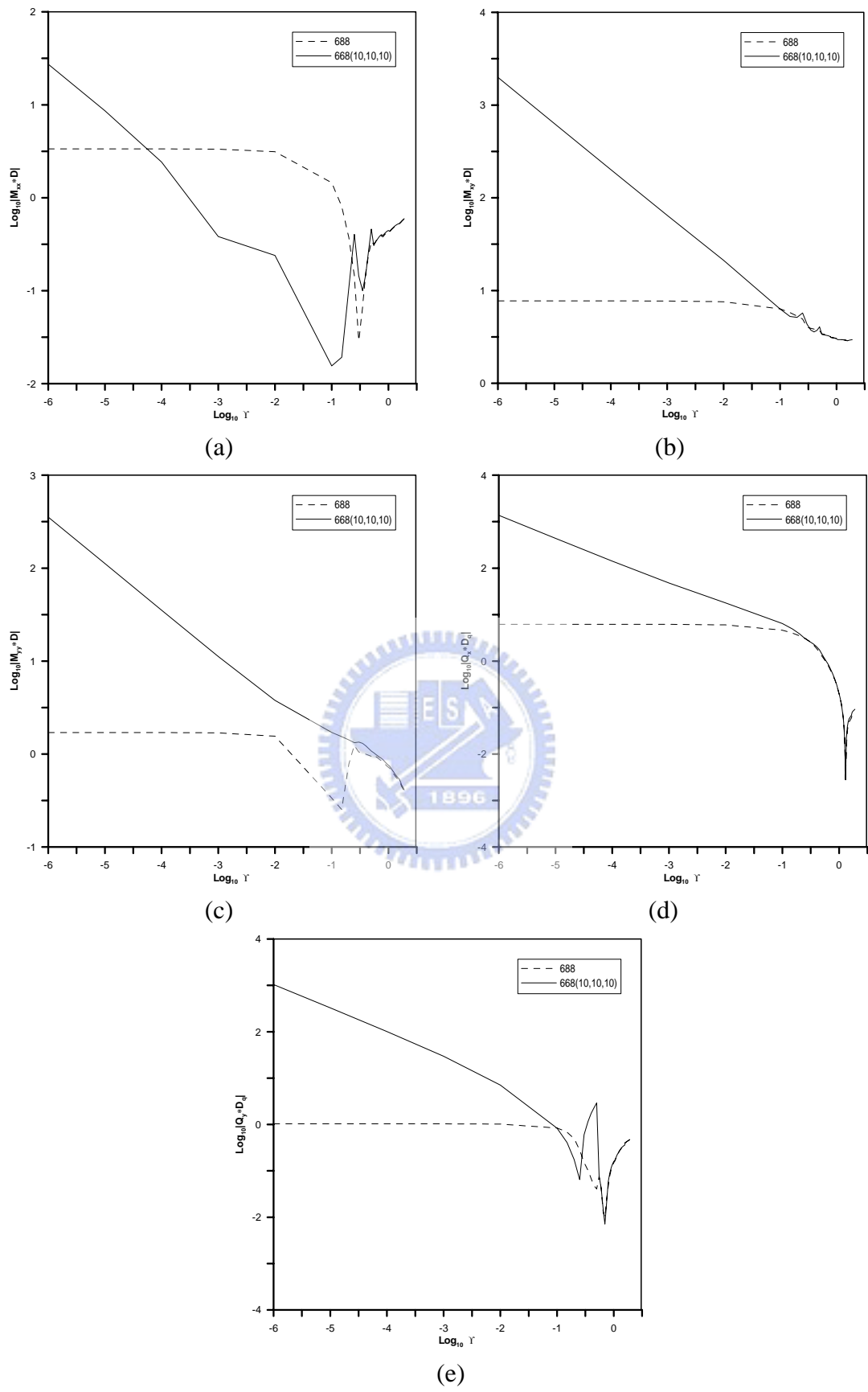


圖 4.30 $\Delta = 30^\circ, c/b = 0.25, b/h = 10, \theta = 45^\circ$ 懸臂板受均載時裂縫處內力分佈

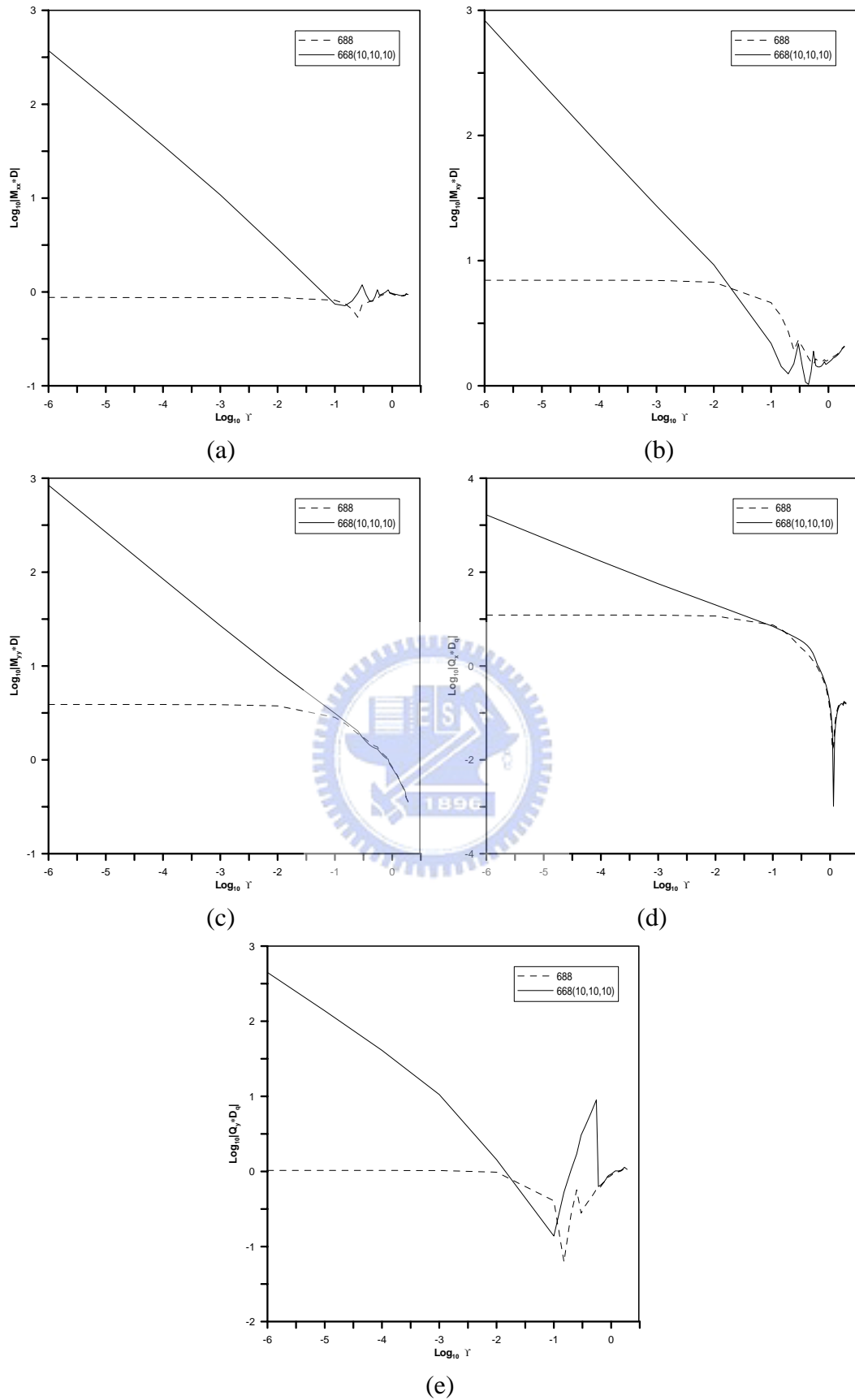


圖 4.31 $\Delta = 30^\circ, c/b = 0.25, b/h = 10, \theta = 90^\circ$ 懸臂板受均載時裂縫處內力分佈

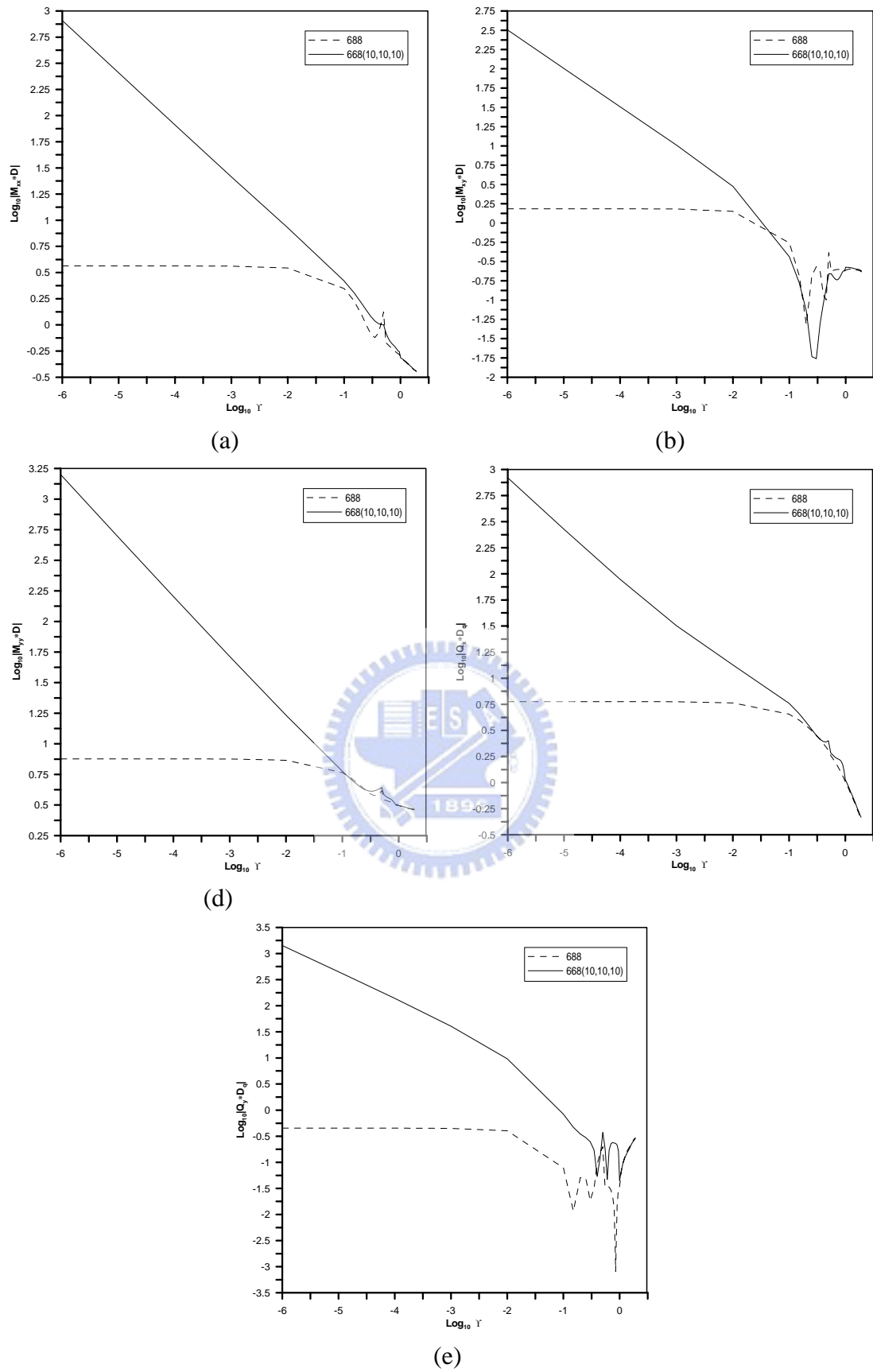


圖 4.32 $\Delta = 150^\circ, c/b = 0.25, b/h = 10, \theta = 0^\circ$ 懸臂板受均載時裂縫處內力分佈

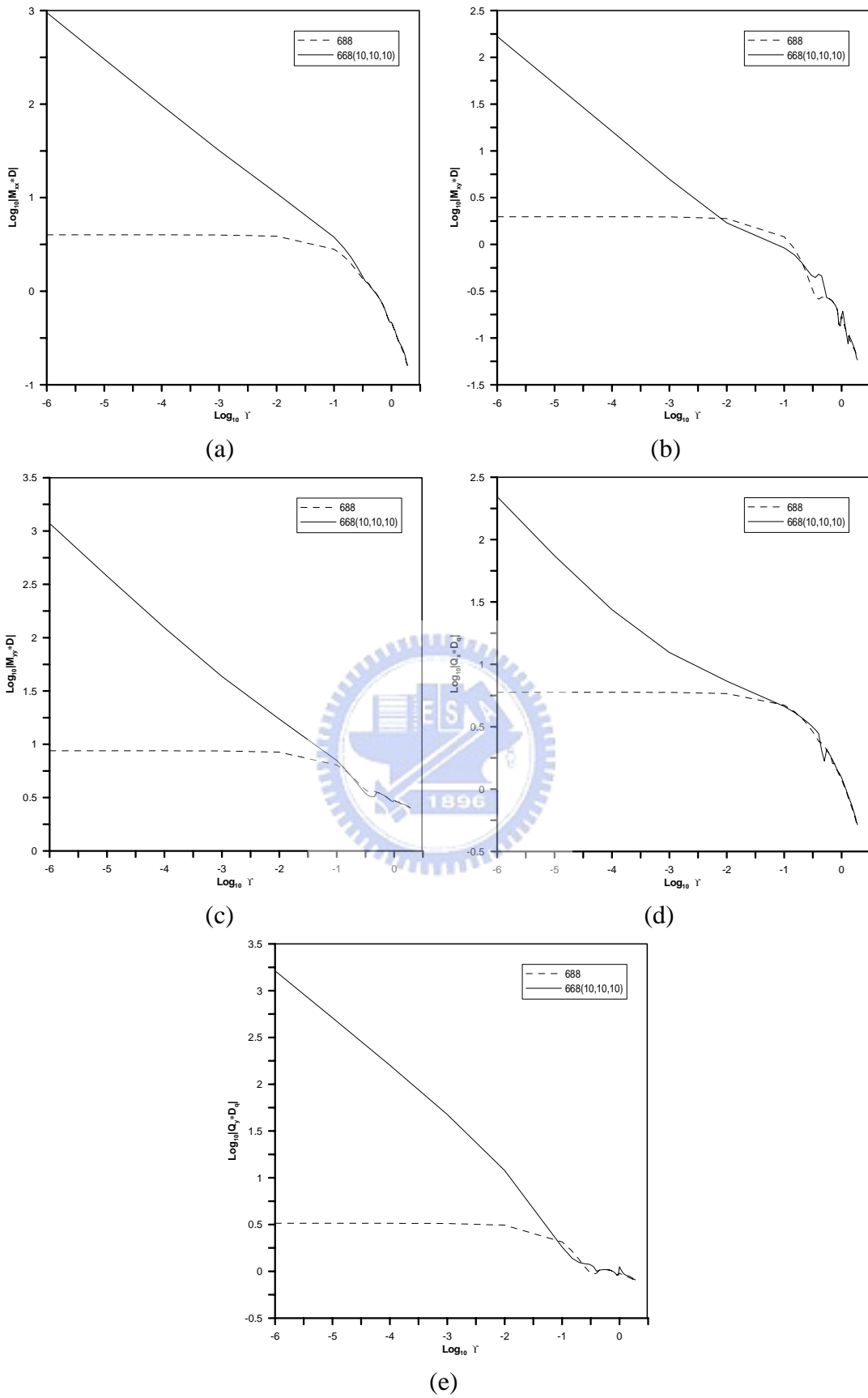


圖 4.33 $\Delta = 150^\circ, c/b = 0.25, b/h = 10, \theta = 45^\circ$ 懸臂板受均載時裂縫處內力分佈

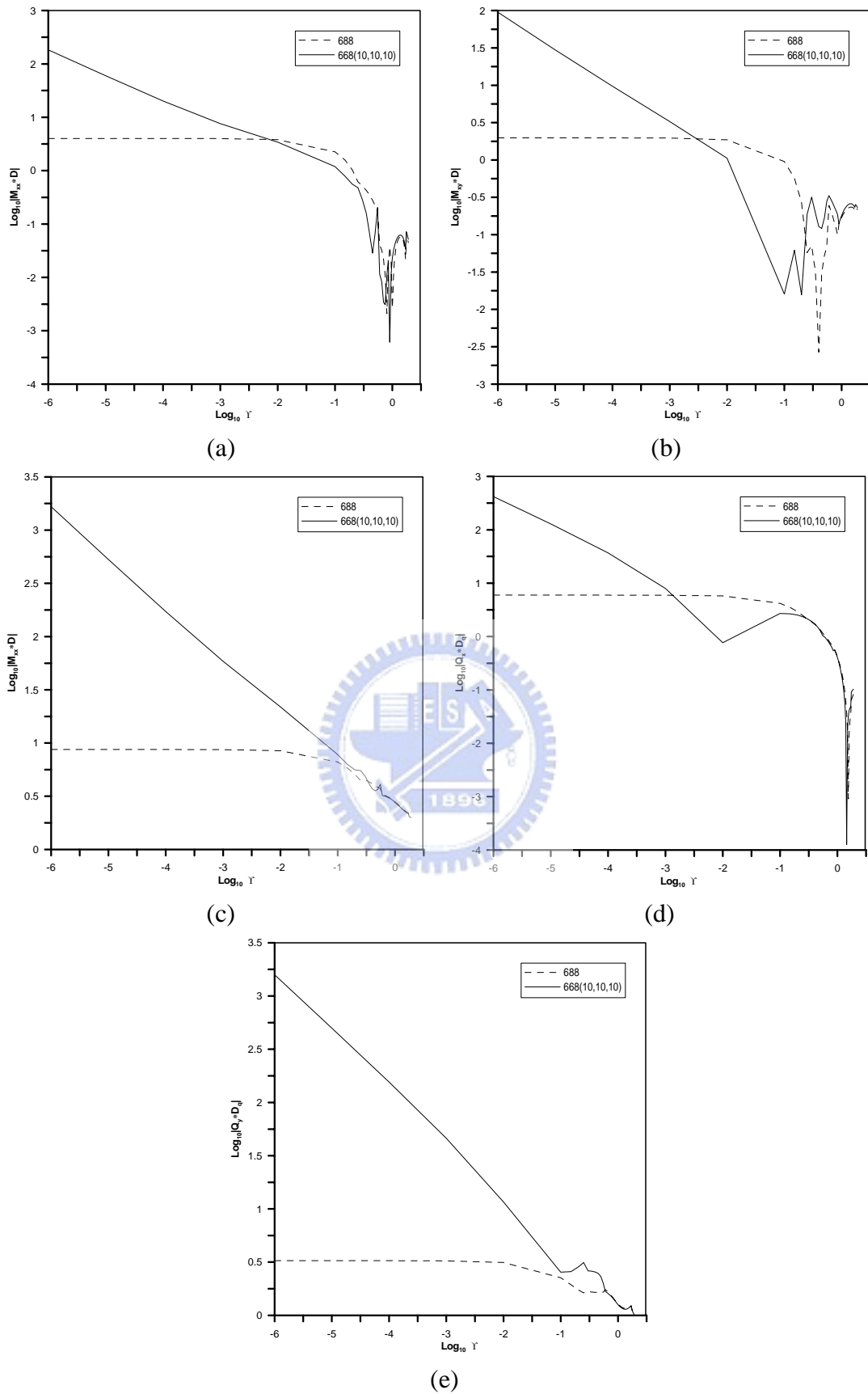
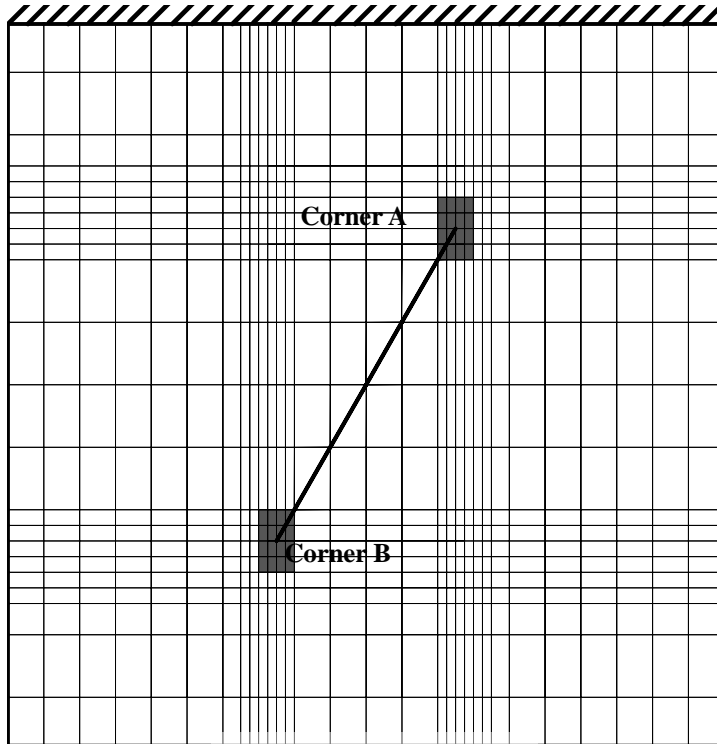
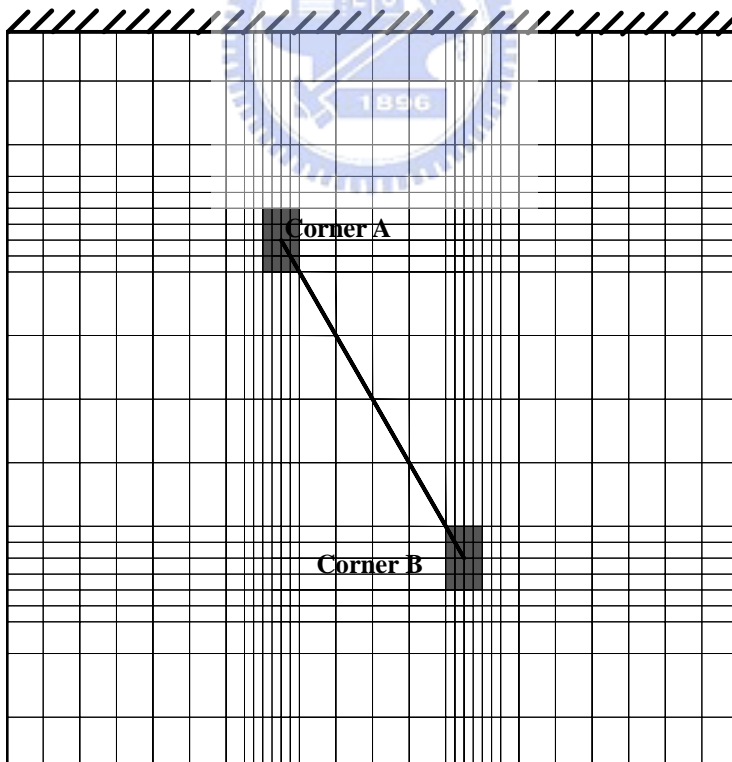


圖 4.34 $\Delta = 150^\circ, c/b = 0.25, b/h = 10, \theta = 90^\circ$ 懸臂板受均載時裂縫處內力分佈



sq7(c)



sq7(d)

圖 4.35 裂縫尖端 Corner A 分別旋轉 60 度(c)及 120 度(d)之
懸臂裂縫厚板有限元素網格分析模型

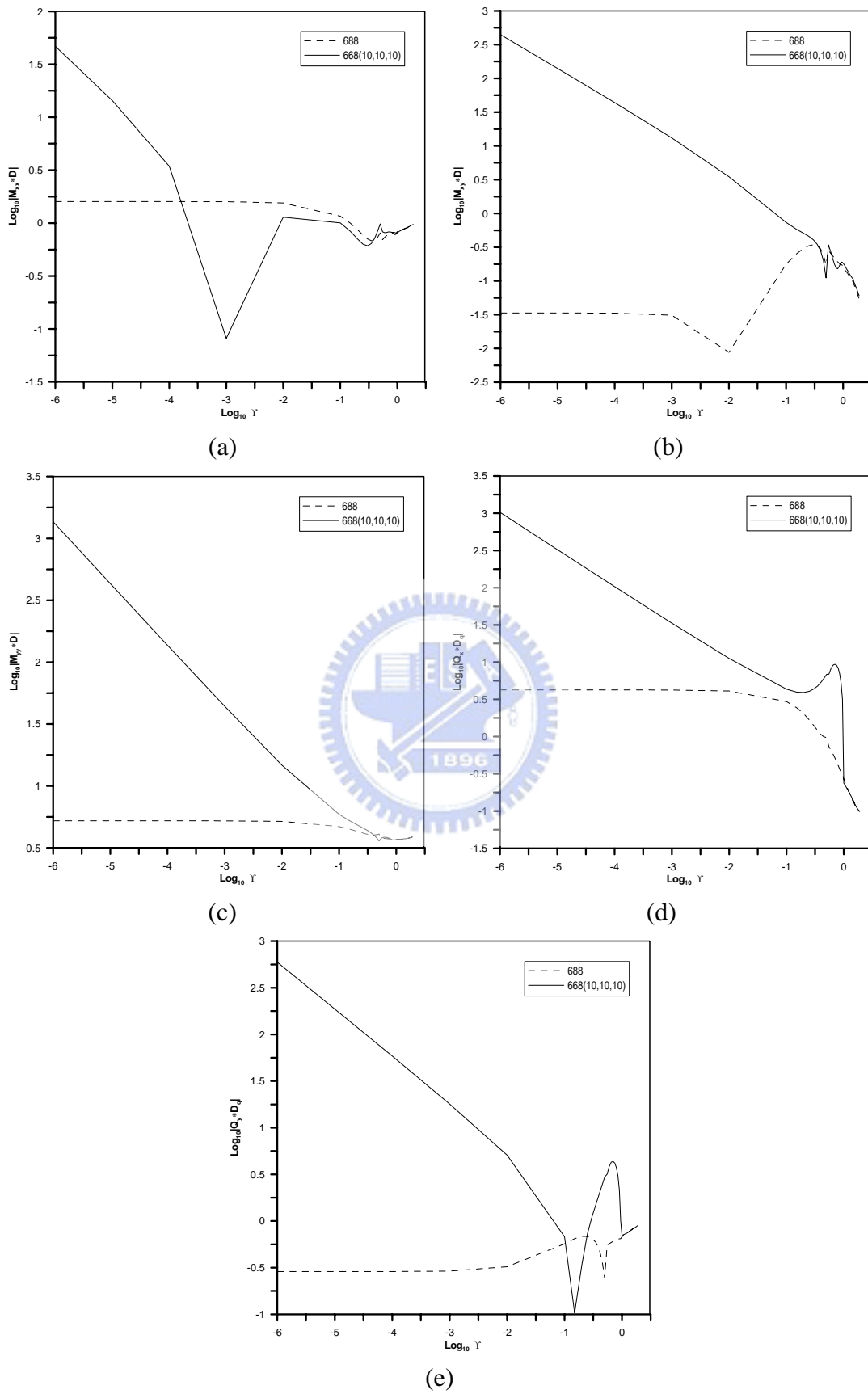


圖 4.36 $\Delta = 60^\circ, c/b = 0.25, b/h = 10, \theta = 0^\circ$ 懸臂板受均載時裂縫處內力分佈

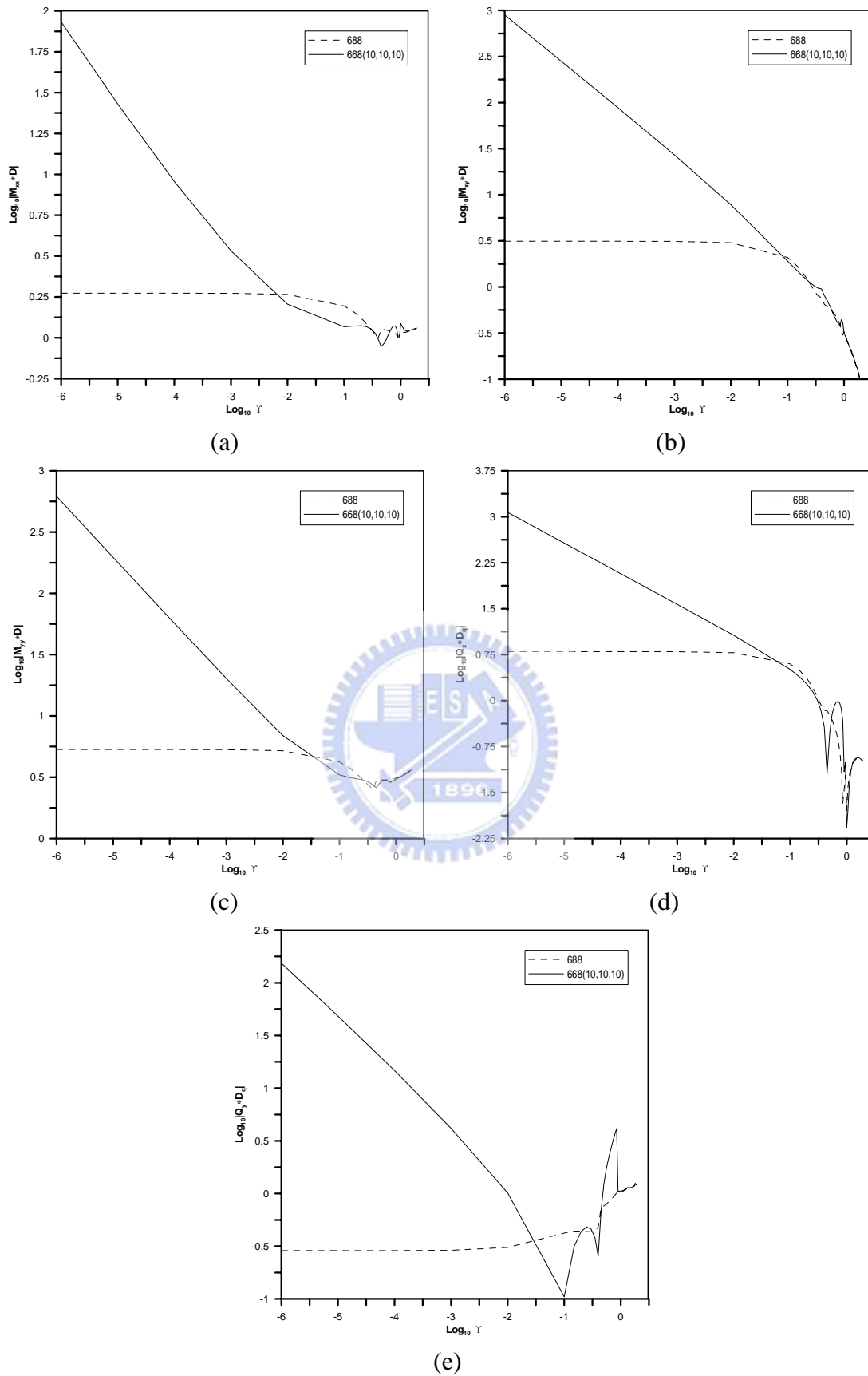


圖 4.37 $\Delta = 60^\circ, c/b = 0.25, b/h = 10, \theta = 45^\circ$ 懸臂板受均載時裂縫處內力分佈

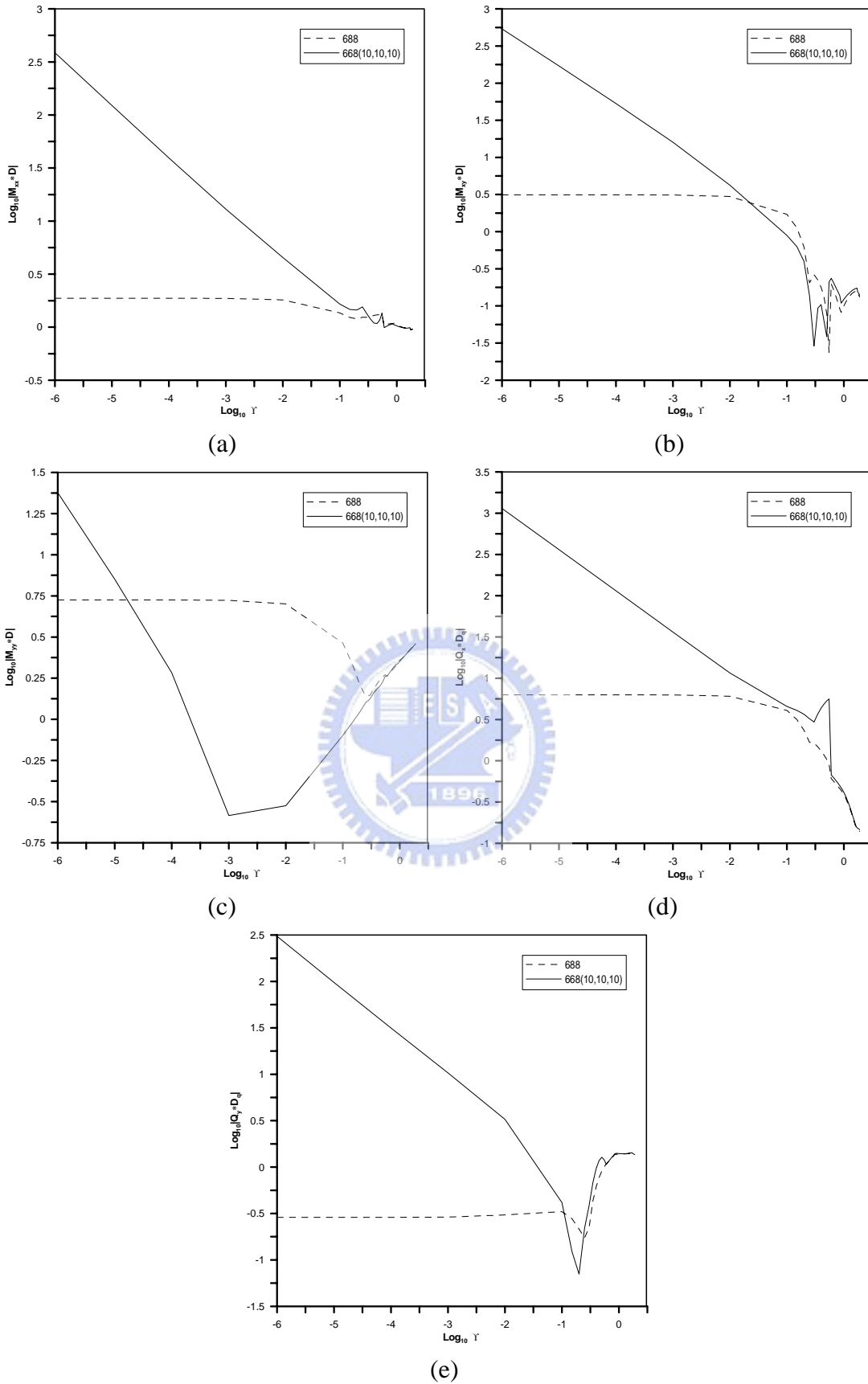


圖 4.38 $\Delta = 60^\circ, c/b = 0.25, b/h = 10, \theta = 90^\circ$ 懸臂板受均載時裂縫處內力分佈

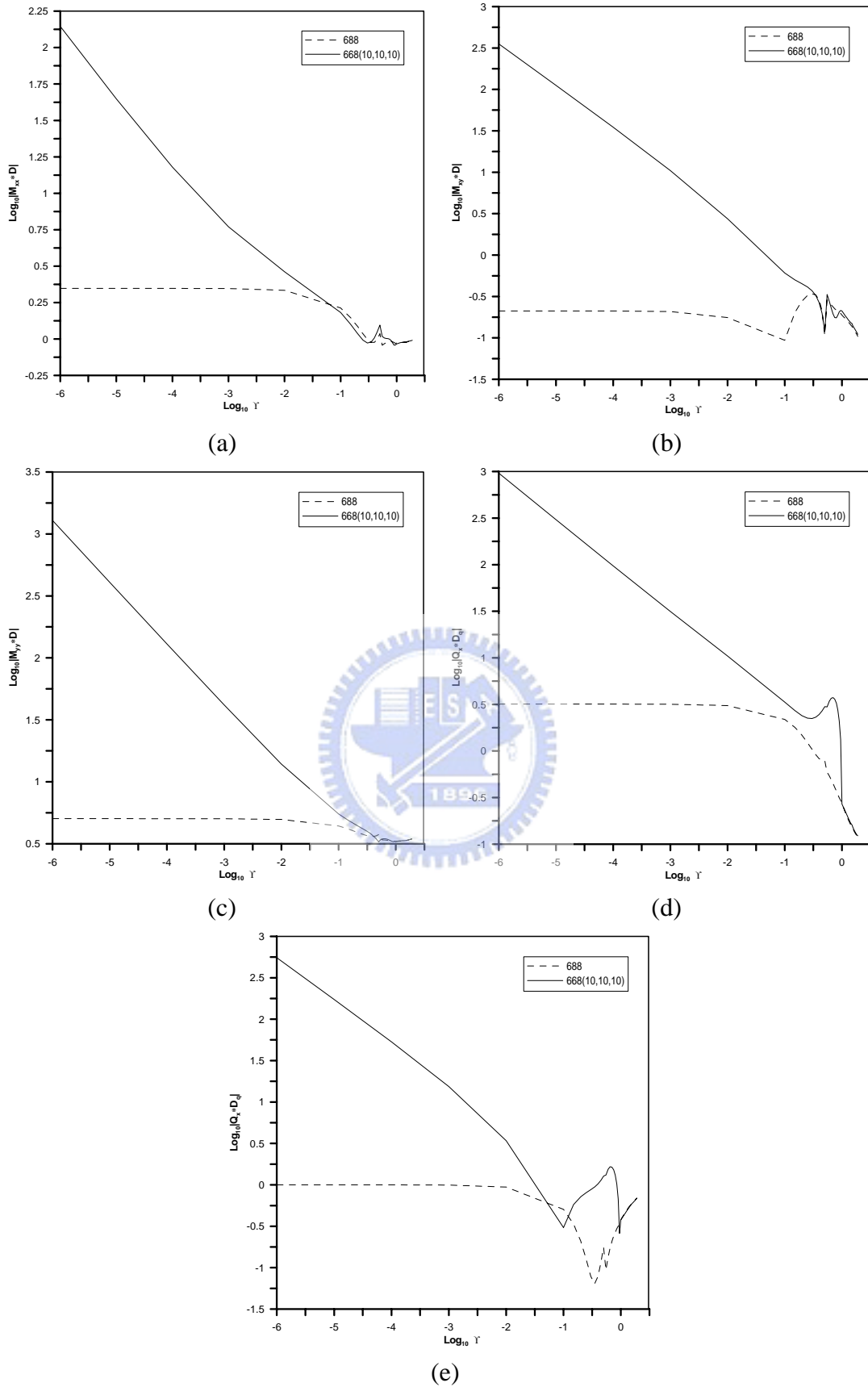


圖 4.39 $\Delta = 120^\circ, c/b = 0.25, b/h = 10, \theta = 0^\circ$ 懸臂板受均載時裂縫處內力分佈

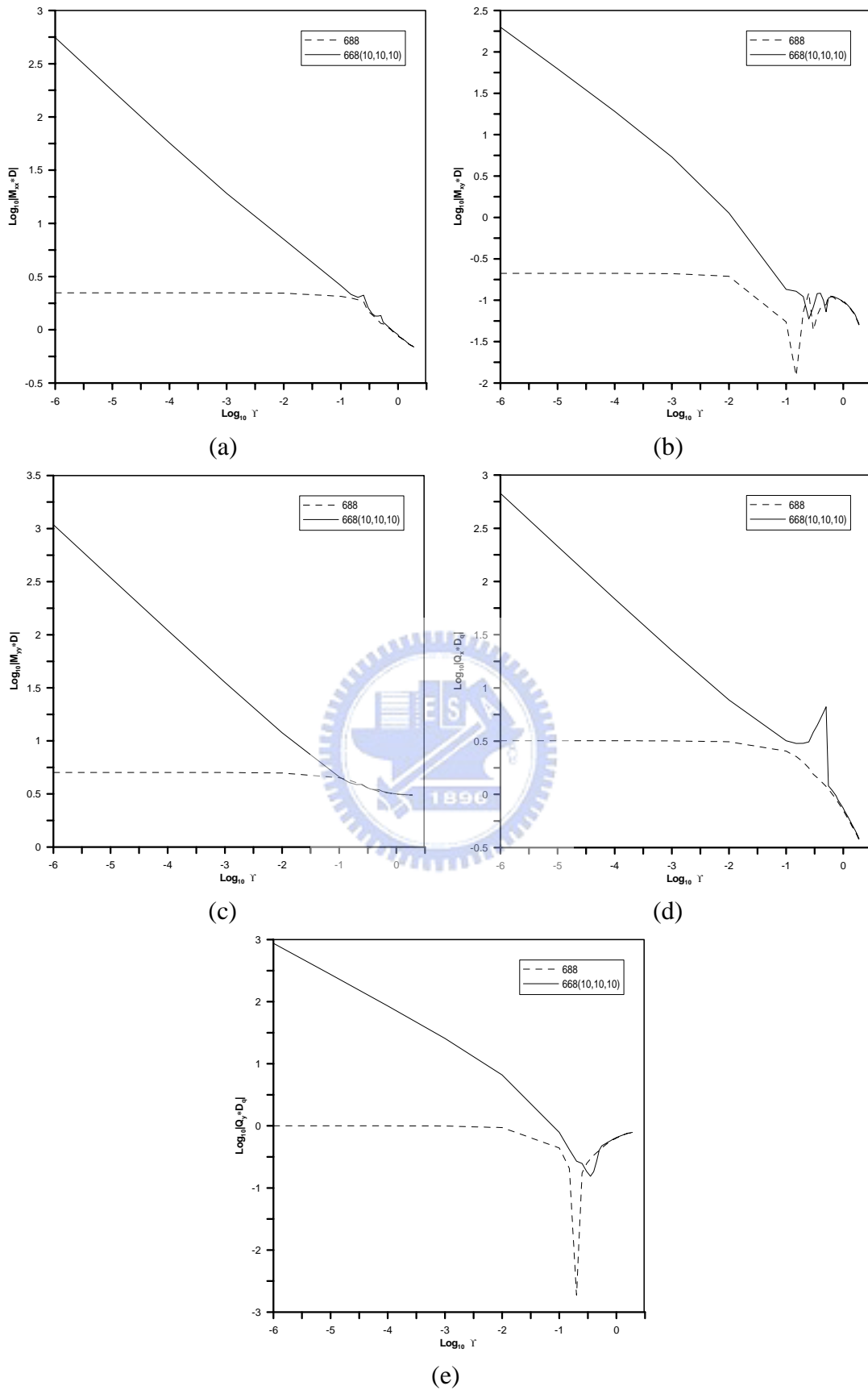


圖 4.40 $\Delta = 120^\circ, c/b = 0.25, b/h = 10, \theta = 45^\circ$ 懸臂板受均載時裂縫處內力分佈

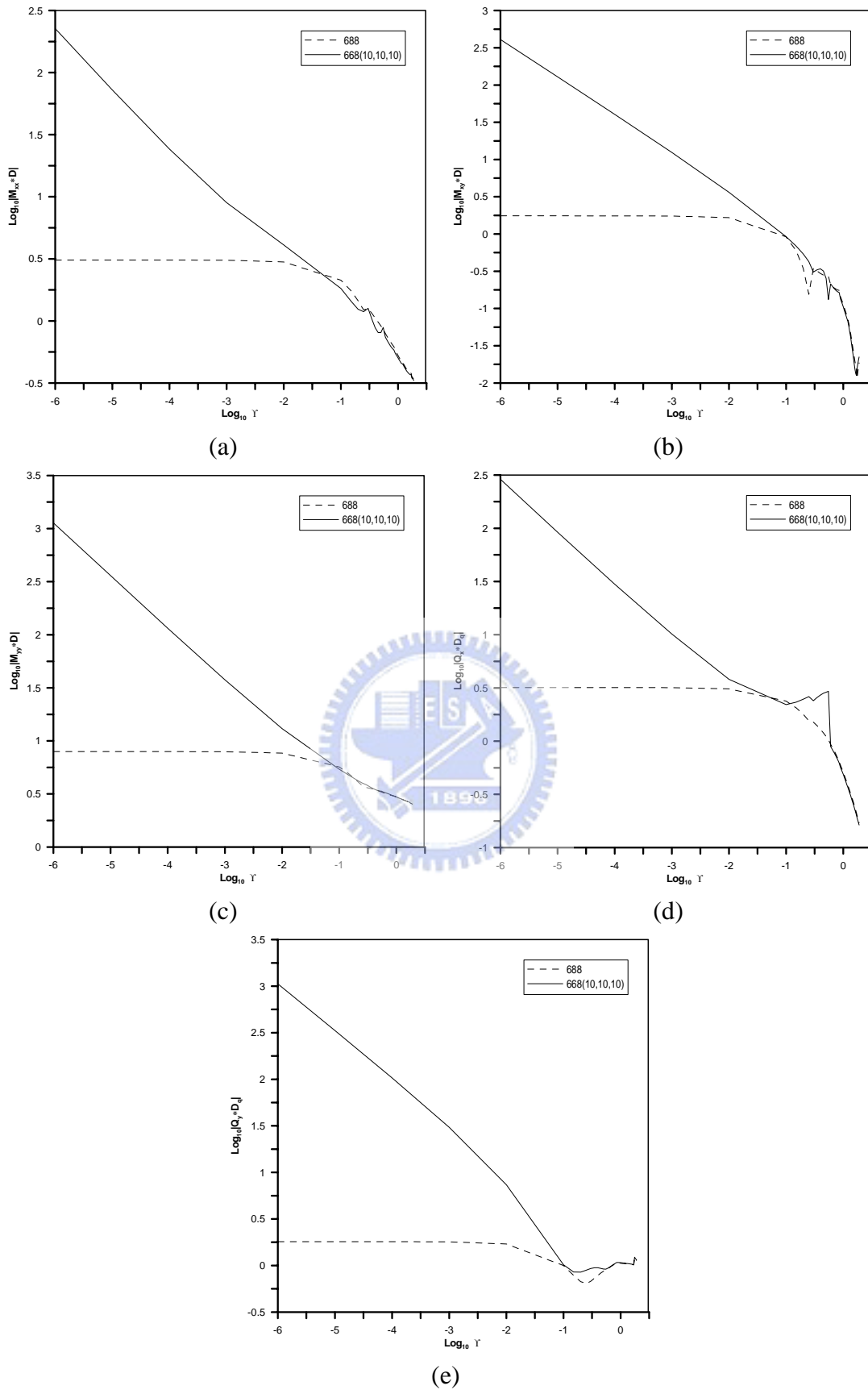
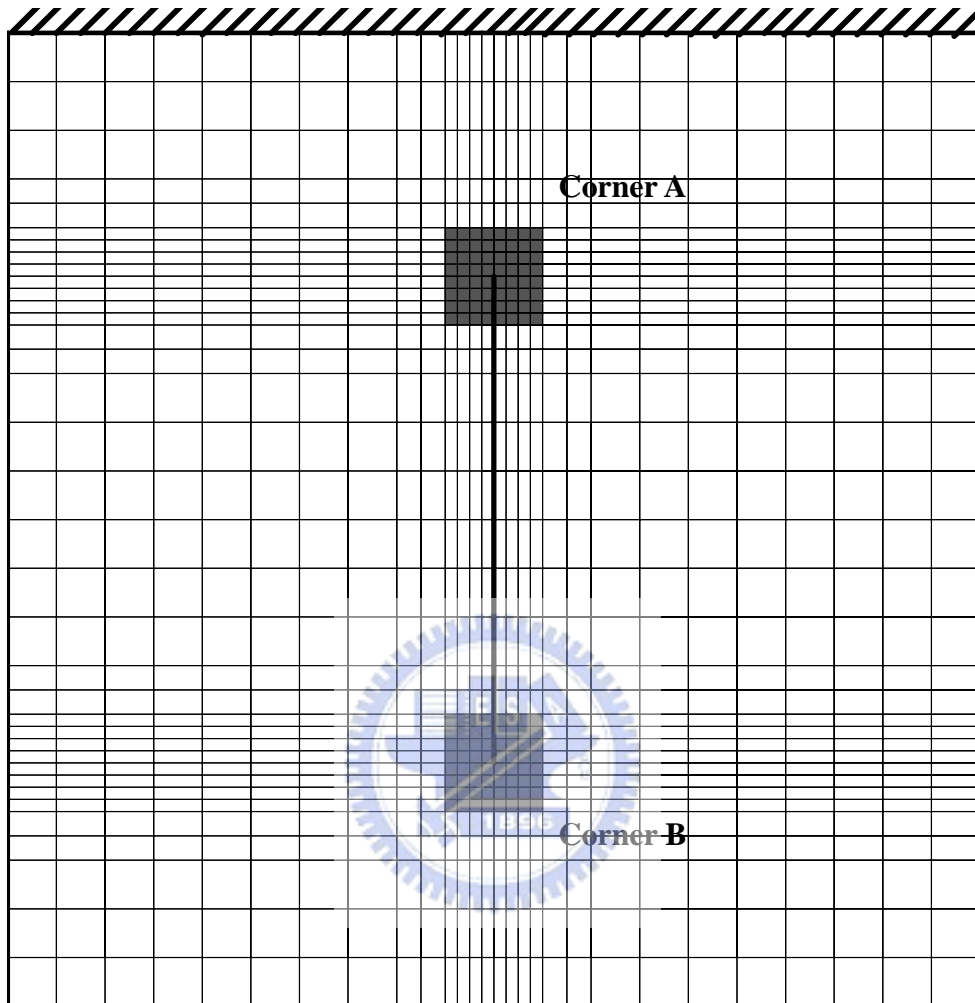


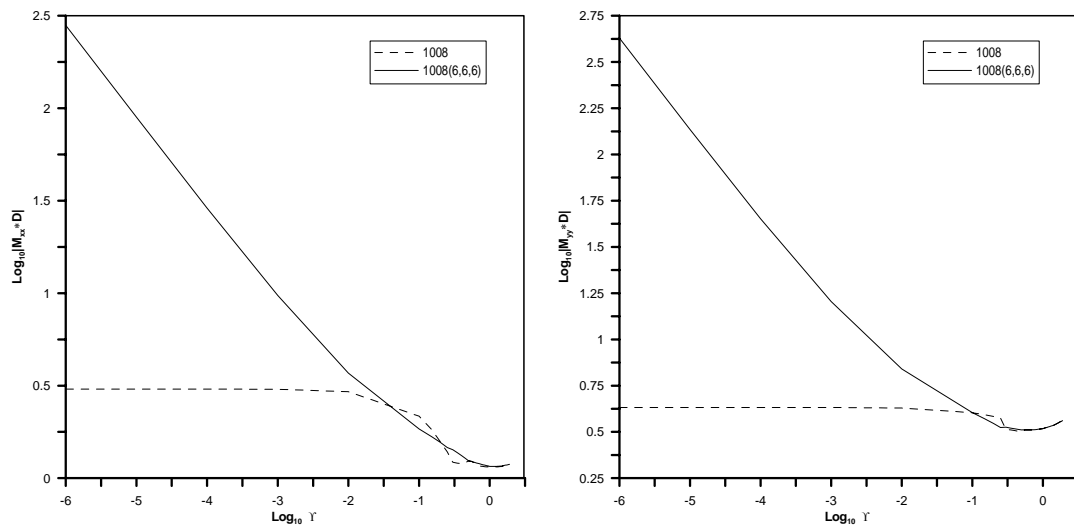
圖 4.41 $\Delta = 120^\circ, c/b = 0.25, b/h = 10, \theta = 90^\circ$ 懸臂板受均載時裂縫處內力分佈



Sq7(e)

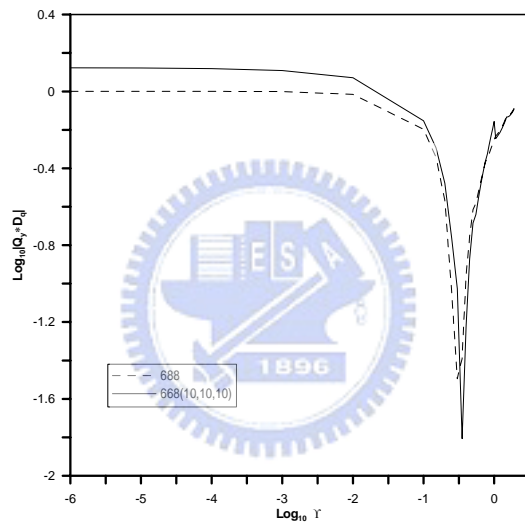
圖 4.42 裂縫尖端 Corner A 旋轉 90 度與 Corner B 旋轉 -90 度之

懸臂裂縫厚板有限元素網格分析模型



(a)

(b)



(c)

圖 4.43 $\Delta = 90^\circ, c/b = 0.25, b/h = 10, \theta = 0^\circ$ 懸臂板受均載時裂縫處內力分佈

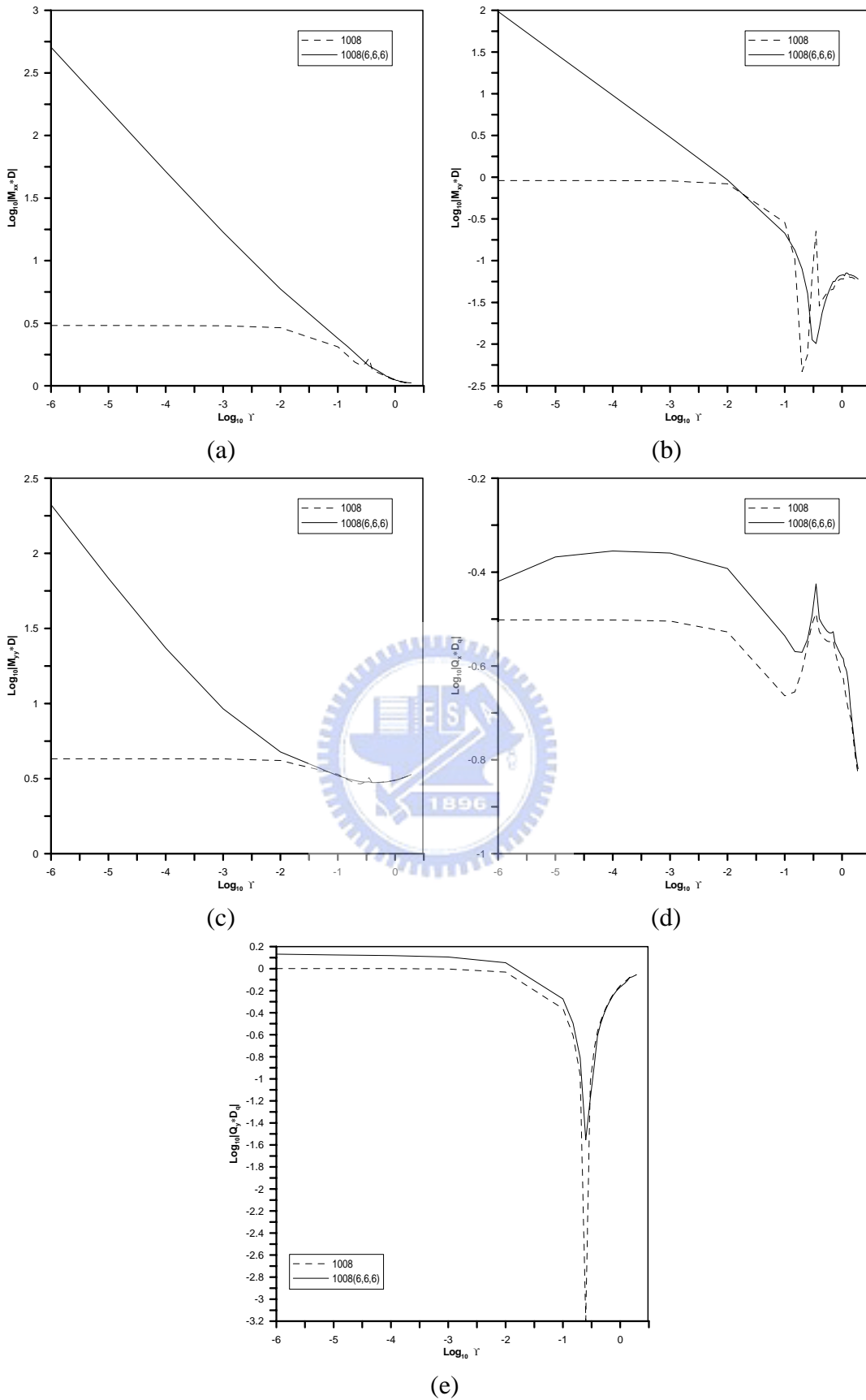


圖 4.44 $\Delta = 90^\circ, c/b = 0.25, b/h = 10, \theta = 45^\circ$ 懸臂板受均載時裂縫處內力分佈

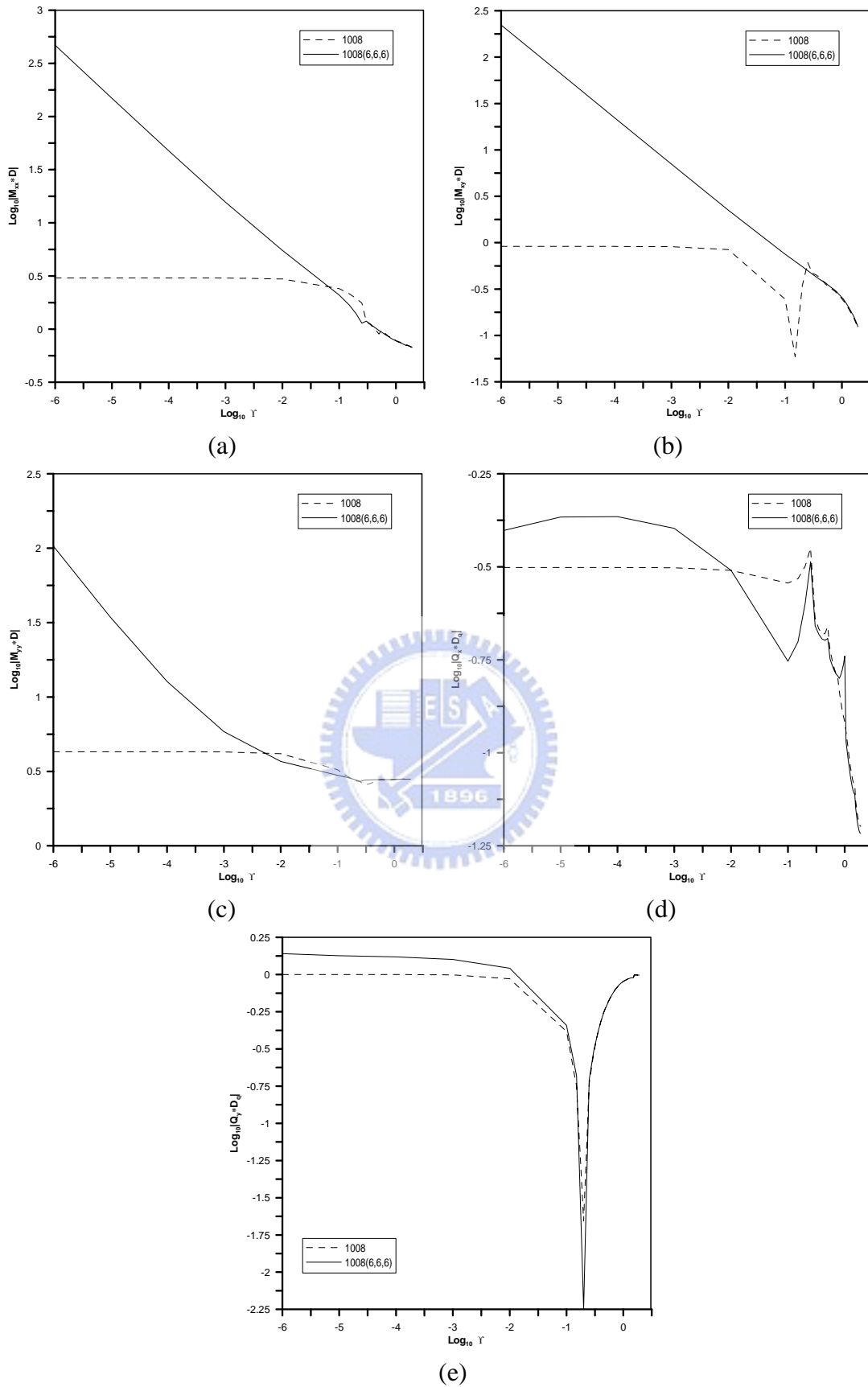
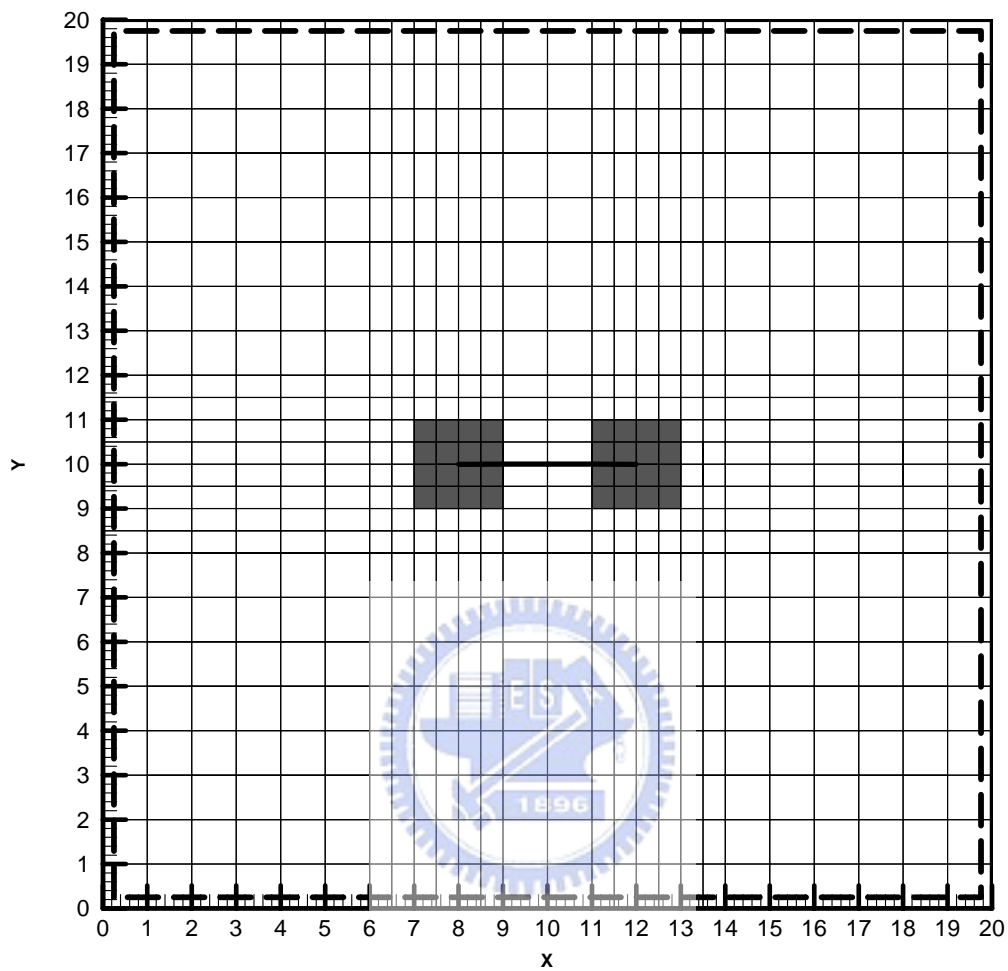


圖 4.45 $\Delta = 90^\circ, c/b = 0.25, b/h = 10, \theta = 90^\circ$ 懸臂板受均載時裂縫處內力分佈



Sq8

圖 4.46 $c/b = 0.1$ 且四端邊界為 SSSS 之方形裂縫厚板

有限元素網格分析模型

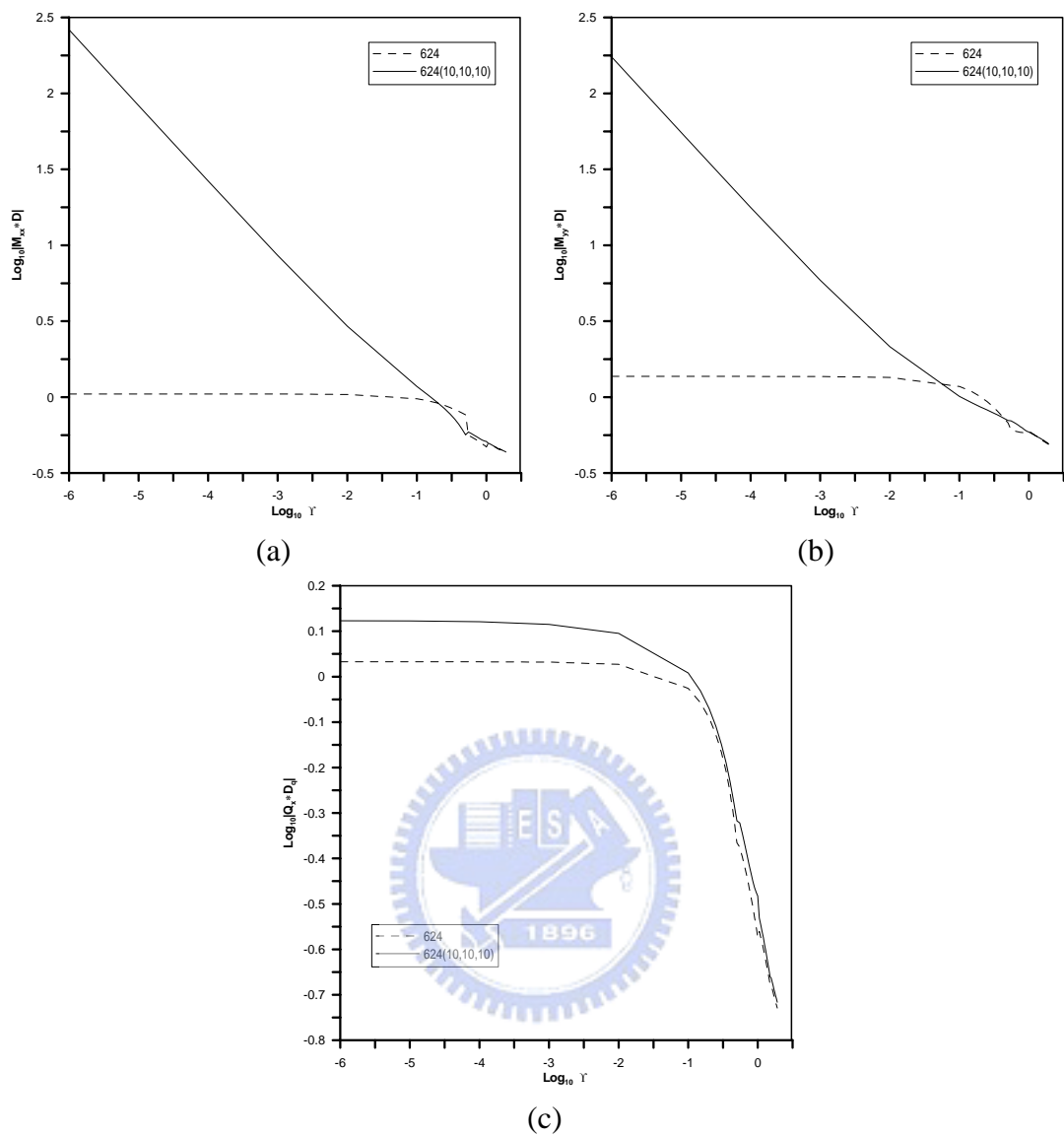


圖 4.47 $\Delta = 0^\circ, c/b = 0.1, b/h = 10, \theta = 0^\circ$ 四端簡支板受均載時裂縫處內力分佈

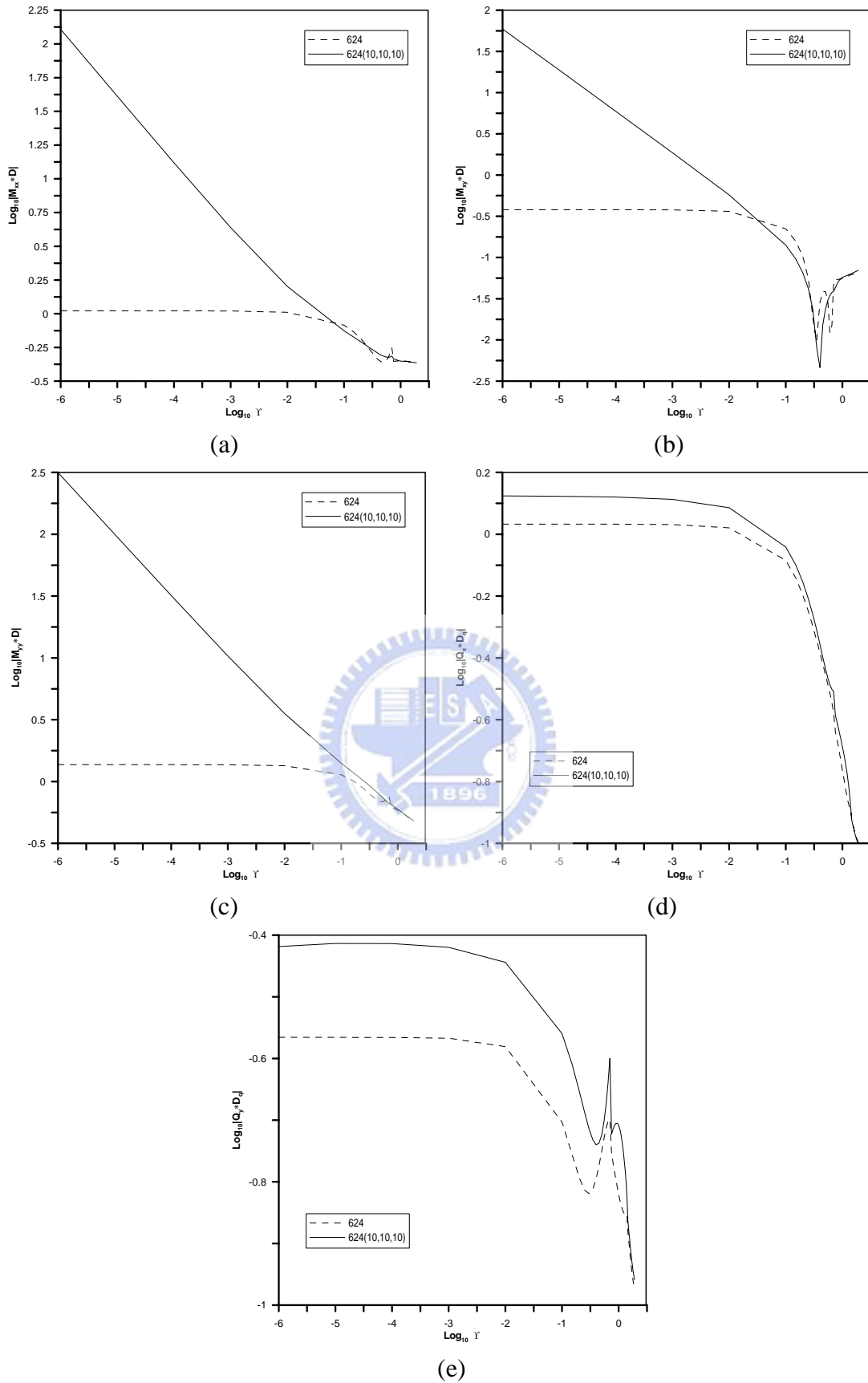


圖 4.48 $\Delta = 0^\circ, c/b = 0.1, b/h = 10, \theta = 45^\circ$ 四端簡支板受均載時裂縫處內力分佈

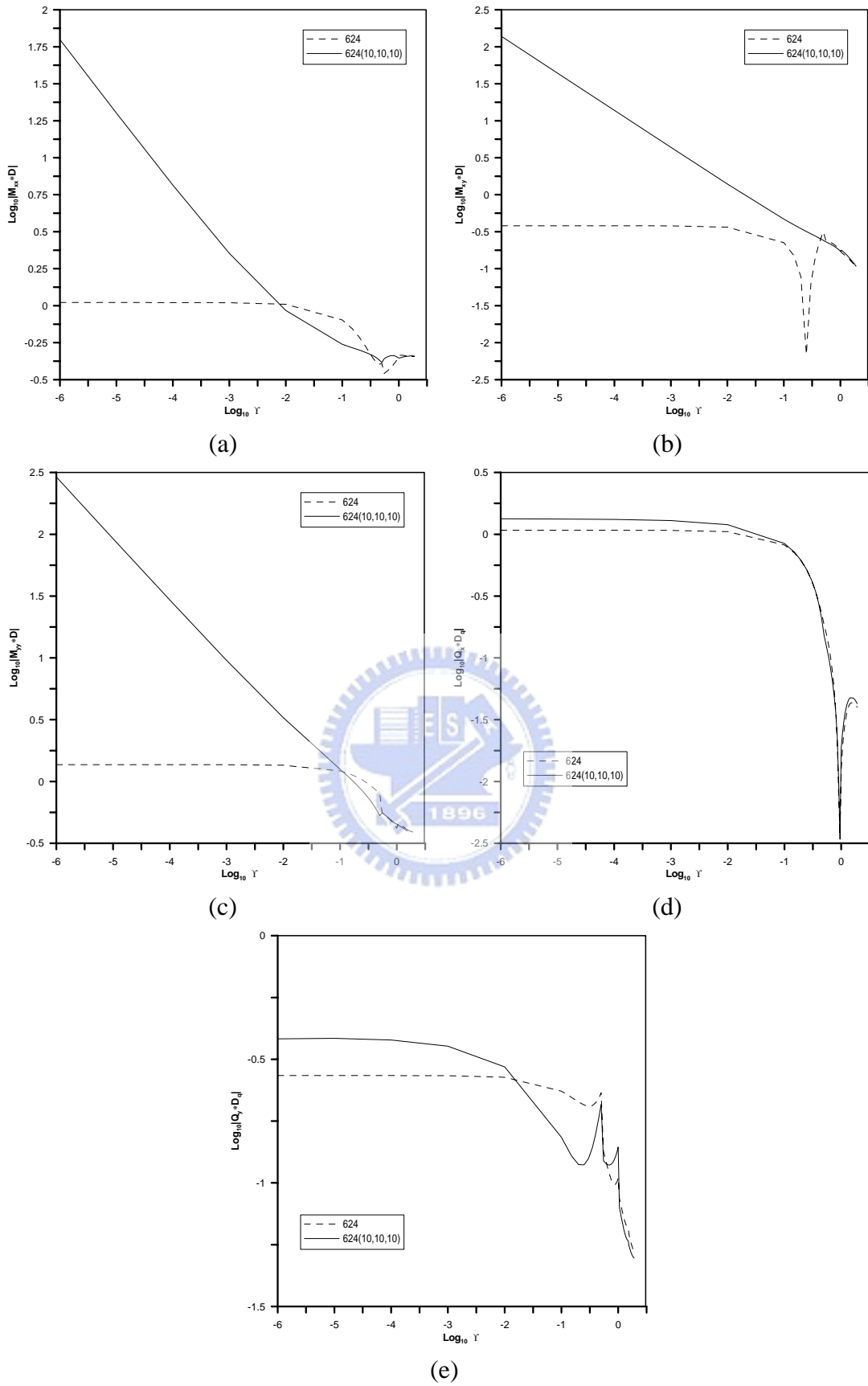
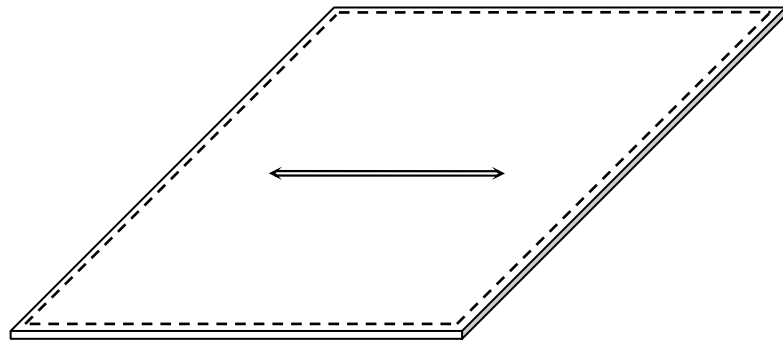
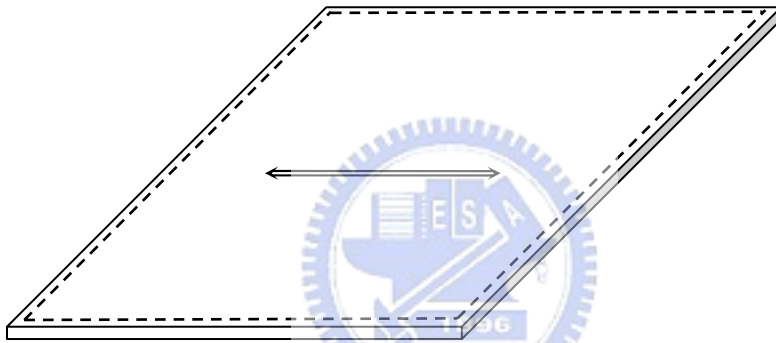


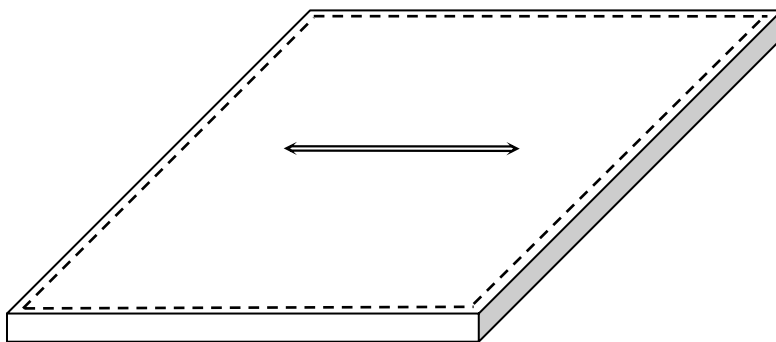
圖 4.49 $\Delta = 0^\circ, c/b = 0.1, b/h = 10, \theta = 90^\circ$ 四端簡支板受均載時裂縫處內力分佈



$$b/h = 20$$



$$b/h = 10$$



$$b/h = 5$$

圖 4.50 不同板厚之示意圖

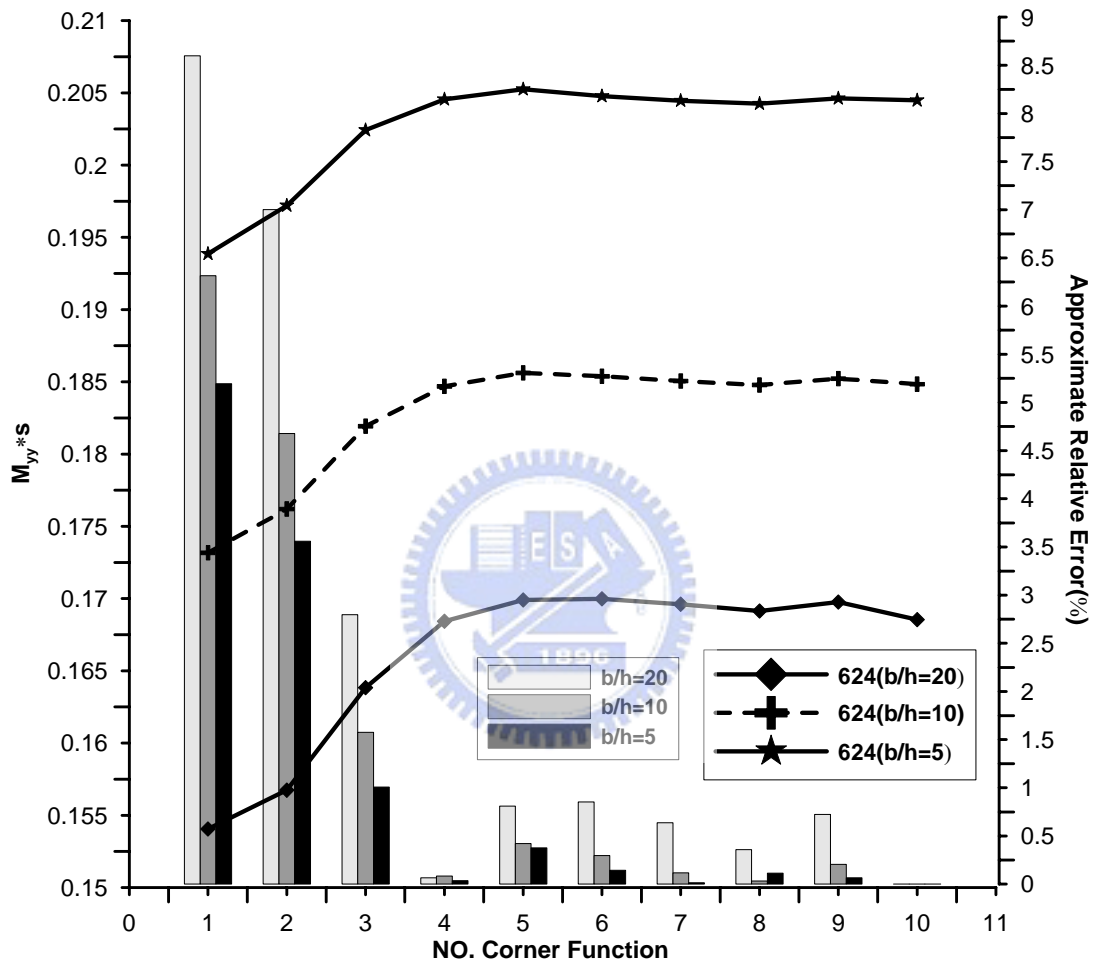


圖 4.51 $c/b=0.1$ 板厚與角函數個數應力強度無因次收斂性分析