潛堤對入射波消波影響之研究

二十五屆力學會議報告

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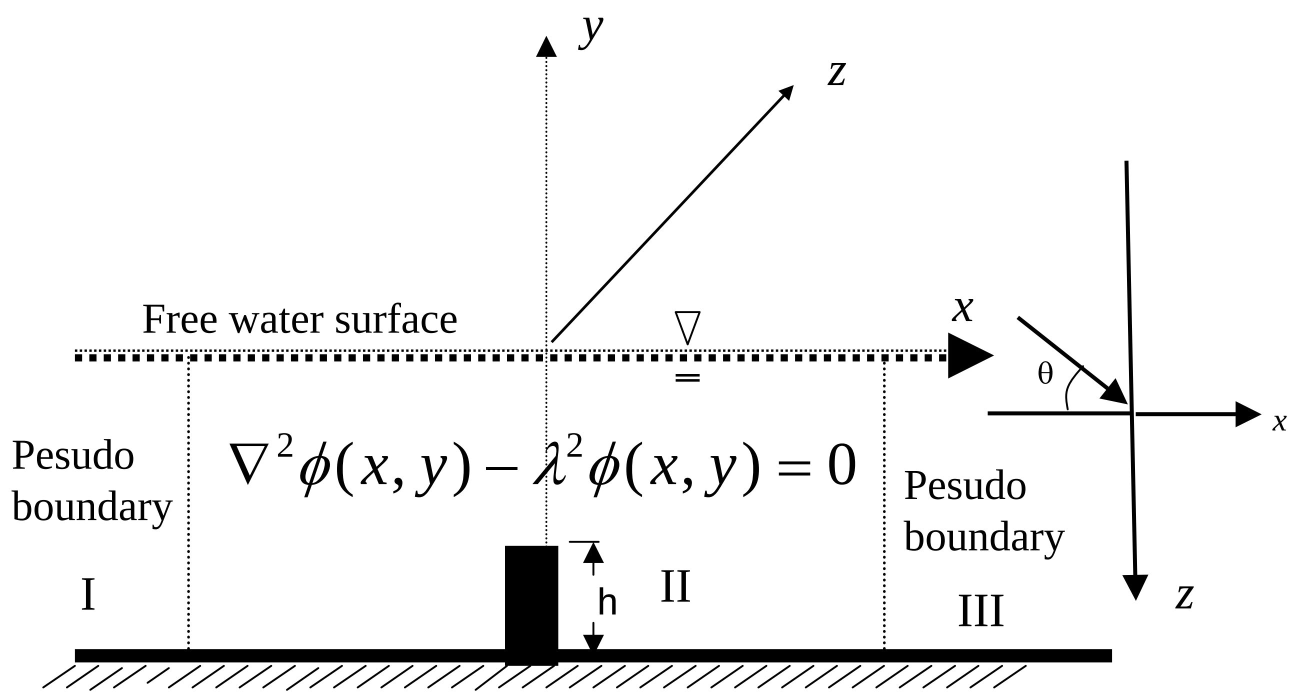
日期：九十年十二月十五日

地點：逢甲大學

報告流程圖

問題描述 → 研究目的 → 研究動機 → Dual BEM 分析方法 → 奇異積分的獲得 → 數值分析 → 結論

問題描述



$\nabla^2\Phi(x,y,z,t)=0 \Rightarrow \phi(x,y)e^{i(\lambda z-\sigma t)}$ Periodic time

$\lambda = k\sin\theta$ uniform water depth in z-axis

研究目的

- 建立一套Dual BEM程式，分析極薄潛堤（退化邊界）承受入射波的消能分析。

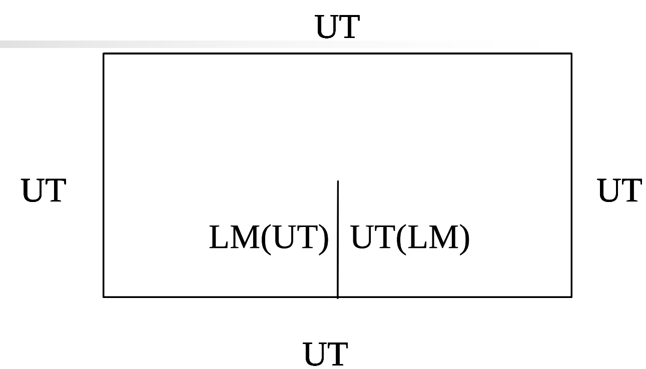
研究動機

傳統邊界元素法 UT equation

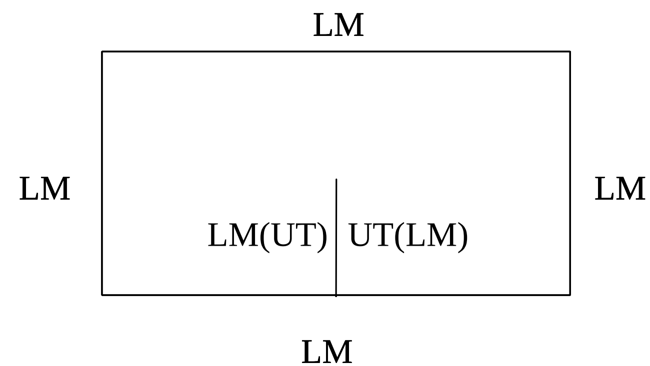
退化邊界
方程組相依

對偶邊界元素法 LM equation

Method UT (normal boundary)+LM



Method LM (normal boundary)+UT



以多項式方程式為例

$$f(x) = (x-a)^2 Q(x) + px + q$$

$$f(a) = pa + q, \quad \text{when } x = a$$

The constraint equation is not enough to determine the coefficients p and q,

another constraint equation is required

$$f'(x) = 2(x-a)\overline{Q}(x) + p$$

$$f'(a) = p, \quad \text{when } x = a$$

分析方法

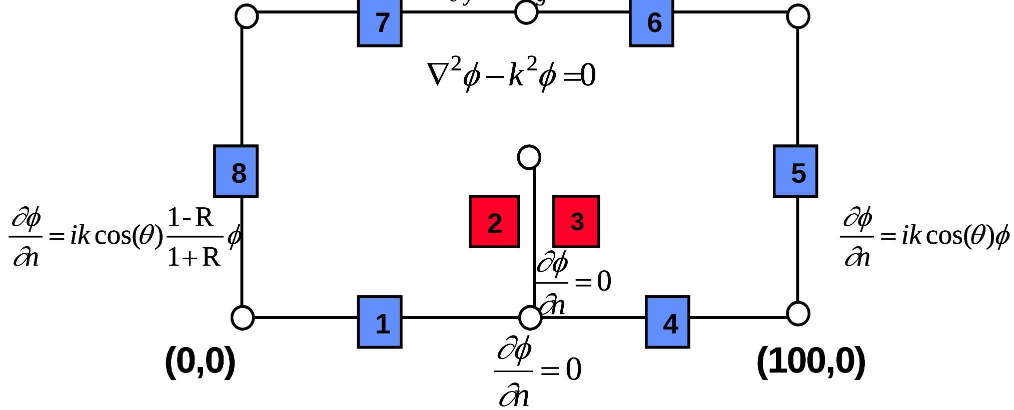
$$2\pi\ u(x)=\int_B\{T(s,x)u(s)-U(s,x)t(s)\}dB(s)$$

$$2\pi\ t(x)=\int_B\{M(s,x)u(s)-L(s,x)t(s)\}dB(s)$$

$$U(\mathbf{s},\mathbf{x})=\frac{-i\pi D_0^{(1)}(\lambda r)}{2},\quad T(\mathbf{s},\mathbf{x})=\frac{-i\lambda\pi}{2}D_1^{(1)}(\lambda r)\frac{y_i n_i}{r}$$

$$L(\mathbf{s},\mathbf{x})=\frac{i\lambda\pi}{2}D_1^{(1)}(\lambda r)\frac{y_i\bar{n}_i}{r},\quad M(\mathbf{s},\mathbf{x})=\frac{-i\lambda\pi}{2}\{-\lambda\frac{D_2^{(1)}(\lambda r)}{r^2}y_i y_j n_i\bar{n}_j$$

$$+\frac{D_1^{(1)}(\lambda r)}{r}n_i\bar{n}_i\}$$



○ geometry node

N the Nth constant or linear element

[U]{t}=[T]{u}

[L]{t}=[M]{u}

U:

		2(+)	3(+)						
	-3.96	.00	.00	.00	.00	.00	.00	.00	
	-.19	-4.3	-4.3	-.19	.00	-.02	-.02	.00	2(+)
	-.19	-4.3	-4.3	-.19	.00	-.02	-.02	.00	3(+)
	.00	.00	.00	-3.96	.00	.00	.00	.00	
	.00	.00	.00	-.06	-4.39	-.06	.00	.00	
	.00	.00	.00	.00	.00	-3.96	.00	.00	
	.00	.00	.00	.00	.00	.00	-3.96	.00	
	-.06	.00	.00	.00	.00	.00	-.06	-4.39	

\+ i

$n(s)$

	2(+)	3(+)						
.1E+08	.4E+08	.4E+08	.8E+22	.7E+23	.1E+23	.5E+08	.8E+08	
.2E+15	.1E+02	.1E+02	.2E+15	.2E+16	.3E+15	.3E+15	.2E+16	2(+)
.2E+15	.1E+02	.1E+02	.2E+15	.2E+16	.3E+15	.3E+15	.2E+16	3(+)
.8E+22	.4E+08	.4E+08	.1E+08	.8E+08	.5E+08	.1E+23	.7E+23	
.4E+30	.1E+16	.1E+16	.3E+15	.3E+02	.3E+15	.4E+30	.3E+31	
.1E+23	.6E+08	.6E+08	.5E+08	.8E+08	.1E+08	.8E+22	.7E+23	
.5E+08	.6E+08	.6E+08	.1E+23	.7E+23	.8E+22	.1E+08	.8E+08	
.3E+15	.1E+16	.1E+16	.4E+30	.3E+31	.4E+30	.3E+15	.3E+02	

T:

-3.14	.00	.00	.00	.00	.00	.00	.00
.13	-3.14	-3.14	.13	.00	.02	.02	.00
.13	- 3.14	-3.14	.13	.00	.02	.02	.00
.00	.00	.00	-3.14	.00	.00	.00	.00
.00	.00	.00	.05	-3.14	.05	.00	.00
.00	.00	.00	.00	.00	-3.14	.00	.00
.00	.00	.00	.00	.00	.00	-3.14	.00
.05	.00	.00	.00	.00	.00	.05	-3.14

\+ i

.0E+00	.3E+08	-.3E+08	.0E+00	.5E+23	.1E+22	.1E+08	.5E+08
.1E+14	.0E+00	.0E+00	.1E+14	.1E+16	.3E+14	.3E+14	.1E+16
.1E+14	.0E+00	.0E+00	.1E+14	.1E+16	.3E+14	.3E+14	.1E+16
.0E+00	-.3E+08	.3E+08	.0E+00	.5E+08	.1E+08	.1E+22	.5E+23
.1E+29	-.8E+15	.8E+15	.2E+14	.0E+00	.2E+14	.1E+29	.2E+31
.1E+22	-.4E+08	.4E+08	.1E+08	.5E+08	.0E+00	.2E+13	.5E+23
.1E+08	.4E+08	-.4E+08	.1E+22	.5E+23	-.2E+13	.0E+00	.5E+08
.2E+14	.8E+15	-.8E+15	.1E+29	.2E+31	.1E+29	.2E+14	.0E+00

奇異積分的獲得

(採常數元素離散)

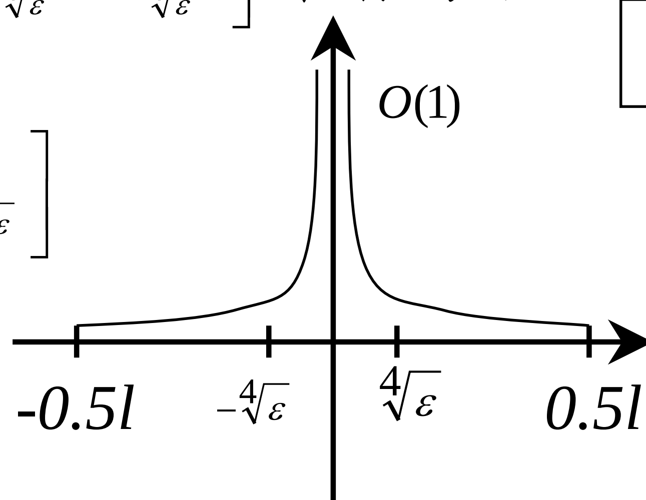
- 奇異積分轉成有限值 $=\pi$
- (1) $L(\mathbf{s},\mathbf{x})$ kernel: *p=q* (singular integral)

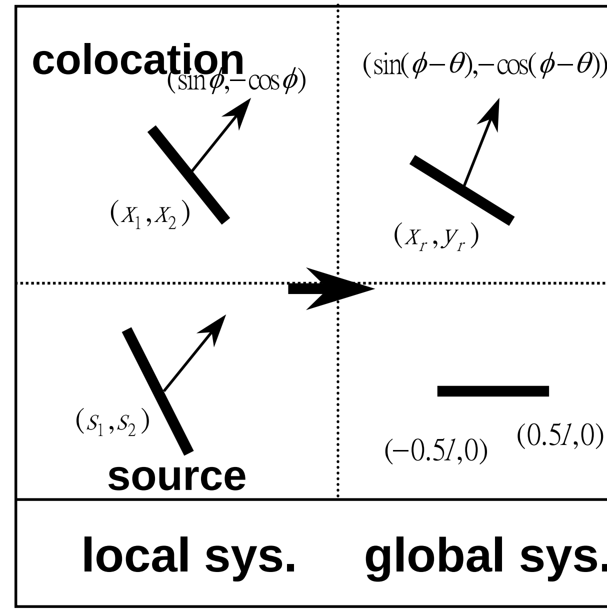
$$L_{pq} = ik \lim_{\varepsilon\to 0} \int_{-0.5l}^{0.5l} D_1^2\left(k\sqrt{s^2+\varepsilon^2}\right)\frac{-\varepsilon}{\sqrt{s^2+\varepsilon^2}}ds$$

$$= -ik \lim_{\varepsilon\to 0}\left[\int_{-0.5l}^{-\sqrt[4]{\varepsilon}} + \int_{-\sqrt[4]{\varepsilon}}^{\sqrt[4]{\varepsilon}} + \int_{\sqrt[4]{\varepsilon}}^{0.5l}\right]$$ 極限方法

$$= -\lim_{\varepsilon\to 0}\left[\tan^{-1}\frac{s}{\varepsilon}\Big|_{-\sqrt[4]{\varepsilon}}^{\sqrt[4]{\varepsilon}}\right]$$

$$= -\pi, \text{ (i no sum)}$$





座標系統轉換

- 超強奇異積分轉成正規積分

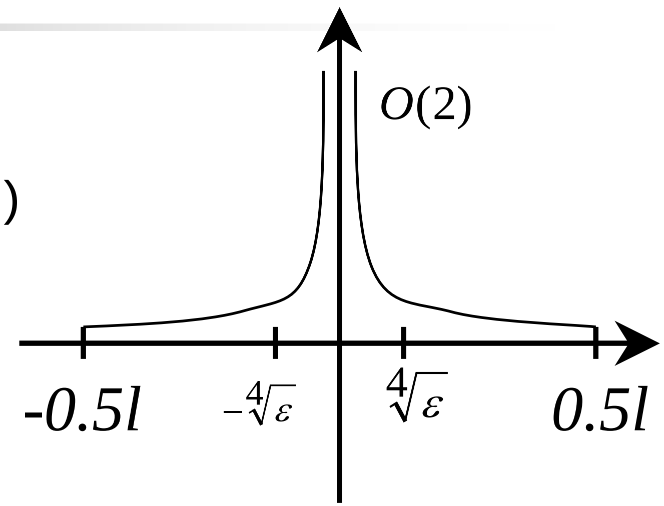
(1) $M(\mathbf{s},\mathbf{x})$ kernel: *p=q* (hypersingular integral)

$$M_{pq} = ik\lim_{\varepsilon\to 0}\int_{-0.5l}^{0.5l} k\frac{D_2^1(k\sqrt{s^2+\varepsilon^2})}{s^2+\varepsilon^2}\varepsilon^2 + \frac{D_1^2(k\sqrt{s^2+\varepsilon^2})}{\sqrt{s^2+\varepsilon^2}}ds$$

$$= ik^2\lim_{\varepsilon\to 0}\left[\int_{-0.5l}^{-\sqrt[4]{\varepsilon}} + \int_{-\sqrt[4]{\varepsilon}}^{\sqrt[4]{\varepsilon}} + \int_{\sqrt[4]{\varepsilon}}^{0.5l}\right]ds$$

(極限方法，部分積分)

$$= ik\left\{-2D_1^2(\frac{kl}{2}) + k\left[D_0^1(\frac{kl}{2}) - k\int_{-0.5l}^{0.5l} D_1^2(k|s|)|s|ds\right]\right\}. \text{ (i no sum)} = \text{H.P.V}$$



- 解題流程

對偶積分方程式的推導

對偶積分方程式的離散化

水面邊界條件

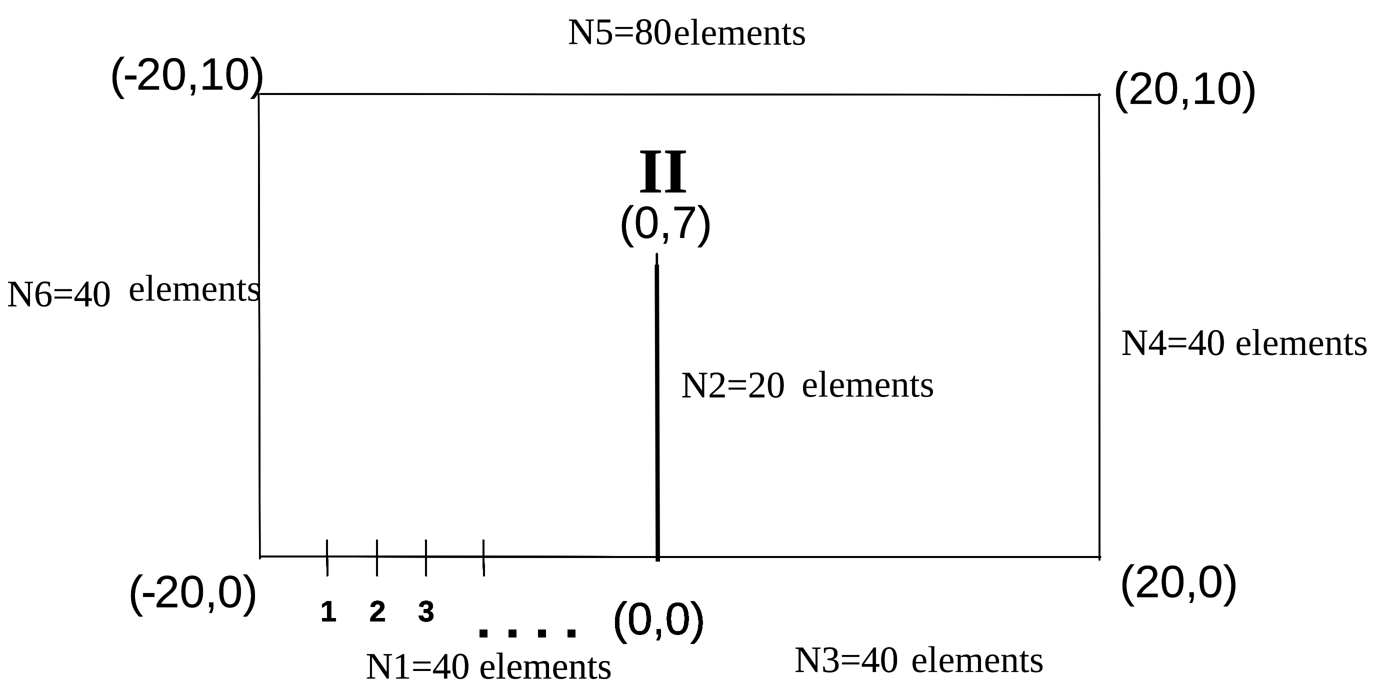
潛堤邊界條件(剛性、柔性、不透水、可透水)

人工邊界

解線性代數方程

計算 Reflection (R)，Transmission (T)

數值分析

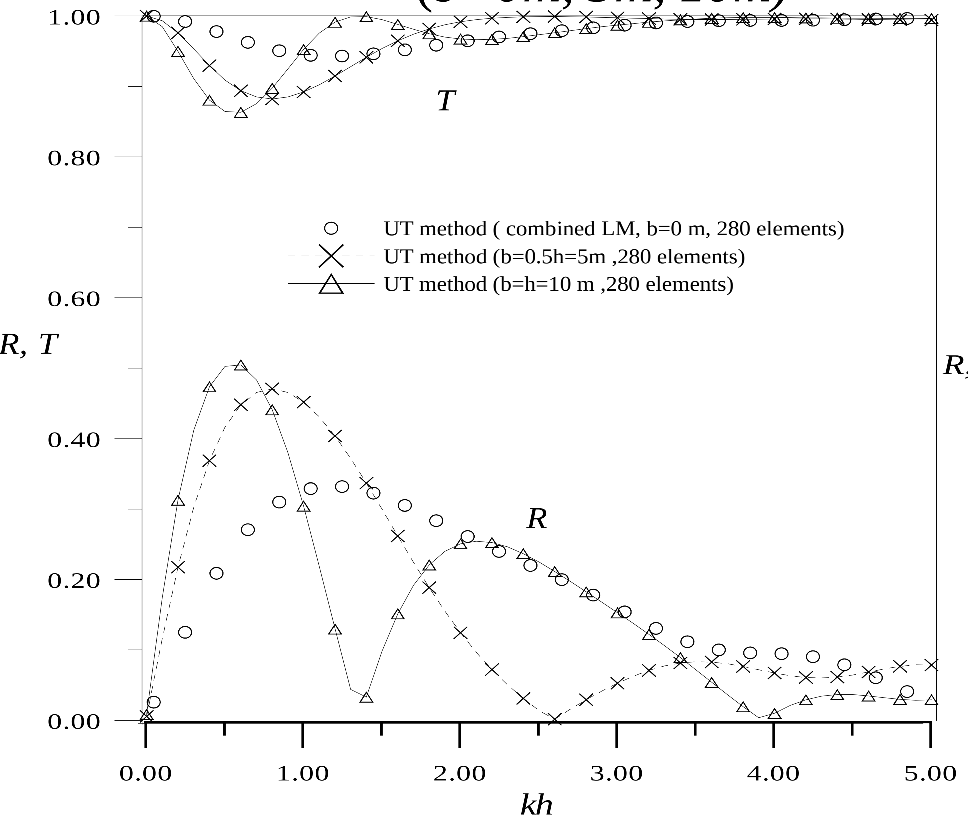


N=N1+2N2+N3+N4+N5+N6=280 elements

•不同週期水波的消波效果（正向入射，$\theta = 0^{o}$）

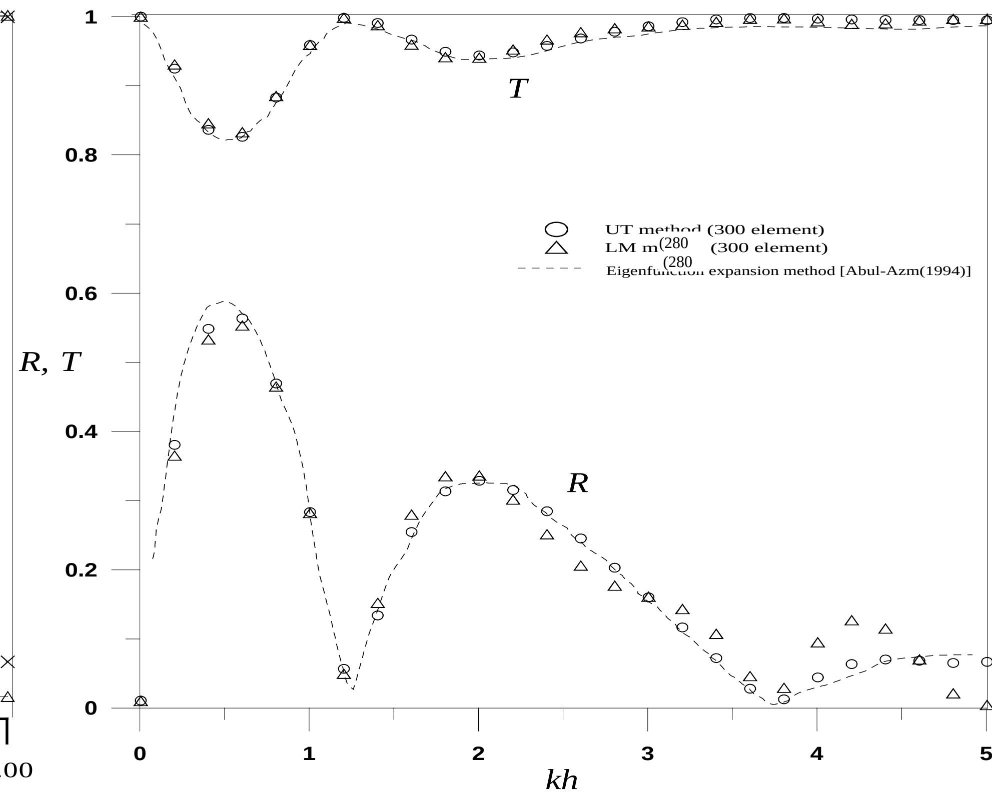
不同潛提厚度

(*b*=0m, 5m, 10m)



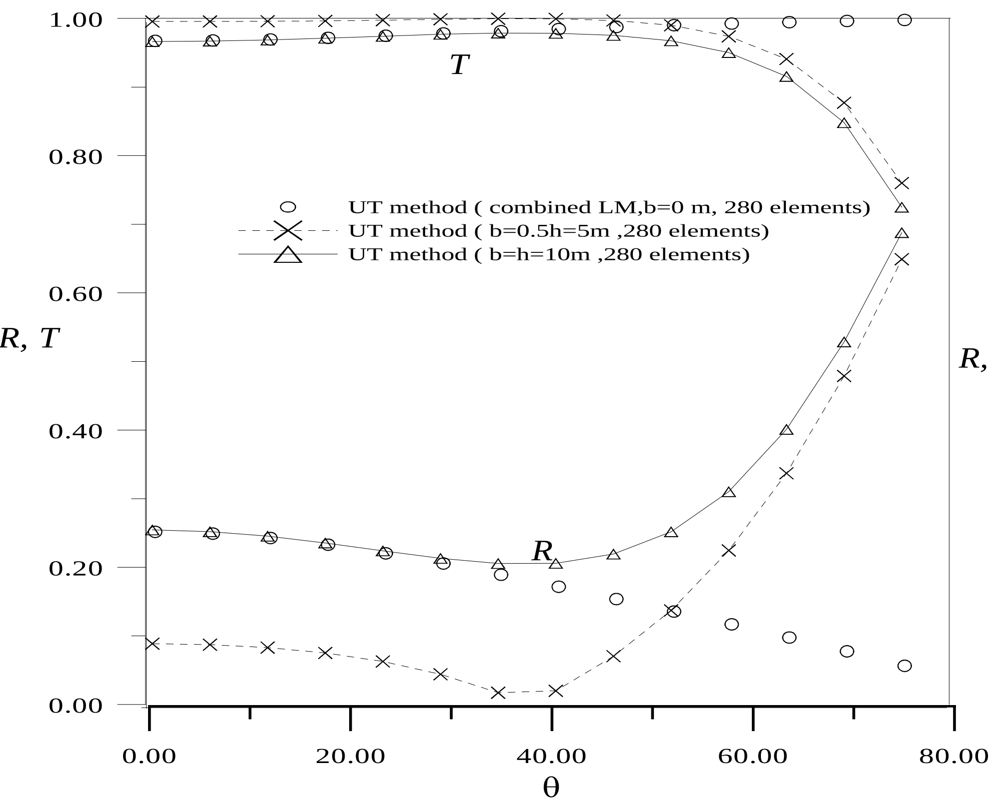
極薄厚度(*b*=0 *m*)不同方法

UT method, LM method, exact solution

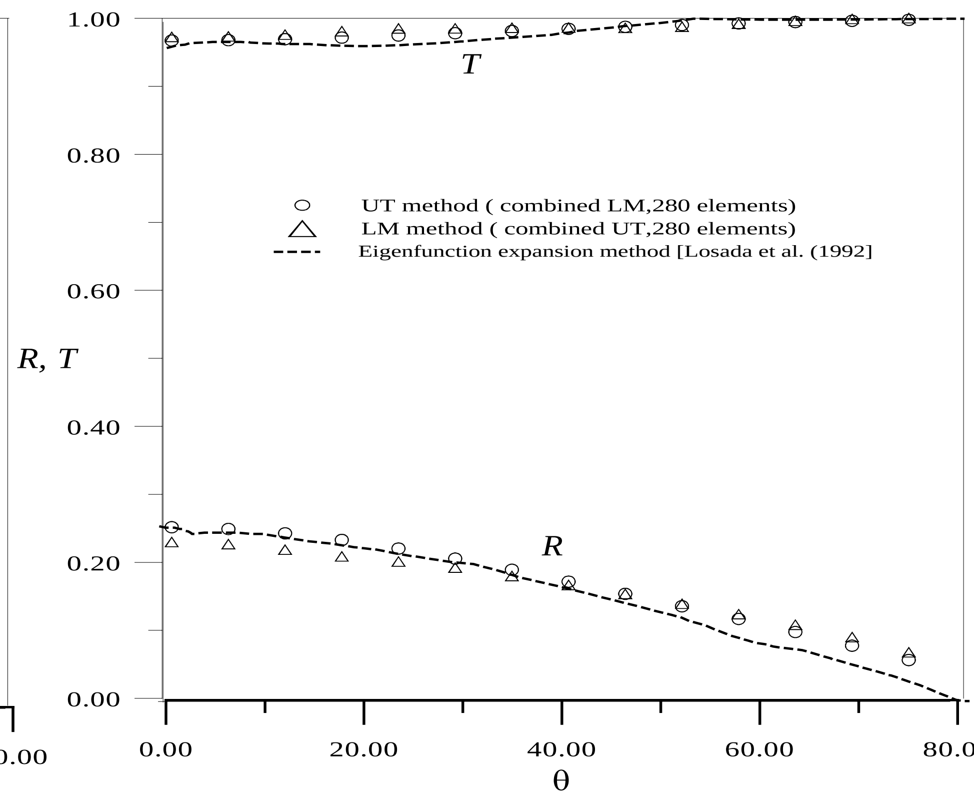


•各種入射水波角度的消波效果，$kh = 2.1362$

不同潛提厚度
(b=0m, 5m, 10m)



極薄厚度(B=0 m)不同方法
UT method, LM method, exact solution



結論

- BEM僅需對邊界切割元素即可，可大大縮短計算與前處理時間。
- 奇異積分與超強奇異積分轉成定值及正規積分（獲得C.P.V.與H.P.V.）。
- 針對含或不含退化邊界之潛提的消波問題，發展一套對偶邊界元素程式。

結束

敬請指教