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National Taiwan Ocean University

應用HHT分析波引致液化底床反應資料

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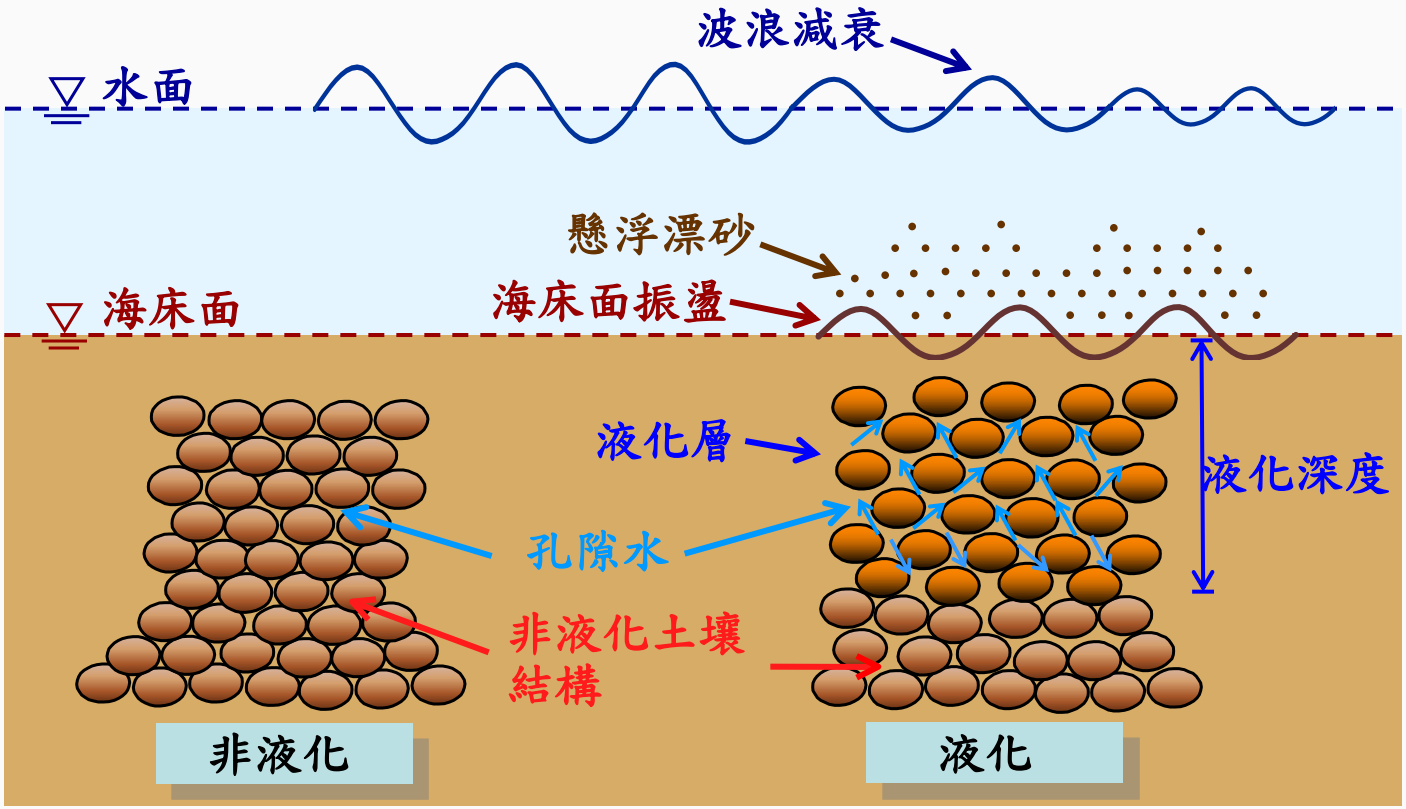
大綱

- 前言
  - 典型液化反應 (細砂質底床)
  - HHT
  - 模態混淆
- 分析方法
  - Ensemble EMD (EEMD)
  - 後處理方法
- 應用分析
  - 規則波
  - 非線性波
  - 不規則波

前言：液化定義



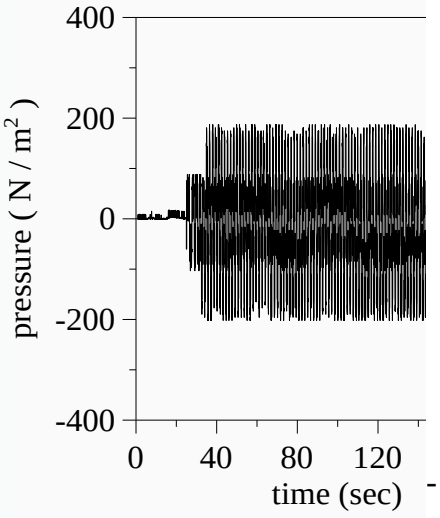
理論靜土壓 $P_s = (1-n)(\rho_s - \rho_w) g d$

液化：超額孔隙水壓抬升量 = 理論靜土壓力值

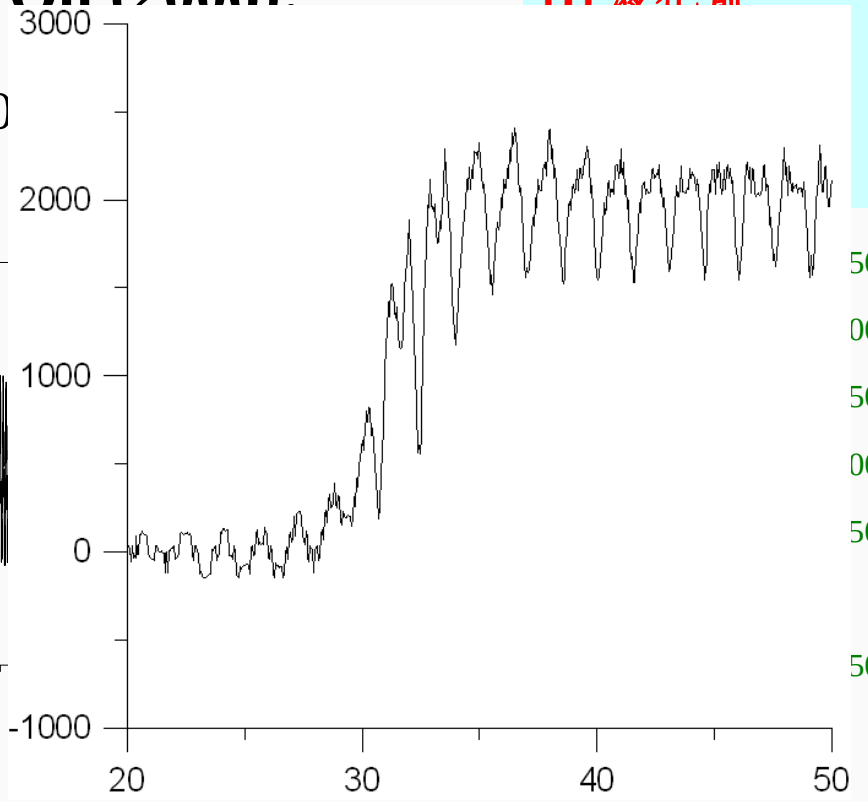
前言：典型液化反應 (細砂質底床)

- **Tzang and Ou (2006):**

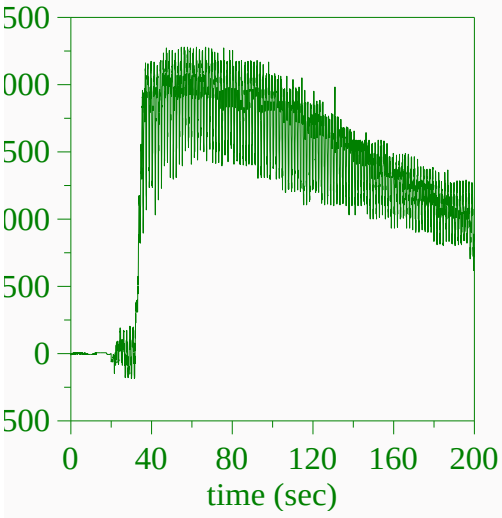
細砂質 (d_{50}=0



非液化

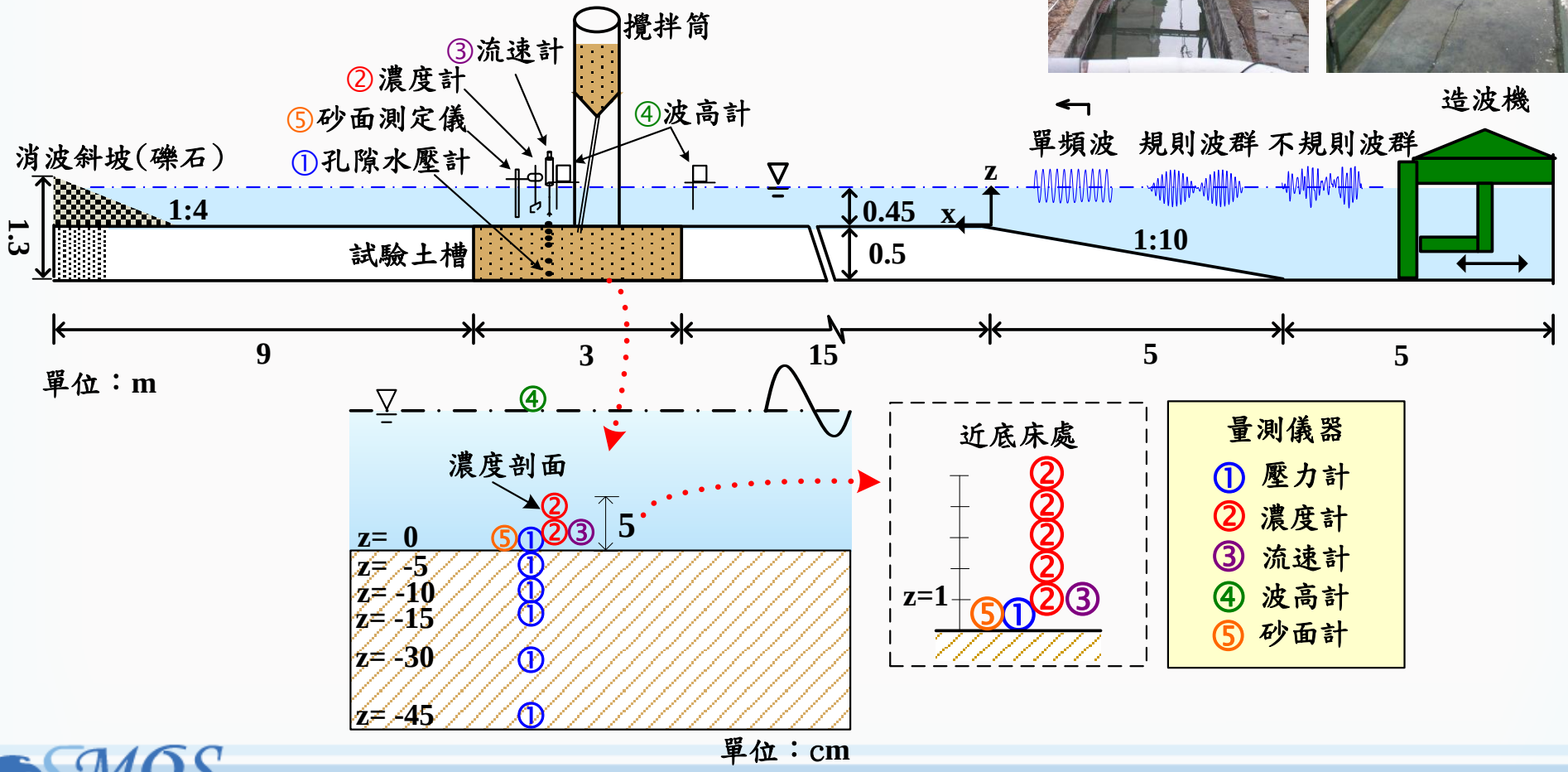


共振式液化



非共振式液化

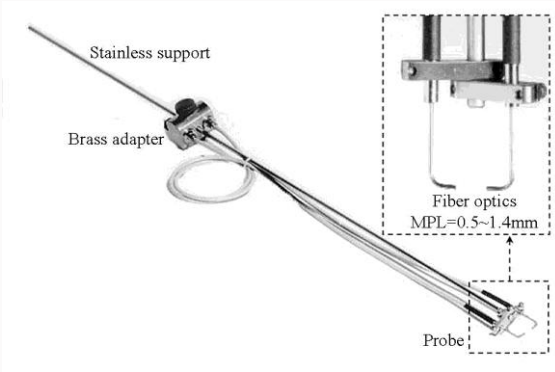
前言：試驗水槽配置


攪拌筒
③流速計
②濃度計
⑤砂面測定儀
④波高計
①孔隙水壓計
消波斜坡(礫石)
1:4
1.3
試驗土槽
0.45
0.5
x
z
1:10
單頻波
規則波群
不規則波群
造波機
9
3
15
5
5
單位：m
④
濃度剖面
z= 0
z= -5
z= -10
z= -15
z= -30
z= -45
5
單位：cm
近底床處
z=1
量測儀器
① 壓力計
② 濃度計
③ 流速計
④ 波高計
⑤ 砂面計

前言：試驗儀器

KYOWA BP-500 GRS

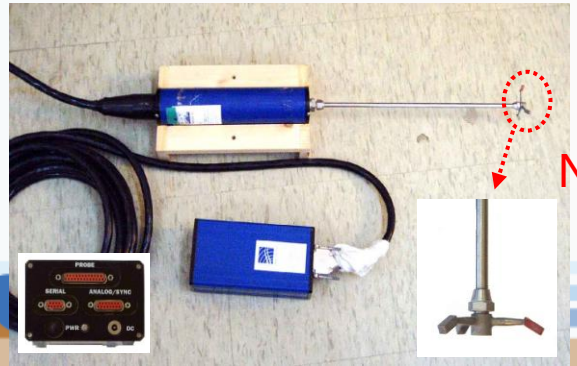
KYOWA DPM-8K



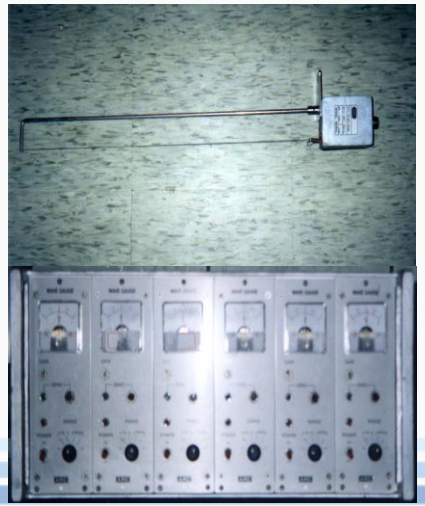
Delft Hydraulics FOSLIM

正豐工學試驗裝置製作所

MT – E.P.I. -4



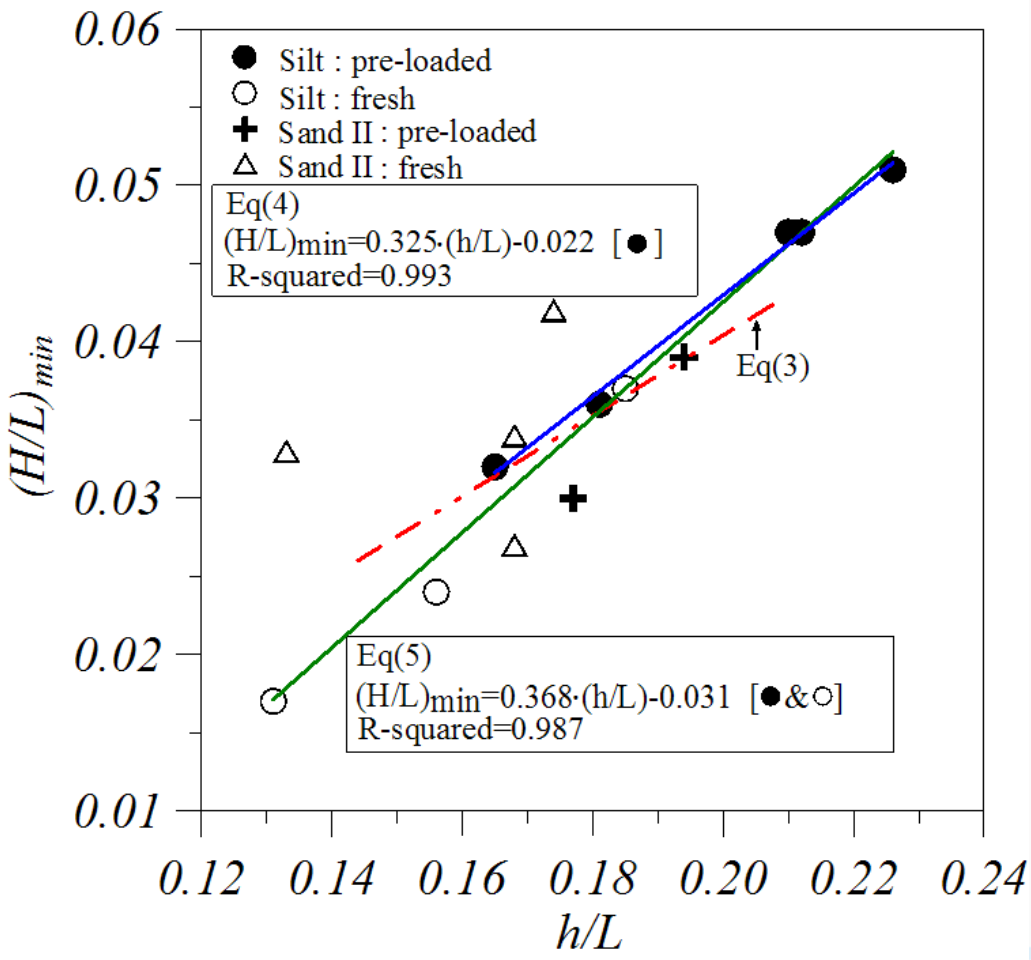
Nortek AS (NDVField)



ARC WHL1050

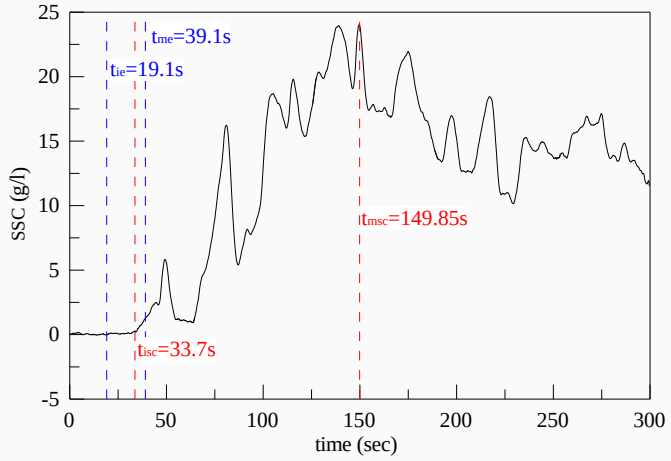
前言：液化水動力條件

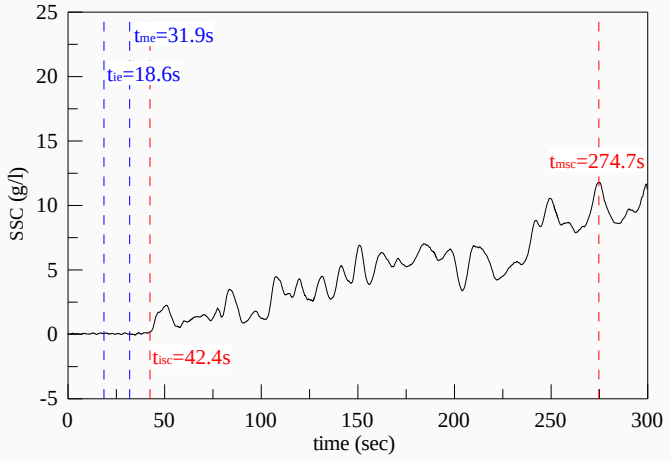
- **Tzang and Ou (2006):**

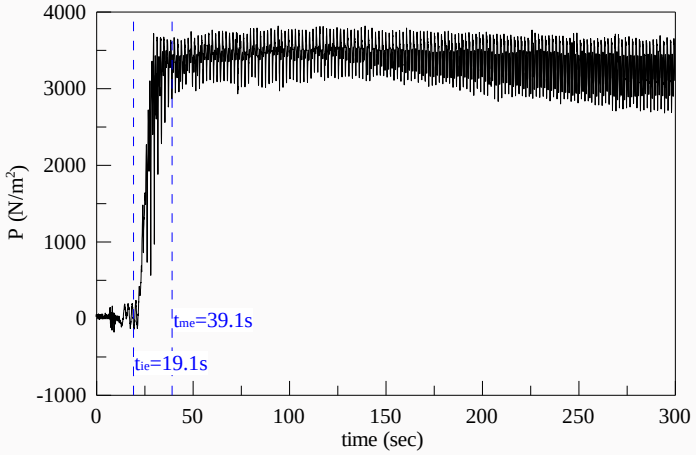


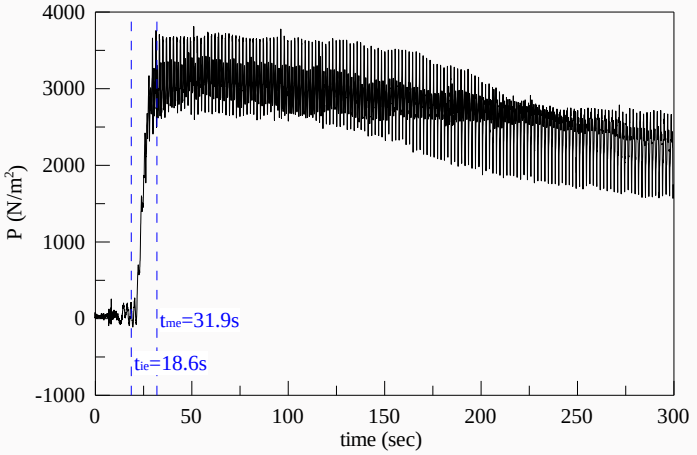
前言：液化底床上懸浮漂砂濃度

- **Tzang et al. (2009):**









共振式液化

非共振式液化

前言：HHT

- **Huang et al. (1998, 1999, 2003)**
  - 非線性 (Nonlinear)
  - 非穩態 (Nonstationary)
- **HHT主要步驟：**
  - 經驗模式分解法(EMD)
    - 拆解出內含模組函數 (IMF)
  - Hilbert轉換分析Hilbert Spectral Analysis (HSA)
    - 利用Hilbert轉換分析完成IMF之瞬時頻率與瞬時振幅
- **主要問題：**
  - **模態混淆 (Mode mixing)** (Huang et al., 1999):
    同一個IMF混入不同頻率尺度的成分
  - 解決方法：**Ensemble EMD**

前言：Ensemble EMD (EEMD)

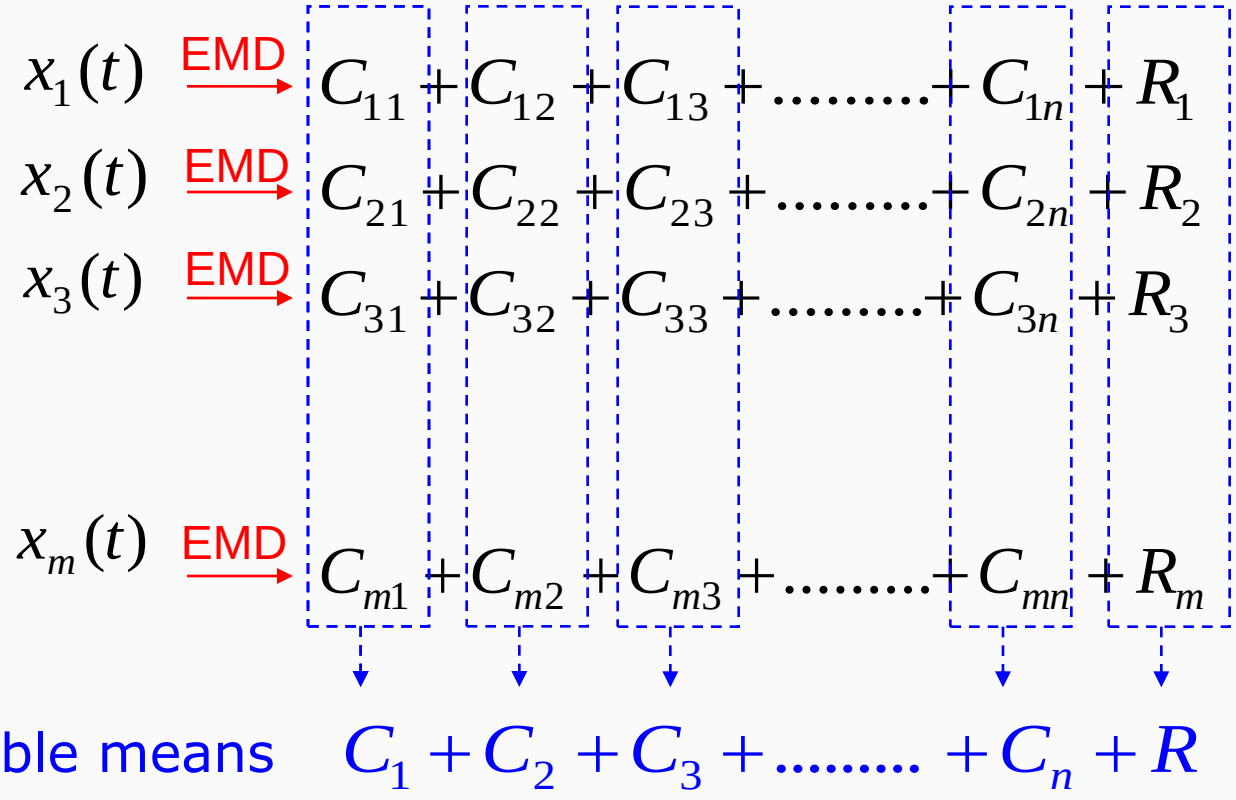
- **Wu and Huang (2005, 2009):**
  - 改進的EMD
  - 基於白噪的重要特性 (Wu and Huang, 2004): 白噪包含所有頻率尺度的訊號
  - EMD的拆解過程中白噪提供均勻分布的參考尺度 (reference scales)
  - 總體平均後可以消掉所加入的白噪訊號

前言：Ensemble EMD (EEMD)

$$x_i(t) = x(t) + w_i(t)$$

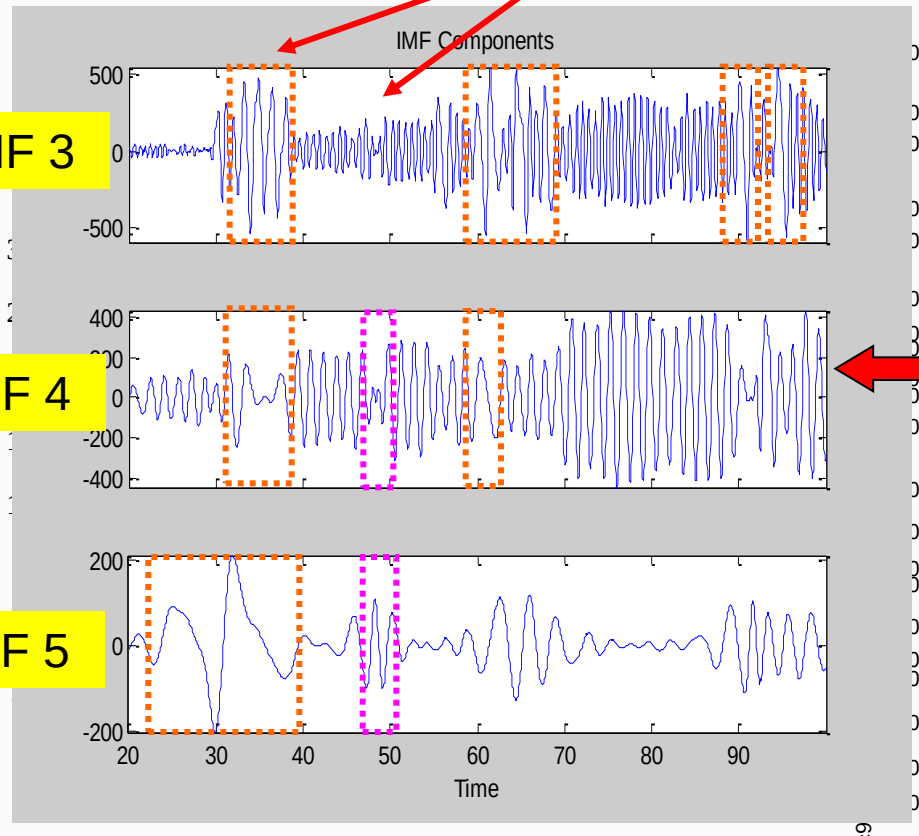
x(t): data

w_i: white nosie



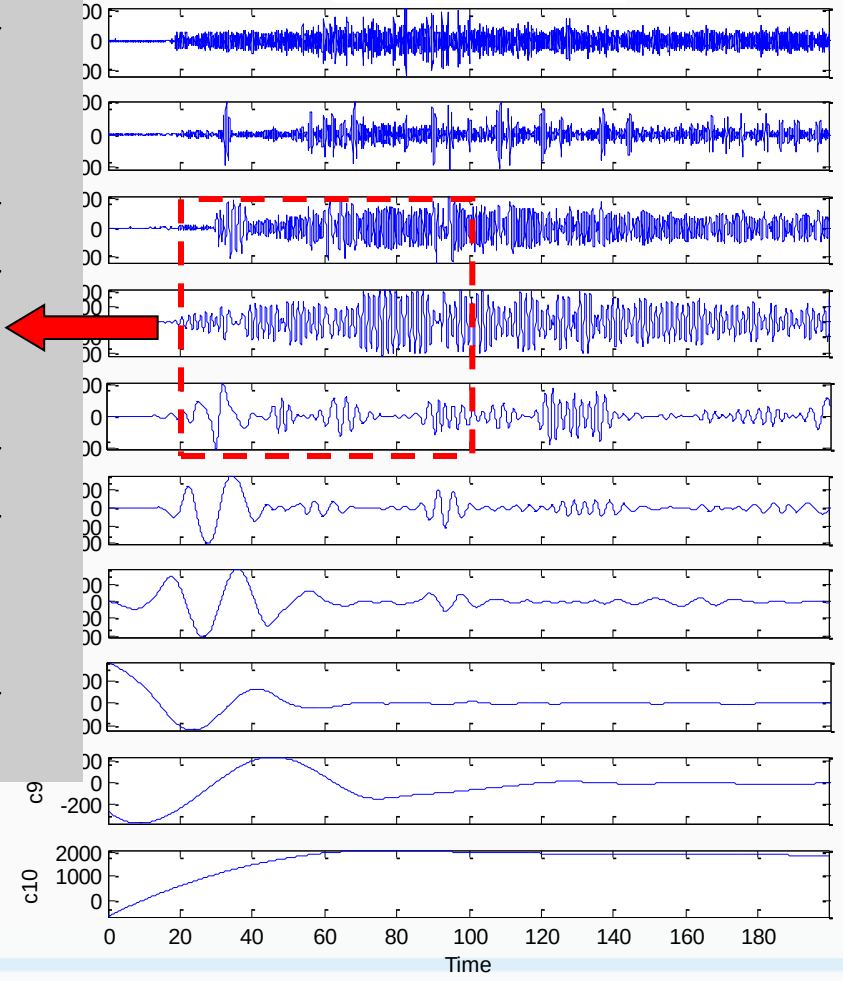
前言：HHT

Mode mixing: **different frequency**

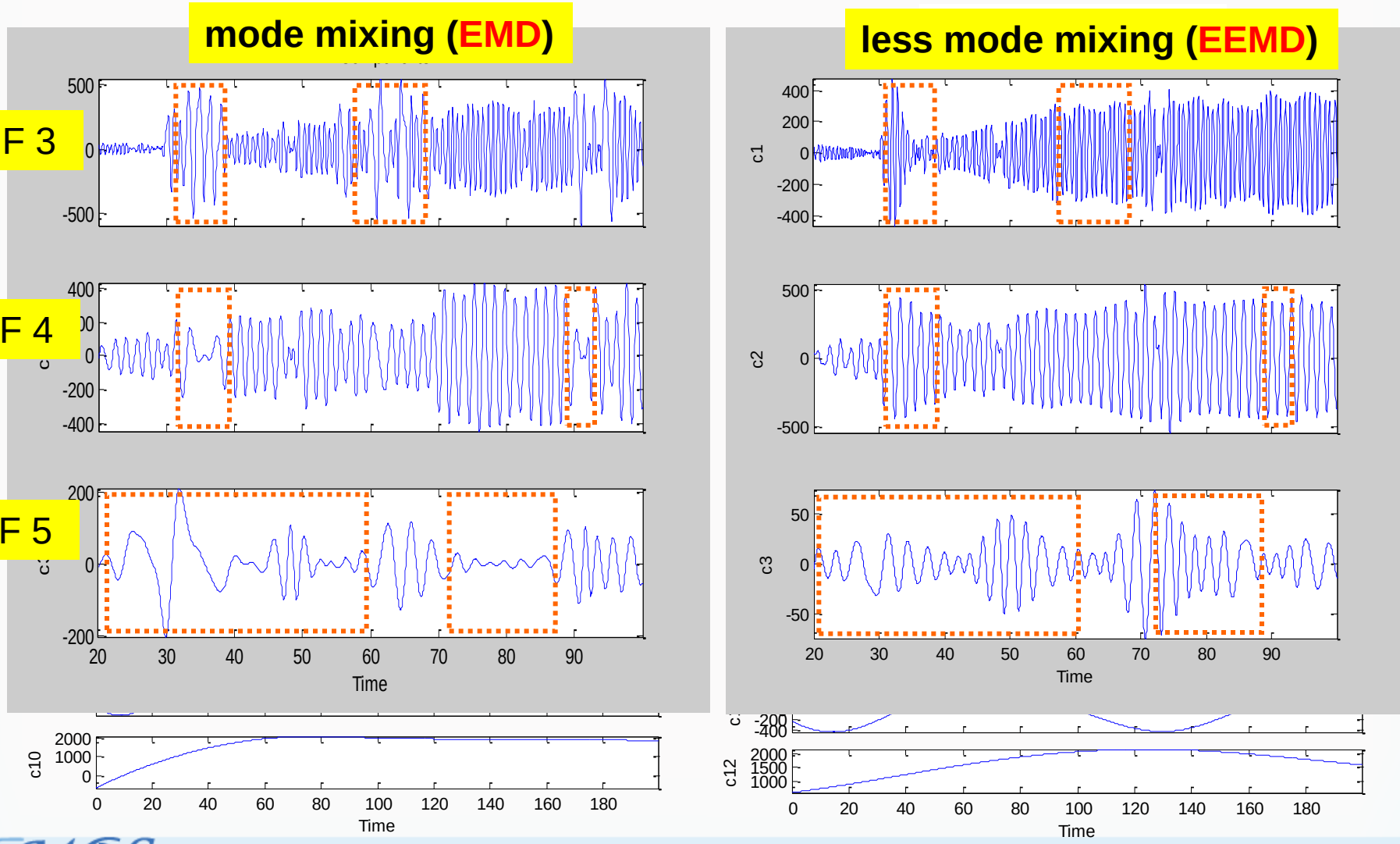


(Tzang and Ou, 2006)

IMF (EMD)



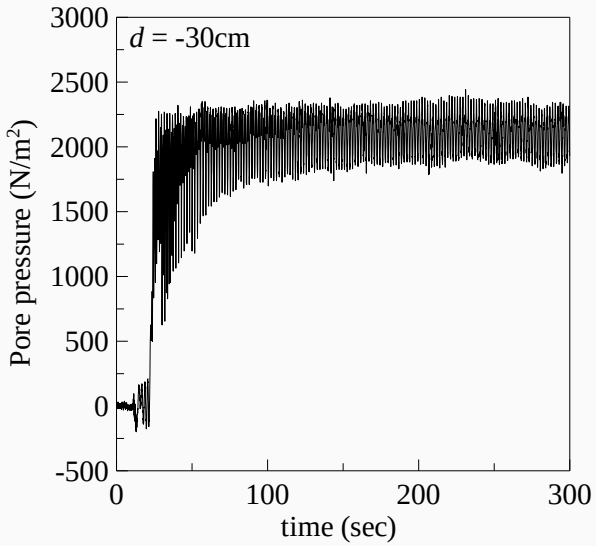
前言：模態混淆 (Mode mixing)



前言：Mode mixing

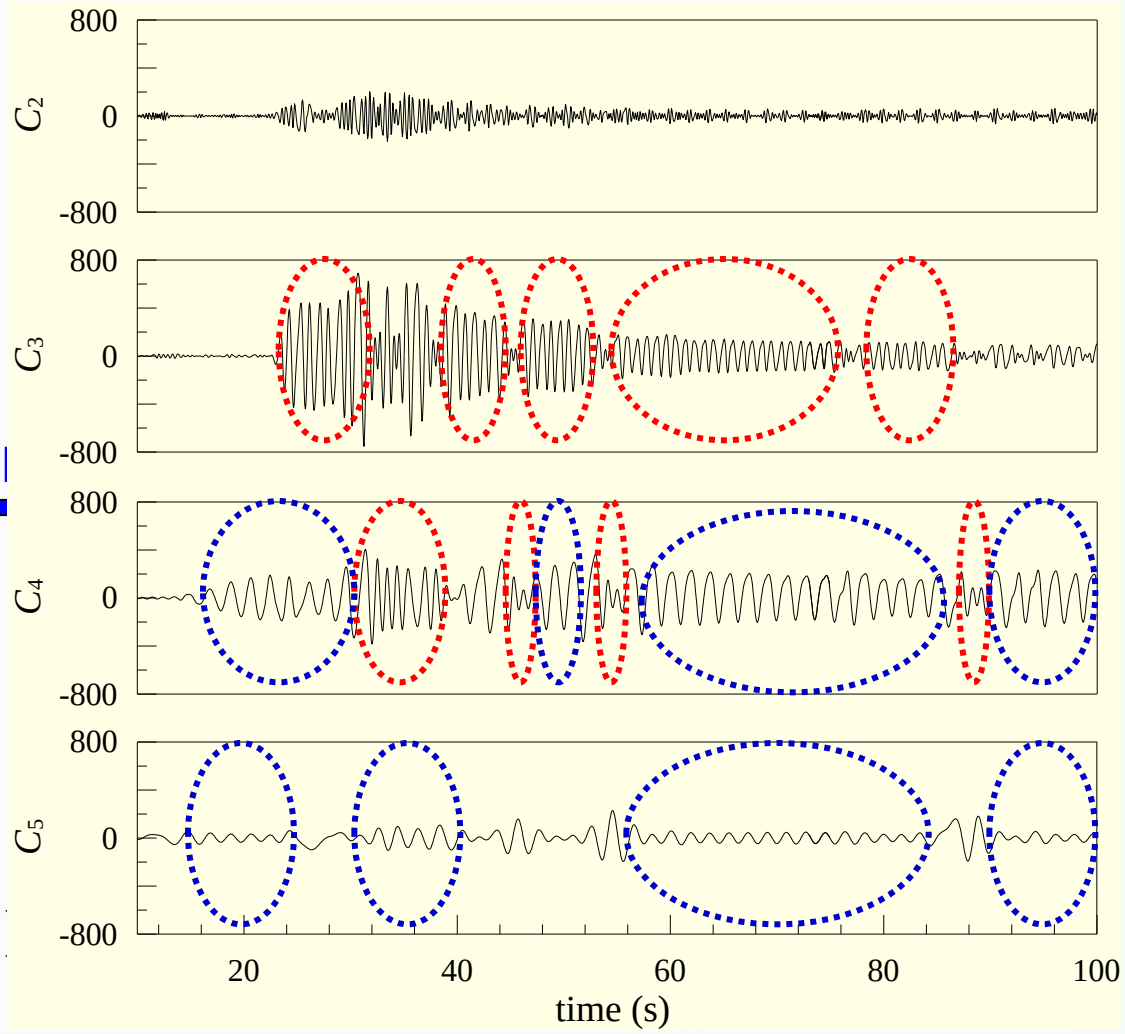
Mode mixing?

Test 8-1



Data: Test 8-1

(Tzang and Ou, 2006

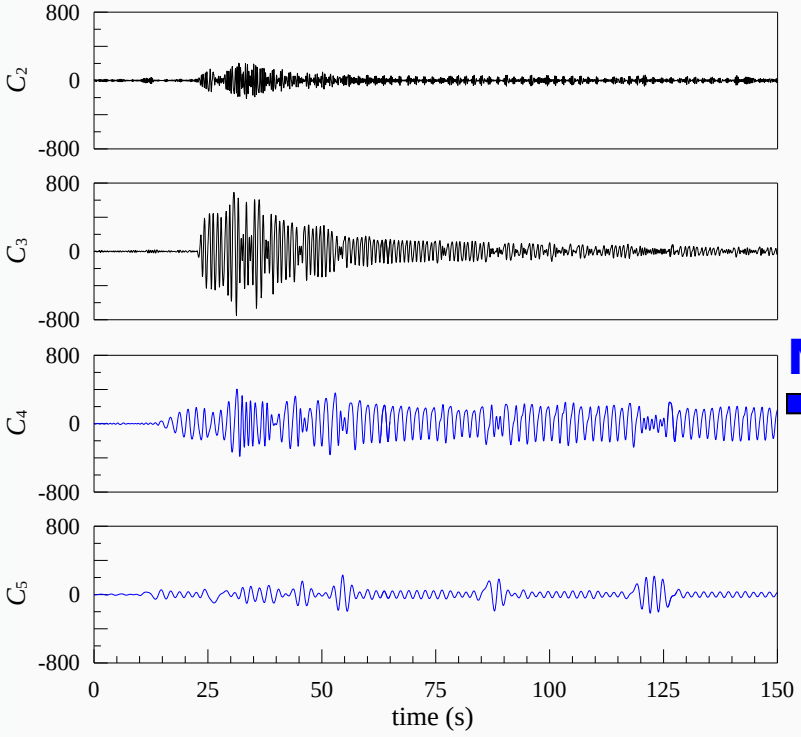


前言：利用MSEMD之後處理

- **Masking Signal EMD (MSEMD):**
  Deering and Kaiser (2005)
  - 為了解決模態混淆
  - 加入簡單的單頻波
- **利用MSEMD之後處理方法:**
  Chen et al. (2009)
  - 校正EEMD之IMFs

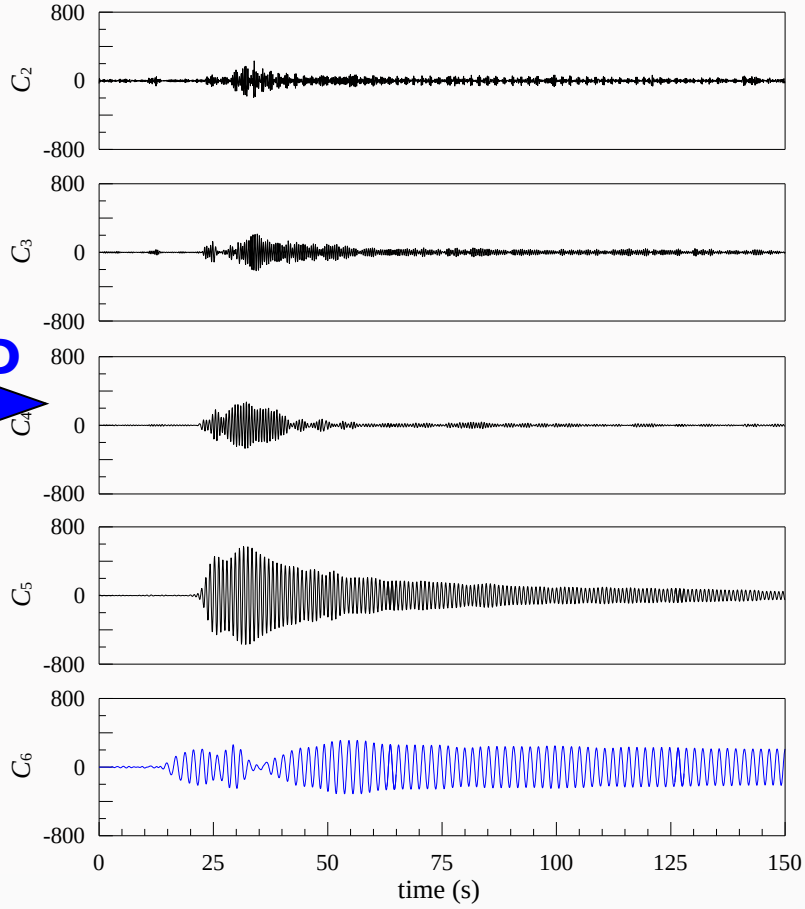
前言：利用MSEMD之後處理

IMF (EEMD)

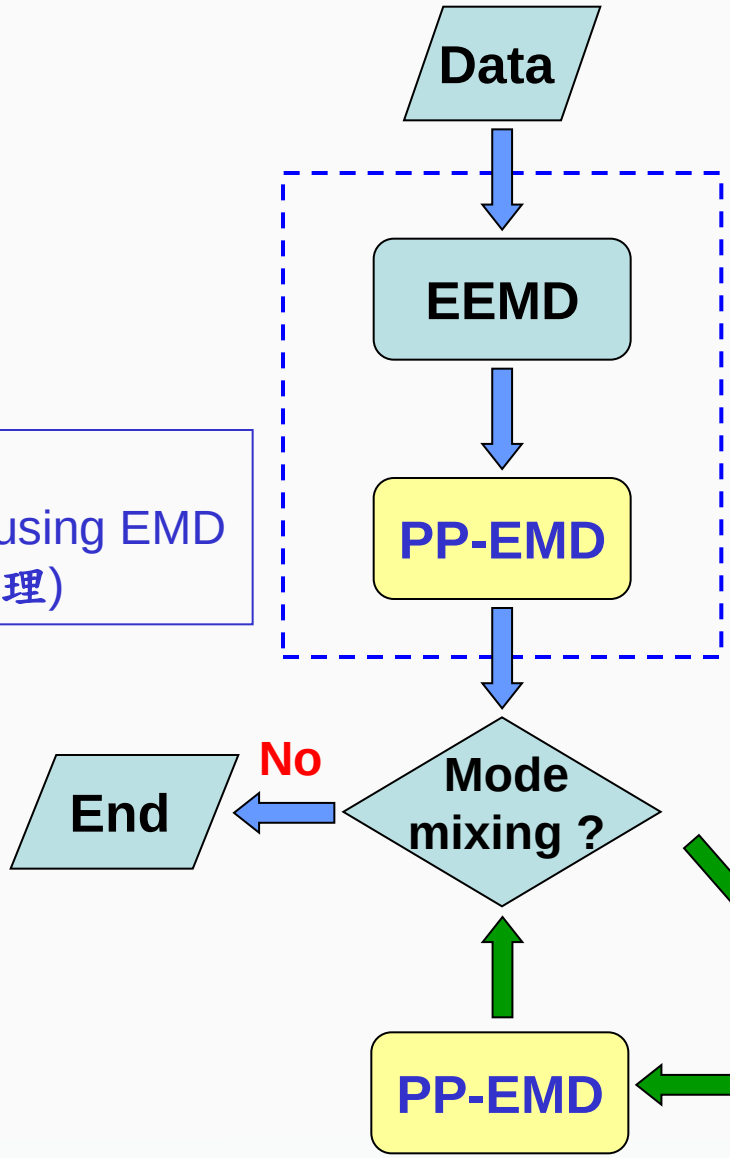


MSEMD

IMF (EEMD+MSEMD)



分析方法: EEMD處理流程



Wu and Huang (2009)

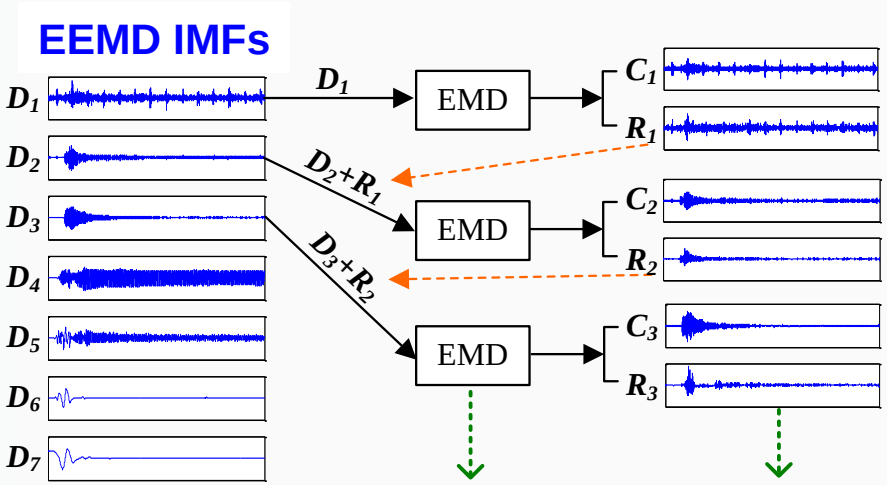
PP-EMD:
Post processing using EMD
(利用**EMD**之後處理)

PP-MSEMD:
Post processing using MSEMD
(利用**MSEMD**之後處理)

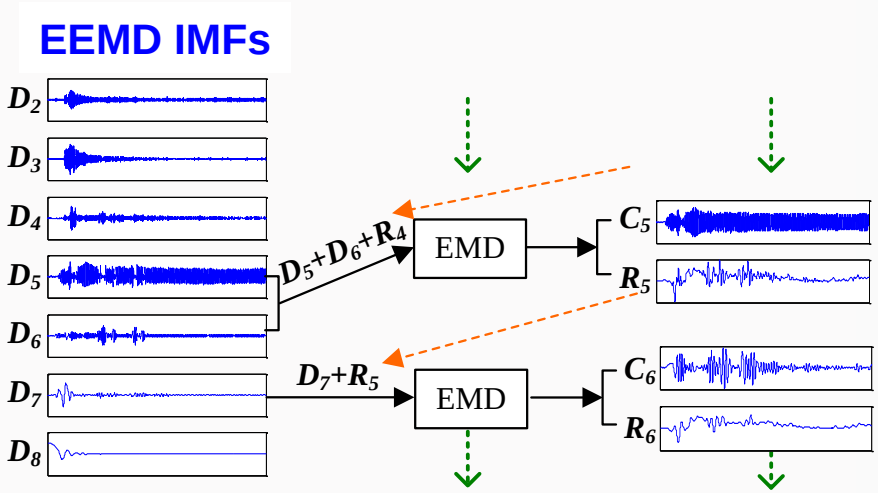
分析方法: 利用EMD之後處理

Wu and Huang (2009):

(1) 單一



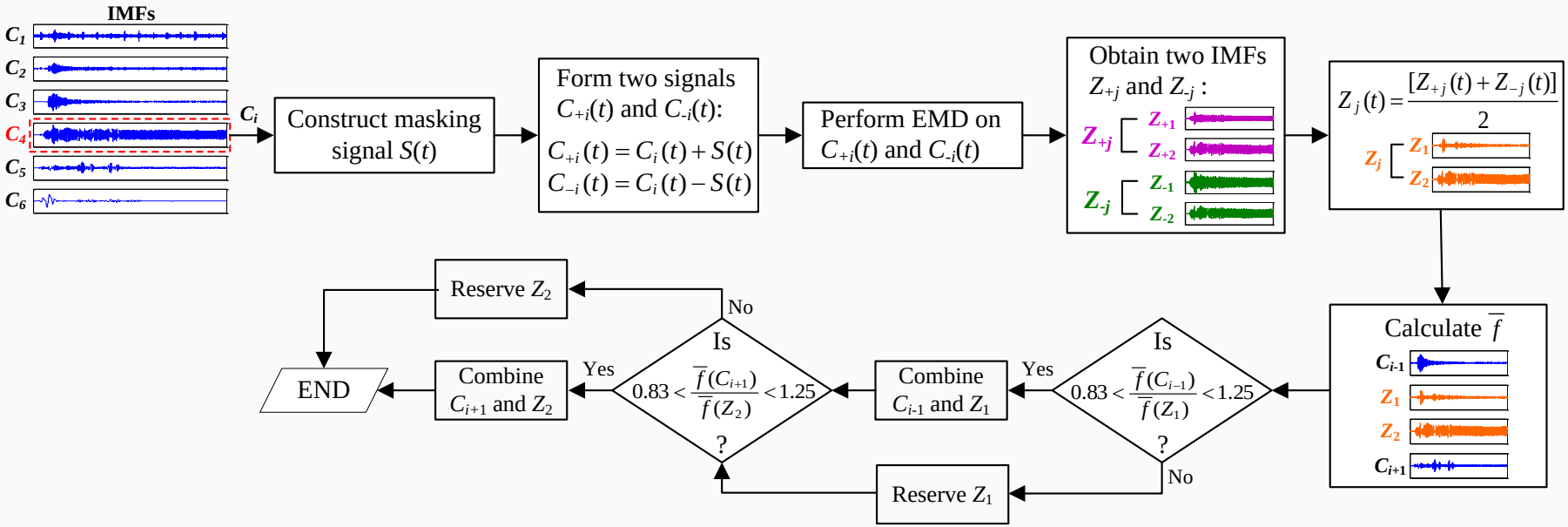
(2) 合成



IMF 準則:

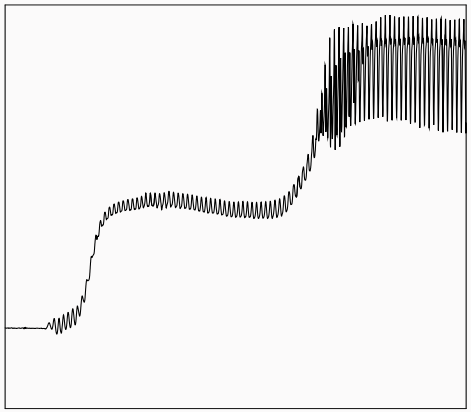
1. 極大和極小值的個數必須要與零上切的數目一樣。
2. 任何一點中，由波動極大值和極小值所得的平均值要為零。

分析方法: 利用MSEMD之後處理

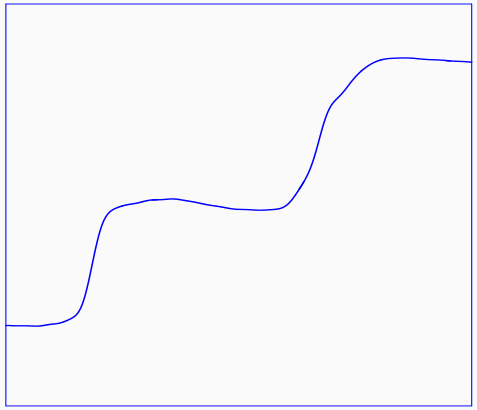


應用分析: 規則波

典型液化孔隙水壓



超額孔隙水壓



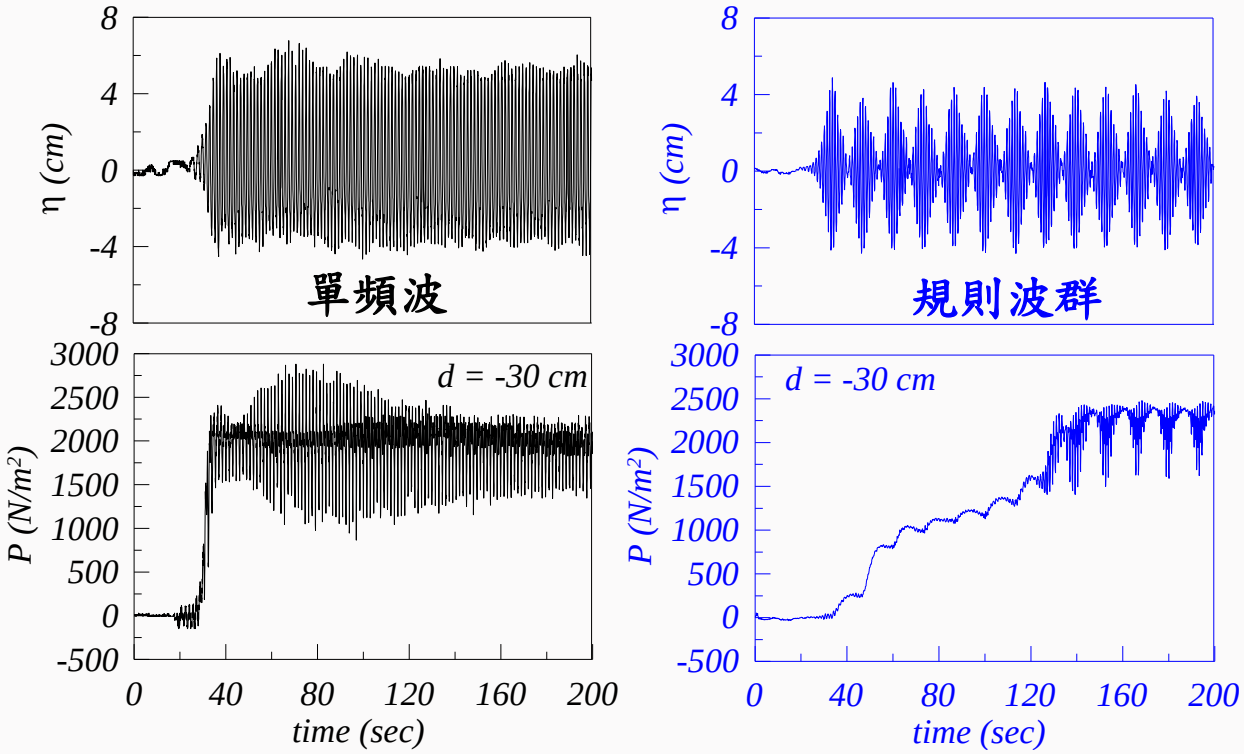
振盪孔隙水壓

應用分析: 規則波

試驗量測資料:

波浪

孔隙水壓



應用分析: 規則波

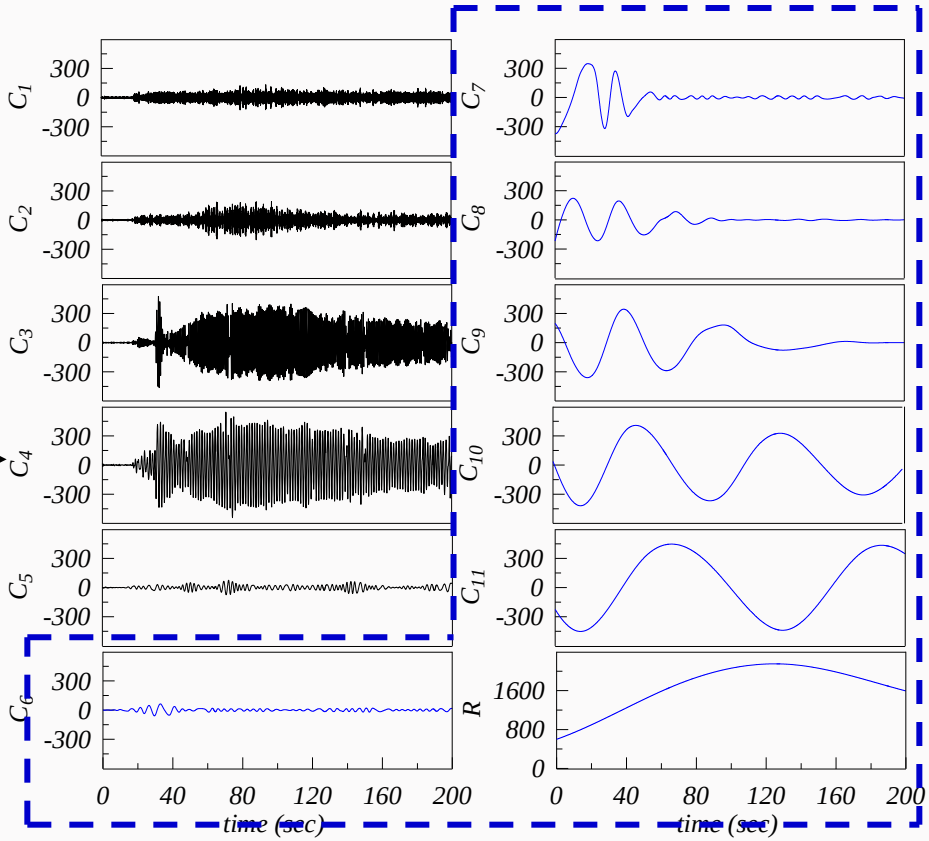
IMFs:

單頻波

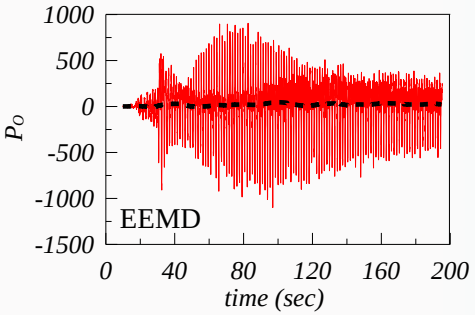
superharmonic

fundamental (f_f)

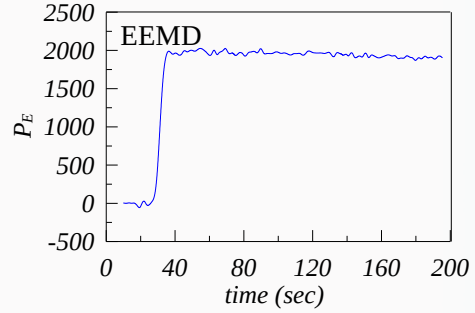
$f<1/4f_f$



振盪孔隙水壓



超額孔隙水壓

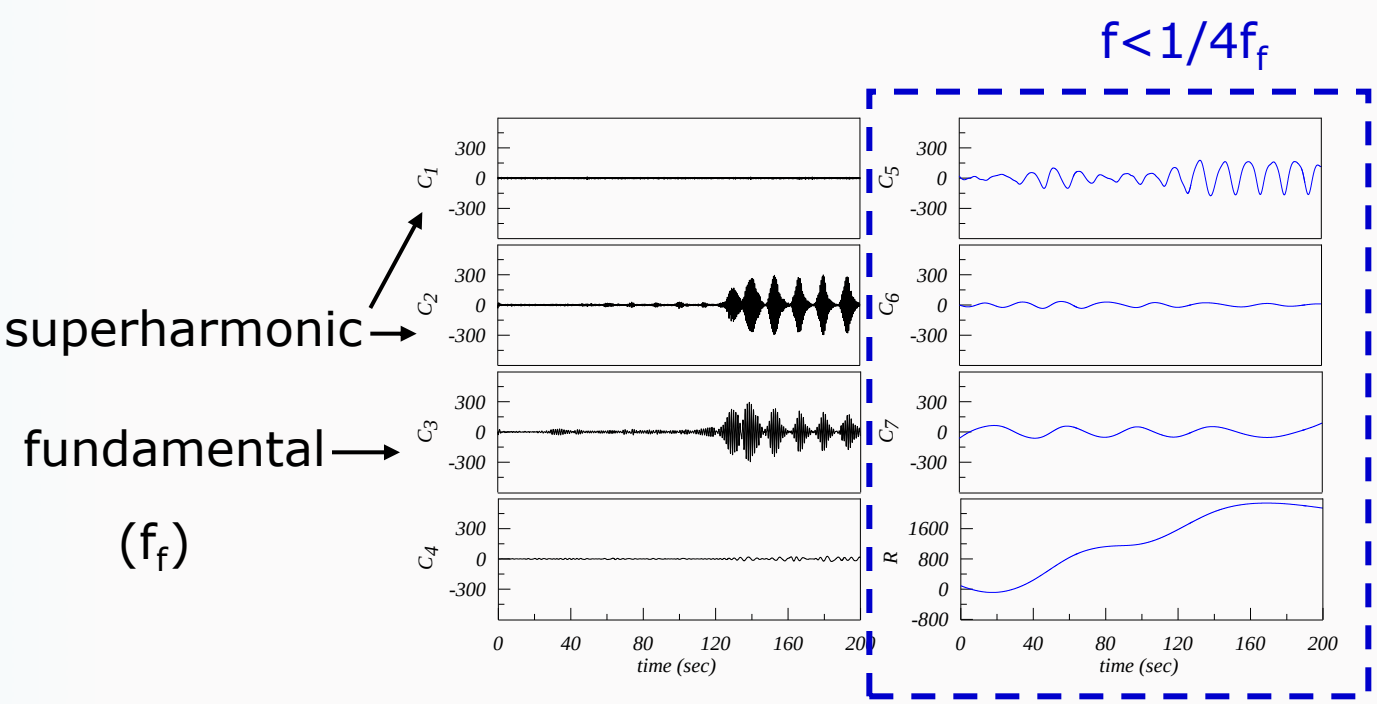


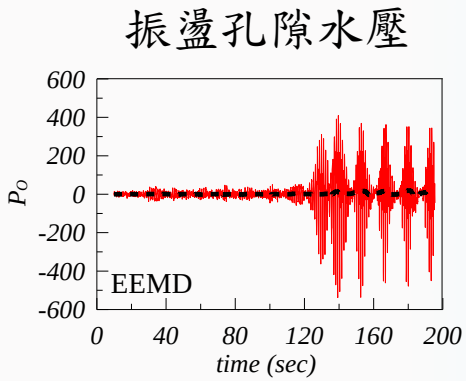
Excess pore pressure: sum of IMF C_6 ~ R

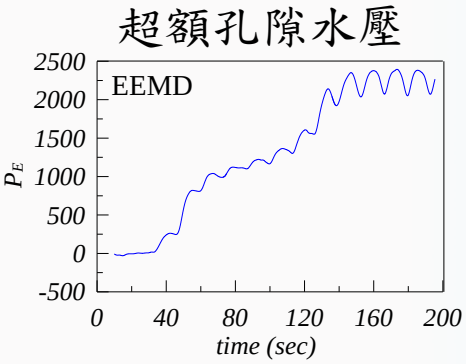
應用分析: 規則波

IMFs:

規則波群





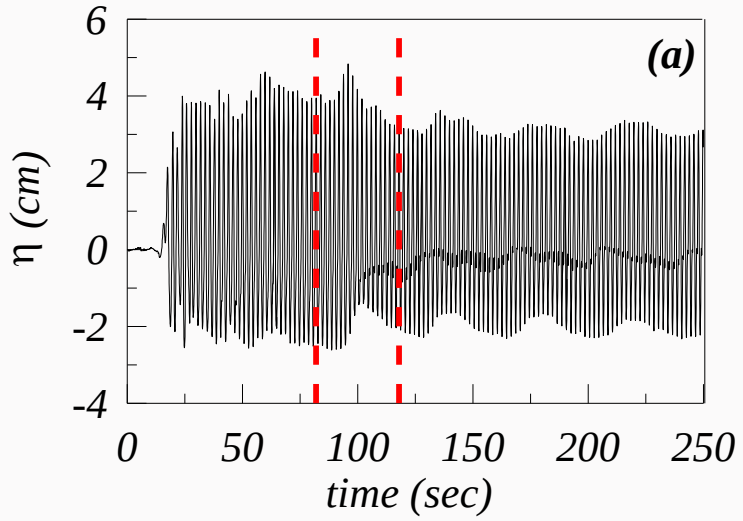


Excess pore pressure: sum of IMF C_5 ~ R

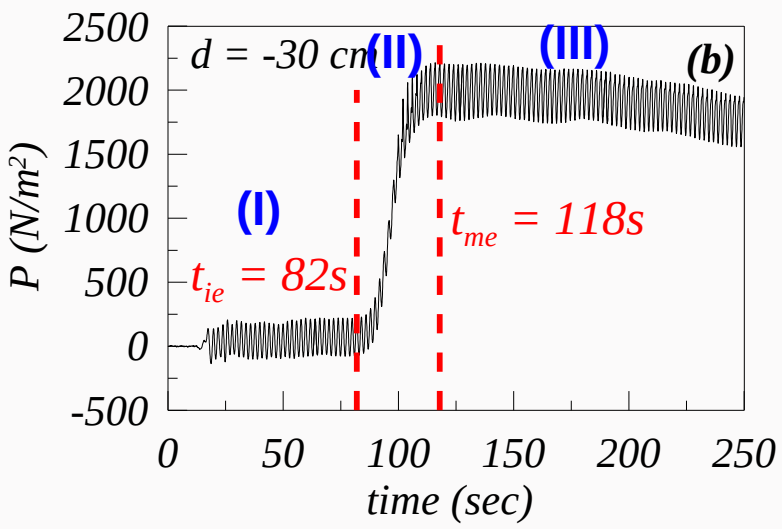
應用分析: 非線性波

試驗量測資料:

非線性波



孔隙水壓



(I): Pre-fluidized
(II): Transient
(III): Post-fluidized

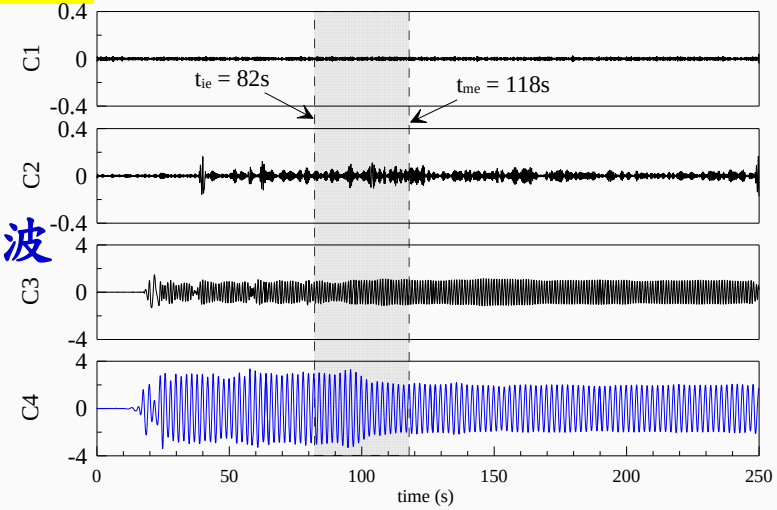
應用分析: 非線性波

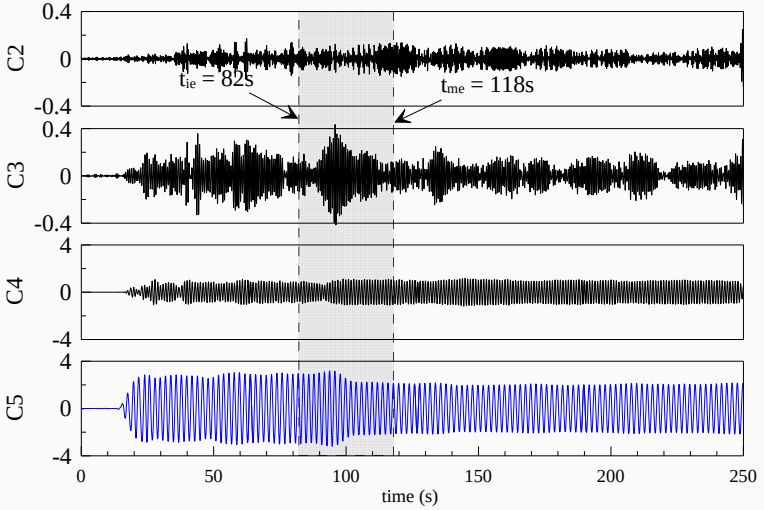
IMFs:

IMF (EEMD)

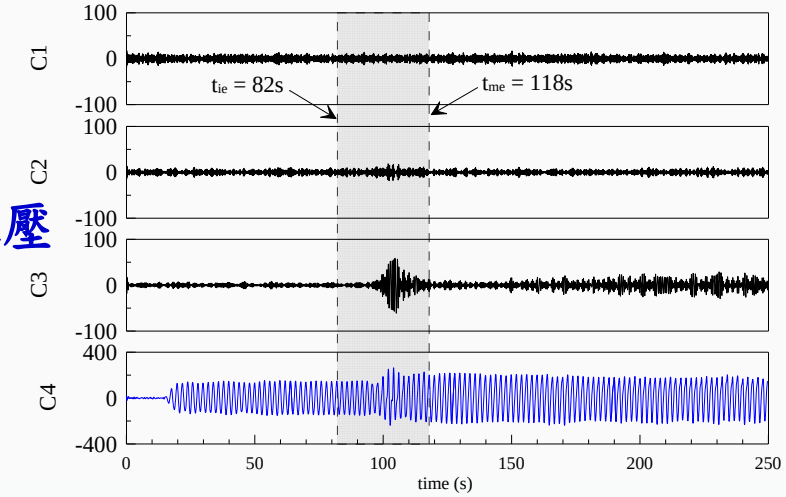
IMF (EEMD+MSEMD)

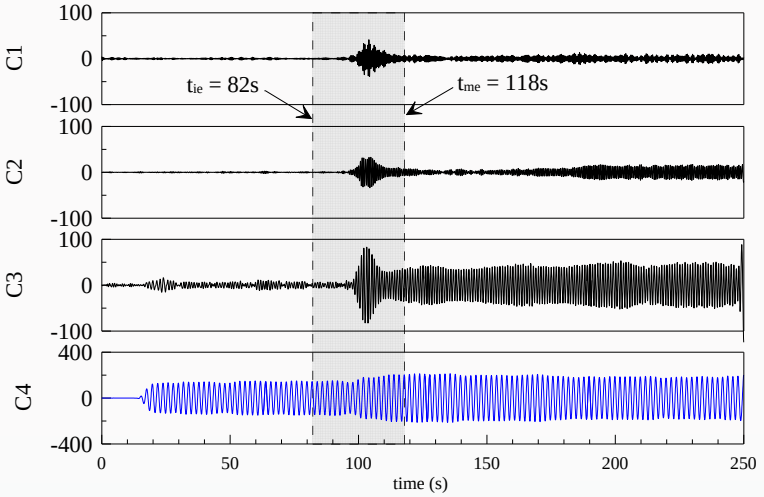
非線性波





孔隙水壓



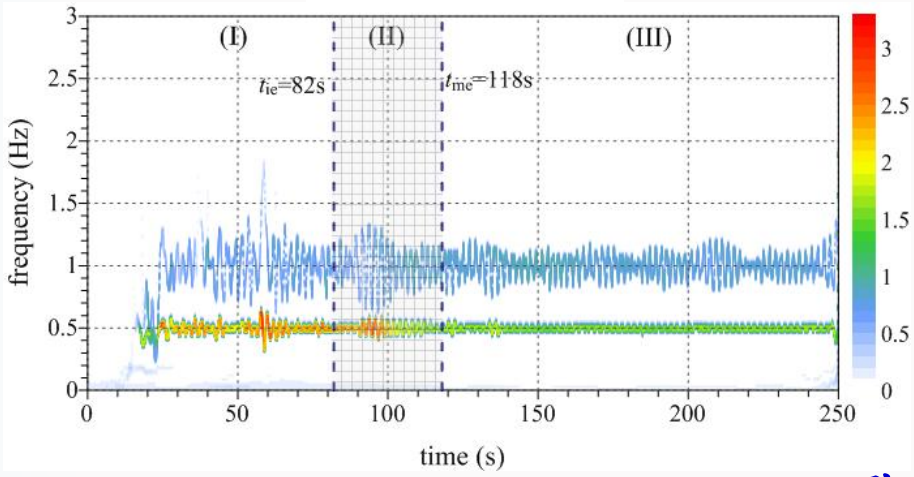


應用分析: 非線性波

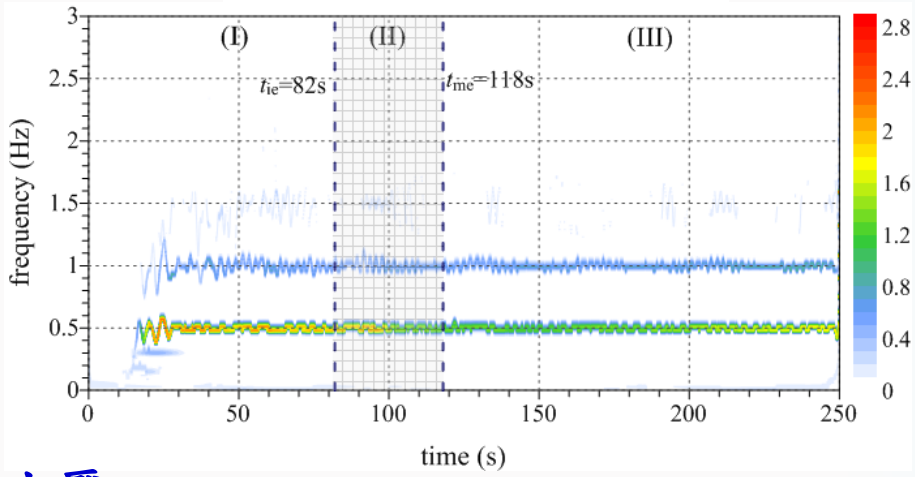
Hilbert 振幅譜:

非線性波

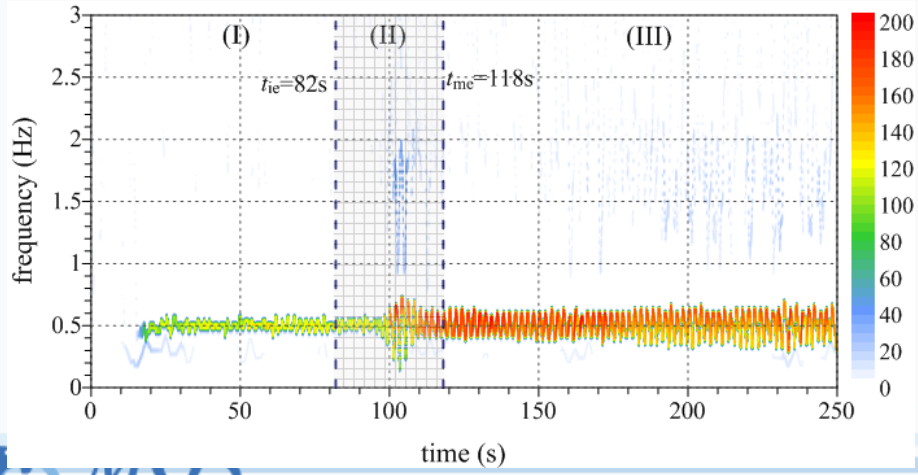
IMF (EEMD)

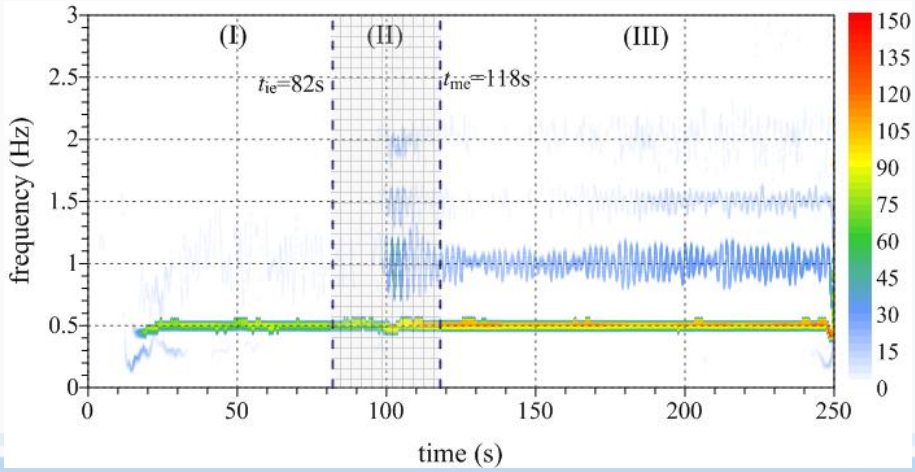


IMF (EEMD+MSEMD)



孔隙水壓





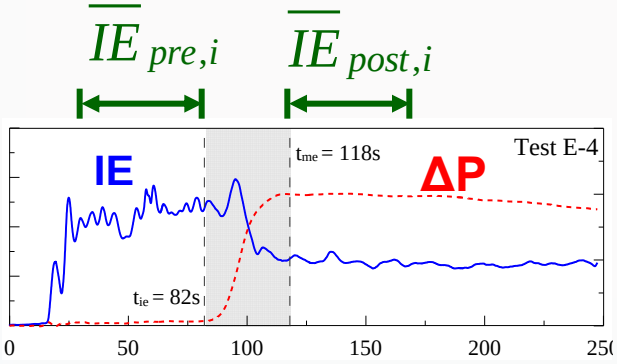
應用分析: 非線性波

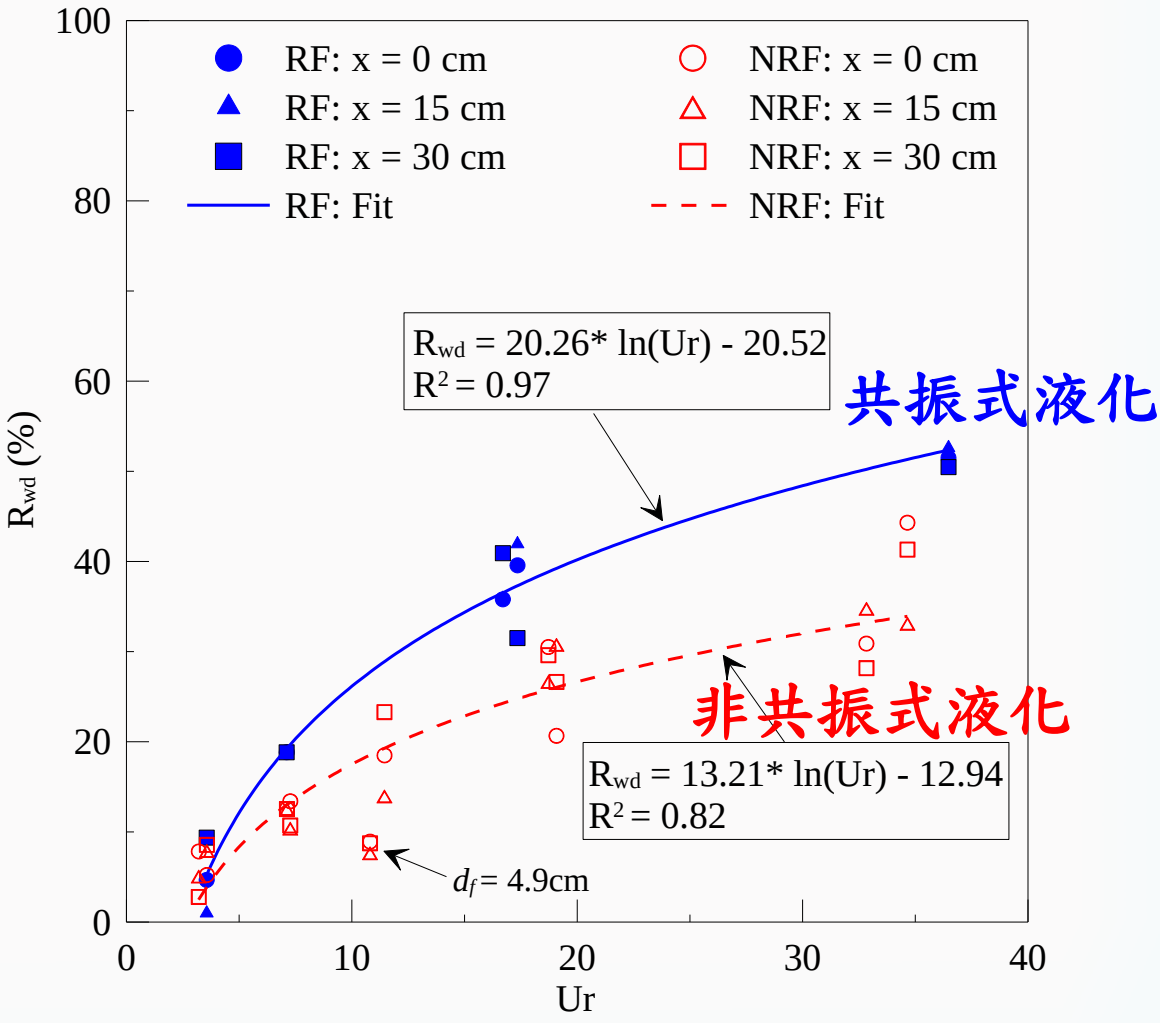
波浪衰減率:

$$R_{wd,i} = 1 - \frac{\overline{IE}_{post,i}}{\overline{IE}_{pre,i}} \Big/ \frac{\overline{IE}_{post,0}}{\overline{IE}_{pre,0}}$$

sandbed　　rigid bed

i: wave gauge no



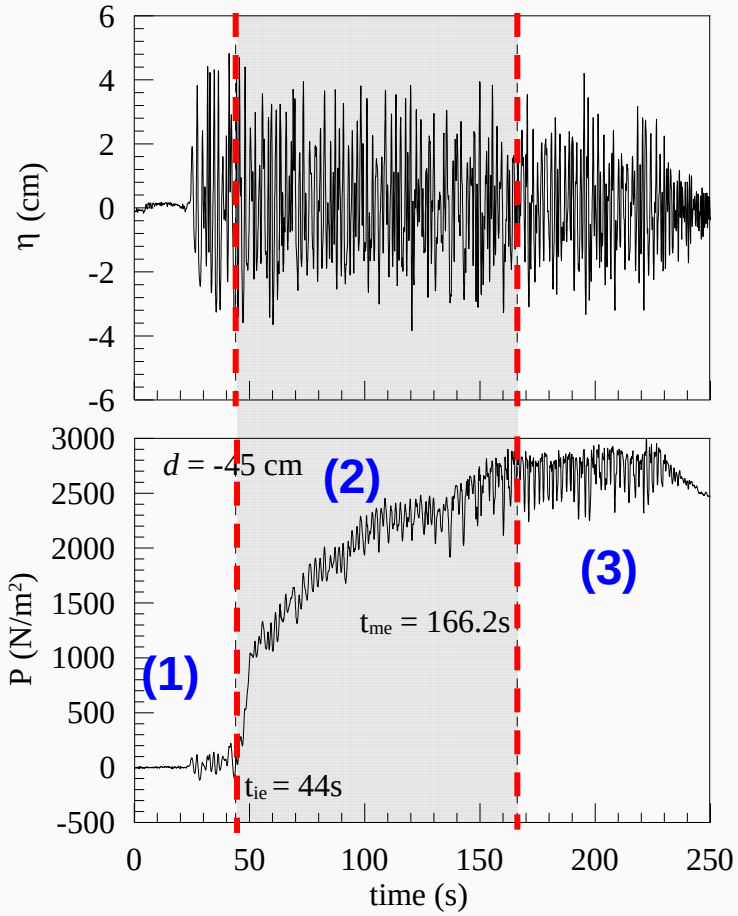


應用分析: 不規則波

試驗量測資料:

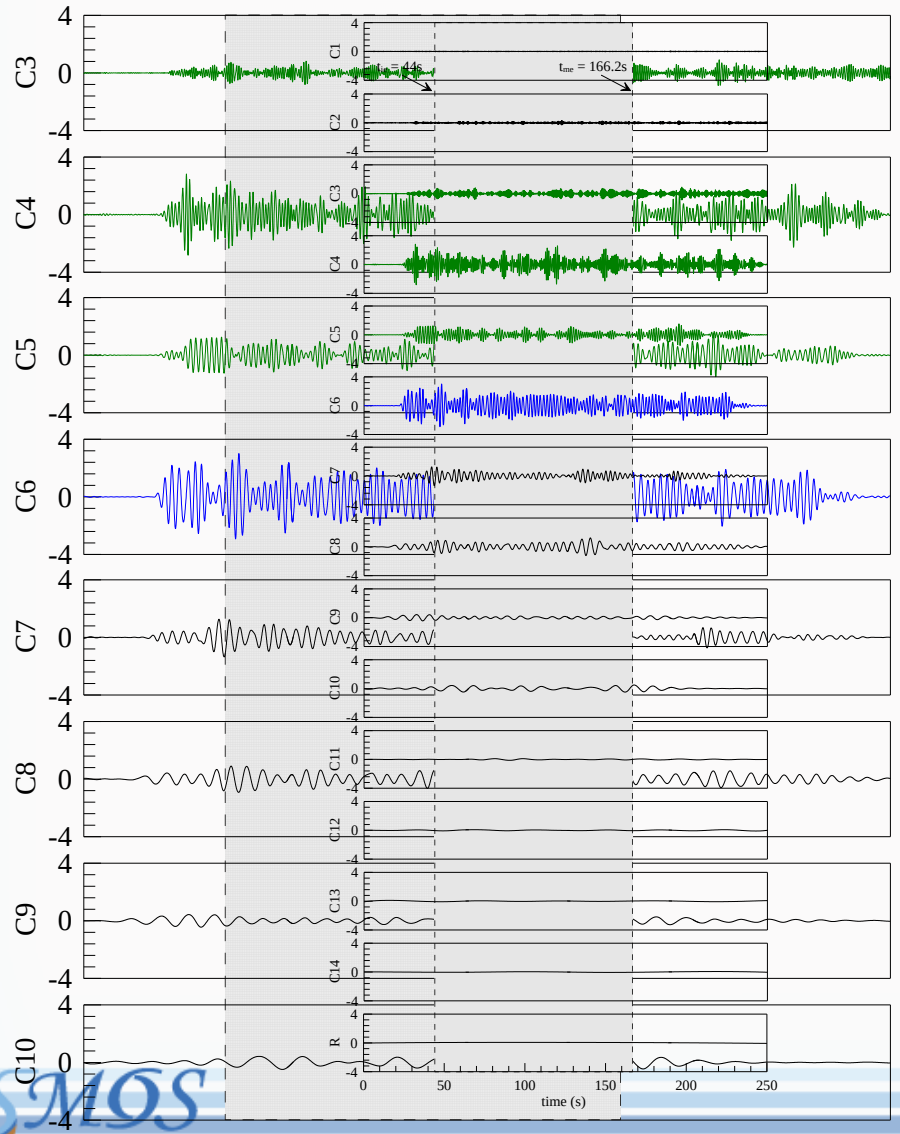
不規則波浪

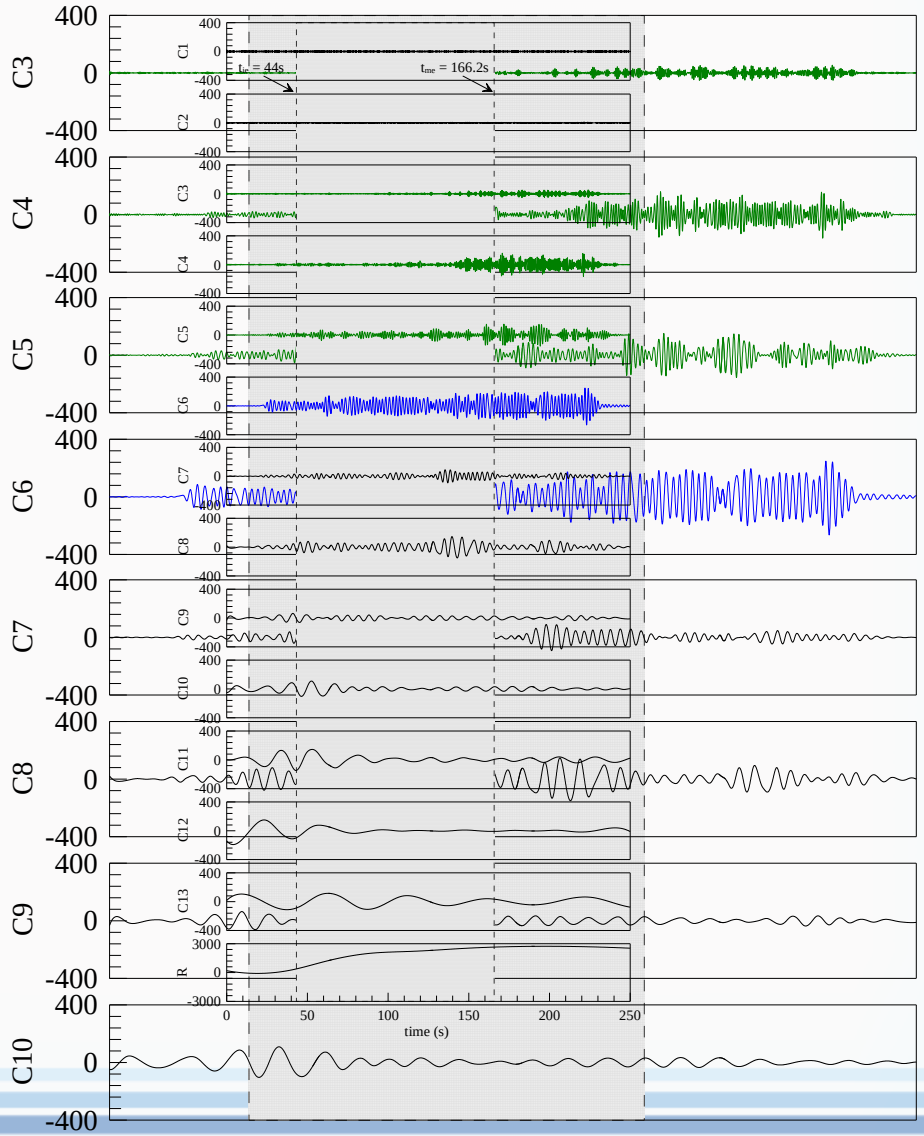
孔隙水壓



應用分析: 不規則波

IMFs:



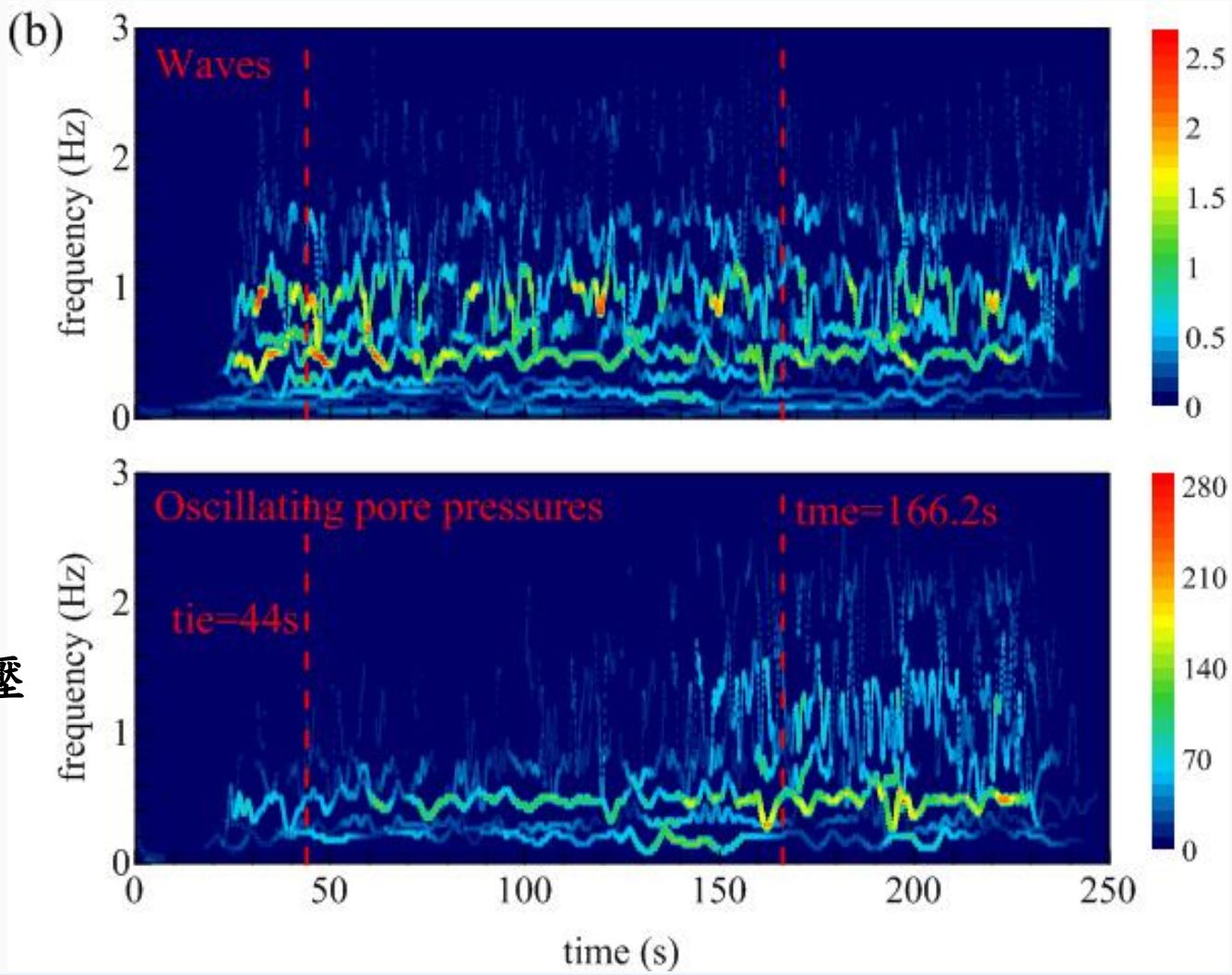


應用分析: 不規則波

Hilbert 振幅譜:

不規則波

振盪孔隙水壓



報 告 完 畢

請 多 指 教

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