隔減震應用之介紹

黃　震　興

國立台灣科技大學營建系

$\frac{1}{2}M(\dot{X}_t)^2 + \int C\dot{X}\ dX + \int KX\ dX = \int M\ddot{X}_g\ dX_g$

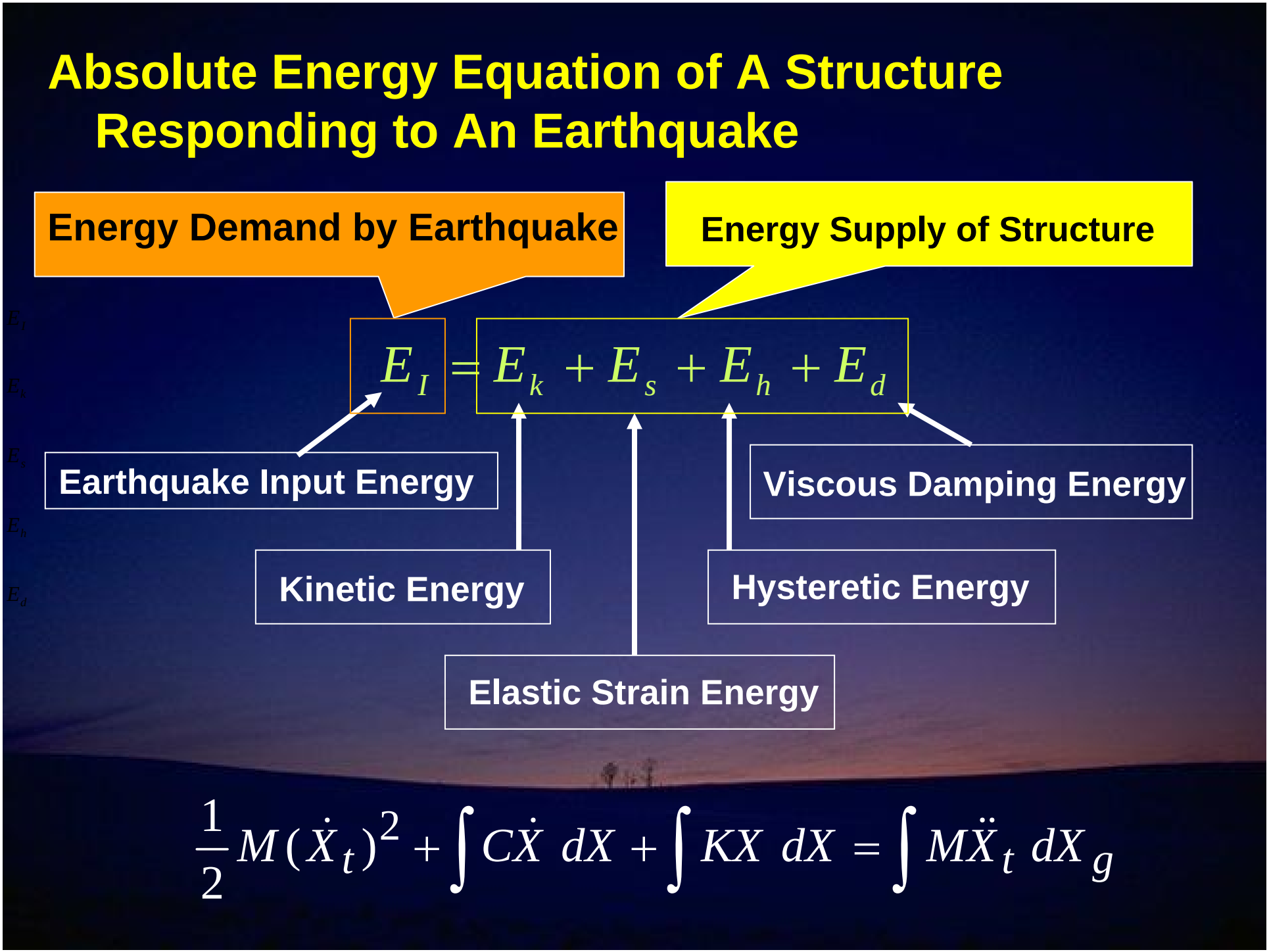
Equation of Motion

$$M\ddot{X} + C\dot{X} + KX = -M\ddot{X}_g$$

Absolute Energy Equation

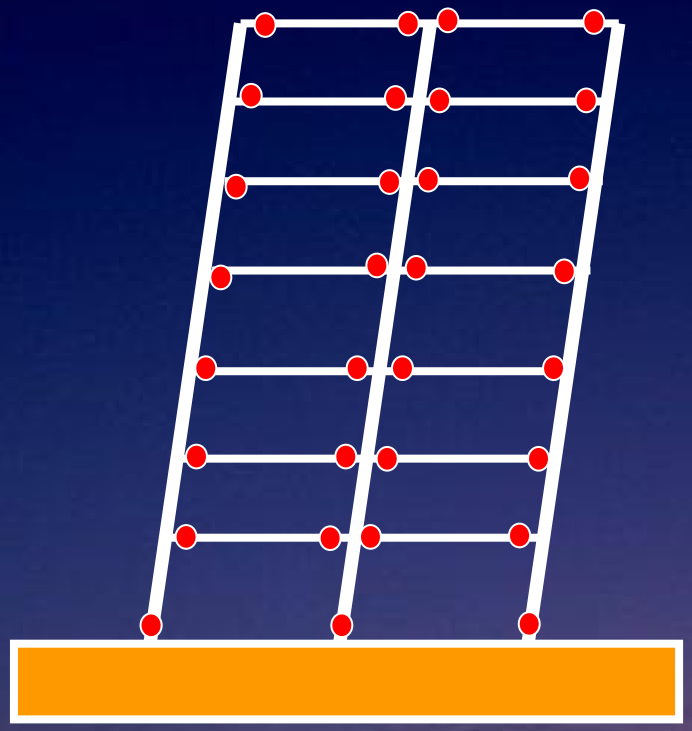
$$\frac{1}{2}M(\dot{X}_t)^2 + \int C\dot{X}\ dX + \int KX\ dX = \int M\ddot{X}_t\ dX_g$$

Absolute Energy Equation of A Structure Responding to An Earthquake



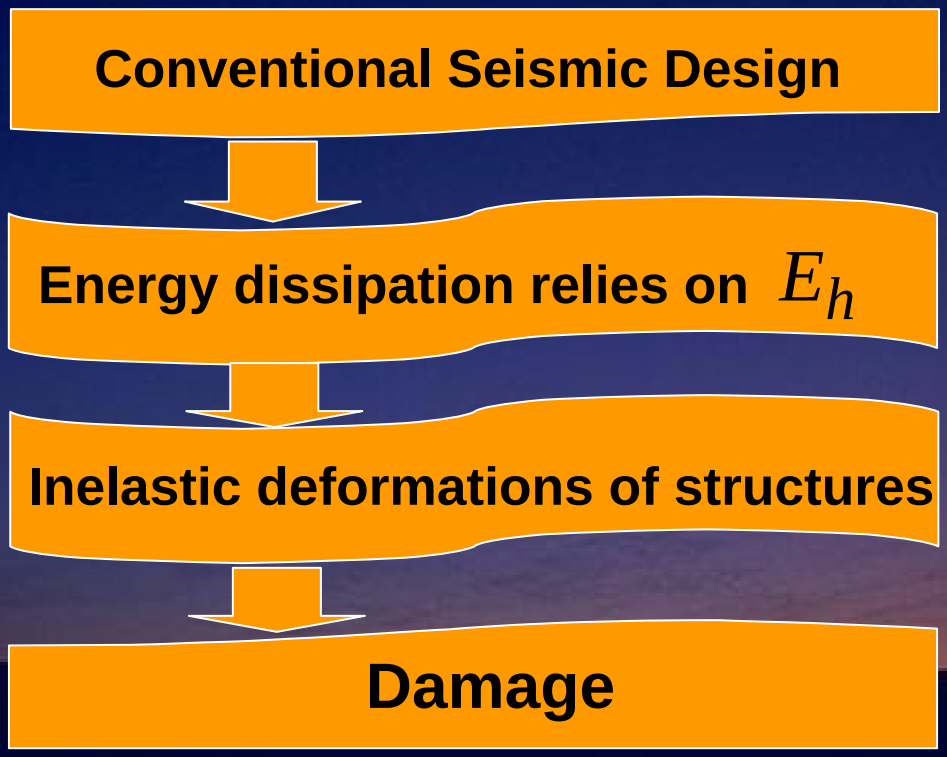
$$\frac{1}{2}M(\dot{X}_t)^2 + \int C\dot{X}\,dX + \int KX\,dX = \int M\ddot{X}_t\,dX_g$$

Ideal Mechanism for Conventional Structures

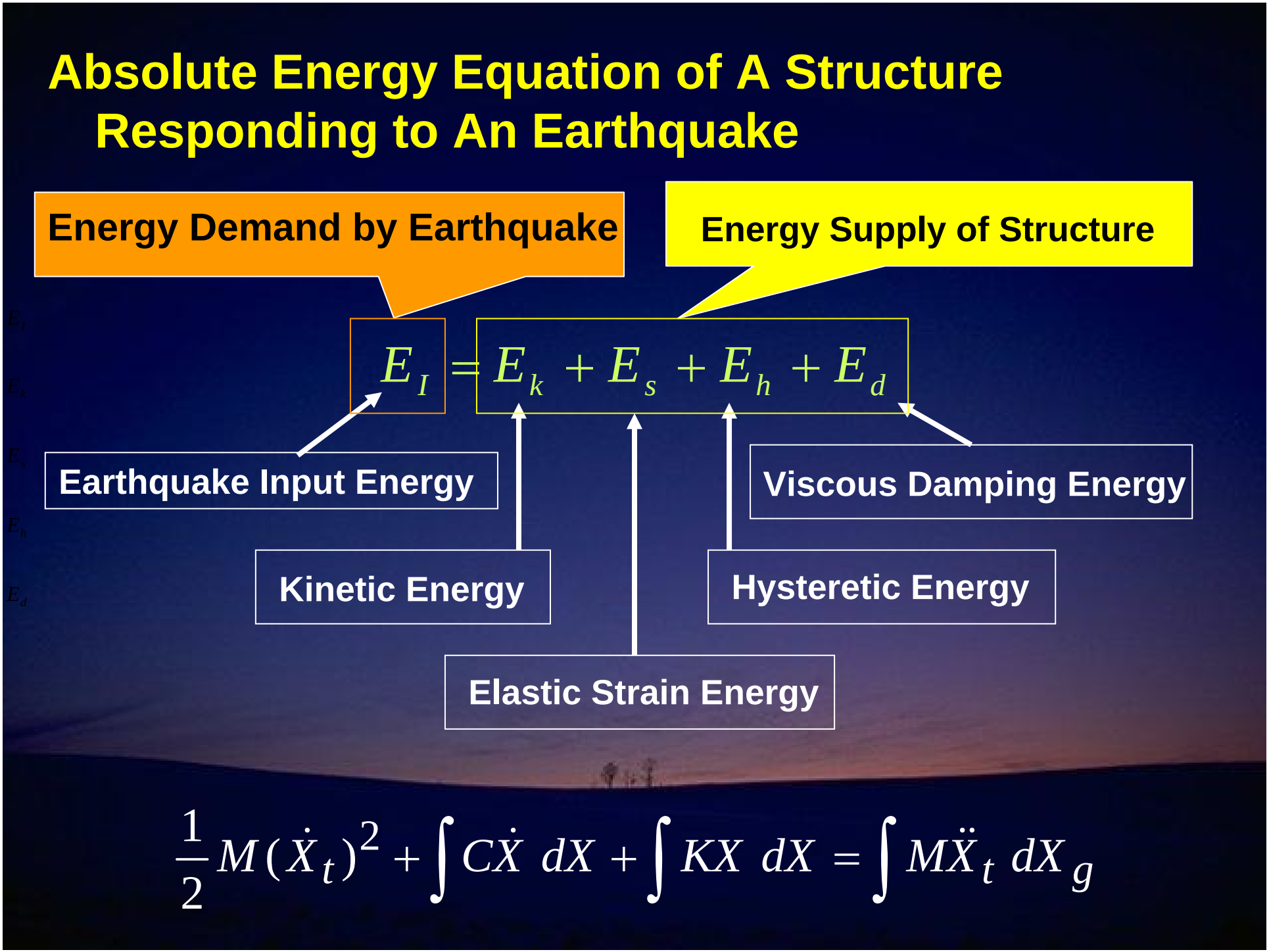


Energy Consideration

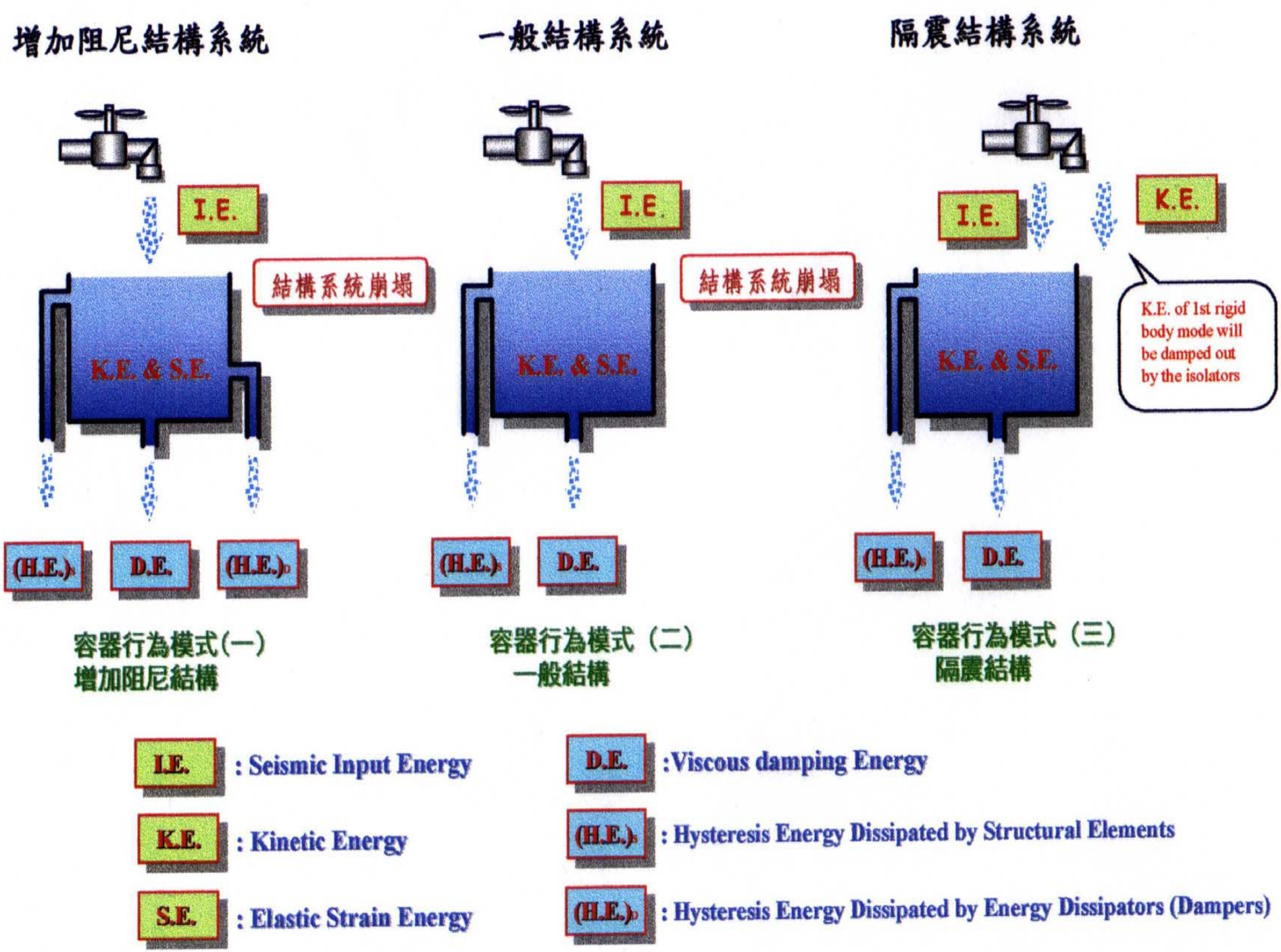
$$E_I = E_k + E_s + E_h + E_d$$



Absolute Energy Equation of A Structure Responding to An Earthquake



$$\frac{1}{2}M(\dot{X}_t)^2 + \int C\dot{X}\,dX + \int KX\,dX = \int M\ddot{X}_t\,dX_g$$


增加阻尼結構系統
一般結構系統
隔震結構系統
I.E.
結構系統崩塌
K.E. & S.E.
(H.E.)s
D.E.
(H.E.)D
K.E.
K.E. of 1st rigid body mode will be damped out by the isolators
容器行為模式(一)
增加阻尼結構
容器行為模式（二）
一般結構
容器行為模式（三）
隔震結構
I.E. : Seismic Input Energy
K.E. : Kinetic Energy
S.E. : Elastic Strain Energy
D.E. :Viscous damping Energy
(H.E.)s : Hysteresis Energy Dissipated by Structural Elements
(H.E.)D : Hysteresis Energy Dissipated by Energy Dissipators (Dampers)

Strategies for Seismic Protection of Structures

(1) Increase Energy Dissipation Capacity of Structures
---- Implementation of Energy Dissipation Devices

(2) Reduce Energy Demand by Earthquake
---- Adoption of Seismic Isolation Design

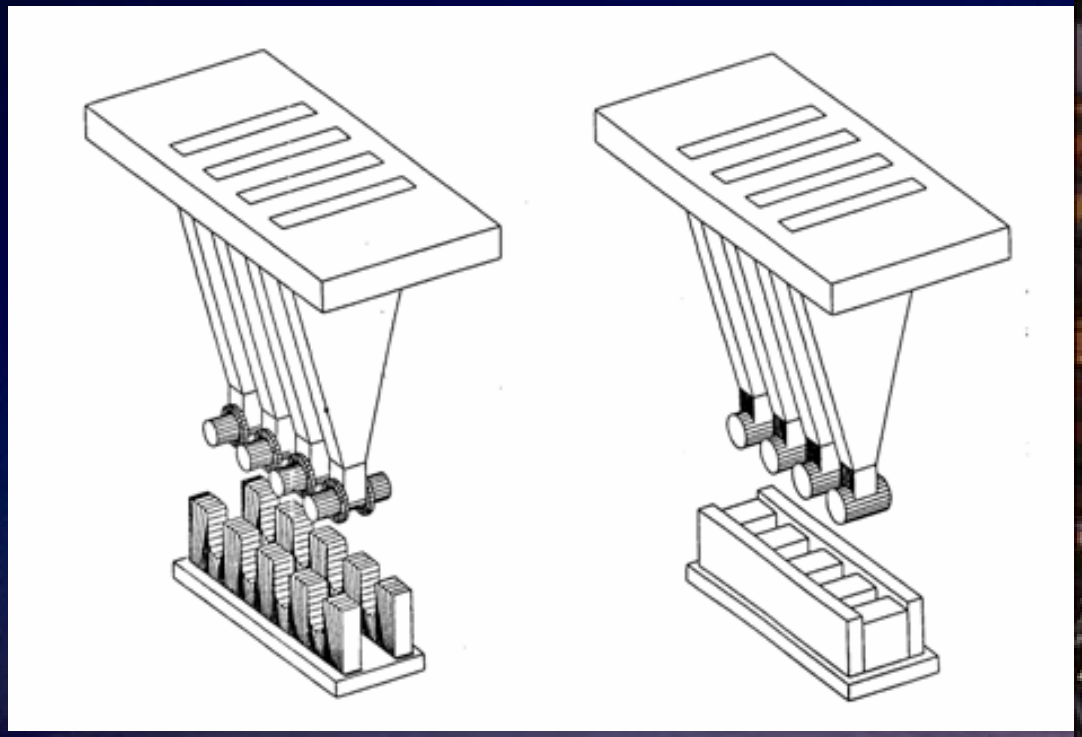
Energy Dissipation Devices Applied In Taiwan

(1) Hysteresis Type Dampers: (Hysteretic Energy)
ADAS (Added Damping and Stiffness)
TADAS (Triangular ADAS)
LYSSP (Low Yield Steel Shear Panel)

(2) Velocity-Dependent Damper: (Viscous Damping Energy)
Visco-Elastic Dampers, Viscous Dampers

(3) Improved Energy Dissipation Design: (Hysteretic Energy)
BRB (Buckling Restrained Braces or Unbonded Braces)

Hysteretic Type Dampers -- TADAS



Experimental Investigation

京華城
Taipei Living Mall

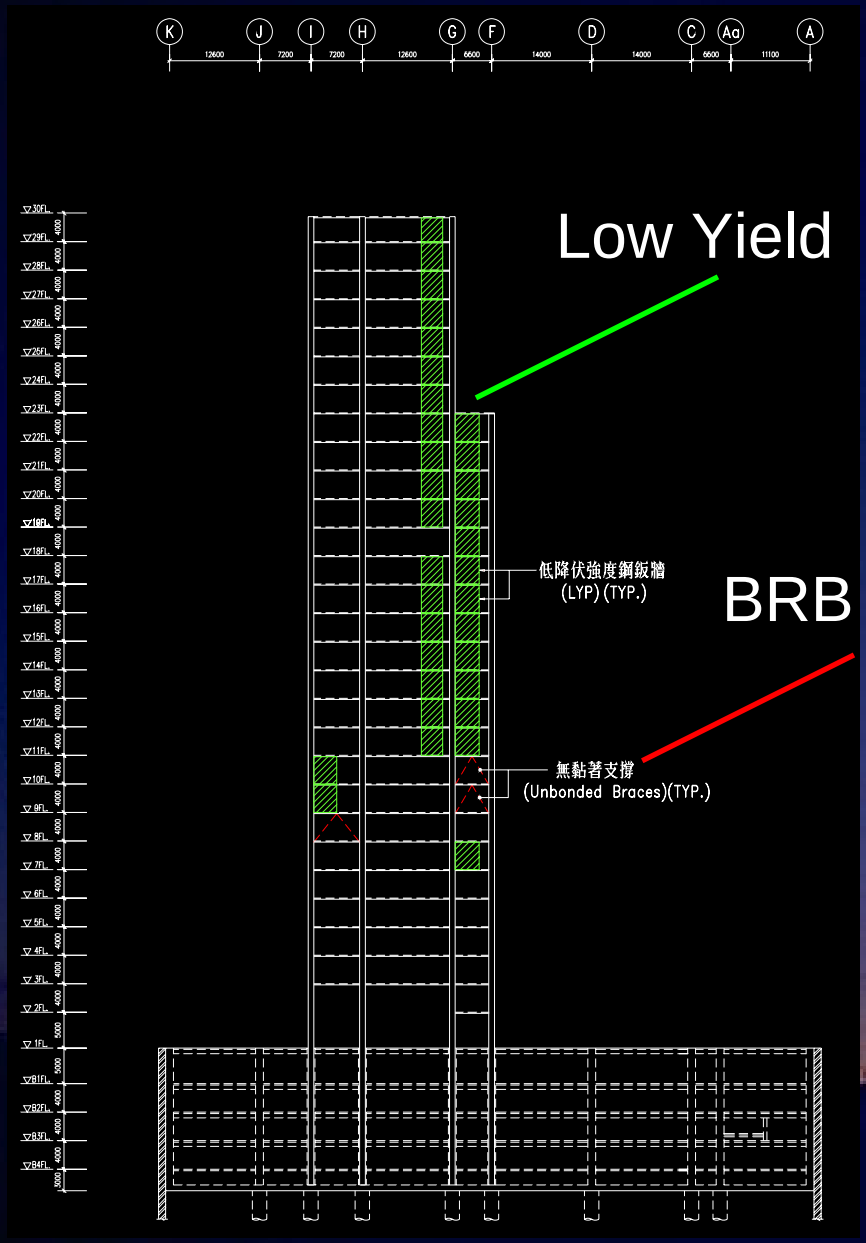
TADAS Installation

Taipei County Hall

33 story steel structure

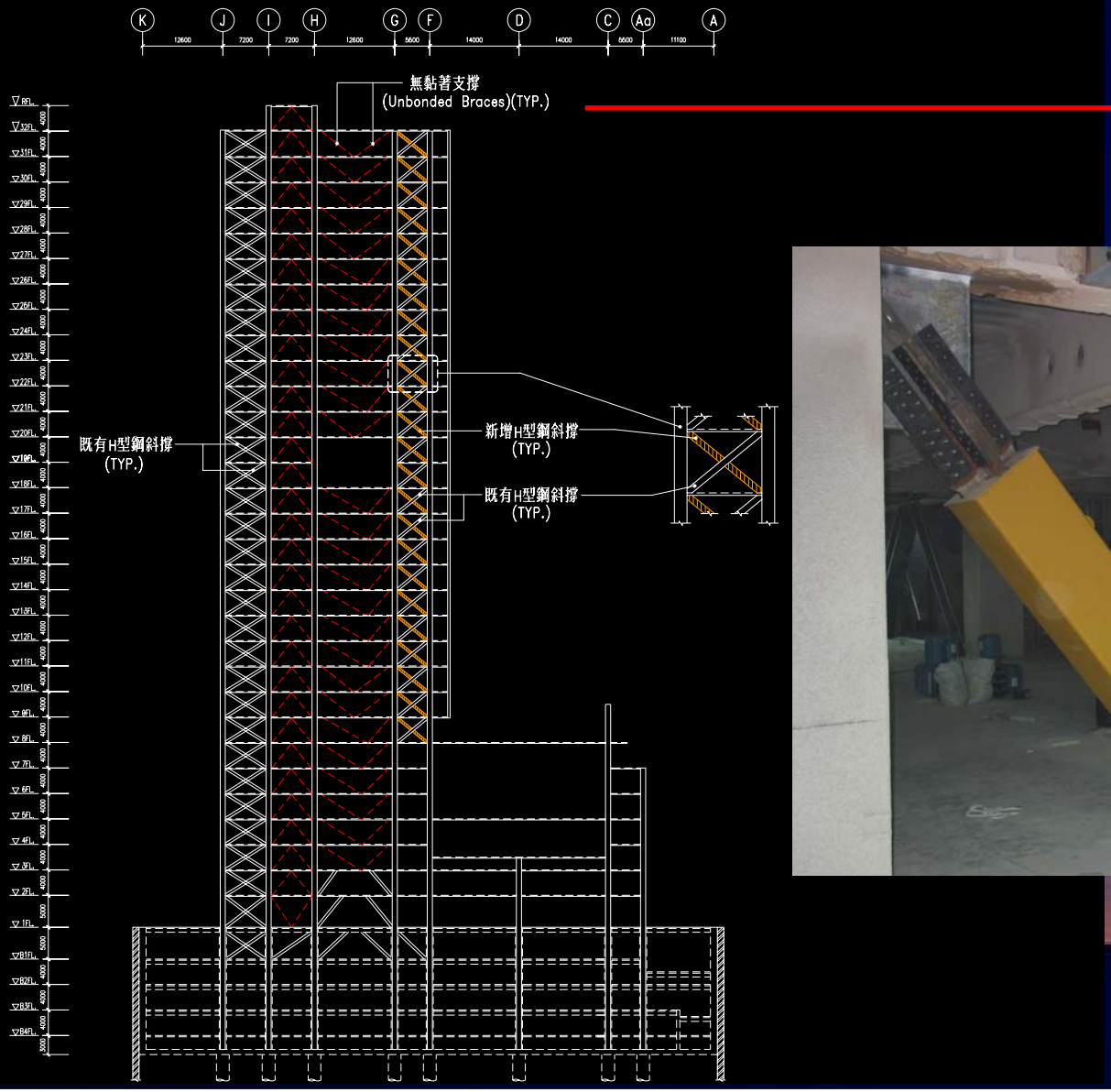
Designed before Chi-Chi

Upgraded after Chi-Chi

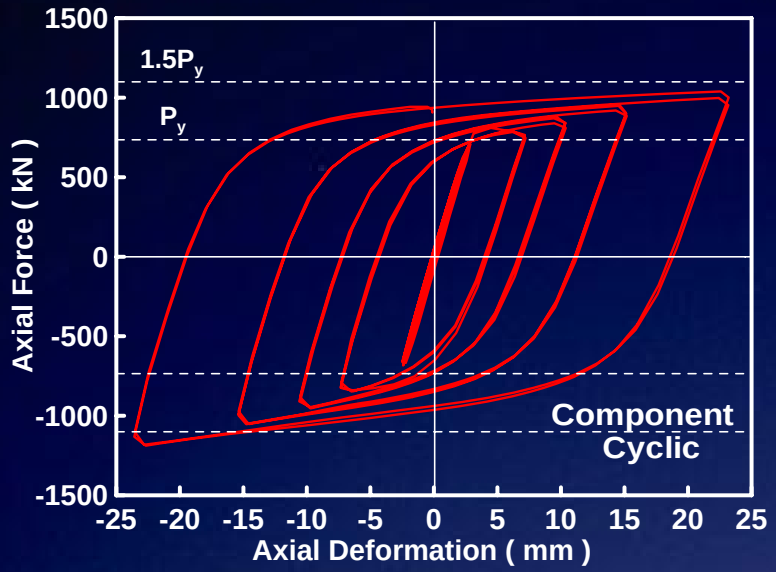


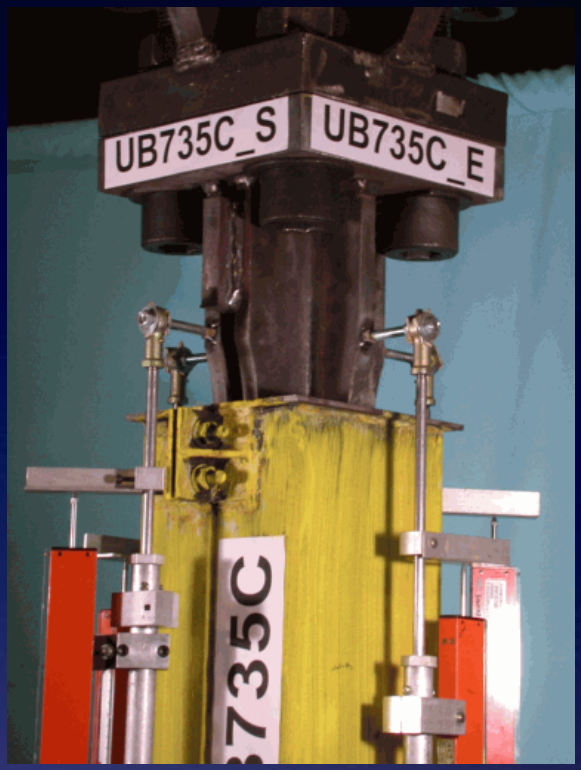
Low Yield Steel Panel

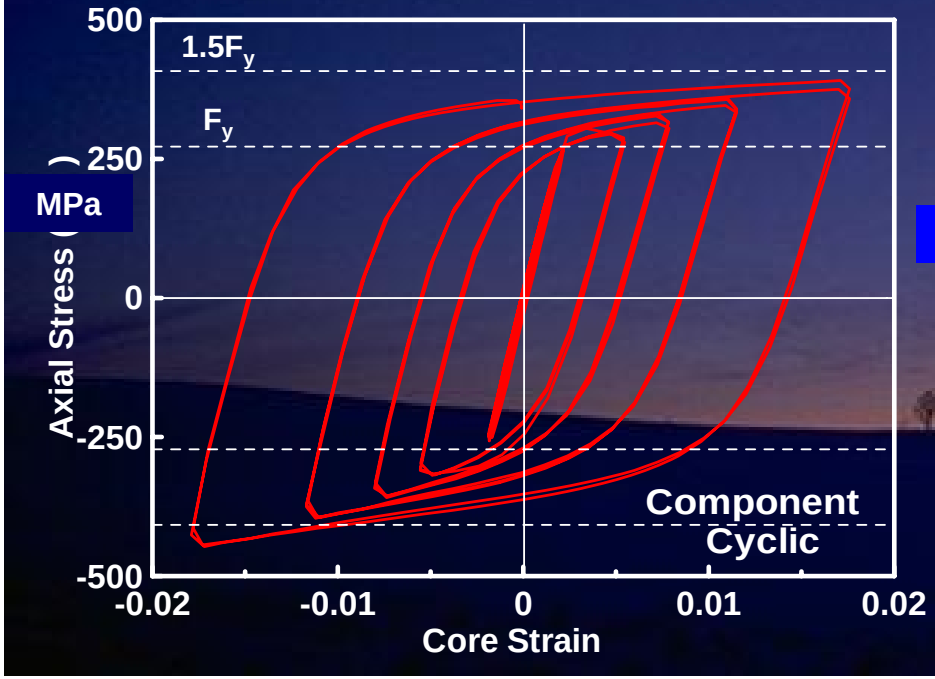
BRB (Buckling Restrained Braces)

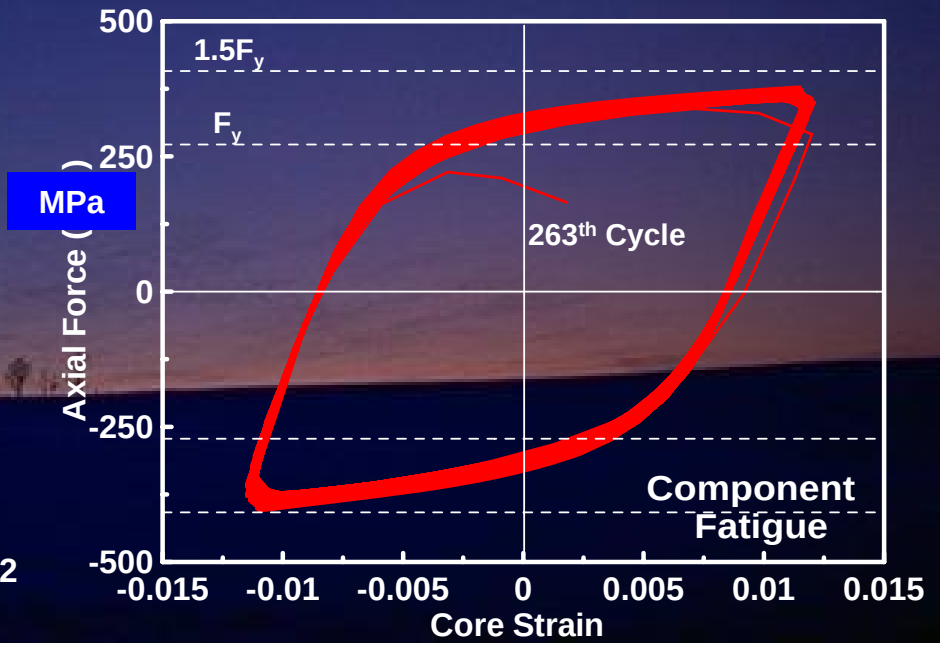

K
J
I
H
G
F
D
C
Aa
A
12600
7200
7200
12600
5600
14000
14000
5600
11100
無黏著支撐
(Unbonded Braces)(TYP.)
既有H型鋼斜撐
(TYP.)
新增H型鋼斜撐
(TYP.)
既有H型鋼斜撐
(TYP.)

BRB Test Results

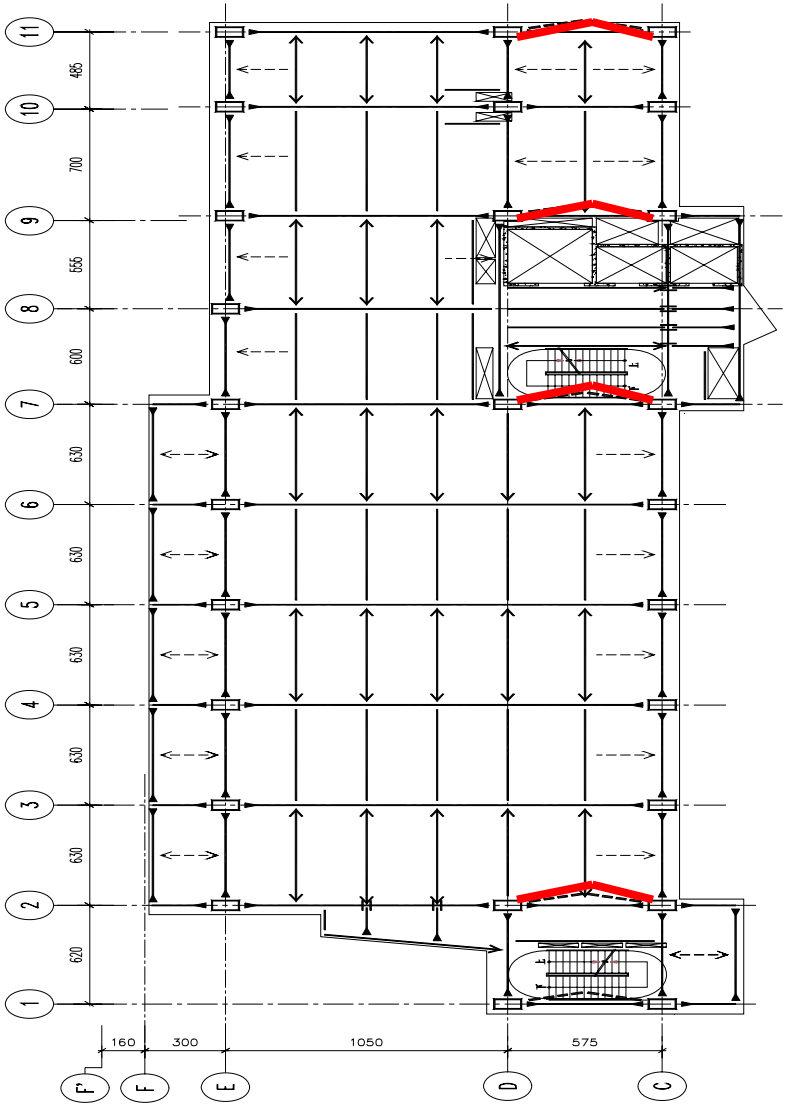




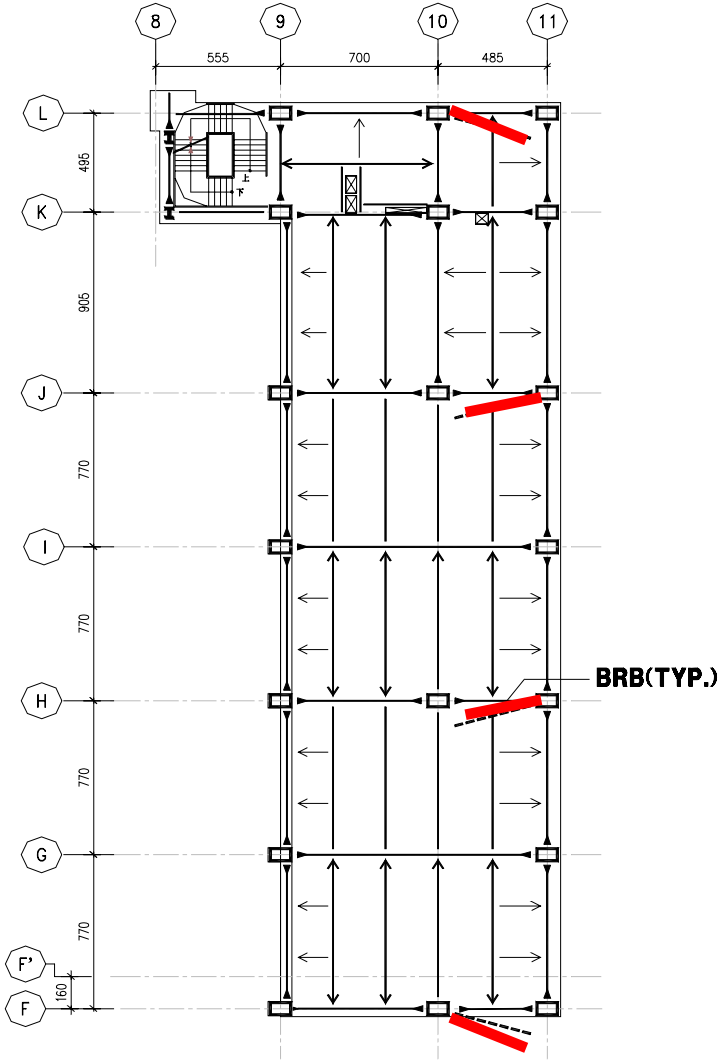


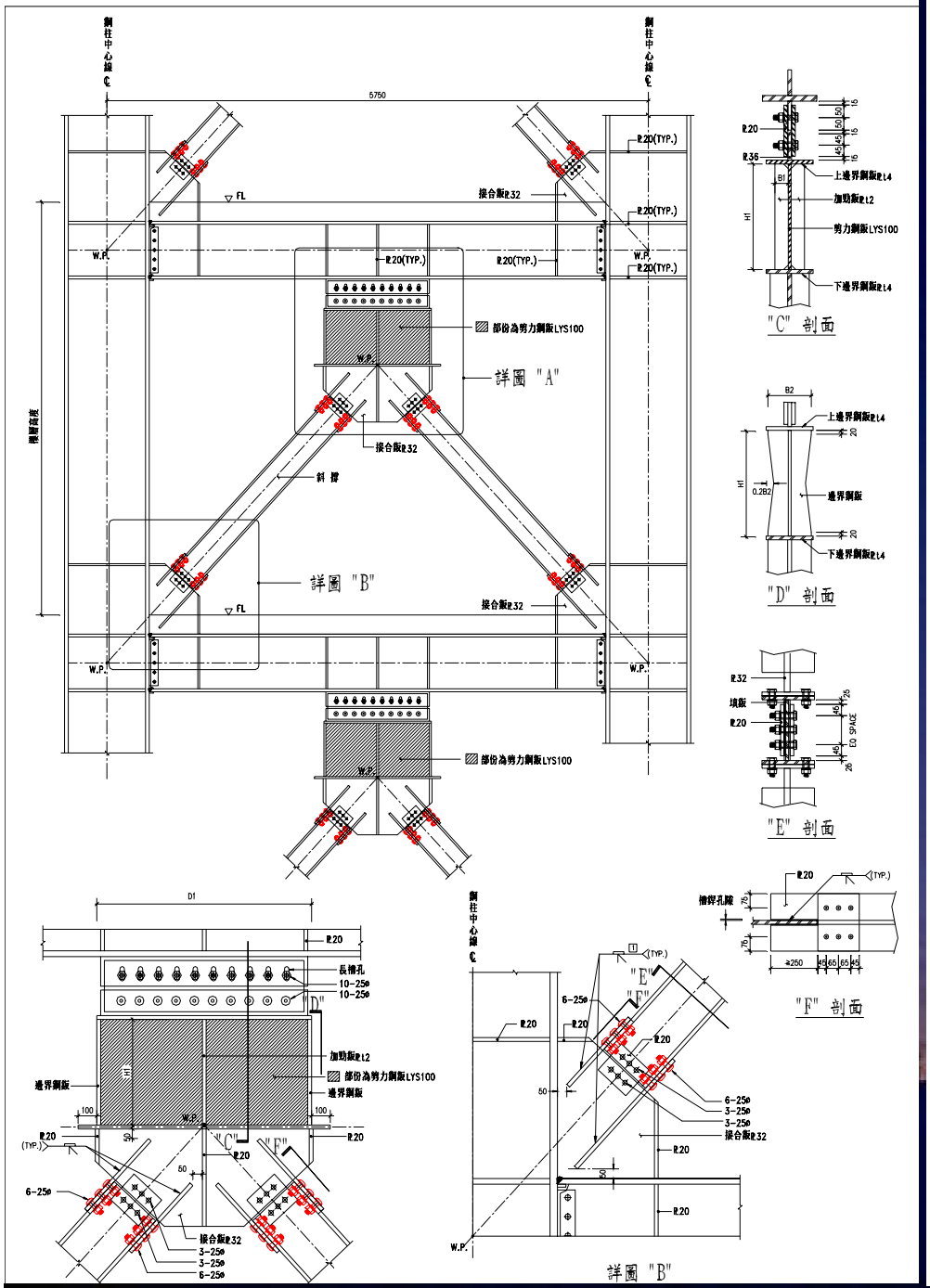


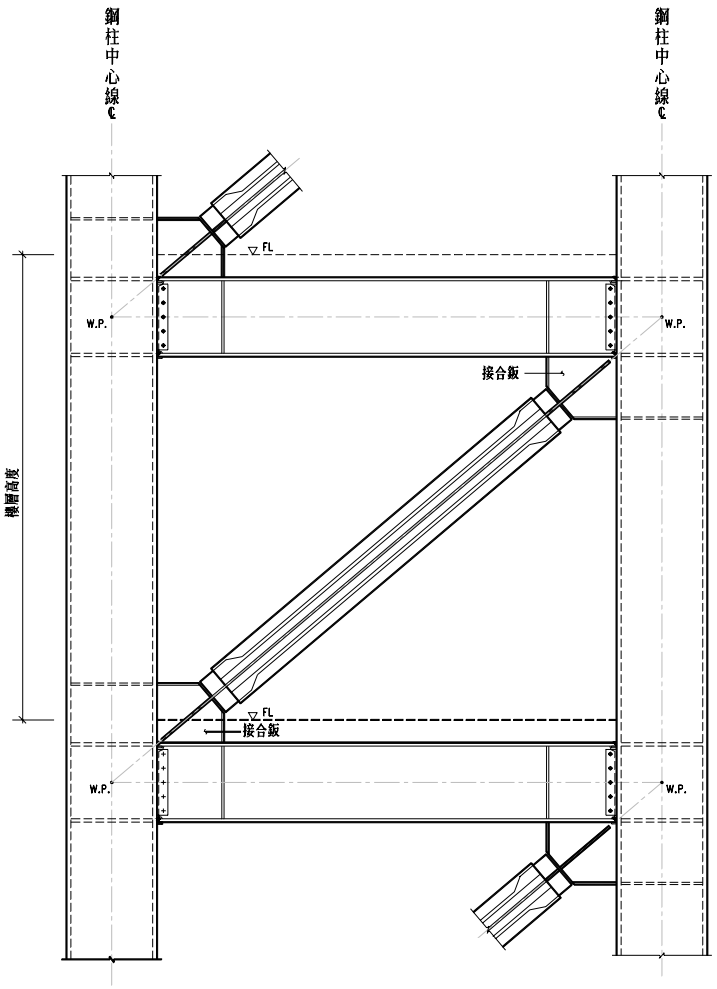
West Wing
LYSSP

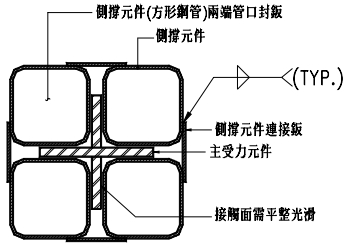


South Wing
BRB



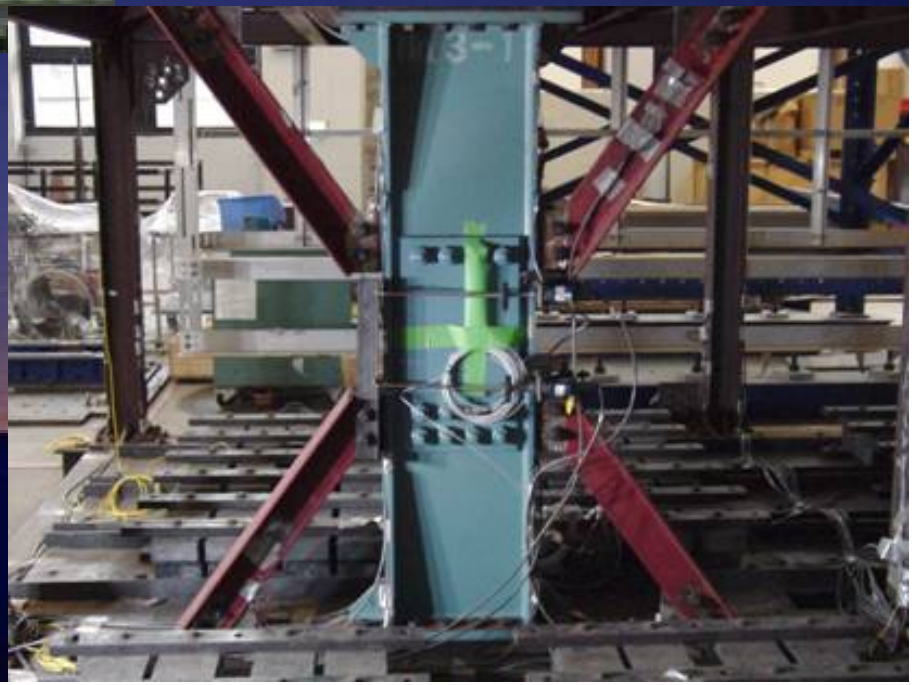

鋼柱中心線℄
鋼柱中心線℄
5750
樓層高度
FL
W.P.
接合鈑R32
R20(TYP.)
部份為劈力鋼版LYS100
詳圖 "A"
斜 撐
詳圖 "B"
"C" 剖面
上邊界鋼版R.L4
加勁鈑R.L2
劈力鋼版LYS100
下邊界鋼版R.L4
"D" 剖面
邊界鋼版
"E" 剖面
填鈑
槽焊孔隙
"F" 剖面
D1
長槽孔
10-25ø
加勁鈑R.L2
詳圖 "B"

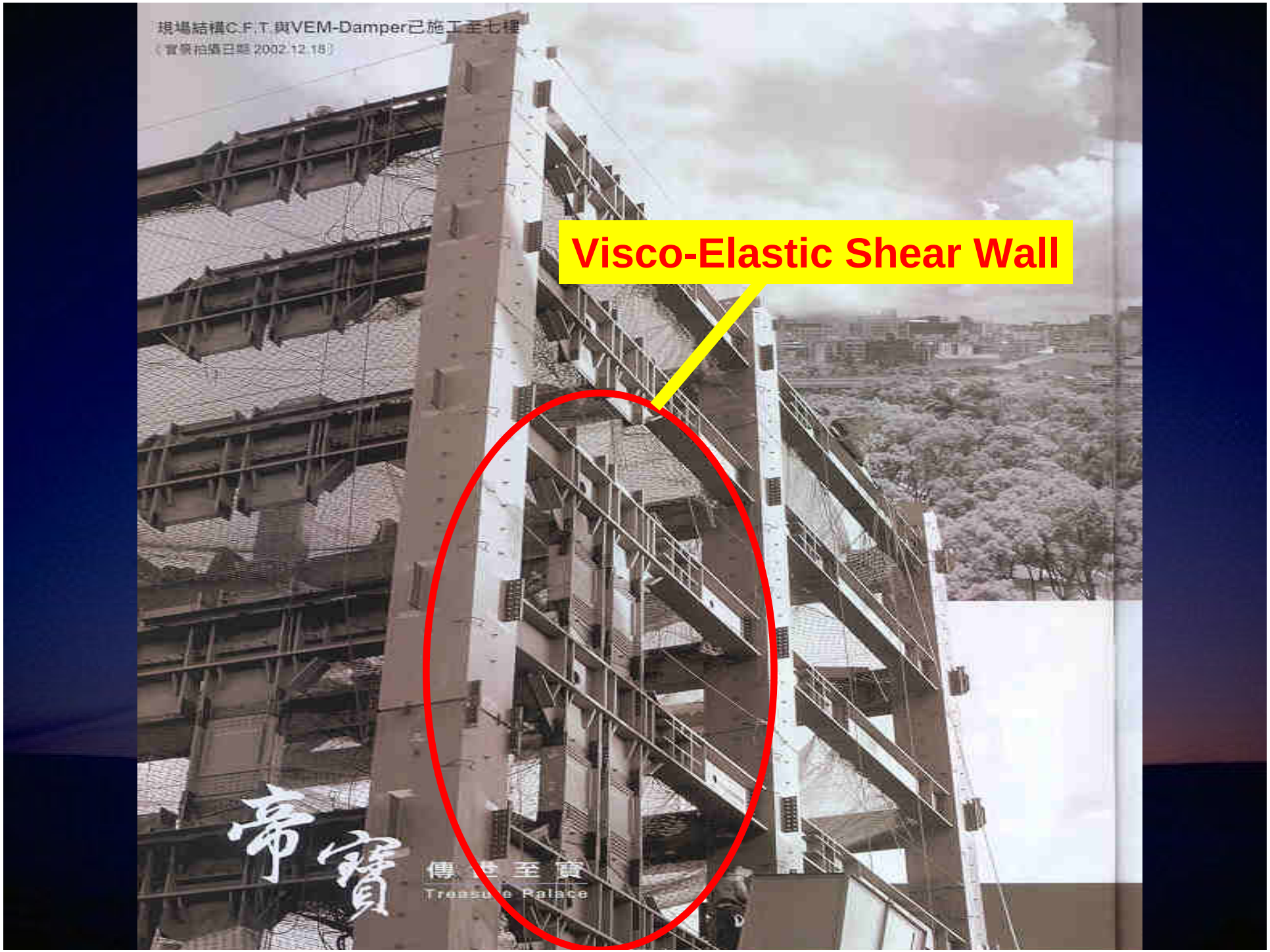

鋼柱中心線℄
鋼柱中心線℄
樓層高度
FL
W.P.
接合鈑


側撐元件(方形鋼管)兩端管口封鈑
側撐元件
(TYP.)
側撐元件連接鈑
主受力元件
接觸面需平整光滑

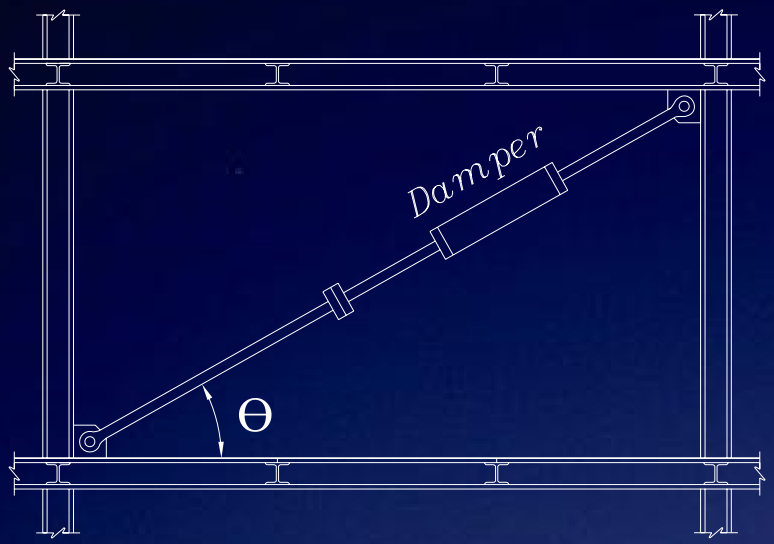
宏盛帝寶
Taipei Treasure Palace

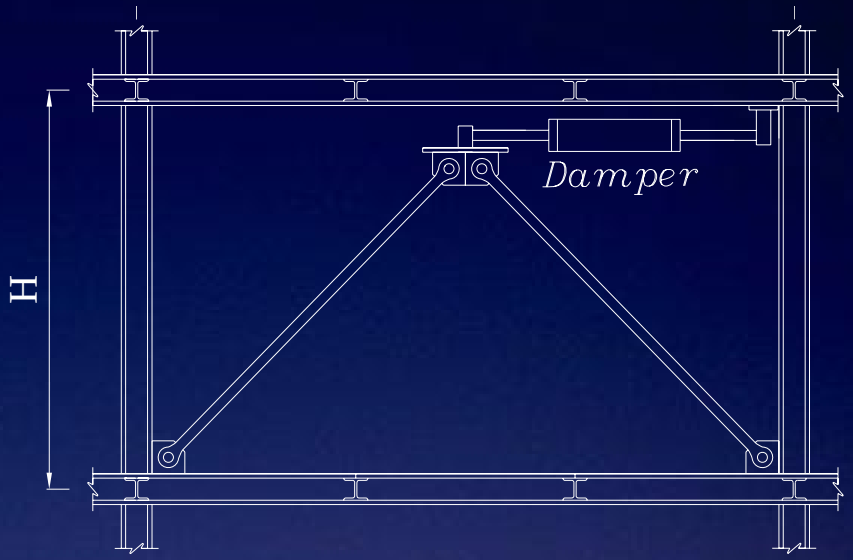
Viscoelastic Damper

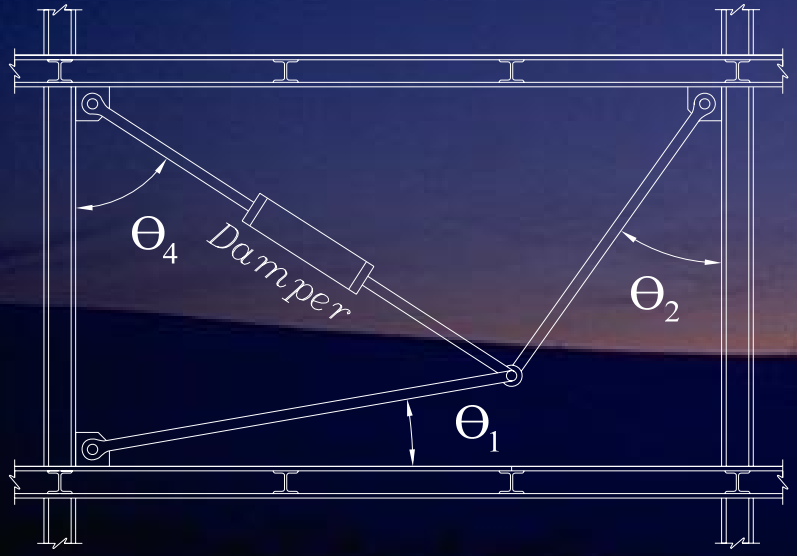


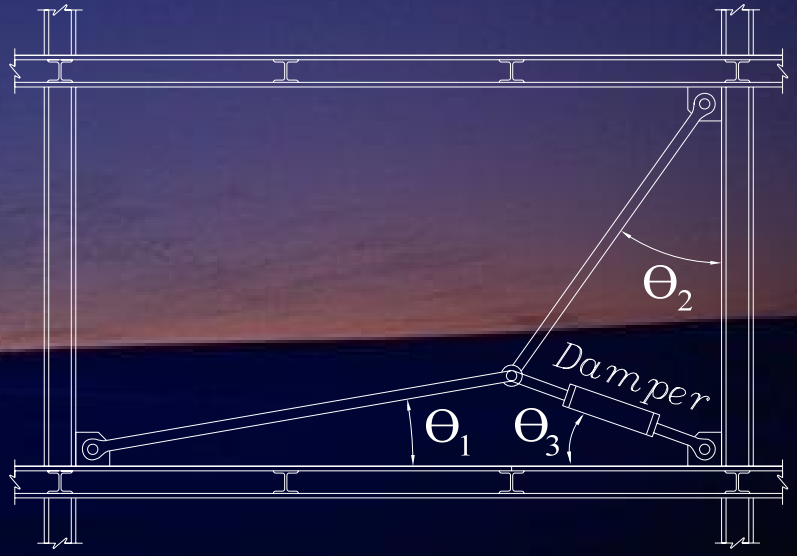

現場結構C.F.T.與VEM-Damper已施工至七樓
(實景拍攝日期 2002.12.18)
Visco-Elastic Shear Wall
帝寶
傳世至寶
Treasure Palace

Typical Installation Scheme of Viscous Dampers



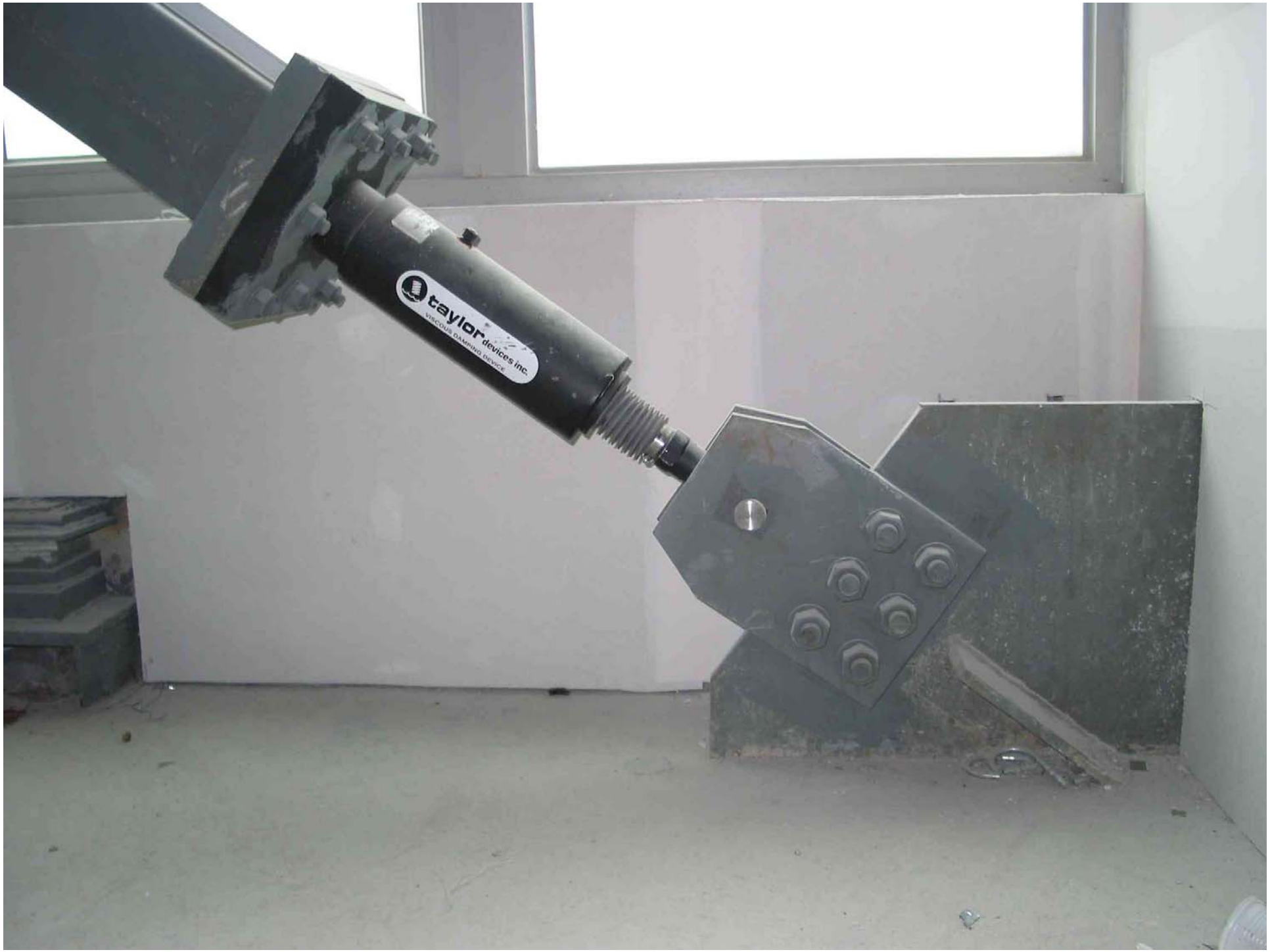






Viscous Dampers

Tai-Shin Bank

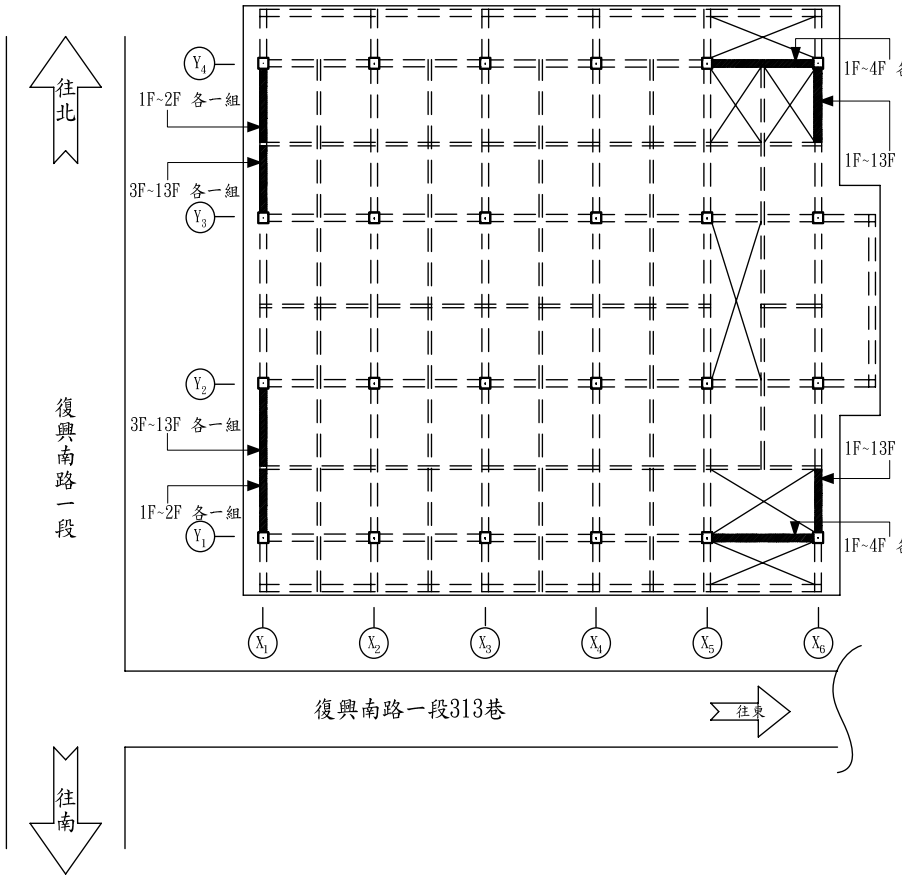

taylor devices inc.
VISCOUS DAMPING DEVICE

Tai-Shin Bank Headquarter

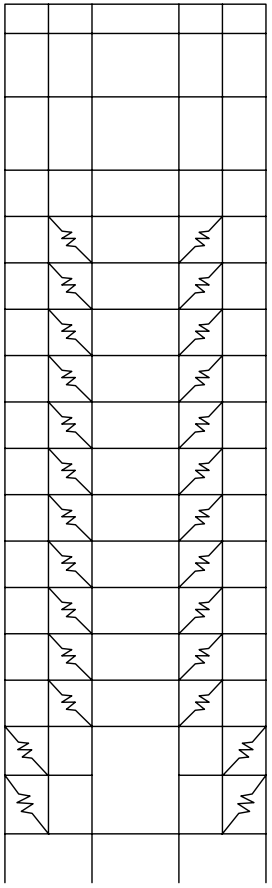

10
4-1
Genie SUPERLIFT

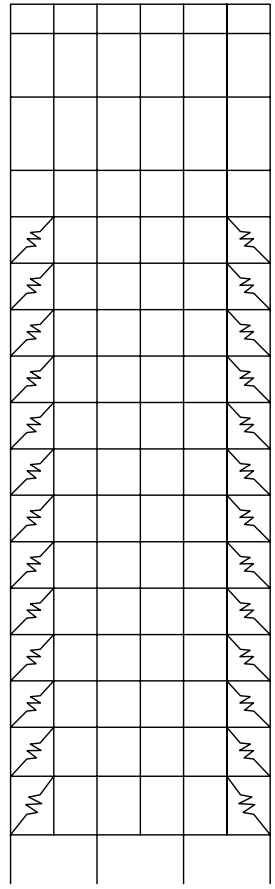
Headquarter of Buddhist Association

Plan



Elevation



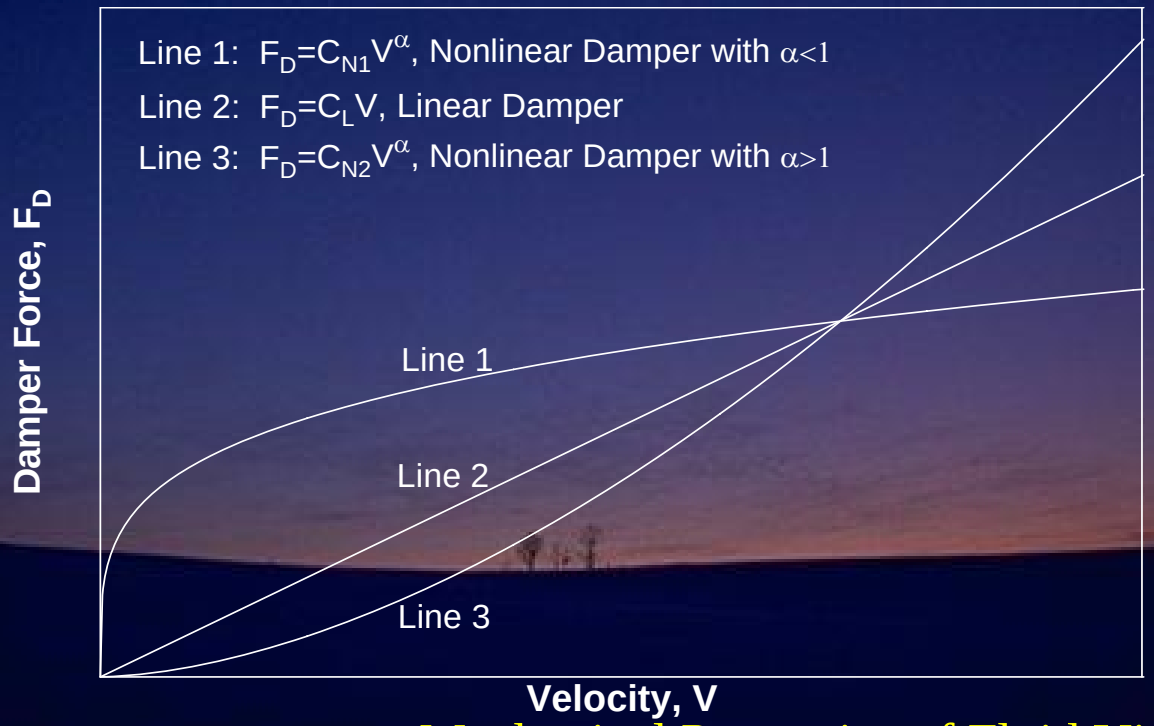


Force-Velocity Relationship of Viscous Dampers

$$F_D = C|\dot{u}|^{\alpha}\,\mathrm{sgn}(\dot{u})$$

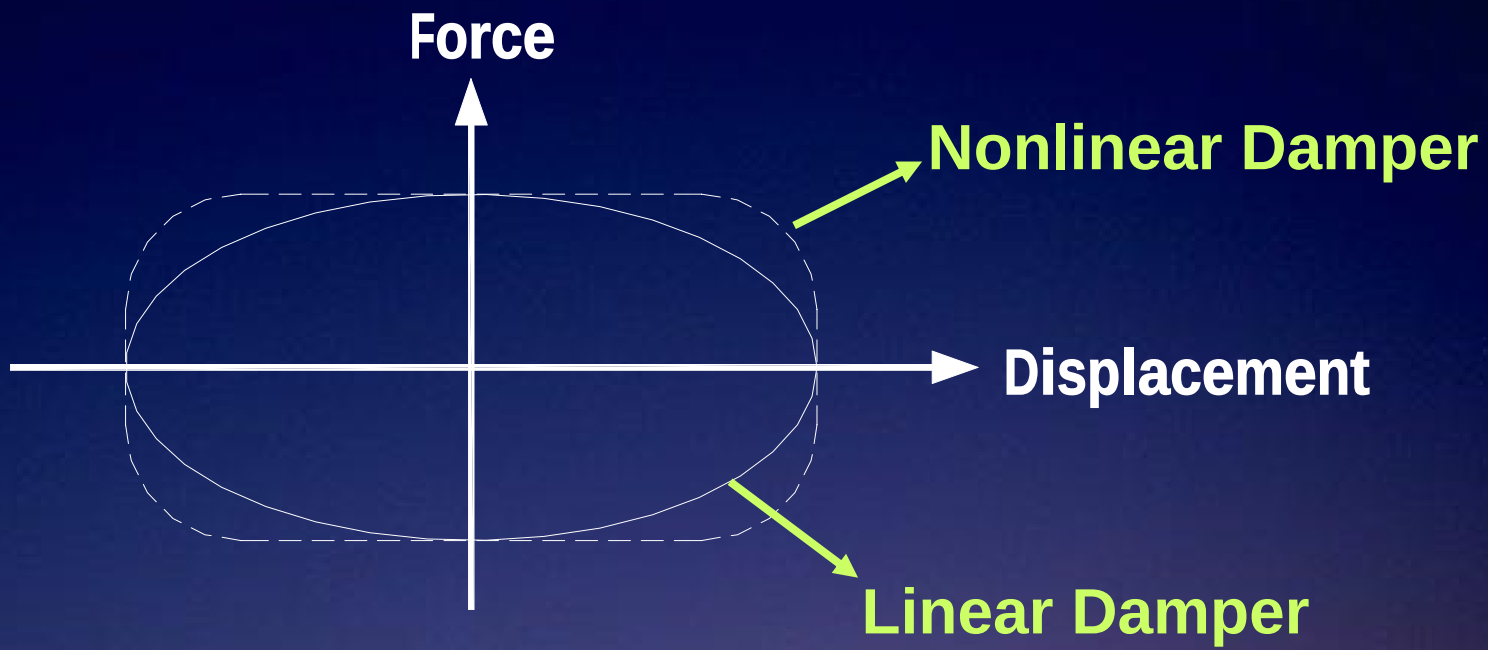
$\alpha = 1$ **Linear Viscous Dampers**

$0 < \alpha < 1$ **Nonlinear Viscous Dampers**



Mechanical Properties of Fluid Viscous Dampers

Hysteresis Loops of Viscous Dampers (Sinusoidal Motion)



No storage stiffness!

Viscous dampers won't change the natural frequency of the primary structure.

Damping Ratio Contributed by Nonlinear Viscous Dampers

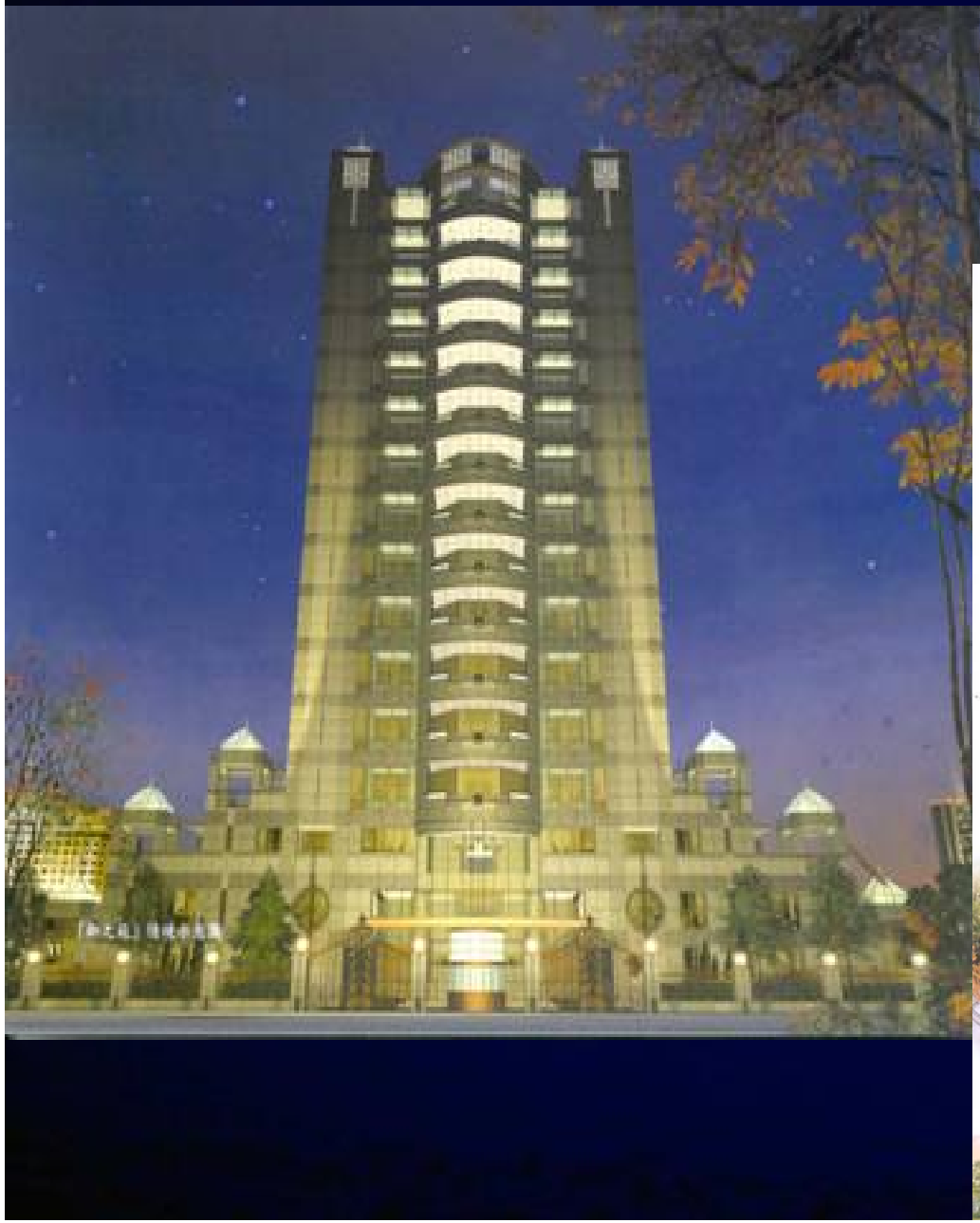
Diagonal Brace $u_j = u_i \cos\theta_j = A\phi_{rj}\cos\theta_j$

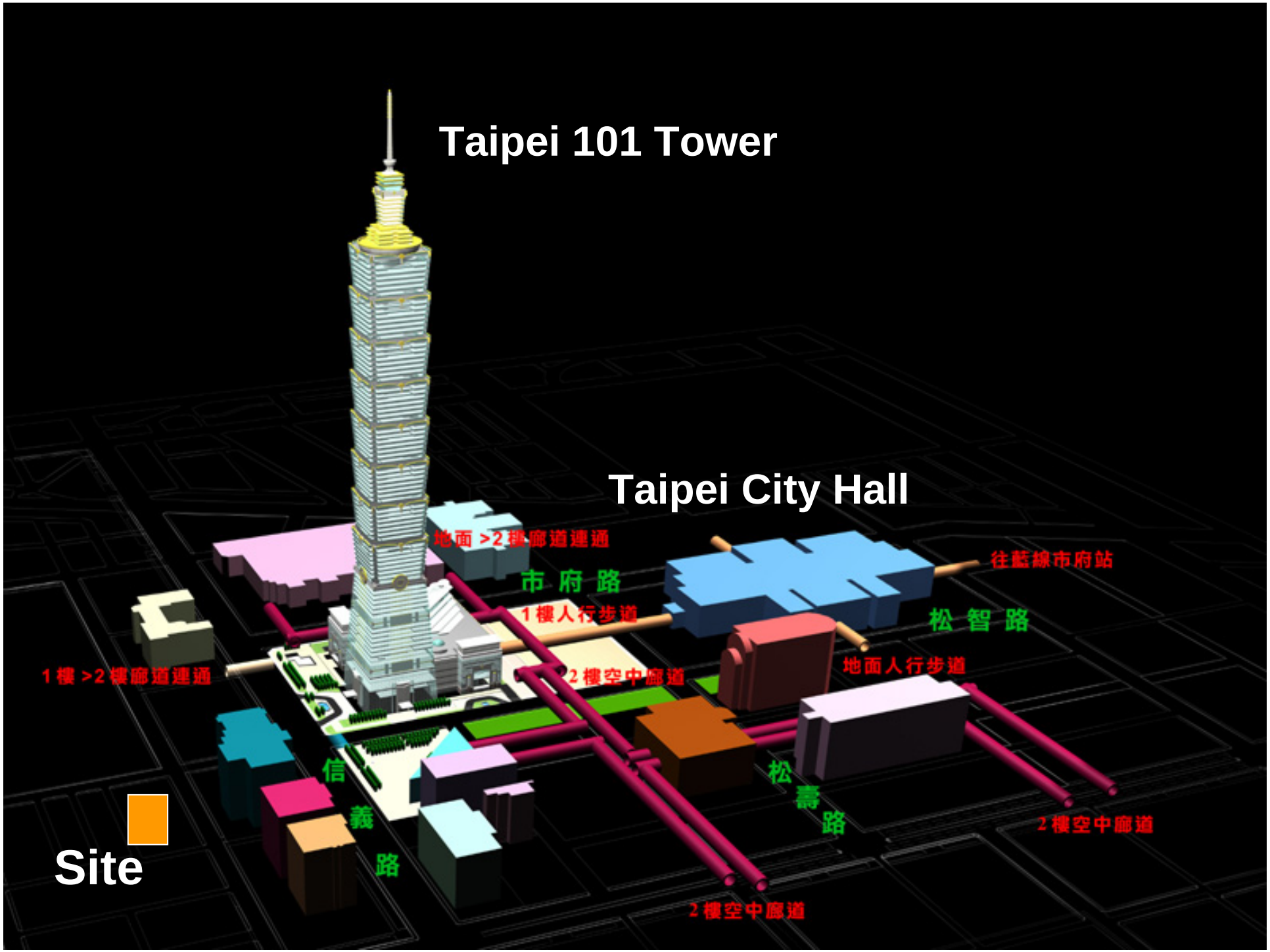
$$\xi_{eff} = \xi_0 + \frac{\sum_j \lambda_j C_j \phi_{rj}^{1+\alpha} \cos^{1+\alpha}\theta_j}{2\pi A^{1-\alpha}\omega^{2-\alpha}\sum_i m_i \phi_i^2}$$

K-Brace $\theta = 0$

$$\xi_{eff} = \xi_0 + \frac{\sum_j \lambda_j C_j \phi_{rj}^{1+\alpha}}{2\pi A^{1-\alpha}\omega^{2-\alpha}\sum_i m_i \phi_i^2}$$

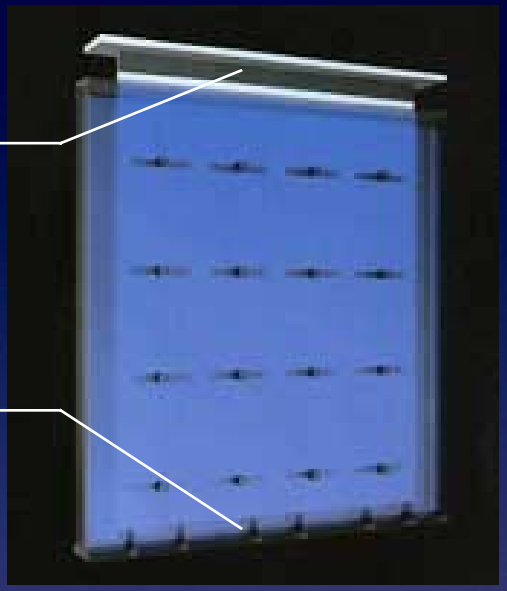
Grand Palace of Taipei




Taipei 101 Tower
Taipei City Hall
地面 >2 樓廊道連通
市 府 路
1 樓人行步道
往藍線市府站
松 智 路
地面人行步道
1 樓 >2 樓廊道連通
2 樓空中廊道
信
義
路
松
壽
路
2 樓空中廊道
2 樓空中廊道
Site

中間層鋼板連接
上部抗彎構架

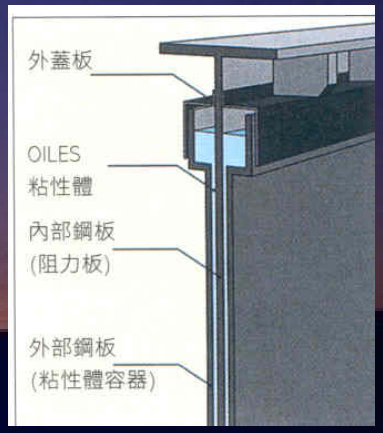
外部鋼板連接
下部抗彎構架



基本構造圖

Viscous
Material

Damper
in Place



Sectional View

Seismic Isolation Design

Lead-Rubber Bearings (LRB)

High Damping Rubber Bearings (HDRB)

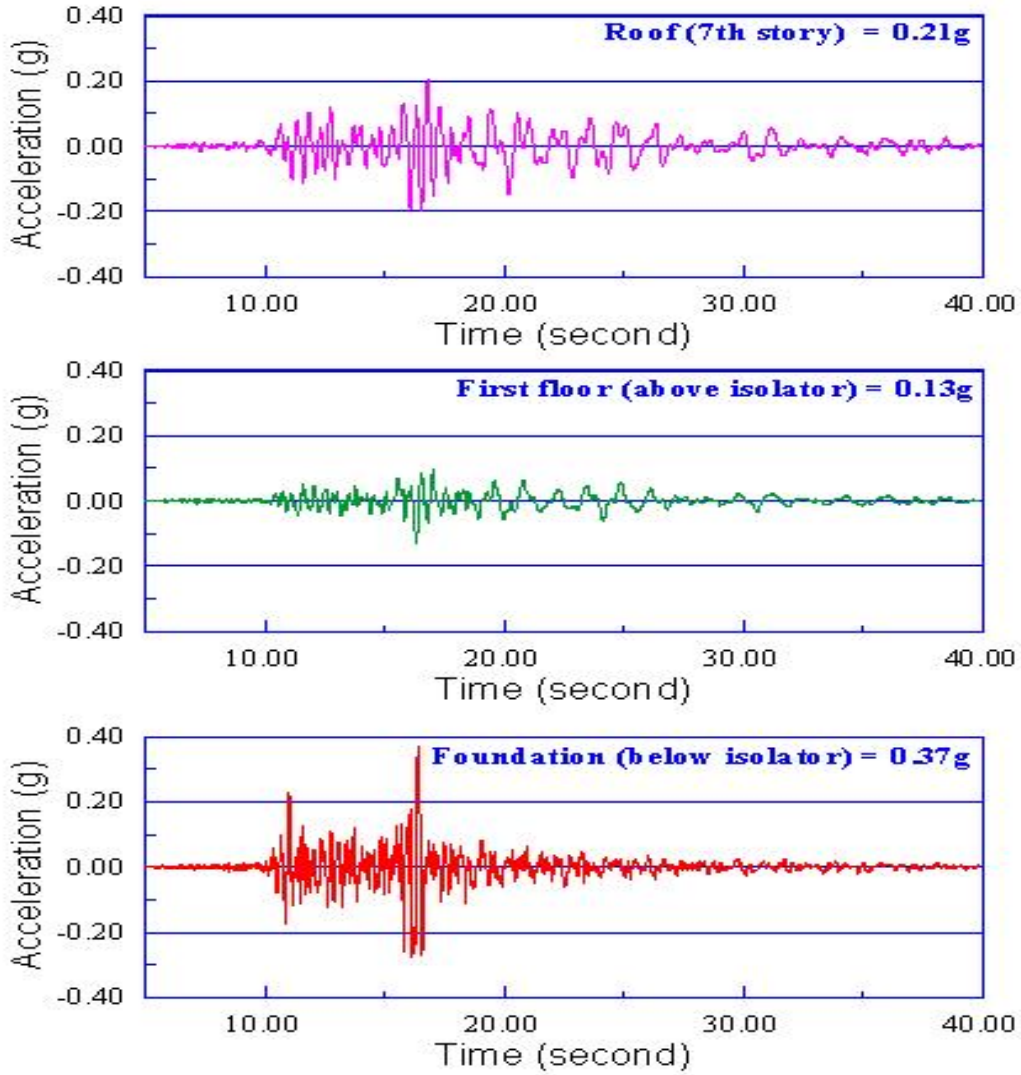
Friction Pendulum Systems (FPS)

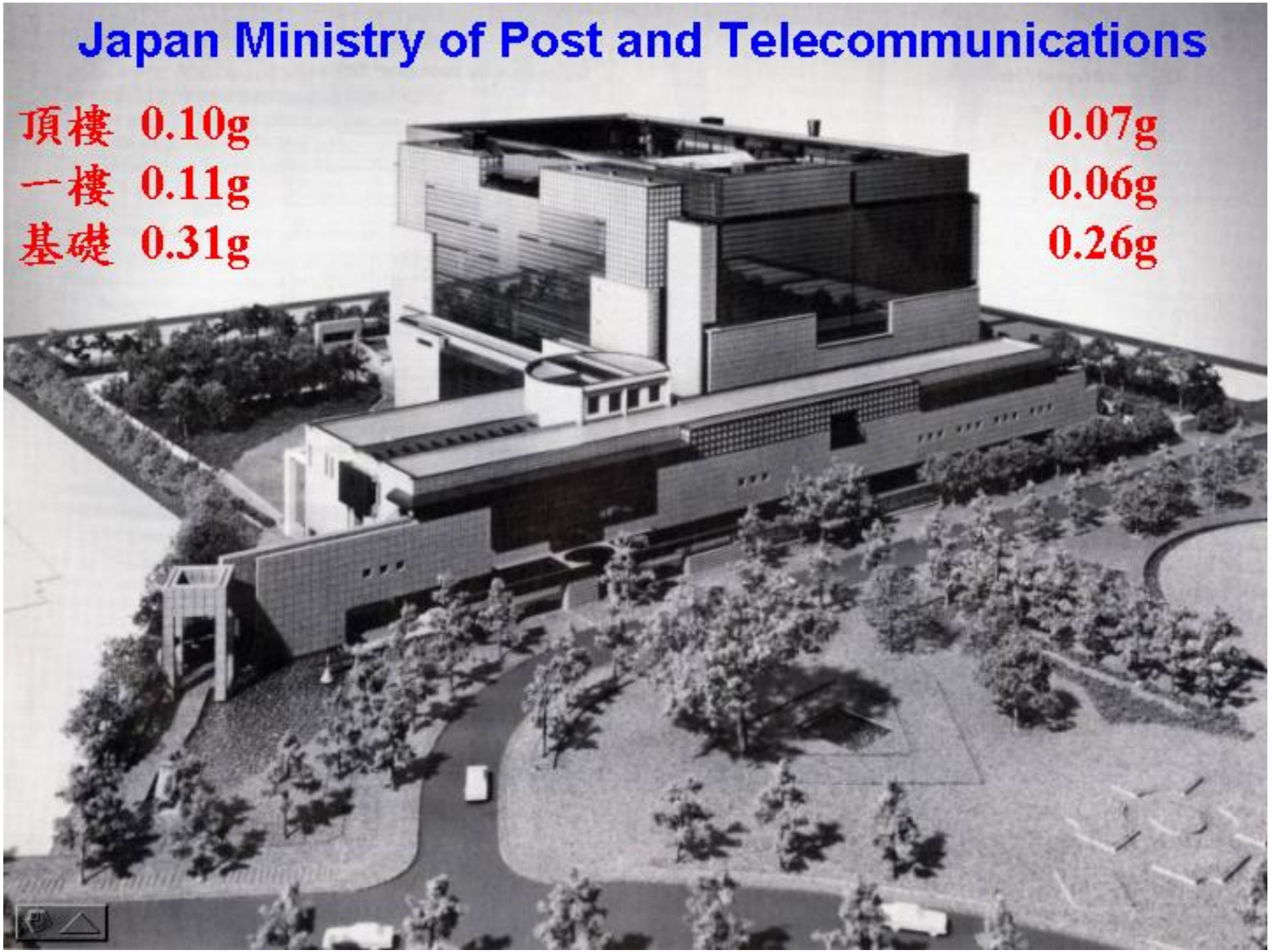
USC Hospital : 1994 Northridge Earthquake

81 Rubber Bearings

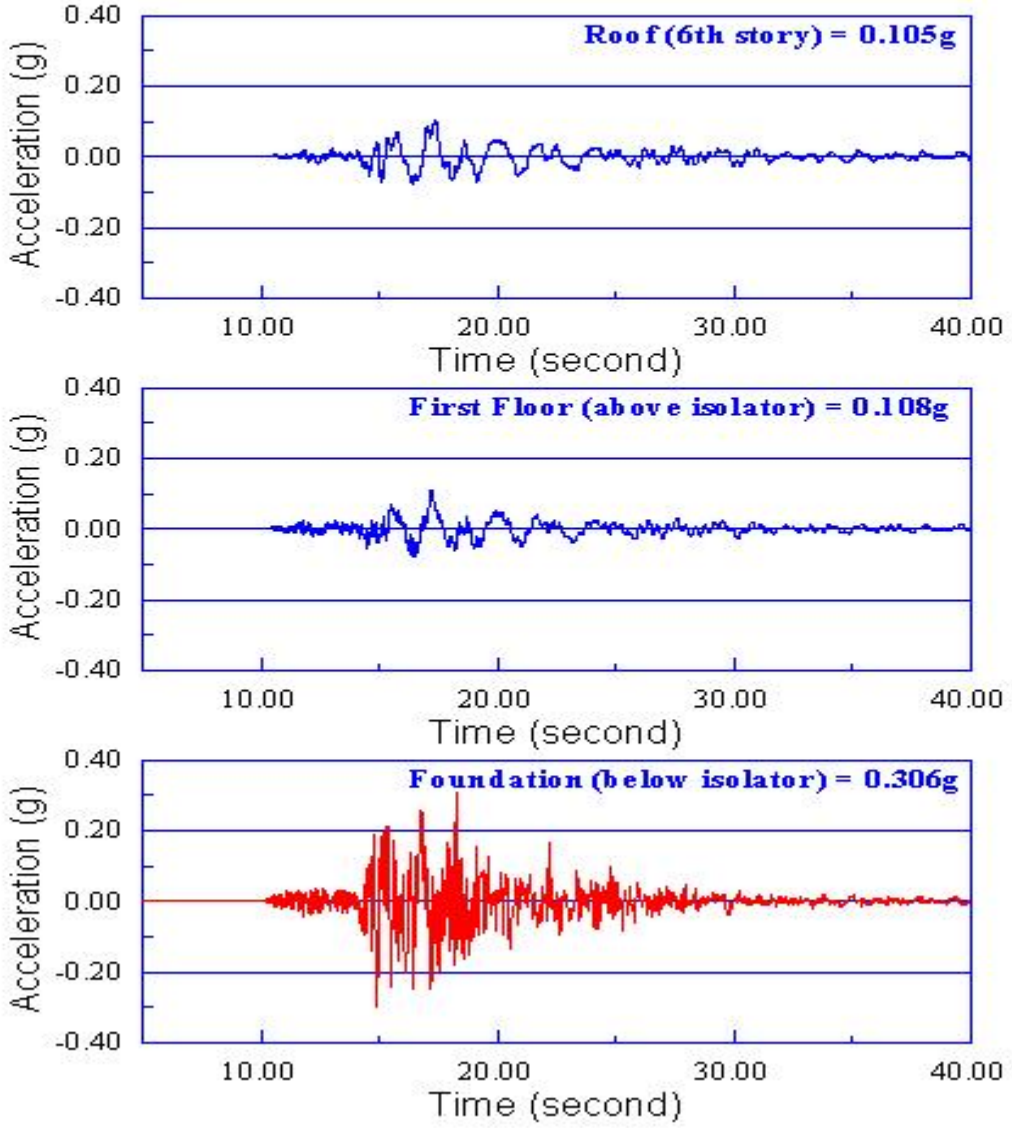
68 Lead-Rubber Bearings

MEASURED SEISMIC RESPONSES OF UNIV. OF SOUTHERN CALIFORNIA HOSPITAL DURING 1994 NORTHRIDGE EARTHQUAKE

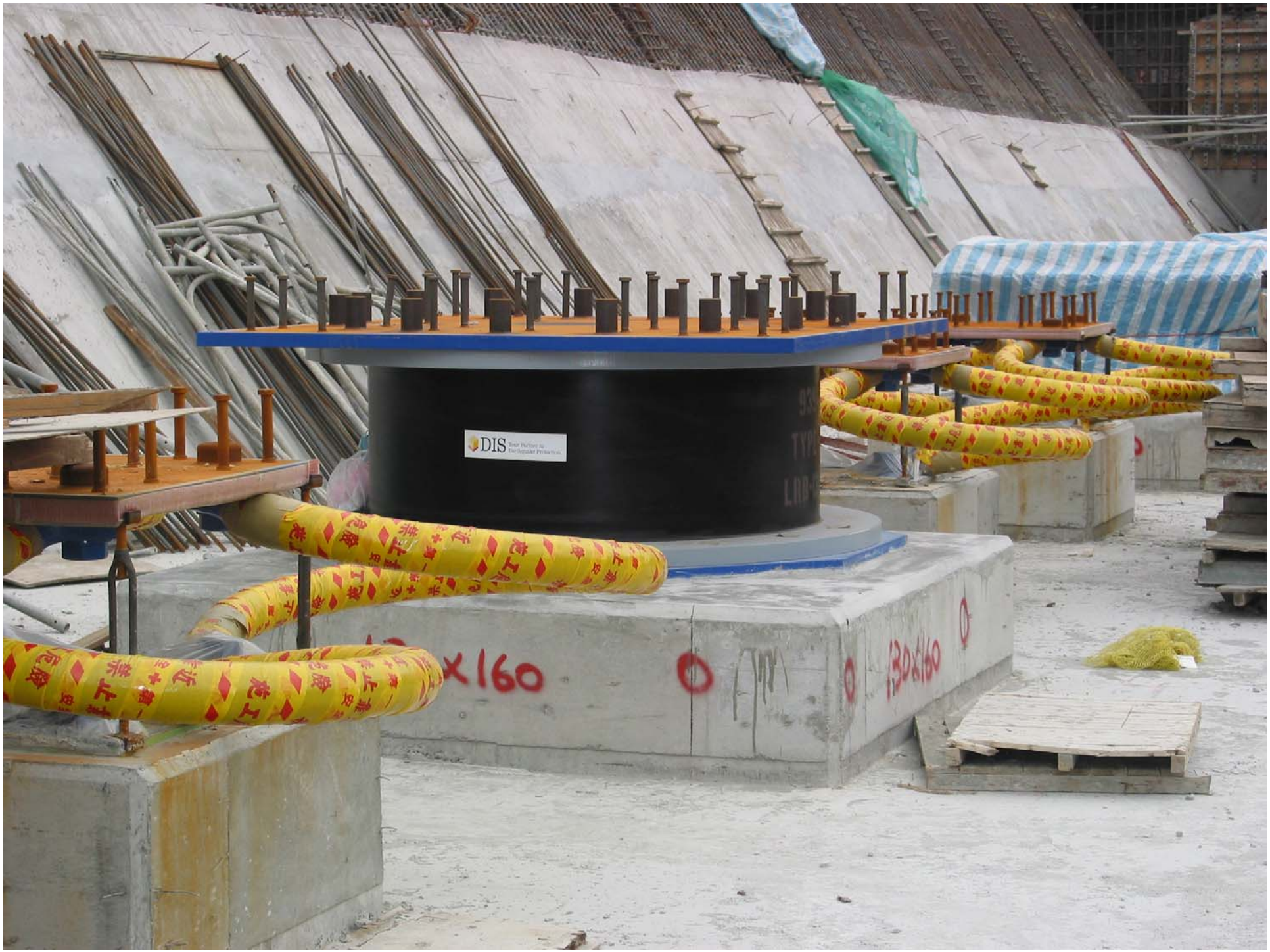



Japan Ministry of Post and Telecommunications
頂樓 0.10g
一樓 0.11g
基礎 0.31g
0.07g
0.06g
0.26g

MEASURED SEISMIC RESPONSES OF THE COMPUTER CENTER OF JAPAN MINISTRY OF POST & TELECOMMUNICATIONS DURING 1995 KOBE EARTHQUAKE



Tzu-Chi Hospital at Taipei


DIS
130×160


069
水電

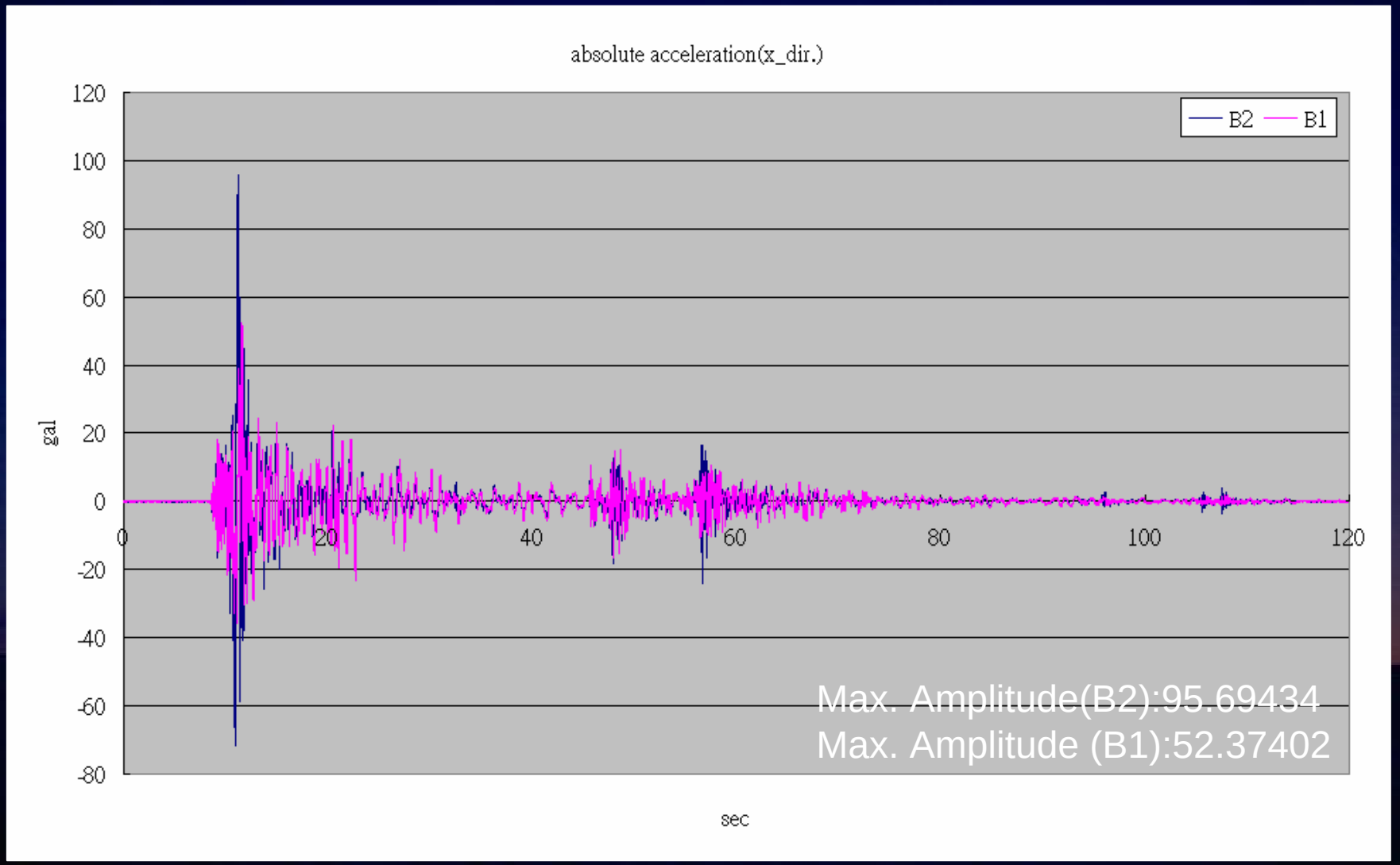

X
Y

Trigger Time 2005/04/30 14:47:37.00

Sampling Freq. (Hz) 200

Duration Time (second) 120.000

Number of Data 24000

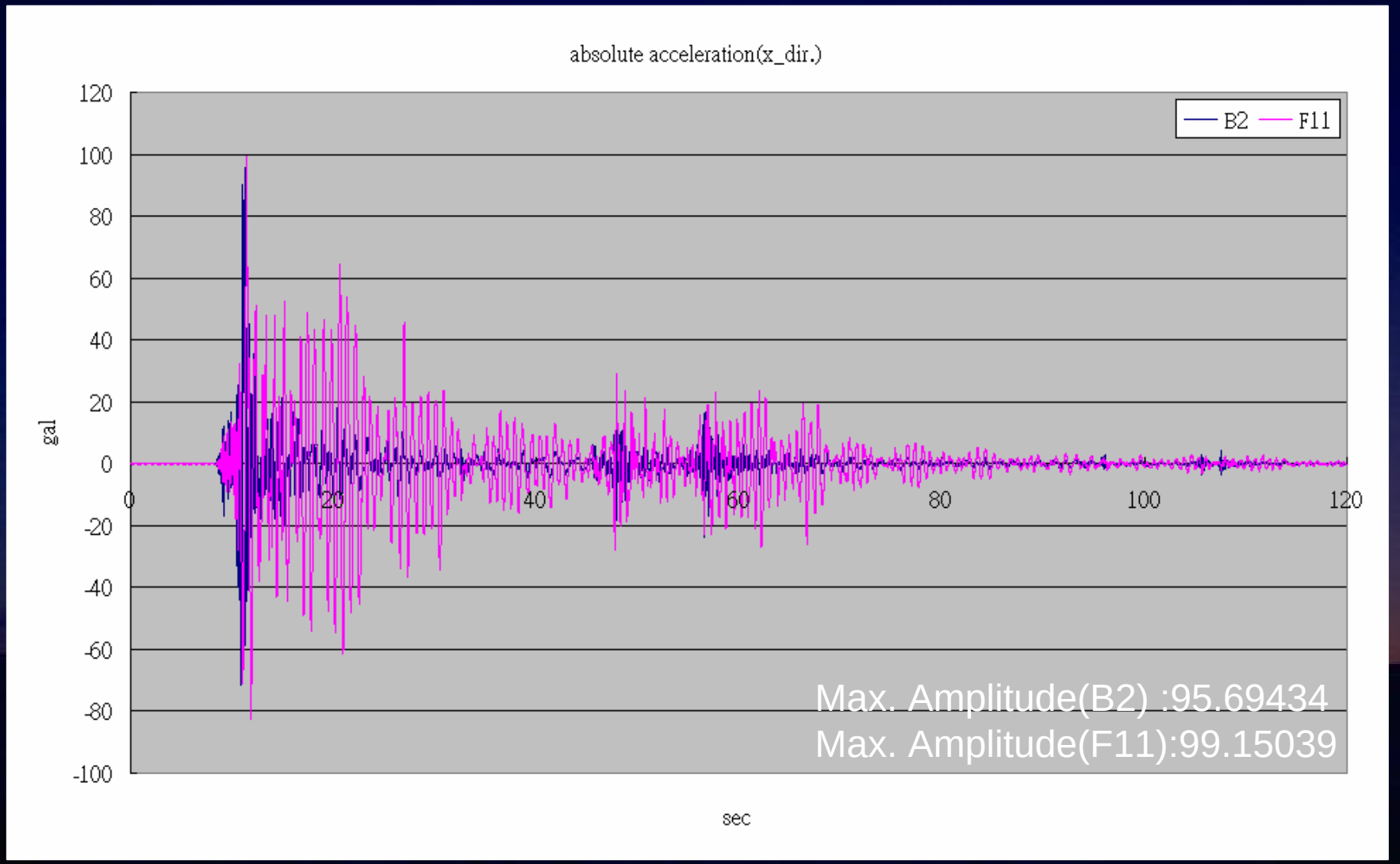


Trigger Time 2005/04/30 14:47:37.00

Sampling Freq. (Hz) 200

Duration Time (second) 120.000

Number of Data 24000

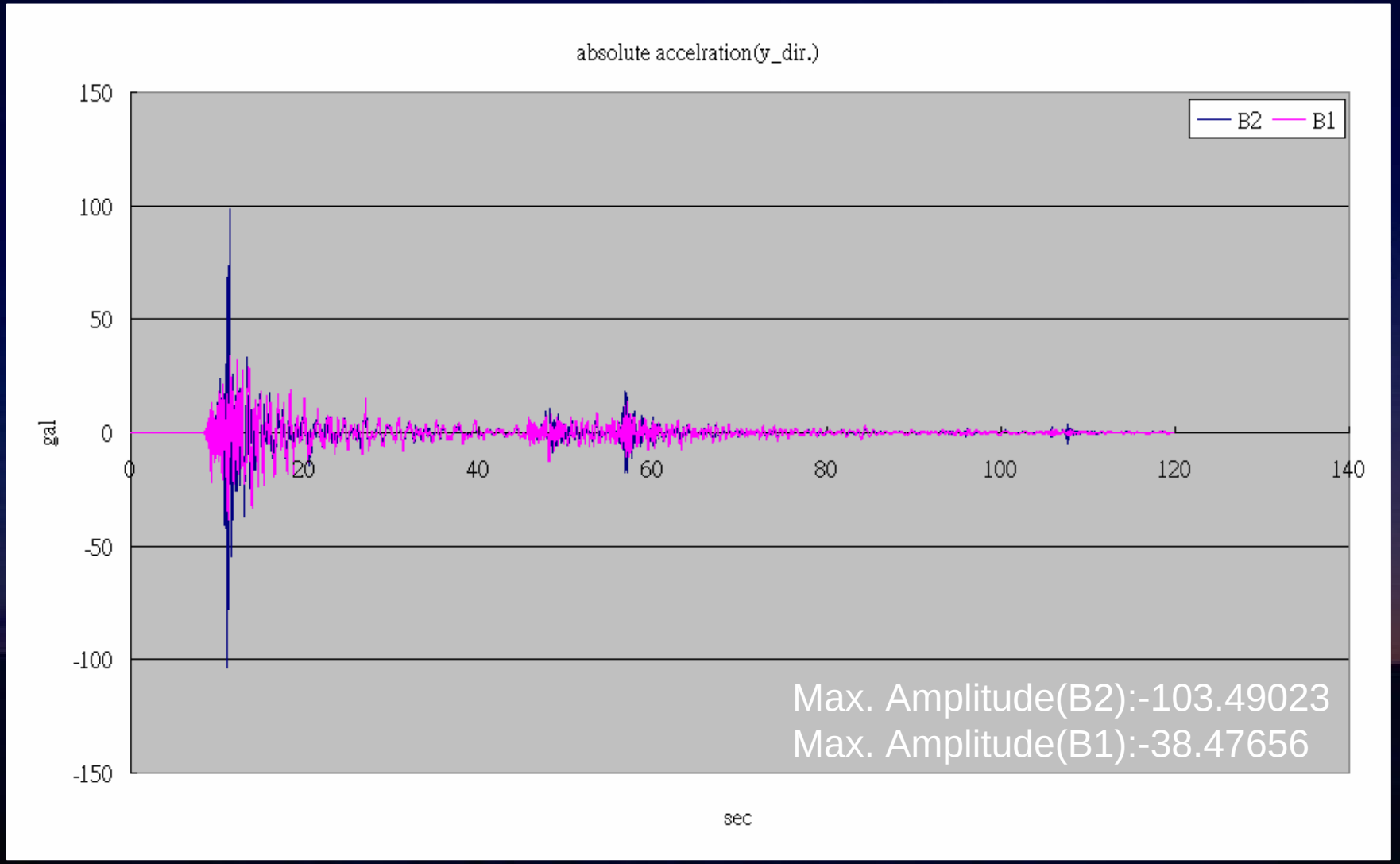


Trigger Time 2005/04/30 14:47:37.00

Sampling Freq. (Hz) 200

Duration Time (second) 120.000

Number of Data 24000

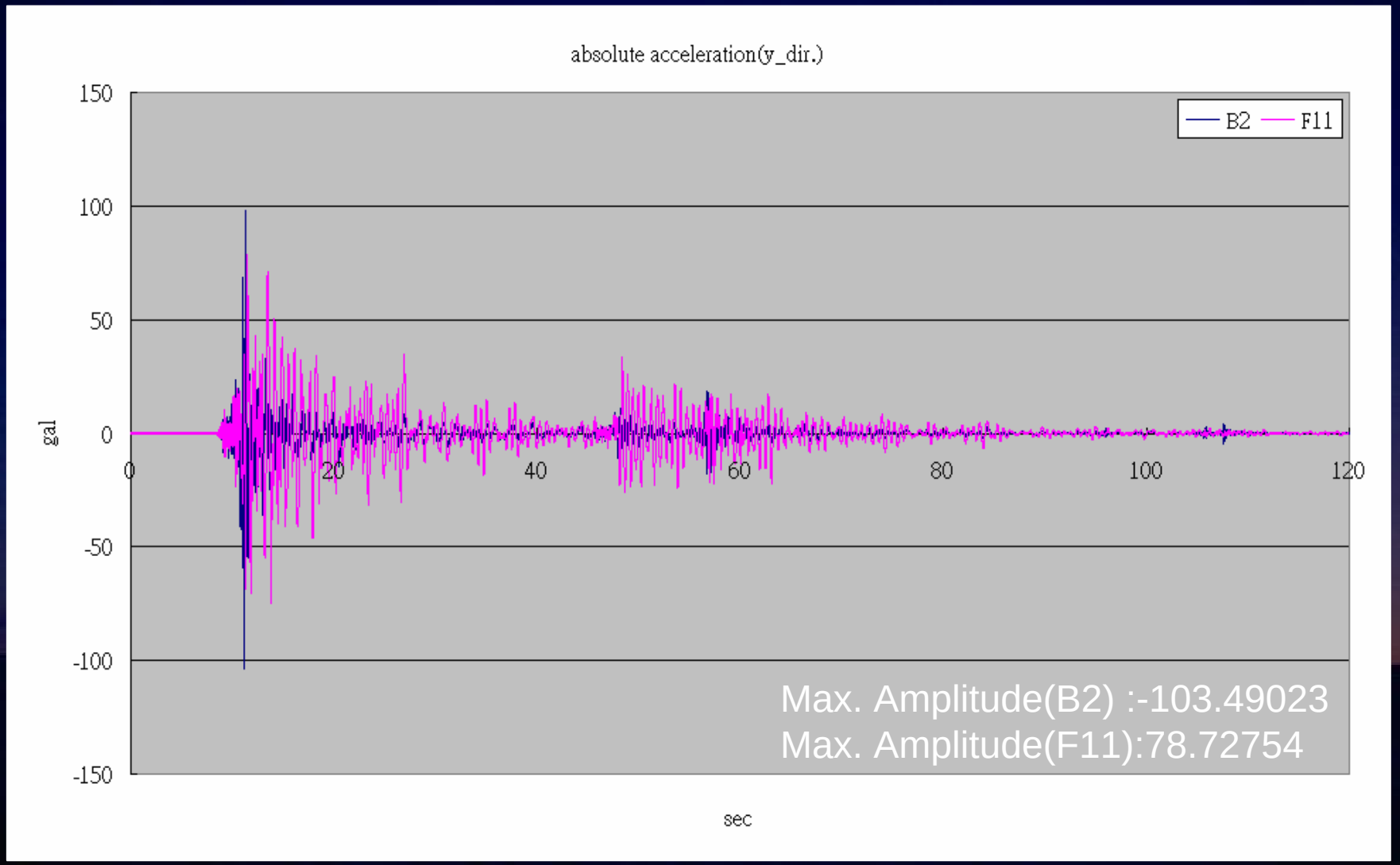


Trigger Time 2005/04/30 14:47:37.00

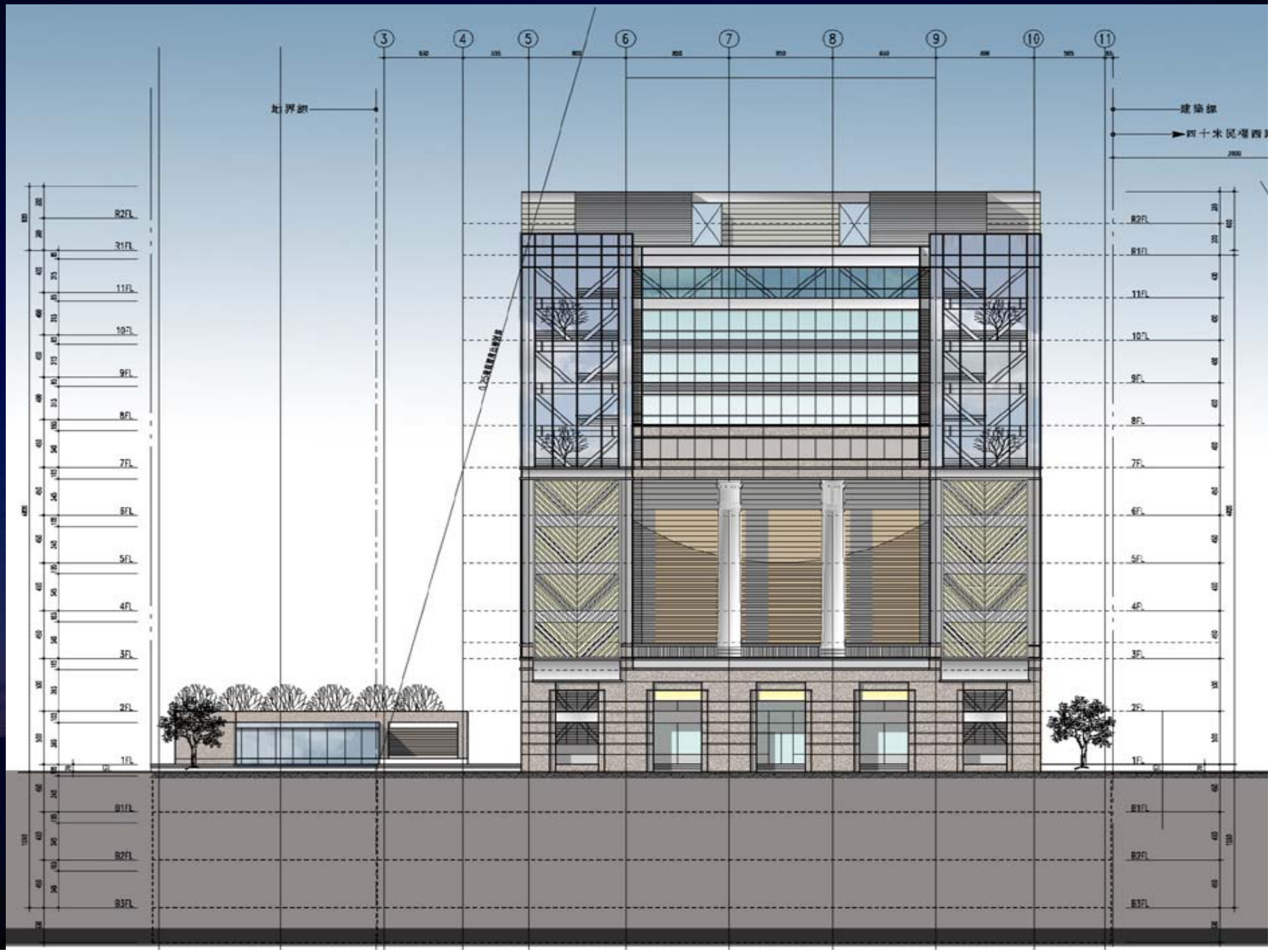
Sampling Freq. (Hz) 200

Duration Time (second) 120.000

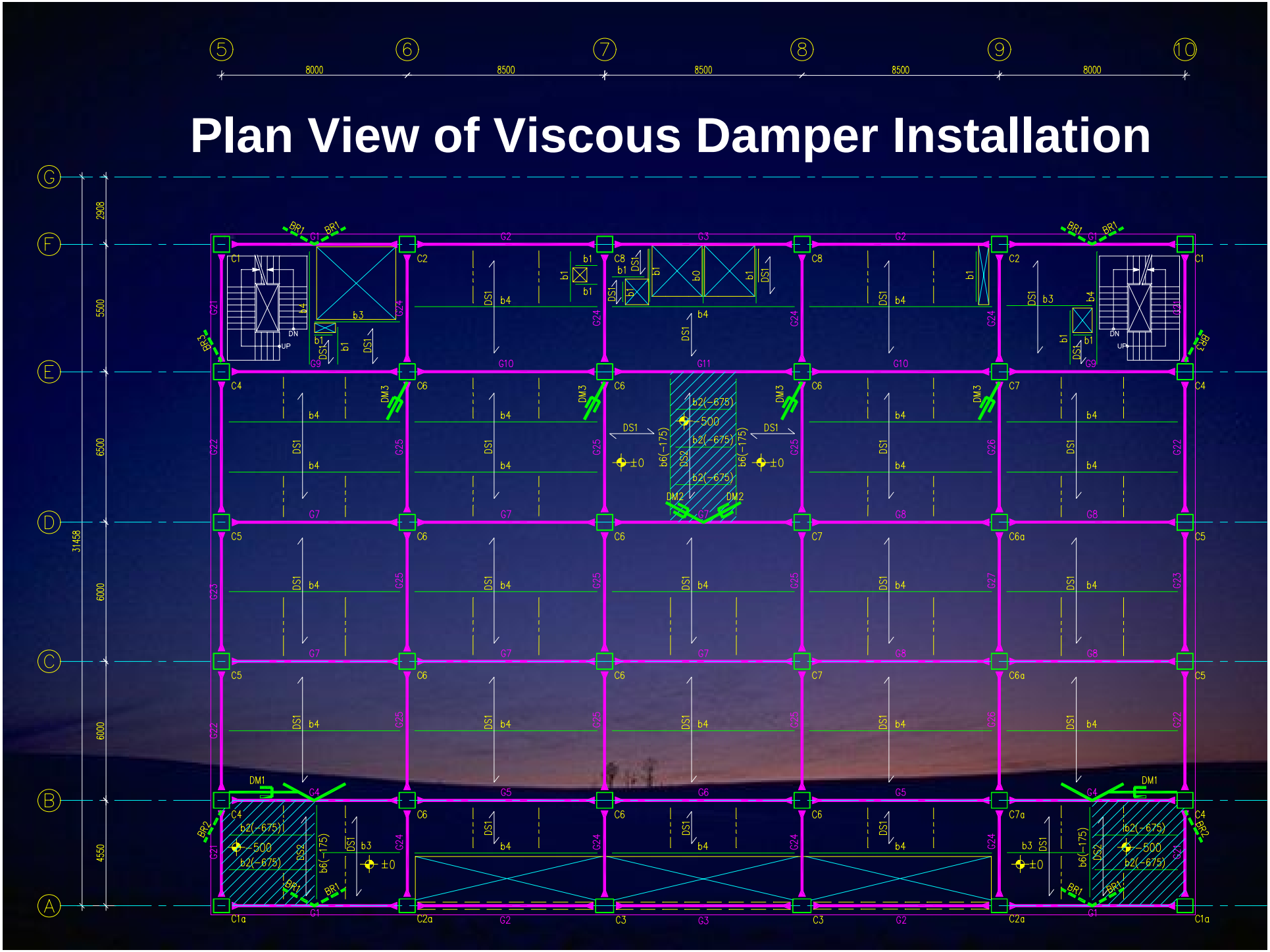
Number of Data 24000



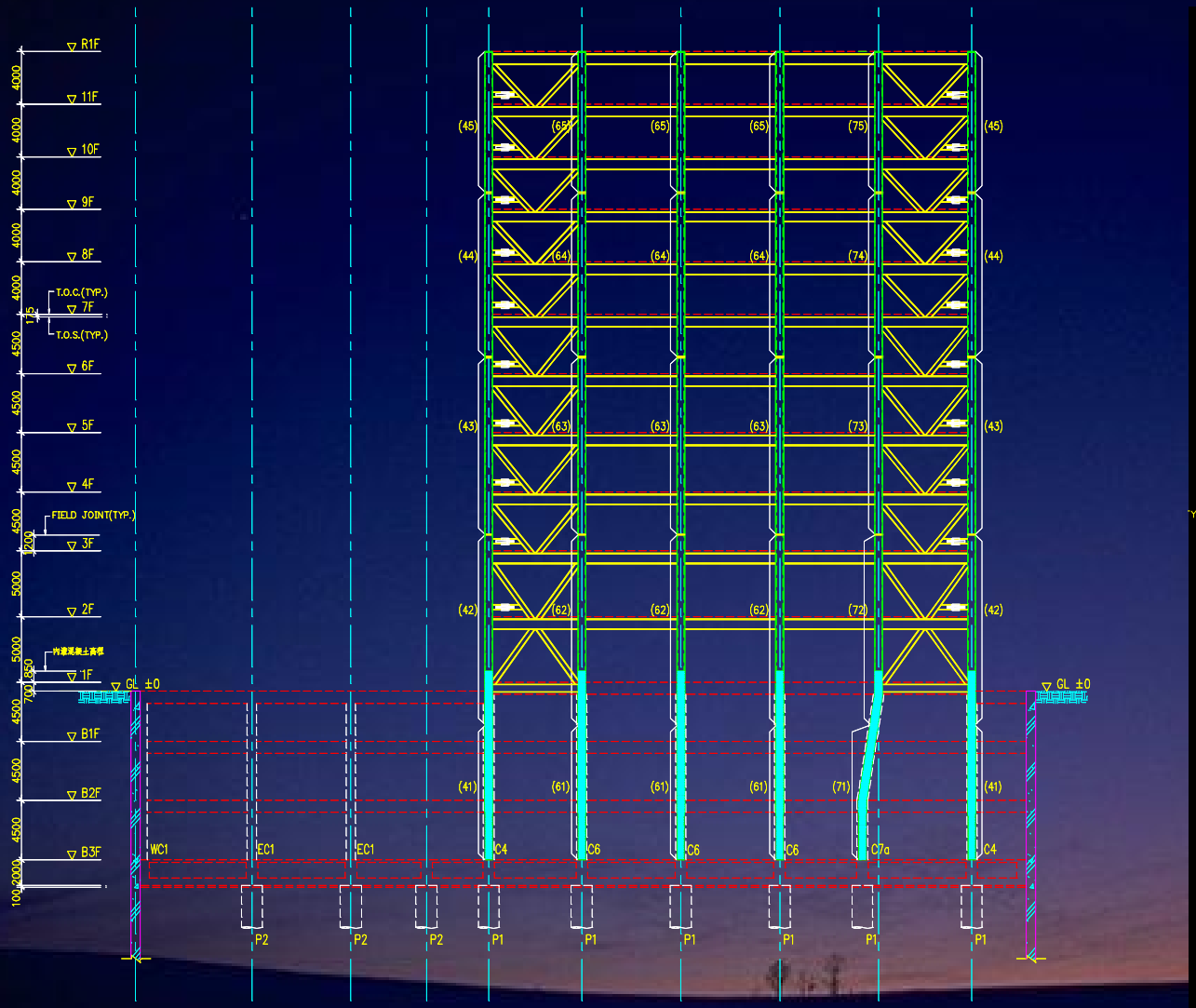
Bank of Taiwan



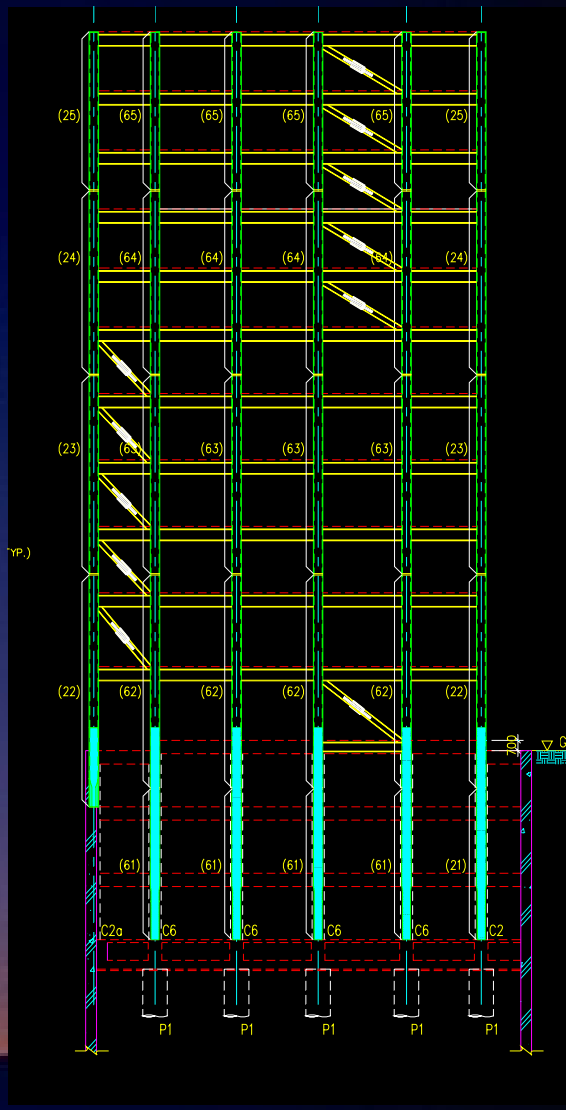
Plan View of Viscous Damper Installation



Elevation View

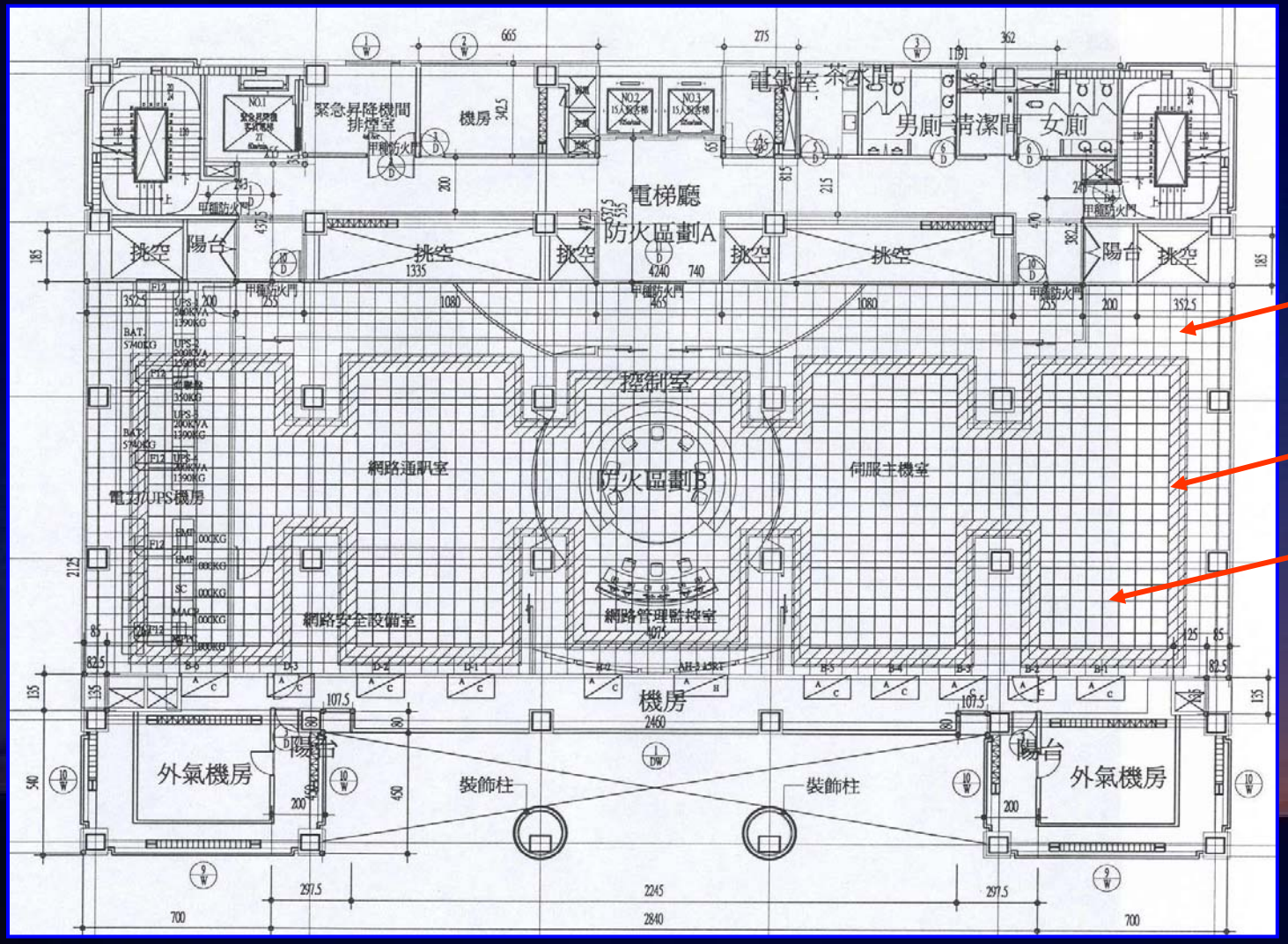


X-B 立構圖

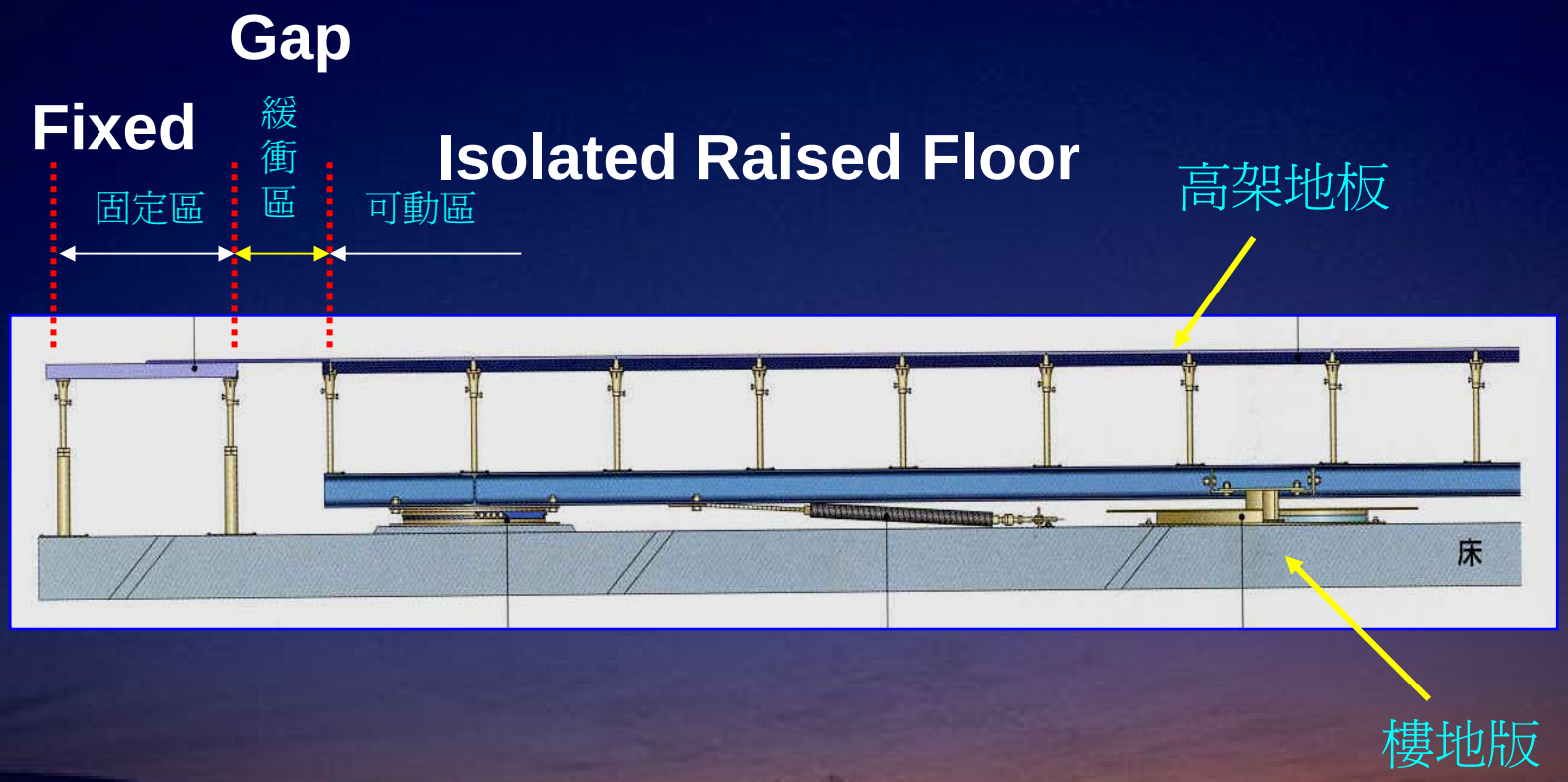


Y-6 立構圖

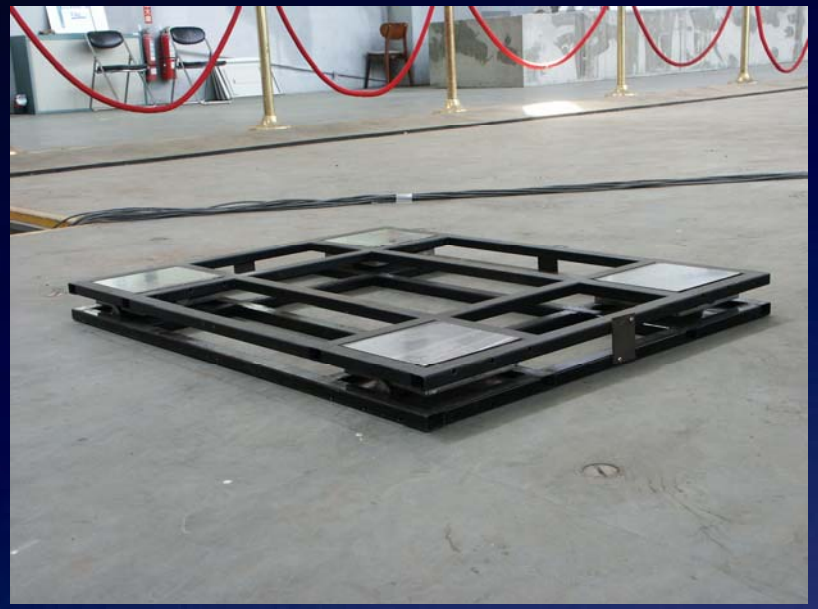
Plan View of Floor Isolation

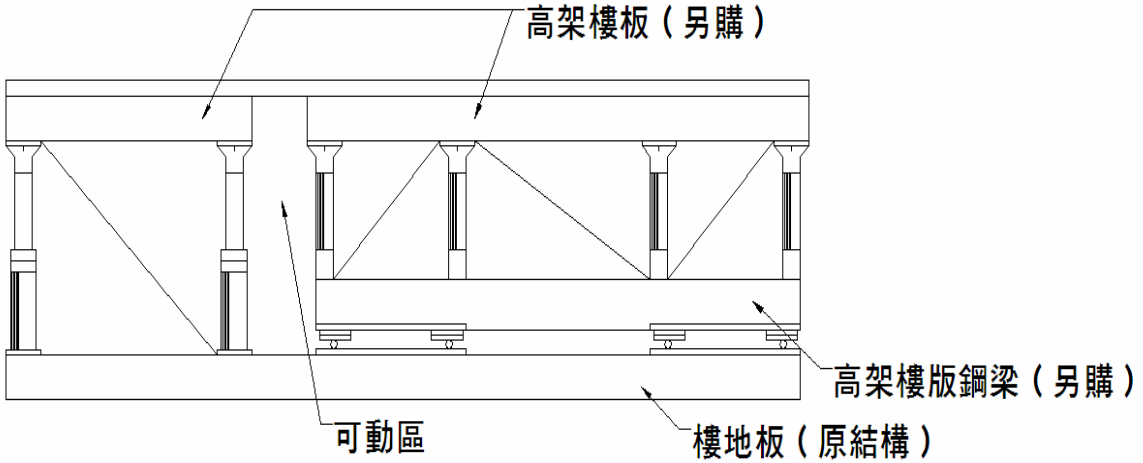


Sectional View of Floor Isolation System

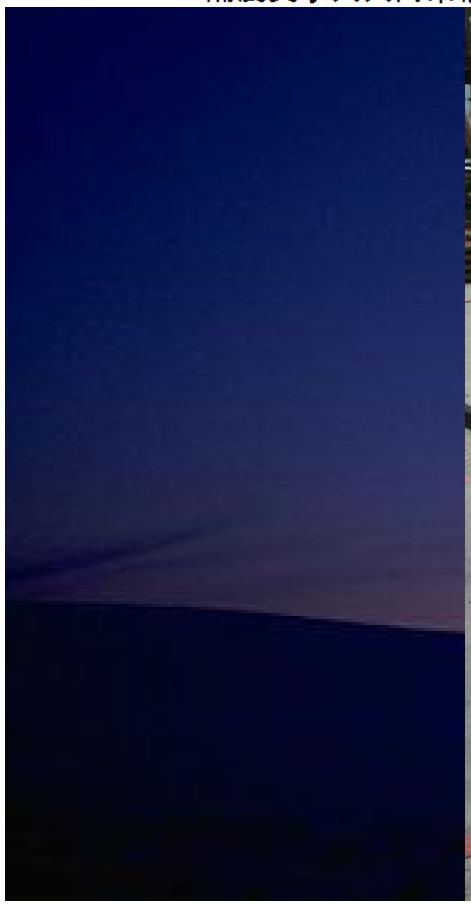


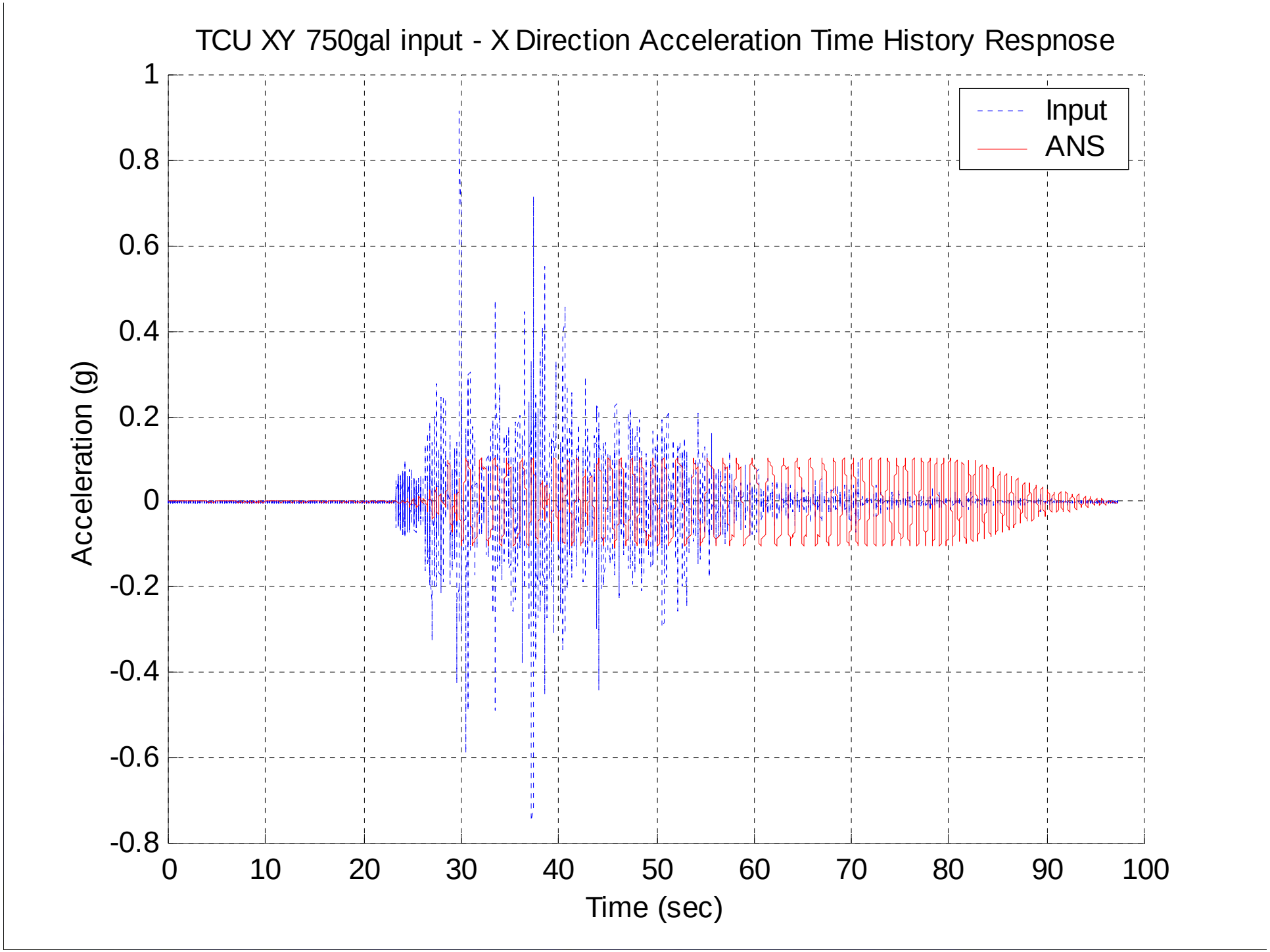
A Floor Isolation System Developed by MCEER and NCREE





隔震支承與與高架樓板組合示意圖




TCU XY 750gal input - X Direction Acceleration Time History Respnose
Input
ANS
Acceleration (g)
Time (sec)
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0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
10
20
30
40
50
60
70
80
90
100