



clc; clear; close all;

ag = filename\_to\_array('I-ELC270\_gal\_l00Hz', 2, 2);

tn = 0.01 : 0.01 : 5;

tn\_length = length(tn);

acceleration = zeros(1, tn\_length);

for index = 1 : tn\_length

[~, ~, a\_array] = newmark\_beta(ag, 0.01, 0.05, tn(index), 'average');

acceleration(1, index) = max(abs(a\_array));

end

acceleration\_normal = acceleration / acceleration(1, 1) \* 0.4;

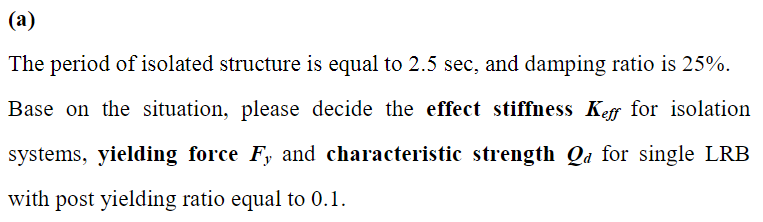
acceleration\_normal(tn == 2.5)

figure;

plot(tn, acceleration\_normal);

xlabel('T(sec)');

ylabel('SaD(g)');



已知：

* TeD = 2.5sec
* Damping Ratio = 25%
* Post Yielding Ratio = 0.1



由反應譜可知 SaD

* TeD => SaD = 0.2324g
* W = 35.53421364 (from ETABS)

由以上資訊經迭代可得

* Keff for isolation systems = 22.8801 tf/m
* Fy for single LRB = 0.2791 tf
* Qd for single LRB = 0.2512 tf

clc; clear; close all;

SaD = 0.2324;

TeD = 2.5;

DampingRatio = 0.25;

*% SaD = 0.195;*

*% TeD = 3;*

*% DampingRatio = 0.3;*

W = 35.53421364;

postYieldingRatio = 0.1;

LRBs = 9;

dleta = 0.000001;

g = 9.81;

KeD = W / ((TeD / (2 \* pi)) ^ 2) / g;

if DampingRatio <= 0.02

BS = 0.8;

B1 = 0.8;

elseif 0.02 < DampingRatio && DampingRatio <= 0.05

BS = (DampingRatio - 0.02) / 0.03 \* (1 - 0.8) + 0.8;

B1 = (DampingRatio - 0.02) / 0.03 \* (1 - 0.8) + 0.8;

elseif 0.05 < DampingRatio && DampingRatio <= 0.1

BS = (DampingRatio - 0.05) / 0.05 \* (1.33 - 1) + 1;

B1 = (DampingRatio - 0.05) / 0.05 \* (1.25 - 1) + 1;

elseif 0.1 < DampingRatio && DampingRatio <= 0.2

BS = (DampingRatio - 0.1) / 0.1 \* (1.6 - 1.33) + 1.33;

B1 = (DampingRatio - 0.1) / 0.1 \* (1.5 - 1.25) + 1.25;

elseif 0.2 < DampingRatio && DampingRatio <= 0.3

BS = (DampingRatio - 0.2) / 0.1 \* (1.79 - 1.6) + 1.6;

B1 = (DampingRatio - 0.2) / 0.1 \* (1.63 - 1.5) + 1.5;

elseif 0.3 < DampingRatio && DampingRatio <= 0.4

BS = (DampingRatio - 0.3) / 0.1 \* (1.87 - 1.79) + 1.79;

B1 = (DampingRatio - 0.3) / 0.1 \* (1.7 - 1.63) + 1.63;

elseif 0.4 < DampingRatio && DampingRatio <= 0.5

BS = (DampingRatio - 0.4) / 0.1 \* (1.93 - 1.87) + 1.87;

B1 = (DampingRatio - 0.4) / 0.1 \* (1.75 - 1.7) + 1.7;

elseif 0.5 < DampingRatio

BS = 1.93;

B1 = 1.75;

end

B = B1;

DD = g / (4 \* pi ^ 2) \* SaD \* TeD ^ 2 / B;

*% syms Qd; % be careful performance issue.*

*% Kd = KeD - Qd / DD;*

*% Ku = Kd / postYieldingRatio;*

*% Dy = Qd / (Ku - Kd);*

*% ATD = 4 \* Qd \* (DD - Dy);*

*% solQd = double(solve(DampingRatio == ATD / (2 \* pi \* KeD \* DD ^ 2), Qd))*

Qd = dleta;

nextDampingRatio = 0;

while abs(nextDampingRatio - DampingRatio) > dleta

Kd = KeD - Qd / DD;

Ku = Kd / postYieldingRatio;

Dy = Qd / (Ku - Kd);

ATD = 4 \* Qd \* (DD - Dy);

nextDampingRatio = ATD / (2 \* pi \* KeD \* DD ^ 2);

Qd = Qd + dleta;

end

B

DD

KeD

*% Fy1 = Ku \* Dy / LRBs*

singleKu = Ku / LRBs

singleKd = Kd / LRBs

singleQd = Qd / LRBs

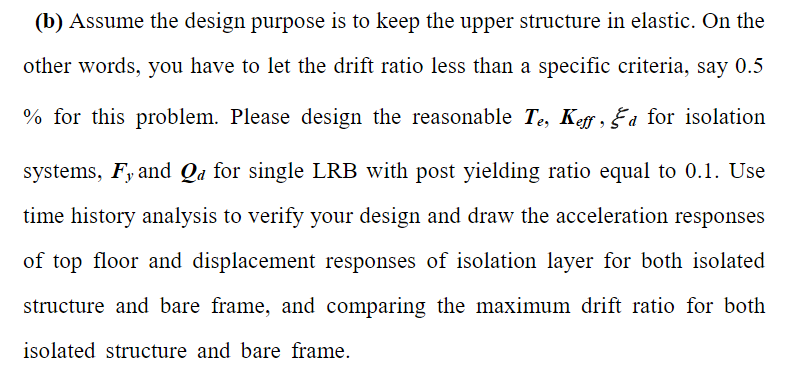
singleKeD = KeD / LRBs

DampingRatio

singleKu = Ku / LRBs

Fy = (Qd + Kd \* Dy) / LRBs

postYieldingRatio



假設初始設計目標：

* TeD = 3sec
* Damping Ratio = 20%
* Post Yielding Ratio = 0.1



* TeD => SaD = 0.195
* W = 35.53421364 (from ETABS)

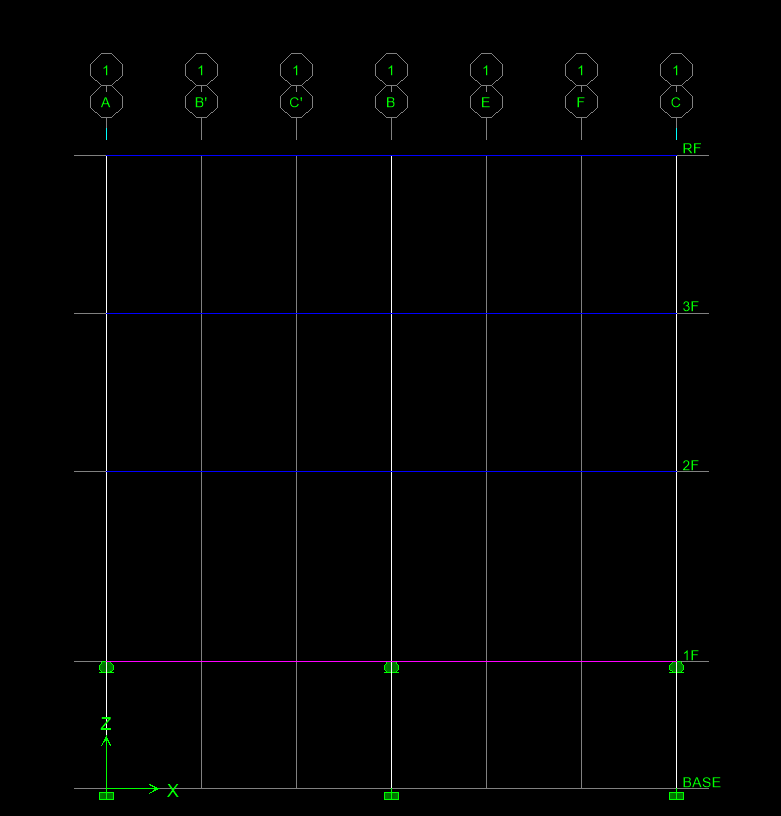
由以上資訊經迭代可得：

* Keff for isolation systems = 15.8889 tf/m
* Fy for single LRB = 0.1897 tf
* Qd for single LRB = 0.1707 tf

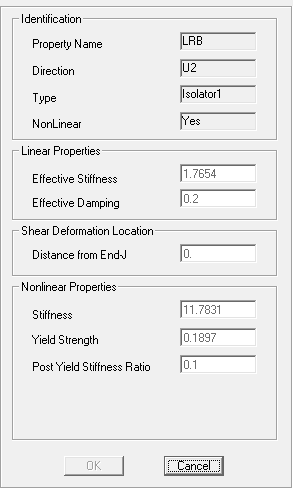
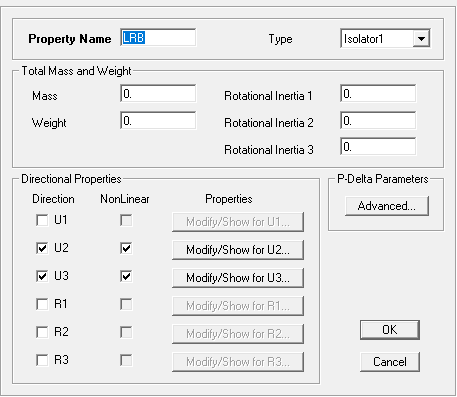
程式碼邏輯同第二題

接著進入模型，模擬 LRB 性質

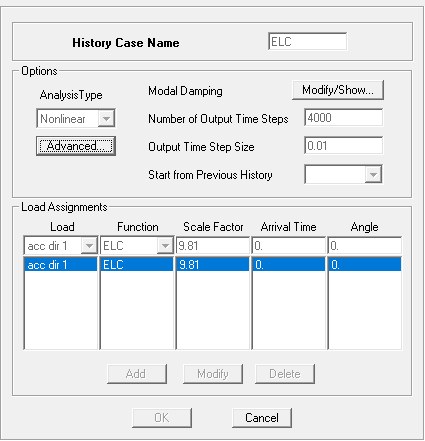
* 首先，底下加一層隔震墊。



* 設定 LRB 性質
* 由於 ETABS 9 U1 方向不能 fix 所以是在模型頂端設定 roller。



* 輸入正規化後的地震歷時



* 畫出頂樓加速度歷時



* 隔震墊位移歷時



* Maximum Drift Ratio



* 遲滯迴圈



clc; clear; close all;

periods = filename\_to\_array('DA\_BARE\_v1', 3, 1, 10);

acce\_bare = filename\_to\_array('DA\_BARE\_v1', 3, 3, 10);

disp\_iso = filename\_to\_array('DA\_ISO\_v3', 3, 2, 10);

acce\_iso = filename\_to\_array('DA\_ISO\_v3', 3, 3, 10);

force\_hysteresis = filename\_to\_array('hysteresis\_v2', 3, 2, 10);

disp\_hysteresis = filename\_to\_array('hysteresis\_v2', 3, 3, 10);

figure;

plot(periods, acce\_bare, periods, acce\_iso);

title('RF acceleration responses');

xlabel('T(sec)');

ylabel('acceleration(m/s^2)');

legend('bare frame', 'isolated structure', 'Location', 'northeast');

figure;

plot(periods, disp\_iso);

title('displacement responses of isolation layer');

xlabel('T(sec)');

ylabel('displacement(m)');

figure;

plot(disp\_hysteresis, force\_hysteresis);

title('hysteresis loop');

xlabel('displacement(m)');

ylabel('force(tf)');

axis([-0.15 0.35 -0.4 0.6]);

附錄：

function *data* = filename\_to\_array(*filename*, *total\_col*, *array\_col*, *headlines*)

*%*

*% 適用於被動控制給的 file\_input.*

*%*

*% @since 3.1.0*

*% @param {string} [filename] 檔案名稱.*

*% @param {number} [total\_col] 總共有幾欄.*

*% @param {number} [array\_col] 要回傳第幾欄.*

*% @param {number} [headlines] 忽略標題.*

*% @return {array} [data] 加速度歷時資料.*

*% @see ignore\_headlines*

*%*

if nargin == 3

headlines = 0;

end

fileID = fopen((filename + ".txt"), 'r');

ignore\_headlines(fileID, headlines);

repeat\_f = repmat('%f', 1, total\_col);

A = fscanf(fileID, repeat\_f, [total\_col Inf]).';

fclose(fileID);

data = A(:, array\_col);

end

function [] = ignore\_headlines(*fileID*, *headlines*)

*%*

*% 忽略標題.*

*%*

*% @since 1.0.0*

*% @param {number} [fileID] fileID.*

*% @param {number} [headlines] 要忽略的行數.*

*%*

for index = 1 : headlines

fgetl(fileID);

end

end

function [*u*, *v*, *a*] = newmark\_beta\_calculation(*m*, *c*, *k*, *up*, *vp*, *ap*, *dp*, *dt*, *gamma\_*, *beta\_*)

*%*

*% newmark beta calculation*

*%*

*% @since 1.0.0*

*% @param {number} [m] 質量.*

*% @param {number} [c] 阻尼.*

*% @param {number} [k] 勁度.*

*% @param {number} [up] 前一個點的位移.*

*% @param {number} [vp] 前一個點的速度.*

*% @param {number} [ap] 前一個點的加速度.*

*% @param {number} [dp] 位移.*

*% @param {number} [dt] 時間間隔.*

*% @param {number} [gamma\_] 常數.*

*% @param {number} [beta\_] 常數.*

*% @return {number} [u] 位移.*

*% @return {number} [v] 速度.*

*% @return {number} [a] 加速度.*

*%*

*%------------------*

*% Calculate effective stiffness*

*%------------------*

k\_s = k + gamma\_ / (beta\_ \* dt) \* c + 1 / (beta\_ \* (dt ^ 2)) \* m;

*%------------------*

*% Compute coefficients a and b*

*%------------------*

a = 1 / (beta\_ \* dt) \* m + gamma\_ / beta\_ \* c;

b = 1 / (2 \* beta\_) \* m + dt \* (gamma\_ / (2 \* beta\_) - 1) \* c;

*%------------------*

*% Calculate effective excitation and all responses*

*%------------------*

dp\_s = dp + a \* vp + b \* ap;

*%~~*

du = dp\_s / k\_s;

*%==*

dv = gamma\_ / (beta\_ \* dt) \* du - gamma\_ / beta\_ \* vp - dt \* (1 - gamma\_ / (2 \* beta\_)) \* ap;

da = 1 / (beta\_ \* (dt ^ 2)) \* du - 1 / (beta\_ \* dt) \* vp - 1 / (2 \* beta\_) \* ap;

*%~~*

u = up + du;

v = vp + dv;

a = ap + da;

end

function [*u*, *v*, *a*] = newmark\_beta(*ag*, *time\_interval*, *damping\_ratio*, *tn*, *method*)

*%*

*% newmark beta.*

*%*

*% @since 1.0.0*

*% @param {array} [ag] input 的地震力歷時資料.*

*% @param {number} [time\_interval] 時間間隔.*

*% @param {number} [damping\_ratio] 阻尼比.*

*% @param {number} [tn] 自然週期.*

*% @param {string} [method] 'average' or 'linear'.*

*% @return {array} [u] 位移.*

*% @return {array} [v] 速度.*

*% @return {array} [a] 加速度.*

*% @see newmark\_beta\_calculation*

*%*

*% average Acceleration Method*

gamma\_ = 1 / 2;

switch method

*% average Acceleration Method*

case 'average'

beta\_ = 1 / 4;

*% linear Acceleration Method*

case 'linear'

beta\_ = 1 / 6;

end

wn = (2 \* pi) / tn;

m = 1;

c = 2 \* damping\_ratio \* wn \* m;

k = (wn ^ 2) \* m;

p\_t = - m \* ag;

u = zeros(size(p\_t));

v = zeros(size(p\_t));

a = zeros(size(p\_t));

a(1) = 1 / m \* (p\_t(1) - c \* v(1) - k \* u(1));

ag\_length = length(ag);

for ag\_index = 2 : ag\_length

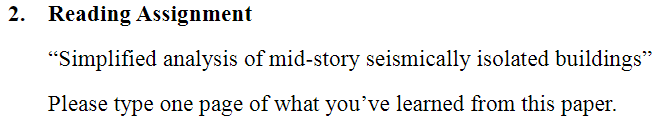
dp = p\_t(ag\_index) - p\_t(ag\_index - 1);

[u(ag\_index), v(ag\_index), a(ag\_index)] = newmark\_beta\_calculation(m, c, k, u(ag\_index - 1), v(ag\_index - 1), a(ag\_index -1), dp, time\_interval, gamma\_, beta\_);

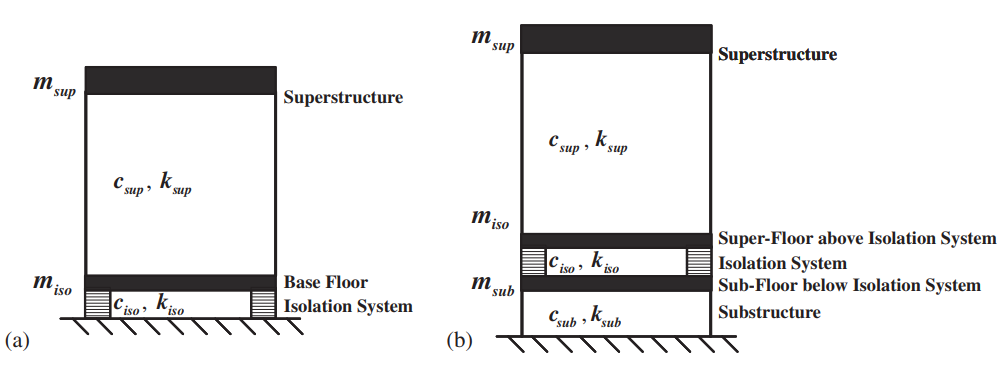
end

a = a + ag;

end



這次 reading assignment 說中間層隔震是越來越受到歡迎的耐震設計。這篇 paper中，中間層隔震建築物的動態特徵與耐震反應是使用簡化的三個 lumpedmass structural model，相較於底層隔震如下圖。



從參數研究中，發現上層結構的頻率和下層結構的頻率會顯著影響隔離的頻率和阻尼。甚至，下層結構的質量和勁度比上層結構的影響還要大。另外，根據反應譜分析，高模態的反應對於下層結構的 story shear force 有顯著影響。所以根據耐震設計規範的 lateral force distribution可能不適用於中間層隔震，中間層隔震需要包含高模態的效應。