

鋼箱型橋梁非線性動力歷時分析 (LRB隔震單元)

台灣邁達斯技術部製作 www.midasuser.com.tw

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概要



本例題介紹使用 midas Civil 的非線性動力歷時分析功能來進行含有 LRB隔震單元的建模分析方法。

例題使用的是簡化的鋼箱型橋梁模型,橋梁結構係由主梁、橫梁和橋 墩構成。橋臺部分由於勁度很大,不另外建立模型而僅輸入邊界條件來模 擬;基礎部分假設完全固定,也只依邊界條件來定義。

以下是鋼橋梁的一些基本資料。

跨	徑:45 m + 50 m + 45 m = 140 m
橋	寬:11.4 m
主梁刑	ジ式:鋼構箱型梁
鎁	材:CNS(S) SM490(主梁)
混 凝	土:CNS(RC) C280(橋墩)

[單位:mm]



圖1. 橋梁剖面圖

設定操作環境及定義材料和斷面

開啟新檔 (L New Project) ·以'Response.mcb'為檔名儲存(Save)。

File		ew	Project.	•••
File	Save	R	esponse)

將單位系統設定為 Tonf, m。

Tools	/	Unit	System	

Length > m ; Force (Mass) > Tonf \dashv

定義材料

分別輸入主梁和橋墩的材料資料。

主選單 Properties>Material Properties Add
Material ID (1); Type of Design > Steel
Standard > $CNS06(S)$; $DB > SM490$
Material ID (2); Type of Design > Concrete
Standard > $CNS560(RC)$; $DB > C280$ OK

Seneral		-		General	-			10	
Material ID 1	Name	SM490		Material ID	2		Name	C280	
lasticity Data				Elasticity Data					
Type of Design	▼ Steel			Type of Design	Concrete	•	Steel		
pace	Standard	CNS06(S)	<u> </u>		Teonarea		Standard		Ŧ
	DB	SM490	-		-		DB		Ŧ
	Concrete						Concrete		
	Standard		<u></u>				Standard	CNS560(RC)	•
Type of Material		Code	~	Type of Materia				Code	Ŧ
Isotropic C Orthotrop	DB		~	(Isotropic	C Ort	hotropic	DB	C280	-
Steel				Steel					
Modulus of Elasticity : 2.0400	le+007 tonf/m^2			Modulus of Elast	icity :	0.0000e+000	tonf/m^2		
Poisson's Ratio :	0.3			Poisson's Ratio	: [0			
Thermal Coefficient : 1.100	0e-005 1/[C]			Thermal Coefficient	ent: [0.0000e+000	1/[C]		
Weight Density :	7.85 tonf/m^3			Weight Density	: [0	tonf/m^3		
Use Mass Density:	0.8005 tonf/m^3/q			🔲 🔲 Use Mass De	nsity:	0	tonf/m^3/q		
Concrete				Concrete					
Modulus of Elasticity : 0.0000	le+000 tonf/m^2			Modulus of Elast	icity :	2.4923e+006	tonf/m^2		
Poisson's Ratio :	0			Poisson's Ratio	: [0,167			
Thermal Coefficient : 0.0000	e+000 1/[C]			Thermal Coefficient	ent :	1.1000e-005	1/[C]		
Weight Density :	0 tonf/m^3			Weight Density	: [2.4	tonf/m^3		
🗖 Use Mass Density:	0 tonf/m^3/q			Use Mass De	nsity:	0.2447	tonf/m^3/q		
Plasticity Data				Plasticity Data					
Plastic Material Name NONE	•			Plastic Materia	I Name	NONE	•		
hermal Transfer				Thermal Transfer					
Specific Heat : 0	cal/tonf*[C]			Specific Heat	: 1	D	cal/tonf*[C]		
Heat Conduction : 0	cal/m*hr*[C]			Heat Conduction	: 1	0	cal/m*hr*[C]		
amping Ratio : 0.05				Damping Ratio	. 6	0.05			

圖2. 定義材料

定義斷面

♀ 輸入斷面尺寸 時,若只輸入tf1,

不輸入tf2,則 tf2 與 tf1相同。 使用 User 自行輸入主梁、橫梁以及橋墩的斷面資料。

主 梁: 箱型梁 2000×2500×12×16/18
 橫 梁: I 型鋼 1500×300×12×12/12
 柱 帽: 長方形斷面 1500×1500
 橋 墩: 圓形斷面 1500

Section ID (4); Name (Column); 斷面形狀 > Solid Round; User (開),輸入: D (1.5)



3

建立結構模型

主梁及橫梁模型

使用 **Create Nodes** 建立節點後,透過 **Extrude Element** 功 能將節點依 28@5m 擴展成梁單元來建立主梁。

🛄 Top ; 🖾 Auto fitting (開)
主選單 Node/Element>Nodes> 🛹 Create Nodes
Coordinates (0 , 0 , 0)
Copy > Number of Times (1)
Distances (dx, dy, dz) > (0, 7.7, 0) \square
主選單 Node/Element>Elements> III Extrude Select All Extrude Type > Node→Line Element Element Attributes > Element Type > Beam Material > 1: SM490 ; Section > 1: Girder
Generation Type > Translate
Translation > Equal Distance
dx, dy, dz (5, 0, 0) ; Number of Times (28) $^{\text{Apply}}$

View Structure Node/Element	Properties Boundary L	Civil 2013 - [E:\02_MII oad Analysis Results	DAS_Works\00_Civil2013_Ma PSCPushoverDesign	nuals\04_Basic\BoxSteel_Re Query Tools	esponse *] - [Model View]		_ □ × Help × _ ∂ ×
Create Nodes	● Mirror N = 0 1 Scale M = 0 1 G = 0 Nodes Table	Create Elements	Extrude Divide Merge 1	Nersect Elements Delete Rotate ↓ Mirror Elements	Auto-mesh Map-mesh Change Parameters	Elements Table	
((1) '€ '¥ '⊆ K(B) (2) ±	1 4 4 8 1 1	- *	· 10 12 = 1				
Tree Menu I X X Irode Elements Image: Second Secon	Hi Base	■IH 					81 = 1 = 1 = 1 = 1 = 1 = 1 = 1 = 1 = 1 =
Generation Type Generation Type Generation Type Generation Type Generation Type Generation Translate Generation Type Generation Type G	4 Nodel View/ Message Window	essage / Analysia Messag	e /				
For Help, press F1		Node-35	U: 85, 0, 0	G: 85, 0, 0	tonf • m • •	None 🕶 👔 🚺 0	÷/2÷

圖4. 輸入主梁

輸入橫梁

在主梁起點處使用 📝 Create Elements 功能連接兩個節點建立一個橫梁後,可透過將該梁依橋梁縱向複製來建立其餘的橫梁。

 Node Number (開)
 主選單 Node/Element>Elements> └ Create Elements... Element Type > General beam/Tapered beam Material > 1:SM490 ; Section > 2:Cross ; Beta Angle (0) Nodal Connectivity (1, 2)[®] Apply
 主選單 Node/Element>Elements> □ Translate... I Select Recent Entities 選取前次建立的物件單元 Mode > Copy ; Translation > Equal distance dx, dy, dz (5, 0, 0)[®]; Number of Times (28)

View Structure Node/Element	Properties Boundary Lo	Crvil 2013 - [E:\02_MIDAS_ ad Analysis Results PS	_Works\00_Civil2013_Manuals\04 SC Pushover Design Oue	4_Basic\BoxSteel_Res rv Tools	iponse *] - [Model View]		_ ⊟ × \$\$ Help * _ ∂ ×
Create Nodes	● Mirror A G Scale Modes *** Nodes *** Table	Create Bements	t∐ X kP X xtrude Divide Merge Intersect	Delete	Auto-mesh Map-mesh Map-mesh Change Parameter	e Elements ers Table	
		- 12		9 046		9 1 111 1 222	
Tree Menu a × Node Element, Boundary Mass Load	Hi Base	- Hi				008 000	
Translate Bements							0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Mode G ⊆ Copy Move Translation □ □ Number of Trans: 1 □ • Equal Distance □ □		8 10 12 14 16 1 7 9 11 13 15 1	18 20 22 24 26 28 17 19 21 23 25 27	30 32 34 36 29 31 33 35	38 40 42 44 4 37 39 41 43 4	6 48 50 52 54 15 47 49 51 53	4 56 58
ax.ov/ad: [5.0,0 m Number of Times: 28							
(Example : 5, 3, 4, 5, 3⊕5,0) Direction Vector : 0, 0, 0 m Material Inc. : 0 m Rep.							10 0 0 0 0
Becknard Implementation Thickness Inc.: 0 Cottets Free Nodes Intersect Node Copy Node Attributes	4 Model View/ Message Window			_		_	0°
Copy Element Attributes	>>						
Tree Menu Task Pane	Command Me	ssage / Analysis Message /			•		•
For Help, press F1	e Avenheeten enke	Node-41 U: 1	00, 0, 0 G: 100,	0, 0	tonf 💌 m 💌 🖞 🖞	🕨 nonx 🕶 🙎 🗾	0 - 1 2 -
				- STL			

圖5. 輸人積梁

輸入橋墩

如圖6所示·在橋墩的位置建立模型後·透過剛性連接(Rigid Link)來 模擬實際結構。橋墩的剖面如圖7所示。







圖7. 橋墩模型

剛性連接

選擇主梁支承處的節點·將其往 z 軸方向複製·產生要進行剛性連接的節點。(參考圖6)

Node Number (開); Node Number (關)
Select by Window (單元:選擇如圖8的單元19~38) ☑ Activate
Node Number (開) Iso View ; Node Number (開)
主選單 Node/Element>Nodes> [□] Translate
Mode > Copy ; Translation > Unequal distance
Axis $> z$; Distance (-1.25, -0.2, -0.75) Apply



圖8. 複製節點

在要建立橋墩和橫梁的位置產生節點。

- 主選單 Node/Element>Nodes> Nodes> Divide ... 建立橋墩柱的位置節點 Divide > Equal Distance (開); Number of Divisions (2) Nodes to Divide (67, 68) (69, 70)
 → 自動建立節點 71, 72
 主選單 Node/Element>Nodes> Translate...產生柱帽節點
 Select Single (節點 : 71, 72)
 - Mode > Copy ; Translation > Unequal distance Axis > y ; Distance (11.7/2, -11.7) \rightarrow 建立節點 73, 74, 75, 76

Select Previous

Axis > z ; Distance (-0.75, 7@-1) ______ → 建立墩柱節點 77~92



圖9. 輸入橋墩的節點

建立橋墩和橫梁

使用 📝 Create Elements 功能建立橋墩和橫梁。(參考圖7)

主選單 Node/Element>Elements> 🗾 Create	Elements
Element Type > General beam/Taper	ed beam
Material > 2:C280 ; Section > 3:C	oping
Beta Angle (0) ; Intersect > Nod	e (開) (圖10的①)
Nodal Connectivity (73, 75) 建	<u> </u>
Nodal Connectivity (74,76) [°] 建	立第
Material > 2:C280 ; Section > 4:C	olumn
Beta Angle (0) ; Intersect > Nod	e (開)
Nodal Connectivity (77,91) ⁶ 建	立第一個墩柱
Nodal Connectivity(78, 92) ³⁰ 建	立第一個墩柱



圖10. 建立橫梁和橋墩

輸入邊界條件

剛性連接

將在實際位置建立的主梁和支承、支承和橋墩分別使用 **剛性連接** 連接起來。(參考圖6)

🖸 Fit, 🔍 Zoom Window (放大第一個橋墩的橫梁部分)
主選單 Boundary> Rigid Link
Master Node Number (20) ⁶
Typical Types > Rigid Body
Copy Rigid Link (開); Axis > x ; Distance (50) \therefore Apply
Select Single (節點:59) Master Node Number (19) ^{个 Apply}
Select Single (節點: 68) Master Node Number (64) ^个 Apply
Select Single (節點: 67) Master Node Number (63) ^个 Apply
Select Single (節點: 77) Master Node Number (71) ^{^个 Apply}



圖11. 主梁和支承及橋墩間的剛性連接

♀ 已輸入的剛性連 接可進行複製。

輸入橫梁的梁端剛域

由於建模時所有的構件單元是以中心軸為基準相互連接的·故會有如 圖13所示的主梁和橫梁間由於主梁的梁寬導致的重複部分出現。對此可使 用 Beam End Offset 功能透過輸入剛域長度使程式在計算勁度時將該部 分的影響排除。

輸入梁端剛域長度的方法有整體座標系(Global)和單元座標系(Element) 兩種類型。若選擇整體座標系類型,則對於所輸入的剛域長度不考慮載重, 只針對扣除剛域後的單元長度計算勁度和自重。

若選擇單元座標系的話,只在計算勁度時排除輸入的剛域長度,而在 計算自重和施加載重時則將該部分包含在內。(參考 On-Line Help)

在此使用**單元座標系**來輸入剛域長度。此時由於需在梁單元的 i、j 端輸入軸向的剛域長度,故需事先確認梁單元的單元座標系方向。

▶ Activate All Left View ; Hidden (開)

主選單 Boundary>Beam End Offsets... Select by Window (單元:橫梁) Options > Add/Replace; Beam Offset > Type > Element RGDi (1.15); RGDj (1.15)



圖12. 輸入橫梁的剛域長度

輸入橋臺的支承節點

主梁與橋臺連接的支承部分將於後續使用非線性連接(Nonlinear Link) 來模擬。使用 Q Zoom Window 放大左右兩側橋臺的連接部分,建立節 點。

QZoom Window (放大左右兩側橋臺的橫梁部分) 主選單 Node/Element > Nodes > 🔽 Translate... **Select Single** (節點: 1, 2, 57, 58) Mode > Copy ; Translation > Unequal distance Axis > z; Distance (-1.25, -0.2) Apply

輸入橋臺與柱底的邊界條件

橋臺與柱底假設其完全固定,故束制各方向的自由度。

🔂 Hidden (關); 🛄 Iso View 主選單 Boundary>Supports> Define Supports...

Select Single (節點: 91, 92, 95, 96, 99, 100) Options > Add ; Support Type > D-All (開), R-All (開) _____ Apply ▶ Node Number (關)



圖13. 輸入邊界條件

ନ

的距離。

定義非線性連接單元

Nonlinear Link (LRB) 非線性連接特性值

Abutment 橋台 (LRB-A)

	Vertical	Longitudinal	Transverse	
	(垂直向)	(縱向)	(橫向)	
Direction	Dz	Dx	Dy	
Nonlinear	No	Yes	Yes	
	Linear Prope	rties		
Effective Stiffness	479100(design)	336.1(iteration)	336.1(iteration)	
Effective Damping	0	0	0	
Nonlinear Properties				
Stiffness	-	1099	1099	
Yield Strength	-	15.69	15.69	
Post yield Stiffness ratio	-	0.08917	0.08917	

Pier 墩柱(LRB-P)

	Vertical	Longitudinal	Transverse	
	(垂直向)	(縱向)	(橫向)	
Direction	Dz	Dx	Dy	
Nonlinear	No	Yes	Yes	
Linear Properties				
Effective Stiffness	1289000(design)	702.2(iteration)	702.2(iteration)	
Effective Damping	0	0	0	
Nonlinear Properties				
Stiffness	-	2204	2204	
Yield Strength	-	33.63	33.63	
Post yield Stiffness ratio	-	0.0862	0.0862	

輸入非線性連接 (LRB) 特性值

輸入鉛心橡膠隔震支承元件 (Lead Rubber Bearing isolators) 的特性值:

Boundary > 🕅	General Link >	General	Link Properties	
Define Ger	Define General Link Properties > Add			
Name (LR	B-A) ; Application	on type $>$ For	·ce;	
Property T	vpe > Lead Rul	ber Bearing	Isolator	
Self Weigh	T > Total Weight	t · (0)		
J. D	it > 10tal weigh	ι. (0)		
Linear Proper	ties			
DOF > D	bx, Dy, Dz (on)	; Effective	Stiffness (479100), (336.1), (336.1)	
Nonlinear Pro	operties			
DOF > D	y (on) ;	Properties		
Stiffness (1	k): (1099)			
Yield Stree	ngth : (15.69)			
Post Vield	Stiffness Patio(r)	·· (0.08017)		
I ost Heiu	Leen Denementen (((0.00917))		
Hysteretic	Loop Parameter ((α) : (0.5)		
Hysteretic	Loop Parameter ((β): (0.5) μ		
DOF > Dz	(on) ; P	roperties	(同 Dy 步驟輸入數值)	
DOF > D z	(on) ; P	roperties	(同 Dy 步驟輸入數值)	
DOF > D z	; (on) ; P	roperties	(同 Dy 步驟輸入數值)	
DOF > Dz	(on) ; P	roperties	(同 Dy 步驟輸入數值) ★ [○] Shear Spring in Lead Rubber Bearing Isolator Nonlinear Prometties	
© Define General Link Properties	roperty Type Description	ad	(同 Dy 步驟輸入數值)	
DOF > Dz Define General Link Properties Name Application Type Pr	roperty Type Description	ed ad	(同 Dy 步驟輸入數值)	
DOF > Dz	roperty Type Description	Ad Dele	(同 Dy 步驟輸入數值)	
DOF > Dz o Define General Link Properties	roperty Type Description	Ad Dele	(同 Dy 步驟輸入數值) Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 15,69 tonf/m Vield Stiength (Fy) : 15,69 tonf Post Vield Stiffness Ratio (r) : 0,06917 Hysteretic Loop Parameter (a) : 0.5	
DOF > Dz • Define General Link Properties Name Application Type • Add/Modify General Link Prop	roperty Type Description	ed ed ed get get	(同 Dy 步驟輸入數值) * Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : IUSS tonf/m Yield Strength (Fy) : IIS.69 tonf Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + lbl = 1.0	
DOF > Dz • Define General Link Properties Name Application Type • Add/Modify General Link Prop Name : LRB-A	roperty Type Description	Add Defe	(同 Dy 步驟輸入數值) * * * * * * * * * * * * * * * * * * *	
DOF > Dz • Define General Link Properties Name Application Type • Add/Modify General Link Prop Name : LIBE-A Application Type : • Element	erties	Add Mod Defe	(同 Dy 步驟輸入數值) Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 15,69 tonf Post Vield Stiffness Ratio (r) : 0.08917 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 A : alpha b : beta lal + lbl = 1.0	
DOF > Dz Offine General Link Properties Name Application Type Pr Add/Modify General Link Prop Name : LRB-A Application Type : Lead Rubber E Property Type : Lead Rubber E Proceedings : Lead Rubber E	reperty Type Description	Inclastic Hinge Properties	(同 Dy 步驟輸入數值) Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : IUSS tonf/m Vield Strength (Fy) : I5.68 tonf Post Vield Stiffness Ratio (r) : 0.08917 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + lbl = 1.0 (= thk.d+(l=t)E.c.	
DOF > Dz	erties	Inclastic Hinge Properties.	(同 Dy 步驟輸入數值) Stear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 15,69 tonf Post Yield Stiffness Ratio (r) : 0,00917 Hysteretic Loop Parameter (a) : 0,5 a: alpha b: beta lal + lbl = 1,0 f = r-k·d + (1-r) Fy·z a = k[L + c ² (r - i = (i =)) + 0)]ja	
c Define General Link Properties Name Application Type c Add/Modify General Link Property Name : LifkB-A Application Type : Property Type : Description : Self Weight : Total Weight :	roperty Type Description rerties Force Bearing Isolator Use Mass Total Mass Total Mass	inclastic Hinge Properties	(同 Dy 步驟輸入數值) • Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 1058 tonf/m Vield Strength (Fy) : 15,69 tonf Post Vield Stiffness Ratio (r) : 0,08917 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + b = 1,0 $f = r \cdot k \cdot d + (1-r) F_{y} \cdot z$ $\dot{z} = \frac{k}{F_y} [1 - z ^2 \{\alpha \cdot sign (d \cdot z) + \beta\}]d$	
DOF > Dz	erties Force Bearing Isolator Use Mass Total Mass	Inelastic Hinge Properties	(同 Dy 步驟輸入數值) Stiffness (k) : 10000 tonf/m Vield Strength (Fy) : 15,69 tonf Vield Strength (Fy) : 15,69 tonf Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + b = 1,0 f = r-k·d + (1-r) Fy·z z = k//(1- z ^2 (α · sign (d·z) + β)]d d	
DOF > Dz	erties erties	Inelastic Hinge Properties Control of the second s	(同 Dy 步驟輸入數值) Suffness (b) : 100000000000000000000000000000000000	
DOF > Dz	erties erties	Inelastic Hinge Properties	(同 Dy 步驟輸入數值) * • • • • • • • • • • • • • • • • • • •	
DOF > Dz	erties erties Bearing Isolator Bearing Isolator Effective Damping 0 tonf sec/m 0 tonf sec/m 0 tonf sec/m	Inelastic Hinge Properties	(同 Dy 步驟輸入數值) * Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : IIIS69 For Vield Stiffness Ratio (r) : (0.00917 Hysteretic Loop Parameter (a) : (0.5) Hysteretic Loop Parameter (b) : (0.5) a : alpha b : beta I al + Ibl = 1,0 $f = r \cdot k \cdot d + (1 - r) F_{y} \cdot z$ $z = \frac{k}{F_{y}} [1 - z ^{2} \{\alpha \cdot sign (d \cdot z) + \beta\}]d$	
DOF > Dz	erties erties	Inelastic Hinge Properties Inelastic Hinge Properties	(同 Dy 步驟輸入數值) * Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : IDSB tonf/m Vield Strength (Fy) : IDSB tonf Post Vield Stiffness Rato (r) : 0.00917 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + Ibl = 1.0 $f = r \cdot k \cdot d + (1 - r) F_{y} \cdot z$ $z = \frac{k}{F_{y}} [1 - z ^{2} \{\alpha \cdot sign (d \cdot z) + \beta\}]d$	
DOF > Dz	erties erties effective Damping O tonf sec/m tonf m sec/[rad]	Inclastic Hinge Properties Inclastic Hinge Properties	(同 Dy 步驟輸入數值) * • • • • • • • • • • • • • • • • • • •	

圖14. 輸入橋台的LRB-A 特性值

OK Cancel Apply

Dy: 0.5 Dz: 0.5

Distance Ratio From End I

OK Cancel

輸入墩柱的LRB元件特性值:

Boundary > 🕅 General Link > 🎫 General Li	ink Properties
Define General Link Properties > Add	
Name (LRB-P) ; Application type > Force	2:
Property Type $>$ Lead Rubber Bearing Is	olator
Self Weight > Total Weight \cdot (0)	
Linear Droparties	
DOF > Dx, Dy, Dz (on) ; Effective St	tiffness (1289000), (702.2), (702.2)
Nonlinear Properties	
DOF > Dy (on) ; Properties	
Stiffness (k) : (2204)	
Yield Strength : (33.63)	
Post Yield Stiffness Ratio(r) : (0.0862)	
Hysteretic Loop Parameter (α) : (0.5)	
Hysteretic Loop Parameter (β) : (0.5)	
Properties (
DOF > Dz (on) ;()	
* Define Reneral Link Prometties	Shear Soring in Lead Rubber Rearing Isolator
Define General Link Properties X	Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be	Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tont/m
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modfy	Shear Spring in Lead Rubber Bearing Isolator Stiffness (k) : 2204 tont/m Yield Strength (Fy) : 33.63 tonf
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modfy Delete	Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : [2204 tont/m Yield Strength (Fy) : [33,63 tont Post Yield Stiffness Ratio (r) : [0662 Husteretic (a) : [055
C Define General Link Properties Name Application Type Property Type Description Add RB-A Force Lead Rubber Be Delete Gose	Sthear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tonf/m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : 0862 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modify Delete Gose Add/Modify General Link Properties X	S Shear Spring in Lead Rubber Bearing Isolator × Nonlinear Properties stiffness (k) : 2204 tont/m Yield Strength (Fy) : 33.63 tont Post Yield Stringes Ratio (r) : 065 Hysteretic Loop Parameter (a) : 0.5 Arysteretic Loop Parameter (b) : 0.5 a : alpha b: beta [a] + [b] = 1,0
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modfy Delete Gose Add/Modify General Link Properties Name : LRB-P	• Shear Spring in Lead Rubber Bearing Isolator × Nonlinear Properties Stiffness (k) : 2204 Vield Strength (Fy) : 33.63 Post Vield Strength (Fy) : 0862 Hysteretic Loop Parameter (a) : 0.5 A: alpha b : beta 1al + 1bl = 1.0
Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modfy Delete Glose Add/Modify General Link Properties Name LEB-P Application Type: Element Force	Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tont/m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : .0862 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + Ibl = 1.0
Define General Link Properties Name Application Type Property Type Description Add LBB-A Force Lead Rubber Be Modify Delete Gose Add/Modify General Link Properties Amme : LRB-P Application Type : Element ● Force Property Type : Lead Rubber Bearing Isolator ▼ Inelastic Hinge Properties	Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : [2204] tont/m Yield Strength (Fy) : [33,63] tonf Post Yield Stiffness Ratio (r) : [.0062] Hysteretic Loop Parameter (a) : [0.5] Hysteretic Loop Parameter (b) : [0.5] a : alpha b : beta lal + b = 1,0
Define General Link Properties Name Application Type Property Type Description Add LBB-A Force Lead Rubber Be Modify Delete Gose Add/Modify General Link Properties Ame EIRB-P Application Type Element Force Property Type Lead Rubber Bearing Isolator Inelastic Hinge Properties Description Self Wainte Self Wa	• Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : [2204] tont/m Yield Strength (Fy) : [33,63] tonf Post Yield Stiffness Ratio (r) : [0662] Hysteretic Loop Parameter (a) : [0.5] Hysteretic Loop Parameter (b) : [0.5] a : alpha b : beta lal + b = 1,0 $f = r \cdot k \cdot d + (1 - r) F_y \cdot z$
C Define General Link Properties Name Application Type Property Type Description Add Undfy Delete Gose Add/Modify General Link Properties Name : LRB-P Application Type : Element ● Force Property Type : Lead Rubber Bearing Isolator ▼ Inelastic Hinge Properties Description : Self Weight Use Mass Total Weight 0 tonf Total Wass 10 tonf/g	Sifter Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tont/m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) :
C Define General Link Properties Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Define Cose Add/Modify General Link Properties Add Defete Cose Add/Modify General Link Properties Name : LRB-P Application Type : Lead Rubber Bearing Isolator Inelastic Hinge Properties Description : Self Weight Total Weight Total Weight Total Weight . . Nonlinear Properties	S Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 ton//m Yield Strength (Fy) : 33.63 ton/ Post Yield Stiffness Ratio (r) : 0062 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + lbl = 1.0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\dot{\mathbf{z}} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^2 \{ \boldsymbol{\alpha} \cdot \operatorname{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta \}] \mathbf{d}$
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modify Delete Cose c Add/Modify General Link Properties Y Name : Cose Cose c Add/Modify General Link Properties Y Name : Self Weight Y Name : Lead Rubber Bearing Isolator Y Inclastic Hinge Properties Description : Self Weight Use Mass Total Weight Total Weight tonf/g Linear Properties Nonlinear Properties DOF Effective Stiffness Effective Damping DOF DoF	S Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 ton//m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : 0062 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta a + b = 1,0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\dot{\mathbf{z}} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^{2} \{ \boldsymbol{\alpha} \cdot \operatorname{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta \}] \mathbf{d}$
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modify Delete C Add/Modify General Link Properties Y Delete Close c Add/Modify General Link Properties Y Name : Link Properties Y Name : Link Properties Y Inelastic Hinge Properties Y Description : Self Weight Use Mass Total Mass : Uonf/g Linear Properties Doff Total Mass : Uonf/g Doff Doff DOF Effective Stiffness Effective Damping Doff Doff Dx Properties	Sittiness (k) : 2204 ton//m Vield Strength (Fy) : 33.63 Hysteretic Loop Parameter (a) : 0.5 a : alpha b : beta I al + Ibl = 1.0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\dot{\mathbf{z}} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^{2} \{ \boldsymbol{\alpha} \cdot \operatorname{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta \}] \mathbf{d}$
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be, Modify Delete C Add/Modify General Link Properties Y Delete Cose c Add/Modify General Link Properties Y Name Inclastic Hinge Properties Name : LRB-P Property Type Lead Rubber Bearing Isolator Y Inclastic Hinge Properties Description : Self Weight Use Mass Total Mass : Uonf/g Linear Properties DOF Effective Stiffness Effective Damping DOF DoF DOF Effective Stiffness Effective Damping Dx Properties Dx DD7 122 Ind/m 0 tonf sec/m Dx Properties>>	Sittiness (k) : 2204 ton//m Vield Strength (Fy) : 33.63 Hysteretic Loop Parameter (a) : 0.5 a : alpha b : beta lal + lbl = 1,0 $f = r \cdot k \cdot d + (1 - r) F_{y} \cdot z$ $\dot{z} = \frac{k}{F_{y}} [1 - z ^{2} \{\alpha \cdot sign(\dot{d} \cdot z) + \beta\}] \dot{d}$
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be, Modify Delete Cose c Add/Modify General Link Properties Y Name Element Force Property Type Element Force Property Type Lead Rubber Bearing Isolator Y Inelastic Hinge Properties Description : Self Weight Use Mass Total Mass : Uonf/g Linear Properties DOF Effective Stiffness Effective Damping Nonlinear Properties DOF DOF Effective Stiffness Effective Damping Dx Properties> Dx Properties>> Ø D2 T022 tonf/m 0 tonf sec/m Ø Dx Properties>> Ø D2 T022 tonf/m 0 tonf sec/m Ø DX Properties>> Ø D2 T022 tonf/m 0 tonf sec/m Ø DX Properties>>	Sifter Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 ton//m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : 0062 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + lbl = 1.0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\dot{\mathbf{z}} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^2 \{ \mathbf{\alpha} \cdot \operatorname{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta \}] \mathbf{d}$
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be, Modify Delete Cose c Add/Modify General Link Properties Y Delete Cose Cose c Add/Modify General Link Properties Y Inclastic Hinge Properties Y Name : LRB-P - - - - Application Type : Element • Force - - - Property Type : Lead Rubber Bearing Isolator V Inclastic Hinge Properties - <td>Stear Spring in Lead Rubber Bearing Isolator Stear Spring in Lead Rubber Bearing Isolator × Nonlinear Properties Stiffness (k) : 2204 tont/m Stiffness (k) : 33.63 tonf Post Yield Stiffness Ratio (r) : 005 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + I bl = 1.0 f = r·k·d + (1-r) Fy·z ż = $\frac{k}{F_y} [1 - z ^2 \{ \alpha \cdot sign (d \cdot z) + \beta \}] d$ f, Na Na f, Fy r·k k, K K</td>	Stear Spring in Lead Rubber Bearing Isolator Stear Spring in Lead Rubber Bearing Isolator × Nonlinear Properties Stiffness (k) : 2204 tont/m Stiffness (k) : 33.63 tonf Post Yield Stiffness Ratio (r) : 005 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + I bl = 1.0 f = r·k·d + (1-r) Fy·z ż = $\frac{k}{F_y} [1 - z ^2 \{ \alpha \cdot sign (d \cdot z) + \beta \}] d$ f, Na Na f, Fy r·k k, K K
c Define General Link Properties Add Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modify Delete Queete Queete Queete Queete c Add/Modify General Link Properties Y Name : LRB-P Application Type : Element Force Property Type : Lead Rubber Bearing Isolator Inelastic Hinge Properties Description Description :	S Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 ton//m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : 085 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta lal + lbl = 1.0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\dot{\mathbf{z}} = \frac{\mathbf{k}}{F_{\mathbf{y}}} [1 - \mathbf{z} ^{2} \{ \boldsymbol{\alpha} \cdot \operatorname{sign} (\mathbf{d} \cdot \mathbf{z}) + \boldsymbol{\beta} \}] \mathbf{d}$
c Define General Link Properties x Name Application Type Property Type Description Add LRB-A Force Lead Rubber Be Modify Delete Code c Add/Modify General Link Properties x X Modify Delete Code c Add/Modify General Link Properties x x X Modify Delete Code c Add/Modify General Link Properties x x X Modify Delete Code c Add/Modify General Link Properties x	S Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tonf/m Yield Strength (Fy) : 33.63 tonf Post Yield Stiffness Ratio (r) : 0052 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta [a] + [b] = 1,0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\mathbf{z} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^{2} \{\alpha \cdot \text{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta\}] \mathbf{d}$ $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (\mathbf{k} - \mathbf{r}) \mathbf{F}_{\mathbf{y}} \cdot \mathbf{z}$ $\mathbf{z} = \frac{\mathbf{k}}{\mathbf{F}_{\mathbf{y}}} [1 - \mathbf{z} ^{2} \{\alpha \cdot \text{sign} (\mathbf{d} \cdot \mathbf{z}) + \beta\}] \mathbf{d}$
C Define General Link Properties * Name Application Type Property Type Description LRB-A Force Lead Rubber Be Modfy Delete Glove Glove Glove • Add/Modify General Link Properties * * Name : LRB-P * Application Type : Element • Force Property Type : Lead Rubber Bearing isolator • Inelastic Hinge Properties Description : Description : . . . Self Weight : . . . Total Weight: : . . . Dof Effective Damping . . . DDF Effectives Stifness Effective Damping . . DDF Tectures: DDF Tectures: DDF Tectures: . . .	S Shear Spring in Lead Rubber Bearing Isolator Nonlinear Properties Stiffness (k) : 2204 tont/m Yield Strength (Fy) : 33.63 tont Post Yield Stiffness Ratio (r) : 0052 Hysteretic Loop Parameter (a) : 0.5 Hysteretic Loop Parameter (b) : 0.5 a : alpha b : beta I al + I bl = 1.0 $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{y} \cdot \mathbf{z}$ $\mathbf{z} = \frac{\mathbf{k}}{\mathbf{F}_{y}} \begin{bmatrix} 1 - \mathbf{z} ^{2} \{\alpha \cdot \text{sign}(\mathbf{d} \cdot \mathbf{z}) + \beta\} \end{bmatrix} \mathbf{d}$ $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{y} \cdot \mathbf{z}$ $\mathbf{z} = \frac{\mathbf{k}}{\mathbf{F}_{y}} \begin{bmatrix} 1 - \mathbf{z} ^{2} \{\alpha \cdot \text{sign}(\mathbf{d} \cdot \mathbf{z}) + \beta\} \end{bmatrix} \mathbf{d}$ $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{d} + (1 - \mathbf{r}) \mathbf{F}_{y} \cdot \mathbf{z}$ $\mathbf{z} = \frac{\mathbf{k}}{\mathbf{k}} \begin{bmatrix} 1 - \mathbf{z} ^{2} \{\alpha \cdot \text{sign}(\mathbf{d} \cdot \mathbf{z}) + \beta\} \end{bmatrix} \mathbf{d}$ $f = \mathbf{r} \cdot \mathbf{k} \cdot \mathbf{k}$ $\mathbf{k} = \mathbf{k} \cdot \mathbf{k}$

圖15. 輸入墩柱的LRB-P 特性值

建立非線性連接 (LRB)

建立支承處的非線性連接 Nonlinear Link (LRB) 單元。 本例題共有8處要設置LRB元件,以下按順序建立左側橋台、左側墩柱、右側 墩柱、右側橋台的非線性連接單元。

建立左側橋台的非線性連接單元:

```
Boundary / M General Link
General Link Property > LRB-A

Zoom Window (放大視窗以便建立左側橋台LRB-A的非線性連接)

2 Nodes (93, 95) <sup>①</sup>

2 Nodes (94, 96) <sup>①</sup>
```



圖16. 建立左側橋台LRB非線性連接

建立左側墩柱的非線性連接單元:

Boundary / M General Link General Link Property>LRB-P ② Zoom Window (放大視窗以便建立左側墩柱LRB-P的非線性連接) 2 Nodes (59, 63) 2 Nodes (60, 64)



圖17. 建立左側墩柱LRB非線性連接

建立右側墩柱的非線性連接單元:

Boundary / M General Link General Link Property > LRB-P ② Zoom Window (放大視窗以便建立右側墩柱LRB-P的非線性連接) 2 Nodes (61, 65) ^① 2 Nodes (62, 66) ^①



圖18. 建立右側墩柱LRB非線性連接

建立右側橋台的非線性連接單元:

Boundary / M General Link

General Link Property > **LRB-A**

Zoom Window (放大視窗以便建立右側橋台LRB-A的非線性連接)

2 Nodes (97, 99)

2 Nodes (98, 100)



圖19. 建立右側橋台LRB非線性連接

輸入靜載重

首先定義靜載重的載重狀況。



圖20. 輸入靜力載重狀況

假設靜載重為 1 tonf/m大小均佈載重,用Element Beam Loads 輸入。

```
Left View
Load>Beam Load>Element ...
Select Window (單元:主梁 · 圖17的①)
Load Case Name > DL ; Options > Add
Load Type > Uniform Loads
Direction > Global Z ; Projection > No
Value > Relative ; x1 (0) ; x2 (1) ; w (-1) Apply
```



圖17. 輸入主梁靜載重

輸入質量

程式中可定義 Structure Mass、Nodal Mass、Load to Mass 等三種類型的質 量數據資訊,各類型質量數據的輸入與應用可參閱on-line線上說明手冊。

當執行模型中具有非線性連接單元(Nonlinear Link)的動力歷時分析時,應 將質量分配給非線性連接單元連接的所有節點。本示範例中,將設定指派 "St ructure Mass"及 "Load to Mass"兩種類型的質量數據。

結構質量 Structure Mass

將模型中結構單元的自重轉換為質量。

Structure / *Structure Type* ☑ Conversion of Structure Self weight into Masses > Convert to X, Y, Z →

♦ Structure Type 🗶
Structure Type • 3-D • X-Z Plane • Y-Z Plane • X-Y Plane • Constraint RZ
Mass Control Parameter • Lumped Mass Consider Off-diagonal Masses • Consistent Mass Convert Self-weight into Masses
Gravity Acceleration : 9.806 m/sec ² Initial Temperature : 0 [C] Align Top of Beam Section with Center Line (X-Y Plane) for Display Align Top of Slab(Plate) Section with Center Line (X-Y Plane) for Display
OK Cancel

圖18. 將結構自重自動轉換為質量

外力轉換質量 Load to Mass

將先前輸入的外力(梁單元載重)轉換為質量。

Load / Static Loads Load	Type /	Loads to Masses	
Mass Direction $> X$, Y, Z		
Load Type for Conve	erting >	Beam Load (Line, Typical)	(on)
Gravity (9.806)	; Load	Case > Dead load	
Scale Factor (1)	; Add	Ļ	



圖19. 將梁單元載重轉換為質量

輸入歷時分析資料

歷時分析函數

本示範例將考慮對靜載重及地震載重的分析。不同於線性分析,疊加原理並不 適用於非線性分析結果中。因此若在分析後以線性組合疊加每次加載的獨立結 果是不正確的。對於歷時分析,我們需要考慮兩種載重同時作用下的受力結果。

為了反應歷時分析中的靜載重,我們將採用 Time Varying Static Load 時變靜 荷載功能。該功能基本上創建了在執行地震荷載的歷時分析時,靜載重到位作 用的條件。我們將建立兩種歷時分析函數,其中 'Ramp'函數指派給靜載重, 而El Centro函數數據用於地震荷載。

首先定義一個斜坡時間函數來表示靜載重作用。

Load / Seismic Load Type / Time History Analysis Data / in *Time History Functions*Add Time Function
Function Name (Ramp)
Enter the data as shown in
10.



圖20. 定義靜載重作用的斜坡時間函數

地震荷載資料採用 El Centro 歷時函數數據。

Load / Seismic Load Type / Time History Analysis Data / Add Time Function Earthquake Earthquake>1940 EL Centro Site, 270 Deg > OK > Apply Earthquake Earthquake>1940 EL Centro Site, 180 Deg > OK > OK







(b) El Centro Site 180Deg (Peak: 0.2142g)

圖21. El Centro 地震函數的輸入

輸入特徵值分析資料

一般而言,進行歷時分析的方法有模態疊加法(Modal Superposition Method) 與直接積分法(Direct Integration Method)兩種。本示範例中,我們將採用模 態疊加法進行分析,故在設定歷時分析載重前需先定義特徵值分析控制項。

對於特徵值分析 · MIDAS/Civil 提供了Eigen Vectors與Ritz Vectors Method兩 種解析方法。通常分析模型中使用非線性連接(Nonlinear Link)時,執行非 線性模態歷時分析比較建議使用Ritz Vectors方法。在此情況下,為了將非線 性連接的變形包含於初始荷載向量的計算,非線性連接的力向量必須包含在初 始載重向量中。

本例我們將採用Ritz Vectors方法分析並勾選"Include GL-link Force Vector"項目。

Load / Seismic / Time History Analys Eigenvalue Analysis Control	is Data / Load Cases
(或 Analysis > <i>Eigenvalue Analysis</i>	s Control)
Ritz Vectors	
Starting Load Vectors	
Load Case > Dead load	; Number of Generations > 1 Add
Load Case > Ground Acc X	; Number of Generations > 8Add
Load Case > Ground Acc Y	; Number of Generations > 8 Add



圖22. Eigenvalue Analysis Control 輸入資訊

設定歷時分析載重狀況

輸入靜荷載與地震荷載的歷時分析載重狀況。

定義"Dead Load"歷時分析載重。

Load / Seismic / Time History Analysis Data / Load Cases			
ADD			
Load Case Name (Dead Load)			
End Time (5) ; Time Increment (0.002)			
Step Number Increment for Output (5)			
Analysis Type > Nonlinear ; Analysis Method > Modal			
Damping > Direct Specification of Modal Damping			
Damping Ration for All Modes > Damping Ratio for All Modes (0.99) ⁹			
<u>ل</u>			

各項目的詳細內容說明請參閱On-line Help。	♀ 99% 阻尼比假設從開始(零秒)到
Add/Modify Time History Load Cases X	結束時間的阻尼為 99%。此設定是為
General Name : Dead Load Description : Analysis Type Analysis Method Time History Type Linear Original Direct Integration	了在使用時變靜荷載的非線性分析中讓 靜載重快速達到收斂。
Nonlinear Static	
End Time : 5 Sec Time Increment : 0,002 sec Step Number Increment for Output : 5	End Time:歷時分析的結束時間。
Order in Sequential Loading Subsequent to Initial Element Forces(Table) Cumulate D/V/A Besults Keen Einal Sten Loads Constant	工程師應考慮地震歷時數據的持續時間 來定義此處的End Time。
Damping Damping Method : Modal Direct Specification of Modal Damping Damping Ratio for All Modes : [.99 Modal Damping Overrides Mode Damping Ratio	Time Increment:時間增量。 歷時分析的時間增量顯著影響分析結果 的準確性。確定時間增量的常用經驗法 則是使用時間強制函數週期中較小者的 1/10或結構的固有頻率。本例由於所輸 入各筆數據資料的最高周期為0.02,因 此這裡使用0.002。
	Step Number Increment for Output: 產生歷時分析結果所需的分析時間步 長。以(輸出步數x時間增量)的間隔 產生的結果。如果指定 1.則每0.002 秒產生分析結果。如果指定 5.則每 0.01秒產生分析結果。此處考量合理的 分析速度,使用5。

圖23. Time History Load Case 輸入資訊

定義"Earthquake"地震荷載歷時分析載重。

Load / Time History Analysis Data / 🙀 Load Cases
Add
Load Case Name (Earthquake)
End Time (50) ; Time Increment (0.002)
Step Number Increment for Output (5)
Analysis Type $>$ Nonlinear ; Analysis Method $>$ Modal ^{Θ}
Order in sequential Loading > Subsequent to > Load Case > Dead Load
Damping > Damping Method > Modal
لم Damping Ratio for All Modes (0.05)

▲ 例亦可採用非線性直接積分方法
(Nonlinear Direct Integration Metho d)進行分析。採用直接積分法可不需 要進行RitzVector分析,但根據時間增 量的設定情況需要較多的分析時間。
Order in Sequential Loading
Order in Sequential Loading .
持續加載的順序。定義與連續加載的多
個時間歷時分析條件順序相關的數據。
Subsequent to: 選擇先前定義的歷時分析條件,該條件 在當前定義的歷時分析條件之前執行。 當前的歷時分析條件中的Analysis Type 分析類型與Analysis Method分析方法必 須與前一個荷載條件的分析類型、方法 一致。根據前面的分析條件,得到位 移、速度、加速度、構件力、非線性鉸 發展狀態和非線性連接的變化。
在加載的情況下,當勾選"Keep Final Step Loads Constant"項目時,在前一分析條件的最終階段下的加載將持續保持在當前的分析條件中。

圖24. Time History Load Case 輸入資訊

輸入地表加速度

接下來指定 El Centro 地表加速度的方向。

先前輸入兩個時間歷時地震數據函數 Elcent_t 和 Elcent_h 的最大加速度分別 為 0.2142g 和 0.3569g。在第一振動模態的方向上輸入與兩個最大加速度中的 較大者相關的地震數據。也就是說,該模型的第一振動模態是在Y方向上,為 該橋梁的橫向方向。 因此,在Y方向上施加更大的加速度數據(Elcent_h)。





圖25. 定義各方向地震資料

設定時變靜荷載

採用 *Time Varying Static Load* 時變靜荷載功能·設定在歷時分析中考慮靜 載重的作用。

Load / Seismic / Time History Analysis Data / Image: Time Varying Static Load Time History Load Case Name > Dead Load Static Load > Dead Load Function > Function Name > Ramp Operations > Add J



執行分析

完成邊界非線性分析的各項輸入後,即可執行分析。

Analysis / 🔨 Perform Analysis

查看分析結果

歷時分析結果圖形

使用 *Time History Graph* 歷時分析結果圖形功能查看作用於LRB隔震器上的 剪力和橋墩頂部的變位情況。

□ Initial View View / 県 Display 或 県Display from the Icon Menu Boundary 表單 General Link (on) ; General Link Number (on) ↓



圖 27. 初始模型視景與顯示 Nonlinear Link 編號

Result / Time History Result / T.H Graph/Text / 🖳 Time History Graph	
Define/Modify Function > General Link Deform/Force Add New Function	
Name (NL3-Shear-y)	
NL-Link No $> 3(nl:59,n2:63)$; Type $> J$ -Node Force	
Components > F -y ; Time History Load Case > Earthquake → Add New Function	
Name (NL3-Disp-y)	
NL-Link No > 3(nl:59,n2:63) ; Type>Deformation	
Components > D-y ; Time History Load Case > Earthquake	

查看非線性連接 General Link No.3 的縱向水平力和變形情況。

C_A 🗱 Help Y _ 🗃 🗙 Structure Node/Element Properties Boundary Load Analysis Results Pushover Design Query Tools
 Ar Influ. Lines *
 Image: T.H. Results *
 Image: T.H. Results *
 Image: T.H. Graph/Text *</t Text Output Results Time History Results Detail Mode shape Moving Load Bridae 1 **6 5 1 4 6** . ¹ ★ | ¹ ★ - : 12 12 = > & 12 : 13 4 G 🔍 🛛 🔺 🔛 🕅 Å Å - **1** | ____ Base • | ||]; ry Analysis Data Time History Result Function
General Link Deform/Force
Name: NL3-Shear-y GL-Link No, : 5 (n1:61,n2:65) • Type : Othermited Type : Other QK Cancel Apply e project will be saved by the auto-save feature Command Message / Analysis Message / nu 🛛 Task Pane U: 0, 7.7, 0 G: 0, 7.7, 0

圖 28. General link No.3 縱向水平力和變形

輸出LRB隔震器的磁滞圖形。

Result / Time History Result / T.H Graph/Text / Karl Time History Graph Check Function to Plot > NL3-Shear-y (on) Click Add from list Horizontal Axis > NL3-Disp-y Type of Display X Axis Decimal Pt. (4) ; Y Axis Decimal Pt. (1) Type > Time History Graph



圖 29. LRB隔震器的磁滯圖形

使用時間歷時圖形查看橋墩頂部的變位情況。

Result / Time History Result / T.H Graph/Text / Karaban Time History Graph
Define/Modify Function > Disp/Vel/Accel
Add New Function
Name: (Disp-Pier-Top)
Node Number: (77)
Type of Result > Displ.
Components > DX
Time History Load Case > Earthquake
Included Mode Number > All



圖 30. 設定顯示橋墩頂部變形的各項參數

查看時間歷時圖形確認橋墩頂部的變位。

Result / Time History Result / T.H Graph/Text / Time History Graph Check Function to Plot > Disp-Pier-Top (on) Click Add from list Horizontal Axis > Time Type of Display X Axis Decimal Pt. (1) ; Y Axis Decimal Pt. (4) Type: > Time History Graph ,J



圖 21. 橋墩頂部(節點 77)的歷時變位圖