Linear Time History Analysis



Program Version	Gen 2015 (v1.1)
Revision Date	05 Nov 2014

Overview

- Linear Time History Analysis
- <u>Model</u>
 - Unit : kN, m
 - Beam, Truss Element
 - Mass
- Load & Boundary Condition
 - Self Weight
 - Floor Load
 - Time history load
 - Support
- <u>Analysis</u>
 - Eigenvalue analysis
 - Linear modal time history analysis
- <u>Result Evaluation</u>
 - Displacement/Velocity/Acceleration
 - Member forces
 - Time history graph

Step 1. Define material properties.

Material Data		_		×
General Material ID 1		2	A53	
Elasticity Data Type of Design Steel	•	Steel Standard	ASTM(S)	- 4
		DB	Mail	- 5
		Standard		-
Type of Material	rthotropic	DB	Code	V
Steel				
Modulus of Elasticity :	1,9995e+008	kN/m²		
Poisson's Ratio :	0,3			
Thermal Coefficient :	6,5000e-006	1/[F]		
Weight Density :	77,09	kN/m⁰		
🔲 Use Mass Density:	7,861	kN/m³/g		
Concrete	0.0000000			
Modulus of Elasticity :	U, UUUUe+UUU	kN/m²		
Poisson's Hatio :	U			
Thermal Coefficient :	U, UUUUe+UUU	1/[F]		
Weight Density :		kN/m³		
Use Mass Density:	0	kN/m®/g		
Plasticity Data				
Plastic Material Name	NONE	•		
Thermal Transfer				
Specific Heat :	0	Btu/kN·[F]		
Heat Conduction :	0	Btu/m·hr·[F]		
Damping Ratio :	0,05			
(<mark>6)</mark>		Sancer Ap	

- 1. Properties > Material > Material Properties
- 2. Name: A53
- 3. Type of Design: Steel
- 4. Standard: ASTM(S)
- 5. DB: A53
- 6. Click [OK] Button.

Section Data

Section ID 1

Name W18×97

Offset : Center-Center Change Offset ...

Show Calculation Results...

_
_
-

Step 2. Define section properties.

AISC2K(US)

Built-Up Section

m

m

m

m

m

m

m

m

OK Cancel Apply

AISC10(US)

0,47244

r2 0

Consider Shear Deformation, Consider Warping Effect(7th DOF) 2

3

-

DB/User Value SRC Combined Tapered Composite

🔘 User

T H-Section

Sect, Name

Н

B1

tf1

B2

tf2

r1

DB

ection Data	
Section ID 2	T H-Section
Name W14X109	OUser
	Sect, Name W14X102 Built-Up Section Get Data from Single Angle DR Manage
	Sect. Name
12 2 → y	B1 0.37084 m tw 0.013335 m tf1 0.021844 m
4 3	tt2 0 m r1 0 m r2 0 m
	Consider Shear Deformation.
Offset: Center-Center Change Offset	Consider Warping Effect(7th DOF)

- 1. Properties > Section > Section Properties
- 2. DB: AISC2K(US)
- 3. Sect. Name: W18x97
- 4. Click [Apply] Button.
- 5. Sect. Name: W14x109
- 6. Click [Apply] Button.
- 7. Sect. Name: W6x20
- 8. Click [OK] Button.

Section Data	×
DB/User Value SRC	Combined Tapered Composite
Section ID 3	T H-Section -
Name W6X20	◯ User
7	Sect, Name 🗰 🗸 🗸
	Built-Up Section
H tw	Get Data from Single Angle
	DB Name AISC1U(US) - Sect, Name -
12	B1 0,152908 m
	tw 0,006604 m
5—+ Y	B2 0 m
4 3	tť2 0 m r1 0 m
	r2 0 m
	Consider Shear Deformation,
Offset : Center-Center	Consider Warping Effect(7th DOF)
Change Offset	
Show Calculation Results	SOK Cancel Apply

<u>Step 3. Create elements (1)</u>

Fra	me Wi	zard					_ X	
	Input	Edit	Insert					
	No. 1 2 3 4	X Co	0 0 8 16 24	No. 1 2 3 4	Z Co	oord. 1: 1:		
)	Distan	се	Repeat	Distant	ce	Rep	eat	(4
	8	m	3 🖃			4		
)		NOO X-U Noto X-U	oora, Coord		100 Z-U	oora. Coord		
		ow Dime	nsions) [De	iete Z-	Coord		
			Redraw &	Update (Data			
		•	•					
		•	•	•				
		•	•	•	•			
			•					
	z Lx	•						
	()K] _ C	lose		Арр	ly	

- 1. Structure > Wizard > Base Structures > Frame
 - "Input" tab
- 2. Distance: 8, Repeat: 3
- 3. Click [Add X-Coord.] Button
- 4. Distance: 6, Repeat: 4
- 5. Click [Add Z-Coord.] Button

5

<u>Step 3. Create elements (2)</u>

Fra	me Wiz	ard					×	J
	Input	Ed	lit Ins	sert			1	
	No.		Start	:		End	<u> </u>	
	1	1 (0,	0,0)		2 (8,0,0)			
	2	2 (8,	0,0)		3 (16,0,0)		
	3	3 (16	5,0,0)		4 (24,0,0)		
	4	5 (0,	0,6)		6 (8,0,6)			
	5	6 (8,	0,6)		7 (16,0,6)	-	
)	Ge	enera	ite Fram	e ([Delete		
1	📃 Sho	w El	ement N	lo, Bet	a Ang, 🏾 🏾) 0 💿 90	Deg.	
)	Materi	al	1	1: A	53	-		
	Sectio	п	1	(1: W	/18X97	•		
/			Bedra	aw & Ur	idate Data	a	-	
			Hodi		dato bat		— I	
				1		_		
				1		-		
				-	_	_		
	z							
	ILx							
		к		Clos		 Δορ	lu	
		11		0.03		(ripp	, y	
								-

- 1. Structure > Wizard > Base Structures > Frame
 - "Edit" tab
- 2. Click [Generate Frame] Button.
- 3. Beta Ang.: 90 Deg.
- 4. Material: 1: A53
- 5. Section: 1: W18x97

Step 3. Create elements (3)

	Frame Wizard		×	
	Input Edit	Insert		
2	0, 0, 5	Insert Point		
3	Alpha -90	Rotations Beta	Gamma 0 🔿	
	Intersect ₪	uplicate Nodes Frame Elements Origin Point		
	Show No	o. (1(0, 0, 0)	•	
	-			
4	ОК	Close	Apply	

- 1. Structure > Wizard > Base Structures > Frame
 - "Insert" tab
- 2. Insert Point: 0,0,5
- 3. Alpha: -90
- 4. Click [OK] Button.









•]...

... ...]

▼ [deg]

🔲 Ortho

Close

En ...]

Ref.



5. Nodal Connectivity: 26, mid point between node 6 and 7





Step 3. Create elements (6)

• ...

... ...

-X

.... •

...

▼ [deg]

📃 Ortho

Close

En

...

Ref.



2. Nodal Connectivity: 27, 41





Step 3. Create elements (7)



 Node/Element > Elements > Create Elements
 Nodal Connectivity: 30, mid point between node 10 and 11



Create Elements

– 🔄 Start Number

Element Type TRUSS

Node Number : 43

Element Number : 58

N1

Name

1 1: A53

Name

3 3: W6X20

💿 Beta Angle 🛛 💿 Ref, Point

Intersect: 📝 Node 📝 Elem

Create Intersecting Nodes Apply

Material No,

Section

Orientation

42, 31

x,y,z 👻

0

💿 Ref, Vector

Nodal Connectivity =

No,



Step 3. Create elements (8)

Ref.

◄]...

...

....

≁ X

-[...]

-....

▼ [deg]

🔲 Ortho

Close

En

...



11



<u>Step 4-1. Assign story data.</u>

-	m									1 1
	Module Name	Story I	Name	Level(m)	н	eight	(m)	Floo Diaphr	or agm	
*										
		ſ	Automatic	Generation of !	Story Da	ata				
			Unselec	ted List		Selec	cted List			
			No	Level		No	Name	Level	Height	
						2	2F	U 5	5 3,5	
• F	Story & Wind & S	Seismic /			->	3	3F 4F	8,5 12	3,5 3,5	
Aut	o Generate Story Data					5	5F	15,5	3,5	
					<-	ь	Hoof	19	U	
			Includ	te Seismic Aci	cidental	Ecce	entricity :	5 % c	if Plan Dime	nsio

	Module Name	Story Name	Level(m)	Height(m)	Floor Diaphragm	
	Base	Roof	19.00	0.00	Consider	
	Base	5F	15.50	3.50	Consider	
	Base	4F	12.00	3.50	Consider	
	Base	3F	8.50	3.50	Consider	
	Base	2F	5.00	3.50	Consider	
	Base	1F	0.00	5.00	Do not consider	
ĸ						

- 1. Structure > Building > Control Data > Story...
- 2. Click [Auto Generate Story Data...] Button.
- 3. Click [OK] Button.
- 4. Click [Close] Button.
- 5. Click *in the "Frequently used" toolbar.*







<u>Step 5-1. Define static load cases.</u>

Stat	ic Lo	oad Cas	ses		x
	Nar Typ Des	me De Scription	: DL : Dead Loa n :	1 (D)	3 Add
		No	Name	Туре	Description 🔶
	►	1	DL	Dead Load (D)	
	_	2	LL	Live Load (L)	
╎┝	*				
					E
	•			III	5 <u>Close</u>

- 1. Load > Static Load > Create Load Cases > Static Load Cases
- 2. Name: DL, Type: Dead Load (D)
- 3. Click [Add] Button.
- 4. Name: LL, Type: Live Load (L)
- 5. Click [Add] Button.
- 6. Click [Close] Button.



Step 5-2. Assign self weight.



- 1. Load > Static Loads > Structure Loads/Masses
 - > Self Weight
- 2. Load Case Name: SW
- 3. Self Weight Factor, Z: -1
- 4. Click [Add] Button
- 5. Click [Close] Button



Step 5-3. Define floor loads.

Floor Load Type		X
- Floor Load Type Name : Description :	Name & Description Retail	
Floor Load & Loa Load Case	ad Case Floor Load	
1. DL 2. LL 3. NONE 4. NONE 5. NONE 6. NONE 7. NONE 8. NONE		 Sub Beam Weight
Define	Load Case	Add
Retail	Description	Modify
		E Delete

1. Load > Static Loads > Initial Foreces/Misc. > Define Floor Load Type... 2. Name: Retail 3. Load Case: DL, Floor Load: -2.4 4. Load Case: LL, Floor Load: -4.8 5. Click [Add] Button. 6. Click [Close] Button.

1. Load > Assign Floor Loads...

2. Load Type: Retail

3. Distribution: One way

4. No. of Sub Beams: 2

6. Unit Self Weight: 10

11. Click [Active] button.

8. Distances: 4@3.5

9. Click on </u> .

Close

5. Sub-Beam Angle (A2): 90

7. Check on "Copy Floor Load".

10. Active Identity: Story, 2F, +Below

12. Click on "Nodes Defined Loading

Area" first and click node No.

17,1,4,20 and 17 consecutively.









🔘 X, Y, Z Load Type for Converting 🔽 Nodal Load 🔽 Beam Load Floor Load Version Pressure (Hydrostatic) Gravity: 9,806 m/sec² Load Case / Factor Load Case : DL ▼ ... Scale Factor: 1 Add LoadCase Scale DL 1 Modify Delete Remove Load to Mass Data Convert dead load 0K Cancel into messes

1. Structure > Type > Structure Type...

- 2. Convert Self-weight into Masses: Convert to X, Y
- 3. Click [OK] Button.
- 4. Load > Static Loads > Structure Loads/Masses > Nodal Masses > Load to Masses...

5. Mass Direction: X, Y

- 6. Load Case: DL, Scale Factor: 1
- 7. Click [Add] Button.
- 8. Click [OK] Button.
- 9. Query>Story Mass Table...

	1 mint	Translatio	onal Mass	Detetional Mana	Center of Mass			
Story (m)		X-Dir (kN/g)	Y-Dir (kN/g)	(kN/g·m²)	X-Coord (m)	Y-Coo (m)		
Use Groun	d Level : OFF	,						
Consider M	ass under Groun	d Level : ON						
Roof	19.0000	373.99484538	373.99484538	42857.2425	12.0000	11.9		
5F	15.5000	379.99305177	379.99305177	43731.4900	12.0000	11.9		
4F	12.0000	379.99305177	379.99305177	43731.4900	12.0000	11.99 11.99 11.99		
3F	8.5000	379.99305177	379.99305177	43731.4900	12.0000			
2F	5.0000	382.49262107	382.49262107	44102.7113	12.0000			
1F	0.0000	0.00000000	0.00000000	0.0000	0.0000	0.0		
	Total	1896.46662176	1896.46662176					
	ADDITIONA	L MASSES FOR TH	E CALCULATION OF	FEQUIVALENT SEIS	MIC FORCE			
Story	Level	Translatio	onal Mass					
Story	(m)	X-Dir	Y-Dir					
Roof	19.0000	0.0000000	0.00000000					
5F	15.5000	0.0000000	0.00000000					
4F	12.0000	0.0000000	0.00000000					
3F	8.5000	0.0000000	0.00000000					
2F	5.0000 0.00000		0.00000000					
1F	0.0000	8.49777569	8.49777569					
Note: The a from the flo two adjace	bove additional m or rigid diaphragm nt stories (ie, mas	asses represent ma n by *Diaphragm Dis sses on columns, br	asses in between tv connect command. races & walls) are p	wo adjacent stories For static seismican proportionally distribu	or on the node: alysis=the mas ited to upper/lo	s release ses bet wer sto		

Step 7-1. Define time history load case

Add/Modify Time History	Load Cas	es		×								
General Name : TX Analysis Type © Linear © Nonlinear	Analy Mo Dir Sta	Description : Analysis Method Modal Direct Integration Static										
End Time : 20 Step Number Incren	nent: 0,001 🚖	sec										
Order in Sequential I Cumulate D/V/A Damping Damping Method : Direct Specification Damping Ratio for Modal Damping O	Order in Sequential Loading Subsequent to Initial Element Forces(Table) Cumulate D/V/A Results V Keep Final Step Loads Constant Damping Damping Method : Modal Direct Specification of Modal Damping Damping Ratio for All Modes : 0.03											
Mod	Mode Damping Ratio											
Time Integration Par Newmark Method : Ocnstant Acceler Nonlinear Analysis (Perform Iteration	ameters Gamma ation C Control Pa	0,5 Linear Accelerat rameters Iteration Con	Beta 0,25 ion User Inp trols	E •								
4) 🖂	OK Ca	ncel Ap	ply								

- 1. Load > Seismic > Time History Analysis Data>Time History Load Cases...
- 2. Name: TX
- 3. Enter all the data referring to the left dialog.
- 4. Click [OK] Button.

Forcing Function Function Type	Add Time Function Add Sinusoidal Modify/Show Delete Close	 Load > Seismic > Time History Analysis Data>Time History Functions Click [Add Time Function] Button. Click [Earthquake] Button. 							
Add/Modify/Show Time History Functions Function Name Function Name Mormalized Scale Factor Scale Factor Time Function Maximum V Maximum V Scale Factor Maximum V Scale Factor Maximum V Scale Factor Maximum V Scale Factor Sca	Data Type Accel, Acceleration Force Moment Normal Gravity Graph Options r 1 9.806 m/sec ² X-axis log scale alue 0 9 F.F.T	4. Click [OK] Butt 5. Click [OK] Butt	on. on.						
1 1 1	Generate Earthquake Acceleration Record Earthquake : 1940, El Centro Site, 270 Deg Amplitude Scale : 1 Time Scale : 1940, El Centro Site, 270 Deg Peak , 0,3569 g Duration , 53,72 sec Imp 4 Ok C	Add/Modify/Show Time History Function Function Name Elcent_h Import Earthquake Heel Drop Time Function (sec) 1 0.0200 2 0.0400 3 0.0600 2 0.0400 3 0.0600 4 0.0800 5 0.1000 6 0.1200 0 0.0047 9 0.1800 10 0.2000 11 0.2200 12 0.2400	Time Function Data Type Normalized Accel, Acceleration Force Moment Normal Scale Factor Scale Factor Maximum Value g g 9,806 m/sec ² X-axis log sca F.F.T						

St	ep 7-3. Create groun
	Time History Analysis Data
	Ground Acceleration 🗸
2	Time History Load Case Name
3	Function for Direction-X Function Name : Elcent_h
	Function for Direction-Y Function Name : NONE Scale Factor : 1 Arrival Time : 0 sec
	Function for Direction-Z Function Name : NONE Scale Factor : 1 Arrival Time : 0 sec
4	Angle of Horizontal Ground Acc, 0 [deg]
	Case Name Angle of Acc,
5	Operations Add Modify Delete
	6 Close

Create ground acceleration.

sec

sec

sec

1. Load > Seismic > Time History Analysis Data> Ground Acceleration
2. Time History Load Case Name: TX
3. Function for Direction-X: Elcent_h
4. Angle of Horizontal Ground Acc.: 0
5. Click [Add] Button.
6. Click [Close] Button.

Step 8. Define eigenvalue analysis control data.

	Eigenvalue Analysis Control
	Type of Analysis © Eigen Vectors © Subspace Iteration © Lanczos
2	Eigen Vectors Number of Frequencies : 15 Frequency range of interest Search From : 0 To : 1600 [cps]
	Remove Eigenvalue Analysis Data 3 OK Cancel

1. Analysis > Analysis Control > Eigenvalue Analysis Control...

2. Number of Frequencies: 15

3. Click [OK] Button.

Step 9. Perform analysis.

1. Analysis > Perform Analysis

<u>Step 10-1. Check displacement/Velocity/Acceleration.</u>

Time History Results				1. Re.	sults >	> Tin	ne His	tory	> Tim	e Hist	ory Re	esults	> Disp	/Vel/A	ccel
Time History Displ/Vel/Acce															
Function		6													
		Mo 🕅	odel View	/ 🕅 Res	ult-[Time Histor	y Analysis([Displ/Vel/Accel)	×		-		-			
		Node	Load	Dx	UX Time/Step	Dv	Uy Time/Step	Dz	UZ Time/Step	Rx	x Time/Step	Rv	y Time/Step	Rz	Time/Step
				(m)	(sec)	(m)	(sec)	(m)	(sec)	([rad])	(sec)	([rad])	(sec)	([rad])	(sec)
Time History Load Case Name		1	TXMax TXMax	0.094467	5.8310 5.8310	0.054497	6.3210 6.3210	0.000131	6.6710 6.6450	0.007508	7.5790	0.013947	5.8390 5.8390	0.004199	7.5880
TX -		3	TXMax	0.094467	5.8310	0.016797	7.5880	0.000052	5.5040	0.002708	6.3320	0.012011	5.8390	0.004199	7.5880
Star 5 00		4	TXMax TXMax	0.094467	5.8310 5.8370	0.050391	7.5880	0.000137	5.4810 5.8620	0.007872	6.3350 7.5790	0.013947	5.8390 5.8470	0.004199	7.5880
Step 5,82 -		6	TXMax	0.072064	5.8370	0.018166	6.3210	0.007438	5.8650	0.002332	7.5800	0.009525	5.8480	0.004199	7.5880
Time Exection [Elevent h		8	TXMax	0.072064	5.8370	0.016797	7.5880	0.006801	6.2990	0.002459	6.3320	0.009525	5.8480	0.004199	7.5880
		9	TXMax	0.054065	6.6950	0.054497	6.3210	0.000136	5.8780	0.006892	7.5790	0.008088	6.6970	0.004199	7.5880
		10	TXMax	0.054065	6.6950	0.016166	7.5880	0.006023	5.6790	0.002234	6.3390	0.007149	6.6980	0.004199	7.5880
a little structure of the		12	TXMax	0.054065	6.6950	0.050391	7.5880	0.000142	5.4570	0.007220	6.3350	0.008088	6.6970	0.004199	7.5880
<u>╶┑┥╢║╊╊╖╢┺╖</u> ┲╍┲╖┺ <mark>╢╢╢╝</mark> ╢╢┝╈╎┟╍╔┝╬╬╔╬┲╼╖╍╼╖┱╴		14	TXMax	0.062917	6.6890	0.018166	6.3210	0.000042	5.8830	0.002254	7.5780	0.008073	6.6900	0.004199	7.5880
A DEALER AND A DEALER A DEALER AND A DE		15	TXMax TXMax	0.062917	6.6					-		-			midas Gen POST-PROCESSOR
		17	TXMax	0.071889	6.6										TH-DISPL/VEL/ACCEL
		18 19	TXMax TXMax	0.071889	6.6										RESULTANT
💿 Displ, 💿 Vel, 💿 Accel,		20	TXMax	0.071889	6.6										X-DIR= 7.943E-002 NODE= 129
		21	TXMax TXMax	0.000000	0.0										Y-DIR= 6.613E-003
Components		23	TXMax	0.000000	0.0			17							NODE= 132
💿 DX 💿 DY 💿 DZ		24	TXMax	0.000000	0.0										Z-DIR= 4.202E-003 NODE= 112
O DXY O DYZ O DXZ		26	TXMax	0.000000	0.0										COMB.= 7.971E-002
		27	TXMax	0.000000	0.0										NODE= 132
O DXYZ		29 30	TXMax TXMax	0.000000	0.0						3 X				SCALE FACTOR=
Type of Display		31	TXMax	0.000000	0.0										1.50021001
· · · · · · · · · · · · · · · · · · ·		32	TXMax TXMax	0.000000	0.0										
🗹 Deform 🛛 🔲 Undeformed		34	TXMax	0.000000	0.0										
🗖 Values 🦳 📝 Legend 🖳		35	TXMax	0.000000	0.0										
		37	TXMax	0.000000	0.0						3 N				
Animate []	4 1)\Disp	lacem	ent 🖌 Velo	city 🖌 i										
Start Time 0,01 sec															
End Time 20 sec															
						1						I ľ			Time Step : 5.82
Increment 0,01 sec							"								MIN : 41
Set Default Time							ų,			1	1			-	FILE: TIME HISTO~ UNIT: m
Ser Delault Time											IJ,				DATE: 11/06/2007
									JII.						X:-0.483
Apply Close															Y:-0.837 🏾 🏎
															Z: 0.259

Step 10-2. Check member forces



1. Results > Time History > Time History Graph/Text >

Step 10-3. Create time history graph (1)



Step 10-3. Create time history graph (2)



1. Select "112-DX".

- 2. Click [Add from List] button.
- 3. Horizontal Axis: Time
- 4. Click [Graph] button.

