« The use of Applied Element Method (AEM) to simulate the bridge collapse due to losing of support: *a case study* »

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SUMMARY

1 | WHY APPLIED ELEMENT METHOD *(AEM)*?

The **Applied Element Method** (AEM) of numerical analysis is a new method of analysis combines traits of both the Finite Element Method (FEM) and the Discrete Element Method (DEM). Simply said, while FEM can be accurate until element separation and DEM can be used while elements are separated, **AEM is capable of automatically simulating through separation of elements to collapse and debris prediction**. With more than two decades of continuous research and development AEM has been proven to be the only method that can track structural collapse behavior passing through all stages of loading; elastic, crack initiation and propagation in tension-weak materials, reinforcement yielding, element separation, element collision (contact), and collision with the ground and adjacent structures.

1 | WHY APPLIED ELEMENT METHOD *(AEM)*?

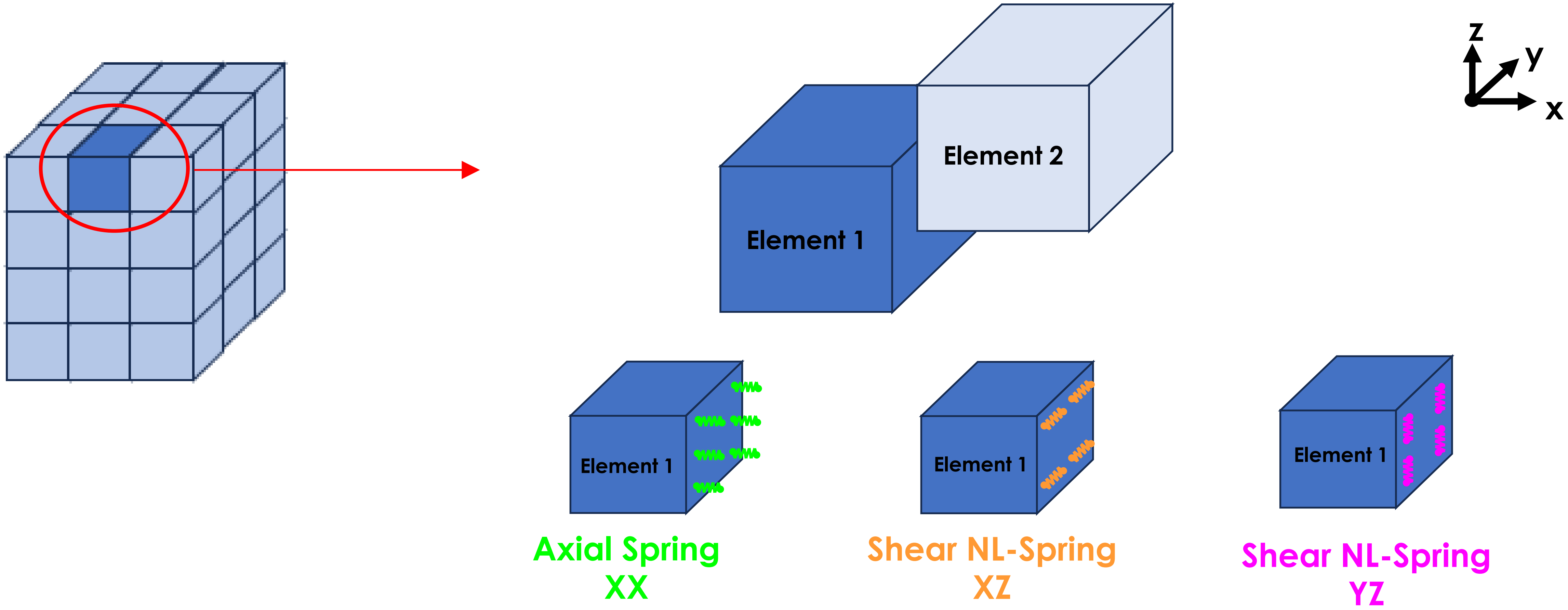
Structural Behavior from Birth to Death

	CONTINUUM			DISCRETE		
	Linear	Cracking, Yeld, Crushing	Buckling, Post-Buckling	Element Separation	Debris Falling As Rigid Bodies	Collision
F.E.M.		Requires assumptions by User		Can not be automated		
D.E.M.	Problems with Static Analysis and Continuum Materials					
A.E.M.						

NOT RELIABLE | RELIABLE | ACCURATE

1 | WHY APPLIED ELEMENT METHOD *(AEM)*?

The continuum is discretized into elements **connected together with nonlinear springs** that represent the material behavior



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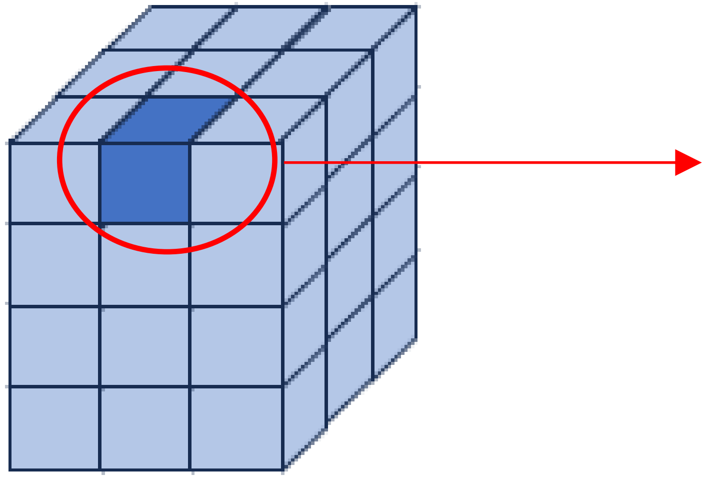

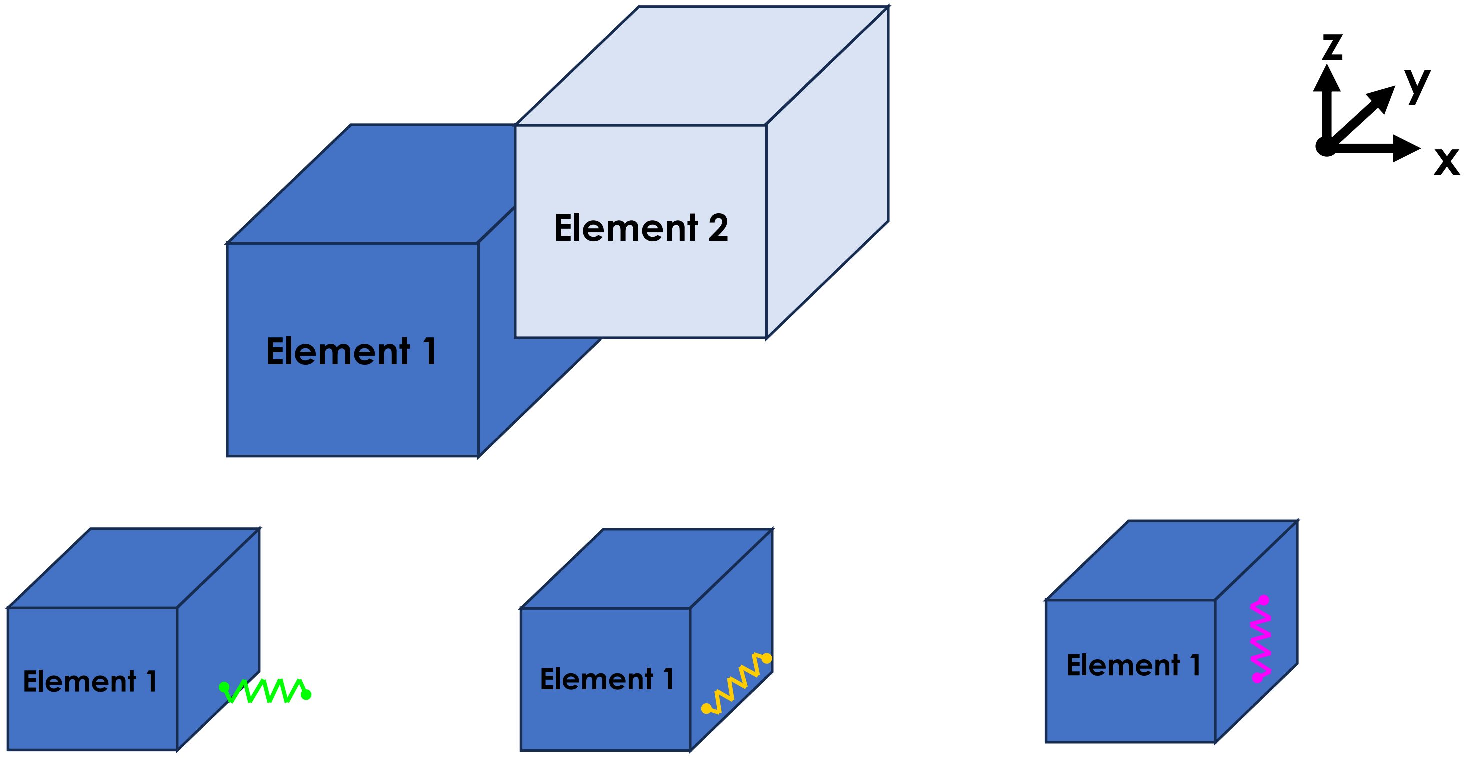

The **REINFORCEMENT** springs represent the **material properties**, exact **location**, and **dimensions of the REINFORCEMENT BARS**.

Axial Spring XX

Shear NL-Spring YZ

Shear NL-Spring XZ

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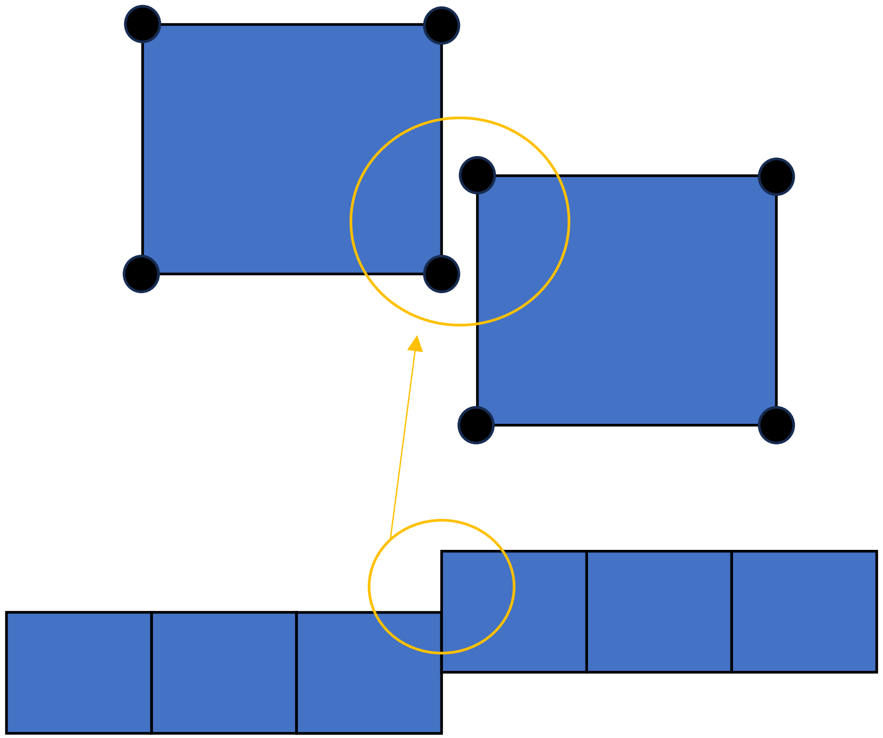
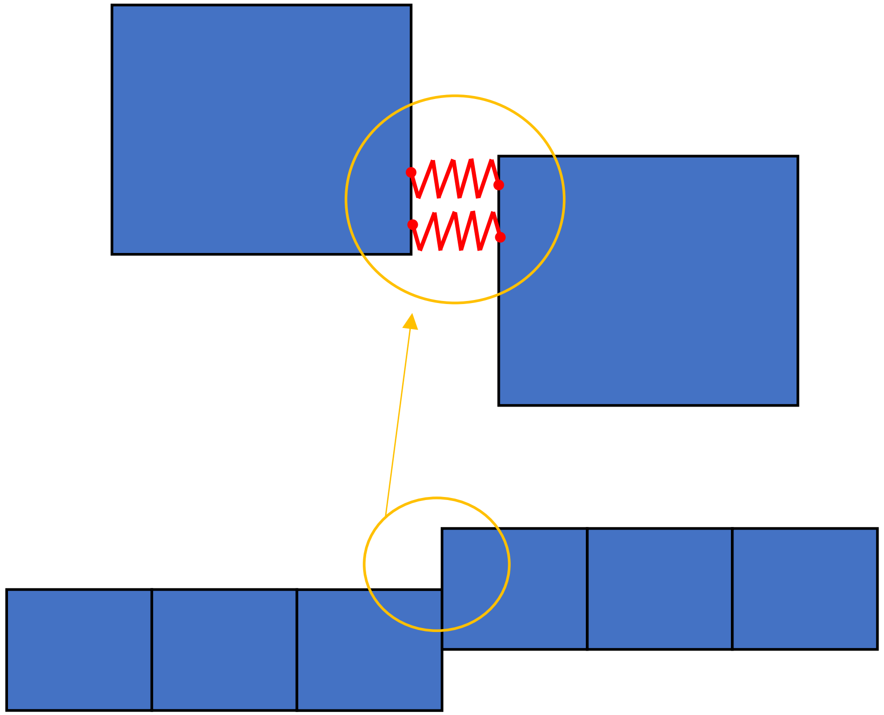
F.E.M.
No connectivity



A.E.M.
Connectivity included



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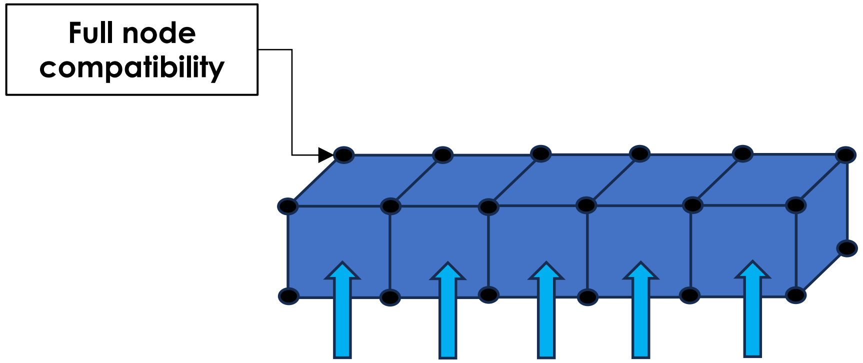
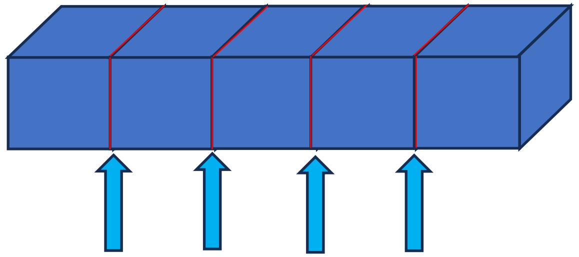


Deformation inside elements

A.E.M.



Deformation outside elements

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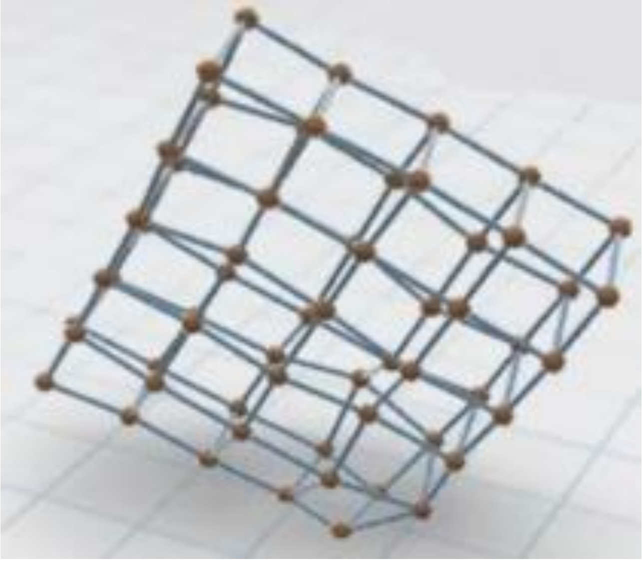
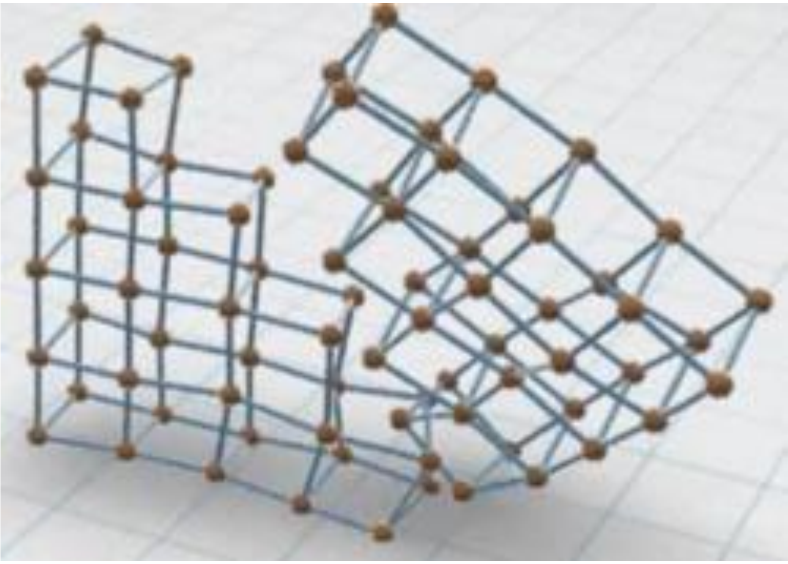


A.E.M.



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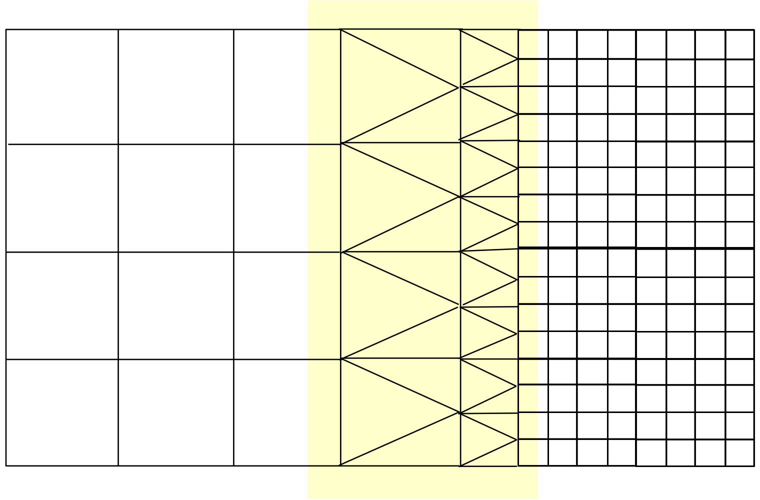
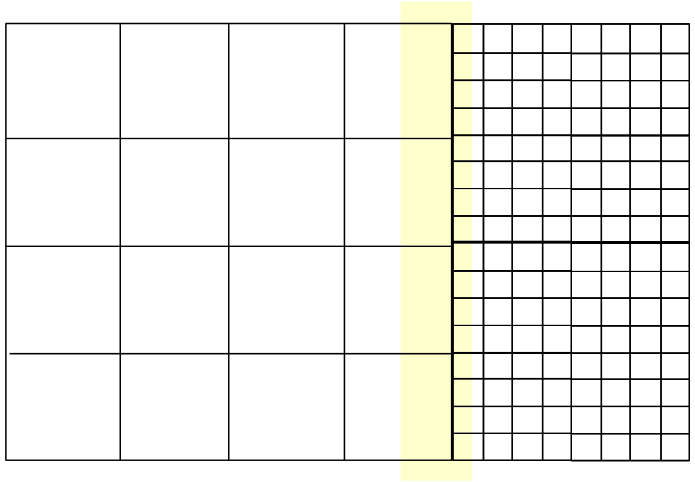


There should be transition elements between large elements and small elements

A.E.M.



There is no need for the transition elements between large elements and small elements

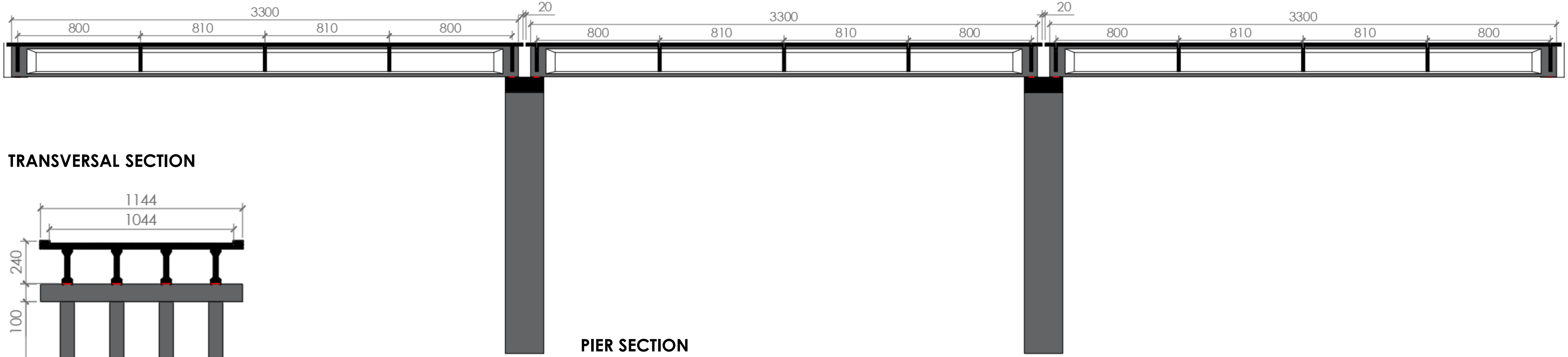
1 | WHY APPLIED ELEMENT METHOD *(AEM)*?

ADVANTAGES OF THE METHOD:

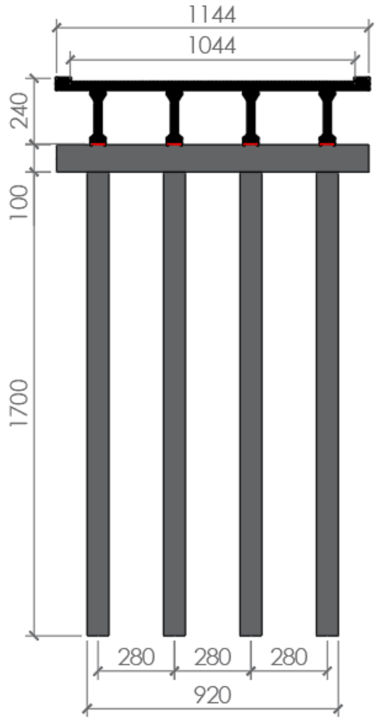
- Engineers don't need to assign locations of plastic hinges.
- AEM solver speed is much faster than FEM Solvers.
- Solid Element Modeling is the most accurate way to model structures subjected to extreme loads
- Solid Element Modeling doesn't mean that you cannot get straining actions.
- Strain Rate Effect is automatically considered in the analysis
- P-Δ effect if automatically considered in the analysis.

2 | THE BRIDGE

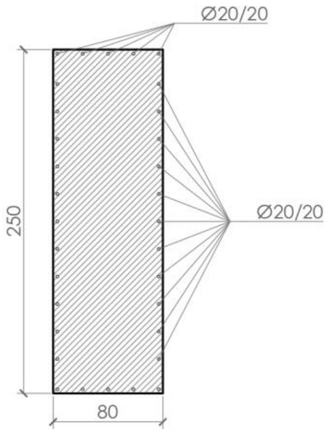
LONGITUDINAL SECTION



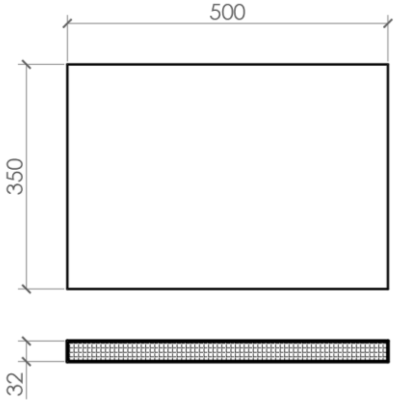
TRANSVERSAL SECTION



PIER SECTION
(reinforced concrete)



BEARING DETAILS



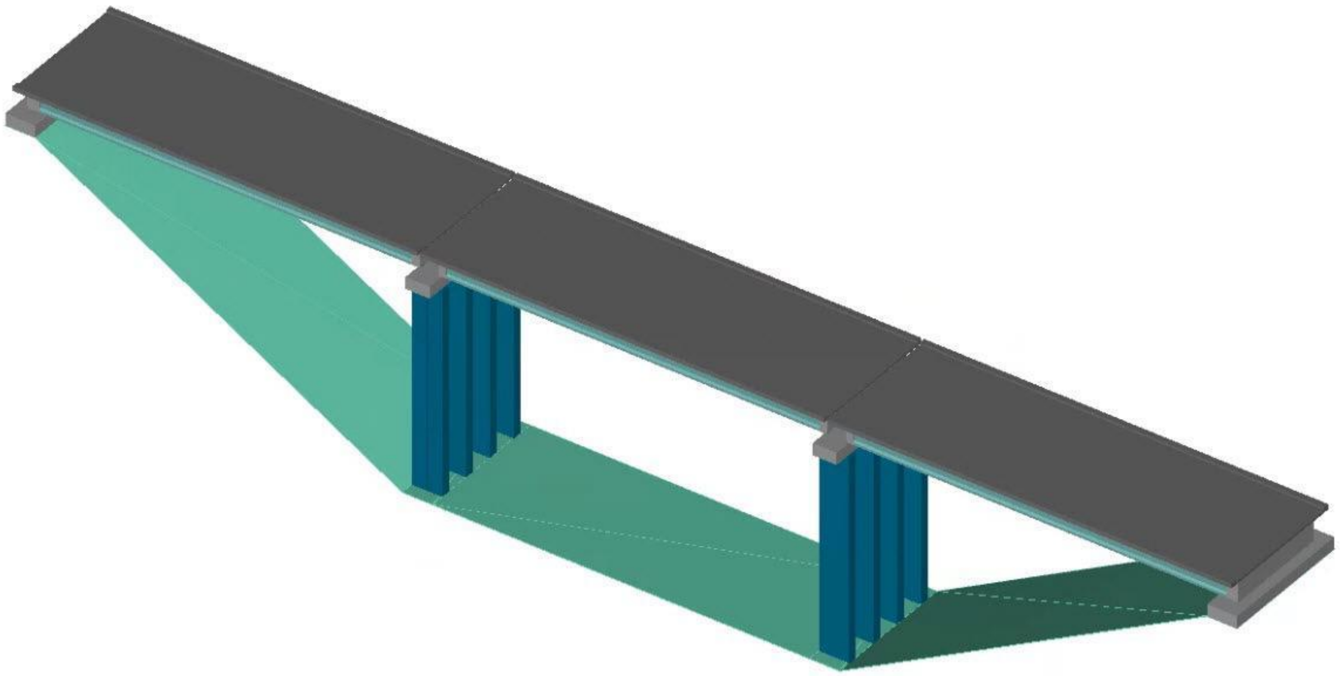
Material	Elastomer	
G	0,9	MPa
L1	500	mm
L2	250	mm
H	32	mm
Friction cls-bearing (μ)	0,5	-

3 | *AE MODEL*

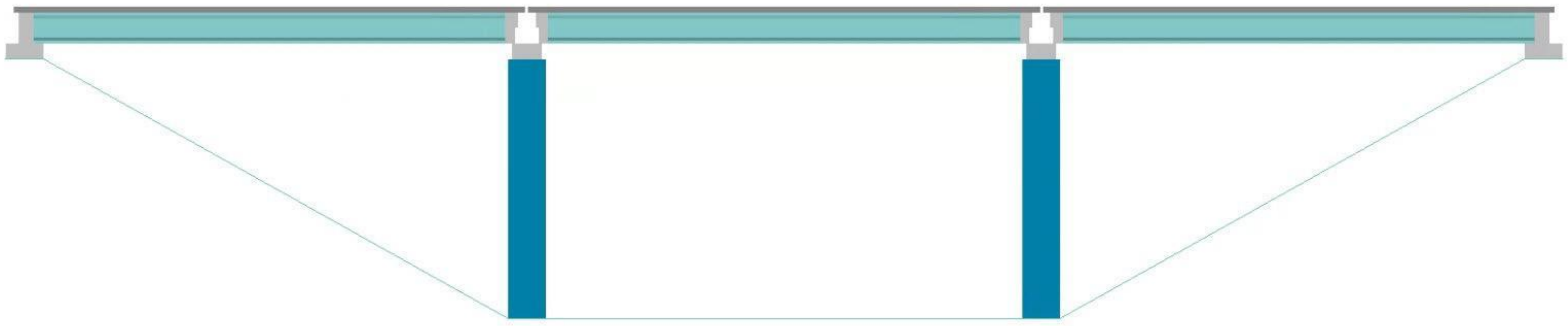
MAIN CHARACTERISTICS

- Accurate modeling by non-linear solid elements;
- Automatic plastic hinges;
- Friction surfaces by non-linear behavior.

AE Model – 3d view

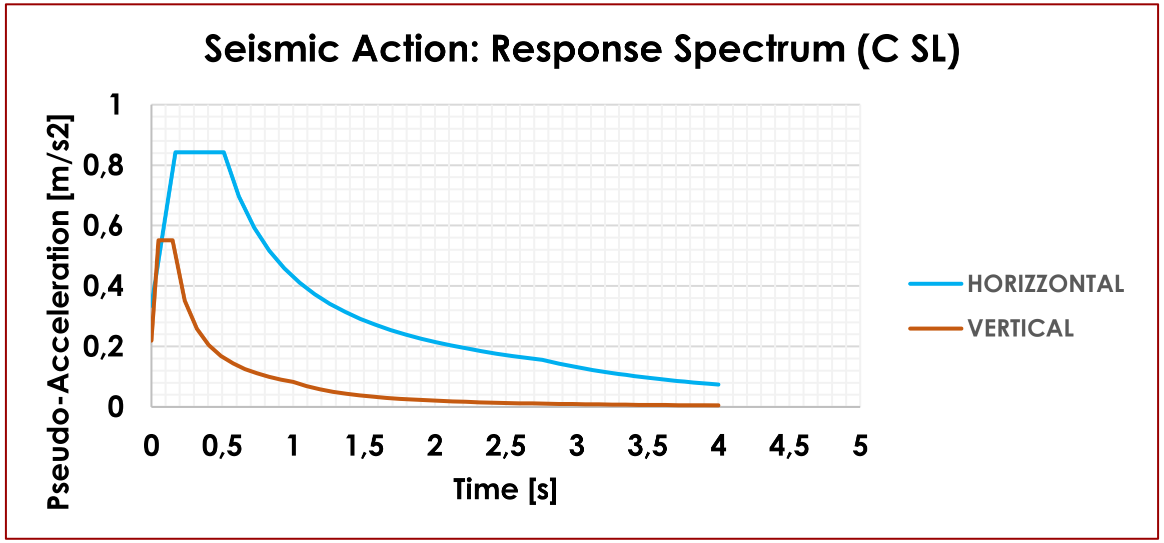


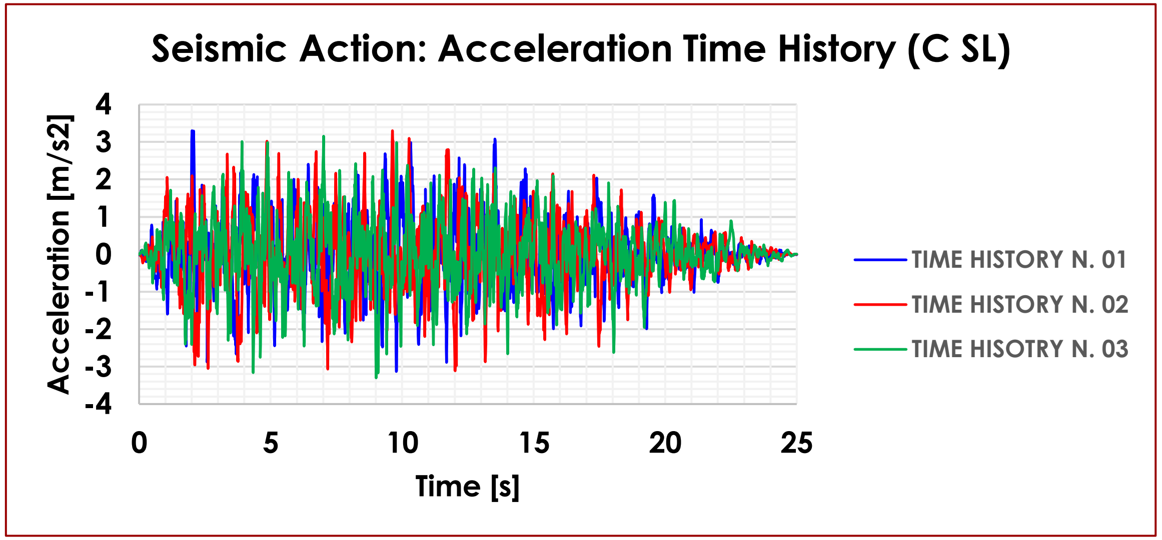
AE Model - Longitudinal view



3 | *AE MODEL*

SEISMIC ACTION





PARAMETERS

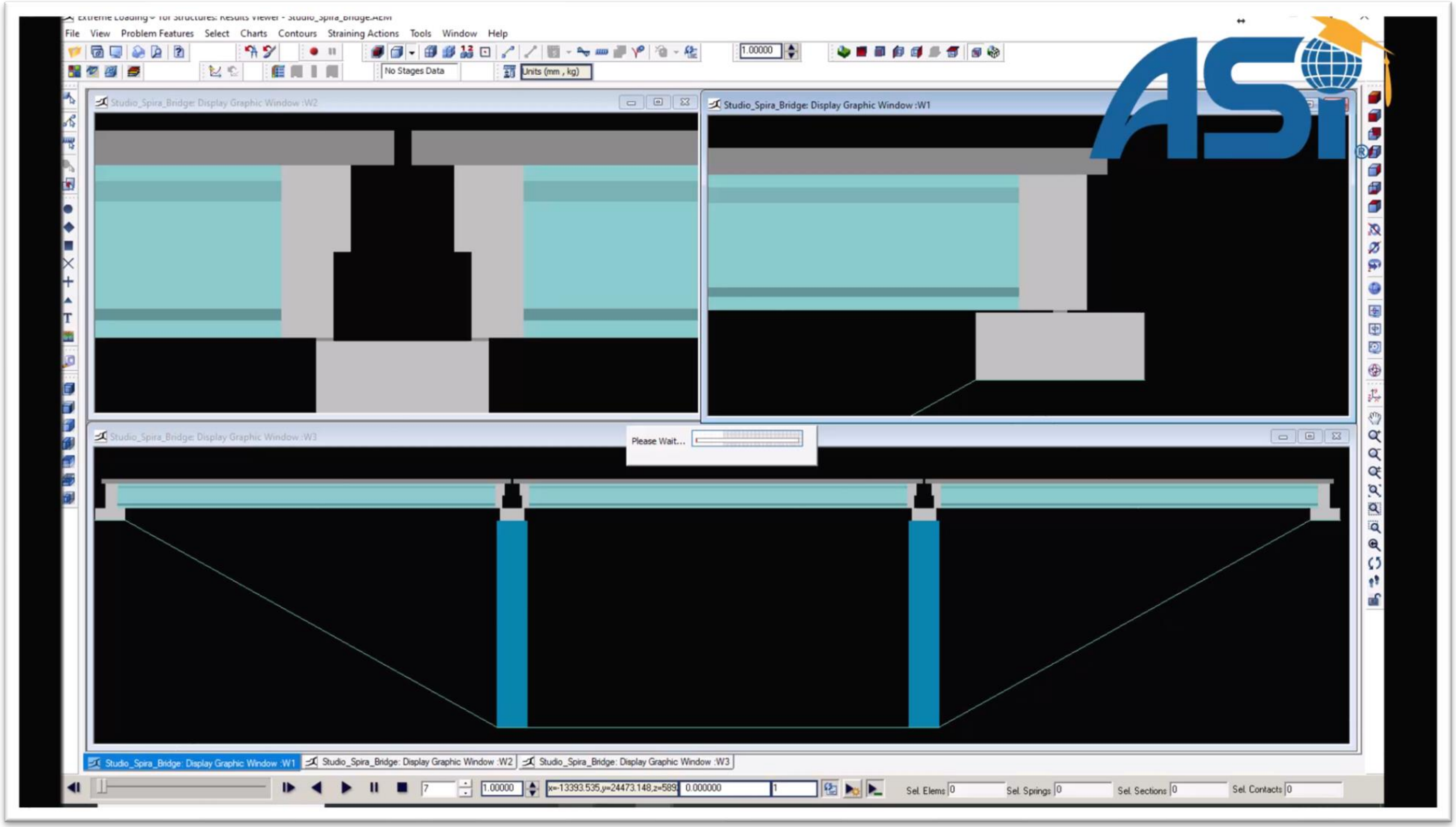
a_g	0,289
Fo	2,514
TC*	0,383
S_S	1,109
C_C	1,333
S_T	1,045
q	1,000

S	1,159
η	1,000
T_B	0,170
T_C	0,510
T_D	2,756

LOAD CASE SETTING

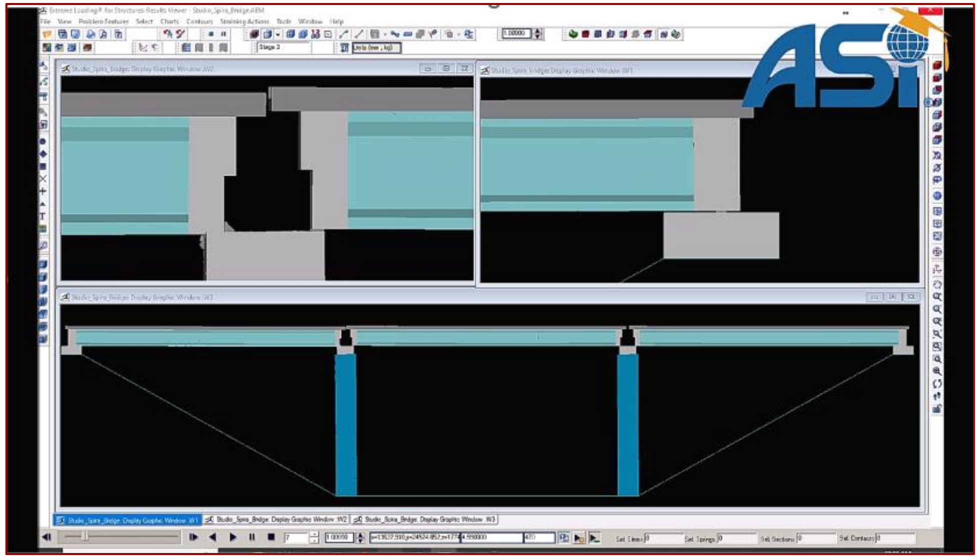
Type	Direct Integration	
Output Time Step Size	500	-
no. of Output Time Step	0,05	s
Total Time	25	s

4 | SIMULATION OF COLLAPSE

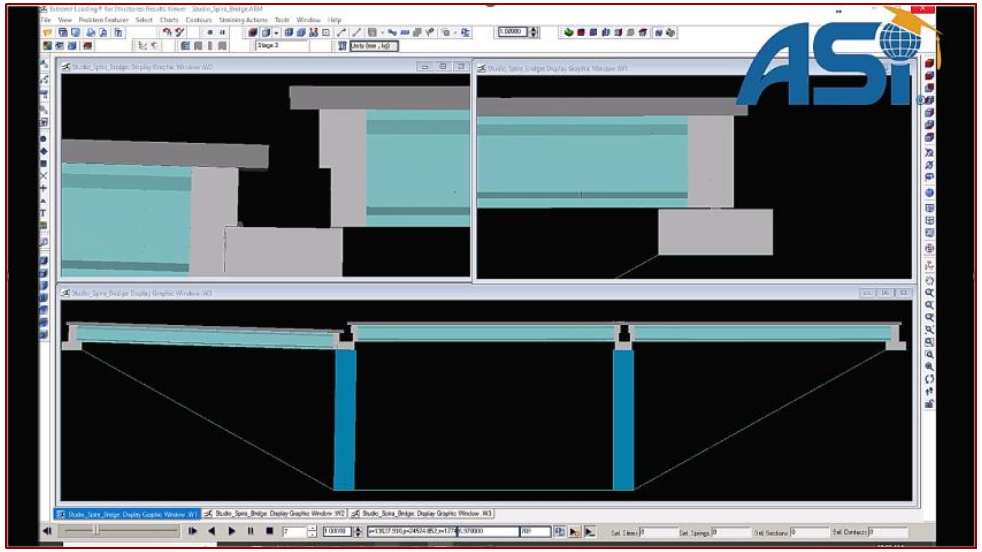


4 | SIMULATION OF COLLAPSE

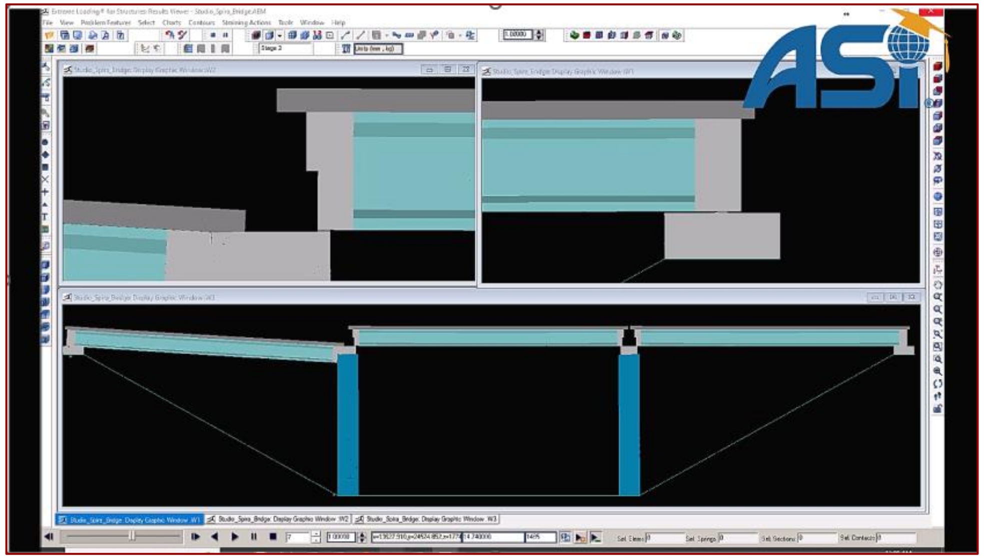
STEP 1



STEP 2



STEP 3



STEP 4