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Effect Of Ground Motion Scaling On RCC Bridge

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Abstract: From the past earthquake, it has been observed that if the bridge are not properly analyzed, designed and constructed with required quality, it may lead to great destruction and loss of human lives. It has been proven that many of the bridges are fully or partial damaged due to earthquakes. This work is divided into two parts; the first one is design the RCC bridges using CSI-Bridge software and the second part is about non-linear Time history analysis. Seismic analysis of the structure is carried out for determination of seismic responses by time history analysis which is one of the important techniques for structural seismic especially when the evaluated structural response is nonlinear in nature. As time history is realistic method, used for seismic analysis, it provides a better check to safety of the structures as compared to equivalent static analysis and response spectrum methods.

***Keywords* – Time history analysis, scaled and unscaled ground motions, RCC T bean bridge, CSI-Bridge**

I. INTRODUCTION

Ground motion is the movement of earth surface from earthquake or explosion. Ground motion is produced by waves that are generated by sudden slips on a fault or sudden pressure at the explosive source, these are likely to affect the performance of the existing structure. Seismic provisions in current model building codes and standard include rules for design of structures using non-linear response history analysis which are based on recommendations for analysis of seismically isolated structures. In seismic performance assessment of buildings is the scaling of ground motions for nonlinear response-history analysis, which should

1) Preserve the distribution (e.g., both median and dispersion) in the earthquake shaking for the selected characterization of the hazard for the site of interest;

2) Enable losses to be computed for structural and non-structural components and systems having different dynamic properties; and

3) be applicable across a wide range of earthquake shaking amplitudes since both structural and nonstructural components in a building may contribute significantly to seismic loss of the building.

II. SIGNIFICANCE OF STUDY

Ground motion analysis is a critical component of engineering and seismology that aims to understand and predict the behaviour of the ground during seismic events such as earthquakes. It involves studying the complex motion of the Earth's surface and its interaction with structures and infrastructure. The primary objective of ground motion analysis is to accurately estimate the ground shaking characteristics, including the amplitude, frequency content, duration, and spatial distribution of seismic waves. This information is crucial for designing and assessing the seismic performance of buildings, bridges, dams, nuclear power plants, and other structures.

Ground motion analysis typically involves several steps:

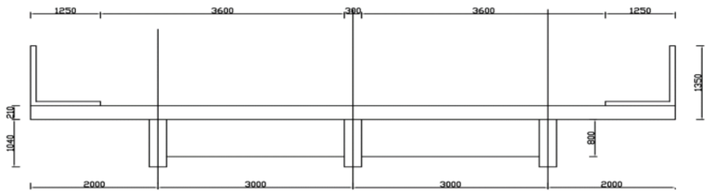
a) Seismic Hazard Assessment: The process begins with a comprehensive evaluation of the seismic hazard in a particular region. This includes the identification of seismic sources, characterization of earthquake recurrence patterns, and estimation of ground motion parameters associated with different magnitudes and distances.
b) Strong Motion Data Collection: Ground motion analysis relies heavily on recorded data from accelerometers and seismometers deployed in earthquake-prone regions. These instruments measure the acceleration, velocity, and displacement of the ground during an earthquake. Historical records and databases of past earthquakes are also used for reference.
c) Ground Motion Modelling: Sophisticated numerical models, such as finite element or finite difference methods, are employed to simulate the propagation of seismic waves through the Earth's crust. These models take into account factors such as the geological structure, soil properties, and the seismic source characteristics.
d) Site Response Analysis: The characteristics of the ground motion at a specific site can significantly vary depending on the local geological conditions. Site response analysis focuses on understanding how the ground motion is modified as it passes through different soil layers. This information helps in assessing the amplification or attenuation effects at a particular location.
e) Ground Motion Characterization: Ground motion analysis involves the statistical characterization of recorded or simulated ground motions. Parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), and spectral acceleration at different frequencies are calculated. These parameters are used in structural analysis and design procedures to ensure the resilience of infrastructure.
f) Seismic Design and Assessment: The results of ground motion analysis are utilized in the seismic design of structures to ensure they can withstand the anticipated ground shaking. Engineers use these data to calculate the forces, stresses, and

Displacements that the structures are likely to experience during an earthquake. The analysis helps in designing appropriate structural systems, selecting materials, and establishing safety factors. Ground motion analysis plays a vital role in mitigating the impact of earthquakes on society. By accurately characterizing and predicting ground shaking, engineers can design structures to withstand seismic forces, governments can develop effective building codes and regulations, and emergency response teams can better prepare for potential disasters. Ongoing research and advancements in ground motion analysis techniques continue to improve our understanding of seismic behavior and enhance the resilience of our built environment

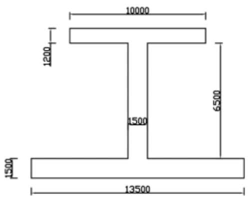
III. BRIDGE GEOMETRY

General information of Bridge

- Number of spans = 3
- Span length = 25m
- Width of bridge = 10m
- Number of lane = 2
- Width of lane = 3.6m
- Width of median = 0.3m
- Total width = footpath width + lane 1 + median + lane 2 + footpath
  = 1.25 + 3.6 + 0.3 + 3.6 + 1.25 = 10m
- Number of longitudinal girder = 3
- Number of cross girder = 6(2@support & 4 between support 5m c/c spacing)
- Material properties = Concrete = M25 & Rebar = Fe 415



Cross section of bridge superstructure



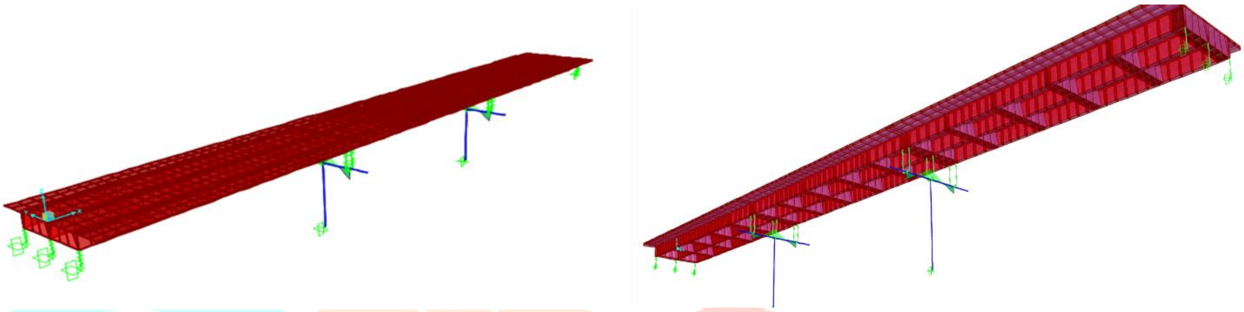
Cross section of Pier cap

A T girder RCC bridge geometry is selected for non-linear time history analysis. All assignments are carried out in CSI Bridge software. All structure is assigned to dead load, lateral loads designed based on IS-1893-2016. Vehicle loads are assigned governing standard specifications and code of practice for road bridges IRC 6.2017.

Selected vehicle class = IRC-A & IRC 70 R

Four ground motions are selected from PEER as per FEMA 695, depending on their Magnitude, Fault type, as follow-

1. NORTH RIDGE AMERIACA -Magnitude 6.69 Fault Type: ALL TYPE Rrup = 6.5km
2. LANDERS - Magnitude 7.28 Fault Type: ALL TYPE Rrup = 2.19km
3. CAPE MENDOCINO - Magnitude 7.01 Fault Type: ALL TYPE Rrup = 6.96km
4. ERZICAN TURKEY - Magnitude 6.69 Fault Type: ALL TYPE Rrup = 4.38km



CSI – Bridge model

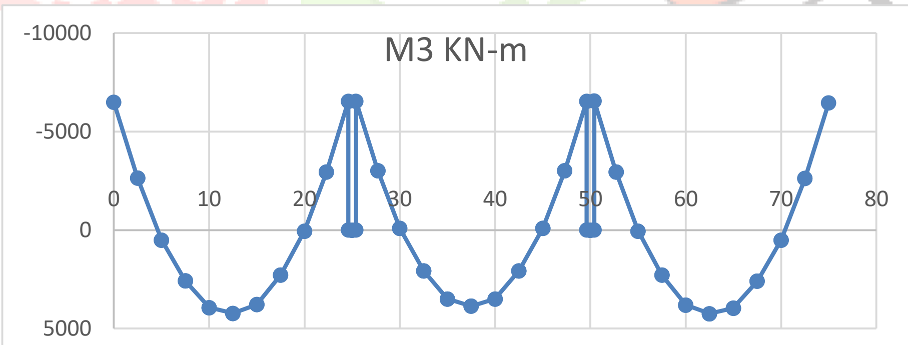
In this, we are going to keep same geometry of the bridge keeping constant values of Modal time period that is
M1=0.5403: M2-= 0.4428: M3= 0.3951, for each time history, to know how displacement and bending moment of the bridge vary with respect to different time histories.

IV. RESULTS-

1. Ground motion – Erzican turkey

Bridge object response display- result type Moment about horizontal axis M3 for entire bridge section

CASE - TH: Erzican turkey Unscaled

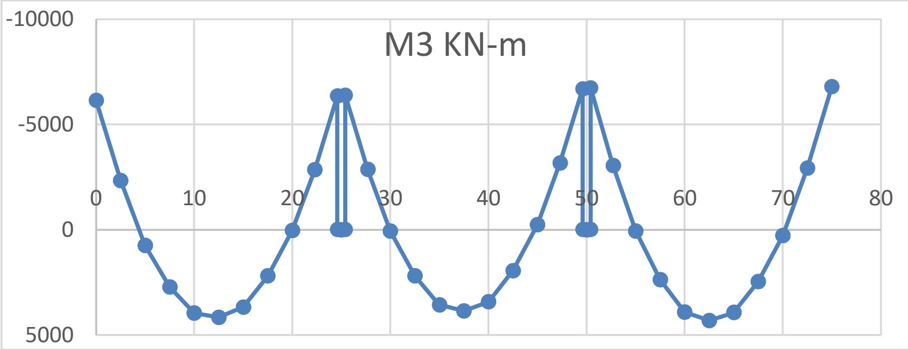


Maximum Moment about horizontal axis **M3 = 4247.66 KN-m**

Minimum Moment about horizontal axis **M3 = -6552.74 KN.m**

Fig. moment M3 - G.M Erzican turkey Unscaled

CASE - TH: Erzican turkey scaled for 0.7

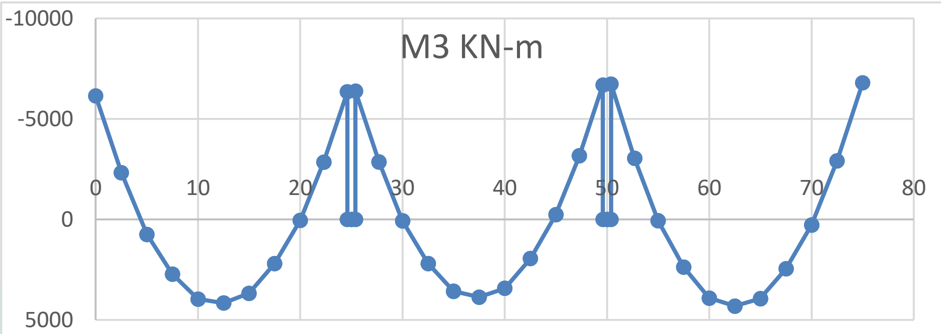


Maximum Moment about horizontal axis **M3 = 4372.75 KN-m**

Minimum Moment about horizontal axis **M3 = -6803.47 KN.m**

Fig. moment M3 - G.M Erzican turkey at 0.7

CASE - TH: Erzican turkey scaled for 1

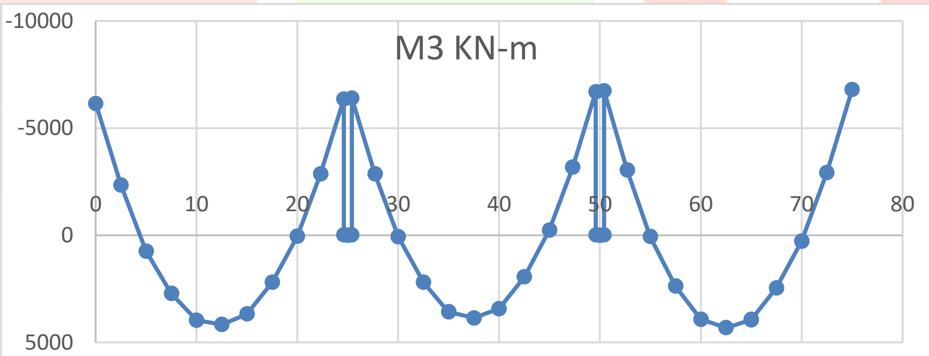


Maximum Moment about horizontal axis **M3 = 4340.34 KN-m**

Minimum Moment about horizontal axis **M3 = -6947.5 KN.m**

Fig. moment M3 - G.M Erzican turkey at

CASE - TH: Erzican turkey scaled for 1.5



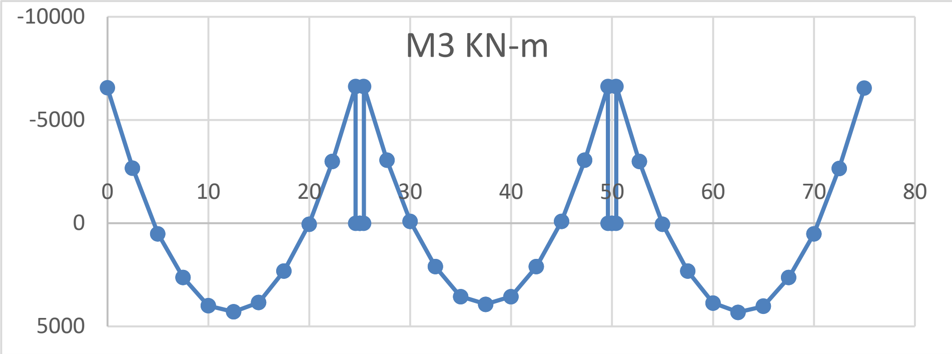
Maximum Moment about horizontal axis **M3 = 4386.3218 KN-m**

Minimum Moment about horizontal axis **M3 = -7187.27 KN.m**

Fig. moment M3 - G.M Erzican turkey at 1.5

2. Ground motion – North ridge America

CASE - TH: North ridge America Unscaled

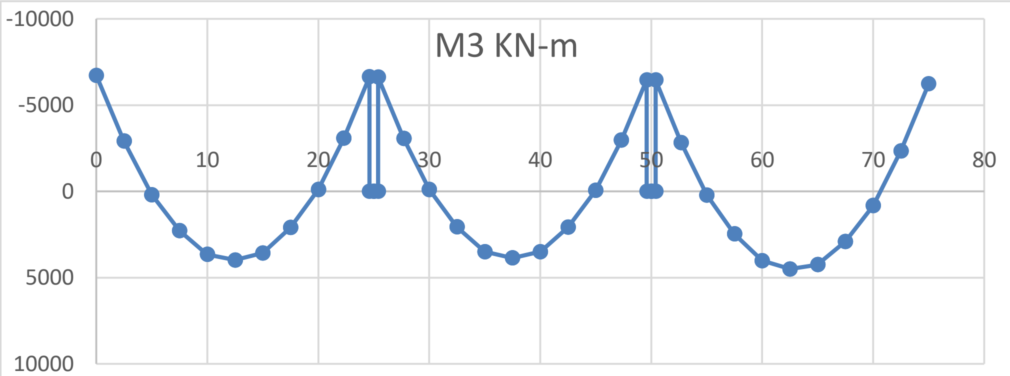


Maximum Moment about horizontal axis **M3 = 4311.8762 KN-m**

Minimum Moment about horizontal axis **M3 = -6638.28 KN.m**

Fig. moment M3 - G.M North ridge America Unscaled

CASE - TH: North ridge America scaled for 0.7

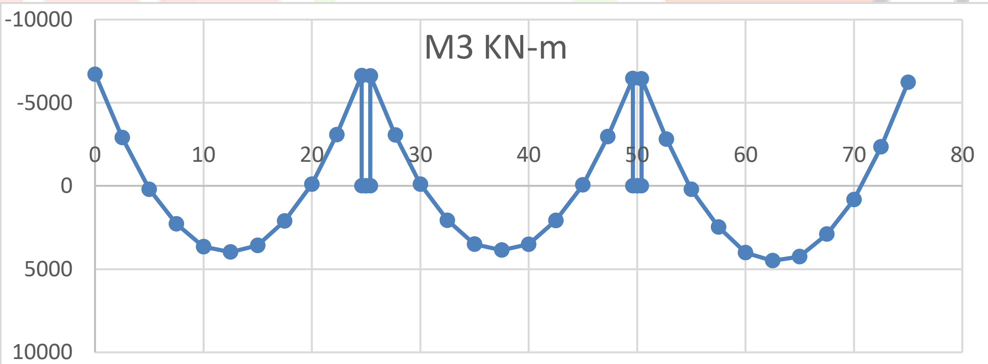


Maximum Moment about horizontal axis **M3 = 4364.8722 KN-m**

Minimum Moment about horizontal axis **M3 = -6595.16 KN.m**

Fig. moment M3 - G.M North ridge America 0.7

CASE - TH: North ridge America scaled for 1

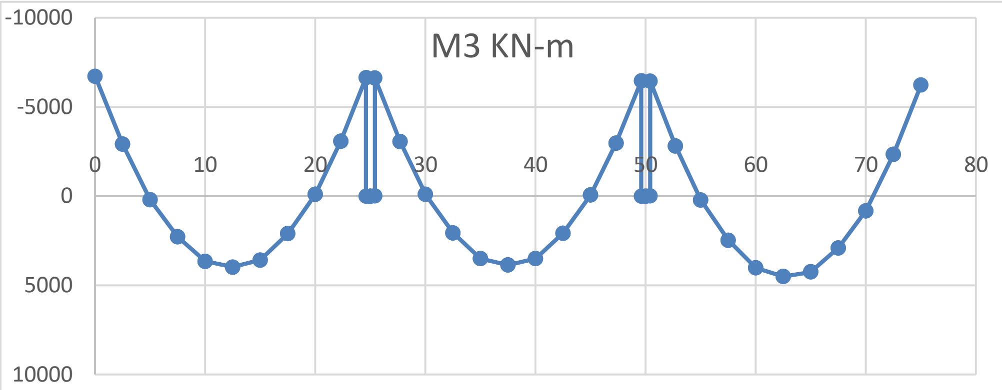


Maximum Moment about horizontal axis **M3 = 4415.0.107 KN-m**

Minimum Moment about horizontal axis **M3 = -6642.68 KN.m**

Fig. moment M3 - G.M North ridge America 1

CASE - TH: North ridge America scaled for 1.5



Maximum Moment about horizontal axis **M3 = 4498.1037 KN-m**

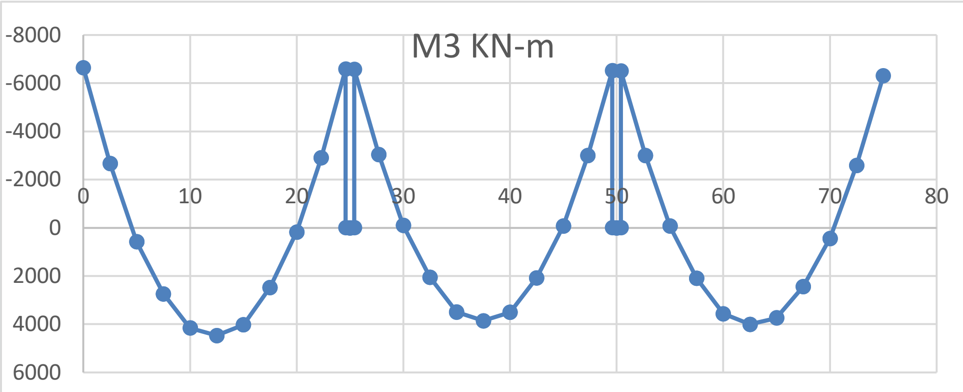
Minimum Moment about horizontal axis **M3 =**

-6721.48 KN.m

Fig. moment M3 - G.M North ridge America 1.5

3. Ground motion – Cape Mendocino

CASE - TH: Cape Mendocino Unscaled

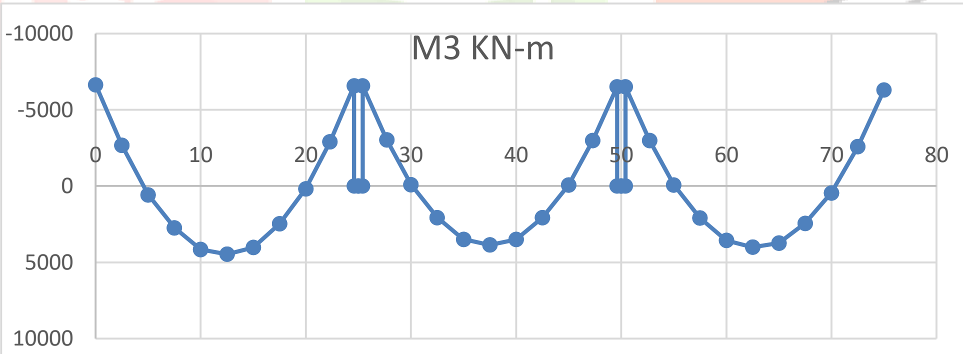


Maximum Moment about horizontal axis **M3 = 4272.098 KN-m**

Minimum Moment about horizontal axis **M3 = -6552.43 KN.m**

Fig. moment M3 - G.M Cape Mendocino Unscaled

CASE - TH: Cape Mendocino scaled for 0.7



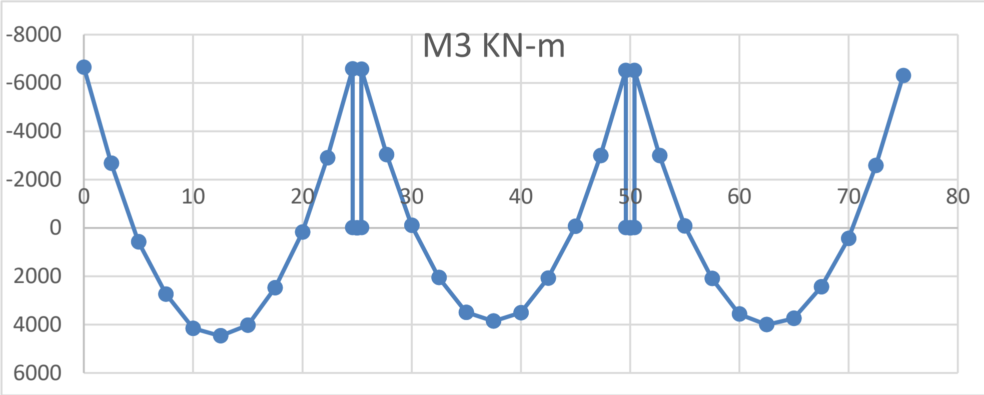
Maximum Moment about horizontal axis **M3 = 4468.383 KN-m**

Minimum Moment about horizontal axis **M3 =**

-6642.44 KN.m

Fig. moment M3 - G.M Cape Mendocino scaled 0.7

CASE - TH: Cape Mendocino scaled for 1



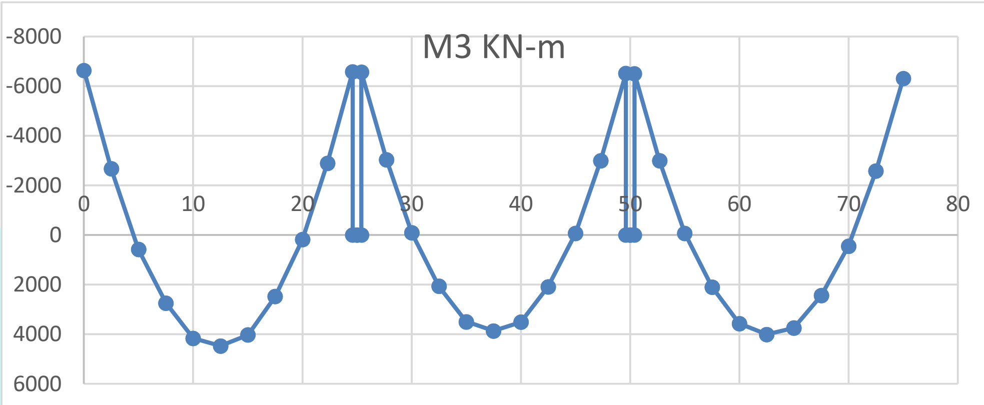
Maximum Moment about horizontal axis **M3 = 4572.228 KN-m**

Minimum Moment about horizontal axis **M3 =**

-6710.06 KN.m

Fig. M moment M3 - G.M Cape Mendocino scaled for 1

CASE - TH: Cape Mendocino scaled for 1.5



Maximum Moment about horizontal axis **M3 = 47745.1328 KN-m**

Minimum Moment about horizontal axis **M3 =**

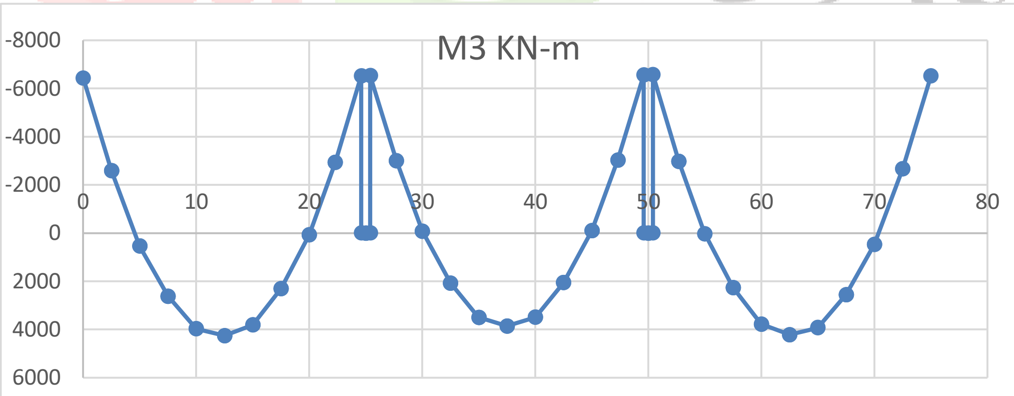
-6822.64 KN.m

Fig. moment M3 - G.M Cape Mendocino scaled 1.5

4. Ground motion – Landers

CASE - TH: Landers unscaled

-



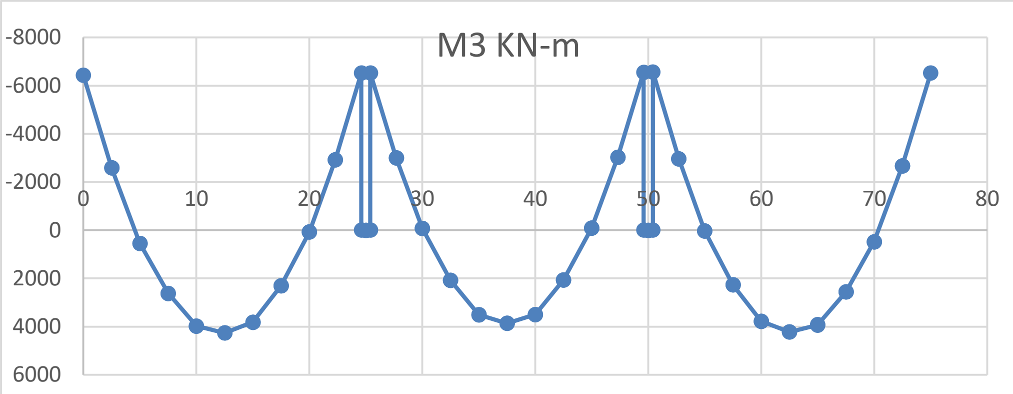
Maximum Moment about horizontal axis **M3 = 4246.4329 KN-m**

Minimum Moment about horizontal axis **M3 =**

-6552.56 KN.m

Fig. moment M3 - G.M Landers unscaled

CASE - TH: Landers scaled for 07



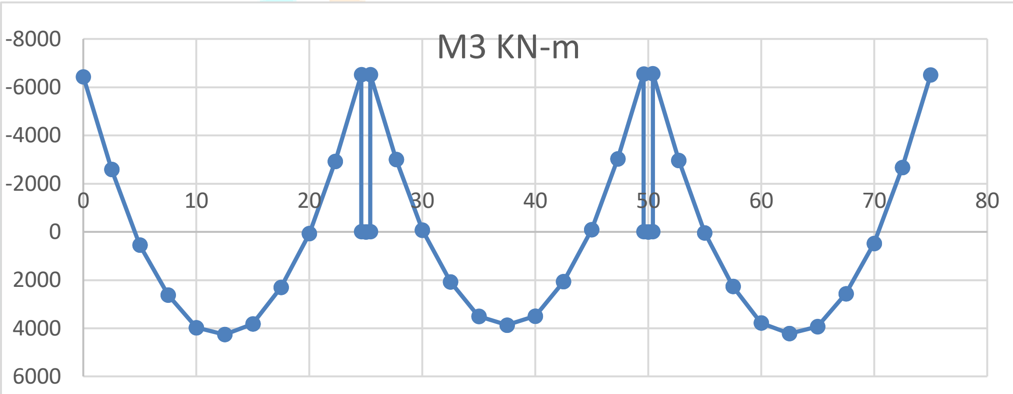
Maximum Moment about horizontal axis **M3 = 4257.299 KN-m**

Minimum Moment about horizontal axis **M3 =**

-6568.88 KN.m

Fig. moment M3 - G.M Landers scaled for 0.7

CASE - TH: Landers scaled for 1



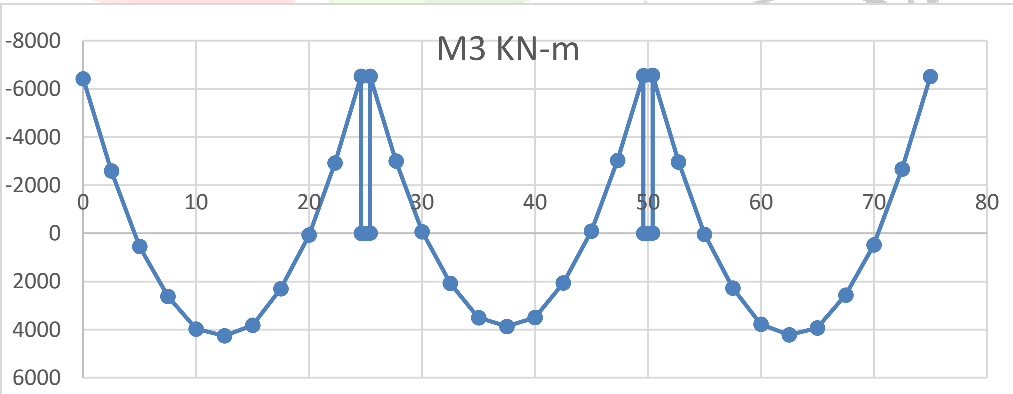
Maximum Moment about horizontal axis **M3 = 4270.537 KN-m**

Minimum Moment about horizontal axis **M3 =**

-6576.38 KN.m

Fig. moment M3 - G.M Landers scaled for 1

CASE - TH: Landers scaled for 1.5



Maximum Moment about horizontal axis **M3 = 4292.595 KN-m**

Minimum Moment about horizontal axis **M3 =**

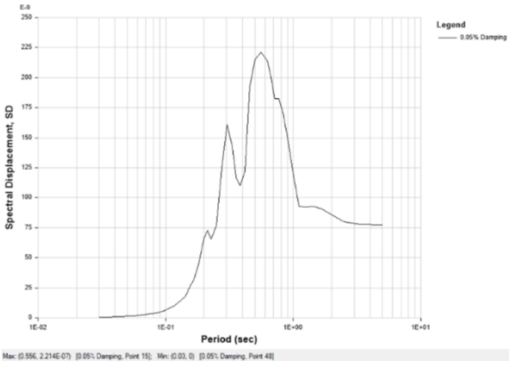
-6588.87 KN.m

Fig. moment M3 - G.M Landers scaled for 1.5

<u>Spectral displacement verses Time at 5% damping</u>

1. Erzican turkey-

Joint id – 293



2. North ridge America-

Joint id – 293

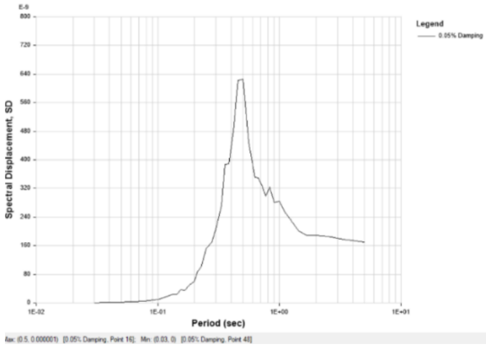
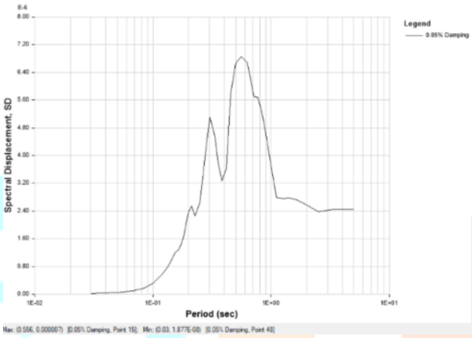


Fig. unscaled SD vs. T



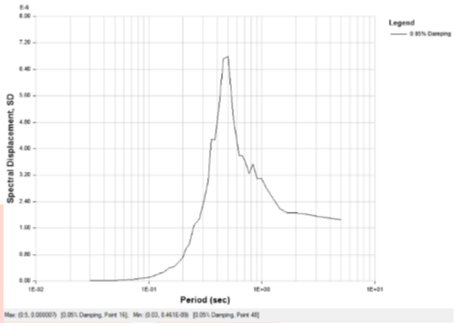
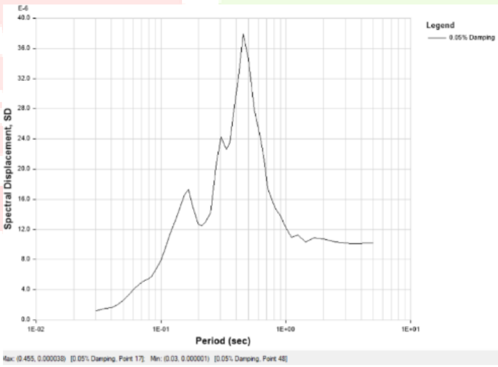


Fig. scaled SD vs. T at 2%



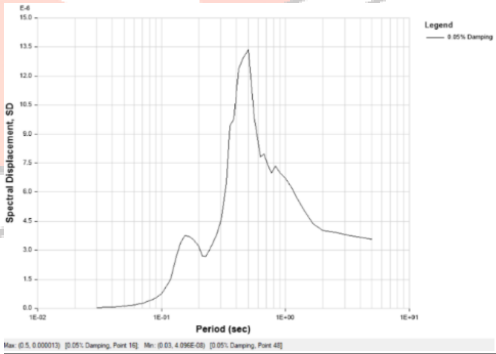
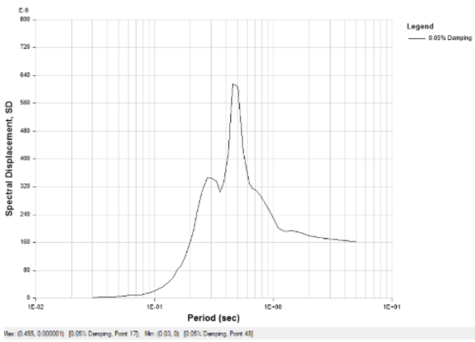


Fig. scaled SD vs. T at 4%

3. Cape Mendocino-

Joint id – 293



4. Landers -

Joint id – 293

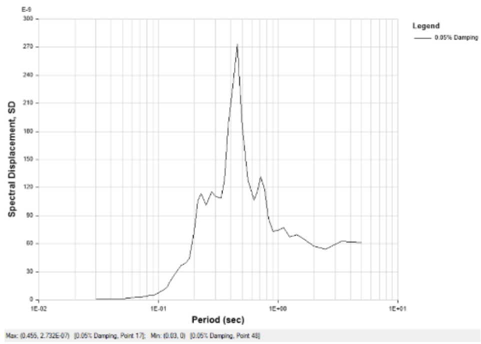


Fig. unscaled SD vs. T

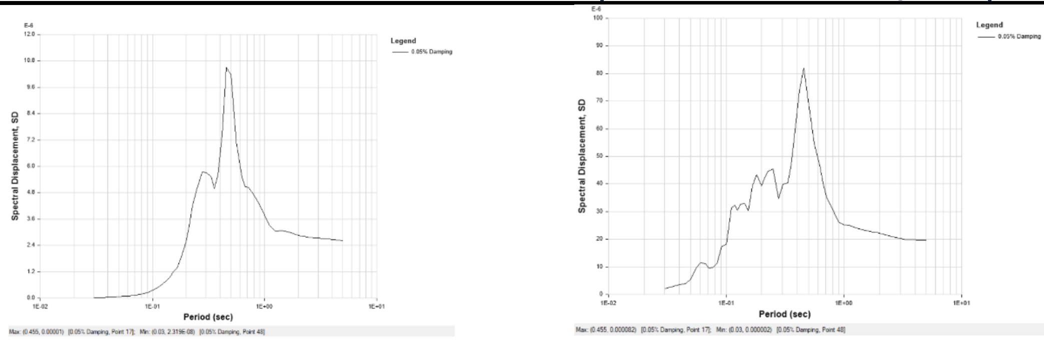


Fig. scaled SD vs. T at 2%

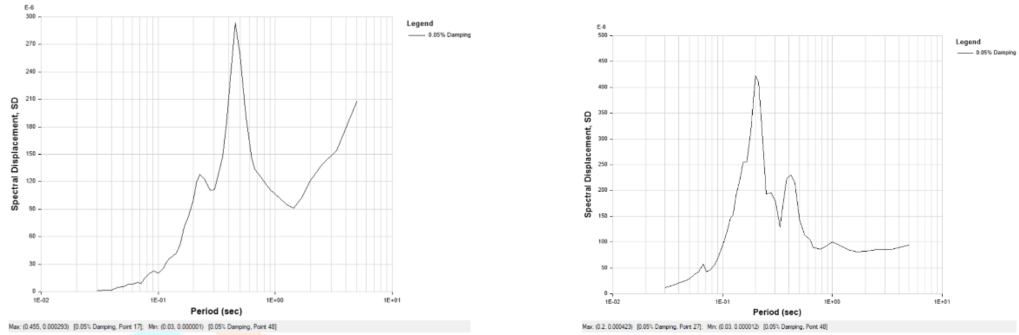


Fig. scaled SD vs. T at 4%

displacement						
no's	output case	joint id	unscaled ground motion (mm)	scaled ground motion for damage parameters (I.O, L.S, C.P) increment 0.7	increment 1	increment 1.5
1	Erzican turkey	101	0.975	159.2	228.3	342.1
		293	0.13	160.5	229.8	344.05
		485	0.641	161.1	229.2	341.5
2	north ridge america	101	0.96	173.1	247.7	370.04
		293	0.12	178.4	256.4	383.3
		485	0.60	172.6	247.5	371.9
3	cape mendocino	101	31	176.8	252.2	378.7
		293	33	177.4	253.9	379.4
		485	32	176.3	253.2	378.3
4	landers	101	11.62	1753.0	2505.1	3758.4
		293	11.66	1757.1	2511.2	3767.68
		485	11.61	1752.9	2505.0	3758.01

V. CONCLUSION -

In the present study, analysis of RCC Bridge, scaled ground motions gives large Base shear

- Time history of North ridge America offers lower base shear than of the other time histories.
- Landers ground motion offers maximum base shear as compares to others.

Displacement at mid span

- For north ridge time history, L.S achieved at scale factor of 3.89 For Increment of 0.7 and C.P achieved at scale factor of 8.34 for Increment of 1.5
- In Cape Mendocino, Life safety achieved at scale factor of 5.3 for Increment of 0.7 and C.P achieved at scale factor of 11.36 For Increment of 1.5.
- It is observed that, after scaling same structure with constant damping ratio for Mode 1 for different ground motion, after scaling their displacement becomes nearly same.

Maximum moment – after scaling moment take higher leap and increases at large amount

- North ridge America- in this TH, unscaled moment is increased by 1.22 % after achieving L.S condition and increases 4.31% after achieving stage of C.P.
- Cape Mendocino – here, unscaled moment increases by 4.59% after achieving L.S and increases by 11.07% after achieving stage of C.P.
- Ground motion landers shows high ground displacements and steepness of theses curves indicated sharp changes in displacements in Spectral displacement verses time curve at damping of 5%

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