PUSHOVER ANALYSIS OF BALANCE CANTILEVER BRIDGE

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ABSTRACT:- *Performance of structure under earthquake ground level motions resulting damage likewise total failures, history is evident damages due to sever upheaval ground motion are hazardous, structure located earthquake prone area must be given due importance for analyzing and designing, we know that in the modern civilization infra structures plays an important rule, therefore considering the importance of bridge located in these regions, long span balance cantilever bridge have been taken for the study, A 3D model of the same bridge have generated in CSI bridge SOFTWARE, bridge loading pertaining to IS Standard i.e. Tracked and Class A & Class AA tracked bridge loads have been applied to the deck of balance cantilever bridge. Since static non linear earthquake (push over)analysis is lot of importance as far as performance of bridge desk is concern, in this type of analysis monotonically increased lateral load is applied till prescribed target displacement achieved. Therefore the bridge has being realized by pushover analysis as per FEMA356&ATC40.Results like fundamental time period, modal mass participation, modal frequencies, and Base shear. SF&BM due to tracked and class A and Class AA. Have been compared in addition pushover analysis results such as generation of plastic hinges and its states, spectral displacement and ADRS curves have been studied in detail.*

1.INTRODUCTION

World had a more number of earth quake hazard in last decade. India north east region side causes great loss of human recourses such as building, bridges and road etc so, nationwide seismic vulnerability assessment of existing structure. Period to period design code have been revised to stabilize seismic zone regions. There are number of technical paper that presents to demonstrate structure. Study on nonlinear static (pushover) analysis. So we all know bridge is backbone of transportation in every country. Past 30years before number of bridges is designed without seismic forces due to which life expense of structure reduces. So, it is essential to design the capacity of bridge against seismic forces. Bridges are defined as structures, which provide a connection or passage over a gap without blocking the opening or passageway beneath. Bridges are now provided across oceans bodies and for linking a number of islands as in Japan. The bridge structure can be for passage or carriage of person, cattle, vehicle, water or other material carried across in pipes or conveyors. No other creation of Civil Engineer has such a general appeal and fascination. Bridge have two portion connected with certain support they may fixed or free from there restrained point to improve connecting path which give modules benefits in public and private sector such as pedestrian, vehicles, railway, river, can move on their own path without any irregular obstacle to improve atmosphere in many ways. For example bridge are mainly constructed now a days to control road traffic and also various purposes were interconnecting problem is occurred so, we can see now a day metro bridges are constructed, flyover, etc.

OBJECTIVES

- The main principle of this project is to analyses balance cantilever Bridge using Nonlinear Static (pushover) analysis by using CSI bridge Software
- Mathematical modeling of balance cantilever bridge including pre stress tendons.
- Nonlinear Static (pushover) analysis by using CSI bridge Software
- Performing vibration analysis of balanced cantilever bridge.
- Knowing the model behavior of bridge.
- Knowing performance levels of bent cap when subjected to earthquake
- To see the overall behavior of bridge when subjected to tracked loading and class A &CLASS B vehicle load.

2. ANALYSIS

2.1 PUSHOVER ANALYSIS:

Basically push over analysis materialize into continuance in past years due to earthquake effect come across the world causes large economical to globe. To reduces this loses push over reasoning become most important step to identify while preparing the model to know its basic properties we discuss following description Push over analysis is a non linear analysis of element and components of above structure which is subjected to monotonically loads increases inertia force to overcome earthquake and seismic effect all this effect couldn't decreases until decrease in target displacement (it is from one point to another point without any inertia forces).for structural performances seismic demand and capacity demand can be calculated by using algorithm, longitudinal and traverse moment are considered to now the center of gravity, columns and pier section. Elastic moments are considered to known the properties of columns ,footing and piers attached to beam are not, push over analysis stop at certain were hinges attached top and bottom of columns and beam push over analysis is also done to find the bent, pier and column properties .response spectrum reasoning is also define as follow:

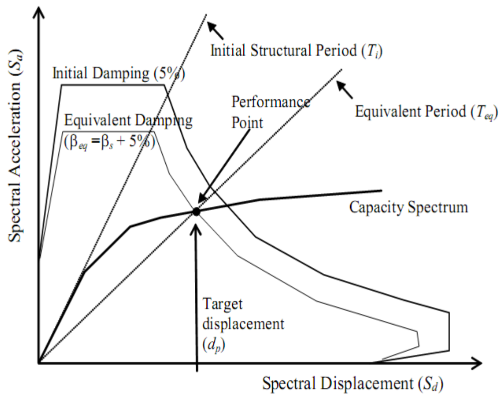
- Force and displacement of the member can be known by yielding the over capacity of curve
- Axial and shear moment are potentially brittle for ductile element.
- Global displacement of Damage Bridge and non structural element such as earthquake ground motion are considered.
- Plastic hinge, crack, yielding all other structural defect is noted.
- Uniform acceleration can be automatically applied on structure.
- Lateral force proportional to mode shape times and its frequency.

2.2 PUSHOVER ANALYSIS PROCEDURE:

- Define push load cases.
- Define static and arbitrary load pattern.
- Now deformation of seismic load to define target displacement.
- Magnitude of lateral load is normally increased due to distribution of depth of structure. Up to control point reaches to target displacement.
- Base shear and control node are most important part of push over rationale.
- Force and deracination of the member can be known by yielding the over capacity of curve
- Capacity curve is a most effective target displacement for the time history and estimation purpose.
- Non linear push over analysis hinges should be defined mainly for cantilever section.
- Compare the relation of base shear and node.
- Displacement should be known for structural members to develop force requirement.
- Response reduction factor known to identified the acceleration.
- Analysis force calculated.
- Analysis mode shape (time period & frequency).

2.3 TARGET DISPLACEMENT FOR PUSHOVER:

Pushover analysis is a magnitude of target displacement gives seismic accomplishment of structure. Target displacement shoes global dimension of the structure is expect to design the earthquake, Center of mass of roof displacement. The target displacement for the MODF structure has been evaluated. The equivalent SODF domain the shape factor, the assumption is always predicted. Under the non linear static a model show the inelastic response to target displacement, which result the force. Model is subjected to lateral forces until target displacement is increased. So, building collapses. In this way target displacement is experienced the architecture earthquake.



2.4 PUSH OVER ANALYSIS OUTPUT:

- Base shear vs displacement can be plot curves for nonlinear static analysis (above figure).
- Demand infra superimposed on structure while program is exsiccated.
- Effective spectrums and effective damping can view on open format of non linear push spectra.
- Hinge properties known for force and displacement.
- Member's forces can graphically know and step by step can analyze.

2.5 CSI BRIDGE

CSI Bridge is most powerful versions to analysis geometrical figures. Well-known Finite Element Program SAP 2000 Structural Analysis Programs, gives appreciates results with or without any defaults, which approach various following features:

- Dynamic and Static Analysis
- Energy Method, to Drift Control
- Linear and Nonlinear Analysis
- Linear shaped figured
- Segmental lanes Analysis

- Classes load design, there are different loads. IRC load for vehicles load to analysis the structure.
- P-Delta Analysis
- Parameters Analysis
- Default analysis

2.6 THE GENERAL STEPS TO BE DEFINED TO ANALYSIS A MODEL USING CSI BRIDGE:

- Geometry of input nodes, define members and joints.
- Joints are free and fixed at restraint so end condition are fixed at every inexorably but, in case of bent cap two are fixed and three should be free as we done while modeling.
- damping data, thermal tract such as properties and time-dependent creep and shrinkage)
- Material Property (Elastic and young Modulus, Poisson's , Shear capacity)
- Loads and un Load cases of structure
- Properties of Stress-strain relationship
- Perform analysis of the model based on analysis cases Bridge experts can use CSI Bridge templates for generating Bridge Models, to analysis the point load, wearing load, wind load (for height portion) to evaluate push over analysis.
- We can either model the structure as a Spine Model (Frame) or a 2D or 3D Finite Element Model.

2.7 BALANCED CANTILEVERED BRIDGE (MODELING FOR PUSH OVER ANALYSIS):

we create a CSI Bridge model interpretation, the Bridge with the help of using the Bridge Wizard for balanced cantilevered Bridge to model a bridge, there are many prospective way in among we analyses various step which shown in step by step way. Which are used to define model and a prospective way, so that we define them in many features

2.8 STUCTURAL MODELLING

The study in this thesis is based on nonlinear analysis RC bridge models. Accurate modeling of non linear properties of different structural elements is required in nonlinear analysis. In the present study, we model cantilever bridge.

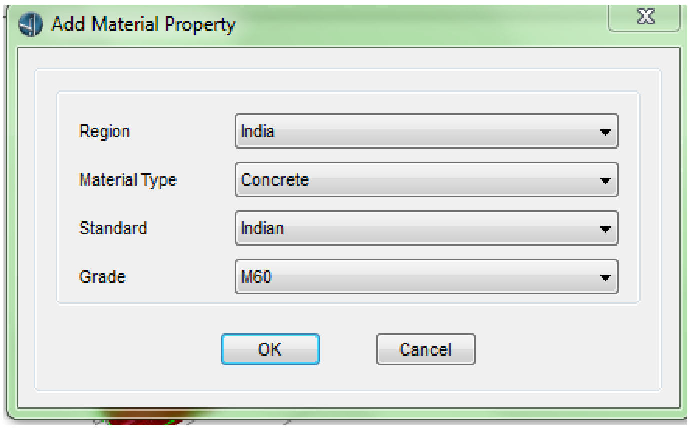
2.9 MODELLING ASPECTS:

Modeling a structure involves the modeling and assemblage of its various carrying loads. Modeling should be done by studying the size, shape and structure which is similar to understand the picture geometry so aspect and prospect of the framework. Modeling of the material properties, structural elements used in contemporary study.

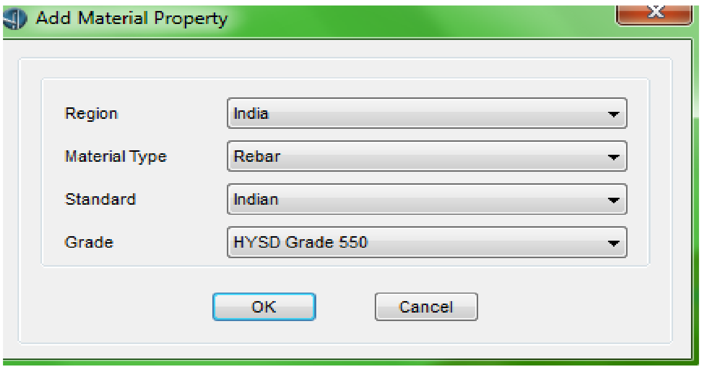
3 MATERIAL PROPERTIES:

In frame properties material is appropriated from Indian code standard for model we considered M-60 grade concrete and rebar steel HYSD-550 (as per IS 456-200), modules of elasticity concrete is 550, compressive strength on concrete is 60 pa at 28 days as also same for rebar the hole material proprieties which is not mentioned as assumed per software code .Dimension are provided as per we considered above

Material properties for concrete:



Material properties for rebar steel:



3.1 GEOMETRICAL LAYOUT MODELLING :-

Layout of the model is prepared in AutoCAD version 2016 to show all respective size and shape in 2D shape Main aim to show geometrical proprieties of structure in way the model have been drawn a)top view of the lane b)side view of hole structure c)bent cap structure all this three are drawn with dimension

3.2 BALANCED CANTILEVER BRIDGE PLAN (DETAILS):

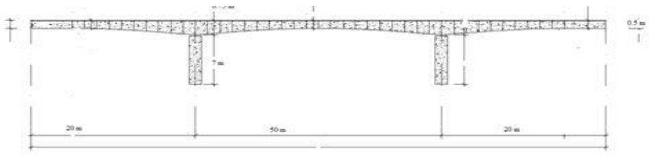
The bridge is supported by three-span pre-stressed concrete box girders. Dimension areas width of the bridge is 15.5 m. Total 3- span total span length of 90 m. In between them two column are spaced at 20m and 70m respectively. At each column point 3 piers are provided diameter 1.5m, Parametric view at both ends points start at 0.5 prolong to 1.5 then in between to piers parametric view be the 0.75 as shown below. Bents are drawn as per modeling we have taken three column and pier cap for bent design .three column are of 5.5m height, diameter 1.5 bent cap is drawn 1.5m width ,length 15.5 in rectangular in shape column are bulboue in shape. Tendons are also added to desk which is precast of length 90m in parabolic in shape.

	Bridge Details	
1	Number of Span	3
2	Centre to Centre Length of first and last Span of Bridge	20 m
3	Centre to Centre Length of intermediate Span of Bridge	50 m
4	Width of Bridge	15.5 m
5	Number of Main Girders	3 No's
6	Total depth	2 m
7	Slab thickness (average)	0.5 m
8	Thickness of Wearing Coat	100mm
9	Longitudinal Girder Size	0.45m X 1.5m
10	Type of Loading	IRC class A Train
11	Loads	DL+LL+IL+EQ
12	Compressive Strength of Concrete (fck) (M60)	60000 KN/m²
13	Modulus of Elasticity E=5000√fck E=5000√60 = 0000 N/mm²	38729833 KN/m²
14	Poisson's Ratio of Concrete	0.2
15	Type of Analysis	Linear and Nonlinear

Table 1: Bridge Details

Input Data for Analysis		
Sl.No	Particulars	
1)	Density of Reinforced Concrete	25 KN/m³
2)	Grade of Concrete	M-60
3)	Type of live load	IRC Class A Train vehicle and IRC 70R vehicles
4)	Importance Factor (I)	1
5)	Response Reduction Factor (R)	5
6)	Poisson's Ratio of Concrete	0.2
7)	Seismic Zone	Zone V
8)	Seismic Zone Factor	0.36

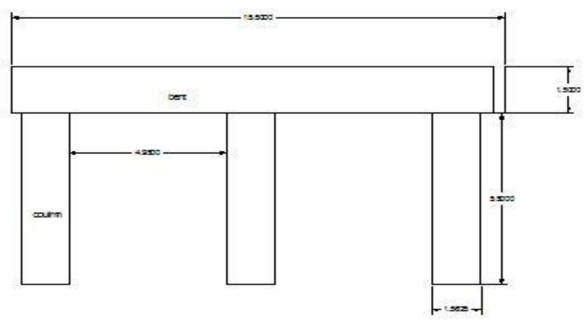
Table 2: Input Data



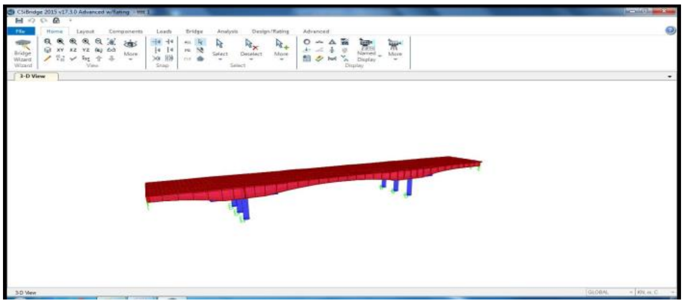
Model (y-z) plane (dimension)

Fig presents a section view of the bridge in Y-Z plane that shows the column and deck arrangement (dimensions).

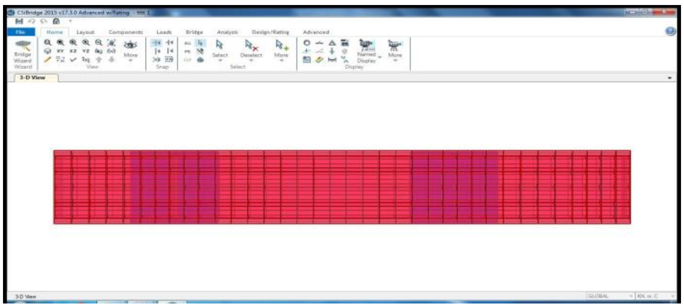
Bent are intermediate portion of the structure inter connected with desk girder and column pier part of structure which is design as rectangle shape pier cap and round circular column the dimensions are 15m l*1.5m b column length is 5.5 three of them are connected as per midpoint distance



Bent cap side view (dimensions)



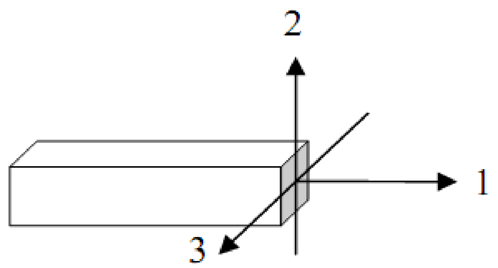
3D Bridge Model in CSI Bridge



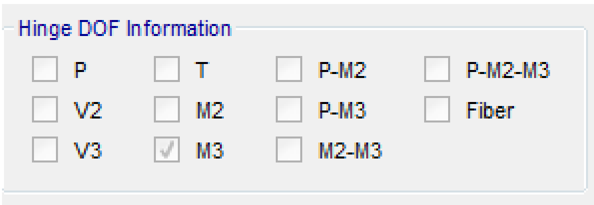
Plan of Model in CSI Bridge

3.3 HINGES MODELLING:

Basically hinges are modeled for cantilever section .degree of freedom for hinges ranges from both the end such as beams and column, a point of plasticity taken into consideration for modeling of plastic hinge .while define piers model with flexure P, V2, V3, T, M2, M3, P-M2, P-M3, M2-M3, P-M2-M3, FIBER are located in information by which structure can be hinge, we assumed three column so all of them are hinge .the flexure hinges must have reinforce concrete which is subjected to load (lateral load).



flexural hinges (coordinate method)



3.4 FLEXURE PROPERTIES

To manipulate hinge section moment curvature of one and each element purpose of this structural values is to dominates plastic hinge and rebar reinforcement. To calculate reinforcement and cross section details at possible hinge surface point noted. Almost all axial forces considered for column flexural hinges. Which give result of axial forces throw gravity load (hinges).

3.5 RESULTS AND DISCUSSIONS

The selected bridge model is analyzed using Linear Static & Nonlinear Static (Pushover) analysis. This lesson presents Linear Static results, Elastic modal properties of the bridge, pushover analysis results and discussions. Pushover analysis was performed first in a load control manner to apply all gravity loads on to the structure (gravity push). In push (gravity) lateral transverse direction was done, displacement control manner which starting at end gravity push. For pushover curve solution come by analyses the spectral demand and spectral displacement.

3.6 LINEAR ANALYSIS RESULTS

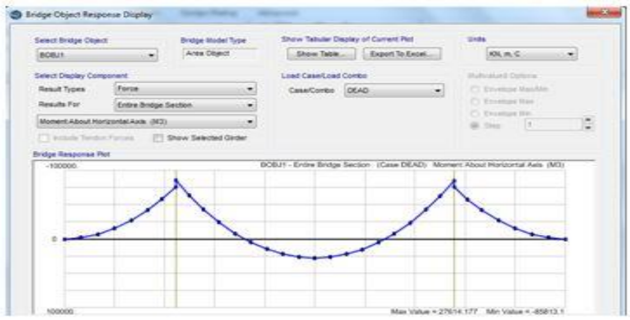
Loads of bending max moment of dead, live & seismic

Sl.no.	Load Case / Combinations	Maximum Bending Moment (KN-m)	
		Positive	Negative
1)	Deal Load (DL)	27614	85813
2)	Live Load (LL)	3585	7889
3)	Seismic Load (EQ)x	50038	6498
4)	Dead Load +Seismic Load DL + (EQ)x	27742	89603
5)	Dead load +Live Load (DL+LL)	31199	93702

Table-3

Sl.no.	Load Case / Combinations	Maximum Bending Moment (KN-m)	
		Positive	Negative
1)	Deal Load (DL)	27614	85813
2)	Live Load (LL)	6392	10983
3)	Seismic Load (EQ)	5038	6498
4)	Dead Load +Seismic Load DL+EQ	27742	89603
5)	Dead Load + Live Load (DL+LL)	34006	96796

Table-4



Model Analysis Results:

Model properties of the bridges model were obtained from the linear dynamic model analysis.

OutputCase	StepType	StepNum	Period	Frequency	CircFreq	Eigenvalue
Text	Text	Unitless	Sec	Cyc/sec	rad/sec	rad2/sec2
MODAL	Mode	1	0.397	2.516	15.809	249.922
MODAL	Mode	2	0.272	3.679	23.116	534.345
MODAL	Mode	3	0.238	4.201	26.393	696.616
MODAL	Mode	4	0.116	8.621	54.168	2934.171
MODAL	Mode	5	0.102	9.792	61.528	3785.688
MODAL	Mode	6	0.099	10.051	63.151	3988.049
MODAL	Mode	7	0.069	14.459	90.849	8253.624
MODAL	Mode	8	0.069	14.535	91.328	8340.893
MODAL	Mode	9	0.067	14.843	93.263	8697.997
MODAL	Mode	10	0.065	15.410	96.825	9375.057
MODAL	Mode	11	0.058	17.306	108.739	11824.177
MODAL	Mode	12	0.055	18.083	113.621	12909.742

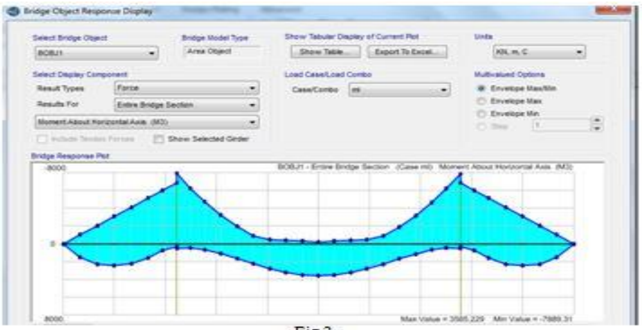
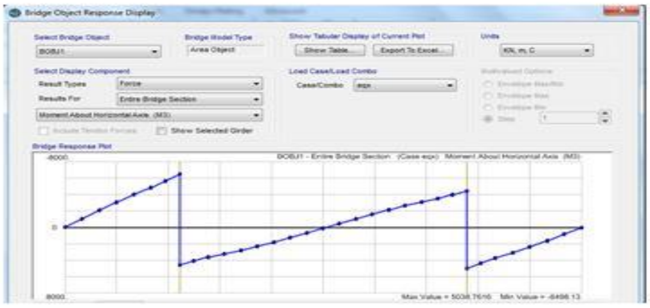
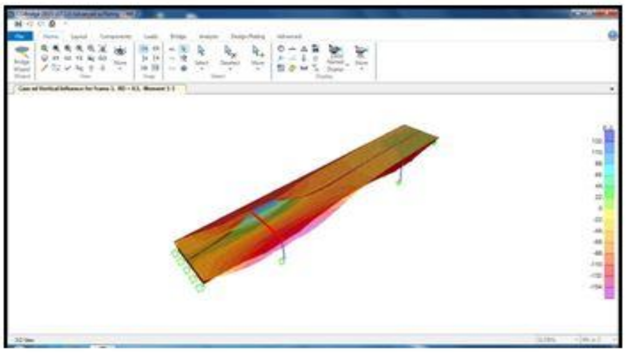
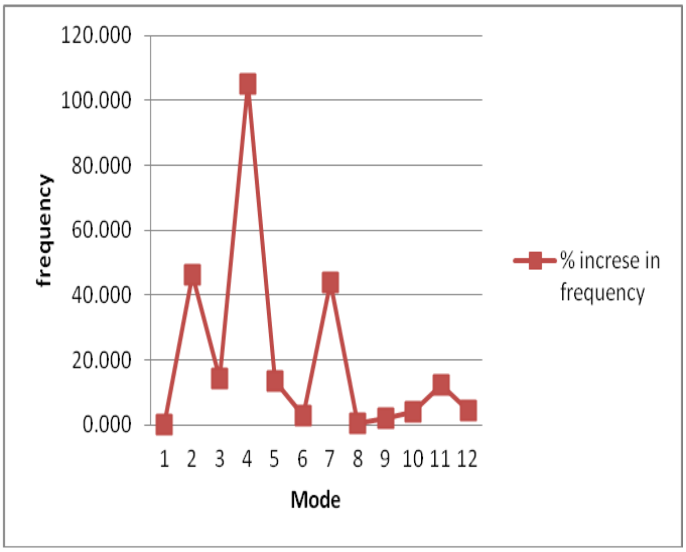


Fig 2







4 OBSERVATIONS AND COCLUSION

OBSERVATIONS:-

- (Sd) Capacity by (Sd) Demand ratio for the analyzed bridge is 0.398 which is less than 1 or almost equal to 1.
- Both push1 and push2 reaches the collapse prevention level.
- Since hinges reaches to Collapse Prevention (CP) level, hence damage may occur to the bridge.
- The percentage of increase in frequency in all modes fluctuating.
- Live Load Bending Moment obtained with IRC Class A vehicle is about 78.29%lesser than the IRC Class AA tracked vehicles.
- It is sanctioned that, the performance level of bent is reaching to CP performance level.
- Modal analysis revealed that, structures in flexible along transverse direction as compare with longitudinal direction and bridge behavior is nonlinear.
- In both the direction bridge bent is reaching to performance point.
- Bent is expectedly reaching to plastic deformation capacity range, which in turn showing ductile behavior.

5 CONCLUSION

- Modal analysis reveals, structures is flexible along transverse direction as compare with longitudinal direction.
- More than 90% of modal mass is participating in first mode which makes the structures to behave in only one direction.
- From the modal analysis, it can be conclude that, bridge is showing non-linear behavior along both the directions.
- In bridges Spectral Displacement Capacity (Sc) is almost same as the Spectral Displacement (Sd) also called as Demand.
- Pushovers conclude monotonically when lateral load is applied to structure the target displacement reaches.

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