Seismic Analysis of Foot Over Bridge for Different Soil Conditions

[1]Mr. Vipin A. Saluja, [2]Mr. S. R. Satone
[1]PG Student, [2]Assistant Professor
Dept. Of Civil Engineering
KDK College of Engineering, Nagpur, India

***Abstract* - Due to fast construction of a large number of foot over bridges, many existing bridges located in seismic zones are deficient to withstand earthquakes. In order fulfil the requirement of this increased traffic in the limited land the length of bridge becomes medium to large. During an earthquake, failure of structure starts at points of weakness. Generally, weakness is due to geometry, mass discontinuity and stiffness of structure. In earlier days, embankment design and construction were not given adequate attention. Embankments were constructed and left for compaction by natural process. Due to loads imposed by heavier axle loads, very high degree of sub-grade support has become necessary in present scenario which requires fast and heavy compaction by suitable compacting equipment. In this project work seismic analysis of foot over bridge for different soil conditions are carried out. This paper highlights the effect of different soil conditions in different earthquake zones with Response Spectrum analysis using Staad-Pro.**

***Keywords* - N-Type Foot Over Bridge Structure, Different Spans of Bridge, Seismic Analysis, Different Soil Conditions.**

INTRODUCTION -

Soil is one of the most abundant materials available throughout the world. This fact along with the demand for local construction material led to this investigation on the suitability of soil for use as a building material.

Structural analysis is a process to analyze a structural system to predict its responses and behaviors by using physical laws and mathematical equations. The main objective of structural analysis is to determine internal forces, stresses and deformations of structures under various load effects. There has been much progress in foot over bridge design in recent years with increasing use of advanced analytical design methods, use of new materials and new bridge concepts.

Truss Element

A truss element is a two-force member that is subjected to axial loads either tension or compression. The only degree of freedom for a truss (bar) element is axial displacement at each node. The cross sectional dimensions and material properties of each element are usually assumed constant along its length. The element may interconnect in a two-dimensional (2-D) or three-dimensional (3-D) configuration. Truss elements are typically used in analysis of truss structures

Figure 1: Foot Over Bridge.

OBJECTIVES –

- To analyze the foot over bridge with different soil conditions during seismic forces for safety of structure.
- Modeling and analyzing the effects of seismic forces for different spans of foot over bridges.

- To analyze foot over bridge by using STAAD PRO software.
- To check the effects of different soil conditions in different earthquake zones for foot over bridge.

MODELLING –

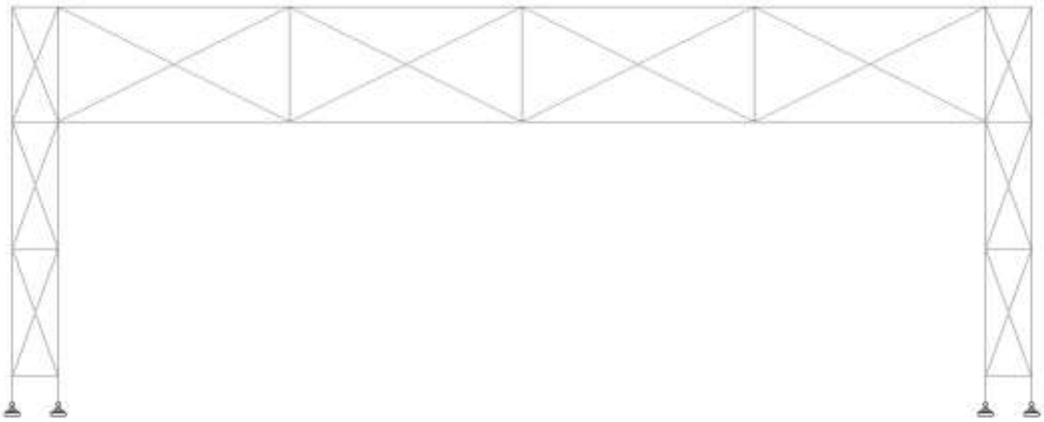

Fig.- Front View of Foot Over Bridge of 20m Span.

GEOMETRY OF FOOT OVER BRIDGE -

SR NO.	DETAILS	DIAMENTIONS
1.	Effective Span of Foot Over Bridge	20 m & 30m
2.	Height of Bridge Deck From Ground Level	6.6m
3.	Panel Length	5m
4.	No. of Panels	4 (20m), 6 (30m)
5.	Width of Bridge Deck	3m

LOADIND CALCULATIONS –

1) Dead Load Calculation of concrete deck slab –

Thickness of concrete deck slab- 200MM
Density of concrete- 25 KN/m3
Dead load of deck slab = 25 * 0.2 * 1
= 5 kN/m2

2) Live load – 4 kN/m2

PHYSICAL PROPERTIES OF STRUCTURAL STEEL -

a) Unit mass of steel, p = 7850 kg/m
b) Modulus of elasticity, E = 2.0 x 10s N/mm2 (MPa)
c) Poisson ratio, p = 0.3
d) Modulus of rigidity, G = 0.769 x 10s N/mm2 (MPa)
e) Co-efficient of thermal expansion cx = 12 x 10' / "c

STRUCTURAL ANALYSIS –

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	12.575	262.156	1.875	0.589	0	17.657
Min Fx	16	7 DL+LL-EQX	-12.51	279.944	1.695	0.538	0	-17.891
Max Fy	16	8 DL+LL+EQZ	-4.287	315.925	9.972	3.131	0.001	11.534
Min Fy	15	3 EQX	7.966	1.796	0.128	0.04	0	28.679
Max Fz	16	8 DL+LL+EQZ	-4.287	315.925	9.972	3.131	0.001	11.534
Min Fz	32	9 DL+LL-EQZ	-3.475	191.638	-9.983	-3.104	0	6.978
Max Mx	16	8 DL+LL+EQZ	-4.287	315.925	9.972	3.131	0.001	11.534
Min Mx	32	9 DL+LL-EQZ	-3.475	191.638	-9.983	-3.104	0	6.978
Max My	16	8 DL+LL+EQZ	-4.287	315.925	9.972	3.131	0.001	11.534
Min My	15	9 DL+LL-EQZ	4.353	227.662	-6.041	-1.89	-0.001	-11.766
Max Mz	16	6 DL+LL+EQX	3.432	283.537	1.951	0.618	0.001	39.496
Min Mz	15	7 DL+LL-EQX	-3.357	258.563	1.619	0.509	-0.001	-39.701

Table Shows Reactions at Nodes in II Earthquake Zone with 1St Soil Condition (i.e. Hard soil) For Foot Over Bridge of 20m Span.

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	13.637	262.396	1.892	0.594	0	21.481
Min Fx	16	7 DL+LL-EQX	-13.572	279.704	1.678	0.533	0	-21.716
Max Fy	16	8 DL+LL+EQZ	-4.253	320.483	11.059	3.471	0.001	11.631
Min Fy	15	3 EQX	9.028	2.036	0.145	0.045	0	32.503
Max Fz	16	8 DL+LL+EQZ	-4.253	320.483	11.059	3.471	0.001	11.631
Min Fz	32	9 DL+LL-EQZ	-3.508	187.08	-11.069	-3.444	0	6.88
Max Mx	16	8 DL+LL+EQZ	-4.253	320.483	11.059	3.471	0.001	11.631
Min Mx	32	9 DL+LL-EQZ	-3.508	187.08	-11.069	-3.444	0	6.88
Max My	16	8 DL+LL+EQZ	-4.253	320.483	11.059	3.471	0.001	11.631
Min My	15	9 DL+LL-EQZ	4.319	223.303	-7.079	-2.216	-0.001	-11.865
Max Mz	16	6 DL+LL+EQX	4.495	283.777	1.969	0.623	0.001	43.321
Min Mz	15	7 DL+LL-EQX	-4.419	258.324	1.601	0.504	-0.001	-43.525

Table Shows Reactions at Nodes in II Earthquake Zone with 2Nd Soil Condition (i.e. Medium Soil) For Foot Over Bridge of 20m Span.

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	13.841	262.442	1.895	0.595	0	22.215
Min Fx	16	7 DL+LL-EQX	-13.777	279.658	1.675	0.532	0	-22.451
Max Fy	16	8 DL+LL+EQZ	-4.304	313.51	9.396	2.95	0.001	11.482
Min Fy	15	3 EQX	9.232	2.082	0.149	0.046	0	33.237
Max Fz	16	8 DL+LL+EQZ	-4.304	313.51	9.396	2.95	0.001	11.482
Min Fz	32	9 DL+LL-EQZ	-3.457	194.054	-9.407	-2.924	0	7.03
Max Mx	16	8 DL+LL+EQZ	-4.304	313.51	9.396	2.95	0.001	11.482
Min Mx	32	9 DL+LL-EQZ	-3.457	194.054	-9.407	-2.924	0	7.03
Max My	16	8 DL+LL+EQZ	-4.304	313.51	9.396	2.95	0.001	11.482
Min My	15	9 DL+LL-EQZ	4.371	229.973	-5.49	-1.718	-0.001	-11.713
Max Mz	16	6 DL+LL+EQX	4.699	283.823	1.972	0.624	0.001	44.056
Min Mz	15	7 DL+LL-EQX	-4.623	258.278	1.598	0.503	-0.001	-44.259

Table Shows Reactions at Nodes in II Earthquake Zone with 3rd Soil Condition (i.e. Soft Soil) For Foot Over Bridge of 20m Span.

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	17.355	263.234	1.952	0.613	0	34.864
Min Fx	16	7 DL+LL-EQX	-17.292	278.866	1.618	0.514	0	-35.106
Max Fy	16	8 DL+LL+EQZ	-4.135	336.436	14.862	4.662	0.001	11.972
Min Fy	15	3 EQX	12.746	2.874	0.205	0.064	0	45.886
Max Fz	16	8 DL+LL+EQZ	-4.135	336.436	14.862	4.662	0.001	11.972
Min Fz	32	9 DL+LL-EQZ	-3.627	171.127	-14.872	-4.636	0	6.537
Max Mx	16	8 DL+LL+EQZ	-4.135	336.436	14.862	4.662	0.001	11.972
Min Mx	32	9 DL+LL-EQZ	-3.627	171.127	-14.872	-4.636	0	6.537
Max My	16	8 DL+LL+EQZ	-4.135	336.436	14.862	4.662	0.001	11.972
Min My	15	9 DL+LL-EQZ	4.2	208.044	-10.713	-3.354	-0.001	-12.212
Max Mz	16	6 DL+LL+EQX	8.215	284.615	2.028	0.642	0.001	56.712
Min Mz	15	7 DL+LL-EQX	-8.137	257.486	1.542	0.485	-0.001	-56.908

Table Shows Reactions at Nodes in III Earthquake Zone with 1st Soil Condition (i.e. Hard Soil) For Foot Over Bridge of 20m Span.

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	19.054	263.617	1.979	0.621	0	40.983
Min Fx	16	7 DL+LL-EQX	-18.993	278.483	1.591	0.506	0	-41.228
Max Fy	16	8 DL+LL+EQZ	-4.082	343.729	16.6	5.207	0.001	12.128
Min Fy	15	3 EQX	14.445	3.257	0.232	0.072	0	52.004
Max Fz	16	8 DL+LL+EQZ	-4.082	343.729	16.6	5.207	0.001	12.128
Min Fz	32	9 DL+LL-EQZ	-3.681	163.834	-16.611	-5.18	0	6.38
Max Mx	16	8 DL+LL+EQZ	-4.082	343.729	16.6	5.207	0.001	12.128
Min Mx	32	9 DL+LL-EQZ	-3.681	163.834	-16.611	-5.18	0	6.38
Max My	16	8 DL+LL+EQZ	-4.082	343.729	16.6	5.207	0.001	12.128
Min My	15	9 DL+LL-EQZ	4.145	201.068	-12.375	-3.875	-0.001	-12.37
Max Mz	16	6 DL+LL+EQX	9.915	284.998	2.056	0.65	0.001	62.833
Min Mz	15	7 DL+LL-EQX	-9.836	257.102	1.514	0.477	-0.001	-63.026

Table Shows Reactions at Nodes in III Earthquake Zone with 2nd Soil Condition (i.e. Medium Soil) For Foot Over Bridge of 20m Span.

			Horizonta	Vertical	Horizonta	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	15	6 DL+LL+EQX	19.38	263.691	1.984	0.623	0	42.158
Min Fx	16	7 DL+LL-EQX	-19.319	278.409	1.586	0.504	0	-42.404
Max Fy	16	8 DL+LL+EQZ	-4.164	332.571	13.94	4.374	0.001	11.89
Min Fy	15	3 EQX	14.771	3.331	0.238	0.074	0	53.18
Max Fz	16	8 DL+LL+EQZ	-4.164	332.571	13.94	4.374	0.001	11.89
Min Fz	32	9 DL+LL-EQZ	-3.598	174.992	-13.951	-4.347	0	6.62
Max Mx	16	8 DL+LL+EQZ	-4.164	332.571	13.94	4.374	0.001	11.89
Min Mx	32	9 DL+LL-EQZ	-3.598	174.992	-13.951	-4.347	0	6.62
Max My	16	8 DL+LL+EQZ	-4.164	332.571	13.94	4.374	0.001	11.89
Min My	15	9 DL+LL-EQZ	4.229	211.741	-9.833	-3.078	-0.001	-12.128
Max Mz	16	6 DL+LL+EQX	10.242	285.072	2.061	0.652	0.001	64.009
Min Mz	15	7 DL+LL-EQX	-10.163	257.029	1.509	0.475	-0.001	-64.202

Table Shows Reactions at Nodes in III Earthquake Zone with 3rd Soil Condition (i.e. Soft Soil) For Foot Over Bridge of 20m Span.

METHODOLOGY –

If the structure not properly designed and constructed with required quality, they may cause large destruction of structures due to earthquakes. Response spectrum analysis is a useful technique for seismic analysis of structure when the structure shows linear response.

- Extensive literature survey by referring books, technical papers carried out to understand basic concept of topic.
- Selection of an appropriate model of foot over bridge.
- Computation of loads and selection of preliminary cross-sections of various structural members.
- Geometrical modeling and structural analysis of foot over bridge for various loading conditions as per IS Codal provisions.
- Interpretation of results.

In the present work it is proposed to carry out seismic analysis of foot over bridge using Response spectrum analysis method considering different soil condition with the help of STAAD PRO software.

CONCLUSION –

Many of the studies have shown seismic analysis of the foot over bridges with different soil conditions. Whenever a structure having different length, it is necessary to analyse the bridge in various earthquake zones. The reactions and moments at nodes goes on increasing with earthquake zone and with change in soil conditions.

REFERENCES –

1. M. Ciampoli and P.E. Pinto. "Effects of soil-structure interaction on inelastic seismic response of bridge piers". Journal of structural engineering, 121(5):806–814, 1995.
2. Durkee, Jackson L., "Foot Over Bridge Erected by Launching", Journal of The Structural Division, ASCE, Vol. 98, No. ST7, Proc. Paper 9028, Pp. 1443-1463, July,1997
3. Durkee, Jackson, "Steel Bridge Construction", Bridge Engineering Handbook, Crcpress, PP 45-58, 2000.
4. Granath, P., "Distribution of Support Reaction Against A Steel Girder On A Launching Shoe." Journal of Constructional Steel Research, Vol. 47, No.3, Pp. 245-270, 1998.
5. G. Mylonakis and G. Gazetas. "Seismic soil-structure interaction: beneficial or detrimental", Journal of Earthquake Engineering, 4(03):277–301, 2000.
6. M.J.N. Priestley and R. Park. "Strength and ductility of concrete bridge columns under Seismic loading". ACI Structural Journal, 84(1):61–76, 1987.
7. D. Resendiz and J.M. Roesset. "Soil-structure interaction in Mexico City during the 1985 Earthquake. In Proc. of Int'l. Conf. on The Mexico Earthquakes – 1985", ASCE, volume Factors Involved and Lessons Learned, pages 193–203, 1987.
8. J.C. Wilson and B.S. Tan. "Bridge abutments: assessing their influence on earthquake response of meloland road overpass." Journal of Engineering Mechanics, 116(8):1838–1856, 1990.