Comparative study on Time period and Frequency of Full Arch and Vierendeel Truss Steel Pedestrian Bridge

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Abstract - *In recent years, there has been a growing trend towards the construction of lightweight foot bridges. A structure provides a passage over an obstacle without closing the way beneath. The passages termed as bridge may be provided for railway, canal, river or road crossing. For the analysis of bridge various gravity loads like dead load and live load are considered along with lateral loads like wind loads. In the analysis of pedestrian bridge, dynamic excitation also plays a major role. The bridge vibrations are dynamically excited due to the pedestrian load. The model analysis for zone II is performed by finite element software package SAP 2000-V14. Here the bridges like full arch bridge and viererndeel truss bridge is analysed for the time history analysis of various spans like 40m,50m and 60m. The obtained response are time period, frequency. There are compared between full arch bridge and vierendeel truss bridge and conclusion are drawn depending upon the obtained results.*

***Key Words*: Time period, Frequency, Time history method, Dynamic excitation, Full arch bridge, Vierendeel truss bridge**

1. INTRODUCTION

In the ancient days timber was the basic material used to construct the bridges, now a days it was slowly replaced by iron, steel and concrete. In 17th century first usage of steel process had been developed by the industries. Now a days most of the footbridges are constructed using steel due it properties like high strength, light weight, economic and can hold more tension. The life of steel bridge is longer than the concrete bridge.The foot bridge due to reduced mass of structures, the dynamic force can cause larger amplitude of the vibration of bridge. The vibration increase for more slender structure and more attention to be paid for vibration phenomena. The natural frequencies are lower in the lightweight foot bridge because of its low mass for which mass of inertia is decrease. Now a day footbridge was excited laterally by pedestrian streams in which pedestrians interacted with the bridge vibration. Vibration of bridge occur in vertical and horizontal directions, torsion of the bridge is possible.

1.1 Arch bridge:

The primarily carries by impact vertical flexure stiffness and lateral flexure stiffness of the arch rib on the structure stability are determine by the mode buckling and the lateral stiffness has been no impact of the structure stability of the bridge. The carries compression load.Deep gorgers with steep rocky banks which furnish efficient natural abutment to receive heavy thrust exerted. Arch bridge better architect view than truss bridge. Long span arch bridges over deep valley have no competitors as far as aesthetic is concerned.

Fig-1:Full arch bridge

1.2 Vierendeel Truss bridge:

The vierendeel truss frame, or truss as it more popular in case of truss type bridges, is a rectangular frames which achieve the stability by the rigid connection of the vertical web members to top and bottom chord. Contrary to the typical pin connected truss in which all members are axially loaded and shear is transferred axially through diagonals, the vierendeel transfers shear from the chords by bending moments at the joints and finally by bending moments in the vertical webs.

Fig-2:Vierendeel Truss bridge

2. Literature review

D E Newland [2004] In there project, the pedestrian – excited vibration of the London millennium bridge. The evidence on dynamic bridge loading caused by pedestrian movement. The result Both lateral and vertical vibration are considered and ARU'S analysis . The main assumption is that movement of a pedestrian centre of the mass has two component. The phenomenon frequency close the natural walking or running frequency is a feature of the component. The paper conclude is that list of following. It is conclude that bridge vibration will become unstable live load, represented by people of mass m per unit length, is too great a proportion of bridge mass M per unit length. The London millennium bridge after modification lies well above upper limit of pedestrian scruton number drawn by assuming the factor of α and β are unity with α=2/3 and β=0.4The worst case assumption for the correlation factor of the β and may be a pessimistic for the value of the amplitude ratio α The permissible m/M ratio depends on the amount of the damping present in the appropriate the vibration modes of the only arise of the frequency when the excitation frequency lightly in vibration modes.

Angus low[1], Peter Burnton[2] [2005] In there project the Millennium bridge relevant effect occurs not only in long span bridge it occurred also in short span bridge the common factor is there has been a later mode with a frequency of 0.5 Hz to 1.0 Hz and show lateral frequencies of number of foot bridge. the studies carried out for the retrofit of London Millennium bridge have provide a model of SLE which allows footbridge checked phenomena. the provide design of data is provide damping of the bridges. Foot bridge design will evolve in response of SLE.

James F.welch[1] , Mohammad A.alhassan[2], Luban K. Amarieh[3].[2012] In there project, The conceptual of the design of the pedestrian bridge considering potential bridge concept of the modelling, analysis and design detail of the selected arch type pedestrian bridge. Which has been average daily traffic are 50,000 vehicles. The pedestrian bridge was analyze and design using SAP2000 for static load, live load and also wind load as per AASHTO specifications and INDOT require It was conclude that the Arch type pedestrian Bridge is most appropriate design intend of the pedestrian bridge on coliseum Boulevard. The analysis software are the SAP2000 is very effective and innovative approach the design pedestrian bridge the considering dynamic and wind load. The construction method must be considering smooth project progress without potential interruption. Its unique feature include in the aesthetically pleasing look, Constructed in a short time with minimal impact on the impact flow. The arch member resisting the applied load in compression. The reduce the overall project cost.

Rakshith S Shetty[1], Prasanth. M.H [2], Chanappa.T.M[3], Ravi Kumar C.M[4] [2013] In there project, the steel Truss railway bridge the span of the bridge is 78.8m the proposal steel Truss railway bridge the improving dynamic performance and the steel Truss railway bridge reduction displacement and acceleration observed compare with tuned mass damper and without tuned mass damper by using the software SAP2000. The steel bridge structure Time Period More than time period 16% first mode the steel bridge with TMD is compared to without TMD The steel Truss Railway Bridge higher modes of vibration ,the time period larger than 48% the bridge compared to without tuned mass damper. The bridge structure with tuned mass damper reducing vibration in parameter (displacement and acceleration) with compared to without tuned mass damper. Tuned mass damper is control of vibration due the earthquake load then the moving Load.

Yong Li[1], Xiao.Xiong Zha[2], Chong.Li.Zhu[3] [2015]. In there project is located in the city of Shenzhen. The bridge is flying swallow type of curve special shaped composited arch bridge main arch span 176.26m and 164.40 respectively the half through arch bridge is 230.50m long span of curve girder 30.25m ,170 and 30.25m. crowd load is 3.0kN/m^2 wind speed 26 m/sec. it can be seen from the results of bridge structure is good stiffness and strong stability, and the design of cured surface improve whole torsional capacity.the bridge is optimal designed to be a flying swallow type curve shaped bending moment and cross section in main rib is small.

3. Objectives of the work

The following are the main objectives of the present study analysis are:
To perform of linear static analysis for steel bridges using SAP 2000 and study the vibration and dynamic excitation of Pedestrian steel bridges.
To analyze the structure by using SAP 2000 software.
To study the time history, vibration and dynamic response as per IRC –SP-56-2011and IRC 006-2014.

To aim at the determination of basic dynamic excitation of Pedestrian steel bridges and time history to the different type of the bridge.
To find the time period, frequency of the bridge.
To obtain the results as per IRC-SP-2011 dynamic excitation method.

Table -1: Bridge description

Serial No	Bridge Description	
1	Zone	II
2	Zone Factor	0.10
3	Damping	5%
4	Height of bridge	5m
5	Top Chord	355.6 x10 mm
6	Top Chord intermediate	139.7 x6.3 mm
7	Top Chord End Bracing	355.6 x 16 mm
8	Top Chord diagonal Bracing	139.7x6.3 mm
9	Deck End Beam	200 x 200 x 10 mm
10	Deck Beam	100 x100 x10 mm
11	Diagonals	163.6 x 12mm
12	Bottom Chord	355.6 x 10mm
13	Bottom Diagonal Bracing	150 x150 x6.3 mm
14	Bottom Edge intermediate bracing	200x 200 x 10mm
15	Bottom End Bracing	355.6x16mm
16	Vertical	169.7x 10mm
17	Span of bridge	40m,50m and 60m
18	Type of bridge	Full Arch bridge and vierendeel Truss Bridge
19	Steel weight per volume	76.98 kN/m^3
20	Modulus Elasticity	$2x10^5$ N/mm^2
21	Passion's ratio	0.3
22	Yield stress	355 N/mm^2

4. Modeling and Analysis

The type of analysis carried by the maximum vertical acceleration with time and that the dynamic loading applied by the pedestrian can represented by pulsating point force F calculated as per IRC:SP:56-2011 with natural frequency with applied time history method. We need input of the pulsating force as a generic function of defined in SAP2000. There are 3 models of span 40m,50m and 60m of full arch and also vierendeel truss bridge. The variation of time period, natural frequency on different type of span bridge are compared from the analysis.

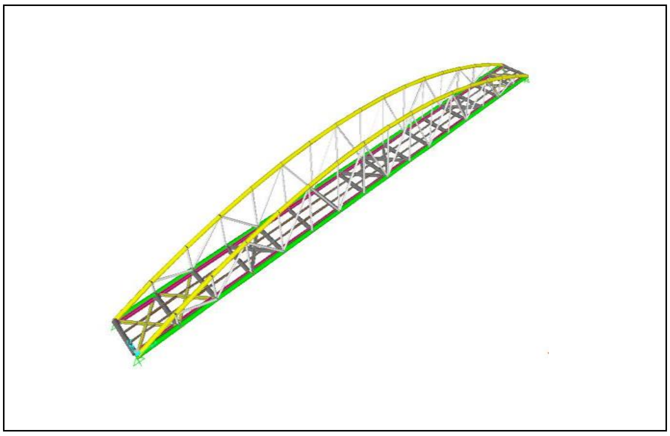

Fig-3: 3D View of full arch bridge

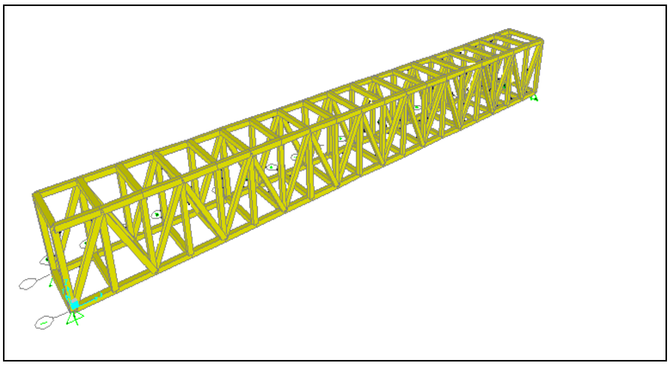

Fig-4: 3D View of vierendeel truss bridge

Table -2: Time period for different spans of full arch and vierendeel truss bridge

Type of bridge	Full arch bridge			Vierendeel truss bridge		
Mode/ span	40	50	60	40	50	60
1	0.419808	0.45524	0.789103	0.630319	0.790585	0.767987
2	0.223675	0.325849	0.396131	0.374230	0.532932	0.624827
3	0.216169	0.294145	0.329569	0.364313	0.484691	0.476255
4	0.207907	0.246345	0267703	0.248046	0.375049	0.348703
5	0.197698	0.228655	0.24111	0.240258	0.252364	0.278313
6	0.139095	0.210332	0.232464	0.214469	0.236624	0.241485
7	0.131036	0.166274	0.187018	0.172792	0.227527	0.238554
8	0.120876	0.146115	0.17566	0.171968	0.160637	0.225619
9	0.118029	0.142498	0.159514	0.168067	0.15956	0.221905
10	0.099971	0.136314	0.150162	0.161449	0.158176	0.200733
11	0.096618	0.125837	0.138871	0.127974	0.15557	0.176662
12	0.088032	0.110893	0.129479	0.126865	0.151922	0.174842

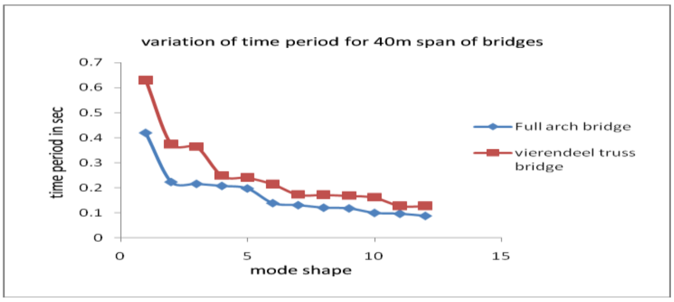

Chart-1: variation of time period v/s mode shape for full arch and vierendeel truss bridge for 40m span

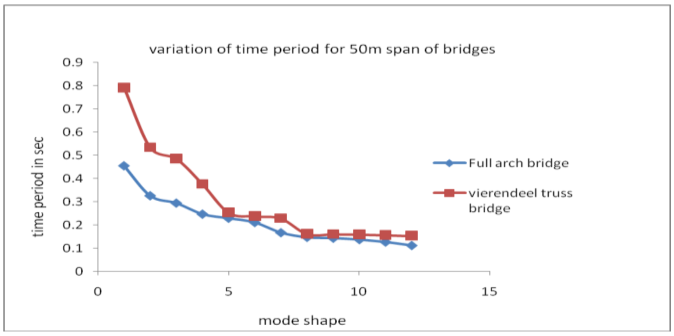

Chart-2: variation of time period v/s mode shape for full arch and vierendeel truss bridge for 50m span

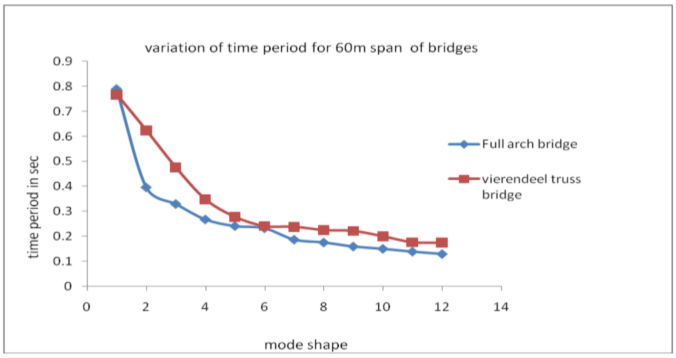

Chart-3: variation of time period v/s mode shape for full arch and vierendeel truss bridge for 60m span

Table -3: Frequency for different spans of full arch and vierendeel truss bridge

Type of bridge	Full arch bridge			Vierendeel truss bridge		
Mode/ Span	40	50	60	40	50	60
1	2.382	2.1966	1.2673	1.5865	1.2649	1.3021
2	4.4708	3.0689	2.5244	2.6722	1.8764	1.6004
3	4.626	3.3997	3.0343	2.7449	2.0632	2.0997
4	4.8098	4.0594	3.7355	4.0315	2.6663	2.8678
5	5.0582	4.3734	4.1475	4.1622	3.9625	3.5931
6	7.1893	4.7544	4.3017	4.6627	4.2261	4.141
7	7.6315	6.0142	5.3471	5.7873	4.3951	4.1919
8	8.273	6.8439	5.6928	5.815	6.2252	4.4323
9	8.4725	7.0176	6.269	5.95	6.2672	4.5064
10	10.003	7.336	6.6595	6.1939	6.3221	4.9817
11	10.35	7.9468	7.2009	7.8141	6.428	5.6605
12	11.359	9.0177	7.7232	7.8824	6.5823	5.7195

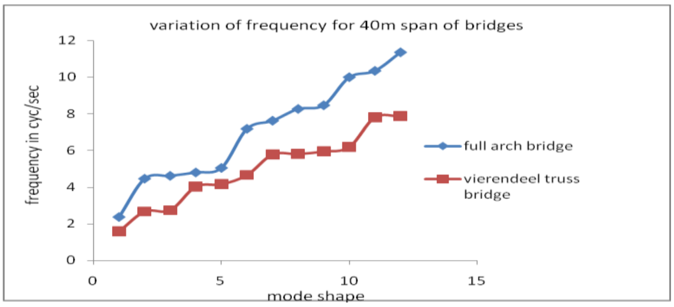

Chart-4: variation of frequency v/s mode shape for full arch and vierendeel truss bridge for 40m span

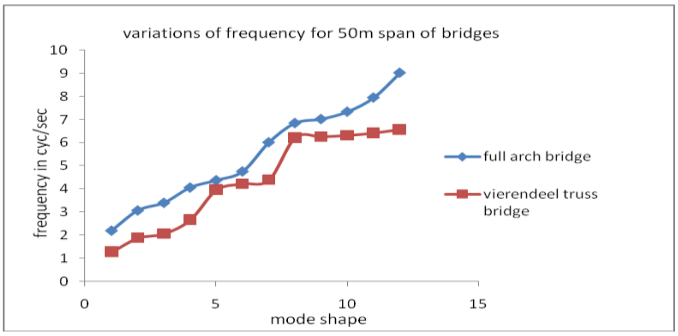

Chart-5: variation of frequency v/s mode shape for full arch and vierendeel truss bridge for 50m span

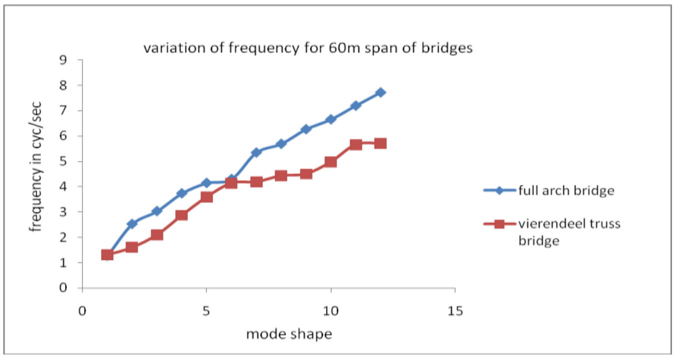

Chart-6: variation of frequency v/s mode shape for full arch and vierendeel truss bridge for 60m span

5. Conclusion

The following conclusions are obtained from the outcomes of the investigation:

1. The time period for vierendeel Truss Bridge for 40m span is 50% more than full arch bridge.
2. Similarly the time period for 50m and 60m span of vierendeel truss bridge is 70% and 53% more than full arch bridges respectively.
3. The frequency of full arch bridge for 40m span is 33% more than vierendeel truss bridge.
4. Similarly the frequency for 50m and 60m span of full arch bridge is 42% and 37% more than vierendeel truss bridge.

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BIOGRAPHIES

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