Dynamic and Vibration Analysis of Foot Over Bridge with Various Frequencies Due to Human Walking by Using Staadpro

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Abstract— Foot over bridges offer a wide range of opportunities for imaginative and innovative architectural design. Design should be as attractive as possible. The structure should be in harmony with surrounding environment. The proportion of different elements of the bridge should be proportionate. The external finish and painting should be such as to enhance the elegance of the bridge. Foot bridges have been constructed with increasingly daring structures encompassing the experience and knowledge of structural designers by using newly developed materials and technologies. This fact has generated very slender structural footbridges and, consequently, changed their associated serviceability and ultimate limit states. A direct consequence of this design trend was a considerable increase of structural vibration problems. In the particular case of pedestrian footbridges this phenomenon occurs when the structural fundamental frequency is near the load excitation frequencies, or higher frequencies multiples. This is the main motivation of this thesis to development of a design methodology to better evaluate the footbridge user's comfort and safety.

Indexed Terms— Foot Over Bridge, Dynamic, Staadpro.

I. INTRODUCTION

The pedestrian bridges are situated across roads to let pedestrians cross safely while not deceleration down the traffic. The latter may be a sort of pedestrian separation structure, samples of that area unit significantly found close to schools, colleges and busy corridors. The pedestrian bridge is taken into idea for developing the transportation, and its infrastructure to meet the needs and demand of the growing population whilst retaining its distinctive and valued market town character. This project has been proposed especially for pedestrian safety considerations, where the bridge cross over structure will serves as a best for both pedestrians and the fastest moving traffic.

The structure provides a strategic and easy access to the bus terminus and in conjunction with the six lanes state highway would enable the traffic to flow at high speed so that the flow should not be disturbed in turn saving the destination, fuel and prevents hazards at a time. Durable and sustainable bridges play an important role for the socio-economic development of the nation. Owners and designers have long recognized the low initial cost, low maintenance needs and long-life expectancy of RCC concrete bridges. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

Fig 1 Foot over Bridge

1.1 Advantages

- Provides safe and sustainable crossings and provides technical assistance to local government and communities need simple, easily applied guidelines on the selection and construction of effective water crossings.
- Much rural travel takes place on local paths, tracks and village roads. These provide essential access to water, firewood, farm plots and the classified road network.
- Communities and/or local government are generally responsible for this infrastructure

1.2 Disadvantages

- Pedestrian overpasses over highways or railroads are expensive, especially when elevators or long ramps for wheelchair users are required.
- Without elevators or ramps, people with mobility handicaps will not be able to use the structure. Often, people will prefer to walk across a busy road at grade rather than expend the effort to climb up the bridge and go over it

II. STATE OF DEVELOPMENT

J. Kala et al (2009) Using the ANSYS programming system, a comprehensive structural model of the Kolin suspension bridge in the Czech Republic underwent dynamic study. An individual and a group of pedestrians' loads were modelled in an experiment, and the movement and speed that resulted were compared to the fitted model.

Iemke Roos et al (2009) Depending on the regulations, the response is given in terms of maximum acceleration or displacement. Crack reaction as seen in the load model. The UK National Annex's data yields the most accurate conclusion for the bridge's real behaviour. It is advisable to use caution while using these loading models and to make improvements to them. Analysis may result in output mistakes depending on the bridge model or time step chosen.

Stana Zivanoviý et al (2010) parameters change with each step within a person's force history (intra-subject variability). This indicates that the walking force is not a deterministic force, but rather a narrow-band stochastic process. This defect means that existing design decision-making is unable to accurately forecast how a human walking on a thin, built-in structure would respond to vibration. The different walking forces must be considered in order to enhance the design process. This suggests that modelling support path experience would be a good fit for the probabilistic approach, which can account for the likelihood of the creation of different paths.

El-Sayed Mashaly et al (2013) There is a live load along the bridge and a dead load in the middle of the span. The generic single-freedom technique was used for response spectrum analysis, and the predictions were verified by contrasting them with the outcomes of multi-degree-of-freedom modelling. The outcomes demonstrate that the response spectrum approach is capable of forecasting the pedestrian bridge's vibration response. The findings also indicate that the pedestrian bridge's size and damping ratio are the primary factors influencing the acceleration caused by pedestrian load in the vertical direction of the pedestrian bridge.

III. METHODOLOGY AND PROBLEM STATEMENT

The main objective of this work is to analyze the Foot Over Bridge with different type of truss patterns and suggest the best truss which is well behaved under dynamic and vibration action, For that analysis following methodology are followed.

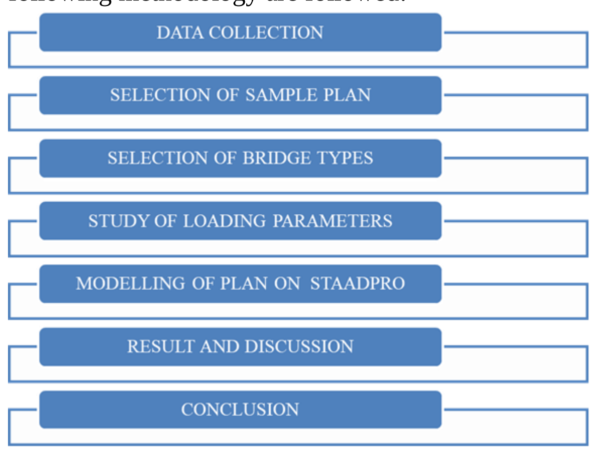


Fig 2 Flow Chart

3.1 Vibration Analysis

Table 1 Vibration Analysis

Sr. No.	Side	Max. Amplitude	Max. Frequency(Hz)	Vibration to Kn 1 hertz in kilonewton = 0.001
1	Left	900.8	90.08	0.09008
2	Middle	4159.7	415.97	0.41597
3	Right	1013.3	101.33	0.10133
Total				0.60738 Kn

3.2 Models

Table 2 Models

Model 1	Pratt Truss
Model 2	Howe Truss

Model 3	Warren Truss

Table 3 Bridge Details

Sr.No	Description	
1	Span of Bridge	30 m
2	Width of Bridge	5 m
4	Total Height	3.5 m
5	Slab thickness (average)	0.15 m

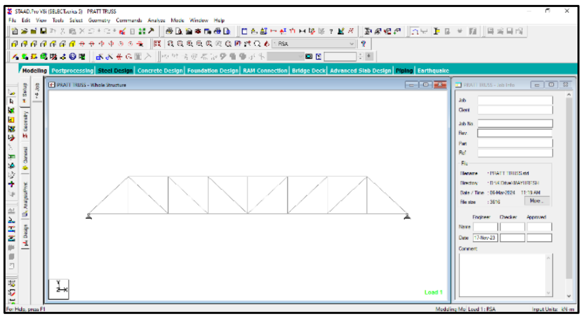


Fig 3 Model 1- Pratt Truss

This truss features diagonal members that slope down toward the centre, which distinguishes it from the Howe truss. The truss's internal diagonals are under tension, while the vertical elements are in compression

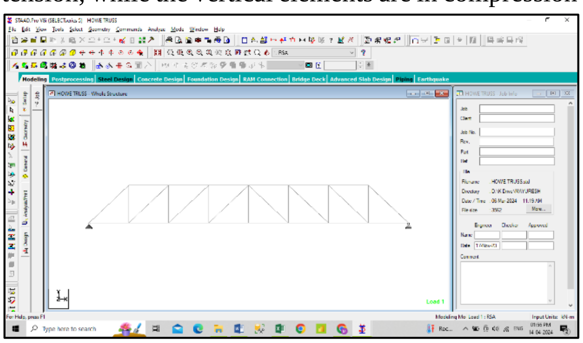


Fig 4 Model 2- Howe Truss

A Howe truss bridge is made up of flanges, purlins, and diagonals, with the vertical elements in tension and the diagonal ones in compression

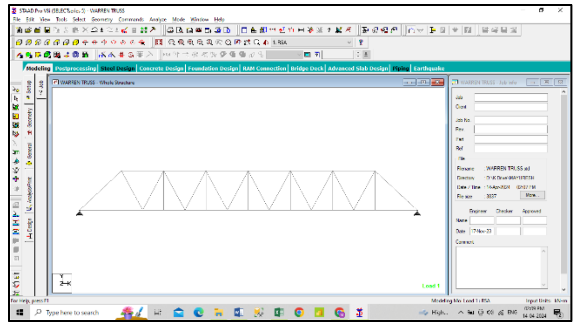


Fig 5 Model 3- Warren Truss

The Warren Truss Bridge is a very common bridge construction that can be seen all over the globe. In this post, we will look at several intriguing facts about its design, such as its history, functioning, advantages and disadvantages, and much more. The Warren truss design distributes the weight on the bridge using equilateral triangles in the construction.

2.3 Add Response Spectrum

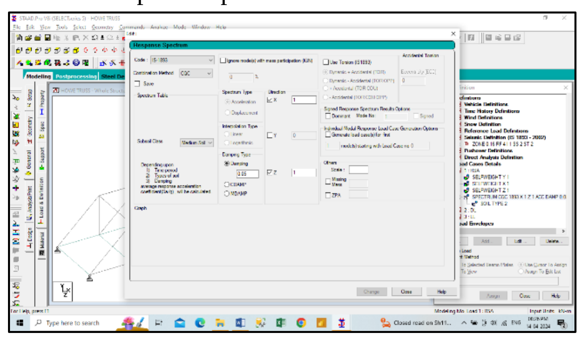


Fig 6 Add Response Spectrum

a) Formulation of an appropriate mathematical model consisting of lumped mass system using 2D / 3D beam elements. The mathematical model should suitably represent dynamic characteristics of superstructure, bearings, substructure, foundation and soil / Rock Springs. In rock and very stiff soil fixed base can be considered.

b) Determination of natural frequency and mode shapes following a standard stiffness matrix, transfer matrix or other standard approach.

c) Determine to al response by combining responses in various modes by (i) by mode combination procedure such as SRSS, CQC, etc. or (ii) time-wise super position of responses using ground motion time history (s). In method (i) Ah shall be computed as explained in (d) below.

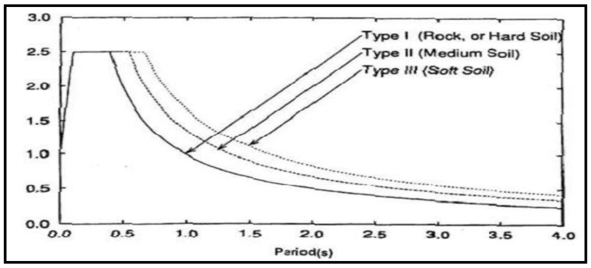


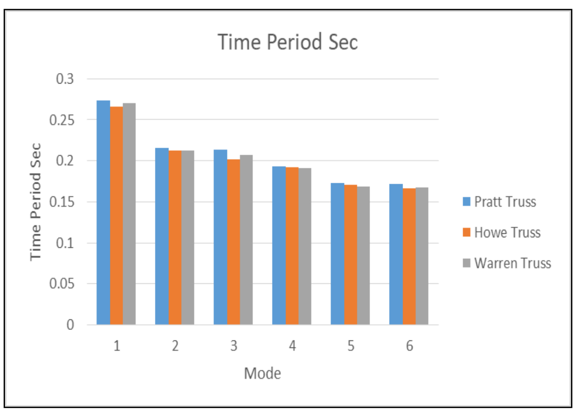
Fig 7 Average acceleration coefficient

IV. RESULTS AND DISCUSSION

4.1 Results for Time period

Table 4 Time Period Sec

Time Period Sec			
Mode	Pratt Truss	Howe Truss	Warren Truss
1	0.274	0.266	0.27
2	0.216	0.213	0.213
3	0.214	0.202	0.207
4	0.193	0.192	0.191
5	0.173	0.171	0.169
6	0.172	0.167	0.168



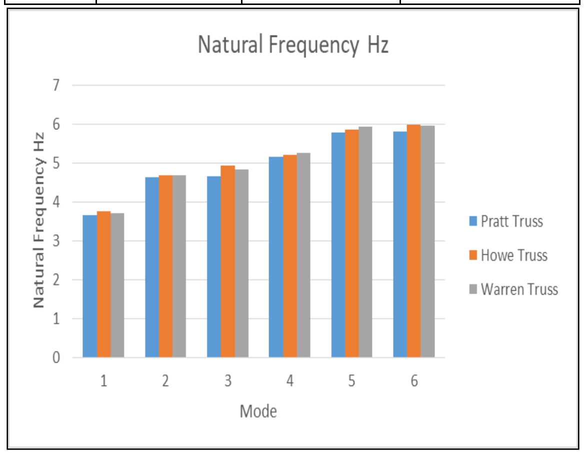
Graph 1 Time Period Sec

The above results show the results for the time period for vibration and response spectrum analysis. The time period for the Howe truss has better results than the Pratt and Warren types of trusses.

4.2 Results for Natural Frequency Hz

Table 5 Natural Frequency Hz

Natural Frequency Hz			
Mode	Pratt Truss	Howe Truss	Warren Truss
1	3.649	3.763	3.701
2	4.632	4.688	4.688
3	4.663	4.945	4.84
4	5.169	5.203	5.246
5	5.784	5.857	5.925
6	5.819	5.975	5.969



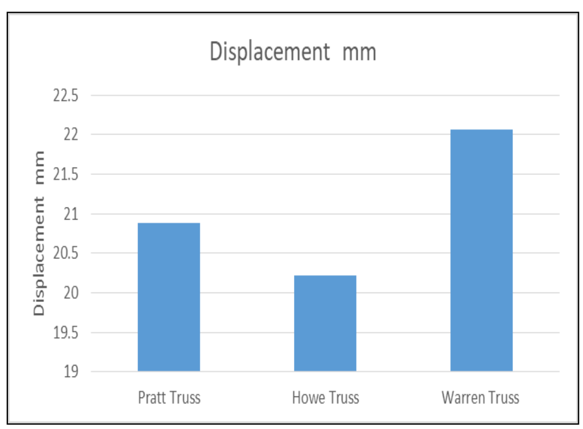
Graph 2 Natural Frequency Hz

The above results show the results for the natural frequency for vibration and response spectrum analysis. The natural frequency for the Howe truss has better results than the Pratt and Warren types of truss.

4.3 Results for Displacement- Top Corner of the Bridge

Table 6 Displacement for Top Corner

Displacement mm		
Pratt Truss	Howe Truss	Warren Truss
20.89	20.218	22.07



Graph 5.3 Displacement for Top Corner

The results mentioned above indicate the displacement at the top corner for vibration and response spectrum analysis. The Howe truss is better than the Pratt and Warren trusses in terms of top corner displacement.

CONCLUSION

With this project, we aim to contribute a working solution to the recurring problem of inconvenience, time, and accidental loss for people. Foot-over bridges make it easier for people to cross the street safely and without fear. In this research, three types of trusses are analysed for vibration and response spectrum analysis to check the effective capacity of the trusses. The Pratt, Howe, and Warren types of truss are used for that research. The research findings suggest that the Howe truss type of foot over bridges is effective in providing safe and efficient passage for pedestrians, particularly in areas with high foot traffic. The all conclusion are find out from following analysis results.

- The time period for the Howe truss has less results than the Pratt and Warren types of trusses by 5-10%
- The natural frequency for the Howe truss has high results than the Pratt and Warren types of truss by 5-10%
- The Howe truss is better than the Pratt and Warren trusses in terms of top corner displacement by 20-25%
- The displacement in the bottom middle for the Howe truss has better results than the Pratt and Warren type of truss by 10-15%.

V. FUTURE SCOPE

The pedestrian bridge is taken into idea for developing the transportation, and its infrastructure to meet the needs and demand of the growing population. It Provides safe and sustainable crossings and provides technical assistance to local government and communities need simple, easily applied guidelines on the selection and construction of effective water crossings. Future research and application are necessary to ensure their continued effectiveness in enhancing pedestrian safety and mobility in different seismic zones and heavy traffic locations.

REFERENCES

[1] J. Kala et al "Footbridge Response on Single Pedestrian Induced Vibration Analysis" World Academy of Science, Engineering and Technology 26 2009

[2] Iemke Roos et al "Human Induced Vibrations on Footbridges" Application & comparison of pedestrian load models, Delft University of Technology, Netherlands 2009

[3] Stana Zivanoviý et al "Probability-Based Estimation of Vibration for Pedestrian Structures due to Walking"2010

[4] El-Sayed Mashaly et al "Evaluating the vertical vibration response of footbridges using a response spectrum approach" Alexandria Engineering Journal 2013

[5] Jianing Hao et al "Natural Vibration Analysis of Long Span Suspension Bridges" 5th International Conferences on Civil Engineering and Transportation (ICCET 2015)

[6] Heena Dewangan et al "A Review on Comparison of Different Types of Trusses in Vibration Analysis Using Staad Pro" IJESRT Impact Factor: 5.164 IC™ Value: 3.00 CODEN: IJESS7 July, 2018

[7] Sabina Piras et al "Footbridge Design For Pedestrian Induced Vibrations" the concrete Nz Conference 2018

[8] Mr. Kaushal Kumar et al "Analysis of Truss Bridge and Cost Optimization by Using Hollow Sections" May, 2019

[9] José Guilherme Santos da Silva et al "Finite Element Modeling of the Dynamic Behaviors of Tubular Footbridges" Finite Element Analysis – New Trends and Developments 2019

[10] Prakash Kumar et al "Serviceability Analysis of a Footbridge Subjected to Pedestrian Walking" Advances in Engineering Design 2019

[11] Arturas Kilikevicius et al "The Influence of Different Loads on the Footbridge Dynamic Parameters" MDPI 2019

[12] V. R. Shinde,Prof. A. S. Patil,Prof. U. A. Mahadik,"Comparative Analysis of Truss Bridges." (2021)

[13] Safwan Asghar Abbas "Designing A Truss Bridge" Ghulam Ishaq Khan Institute of Engineering Sciences and Technology July (2020)

[14] Varsha Patil, et. al. "Damage detection of warren truss bridge using frequency change Correlation" Science Direct International Conference on Materials, Machines and Information Technology-(2022)

[15] S. Rajesh et. al. "Design Of A Steel Foot Over Bridge In A Railway Station" International Journal of Civil Engineering and Technology (2017)

[16] Gokul E. et. al. "Analysis and Design of a Steel Foot Over-bridge with Tubular Sections using STADD. Pro" IJIRMPS (2023)

[17] Syed Iftequar Hussaini et. al. "International Journal of Research Publication and Reviews" International Journal of Research Publication and Review (2023)

[18] Aishwarya Kulkarni et. al. "Materials For Footover Bridges" International Research Journal of Engineering and Technology (2016)

[19] Ajit kumar Jha et. al. "Analysis of RCC Foot Over Bridge and Economical Comparison of RCC and Steel Foot Over Bridge" International Journal of Engineering Research & Technology (2023)

[20] Aditya Gaikwad et. al. "Design And Shape Optimization Of Footover Bridge" International Journal of Creative Research Thoughts (2024)