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ANALYSIS OF DESIGN ON LONG SPAN METRO RAIL BRIDGE STRUCTURE UNDER CONSTRUCTION PROJECT DELHI–MEERUT RRTS

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ABSTRACT

Bridges are an important aspect of local and international transportation, facilitating global commerce and economy. With shifting trends, however, more and more advancements in bridge design for increased performance and aesthetics have emerged. When the environment favors more than one bridge building system, it might be difficult to begin planning and designing a certain kind of bridge without first assessing the alternatives. As a result, our study provides a foundation for comparing two kinds of bridges: Prestressed Concrete Bridges and Plate Girder Bridges. Both bridges will be developed using MIDAS software, which is the most recent technological innovation in bridge design. Further planning, drawing preparations, and estimating may be done based on the design. As a result, a significant amount of money is saved, and the potential of resale value is increased due to definite judgments on the kind of building. We want to provide a critical assessment of the works and research done in this and adjacent topics via this publication. Keywords: Moving Dynamic loads, Resonance, Tuned mass dampers, Vibration management, Dynamic behavior, semi high-speed railway bridges.

Keywords: Bridges, Plate Girder, Midas, Pre-Stressed Concrete.

I. INTRODUCTION

Bridges have a long history of facilitating trade and commerce. They were first constructed based on ideas developed throughout Mesopotamia's civilization. The first bridge may have been built as early as the 13th century BC in Ancient Greece. Bridge construction began with Arches and progressed to temporary cement. Bamboos were purchased by an increasing number of concepts in the industry. They began to be employed for both commercial and military purposes. They have proven to be quite useful in military operations for nations such as India. Timber, ropes, and iron bridges all existed by the time of the Industrial Revolution, allowing for some substantial advancements. Modern infrastructure has allowed for increased growth in this area, with Prestressed, Girder, and RC boxes being some of the most often utilized bridge types. This, along with a huge advance in combining technology and civil engineering, has been a proven instrument for the simpler and quicker creation of bridge infrastructure all over the globe. Bridges are categorized depending on a variety of factors, including •superstructure type - Arch Bridges, Girder Bridges, Truss Bridges, Suspension Bridges, and Cable-Stayed Bridges. According to the kind of material used: timber, masonry, steel, RCC, and prestressed concrete bridges. Culvert Bridges, Minor Bridges, Major Bridges, and Long Span Bridges are the different types of spans. Simply Supported Bridges, Continuous Bridges, and Continuous Bridges are the three types of bridges. In nations like India, where population density, as well as commerce and travel, is very high, it is critical to construct flyovers and bridges to ensure seamless road transportation. They are also an important element of the Indian infrastructure. They also foster peace by bridging the gap between diverse local cultures via a worldwide connection. With all of these great advantages of bridges, it's crucial to keep track of how bridge design evolves. Various software tools, such as STAAD.Pro, ETABS, MIDAS, and others, have shown to be effective in tackling complicated problems. These aid in the development of cost-effective bridge designs, resulting in a more stable profile for Indian infrastructure. Although there is still much more study to be done, current advancements have given bridge designs a bright future. The software programs have been created to comply with the standard requirements for materials and Limit States, as well as to make them user-pleasant for novices so that they may instill quicker learning while collecting more and more know-how from untrained brains. It becomes necessary to create a prodigious design with maximum value so that ordinary people may benefit from it without having to pay more for returns. Firm judgments may be made between possibilities with adequate analysis without deviating from the Standard Codes of Practice (e.g. ISC) mandated by ministries of regulations (e.g. MORTH). Excel sheets provide another handy option for doing difficult computations and providing immediate results for useful site feedback. They offer the structure with ordered details, with practically all sections capable of being developed and studied by it. However, as the world's population grows, it becomes more important to create ecologically sustainable constructions that meet the aforementioned criteria. Biomimicry may help establish the groundwork for bridge infrastructure that is energy, waste, and material efficient.

II. NEED FOR STUDY

The different alternatives that have been given forth for the engineers and consultants to pick from throughout the years form the foundation of this project. It must be thoroughly investigated if the selected design would pose any dangers throughout its development. Any flaws in the product? The design or kind you choose might have devastating consequences. As a result, for a large-scale infrastructure such as a bridge, each alternative's accurate and complete facts must be prepared. Surveys should be the following step after thorough planning. On-site inspections or legality checks on paper are critical for Getting any project off the ground, many alone bridges, are difficult. The surveys must determine what kind of materials would work well in the given context. The availability of resources and manpower, as well as the investors' secondary requirements. After deciding on the sort of bridges that would be appropriate for the site, a thorough investigation is essential to avoid financial loss due to mistakes. The number of interpretations is kept to a minimum. The main operating procedure is to verify the safety of each kind using the Limit State.

A Case Study on Recent Under Construction Project

The Delhi–Meerut Regional Rapid Transit System is a semi-high-speed rail route linking Delhi, Ghaziabad, and Meerut that runs for 82.15 kilometers (51.05 miles). It is one of three fast rail lines proposed under Phase I of the National Capital Region Transport Corporation's Regional Rapid Transport System (RRTS) project (NCRTC). The distance between Delhi and Meerut will be covered in less than 60 minutes at a maximum speed of 180 km/h (111.85 mph). The project is expected to cost Rs 30,274 crore (US$ 4.0 billion) and would have 24 stations, including two depots in Duhai and Modipuram. The Regional Rapid Transit System (RRTS) is a new, dedicated, high-speed, high-capacity, and pleasant commuter service that connects regional nodes in the National Capital Region (NCR). The DD-20 contract covers "Detail Design services for Civil, Architectural, Structural, MEP, Property Development, and other related fields, as well as seamless integration with current means of transportation." The scope of work includes. The National Capital Region Transport Corporation (NCRTC) has completed the installation of a 73-meter-long, 875-tonne Special Steel Span (bridge) for the Delhi-Ghaziabad-Meerut RRTS corridor, which crosses the main road of the Eastern Peripheral Expressway (EPE) near Duhai on the main carriageway of the Delhi-Meerut Road.

Fig 1: Design of Long Span under Construction Project for the Delhi–Meerut RRTS Metro rail Bridge Structure

III. METHODOLOGY

3.1 Input Parameters in MIDAS Civil

Analysis Type

Linear Analysis with Direct Integration Analysis method is used in MIDAS Civil.

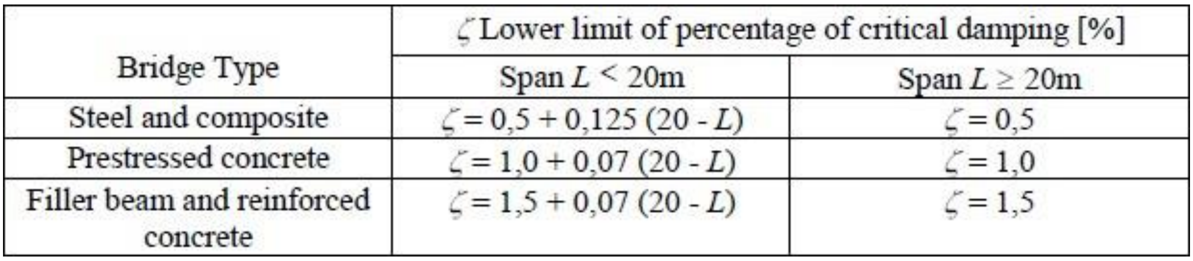
Time Increment

Time increment is taken as "TP/10" = 0.001 sec.

Damping Ratio of the structure

It is taken as per Table 1 of BS EN 1991-2:2003

Table 1: Damping Ratio of the structure6 of BS EN 1991-2:2003



Bridge Type	ζ Lower limit of percentage of critical damping [%]	
	Span $L < 20$m	Span $L \geq 20$m
Steel and composite	$\zeta = 0{,}5 + 0{,}125\,(20 - L)$	$\zeta = 0{,}5$
Prestressed concrete	$\zeta = 1{,}0 + 0{,}07\,(20 - L)$	$\zeta = 1{,}0$
Filler beam and reinforced concrete	$\zeta = 1{,}5 + 0{,}07\,(20 - L)$	$\zeta = 1{,}5$

$$\Delta\zeta = \frac{0{,}0187L - 0{,}00064L^2}{1 - 0{,}0441L - 0{,}0044L^2 + 0{,}000255L^3}\,[\%]$$

According to BS EN 1991-2:2003, the aforementioned character for spans less than 30m may increase the bridge is prestressed concrete and the bearing c/c is 16 meters, the analysis uses 1.917 percent damping using the modal damping approach, as shown in the table and formula above.

3.2 Checks for Analysis

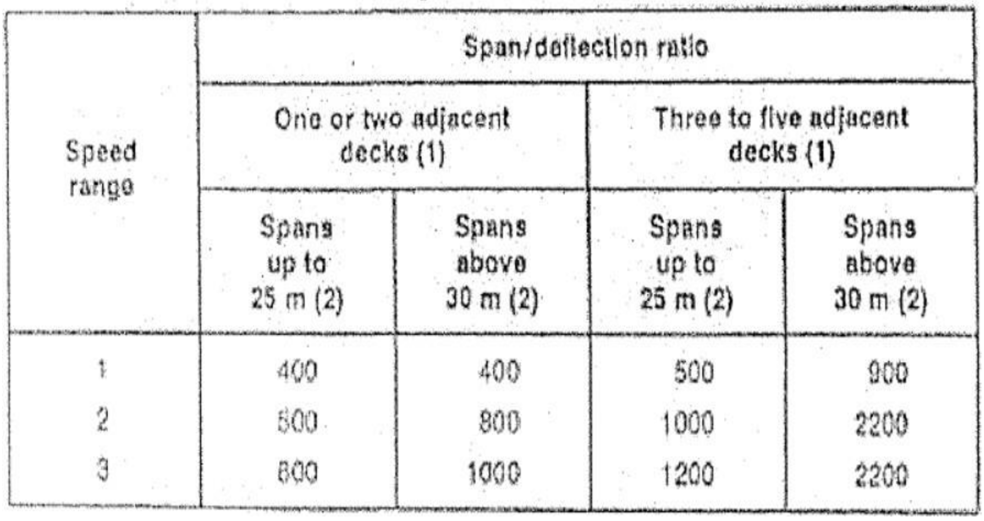
Check for acceleration

The maximum permissible acceleration is 5 m/s2, according to Sec A2.4.4.2.1 (4).

Check for deflection

The deflection is calculated according to the UIC-776-3R specifications. According to DBR Sec 10.4, speed range 2 is taken into account. According to Table 2 of UIC-776-3R, for high-quality passenger comfort.

Table 2: Data of UIC-776-3R, for high-quality passenger comfort



Speed range	Span/deflection ratio			
	One or two adjacent decks (1)		Three to five adjacent decks (1)	
	Spans up to 25 m (2)	Spans above 30 m (2)	Spans up to 25 m (2)	Spans above 30 m (2)
1	400	400	500	900
2	600	800	1000	2200
3	800	1000	1200	2200

Natural Frequency for Lateral Vibration

The first natural frequency of lateral vibration of a span shall not be less than 1.2 Hz, according to Sec A2.4.4.2.4 (3).

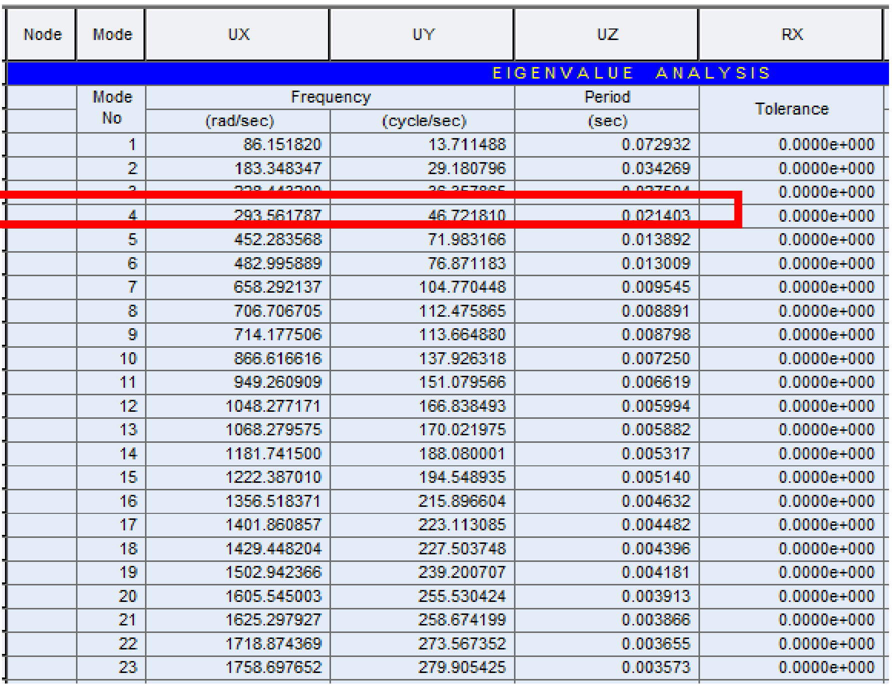
IV. RESULT

MIDAS Civil Results: Axis Convention

Direction X-Longitudinal the Y-Direction is the opposite of the X-Direction. Z-Vertical Direction Z-Vertical Direction Z-Vertical Direction Z

Natural Vibration Modes: Table-2 shows the frequencies associated with various mode shapes:

Table 3: Natural Vibration Mode



Node	Mode	UX	UY	UZ	RX
EIGENVALUE ANALYSIS					
	Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance
	1	86.151820	13.711488	0.072932	0.0000e+000
	2	183.348347	29.180796	0.034269	0.0000e+000
	3	[illegible]	[illegible]	[illegible]	0.0000e+000
	4	293.561787	46.721810	0.021403	0.0000e+000
	5	452.283568	71.983166	0.013892	0.0000e+000
	6	482.995889	76.871183	0.013009	0.0000e+000
	7	658.292137	104.770448	0.009545	0.0000e+000
	8	706.706705	112.475865	0.008891	0.0000e+000
	9	714.177506	113.664880	0.008798	0.0000e+000
	10	866.616616	137.926318	0.007250	0.0000e+000
	11	949.260909	151.079566	0.006619	0.0000e+000
	12	1048.277171	166.838493	0.005994	0.0000e+000
	13	1068.279575	170.021975	0.005882	0.0000e+000
	14	1181.741500	188.080001	0.005317	0.0000e+000
	15	1222.387010	194.548935	0.005140	0.0000e+000
	16	1356.518371	215.896604	0.004632	0.0000e+000
	17	1401.860857	223.113085	0.004482	0.0000e+000
	18	1429.448204	227.503748	0.004396	0.0000e+000
	19	1502.942366	239.200707	0.004181	0.0000e+000
	20	1605.545003	255.530424	0.003913	0.0000e+000
	21	1625.297927	258.674199	0.003866	0.0000e+000
	22	1718.874369	273.567352	0.003655	0.0000e+000
	23	1758.697652	279.905425	0.003573	0.0000e+000

Types of Mode Shape

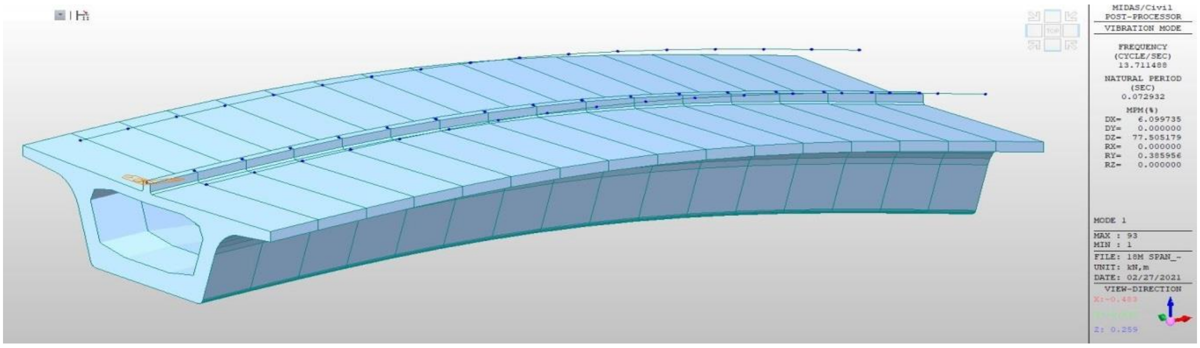


Fig 2: Mode 1

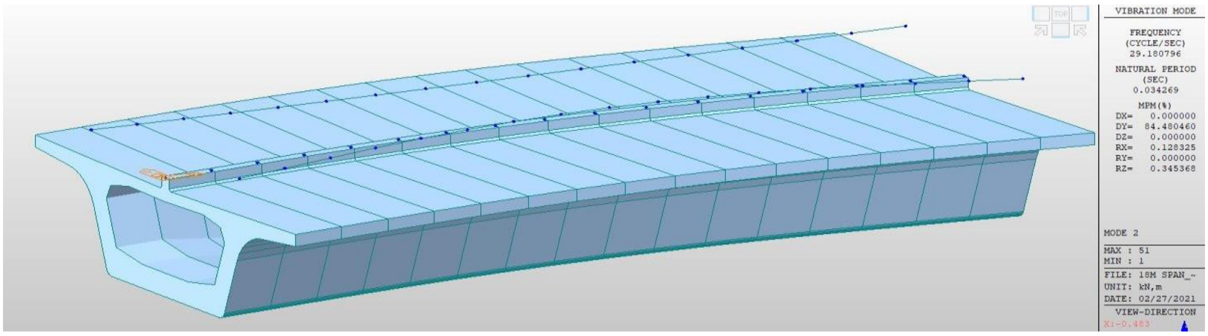


Fig 3: Mode 2

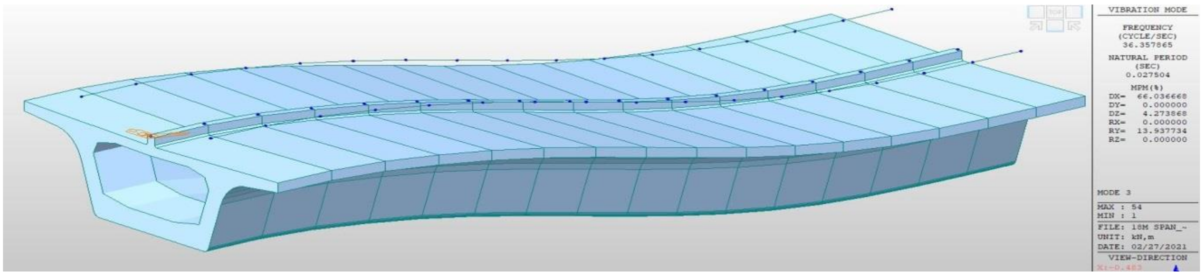


Fig 4: Mode 3

Acceleration

Midas provides acceleration at mid-span for dynamic live load. The vertical acceleration diagram for a 180kmph speed and a vehicle length of 21.34m is shown below.

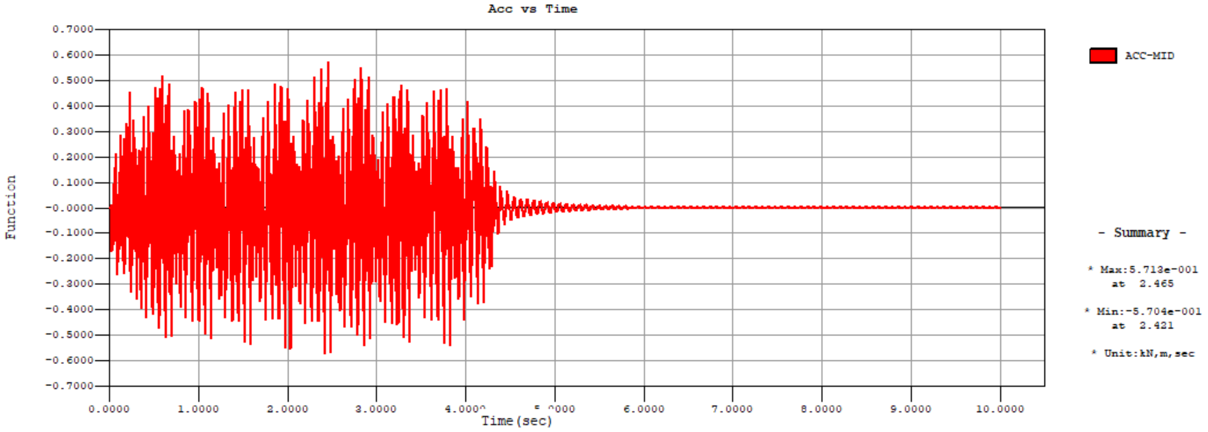


Fig 5: Mid-span acceleration (in m/s2) on the vertical axis and time (in a sec) on the horizontal axis at 180kmph with a 22.34m vehicle length.

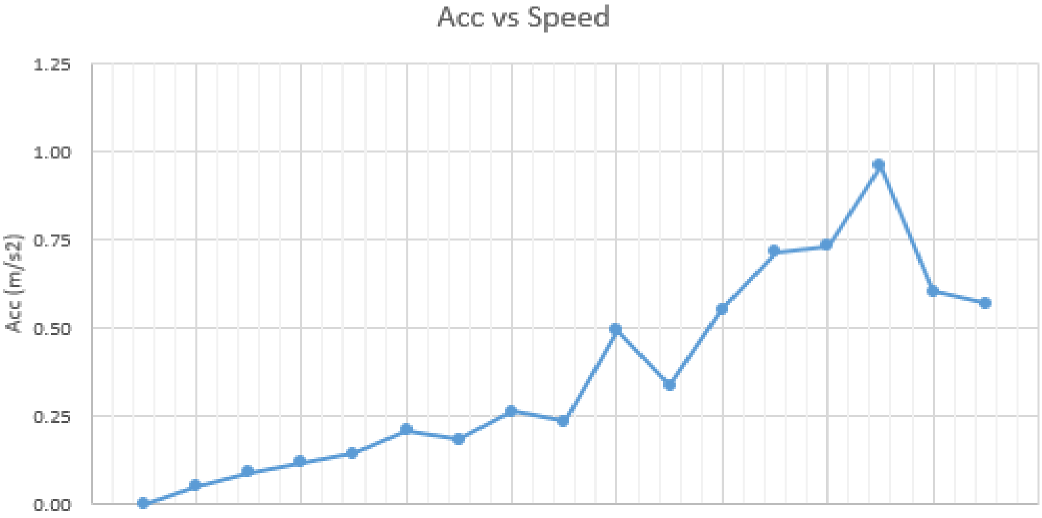


Fig 6: Acceleration vs Speed graph 1

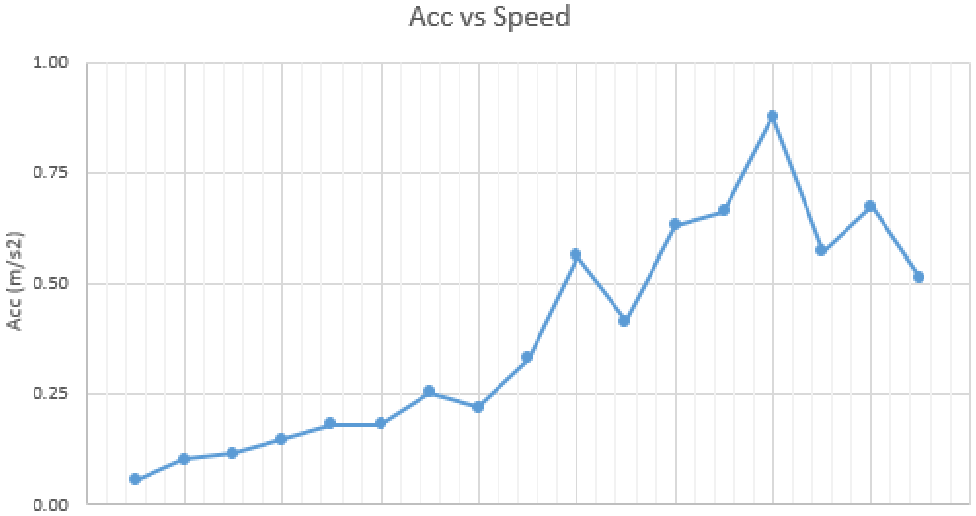


Fig 7: Acceleration vs Speed graph 2

V. CONCLUSION

Even though pre-stressed bridges offer greater advantages over plate girder bridges under the same arbitrary conditions, it has been determined that in situations of lighter traffic, mild environmental conditions, and relatively insignificant transportation, plate girder bridges must be used due to fewer design stipulations and thus must be used. A smaller economy is reliant on the time-consuming design step. For automotive design speeds up to 180 kmph, a 16.00m c/c bearing PSC Box-girder is assessed for dynamic and static loads. Under dynamic live loads, maximum acceleration was 0.96 m/s2 and maximum vertical deflection was 0.44 mm, according to the findings. According to the model, the dynamic factor is 1.208, but the IRS Bridge rules are 1.514. As a result, the dynamic factor from IRS Bridge Rules is larger, and it may be used in the design. The following Suggestion is the highest possible speed, Deflection maximum, and The Factor of Change.

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