Dynamic Analysis of Pre-stressed Concrete Bridge Using MIDAS Civil Software

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Abstract -The present work involves dynamic analysis of river crossing PSC box Girder Bridge. A Prestressed concrete box girder bridge over a river Mula near Khadki railway station has been considered. The box girder is a single cell and of the trapezoidal with straight alignment with a span length of 42m. Pot PTFE bearings are provided at girder supports. The pier is of rectangular shape. Pile foundation is used for the bridge piers. The box girder bridge is model and analyzed using MIDAS-Civil software. The bridge model with superstructure and substructure is subjected to moving loads according to Class AA for tracked vehicles, and self-weight of the structural components.

The static and dynamic analysis is carried out for determining support reactions, shear forces and bending moments under IRC Standard Class One, Class Two and Class AA tracked vehicle loads. For dynamic analysis, Response Spectrum Method is used. To consider effect of soil-structure interaction, a soil-spring element is attached to the piles in the foundation. The analysis is completed for all structural components and the design is further checked for strength and serviceability criteria.

Key Words: Prestressed concrete, Response spectrum method, soil structure interaction.

1. INTRODUCTION

Prestressed box girder bridges are amongst the most common types of highway bridges. These bridges allow long spans to be achieved economy and safety due to the prestress and they are excellent in resisting torsion due to their closed sectional nature. The design of such bridges had developed over time, and the design of prestressed bridges which were horizontally straight in form was a well-understood process. The design of PSC Bridge was quite intricate due to various site condition related to geological and Geotechnical data. However, the engineer may well be faced with the situation where a superstructure and substructure construction is going on. The conventional design consideration for prestressing is the resistance of vertical load actions, hence prestressing cables are usually straight in the vertical plane to produce bending moments which oppose those produced by the loading. A horizontally straight bridge, by its geometric nature, will require the prestressing cable to achieve the maximum strength. However, as straight bridges will suffer from different loading effects as well as forces, the impendence of the prestress may well prove beneficial in resisting any additional torsional effects, coupled with the sectional geometry of the PSC box girder bridge.

Also, With the new technology in Structural Engineering, long span bridges with maximum span to depth ratios were built with structural steel or pre-stressed concrete as it has excellent riding features that minimize cyclic vibrations, torsional rigidity, and strength, hence results in static, dynamic, long lasting and attractive bridges. The most important factors responsible for dynamic response are the basic flexibility of the structure and, more particularly, the relationship between the natural frequency of the structure and stimulating frequency of the vehicle. Live loads are responsible for the vibration of the bridges which is an important factor while analyzing dynamic responses of bridges. Any passage of load cause the span deflected from its equilibrium position and result in oscillation of the bridge. This process continues until it goes back to its equilibrium position or another load acts upon it. Therefore, "dynamic behavior of bridge deck" is necessary.

The design of the PSC bridge superstructure and substructure is done manually as per IRC Specifications for the effective span. The main objective of this study is to study the dynamic behavior of PSC box Girder Bridge and in order to check the echo criteria of the bridge. Use of box girder is gaining popularity in bridge engineering fraternity because of its better stability, serviceability, economy, aesthetic appearanceand structural efficiency. Even though generally the box girder bridge is a kind of beam Bridge, box girders may also be used on cable-stayed bridges and other structures. Box girders and other structural elements can be classified in so many ways, according to their method of construction, uses, and different shapes. Box girders can be constructed as a single cell, double cell or multi-cell. It may be homogeneous constructed with the deck, called closed box girder or the deck can be separately constructed afterwards called an open box girder. Box girders may be rectangular, trapezoidal and circular in shapes.

2.Classifications of bridges

It depends on different types of materials; shape, uses and Inter span relationship. The main types of bridges are under

a) Steel Bridges: steel bridge may use a wide variety of structural steel components and systems. For examples - girders, frames, trusses, arches, and suspension cables.

b) Concrete Bridges: There are two primary types of concrete bridges
i) Reinforced Concrete Bridges
ii) Prestressed Concrete Bridges

c) Timber Bridges: Timber bridges are used when the span is relatively short.

d) Metal Alloy Bridges: Metal alloys such as aluminum alloy and stainless steel are also used in bridge construction.

e) Plate Girder Bridges: The main girders consist of a plate assemblage of upper and lower flanges and a web. H or I cross-sections effectively resist shear and bending.

f) Box Girder Bridges: The single or multiple main girders consists of a box beam prepared from steel plates are formed from concrete, which resists not only bending and shear but also torsion effectively.

g) Composite Girder Bridges: The concrete deck slab works in conjunction with the steel girders to support loads as a united beam. We know concrete is always strong in compression and weak in tension so steel bridges always in the tension form.

h) Culverts: Bridges have a length less than 8 m are called culverts.

2.1 Box Girder Bridge

Box girder bridges comprise girders with a hollow box shape and are constructed from materials such as concrete, steel, or a composite of steel and reinforced concrete.

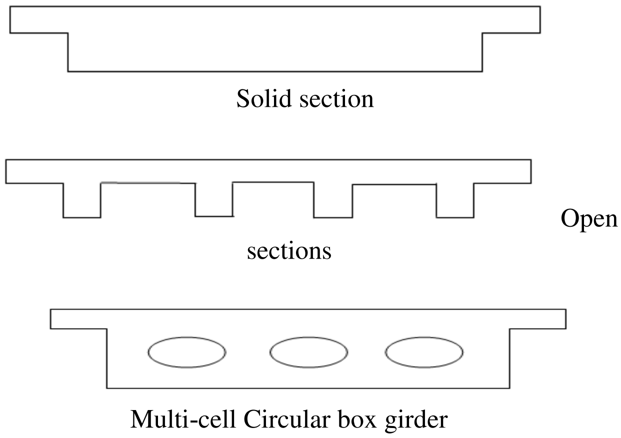

Fig (1): Various cross section of box girder

Box girder bridges have become a popular construction in recent highway systems. There are many reasons for their desirability, such as the rise in traffic volume, economics and aesthetic designchoices. The use of straight segmental construction has decreased compared with curved girders because, in urban areas where elevated highways and multi-level structures are necessary.
Modern highway bridges are often subjected to severe geometric restraints; consequently, there must be constructed as a straight alignment.

3. RESULT AND DISCUSSION

The bridge model is analyzed statically and dynamically using MIDAS Civil software. Response spectrum method is used to determine the dynamic behavior of PSC Bridge in X and Y direction.

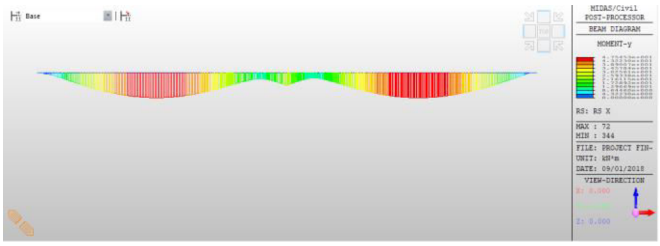

Fig. (2): Response spectra in x direction –BM in box Girder

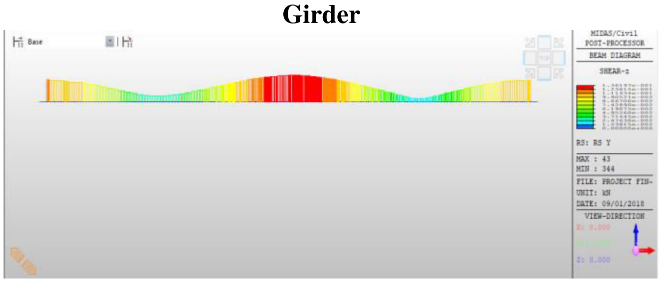

Fig.(3): Response spectra in Y direction –BM in box girder

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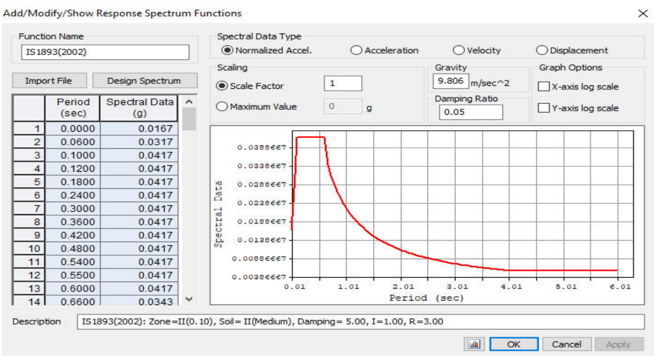

Fig.(4): Response spectra graph

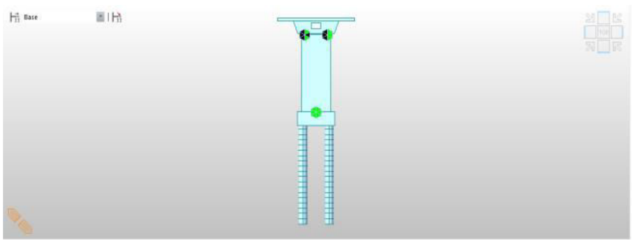

Fig.(5): Bridge POT PTFE bearing support cross section view

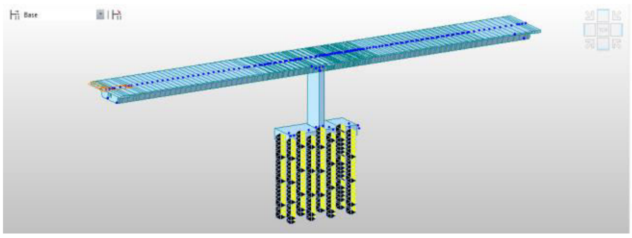

Fig.(6): Elastic spring for pile foundation

Sr. No.	Load	SF Manual Calculation (KN)	SF Finite Element Analysis (KN)	Percentage Difference for SF
1	DL	4586.4	3980	6.06
2	SIDL	630	278	3.52
3	C70R1L	702.1	1060	3.57

Table No.-1- SF Analysis of Box Girder Bridge

Sr.No.	Load	BM Manual Calculation (KNm)	BM Finite Element Analysis (KNm)	Percentage Difference for BM
1	DL	Sagging 13544.2 Hogging 24078.6	Sagging 12600 Hogging23300	9.44 7.78
2	SIDL	Sagging 1860.46 Hogging 3307.5	Sagging 1235.44 Hogging2416.4	6.25 8.91
3	C70R1L	2620.20	2817.4	1.97

Table No.-2- BM Analysis of Box Girder Bridge

Sr.No.	Direction	BM Finite Element Analysis (KNm)	SF Finite Element Analysis (KN)
1	X	12100	2900
2	Y	1.32	13.6

Table No.-3- Response Spectrum Applied At the foundation level

4. CONCLUSION

Based on the FE analysis following points are observed.

1. 1. According to IRC codes, Dynamic Analysis as well as manual design of the PSC Bridge with respect to support reaction considering two basic entities i,e Shear Force and Bending Moment for various types of loading conditions. Those are 70R tracked; class A and class AA etc., the manual calculation and the software calculation result differ from each other by near about 10 percent.

2. A response spectrum is applied in the girder support and at the foundation level; it shows the maximum effect in X direction and minimum effect in Y direction.

3. When elastic spring is provided to the Bridge foundation thus it becomes rigid and NO stiffness is observed in Y direction nor the displacement are observed in X direction.

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