International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 4 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

STUDY AND ANALYSIS OF BALANCED CANTILEVER BRIDGE AT KOCHI METRO

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Abstract - *A cantilever bridge is made when the span is large and there is a need to avoid piers. Balanced cantilever bridge is the most efficient method of building bridge without the need of false work. The bridge on which the analysis was done is a curved balanced cantilever bridge which is a part of Kochi Metro .The construction commences from the permanent piers and proceeds in a balanced manner to mid span .The study is conducted in 2 stages: The construction stage and The working stage .In the construction stage ,the bridge is cast in situ with the help of formwork and by cantilever construction method. After the construction a final closure joint or stitching is done at the mid span which connects cantilevers from adjacent piers. Once the prestressing is provided, the bridge act as a continuous bridge in its working stage. The study of the bridge model behavior during construction stage when subjected to dead load and working stage when subjected to live load namely the live load is being done here. From IS456, limiting moment value was calculated and compared with moment value obtained from the STAAD analysis.*

Key Words: Balanced Cantilever, STAAD,Prestressing,Load-Deflection Diagram

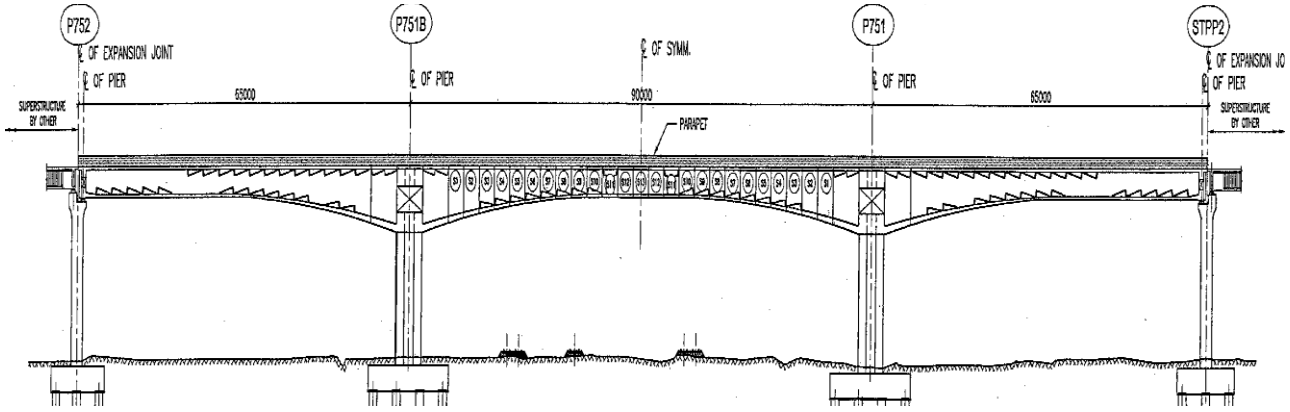
1. INTRODUCTION

With growing population and mega development plans coming up for this port city, the travel demand is expected to grow steeply. With inadequate public transport services, passengers will shift to private modes, which is already evident from the high ownership trends in the region. This will not only aggravate the congestion on the city roads but will also increase the pollution level. Road-based public transport, therefore, cannot meet this demand. There is an urgent need to introduce a light Metro system in the city to provide fast, safe, economic, and environment-friendly mode for mass movement of passengers.

The type of bridge in this study is balanced cantilever bridge (Railway bridge), a part of Kochi Metro Project of Maharajas- Petta stretch at Ernakulum. A cantilever bridge is a bridge built using cantilevers, structures that project horizontally into space, supported on only one end. It is the fifth balanced cantilever bridge and first curved balanced cantilever bridge of India. The 90-metre span will be balanced on either end by 65-metre-long concrete spans, taking the total length of the structure to 220 metres and a curve of 152 m long radius. Such a lengthy span is rare in any metro-rail system in India. The reason for adopting a cantilever bridge instead of ordinary bridges are the presence of overhead electric lines of the nearby railway station, underground pipes causing difficulties for piling, non- availability of vacant space between the tracks for erecting pillar, and to avoid interruptions of the underneath railway transportation. Due to long span the bridge is constructed as segments. Segmental bridge construction is one of its specialty. it is even more an engineering challenge since the span is located at a curve having a 152-metre-long radius. Such spans are generally made for over bridges carrying vehicles.

2. Methodology

The details required for analysis are collected from the site and certain parameters are assumed as per the standard specifications. The study is focused on the deflections of cantilever span under different loading conditions such as dead load and live loads. The analysis of balanced cantilever bridge is done using STAAD Pro software and behavior of cantilever bridge is studied by considering construction methodology, load-deflection characteristics. Since beams curved in plan cannot be analyzed using STAAD Pro software, the bridge is analyzed as straight.



Balanced cantilever bridge

Carrying capacity of Light Rail Vehicle

	Driving Motor Car		Trailer Car		3 Car Train	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	35	35	44	44	114	114
Standing	78	156	87	174	243	486
Total	113	191	131	218	357	600

NORMAL-3 Person/sqm of standee area CRUSH -6 Person/sqm of standee area

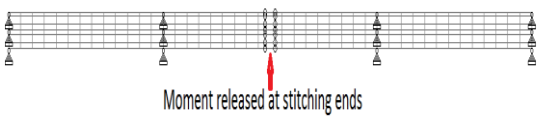
2.1 Capacity

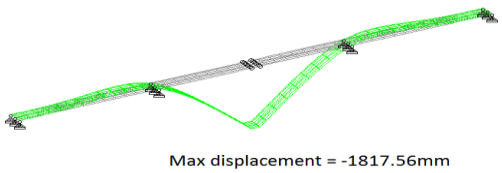
- DMC: 191 passengers (Sitting-35, Crush Standing-156)
- TC: 218 passengers (Sitting-44, Crush Standing-174)
- 3 Car Train: 600 Passengers (Sitting-114, Crush Standing-486)

2.2 Load calculations

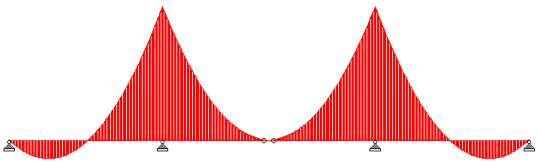
Average weight of passenger = 65kg
Coach and bogie is designed for 13 T
Weight of one passenger = 65 x 10 = 650 N
Weight of 600 passengers = 650 x 600 = 390 kN
Weight of coach and bogie = 130 kN
Total weight = 390 + 130= 520 kN

2.3 Construction stage analysis





Max displacement = -1817.56mm

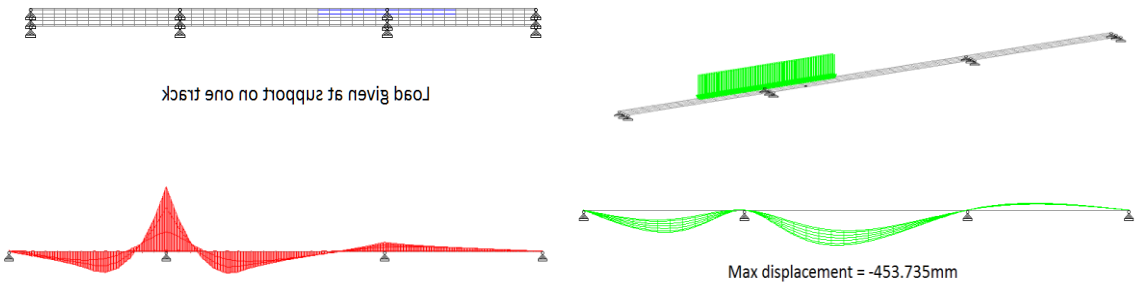


Since during the construction stage, only self-weight will be acting, therefore self-weight with factor -1 was assigned to the structure. At this stage bridge will act as a cantilever bridge, so at the free end moments were released. Using this first load case, bridge was analysed and deflection and bending moment diagrams were obtained.

2.4 Working stage analysis

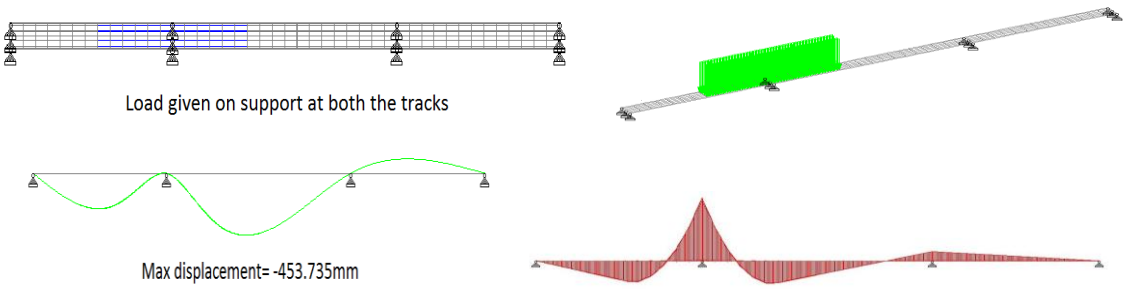
During working stage, after prestressing, the bridge will act as a continuous bridge. So in this stage moment releases were removed. Here live load of metro rolling stock is considered. From the Kochi Metro DPR it was obtained that train consisting of three-car was 60m in length with concentrated load of 520kN. Thus a UDL of 8.67kN/m is considered as live load. Two cases were studied to get maximum deflection.

Case:1- Live load given only on one track



Bending moment diagram

Case:2- Live load given on supports on both tracks

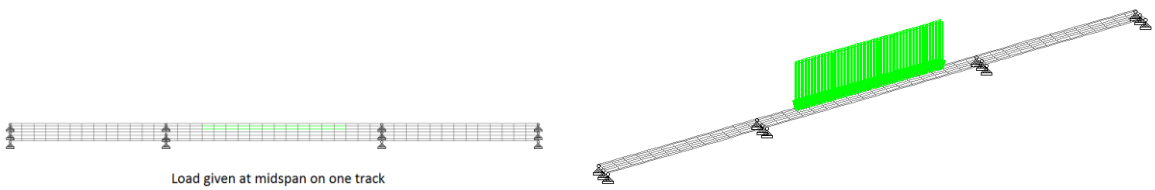


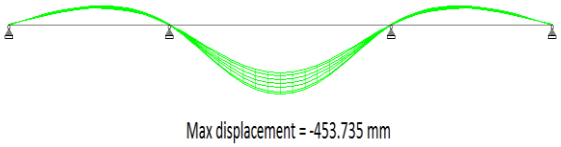
Deflection Diagram

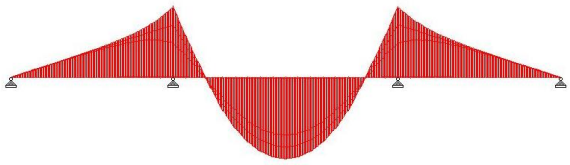
Bending moment diagram

For both these cases analysis was done and their corresponding deflection and bending moments were obtained.

Case 3: Load given at mid span on single track

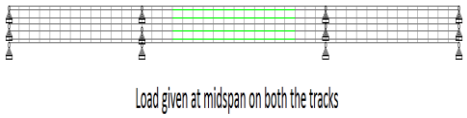


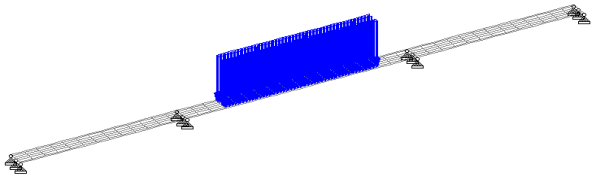


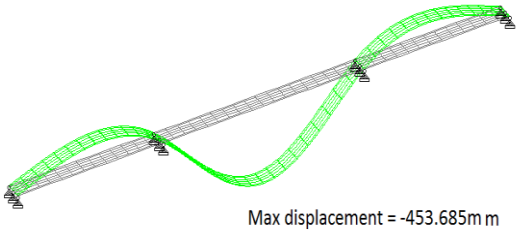


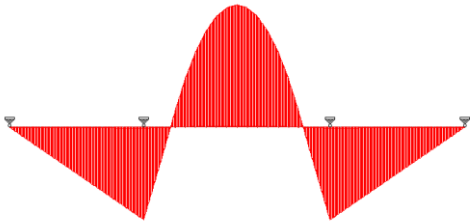
Deflection diagram Bending moment diagram

Case 4: Load given at mid span on both the tracks









BMD

3. Results and conclusion

For different load values from 1 to 8.67 KN moment and deflection values obtained from STAAD, the following graph was plotted

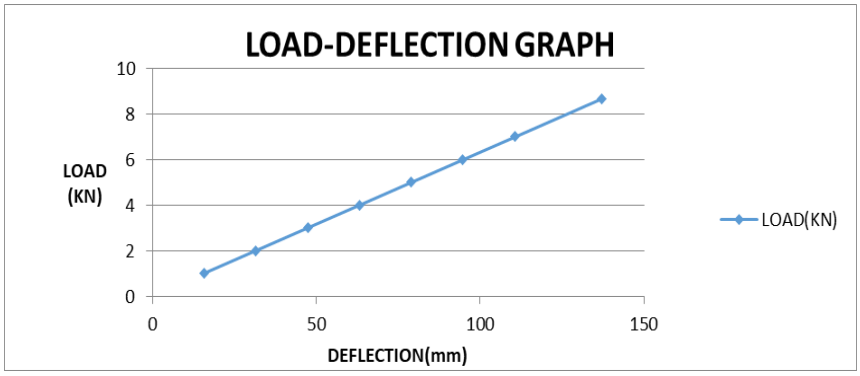


Chart 1 : Load –deflection graph

3.1 Check for moment and deflection

We assumed the values of
F_{ck} = 25 N/mm^2 and b=3000mm ,d= 600mm
From IS 456 , Mu_{lim} /bd^2 =3.33
Mu_{lim}=17820 kNm
the values obtained from the analysis are within this limit
For simply supported beam limit state of serviceability has given the limit for deflection as span/250
From the observed values deflection is within the range

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