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ABSTRACT

Identifying the appropriate type of abutment considering the site conditions for a bridge is an important aspect in economics of the entire bridge project. This study includes the seismic analysis and design of different types of non-submersible type of bridge abutments viz. box type, counter fort type abutment, C- attached, C-type detached and gravity type abutments. The abutments considered are related to the live project of major high level bridge on Venna river (between Sawali to Mhate) at Jawali, Satara, India. The comparative study of different types of bridge abutments under the dynamic earth pressure and super structure loading and live surcharge is carried out using IRC specifications. The dimensions of the deck slab, girders and abutments are provided as per PWD standard manual for two lane traffic. The selected bridge abutments are modeled in STAAD PRO software to check the structural behavior for total eight HFL and OFL load combinations. Cost analysis is done based on design of abutments. The box type abutment has come out with relatively good structural behavior along with economic cost benefits. Comparison of all abutments based on the bending moment, shear force and deflection, the box type abutment has performed well than other type abutment. The gravity type abutment, attracted less bending moment than box type abutment but it failed in the stability check for seismic condition.

Key words: Abutment modeling, seismic performance, box type abutment.

INTRODUCTION

An abutment should be designed so as to withstand damage from the earth pressure, gravity loads of the bridge super structure and abutment, live load on the super structure or the approach fill, wind loads and the transitional loads transferred through the connection between the super structure and the abutment. Any possible combinations of those forces, which produce the most severe condition of loading, should be investigated in the abutment design. This study focuses on identifying the seismic behavior of different

types of bridge abutments under the earthquake loading, live load and superstructure load. Types of abutments are to be considered as per the IRC 78- 2014 are gravity type abutment, box type abutment, counter fort type abutment, cantilever attached and detached type abutment.

To over view the some of the primary fields that were either used or investigated in this research. This literature review is designed to give background information and hence help identify the goals of the current study on seismic analysis of different type of bridge abutments. Related to seismic behavior some of authors' have studied seismic behavior of reinforced concrete bridges with skew-angled gravity-type abutments, and some studies are focused on experimental study of the seismic behavior of an existing bridge abutment located on soft clay deposits.

Based on the area decided and the literature review carried out in details, the aim and objectives for the project has decided. The aim of the project is to carry out comparative study on design and estimation of gravity type, counter fort type, box type, cantilever(C) attached type and cantilever(C) detached type abutments.

METHODOLOGY

The abutments considered for the seismic analysis and design are related with the live project of major high level Bridge on Venna River (between Sawali to Mhate) , Taluka - Jawali, Dist- Satara under the Pune PWD region. This study will focus on the analysis and design of different types of bridge abutments that will suitable for this bridge under the seismic zone IV as per tender document. As per the geological report the hard strata is available to 2m below river bed, so open raft foundation to be recommended. Maximum water current speed for this river is of 5.25 kmph in the rainy season and the high flood level (HFL) is below the soffit level of bridge. Hence the design is in the category of non submersible type. Provision of gravity type, counter fort type, box type, cantilever attached type and cantilever detached type abutments, for the bridge will be provided and its analysis & design will be carried out. Grade of concrete considered for abutment wall is M30 and for pedestrian is M35, grade of steel is use as Fe500 and 75mm cover is used at earthen side and 40 mm cover is used for other face. The codal references of IRC- 6: 2017: Load and load combinations, IRC- 112: 2019: Standard specification & code of practice for concrete road bridges, IRC – 78: 2014: Sub structure and foundation and IRC - SP-114: 2016: Guidelines for seismic design of road bridge are to be used.

This study includes the seismic analysis of the bridge abutment based on static coefficient method by using the staad pro software and design of all types of abutment is carried out. The final results will be compared based on bending moment behavior, shear force behavior, deflection behavior results under the

seismic load and also comparative study on estimation and costing will be carried out. The methodology is considered as review of literature, aim & objectives, problem statement, drawing, modeling and analysis, design, parametric and comparative study, results and discussion are adopted.

The super structure load includes self weight of the deck slab, girders and wearing coat, etc and vehicular live load. For super structure dead load calculation prepared a grillage model of deck slab and girder in the staad pro software and applied the static loads of super imposed surface dead load and wearing coat load on grillage model and get the reactions of dead load. For vehicular live load calculations prepare the line model in staad pro and generate the moving loads as per live load combination on it and get the reactions.

3D MODELING AND ANALYSIS

To analysis of abutments prepare the 3D model in staad pro software using finite element method. The dimensions of abutments are as base width is 6m, base length is 8m and total height is 9.4m has been used. The all types of abutments has been modeled using the meshing of plate elements for abutment wall, return wall and tie walls and provide the fixed support to the bottom most node as it has raft foundation. The calculated horizontal super structure load and seismic earth pressure load has been applied in staad model. The super structure loads are applied as uniformly distributed load on top of the abutment cap in negative Y- direction and the seismic earth pressure has applied as trapezoidal load per square meter area on the plate element. These loads are applied to all types of abutment and performed analysis. The maximum bending and shear stresses will get at the bottom side of the abutment wall as shown in figures below.

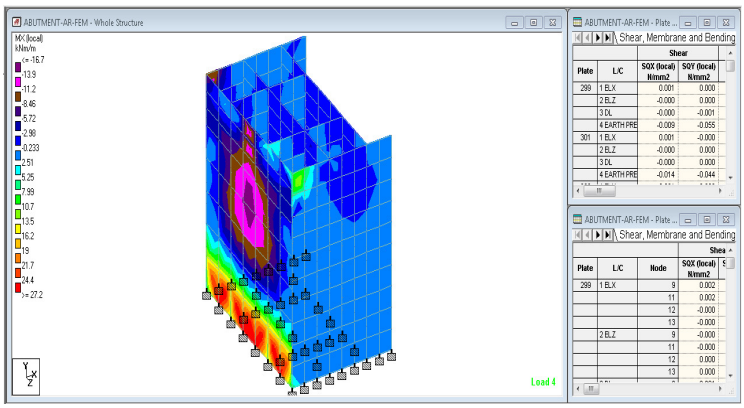


Fig.1: Box type abutment

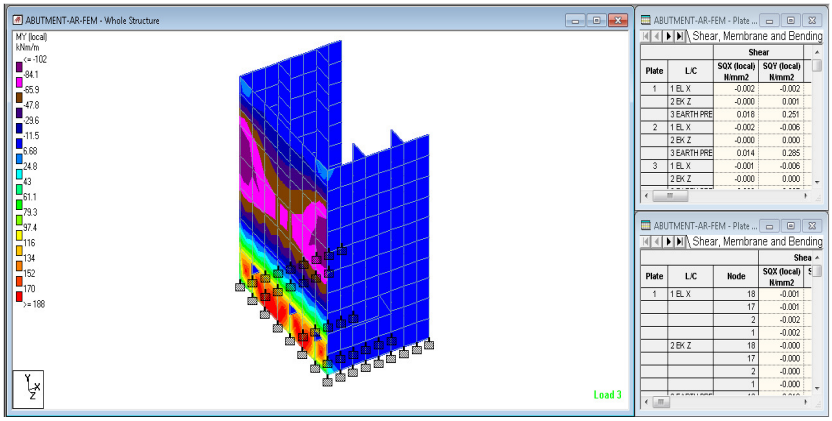


Fig.2: Counter fort type abutment

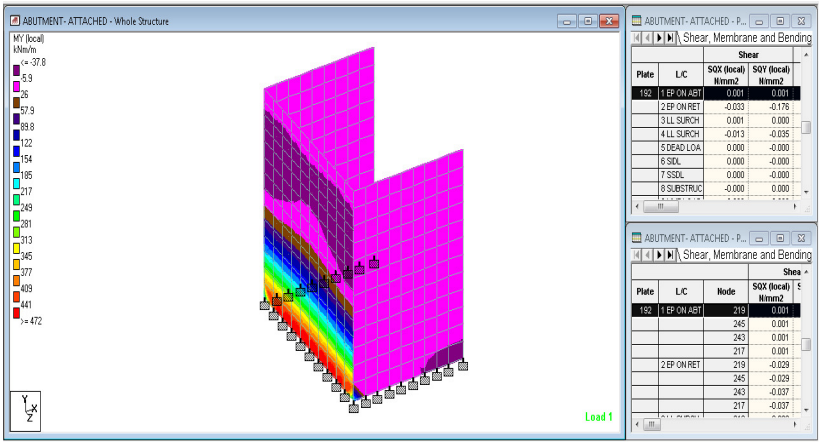


Fig.3: C-type attached abutment

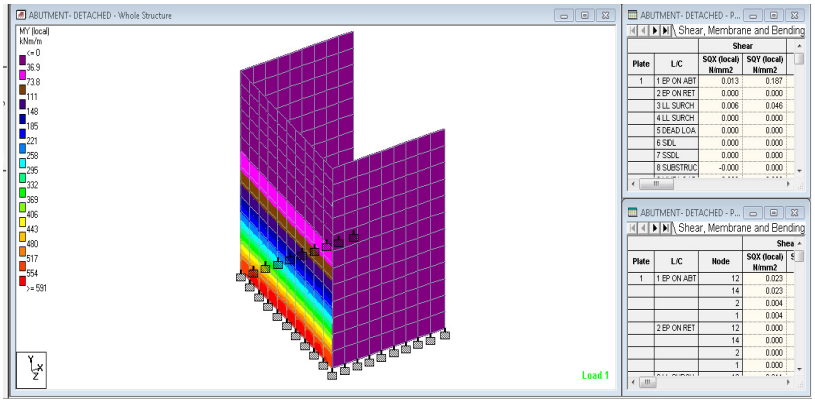


Fig.4: C-type detached abutment

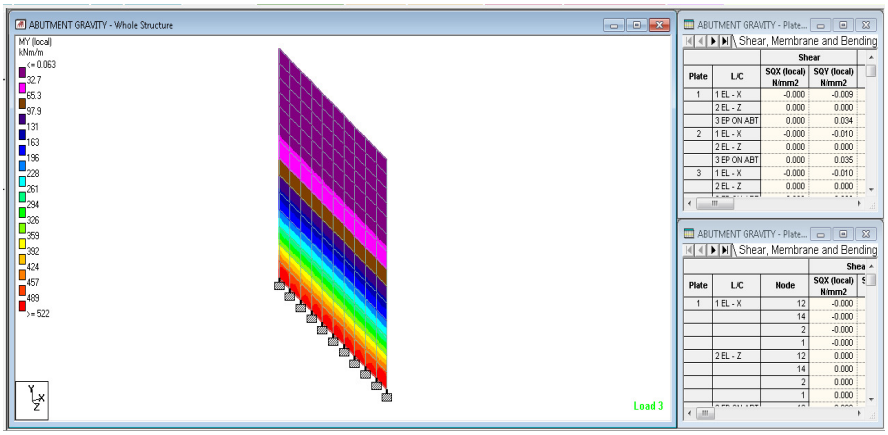
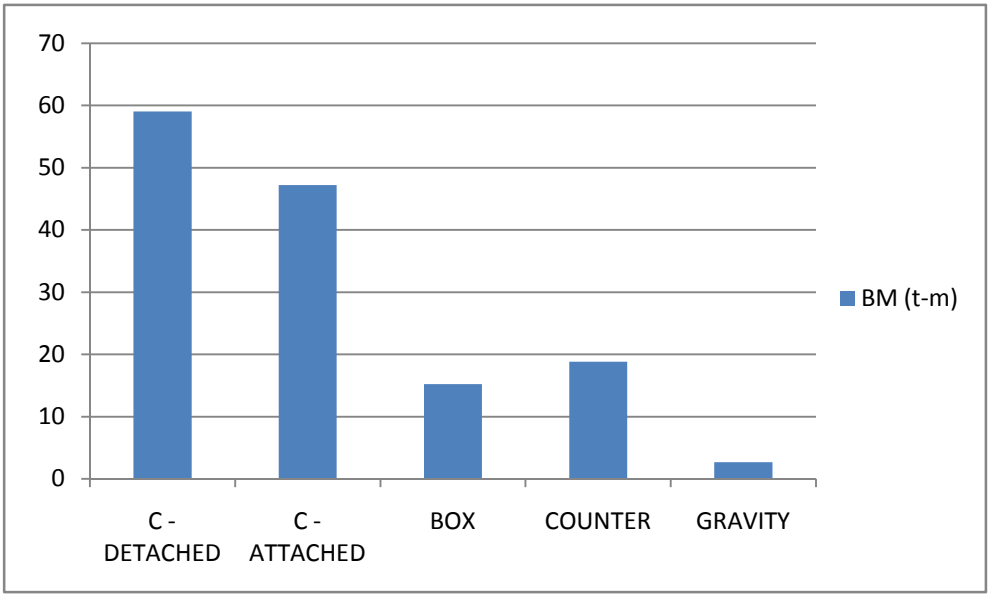
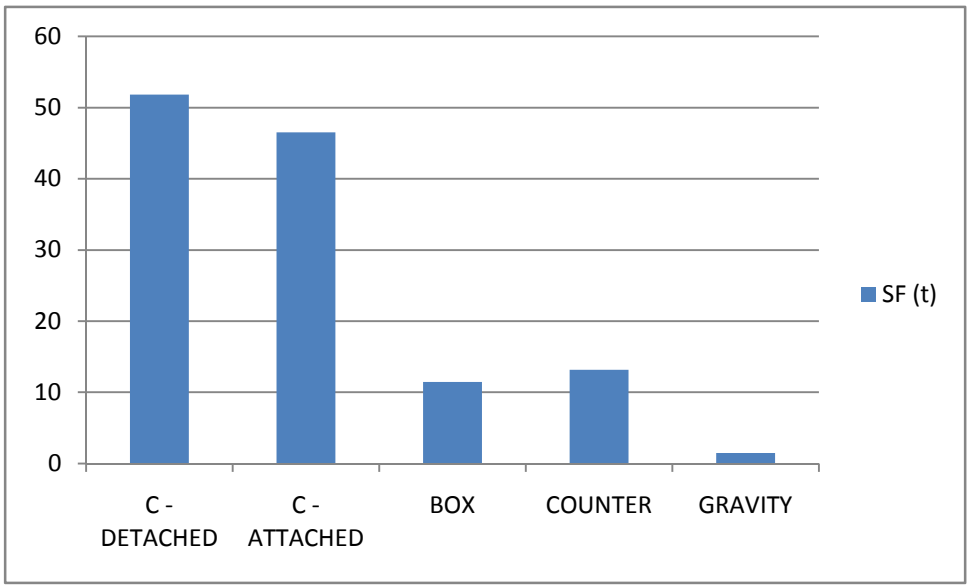


Fig.5: Gravity type abutment

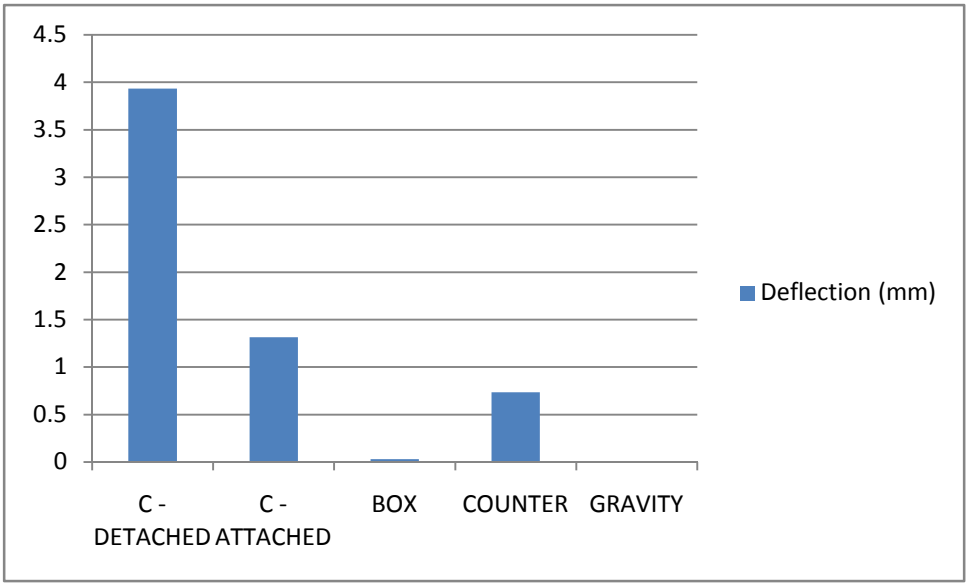
Results:



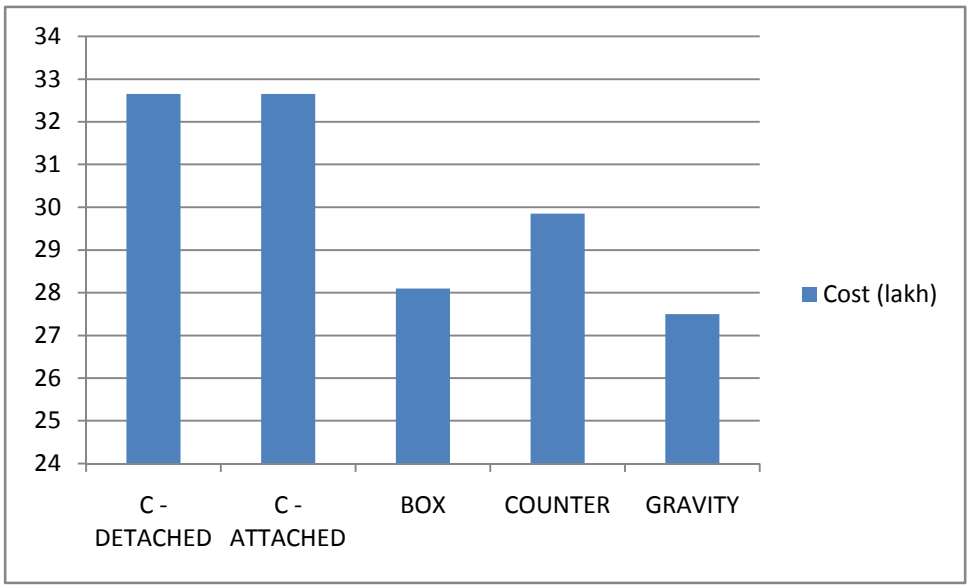
Graph-1: Bending moments



Graph-2: Shear Force



Graph-3: Deflection



Graph-4: Cost of abutments

Conclusion:

Based on the results and discussion regarding comparative study of abutments the following concluding remarks have been made.

- Comparison of all abutments based on bending moment it is clear that the box type abutment has performed well than other type abutment. The gravity type abutment has less bending moment than box type but it has fail in the stability check for seismic condition.
- The box type abutment is performed well in the shear force behavior it has resist the shear failure with the average thickness of 500mm and the tie wall thickness of 300mm.
- In deflection criteria box type abutment has less deflection ideally zero. The deflection has reduced due to providing the tie walls for abutment wall and return wall.
- The cost of box type abutment also less than the other type of abutment. It has almost same as gravity type abutment.

Summarizing the project, the box type abutment has shown better structural behavior considering all the load cases including the seismic effect. It has also turned out to be cost effective.

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