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"Parametric Study of Box Cell Type Bridges by Changing Configuration of Box Cell"

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ABSTRACT— the main advantage of IRC types of bridges Box cell in the high torsional stiffness available because of the closed box section. Torsional stiffness provides stability and load distribution characteristics and makes this form particularly suitable for the separation of two parts. Double cell box type bridges have been used worldwide because they resist heavy earthquake load and live load. Deflection is important criteria of double box cell system and therefore geometry or configuration is important. A double box cell bridge girder is a bridge in which the main beams comprise girders in the shape of a hollow double box cells. The double box cell type bridge may be rectangular or trapezoidal in cross-section. Double box cell type bridge girder is generally used due to because of its better stability, good aesthetic appearance, serviceability, structural efficiency, economy (less cost) etc. In this research work use three cases for analysis a beam with different section like 45 degree, last one is single box. In first case, the IRC Class A and IRC Class B Loading for study. In second case use response spectrum method is used for study and in last third case applies combination of response spectrum and IRC loading for study. ETABS 2016 used for modelling and analysis work. "In this study, the form and IRC Loading with shapes of two boxes Cell Bridge are modified to study for economy and better structural stability".

Key point: - Box cell, bridge box, Class A load, dead load, IRC, Earthquake Load etc.

I. INTRODUCTION

General Introduction

Box cell bridges in prestressed concrete with one or more cells are generally used today because they offer economic and aesthetic solutions and overcome the constraints, distances, structures and dividing Road lines that are found today in modern and metropolitan road systems. The main advantage of this bridge box is the high torsional rigidity, available thanks to the closed box cell section. The torsional rigidity offers stability, Strength and load distribution properties and makes this form particularly suitable for level separation.

A bridge is a structure that spans a wide area or distance, providing a passage for vehicles, pedestrians, or both. It serves as a connection, enabling transportation and facilitating movement across obstacles such as rivers, valleys, roads, or railways. Constructing bridges requires careful attention to safety and durability. Bridges must be designed and built to withstand their own weight, as well as the loads imposed by people and vehicles using them. They need to be resilient against factors such as corrosion, extreme weather conditions including high winds and temperature variations, and even seismic activities like earthquakes.

Box Cell Type

Double-cell box bridges have been used worldwide because they withstand high seismic loads and high payloads. Deformations is an important criterion of the box cell system and therefore geometry or configuration is important. A box cell beam is a bridge where the main beams contain beams in the form of an empty in box cell. In the current scenario, the construction of box cell bridges is of global importance. The region behind is the efficient spread of traffic jams, economics and aesthetics. A double box bridge or pipe stand is a stand that forms a closed pipe with multiple cells. Double box beams are generally used for subway, highway, overflight and light rail transport, etc.

Fig 1.1 Typical Box Cell Section

II. PROPOSED STUDY

This work investigates the parametric analysis of a double box cell bridge as well as its configuration. The goal of this study is to find the greatest configuration of the box cell bridge for the specified parameters. The variables are altered and varied in order to obtain alternative configurations of double box cells, and a parametric research is conducted with all conditions of bridge cells and loads with analysis.

III. PROJECT STATEMENT

This method is applicable for those structures where modes other than the fundamental one affect significantly the response of the structure. In Response spectrum method the response of multi degree of freedom system is expressed as the superposition of modal response, each modal response being determined from the Response Spectrum analysis of single degree of freedom system, which is then combined to compare the total response. Modal analysis of the response history of structure to specified ground motion; however, the method is usually used in conjunction with a response spectrum.

1. Box cell Type Bridge comprises of pre-stressed concrete, steel, or combination of steel and RC materials.
2. The box cell bridge may be rectangular, trapezoidal, and circular in cross-section.
3. Box cells taper edges bridges are commonly used for highway flyovers, metro, and for modern elevated structure like rail transport.
4. Very High torsional rigidity provides bridge box tapers to resist the torsional forces which are due to loading.
5. Analysis & design of box cell bridges are very complex due to its 3-Dbehaviors consisting of torsion, bending in longitudinal & transverse directions.

Types of Loads

Different loads and stresses ought to be considered into account while outlining the superstructure: -

1. Dead load
2. Live load
3. Dynamic load

Standard Specification for Loading Using IRC

1. IRC Class AA loading: - Within certain municipal limits in certain existing or industrial areas, in other indicated zones and along certain predefined roadways this loading is adopted. In order to design Bridge for class AA loading, it is ought to be checked for class A loading as well, Heavier stresses may be taken under class A loading under specific conditions.

2. IRC class "A" loading: - On permanent loading as per IRC bridges and culverts this loading is applied.

3. IRC class "B" loading: - Temporary structure and bridges in specified areas this loading is adopted. Detail of IRC loading: - The designed live load might comprise of standard wheeled or tracked vehicle or train of vehicles for bridges. The standard vehicle or trains might be expected to parallel to the length of bridge and to possess any position which will produce maximum stresses, within the kerb to kerb width of roadway. For every vehicle or train all the axles of unit of vehicle shall be in position causing maximum stresses. Vehicle in adjacent lanes should be considered as headed in the direction of maximum stresses. The spaces on carriageway left uncovered by the standard train of vehicles shall not be assumed. For wind load all the structure ought to be designed for the lateral wind forces. These forces ought to be considered to act horizontally and in the direction that resultant stresses in member under consideration are maximum. The intensity of wind forces should be based on wind pressures and wind velocities which are allowed for design. "Analysis and Design of ETABS Software" 2016.

IV. PROBLEM FORMULATION

In this title of parametric investigation a detailed study of Double Box Cell Type Bridges by Changing Configuration of Box Cell. Design of Bridge structure using IS codes has been presented. Study has been done on Reinforced concrete structure. Analysis of all the above mentioned structures has been carried out by using Indian Standard with Response Spectrum Analysis Method. Cost effectiveness of structures has also been studied only from material point of view.

Table 1 Detail Features of IRC Class "A" and IRC Class "B" Loading

Sr .No	**Parameters**	**Values**
1	Material Used	Steel Grade Fe-500
2	Plan Dimension	6m X 18m
3	Total height of Bridge	6m
5	Unit weight Of steel	78.50 KN/m3
6	Poisson Ratio	0.2-Concrete And 0.15-Steel
7	Code Of Practice Adopted	IS800:2007 , IS1893:2002 IS875-part -III
8	Seismic Zone For IS1893:2002	III
9	Importance Factor	1.5
10	Response Reduction Factor	5
11	Foundation Soil	Medium
12	Earthquake Load	As Per IS 1893-2016
13	Ductility Class	IS1893:2002 SMRF

Indian Road Congress (IRC) and Bridge Loading Standards: IRC Class AA, 70R, A and B Loading

A. Indian Road Congress

Indian Road Congress (IRC) is the governing Loading which decides the rules and regulation along with technical details regarding roads, highways, state Highway and bridges. The first loading standard in India was published by IRC in 1958 and subsequently reprinted in 1962 and 1963. The metric version was introduced in the second revision published in 1964.

B. IRC Bridge Loading Standards

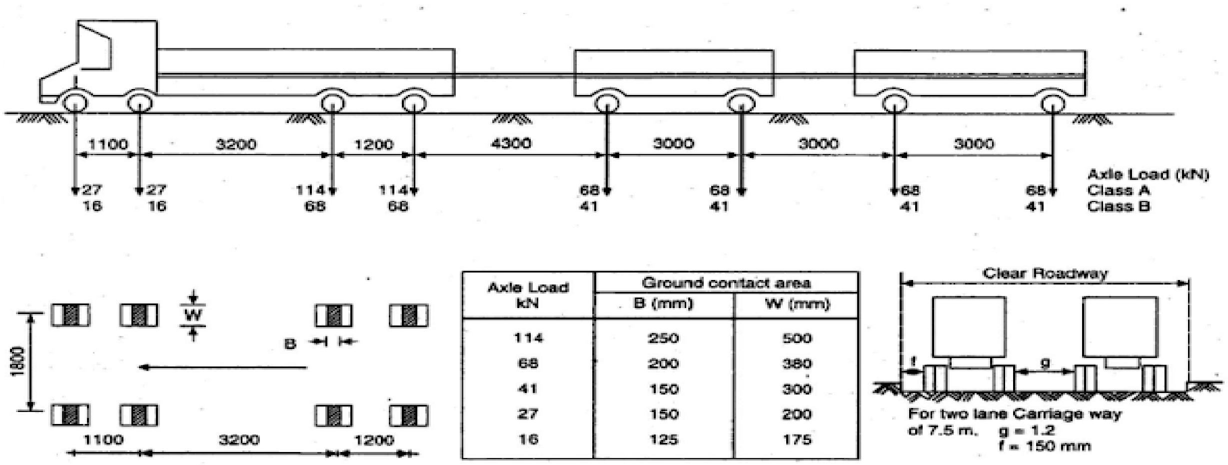
The standard IRC loads specified in IRC: 6-2000 are not changed since 1958 and grouped under four categories as detailed below:

C. IRC Class "A" Loading

The IRC Class "A" loading is consisting of a wheel load train of a total load of 554 KN. It comprises a heavy-duty truck with two trailers that transmitting the loads from 8 axles varying from a minimum of 27 KN to a maximum of 114 KN as shown in the figure. IRC types of loading is recommended for all roads on which permanent IRC bridges and culverts are constructed.

D. IRC Class "B" Loading

The loading of this class is similar to the Class A loading except that the axle loads are of lesser Loading. The total axle loads of this Class are 332 KN with a train of wheeled vehicles on eight axles as shown in the figure. This type of loading is adopted for temporary structures and timber bridges.



Axle Load kN	Ground contact area B (mm)	Ground contact area W (mm)
114	250	500
68	200	380
41	150	300
27	150	200
16	125	175

Fig. 2 IRC Class A and B Loading

A. IRC Class "A" loading And IRC Class "B" loading 3D Model

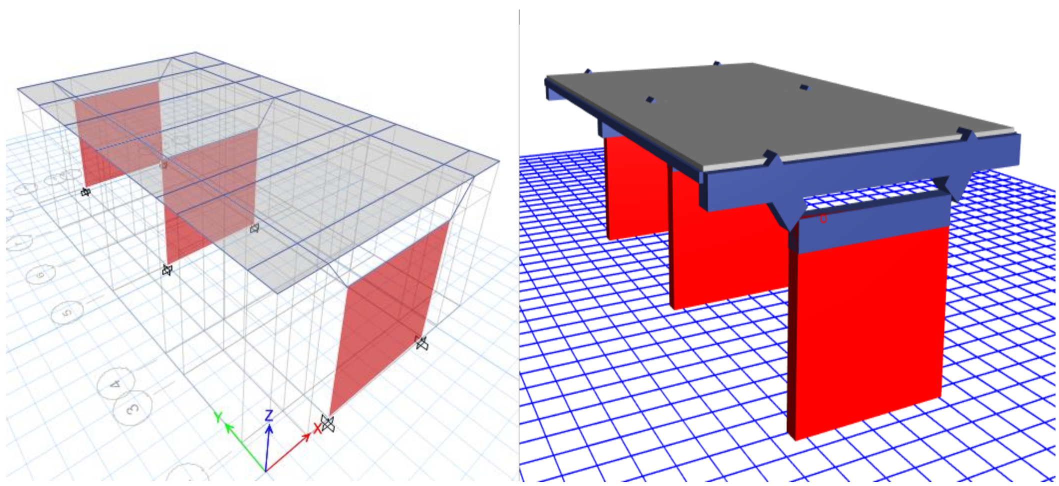


Fig. 1.3 3d Box Cell Model (1mx1m Box Cell)

Types of Loads

Unless otherwise specified, all loads show in below, shall be considered in design for the Indian Code following load combinations shall be considered for Analysis

Load Case

1) DL: Dead load
2) LL: Live load
3) EQ: Earthquake load
4) WL: Wind Load

Load Combinations:-

1. DL + (LL+IL)
2. DL + (LL+IL) + BRAKING LOAD
3. DL + (LL+IL) + BRAKING LOAD + WIND LOAD
4. DL + VLL
5. DL+VLL+BRAKING LOAD
6. DL+VLL+BRAKING LOAD +WIND LOAD

V. RESULTS

Base shear is a Find out of the maximum expected lateral force that will occur at the Reference of the structure due to the seismic ground motion. During the Model analysis, the codes required for the use of the static force procedure and a dynamic Analysis procedure. Hence, the base shear obtains or calculated from the dynamic analysis should be reduced to a specific percentage of the base shear results that is determined from the static Analysis Method.

Table 5.1 Base Shear Results for IRC Class "A" Loading for 1 X 1m and 1.5mX 1.5m Box Cell.

TABLE: Auto Seismic - IS 1893:2002								
Load Pattern	**Z**	**Soil Type**	**I**	**R**	**Period Used**	**Co-eff Used**	**Base Shear**	**Base Shear**
					sec		kN	kN
EQ+X	0.16	II	1	5	0.08	0.08	337.1769	335.4428
EQ-X	0.16	II	1	5	0.08	0.08	337.1769	335.4428
EQ+Y	0.16	II	1	5	0.391	0.04	168.5885	167.7214
EQ-Y	0.16	II	1	5	0.391	0.04	168.5885	167.7214

Graph 5.1 Base shear IRC Class "A" Loading in 1m Box Cell vs. IRC "A" Loading in 1.5 Box Cell

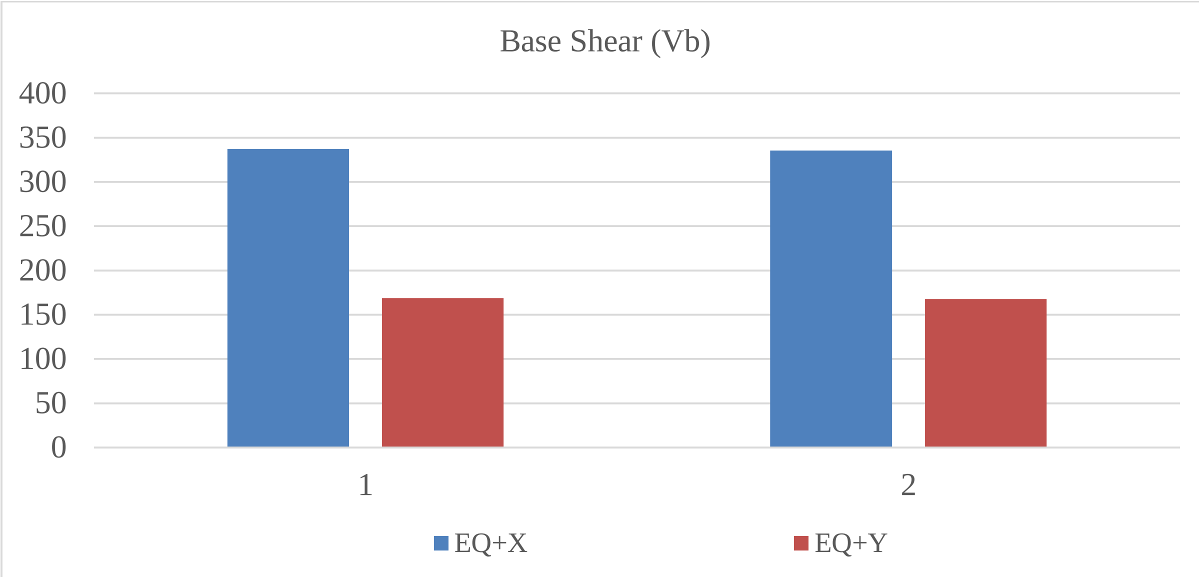


Table 5.2 Base shear Results for IRC Class "B" Loading for 1 X 1m Box Cell

TABLE: Auto Seismic - IS 1893:2002								
Load Pattern	**Z**	**Soil Type**	**I**	**R**	**Period Used**	**Co-eff Used**	Base Shear	Base Shear
					sec		kN	kN
EQ+X	0.16	II	1	5	0.075	0.08	292.9238	301.6569
EQ-X	0.16	II	1	5	0.075	0.08	292.9238	301.6569
EQ+Y	0.16	II	1	5	0.367	0.04	146.4619	150.8285
EQ-Y	0.16	II	1	5	0.367	0.04	146.4619	150.8285

Graph 5.2 Base shear IRC Class "B" Loading 1m Box Cell vs. IRC "B" Loading in 1.5 Box Cell

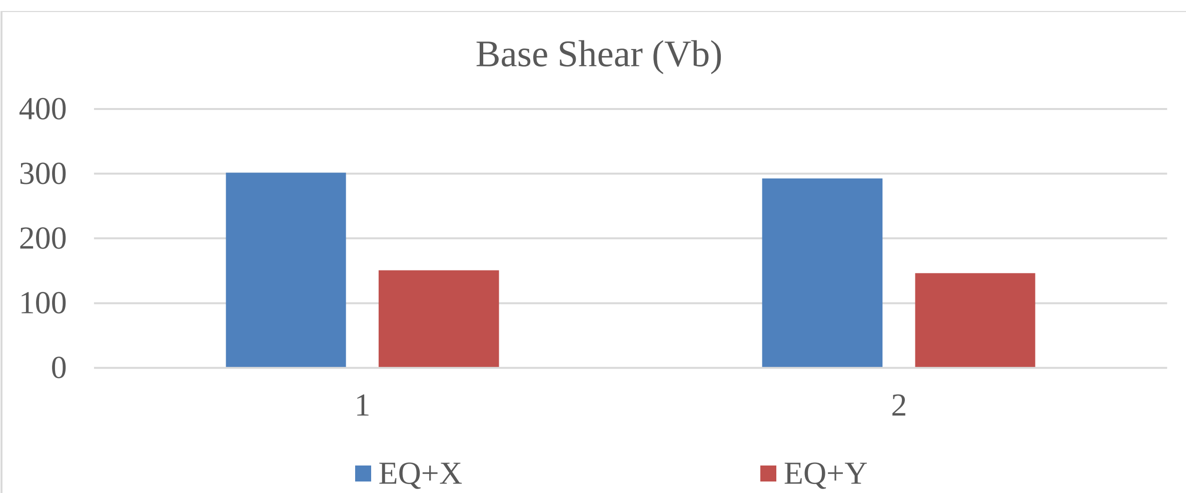


Table 5.3 Shear force in IRC Class "A" Loading for 1.0 X 1.0m and 1.5X1.5m Box Cell

Story	Joint Label	Unique Name	Load Case/Combo	FZ	FZ
				kN	kN
Base	1	5	1.5(DL+LL)	1204.843	1186.7007
Base	2	6	1.5(DL+LL)	1204.7929	1187.3233
Base	3	11	1.5(DL+LL)	752.7568	662.9822
Base	4	12	1.5(DL+LL)	752.7843	662.4509
Base	5	17	1.5(DL+LL)	683.8873	730.9591
Base	6	18	1.5(DL+LL)	683.9099	731.5067

Graph 5.3 Shear Force for IRC Class "A" Loading in 1m Box Cell vs. IRC Class "A" Loading in 1.5 Box Cell

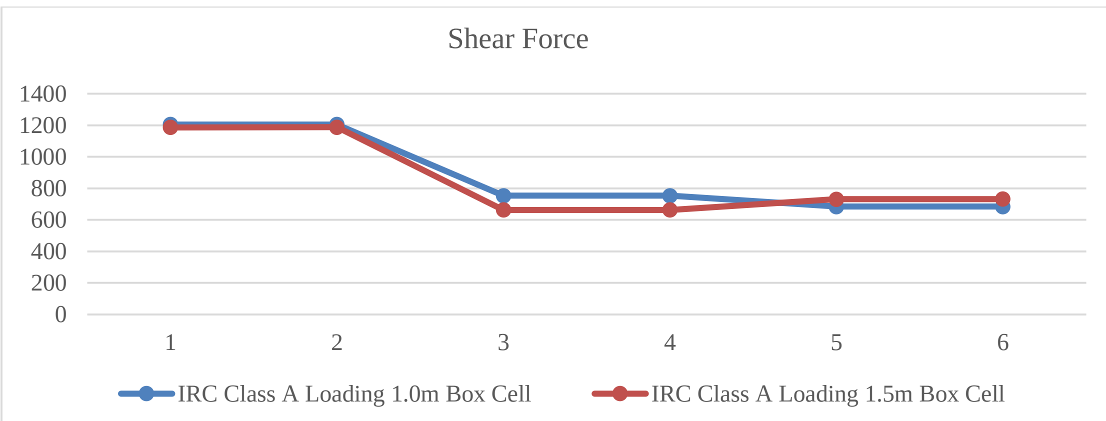
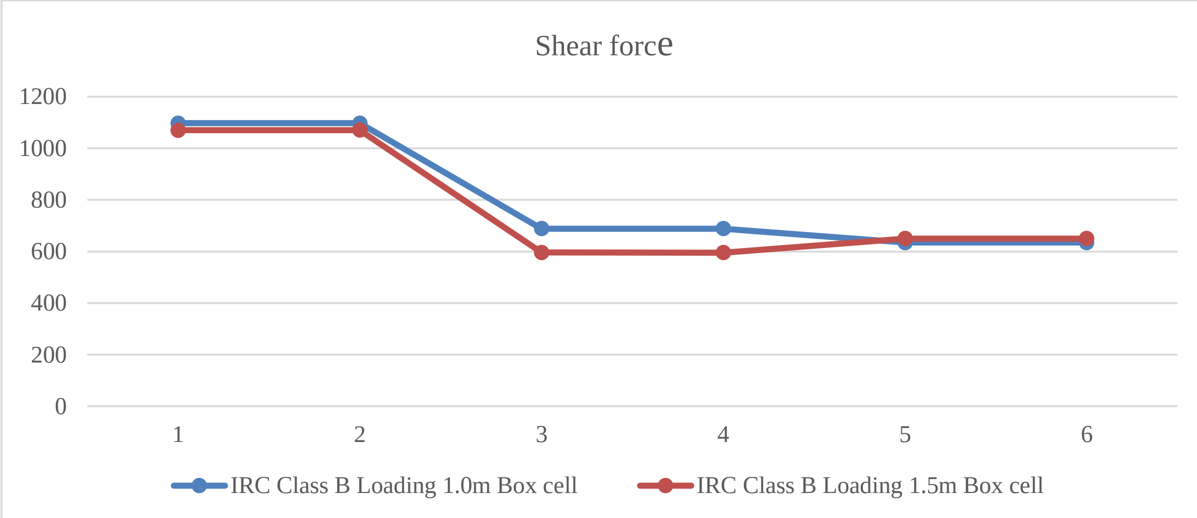


Table 5.4 Shear Force for IRC Class "B" Loading for 1.0 X 1.0 Box Cell

Story	Joint Label	Unique Name	Load Case/Combo	FZ	FZ
				kN	kN
Base	1	5	1.5(DL+LL)	1096.8734	1069.3926
Base	2	6	1.5(DL+LL)	1096.8287	1069.9938
Base	3	11	1.5(DL+LL)	688.4551	595.8084
Base	4	12	1.5(DL+LL)	688.4784	595.3555
Base	5	17	1.5(DL+LL)	634.1586	649.6979
Base	6	18	1.5(DL+LL)	634.1799	650.1863

Graph 5.4 Shear Force for IRC Class "B" Loading in 1m Box Cell vs. IRC Class "B" Loading in 1.5 Box Cell



VI. CONCLUSION

In the present study, Relative Analysis of RCC Bridge structure with different type of loading i.e. IRC Class "A" loading and IRC Class "B" loading in Different Box Cell type of bridge structure using various loading i. e. Dead Load, Live Load, Wind Load and Earthquake Loading.

1. The IRC Class "A" and IRC Class "B" Loading Bridge structures are analyses for earthquake zone III with medium soil and Results Compare. It has been made on different structural parameters viz. Base Shear, Earthquake Displacement, Story Drift, Story Force and Shear Force and Bending Moment etc. Grounded on the analysis results following conclusions are drawn.
2. Analysis of IRC Bridge structure with different types of loading i.e. IRC Class "A" Loading and IRC Class "B" Loading with earthquake zone III with medium soil condition. The base shear in x- direction, IRC Class "A" loading structure with 1m X 1m box cell with 1.5mX1.5m Box cell, the base shear is increased 1.151 times as compare to 1.5mX1.5m Box Cell shaped structure. And IRC Class "B" loading structure with 1m X 1m box cell with 1.5mX1.5m Box cell, the base shear is increased 0.8992 times as compare to 1.5mX1.5m Box Cell shaped structure.
3. In Bridge structure, IRC class "A" Loading and IRC Class "B" Loading structure with analysis at zone III. But results indicate that variation of base shear increase in IRC Class "A" Loading 1mX1m Box Cell, As Compare to IRC Class "A" loading in 1.5mX1.5m Box Cell, means Self-weight of IRC Class "A" Loading structure is maximum hence IRC Class "B" Loading structure is economical as compare to IRC Class A loading.
4. Comparing the earthquake displacement in IRC Class A loading with 1mX1m Box Cell as compare to IRC Class A loading with 1.5mX1.5m Box Cell, displacement increased 1.243 and 1.337 times as compare to 1.0mX1.0m Box cell but relatively both box cell structure shows good performance in earthquake displacement.
5. Comparing the story drift results in IRC Class A loading in 1mX1m Box cell Structure with 1.5mX1.5m box cell bridge structure Both IRC Loading Structure shows linear behavior, also good performance in

Drift.

6. Comparing The Story force Results in IRC Class “A” Loading and IRC Class “B” loading with 1.0mX1.0m & 1.5mX1.5m Box cell Structure story force is increased in 1.5mX1.5m Box Cell bridge structure.
7. In IRC Class “A” and IRC Class “B” Loading, the shear force and Bending moment results are compared shear force is increased 51.1% in IRC class “A” loading with 1.0mX1.0m box cell structure also in IRC B class Loading 57.2% increased. Also moment is increased 5.9 % in IRC class “A” loading with 1.0mX1.0m box cell structure also in IRC B class Loading 4.8% increased.
8. The overall performance of IRC Class “B” Loading with 1.0mx1.0m Box cell structure is most economical in constructions.

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