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Cost Aanalysis and Comparison of Rectangular and Trapezoidal Box Girder Section

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Abstract: The present study aims at design, analysis and parametric comparison of two different cross section of box girder deck system. Objectives of this study are to compare the stresses at important location like top slab and bottom slab using analysis tool MIDAS-2016. And design and estimates different sizes of rectangular and trapezoidal box girder section using hand calculation.
Keywords: Box Girder, Rectangular box girder, Trapezoidal box girder and MIDAS-2016.

I. INTRODUCTION

Box girder beam bridges are widely used in .today is due to its various advantages over to the slab-beam-type bridges. Box girder bridges are often used in long-span bridges. Box girder bridges are usually pre-stressed concrete in the forms of long-span bridges. However, THE box-girder bridges are used for medium spans. Box girder bridges are to be preferred over the slab and girder bridges, so as to provide the best structural efficiency and the stability of the economy, and I look for a long-span bridges. The bridges are bridges, in which the cross-section is similar to the shape of the box. There are usually two vertical lintels, which are connected by two horizontal flanges on both the top and bottom of the grid. However, many of the intermediate sheets in the structures is sometimes laid down, in order to allow for a multi-cell box-type girder bridge. Box girder bridges are widely used.

Box girders are used for spans from 40m up to 300m using either in-situ or precast concrete segmental construction. Box girders produce elegant and robust solutions. The nature of complexity of box girder bridges makes it difficult to accurately predict the structural response of box girder under loading. However, this complexity and difficulty in the design and analysis of box girder bridges can be handled by the use of the digital computer software in the design. Now a days box girder is widely used for the construction of the bridge. The box girder beam has following advantages:

A. It is a hollow rectangle-section mesh of the structure considerably reduces the dead load, and thus, plenty of margin and cost savings.
B. The Box girders are used for large spans and with a wider tire, box beams, it should be in line with the cross-section. They are sleek, and slender. The economics and aesthetics of an additional lead to the development of the outliers on the upper flanges, and a sloping pattern of the box girder of the cells. The size of the mobile is able to be controlled by the primary voltage.
C. Any way the load causes the voltage, the voltage will be at the box-section. The analysis of these cross-sections are much more complex due to the combined effects of bending, shear, rotation, and distortion. However, this is a more effective, the more layer. It is used for large spans a wide cross-section. It can be used for spans of up to 150 meters, depending on the design.
D. Over the past few years, single-or multi-cellular, reinforced concrete, box girder has been proposed and it has been used as a cost-effective aesthetic solution to the crossing, the sub-routes, the grade separation of the design, and bridges that are used in modern highway system.
E. The high torsional strength of the closed square box girder section, the structure of the aesthetic appeal of many types of open-web system.
F. In this case, the long-bridge-inch, large-deck width is available, in order to adapt to the pre-tensioning of the cables to the reduction in the level of the flange.
G. The single box girder bridge can be used to personalize the services, including gas -, water -, network-related, etc
H. A large scale, of the lower flange can not be used as a second-deck to accommodate the movement.
I. The service, the box beams on the interior design is instantly available, without the use of scaffolding.

So the objectives of this study are is to compare the stresses at important location like top slab and bottom slab using analysis tool MIDAS-2016 and to compare the design sizes of rectangular and trapezoidal box girder section using hand calculation.

II. LITERATURE REVIEW

Abrar Ahmed, P.R. (2017): presented a comparative analysis and design of T-beam girder and box girders. The purpose of this study was to identify the suitable No. section for bridges of different spans. For the analysis Working Stress Method is being used for the Manual design whereas the CSI bridge for Software analysis. Cost comparison for cases was done by estimating the Concrete and Steel quantity for two different girders. Structural components are designed by selecting the trail section. It was found that the IRC 70R vehicle producing maximum effect on the sections. Cost comparison has shown that the T-beam girder is suiTable No. : for spans up to 30metre, as we go for higher spans the depth of T-beam girder increases drastically which makes it uneconomical. For lower spans the T-beam girder can be adopted which is easy to install and maintain and for higher spans the box girder is suiTable No. : and number of cells in the box girder can be increased to decrease the overall depth of the girder for higher spans .From the obtained results we can conclude that the software results are accepTable No. : and can be adopted for the design of substructures also. For lower spans the T-beam girder can be adopted which is easy to install and maintain.

P.K. Gupta, K. K. Gupta (2010): This paper presents a parametric study of the deformation, the longitudinal and transverse bending stresses, and the shear lag of rectangular, trapezoidal and circular cross-section. In order to carry out the analysis, the economic activity in the SAP 2000 software was used in the Fields of the beams. The three sizes of a 4-node shell elements were used for the sample in the field and to analyze the complex behavior of a variety of box girders. A linear analysis is performed for the Dead Loads (dead weight) and Live loads, the IRC channel: 70R zero eccentricity, as well as the maximum mid-span of the eccentricity. Is that a rectangle section, which is superior to the other two sections. In a rectangular-shaped box in the light, as the depth of the enclosure of the beam increases, and the bending reduced, but not to the extent, and at the same time, to increase the depth. The same thing with the increasing of the depth, and the distribution of the bending stresses along the span to decrease, but this decrease was, without a country, are in the same ratio with increasing depth. The shear stress distribution over the cross-section indicates that the value is at the junction of the product, the lip is very high. Like the slide, the depth increases, the tension decreases, but this decrease is not proportional to the increase of the depth. In this case, the distribution of the load under balanced load is zero at the center of the lips, but the eccentrically positioned in the loading of the distribution of the center of the flange to the changes, it is at its greatest. Between the box-shaped beams of rectangular, trapezoidal and circular sections on each to the bending depth to the top of round beam, where the dead loads and the live loads for central and eccentric), and the smallest of the rectangular beam. Therefore, we can conclude that the rectangular cross-section is the most complex section, one of them is in three sections.

Ankush et al. A comparative study of the T-shaped girder, and box girder bridges to a different angle of twist and to the terms and conditions contain the load, is presented. Studies have been carried out in order to understand the behavior of a two-lane to a tilted T-shaped bridge and a wide box girder bridge with a fixed span of 20 m, and the tilt angles of the 10°, 20°, 30°, 40°, 50° 60° or less. The Live loads to be considered, the IRC class AA robot train, and the ip class of A train. The modeling and the analysis of the models of the bridge are carried out by SAP2000 program (version 14) after having verified its value, the estimates produced from the manual.

Mulesh et al. The study of the operational characteristics of a box-shaped superstructure, in the RSS feed are presented. The arched bridges. This article presents a variety of behaviors, such as bending, shear, axial, and the rotation of the horizontal, box-shaped and curved, THE bridges, with a view of the 3d-FEM with the help of SAP. The fem model has been prepared in three different lengths, which extends over the preservation of the same material, the degree of a different curvature from 0° to 90°, for a variety of loads and their combinations, in order to obtain the multiplication factor for a variety of activities such as, BM, SF, AF, and the R-w. s (t).straight out of the bridge, in order to multiply the necessary settings directly onto the bridge in order to get to a bridge. The results show that the increase in the torsional strength for a variety of applications, as compared to the cold, increased bending moment, shear force, and the axis of the load-bearing capacity, which indicates that the section has a higher stiffness, and changes non-linearly with the degree of the curve. The studies also provide multiply the coefficients of all of the parameters for the different degrees of curvature (i.e. 10° c to 90° c), the w. s (t). the bridge itself (at 0°) and span (from 15 to 30 m) or more. As a result of the research, it should be noted that the various spans of the variable, the degree of curvature of the line of the ranges of the axial force and the bending moment, which is approximately 1.2-1.3 for the curvature of 90 degrees. The element in a given moment of torsion varies non-linearly, that is, from 1.8 to 1.9 for at least 90° of flexion, and there is no need to apply a factor to the power of the moving.

Khaled et al. This paper presents highlights of references pertaining to straight and curved box girder bridges in the form of single-cell, multiple-spine, and multicell cross sections. The literature survey presented here deals with elastic analysis and experimental studies on the elastic response of box girder bridges. Among the refined methods, the finite-element method is probably the most involved and time consuming. However, it is still the most general and comprehensive technique for static and dynamic analysis,

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capturing all aspects affecting the structural response. The other methods proved to be adequate but limited in scope and applicability.

Gokhan et al. This paper examines the seismic performance of a three-span continuous concrete box girder bridge with skew angles from 0 to 60 degrees, analytically. The bridge was modeled using finite element (FE) and simplified beam-stick (BS) using SAP2000. Different types of analysis were considered on both models such as: nonlinear static pushover and linear and nonlinear time history analysis. A comparison was conducted between FE and BS, different skew angles, abutment support conditions, and time history and pushover analysis.

III. PROBLEM IDENTIFICATION

The expansion and growth in highway network has lead to many changes in the use and development of various kinds of bridges. The bridge type is related to providing maximum efficiency of use of material and construction technique. As the span increases, dead load of structure simultaneously increases and to counter it cellular structure or box girder structures are adopted. Box girder bridge decks are generally rectangular, trapezoidal and circular in cross section. Recent literature indicates that rectangular and trapezoidal sections are generally adopted, and it was also observed from the literature review that no author has compared rectangular and trapezoidal section for bridge deck construction. Hence, this study aims at comparison of bridge deck construction using rectangular and trapezoidal box girder section.

The objective of the work are-

1) To compare the stresses at important location like top slab and bottom slab using analysis tool MIDAS-2016.
2) To compare the design sizes of rectangular and trapezoidal box girder section using hand calculation.

IV. METHODOLOGY

Design Details of the Cross sectional diagram of both the sections are as

S. No.	Particulars	Rectangular Section	Trapezoidal Section
01	Top width	13.00 m	13.00 m
02	Bottom width	10.05 m	07.73 m
03	Length of cantilever	01.47 m	1.850 m
04	Span	29.00 m	29.00 m
05	Thickness of top slab	0.250 m	0.300 m
06	Thickness of bottom slab	0.200 m	0.210 m
07	Thickness of rib	0.400 m	0.400 m
08	Depth	2.500 m	2.500 m
09	Width of hollow box	2.850 m	4.250 m
10	Bottom width of hollow box	2.850 m	3.465 m
11	No of continuous slab	3	2
12	No of bottom slab	3	2
13	No of cantilever slab	2	2
14	No of rib	4	3

Material of construction for both the section of box girder are taken as-

1) Grade of concrete = M 40
2) Type of reinforcement bars-HYSD bars (Fe 415)

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A. Design Philosophy

Working stress method is generally adopted for the design of bridges, Design steps of each structural element is as follows:

1) Design of Cantilever Slab

a) IRC Class A loading is considered as for IRC Class 70 R loading space for placing of vehicle is insufficient.
b) Moments due to Dead load and live load are calculated. Live load is calculated by placing maximum load of class A train of vehicle on 1 meter width on cantilever slab.
c) In case of cantilever slab when live load is considered only one wheel of the axle is on the continuous slab as for placing the whole axle the distances are insufficient. Effective width of load dispersion is calculated. In both the cases effective width of load dispersion is greater than one meter. Hence, in both the cases two axles are considered.
d) Depth of the slab is checked by codal provisions.
e) Area of steel required is calculated and distributed evenly on cantilever slab.

2) Design of top slab

a) The central continuous slab is divided in to three equal parts for ease in calculation.
b) IRC class 70R loading is considered for continuous slab for maximum effect the load is placed at center of the span.
c) For the designing strip of one m considered and one of the heaviest axle is placed on the strip. On calculating effective width of load dispersion it was found that it exceeds one meter here by two axle of the IRC class 70R loading is placed on the span.
d) It is assumed that dead load and load due to wearing coat is considered as uniformly distributed load and live load is considered as point load.
e) Slab is one way and fixed at both the ends. Hence, maximum negative and maximum positive bending moments are computed.
f) Reinforcement for top layer is computed from the effect of maximum positive bending moment and that for bottom layer is computed from maximum negative bending moment.
g) Weight of reinforcement required for continuous slab is computed by taking into account unit weight of steel i.e. 7850 kg/m^3.

3) Design of Bottom Slab

a) In bottom slab it is considered that bottom slab is not affected by live load and it is only subjected to dead load and load due to maintenance during its service period.
b) Slab is one way and fixed at both the ends. Hence, maximum negative and maximum positive bending moments are computed.
c) Reinforcement for top layer is computed from the effect of maximum positive bending moment and that for bottom layer is computed from maximum negative bending moment.
d) Weight of reinforcement required for continuous slab is computed by taking into account unit weight of steel i.e. 7850 kg/m^3.

4) Design of Rib

a) By maximum bending moment in the section area of steel required in ribs are calculated. Then this area of steel is divided in ribs and some part of this in bottom slab.
b) Ribs are designed assuming it as deep beam as depth of beam is higher.
c) Check for shear stress is done. And for excess shear stress stirrups are designed..
d) As rib is designed as deep beam side face reinforcements are calculated.
e) Weight of reinforcement required for continuous slab is computed by taking into account unit weight of steel i.e. 7850 kg/m^3.

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V. RESULTS

Result obtained by MIDAS are as-

A. For Rectangular section

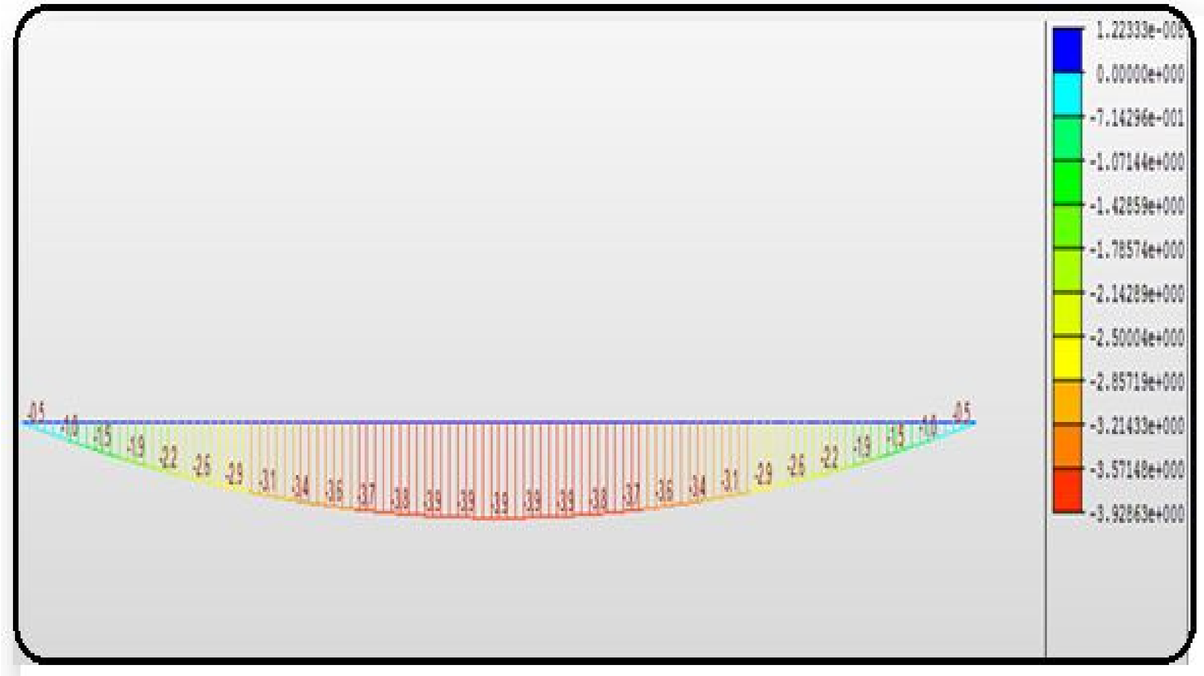

Figure: Variation of bending stresses at top flange rectangular cross section

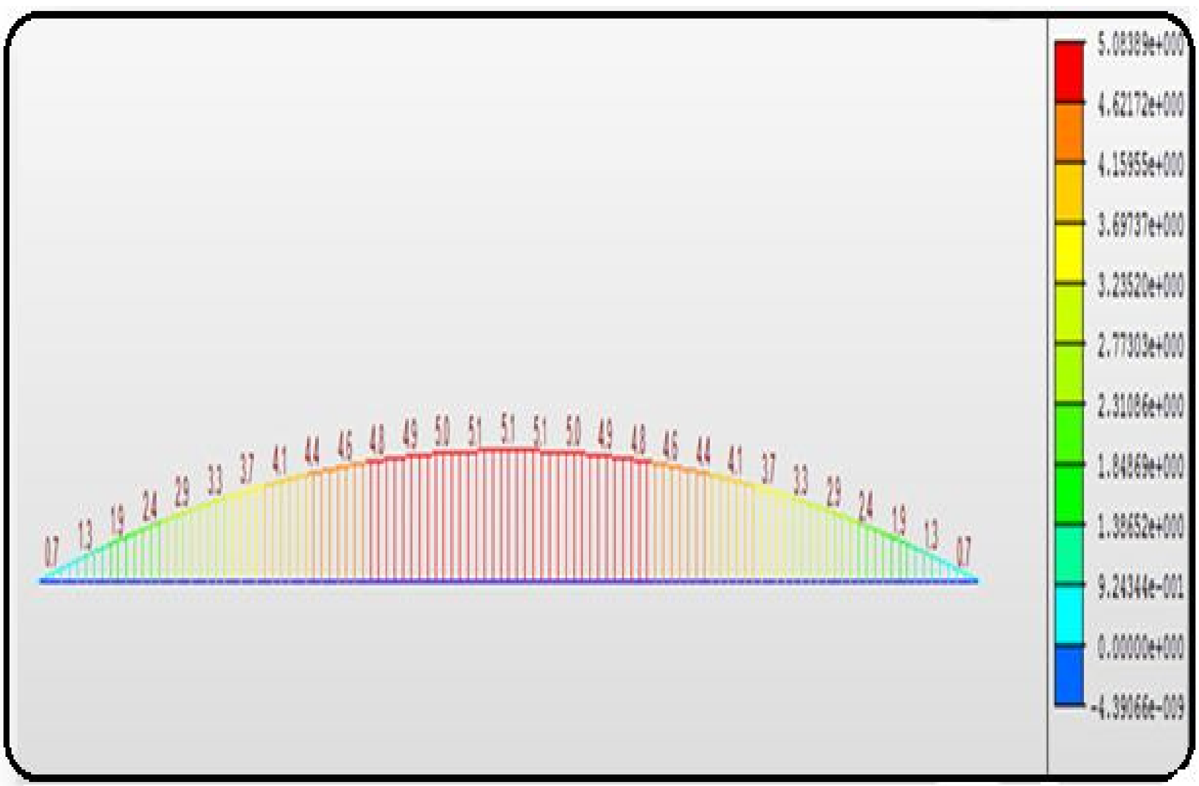

Figure : Variation of bending stresses at bottom flange of rectangular cross section

B. For Trapezoidal Section

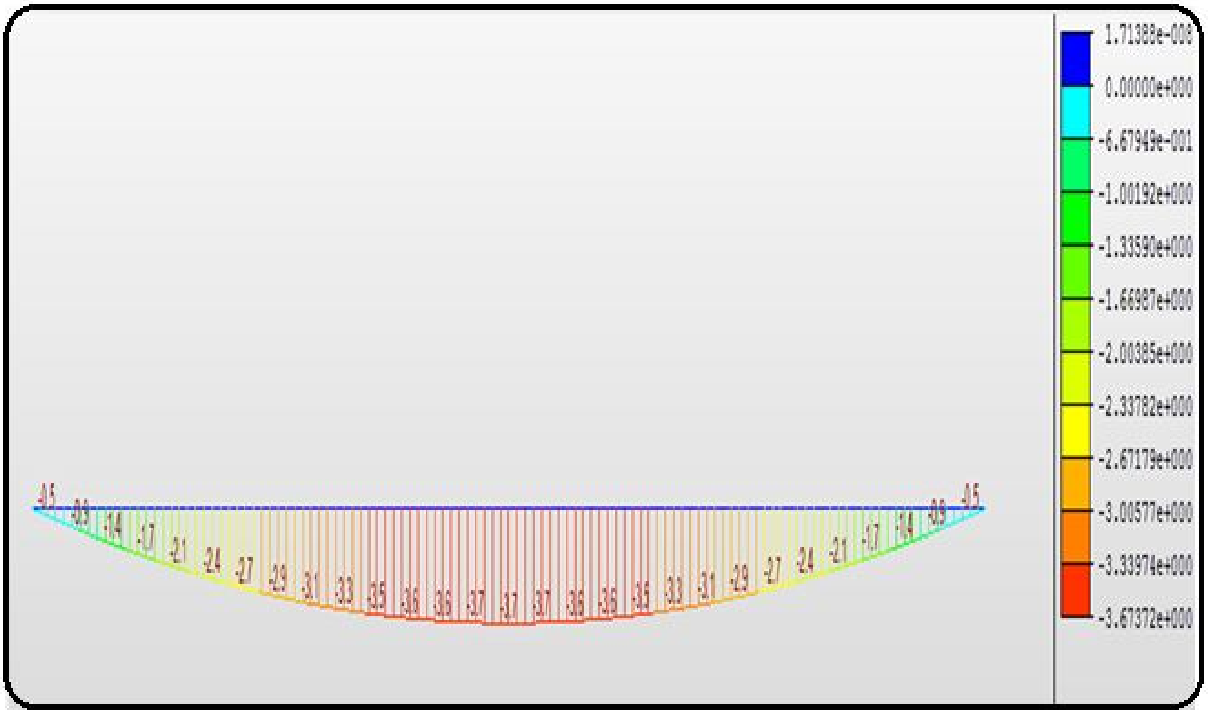

Figure: Variation of bending stresses at top flange of trapezoidal cross section

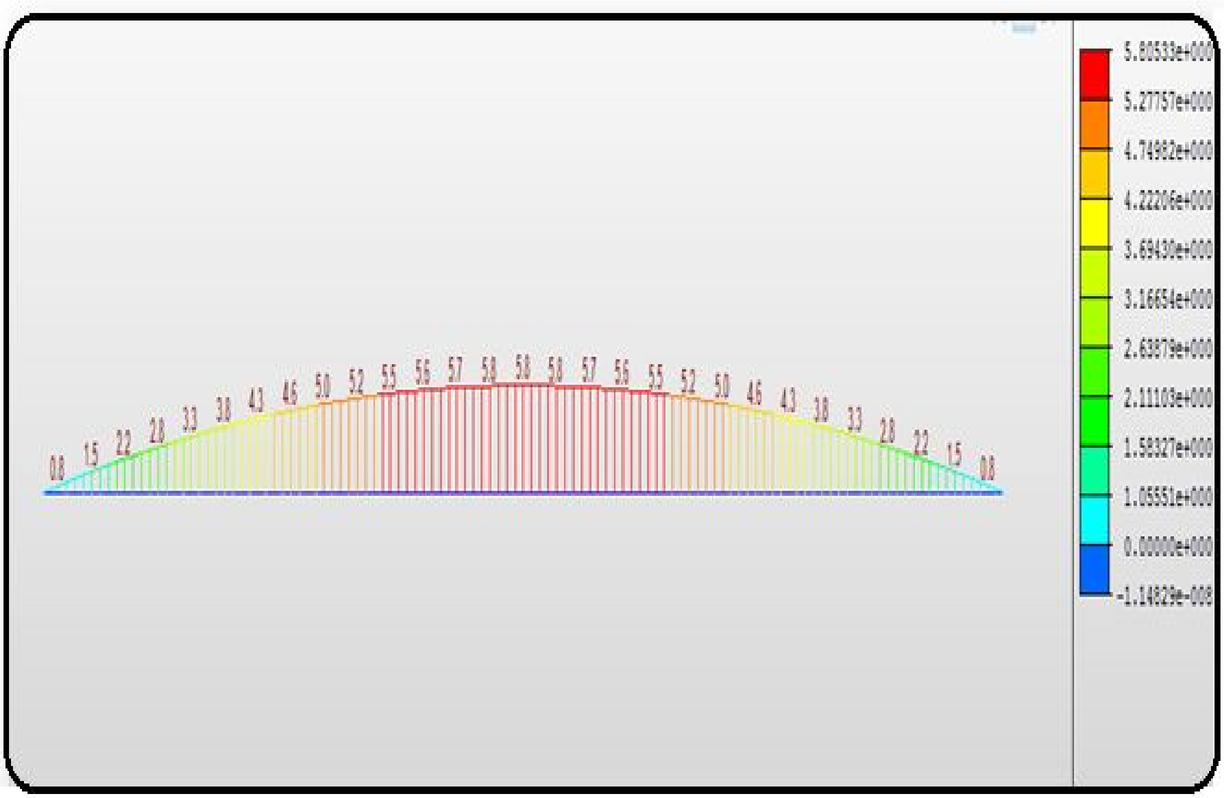

Figure: Variation of bending stress at bottom flange trapezoidal cross section

C. As Per Design Details Weight Of Steel Required For Each Member In Rectangular Cross Section

S. No	Particulars	Weight (kg)
1.	Cantilever slab	7140.00
2.	Top slab	24983.67
3.	Bottom Slab	4312.50
3.(1)	Due to rib	3861.98
4.	Longitudinal Reinforcement bars	
4.(1)	Cantilever Slab	320.40
4.(2)	Top Slab	3843.64
5.	Rib	98868
5.(1)	Stirrups	3113.74
5.(2)	Side face reinforcement	8785.46
Total		155229.39 Kg

1) Longitudinal Analysis

a) For cantilever slab

Use 14 nos 8 ⌀ bars at top and bottom @170 mm c/c.

Total weight of bars = 14 X 29 X 50.26 X 10^{-6} X 7850

= 160.20 kg

As the cross section is having 2 cantilever slab having same cross sectional area. So, weight of reinforcement will be same for both the slab.

Total weight of reinforcement in both cantilever slab =320.40 kg

b) For top slab

Use 14 nos 16 ⌀ @ 200 c/c at top and bottom of one top slab.

Total weight of bar in one top slab = 28 X 29 X 201 X10^{-6} X 7850

= 1281.214 kg

The central widths expect cantilever from both the ends is divided into 3 parts.

Total weight of reinforcement bars in top slab = 3843.64 kg

D. As per Design Details Weight of reinforcement required for trapezoidal section

S. No	Particulars	**Weight in kg)**
1.	Cantilever slab	8327.89
2.	Top slab	13086.68
3.	Bottom Slab	2212.60
3.(1)	Due to rib	6007.53
4.	Longitudinal Reinforcement bars	
4.(1)	Cantilever Slab	320.36
4.(2)	Top Slab	2562.42
5.	Rib	74151.45
5.(1)	Stirrups	2335.29
5.(2)	Side face reinforcement	6589.10
Total		115593.32 kg

1) Longitudinal analysis

a) For Cantilever Slab

Use 14 nos 8 ⌀ bars at top and bottom @170 mm c/c.

Total weight of bars = 14 X 29 X 50.26 X 10^{-6} X 7850

= 160.20 kg

As the cross section is having 2 cantilever slab having same cross sectional area.so weight of reinforcement will be same for both the slab.

Total weight of reinforcement in both cantilever slab =320.40 kg

b) For top slab

Use 14 nos 16 ⌀ @ 200 c/c at top and bottom of one top slab.

Total weight of bar in one top slab = 28 X 29 X 201 X10^{-6} X 7850

= 1281.214 kg

The central width except cantilever from both the ends is divided into two parts.

Total weight of reinforcement bars in top slab = 2562.42 kg

Consumption of steel

S.No	Type of cross – section	Total weight of steel (MT)	Cost (@ 41500 Rs /Mt)
01	Rectangular	155.229	6442003.5
02	Trapezoidal	115.593	4797109.50
Total Saving		39.636	1644894.50

Rate of steel is taken from Schedule of rates published by public works department (Chhattisgarh). Rate of Fe415 bars is 41500 Rs per MT

VI. CONCLUSIONS

A. Quantity of steel used in rectangular section 155229.39 Kg and in trapezoidal section this quantity is 115593.32 kg. So, 39636.07 kg of steel can be saved.

B. The Cost of steel for rectangular section is 6442003.5 Rs and that in trapezoidal section is 4797109.50 Rs. there by 1644894 Rs. Can be saved by adopting trapezoidal section, hence it's clear that the cconsumption of concrete and steel is more in rectangular section than in trapezoidal section.

C. Bending stresses are higher in rectangular section as compared to in trapezoidal section.

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