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Study of Girder Selection as per IRC 18:2000, IRC 21:2000 and IRC 112:2011

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Abstract*— The design of a highway bridge is critically dependent on standards and criteria. Naturally, the importance of highway bridges in modern transportation system would imply a set of rigorous design specifications to ensure the safety, quality and overall cost of the project. Bridge design practices differ very extensively throughout the world. Many codes are currently dealing with limit state method; IRC 112:2011 combines specifications for both RCC and pre-stressed concrete bridges. It introduces durability of concrete, general dealing requirement of different bridge members, grade of concrete is allowed up to M90 and grade of steel used up to Fe 600. In the present work, an attempt will be made to compare between IRC 21:2000 "Standard Specification and Code of Practice for Road Bridges Section III, Cement Concrete (plain and reinforced)" and IRC 18:2000 "The Design Criteria for Pre-Stressed Concrete Road Bridges (Post-Tensioned Concrete)" with IRC 112:2011 "Code of Practice for Concrete Road Bridges" for understanding both the codes.

Keywords—Highway bridge, Bridge Design, Prestresssed Concrete design, IRC 112:2011, IRC 18:2000

I. INTRODUCTION

Bridge is key element in transportation system. A bridge can be defined as a structure, which provides a passage over an obstacle without closing the way beneath. They may be needed for the passage of rivers, railways, roadways, footpaths and even carriage of fluids. Bridge engineering is one of the most challenging areas of all the engineering disciplines. It is most important part of infrastructure development. In India, large numbers of bridges of various types are under construction and many more are in planning stage. These bridges include flyovers, interchanges and major/ minor bridges across river, open sea etc.

With the advent of pre-stressed concrete industry in the 1930s by French engineer Eugene Freyssinet (Nilson 1987), the use of high strength concrete and high strength steel became economically feasible. Pre-stressing concrete reduces service load stresses, eliminates or limit cracks, control deflections and allows for the use of smaller and lighter members over increased span lengths. These aspects make pre-stressed concrete ideal for use in bridges. The development of bridge construction has been growing with the development of human civilization.

The unified concrete code (IRC 112) published by the Indian Roads Congress (IRC) in November 2011 combining the code for Reinforced Concrete and Pre-stressed Concrete structures represents a new generation code, which is significantly different as compared to the previous codes (i.e. IRC 21 for RCC structures and IRC 18 for PSC structures). IRC 21 and IRC 18 stand withdrawn, with the publication of IRC 112. The fundamental difference between IRC 112 and the old set of codes is that IRC 112 is based on limit state theory while the previous codes were based on working stress design philosophy.

II. METHODOLOGY

The objective of this study is to compare the design of super structure elements of bridge using IRC 21:2000, IRC 18:2000, and IRC 112:2011 for different span length on the basis of the quantity of the materials and its cost. Ultimate aim of any design is to achieve economy. For design of super structure, RCC deck slab, PSC I and box girders are considered. Three different spans 20 m, 35 m, 50 m are considered for design.

Step 1: Review of various technical papers presented by different researchers.

Step 2: Selection of dimensions of I – girder and box girder for present study. The dimensions used for study are as follows

At Midspan	I - Girder					
	20 m		35 m		50 m	
	Girder	Composite	Girder	Composite	Girder	Composite
Bs	-	3000	-	3000	-	3000
Ds	-	250	-	250	-	250
Btf	1000	100	1400	1400	2000	2000
Dtf	200	200	300	300	300	300
Dth	100	100	150	150	150	150
Bw	350	350	350	350	350	350
Dbh	100	100	200	200	200	200
Dbf	200	200	250	250	250	250
Bbf	600	600	600	600	600	600
Dg	1400	1400	2400	2400	3300	3300

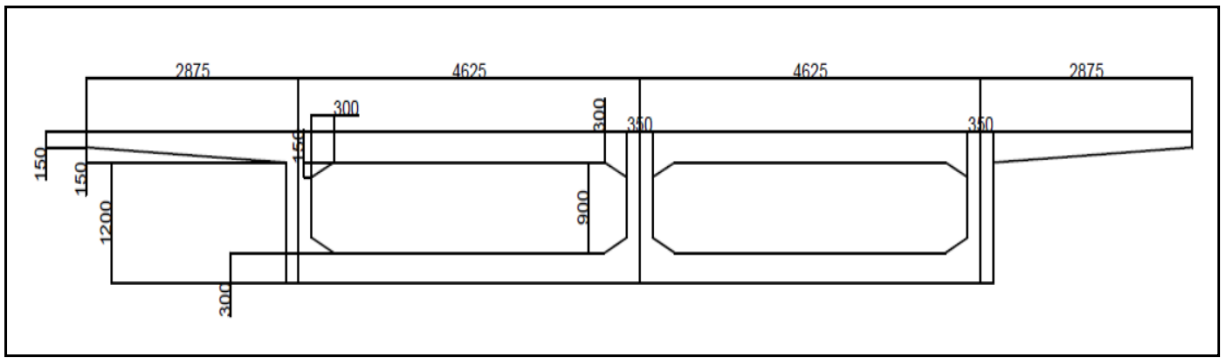


Fig. 1 20 m Box Girder Dimensions at mid span

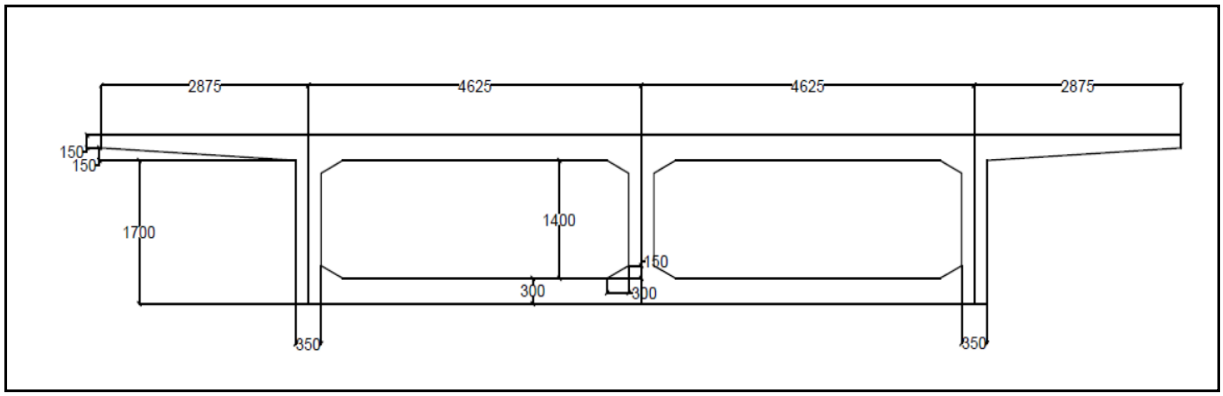


Fig. 2 35 m Box Girder Dimensions at mid span

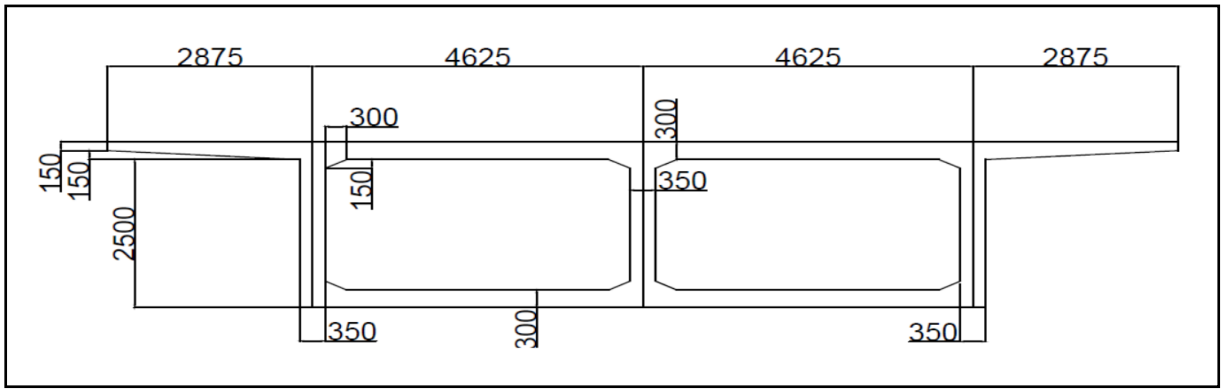


Fig. 3 50 m Box Girder Dimensions at mid span

Step 3: Modelling of above selected dimensions in Midas Civil 2018 software.

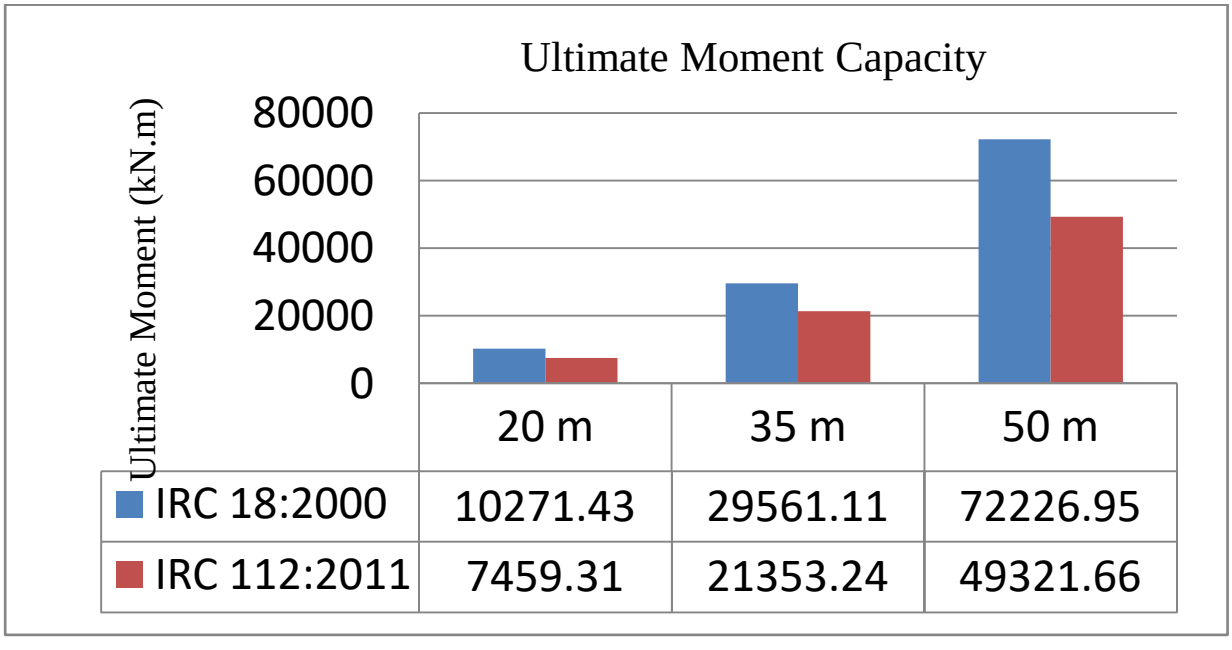
Step 4: Analysis and design of models as per IRC 18:2000, IRC 21:2000, IRC 112:2011.

Step 5: Interpretation of various results.

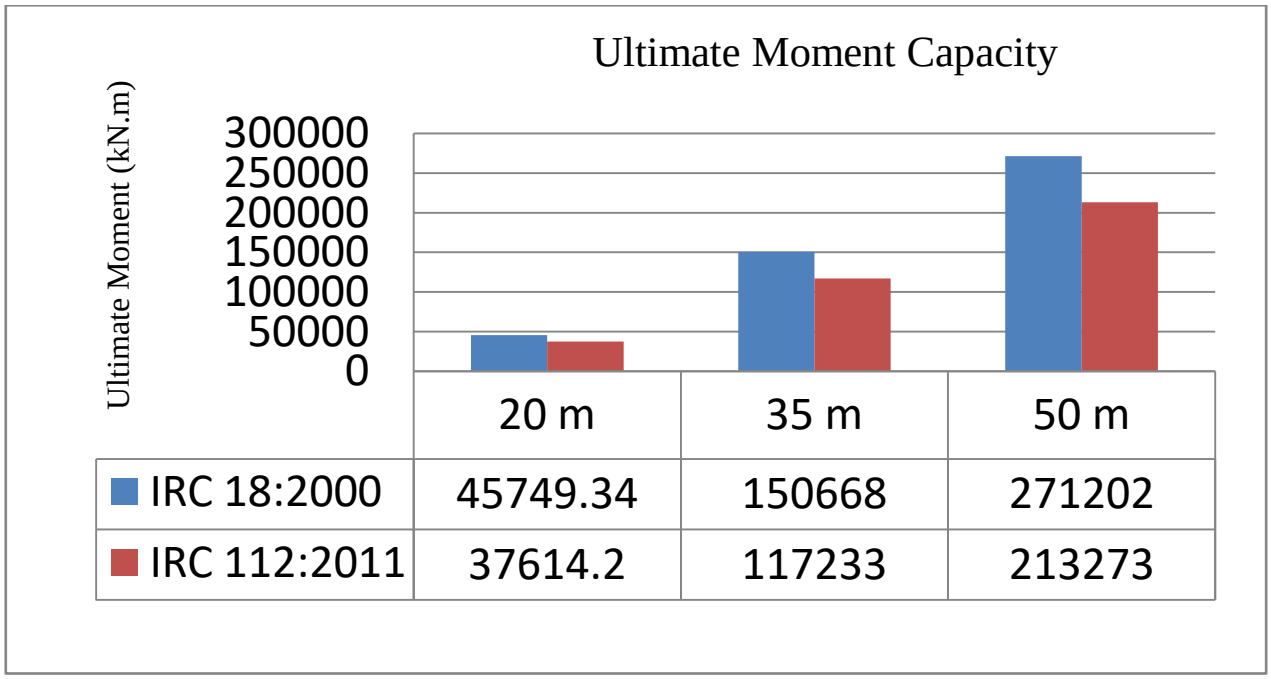
III. PROCEDURE FOR CALCULATING FLEXURAL STRENGTH BY IRC 112:2011

1. Find the prestrain in cables arranged according to their levels, taking losses into account.
2. Assume depth of neutral axis.
3. According to the neutral axis depth assumed find compression areas and force in that area.
4. Calculate Strain limit of prestsressing steel = (f_{pd}/E_s)
5. Calculate strain at different levels according to the arrangement of cables, then calculate total strain.
6. From total strain we can get stress in cables.
7. From stress we can get tensile force in cables = Stress * Area of prestressing cables.
8. Now, Tensile force = compressive force, if not then change depth of neutral axis and repeat the whole procedure.
9. Calculate the moment of resistance by taking moment about neutral axis.

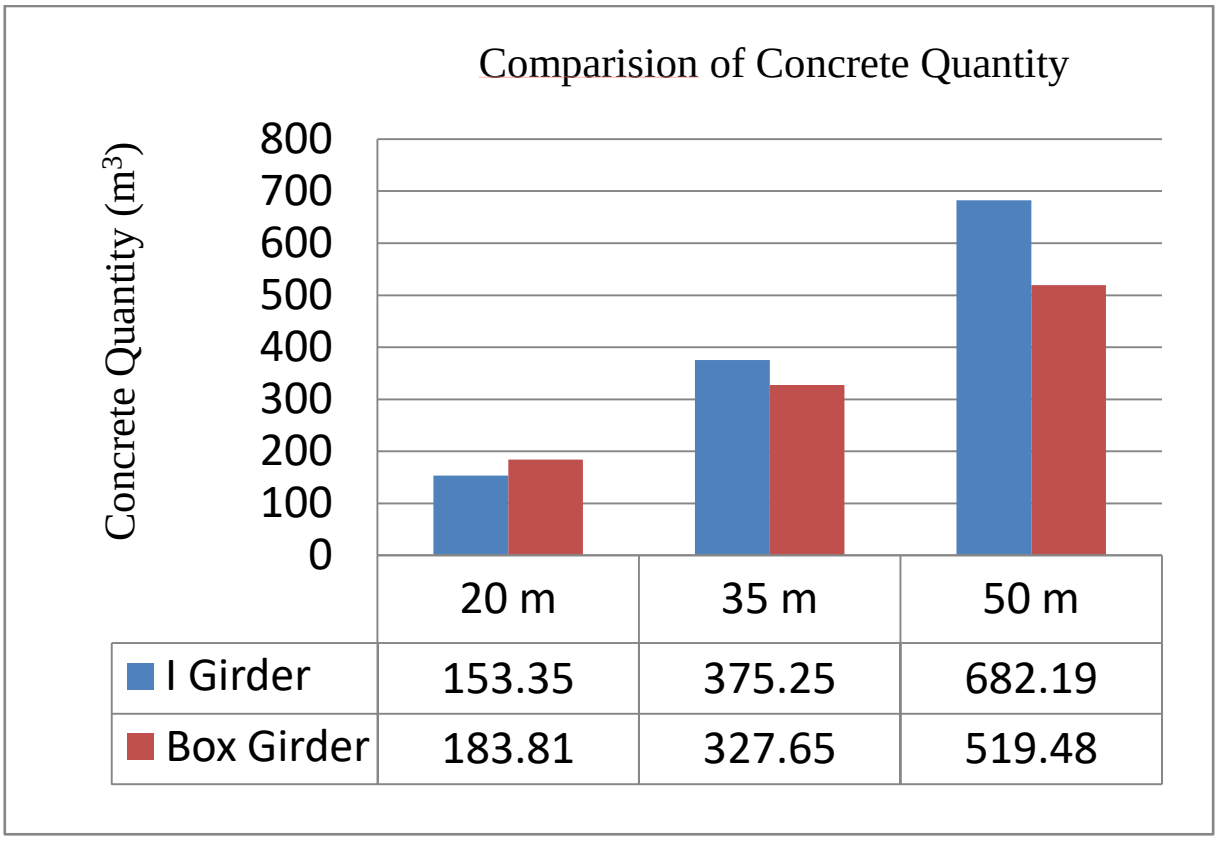
IV. RESULTS



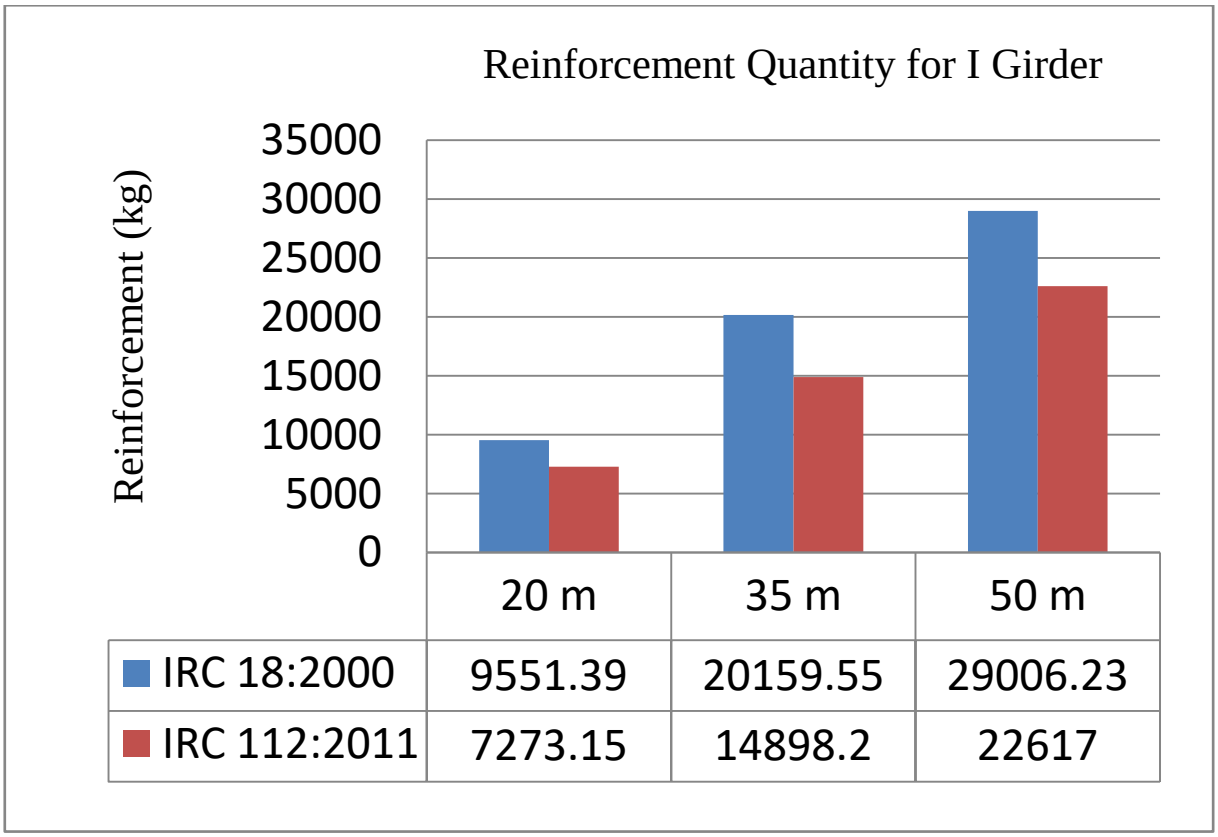
Graph 1: Span vs. Ultimate moment of I girder at Mid span



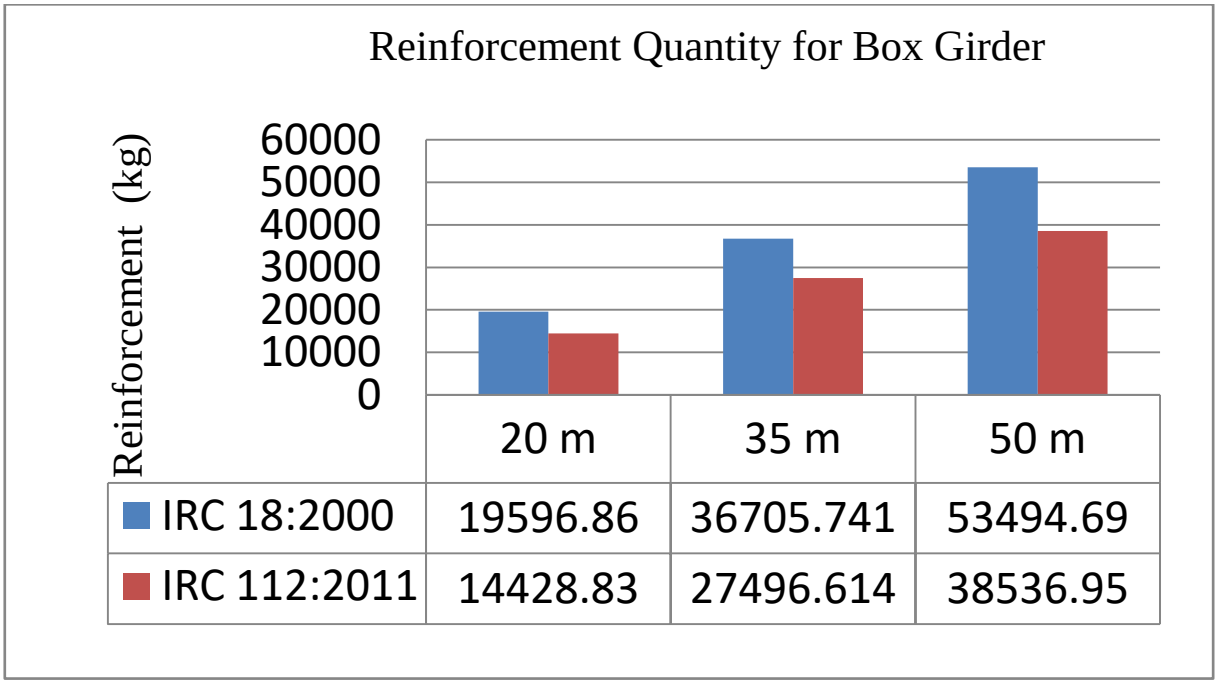
Graph 2: Span vs. Ultimate moment of Box girder at Mid span



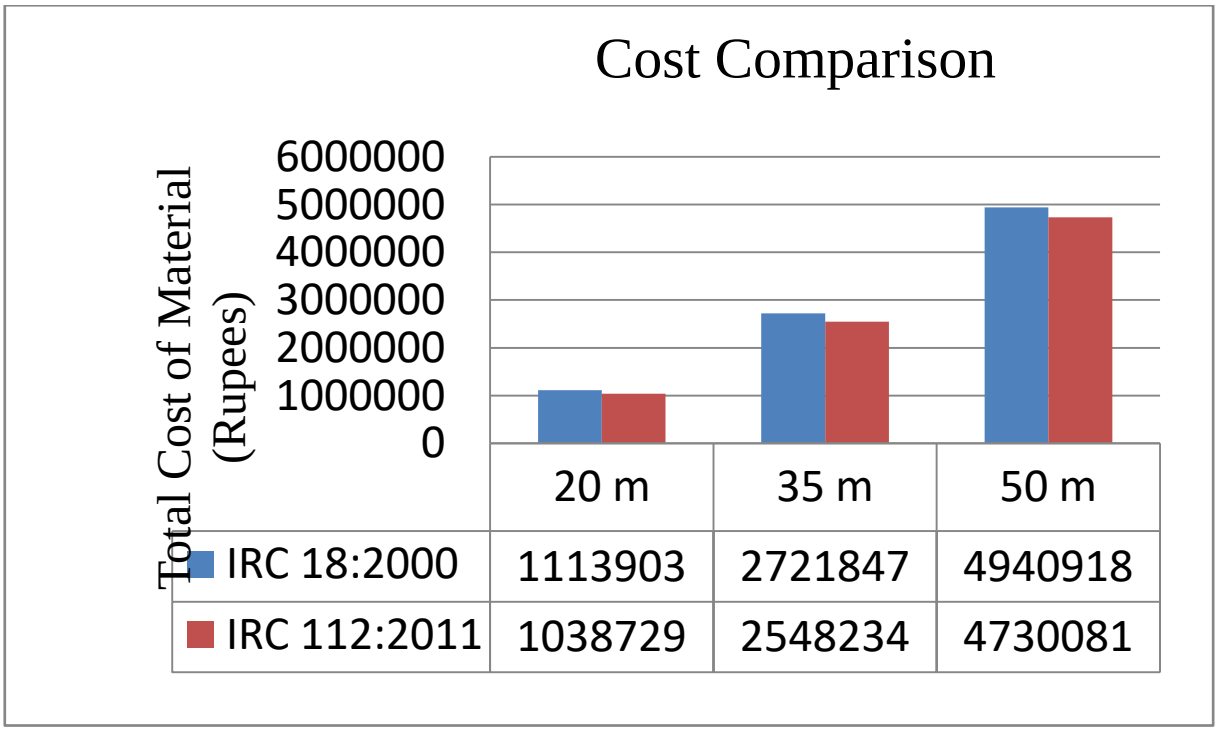
Graph 3: Comparison of Concrete Quantity for I girder and Box girder



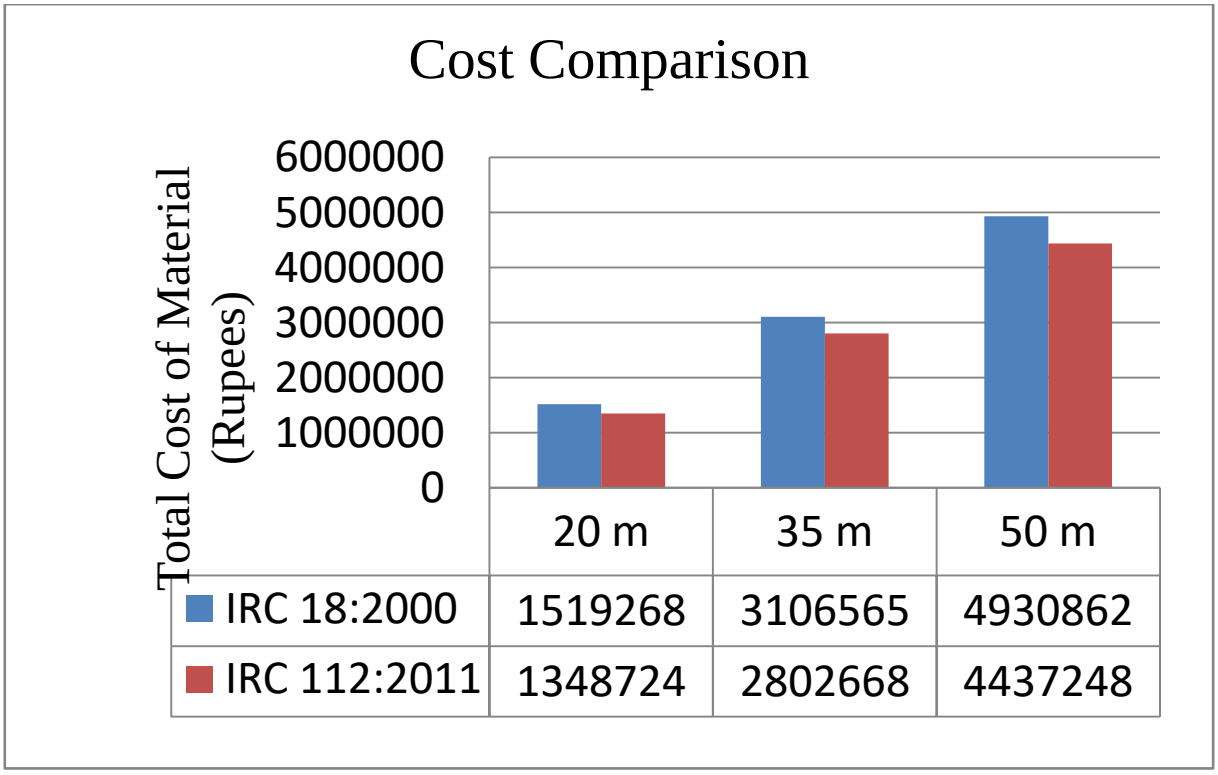
Graph 4: Comparison of Reinforcement Quantity for I girder by IRC 18:2000 and IRC 112:2011



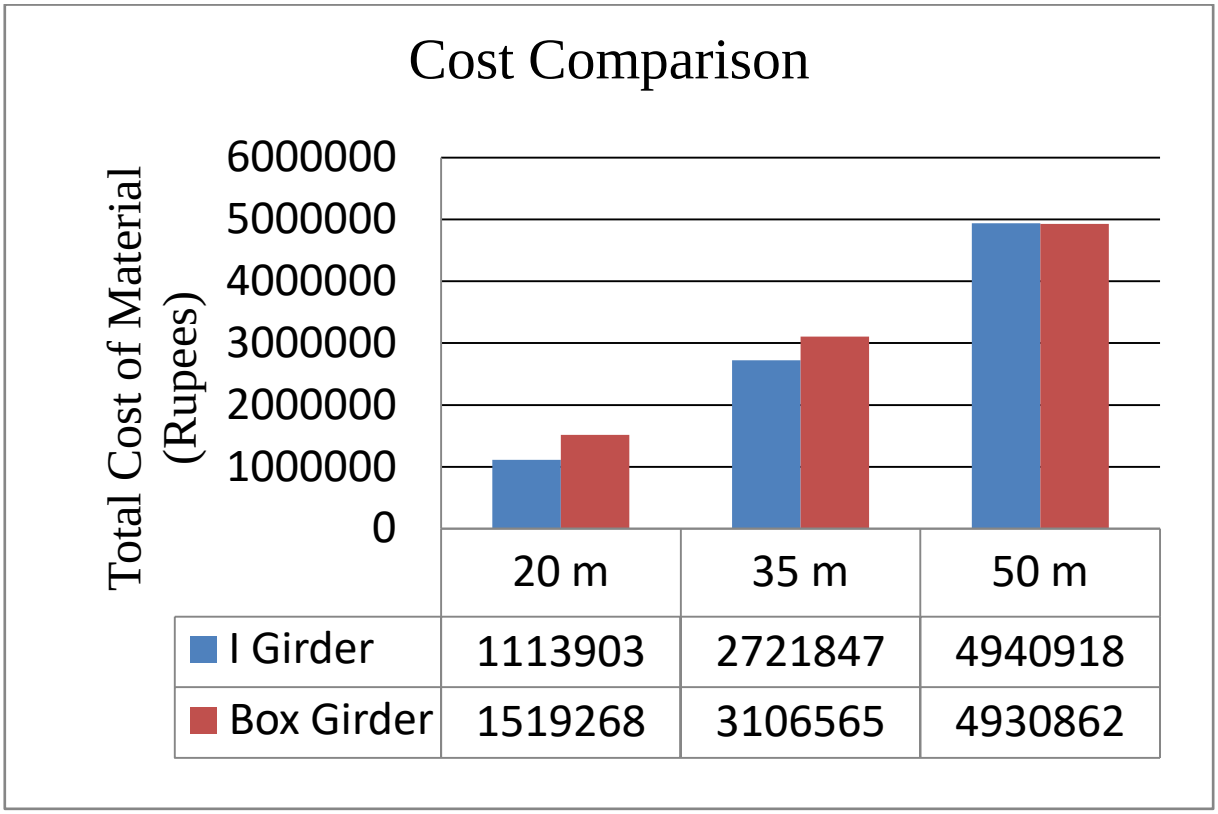
Graph 5: Comparison of Reinforcement Quantity for Box girder by IRC 18:2000 and IRC 112:2011



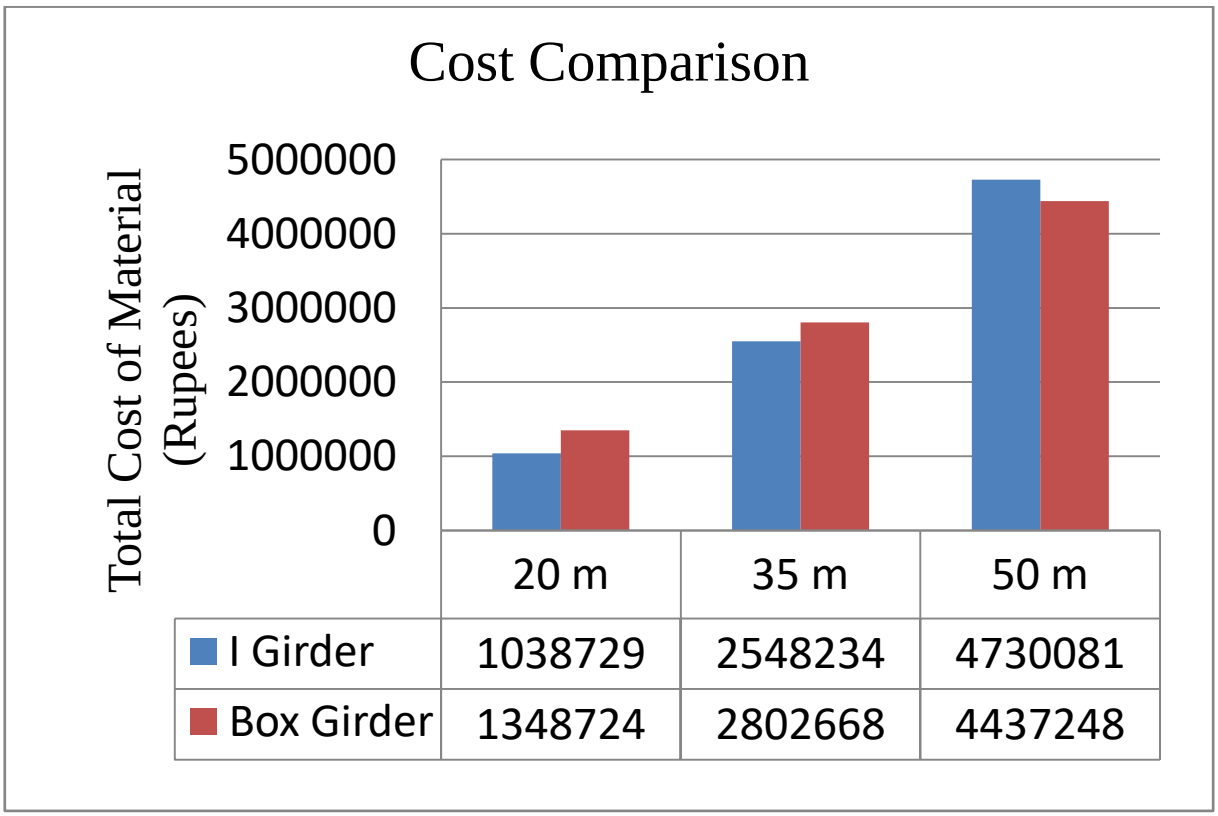
Graph 6: Comparison of Total cost of Material for I girder by IRC 18:2000 and IRC 112:2011



Graph 7: Comparison of Total cost of Material for Box girder by IRC 18:2000 and IRC 112:2011



Graph 8: Comparison of Total cost of Material for Box girder and I girder by IRC 18:2000



Graph 9: Comparison of Total cost of Material for Box girder and I girder by IRC 112:2011

V. CONCLUSIONS

Design of super structure of bridge (RCC Deck Slab + PSC Girder) is prepared for different spans i.e 20 m, 35 m, 50 m. RCC deck slab is designed as per the provisions of IRC 21:2000 and IRC 112:2011. PSC I Girder and PSC Box Girder is designed as per the provisions of IRC 18:2000 and IRC 112:2011. An attempt is made to achieve economical bridge super structure.

1. From graph 1 and 2, it is concluded that Ultimate Moment at mid span due to loading for IRC 18:2000 is greater than IRC 112:2011, this is due to partial safety factors used in IRC 18:2000 are greater than that in IRC 112:2011.
2. From graph 3, it is concluded that when the span is small quantity of concrete required for I – Girder is less than box girder but as the span increases it becomes vice versa.
3. From graph 4 and 5, it is concluded that there is around 22 to 28 % of saving in quantity of reinforcement when IRC 112:2011 is used instead of IRC 18:2000.
4. From graph 6 and 7, we can conclude that there is around 4 to 11% of cost saving when IRC 112:2011 is used instead of IRC 18:2000.
5. From graph 8 and 9, we can conclude that when the span of super structure is small (i.e 20 to 35 m) use of I – girder is economical, but as the span increases box girder becomes economical.

From above graph results, it is concluded that the design of bridge super structure using IRC 112:2011 is more economical than IRC 21:2000 and IRC 18:2000.

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