“ANALYSIS AND DESIGN OF STEEL I-GIRDER BRIDGE USING CSI-BRIDGE SOFTWARE”

A thesis

submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

Civil Engineering

with specialization

in

Structural Engineering

under the supervision of

Dr. Gyani Jail Singh

and

Dr. Ashok Kumar Gupta

by

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"ANALYSIS AND DESIGN OF STEEL I-GIRDER BRIDGE USING CSI-BRIDGE SOFTWARE"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Akshi Dhanotia** (Enrolment no. 152651) during a period from July 2016 to May 2017 under the supervision of Dr. Gyani Jail Singh **(**Assistant Professor) and Dr. Ashok Kumar Gupta (Professor), Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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DECLARATION

I hereby declare that the work reported in the M-Tech thesis entitled **"ANALSIS AND DESIGN OF STEE-I-GIRDER USING CSI BRIDGE SOFTWARE"** submitted at Jaypee University of Information Technology, Waknaghat, India, is an authentic record of my work carried out under the supervision of Dr. Gyani Jail Singh and Dr. Ashok Kumar Gupta **.** I have not submitted this work elsewhere for any other degree or diploma.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

f_{ck}	Characteristic strength
f_y	Yield strength
σ_c	Permissible direct compressive strength
σ_{cbc}	Permissible flexural compressive strength
σ_{st}	Permissible flexural tensile stress
σ_{co}	Permissible direct compressive stress
τ_{max}	Maximum shear stress
M_d	Dead load moment
$M_{(d+l)}$	Dead and live load moment
M_l	Live Load Moment
V_u	Shear force
D	Depth of I – girder
t_w	Thickness of web
t_f	Thickness of flange
b_f	Width of flange
M	Moment of entire bridge
V	Shear force of entire bridge

ABSTRACT

Today overall significance has been accomplished by bridge construction. In road network, the most important element is bridge. There is requirement for understanding the interaction of vehicle-bridge due to degradation of bridges under repetition of traffic loading. The principle point is to utilize parts of composite material to work in an compelling way.

A different design guideline has been composed during the work and is introduced in this thesis. The principal attention of this article is to view the strategies currently used. This report presents the relative study of the provision of the codes and specifications of IRC and AASTHO.

These provisions cover the design of steel I-Girder bridge. CSI-BRIDGE finish a parametric object based modeling while at the same time establishing analytical bridge systems. This object oriented approach reduces the modeling process and merge all materials.

Keywords: Structural analysis, CSI- Bridge, IRC, AASHTO

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Bridge is a structure which permits the section of people on foot or vehicles worked over any hindrance or water body [i]. There are several bridge designs that serve an appropriate purpose. Depending on the behavior of bridge [ii].

There are various types of bridges [iii]:-

1. Timber bridge
2. Concrete bridge
3. Steel bridge
4. Composite bridge

Bridge has mainly two sections the superstructure and the substructure. The superstructure has deck slab, I-Girder and shear connectors though substructure has of the footer, stem and the cap. Composite construction consists of two unique materials which are strongly bound to form a solitary unit.

“Composite” implies that the concrete portion of the deck is associated with the steel portion of the bridge by shear connectors [iv]. Shear connectors are fundamentally fixed on steel beams and then they are embodied in the concrete slab. Shear connectors can be associated by welding, or utilizing nut and bolts [v].A steel beam which is assembled composite by utilizing the shear connectors and concrete which is more strong and stiff as compared to beam.

Figure 1.1 Composite bridge

Various types of bridges:

- Arch bridges
- Rigid frame bridges
- Cable stayed bridges
- Truss bridge
- Girder bridge

Arch bridges: Arches have curved structure which provides high resistance to bending forces. Arches are used where foundation or ground is stable and solid. Basic types of bridges are hinge less, 2 hinged, 3 hinged.

Rigid frame: In this the piers and girders are one frame structure. They are also known as Rahmen bridges. The cross section of the beam is usually I- shaped or Box type

Cable stayed bridges: Steel cables are flexible and strong. They can be used for greater span lengths as they are lighter and economical.

Truss bridge: In this type of bridge small beams are joined together to carry large amount of loads.

Girder Bridge: There are two basic types of bridges I shaped girder and Box girder. Box girder has two flanges and two webs. Box girders are more stable and strong and are preferred over I-shaped girder.

Composite bridge consists of various members :

1. Steel I-Girder: - They are the primary support for the deck and are responsible to transfer the load to the foundation. Cross girders are the transverse beams which are provided for the transverse stiffness [i].

Figure1.2 Steel-I- Girder

Shear connectors: - They are commonly referred to as "shear studs." To achieve the composite effect between the girder and the deck slab they are provided on the top flange of the girder thus increasing both stiffness and strength [i].

Figure 1.3 Shear Connectors

3. Deck slab: - It is the important part of the bridge which is supported on the I-Girder. It transfers various loads such as vehicular load to the girder.

Figure 1.4 Deck slab

1.2 ADVANTAGES

The benefits of composite bridge are that there is weight reduction because of higher specific strength. They have a prevalent situation resistance in all conditions. It is cost effective and has a low life-cycle cost. The modular approach not only lessens the cost of construction but also saves time.

1.3 SCOPE

Presently, Composite bridges are utilized over normal bridges since they are exceptional slender and aesthetic. It has low dead weight which additionally helps in the design of foundation and investigation of settlement of supports [i].

There are many issues like deflection and design criteria, long term performance, and extraordinary temperature behaviour. By utilizing CSI-BRIDGE software, modelling of bridge systems, loading, analysis, design and output can be done.

1. Modelling of the bridge: - It applies the parametric object based modelling approach.
2. Loading and analysis: - In software we need to apply the load cases and its combinations. Vehicle, wind loading etc are produced according to the building code IRC :5-1998 (Road bridges),IRC :006-2014 (Load and stresses) , IRC :18-2000 (Concrete road bridges), IRC: 21-2000 (Concrete road bridges reinforcement),IRC :83(part3-2000),IRC :112-2011 (Concrete road bridges) ,IRC:SP:075-2008(Steel bridges),IRC:SP:71-2006(Girders for bridges),AASTHO LRFD 2012(Bridge design specification),AASTHO 1973(Highway bridge specification).
3. Design and output: - The design process along with the analysis a report is automatically generated. Moment, shear force, axial response, load rating, displacement reaction etc all are the parts of output generation

CHAPTER 2

LITERATURE REVIEW

- **F.N. Catbas, H. Darwash and M. Fadul (2004)[9]**The author proposed that it is possible to expect 20% higher live load capacity for interior girder and 40% higher for exterior girder using the FIB girder as contrasted to AASTHO girder by lessening the cost by about 24%. FIBs are designed so that they can have higher load capacity. Efficient fabrication and increase in lateral stiffness because of thick top and bottom flanges.

- **Aixi Zhou, Thomas Keller (2004)[10]**The author indicated that the overall stiffness and the load resistance capability of the associated system can be increased as contrasted to the individual components. A potential ductile behavior can be seen by providing a ductile bonding layer in the connection. Even if unexpected failure occurs, underneath girders can still take the loads.

- **Amir Gheitasi, Devin K.Harris (2005)** **[11]** In this the author indicated the overall execution of steel-concrete composite bridge superstructure. A numerical modeling approach was established to study the impact of deck delamination of the reinforced concrete slab. The main source of material nonlinearities are inelastic stress-strain relationships, cracking, crushing, yielding and plasticity of steel components.

- **S.J.Fatemi, M.S. Mohamed Ali, A.H. Sheikh (2005)** **[12]** The author did the parametric study to determine the load distribution factor for moment and shear of horizontally curved girder. The load distributions according to the AASTHO are extensively higher than the Australian Bridge Design Code. The load distribution factor is utilized to calculate stress resultant from total shear, bending moment and torsion.

- **S Dhanush, K Balakrishna Rao (2005)** [13] The author proposes that the load carrying capacity of the slab decreases as the angle of skewness of the slab increases. The load gap between the solid and the non composite slab decreases as the angle of skewness of the slab increases. The shear connectors which are provided in the transverse direction do not improve the behaviour.With the increases in the connectors in the longitudinal direction, the load carrying capacity also increase.

- **Telmo Alexandre Alves Mendes (2006)** [14] The author indicate that the deck with double composite action use less structural steel per unit area having higher resistance to bending moments and better response to torsional effects, when compared to composite steel-concrete deck even though the deck section becomes heavier

- **Fang-Yao Yen, Kuo-Chun Chang, Kuo-Chun Chang, Hsiao-Hui Hung, Chung-Che Chou (2007)** [15] The author proposed a movable temporary bridge that is foldable and stretchable. Following design requirements were taken as For light weight requirement composite structure can be used and for short to medium span beam or truss type bridge is considered. The disadvantages are that the low modulus and low stiffness which leads to large deflections.High price of composite materials.

- **Yingli gao, Liang Huang(2008)** [16] Significant research has been done that, under adverse weather conditions the friction coefficient of the pavement decreases and finally leads to thawing. In order to prevent this various methods like scavenging with artificial and mechanical,with scattering snow melting agent,with heating cable method.The disadvantages are that it has low efficiency ,waste of man power and can easily harm the pavement.It can easily erode the pavement material due to snow melting material.It doesn't meet the current demand of energy conservation. The authors have proposed that the steel pipes used in the phase change functional provide reinforcement which improves the strength of the bridge deck. The sections with steel pipes and PCM(Phase Change Materials) thaw ice more easily and hence improving the anti freezing and anti sliding capabilities of bridge deck

- **Ibrahim S.I. Harba (2009)[17]** In this the author indicated that for skew bridges maximum live load ,bending moment and deflection decreases while maximum shear, torsion and support reaction increases.

- **Pranathhi Reddy, Karuna S (2010) [18]** In this the author has compared the behavior of normal bridge to skew bridge at different angles. Magnitude of shear force reduces with the increase in skew angle.In case of moving loads, the shear force increases with increase in skew angle.

- **Arindham Dhar, Mithil Mazumdar, Mandakini chowdhary and Somnath Karmakar(2012)[19]**Significant research has been done on the mid span longitudinal moment which steadily increases with the increase in the skew angle for obtuse angles girder and decreases for the acute angle. In obtuse angled girder there is rapid increase in the torsional moment with the increase in the skew angle.

- **C. Topkaya, J. A. Yura, E. B. Williamson, and K. H. Frank (2012)[20] :** In this the author indicates the concrete deck behavior and the interface of steel girder at early stages .The deck, due to large volume of concrete is casted in two stages , in order to control shrinkage. The measured and the predicted quantities are observed and it gives an indication that concrete act compositely with bridge at early times.

- **Amir Reza Ghiami Azad, Hemal Patel, Michael Engelhardt, Todd Helwig, Eric Williamson, Richard Klingner (2013)[21] :** It indicates that the non composite steel girder bridges which are continuous and post installed shear connectors and moment distribution is possible and efficient in extending the life of the bridge. By strengthening the composite by 30%, the load ratings can be increased by 60 %. By simple plastic analysis ultimate strength can be calculated.

- **VICTORIA E. ROŞCA*, ELENA AXINTE , CARMEN E. TELEMAN (2013)[22] :** In this the author proposes the composite I beam's cost optimization .Non linear approach is followed for the optimization.The design of composite beams are performed by design module,cost ofcomposite beams by cost module,search for optimaldesign by optimization module.

- **Vikash Khatri, Pramod Kumar Singh , P.R.Maiti (2013)[23]** : In this the comparison of prestressing force and the totalarea of steel is described and the stresses in the deck slab.By anchoring tendons, shrinkage strain can be modified.Prestressing force for 5 girder bridge is more than that of four girder bridge.The maximum stress for five girder bridge ismore than that of 4 girder bridge.

- **Zhou Wangbao, Jiang Lizhong, Kang Juntao, Bao Minxi (2013)[24]** : In this the author the coupling effect of loads are improved by elastic methods . Critical methods are developed and are compared with traditional methods. There is linear relation between vertical loads and lateral strains. Critical bending buckling is rarely affected by the moment and length.

- Y**.P.Pawar, S.S.Kadam, D.D.Mohite, S.V. Lale, C.M. Deshmukh (2013) [25]**: In this the author explained the moment variation in T girder. In T- section only one flange and web will be in low resistance against torsion. It explained the variation in bending moment along long span and short span due to girder's self weight.

- **Ashraf Ayoub, Associate Member, ASCE, and Filip C. Filippou, Member, ASCE (2014)[26]:** In this analysis of steel girders isdone by inelastic beam element. BY interface model shear connectors's partial interaction can be maintained . The stability characterstics are presented in a program using non linear analysis

- **Jan Bujnak , Jaroslav Odrobinak(2014)[27]** : In this the author proposes the hogging area influence of the slab stiffeness. The influenced flexural behavior of non structural parts canbe ignored,minor difrences are explained. The structural behavior can be done by spatial model ofcomposite bride approximation

- **Epuri Pavan Kumar, Arepally Naresh, Sri Ramoju Praveen Kumar,Amgoth Ashok (2015)[28]**: In this paper it showsthe comparative study of the AASHTO and IRC codes. The stress values are compared for different sections. It concluded that AASHTO code hasless value than IRC code.

- **H.R.Nikhade, A.L.Dandge, A.R.Nikhade(2015)[29] :** In this the author explains that with the increase in grade ,moment decreases. Analysis of box girder is carried out by mathematical models.

CHAPTER 3

MATERIAL AND METHODLOGY

3.1 TYPES OF LOAD

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

1. Dead load
2. Live load
3. Dynamic load
4. Longitudinal forces due to tractive exertion of vehicles.

DEAD LOAD :

1. Self weight of structure for example Deck main girder, cross girder and deck itself.
2. Wearing coarse

LIVE LOAD :

1. Footway and kerb loading: - The loading ought to be 4000 N/m^2 for all footways.
2. The load is increased from 4000 N/m^2 to 5000 N/m^2 in crowd loads.
3. Live load shall not be applied and kerbs ought to be less than 60 cm.
4. For effective span over 7.5 m but less than 30 m, $P = P' - (\frac{400L-3000}{9})$
5. Traffic loads on bridge decks are utilized to stimulate the impact of vehicles. Some traffic loads represent the weight of real vehicles that can travel over the bridges, other values and distribution is selected so that they produce maximum internal forces in bridge structures similar to the ones by real vehicles
6. The positive longitudinal moment in the span is controlled by vehicular loads, greatest longitudinal moment at change of girder cross section, maximum shear at supports and maximum reaction.

DYNAMIC LOADS: - The vehicle bridge interactions play a huge role in the behavior of dynamic forces. It relies on the dynamic properties of the bridge and the vehicle, bridge surface roughness .The dynamic vehicle load causes various issues which could prompt to fatigue, surface wear, cracking of concrete which at last prompts disintegration.

LONGITUDINAL FORCES DUE TO TRACTIVE EFFORT OF VEHICLE:-

1. Through increasing speed of driving tractive impact is brought about.
2. Application of brakes in the braked vehicles, breaking impact is brought on.
3. The development of free bearing is offered frictional resistance because of progress in temperature or any other cause.

3.2 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 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.

LOAD COMBINATIONS :-

- DL +(LL+IL)
- DL +(LL+IL)+ BRAKING LOAD
- DL +(LL+IL) + BRAKING LOAD + WIND LOAD
- DL + VLL
- DL+VLL+BRAKING LOAD
- DL+VLL+BRAKING LOAD +WIND LOAD

CHAPTER 4

OBJECTIVE

1. To review the modeling of the bridge using CSI-BRIDGE 2000(software) and establish an object based modeling approach. It assigns bridge composition as an assembly of objects.
2. Application of load and its combination to further analyze the bending moment and shear force. Software gives different building code (AASTHO, IRC), by using those vehicle, wind, seismic loading can be calculated.
3. To determine all the variables of design, construction and material relative to the basic structural calculations.

CHAPTER 5

ANALYSIS OF STEEL-I-GIRDER BRIDGE

5.1 DESIGN USING CSI-BRIDGE :

Model the bridge :

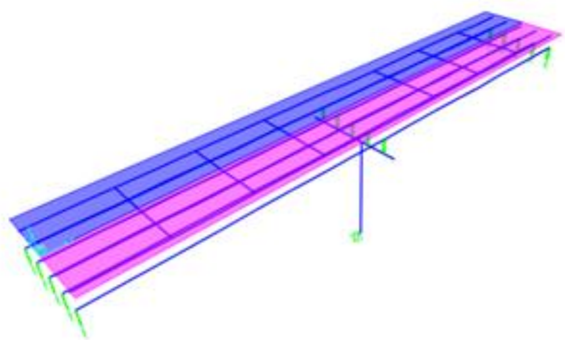

Figure 5.1 Bridge Model

Start the modeling of bridge by specifying the lane width. Utilizing bridge wizard change the material properties and also entering the vehicle classes i.e. IRC class AA loading, IRC class A loading ,IRC class 70 R loading using Indian codes. Mention the deck section properties. Using the bride object data enter the diaphragms along the span of the bridge at equal interval. Mention the abutments, bents, bent cap with its dimensions in the frame properties, Specify where the bent assignment is being applied, it is basically applied at the end of the span. The diaphragm assignment includes a diaphragm location, property, and orientation, in span diaphragms are assigned as a part of bridge object definition. Diaphragms that occur at abutments, bents and hinged are assigned as a part of the bridge object abutment, bent and hinge assignments respectively.

Load the bridge model available in CSI- Bridge. A moving load analysis can be utilized to decide the reaction of a bridge structures as a result of weight of vehicular live loads. Lanes are required if vehicular loads are to be added to a bridge model. Vehicles move in both directions along each lane of the bridge. Vehicles are consequently situated at such positions along the length and width of the lanes to produce the maximum and minimum response quantities throughout the structure.

After the bridge model geometry, load patterns and load cases have been characterized, the bridge model is prepared for analysis .the result is shown graphically.

5.2 FLOW CHART OF DESIGN

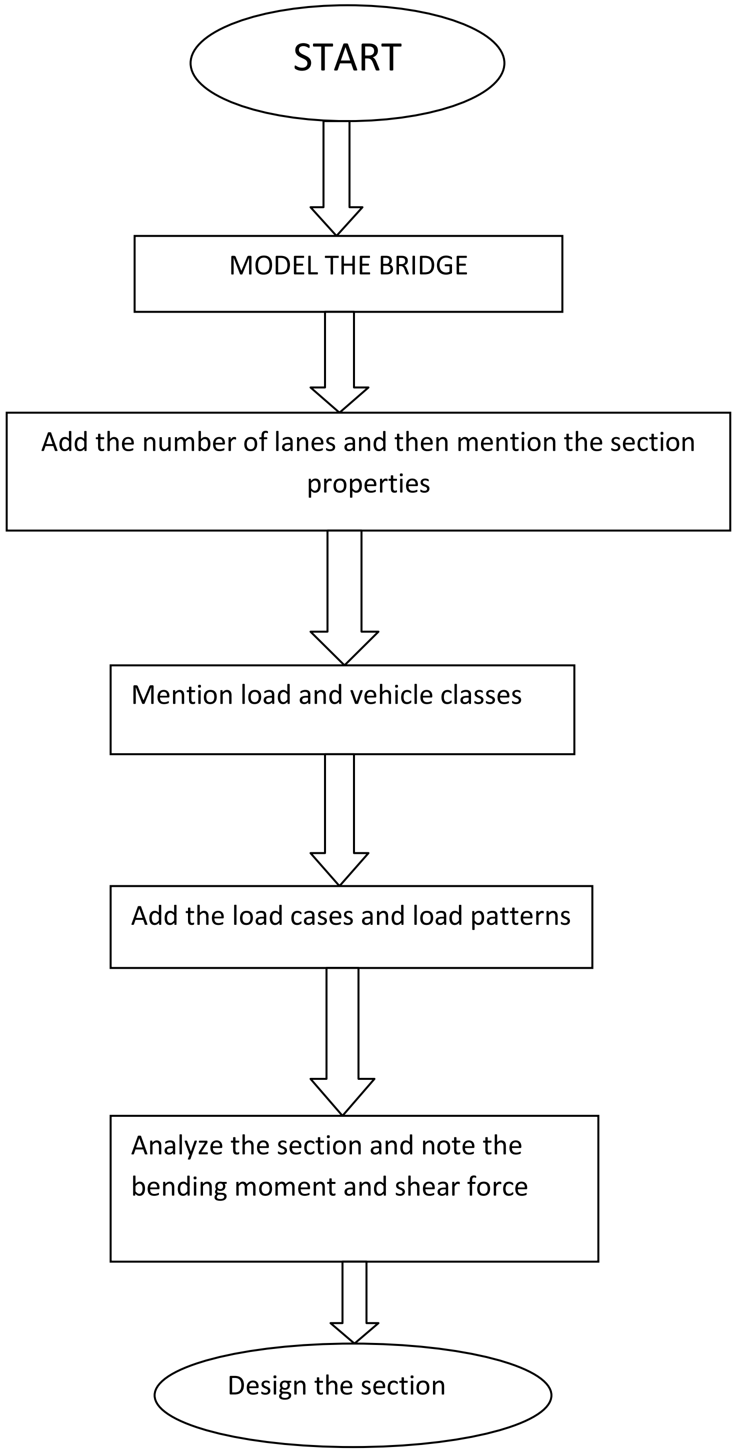

Figure 5.2 Flowchart

5.3 DESIGN DATA :

TABLE 5.1 Material And Its Properties

1.	Characteristic strength	fck	25 MPa
2.	Permissible direct compressive strength	σ_c	6.2 MPa
3.	Permissible flexural compressive strength	σ_{cbc}	8.3 MPa
4.	Maximum permissible shear stress	τ_{max}	1.75 MPa
5.	Permissible flexural tensile stress	σ_{st}	200 MPa
6.	Permissible direct compressive stress	σ_{co}	170 MPa
7.	Self weight of material concrete		24 kN/m^3
8.	Self weight of binder mix		22 kN/m^3

TABLE 5.2 Geometrical Properties

1.	Effective span of bridge	40 m
2.	Number of span	2
3.	Number of longitudinal girders	4
4.	Spacing of the girder	1.8m
5.	Overall depth of main girder	0.2 m
6.	Depth of kerb above the deck	0.2 m
7.	Number of cross girder	3
8.	Spacing of cross girder	0.5m
9.	Thickness of wearing coat	0.80 m

TABLE 5.3 Bridge Width :

1.	Carriageway width	7.5 m
2.	Density of wearing coat	22 kN/m^3
3.	IRC class AA loading	37.5 kN
4.	Depth of web	1.2m
5.	Thickness of web	0.025m
7.	Thickness of flange	0.05m
8.	Width of Flange	0.6m
9.	Density of concrete	24kN/m^3

TABLE 5.4 Manual Calculations

Steel - I Girder Bridge		
Material		
Yield strength	f_y	415 Mpa
Unit weight of concrete		24 kN/m^3
Unit weight of binder mix		22 kN/m^3
Grade of concrete	f_{ck}	30 Mpa
Dimensions		
Span	L	40m
Carriageway width	w	7.5 m
Lane 1		3.6m
Lane 2		3.6m
Slab thickness		0.2m
Longitudinal girder		4
Cross girder		3
Girder depth		1.2m
Flange width		0.6m
Flange depth		0.05m
Web width		0.025m
Cover		0.04m
Thickness of wearing coat		0.08m
Load calculations		
Dead load of slab		4.8 kN/m^2
Dead weight of wearing slab		1.76kN/m^2
Total deadload		6.56kN/m^2
IRC class AA loading		37.5kN/m^2

Moment And Shear Force		
Slab size	L	40m
	W	7.5m
Moment calculation		
Moment of dead load	M_d	1968Nm
Moment due to dead + live load	$M_{(d+l)}$	13218Nm
Moment due to live load	M_l	11250Nm
Shear force calculation		
Shear force	Vu	1321.8 kN
Depth of web	D	1.2m
Thickness of web	t_w	0.025m
Thickness of flange	t_f	0.05m
Width of Flange	b_f	0.6m

- Shear Force Of Entire Bridge

TABLE 5.5. Shear Force of Entire Bridge

Layout Line Distance (L)	**Shear Force (V)**
m	kN
0	-36.907
5	-36.907
10	-36.907
15	-36.907
20	-36.907
25	36.907
30	36.907
35	36.907
40	36.907

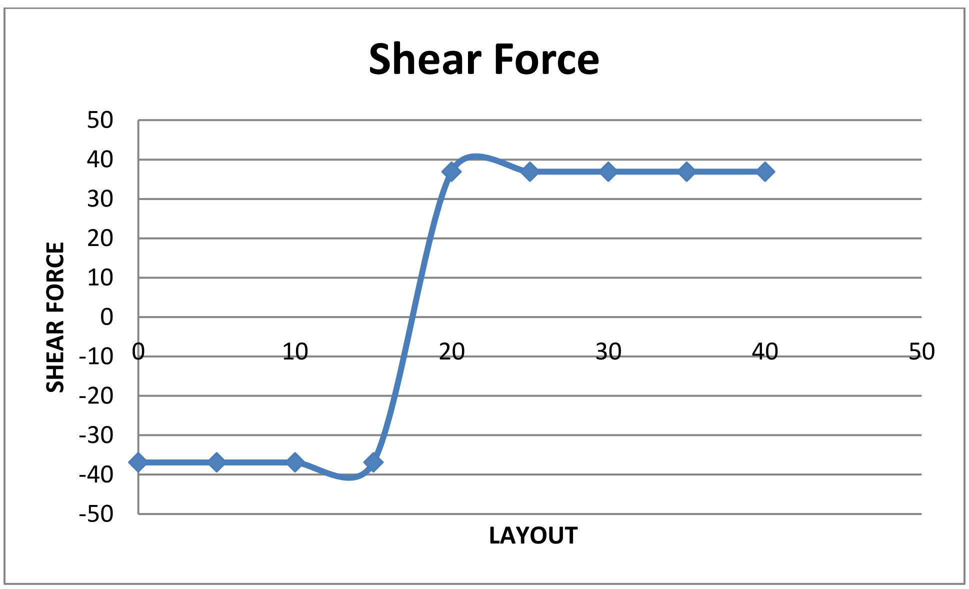

Figure 5.3. Shear Force

- **B**ending Moment of Entire Bridge

TABLE 5.6 Bending Moment of Entire Bridge

Layout Line Distance	**Moment (M)**
M	kN-m
0	-220.646
5	1966.252
10	2179.283
15	418.4461
20	-3316.26
25	418.4461
30	2179.283
35	1966.252
40	-220.646

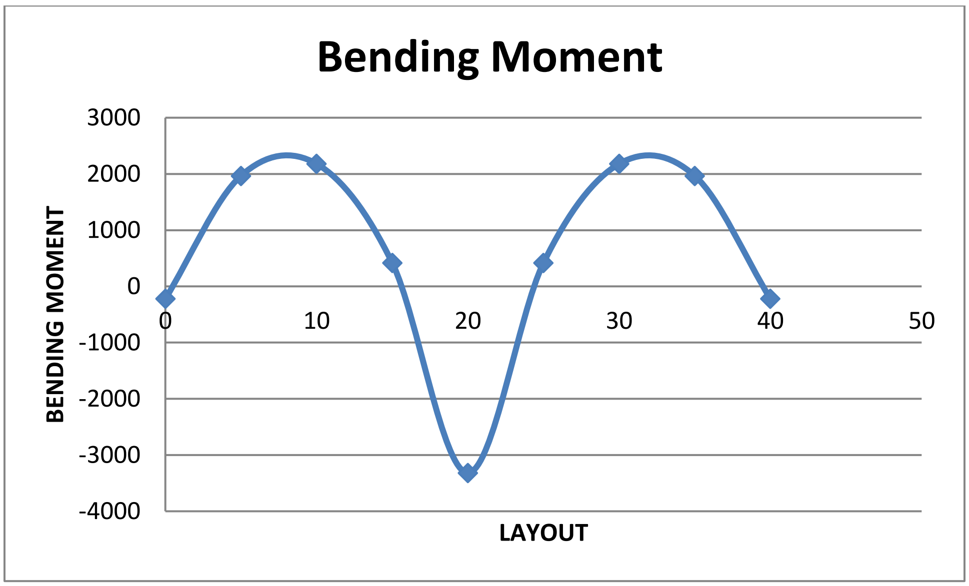

Figure 5.4. Bending moment of entire bridge

5.4 Correlation between Grade of concrete and moments

With the increase in grade of concrete moment decreases, for different span lengths. **Figure 5.5** shows the variation of the height of web with span length. With the increase in span length, height of the web is increased consecutively and hence it is further utilized for the analysis of bending moment. From the **TABLE 5.8 a, TABLE 5.8 b, TABLE 5.8 c** variation of bending moment is compared with different grades of concrete i.e. M30, M35and M40. And it can be analysed that bending moment increases with the decrease in grade of concrete and hence it can further help in the effective design.

TABLE 5.7 Variation in the height of web with different span

Grade	Span Length	Height Of Web
30	25	1.5
30	30	1.8
30	35	2.1
30	40	2.4
30	45	2.7
30	50	3.0

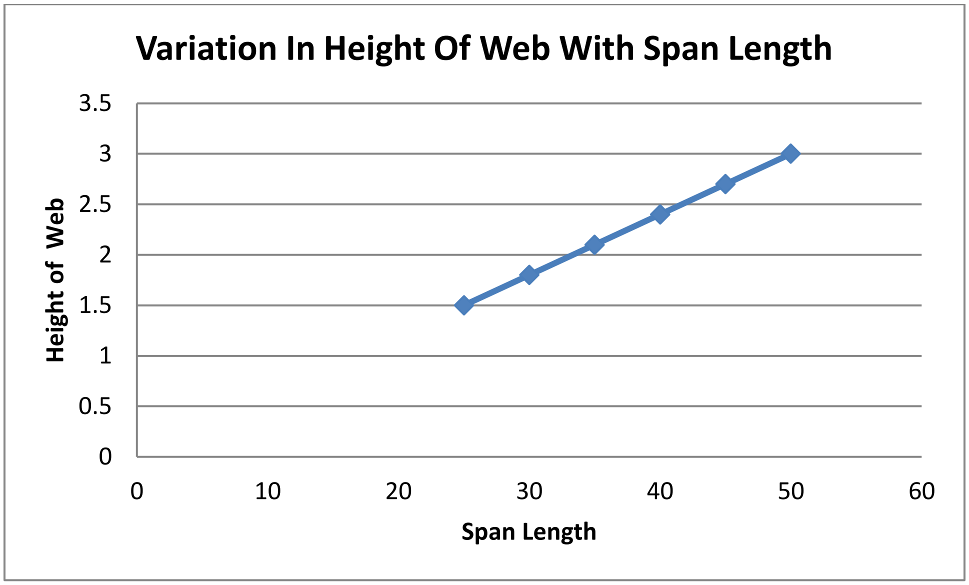

Figure 5.5. Variation of web with span

TABLE 5.8 a Variation of Bending Moment with Span

Grade M30	
Span Length	Bending Moment
25	3086
30	4919
35	7265
40	9869
45	12857
50	16379

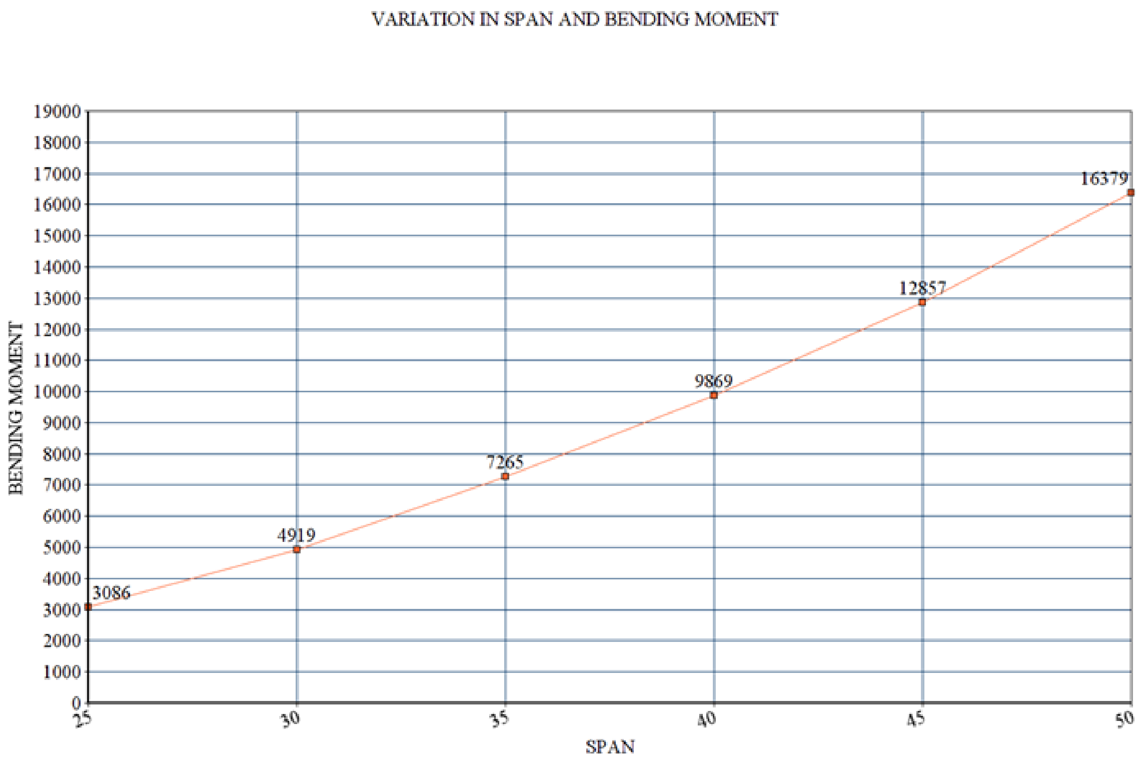

Figure 5.6. Variation in Span and Bending Moment For Grade M30

TABLE 5.8 b Variation of Bending Moment with Span

Grade M35	
Span Length	Bending Moment
25	3024
30	4910
35	7261
40	9864
45	12853
50	16375

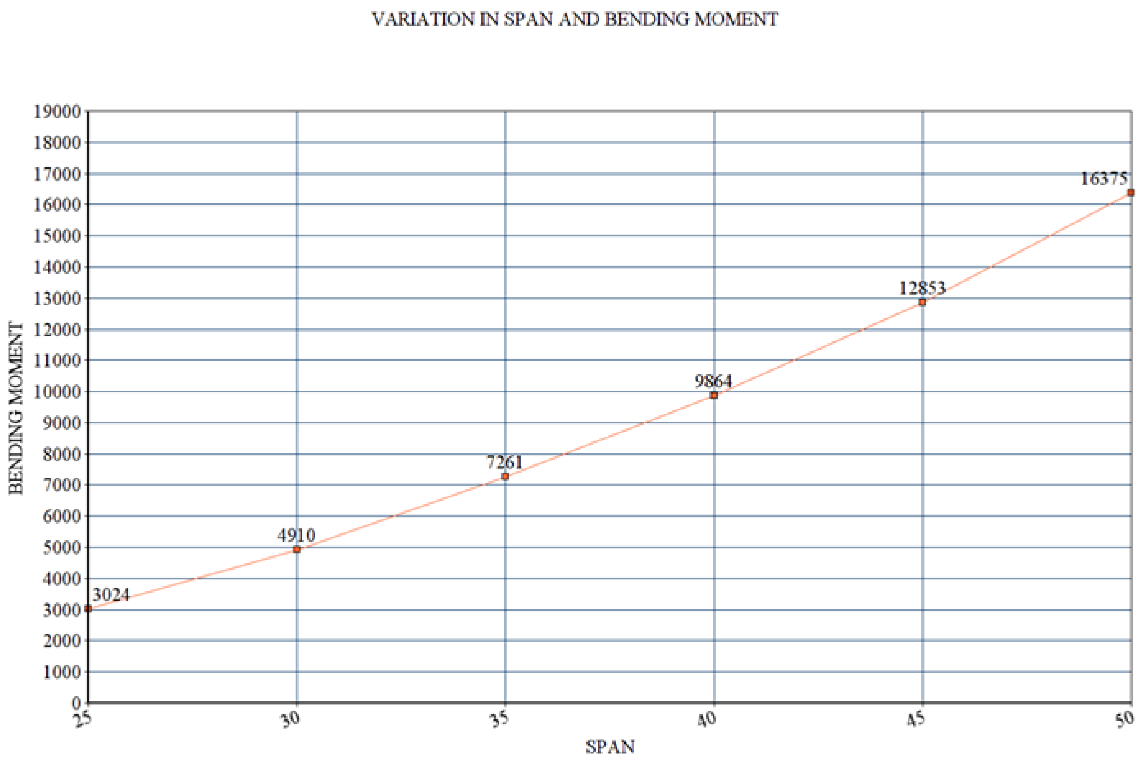

Figure 5.7. Variation in Span and Bending Moment for Grade M35

TABLE 5.8 c Variation of Bending Moment with Span

Grade M40	
Span Length	Bending Moment
25	3018
30	4903
35	7257
40	9861
45	12850
50	16372

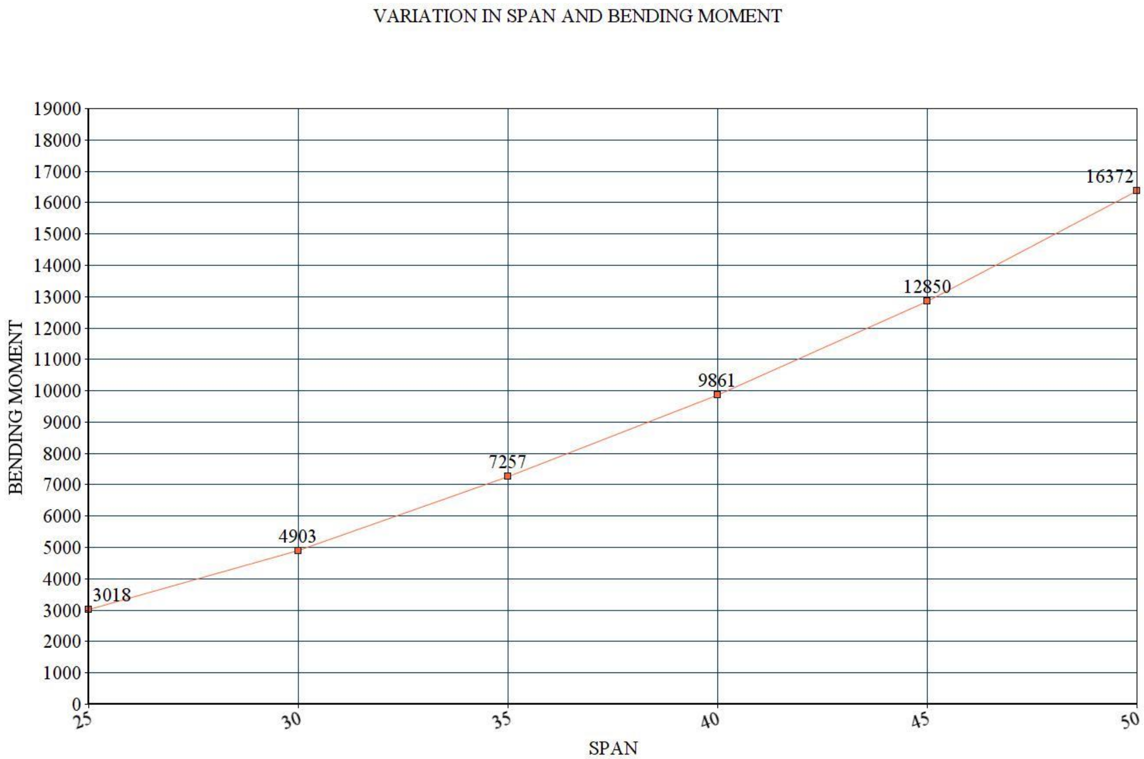

Figure 5.8. Variation in Span and Bending Moment for Grade M40

5.5 STRESSES ON ENTIRE BRIDGE ON DIFFERENT SPANS COMPARABLE TO DIFFERENT GRADES:

With the decrease in span length, stress increases with the gradual decrease in grade of concrete. Compression occurs in top portion of the deck and tension occurs at the bottom side. And mostly stress is on flange of the steel –I- Girder.

TABLE 5.9 a Variation of Stress with Span Length

Grade M40	
Span length (50m)	Stress (σ)
0	5755.66
25	5642.46
50	15520.4
75	5642.8
100	5755.5

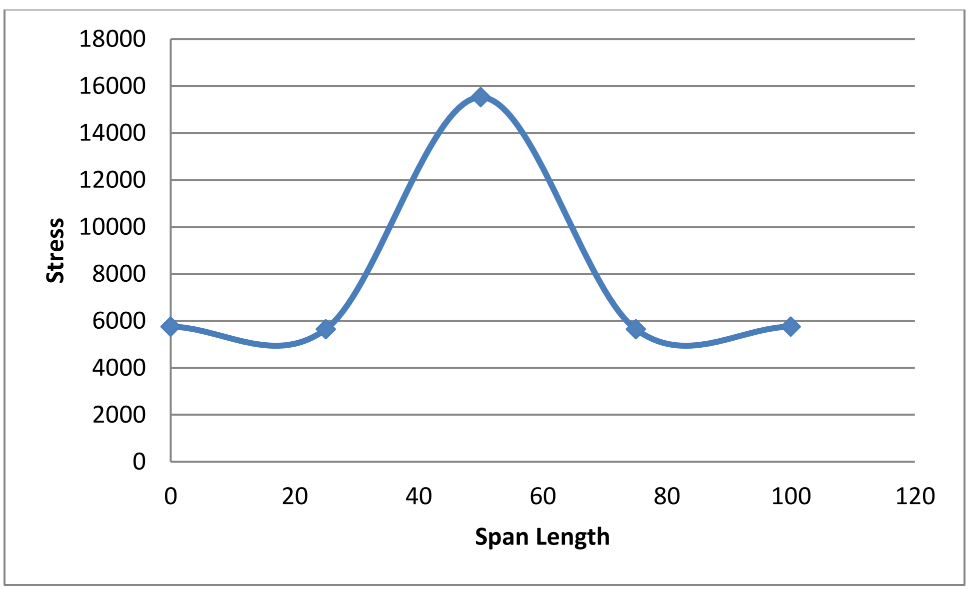

Figure 5.9 a. Variation in span length and stress

TABLE 5.9 b Variation of Stress with Span Length

Grade 40	
Span length (45 m)	Stress (σ)
0	6094.1
22.5	4327.8
45	14178
67.5	4327.93
90	6094.2

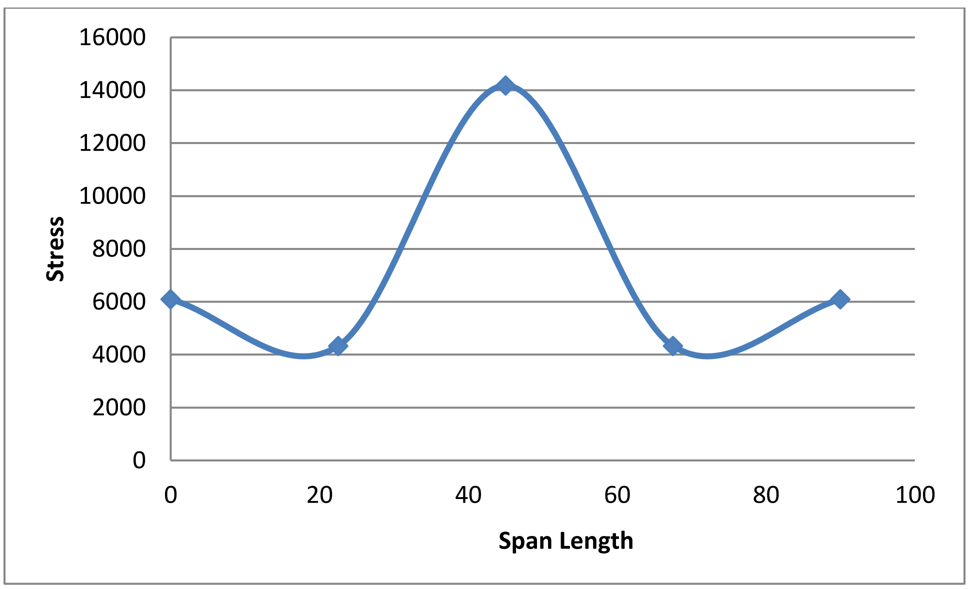

Figure 5.9 b. Variation in Span Length and Stress

TABLE 5.9 c Variation of Stress with Span Length

Grade 40	
Span length (40m)	Stress
0	6172.4
20	4735.6
40	9492.9
60	4735.7
80	6172.6

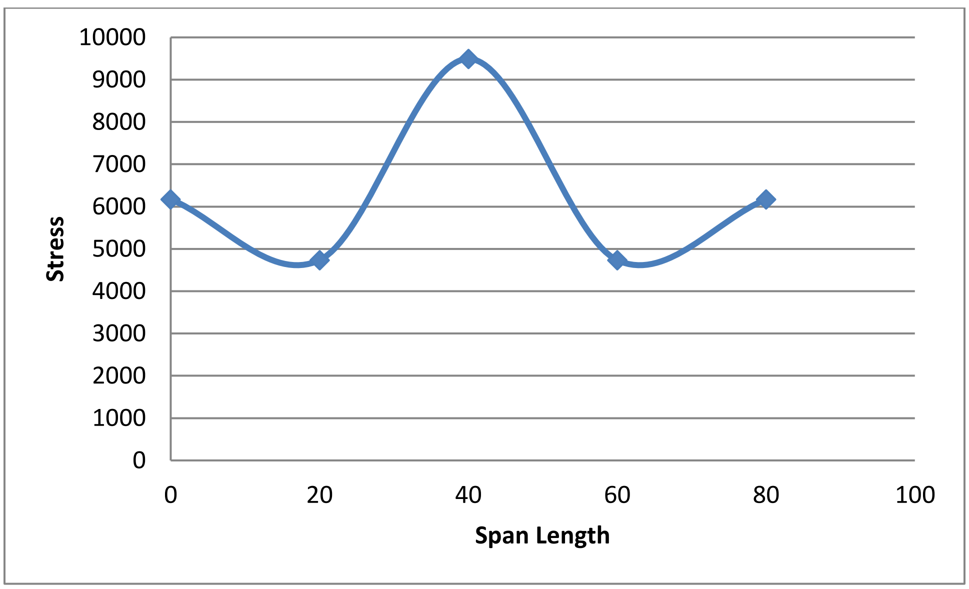

Figure 5.9 c. Variation in Span Length and Stress

TABLE 5.9 d Variation of Stress with Span Length

Grade 40	
Span length (35 m)	Stress
0	6459.7
17.5	5084.9
35	13748
52.5	5084.6
70	6460.2

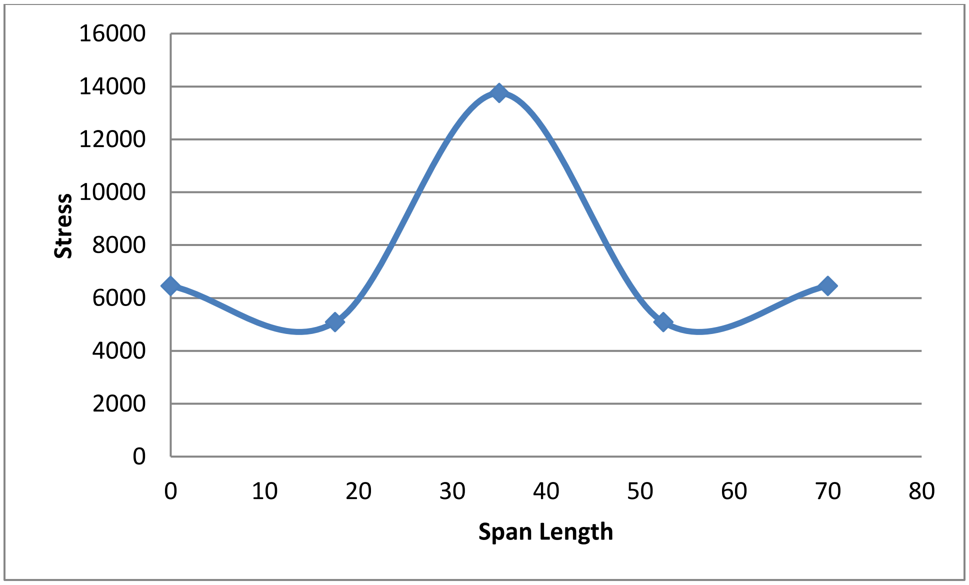

Figure 5.9 d. Variation in Span Length and Stress

TABLE 5.9 e Variation of Stress with Span Length

Grade 40	
Span Length(30m)	Stress
0	6748.64
15	4642.51
30	12070
45	4642.61
60	6748.8

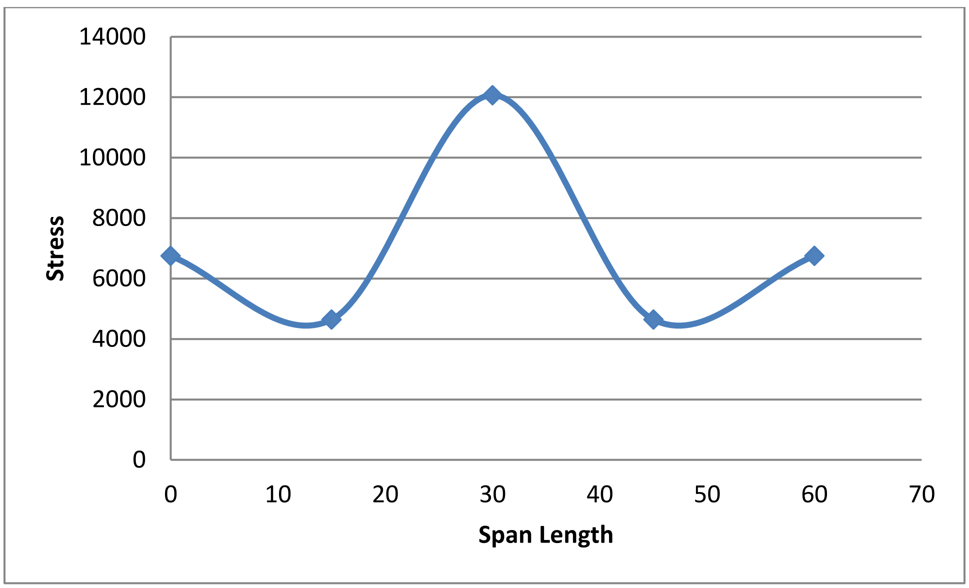

Figure 5.9 e. Variation in Span Length and Stress

TABLE 5.9 f Variation of Stress with Span Length

Grade 40	
Span Length (25m)	Stress
0	7025.82
12.5	3353.6
25	10627
37.5	3354
50	7026.21

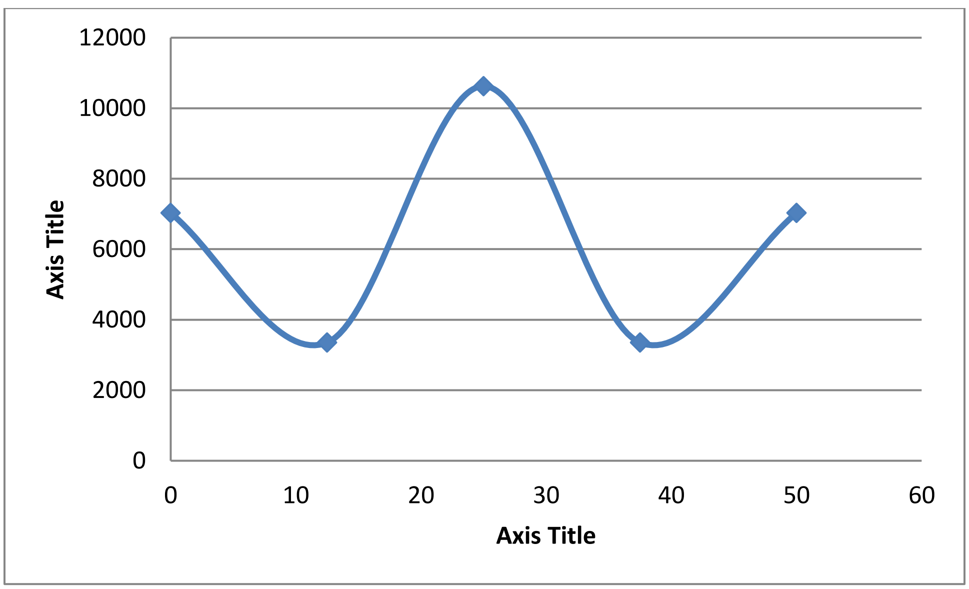

Figure 5.9 f. Variation in Span Length and Stress

TABLE 5.9 g Variation of Stress with Span Length

Grade 35	
Span Length (50m)	Stress
0	5772.3
25	5869.3
50	15837.98
75	5870.2
100	5772.6

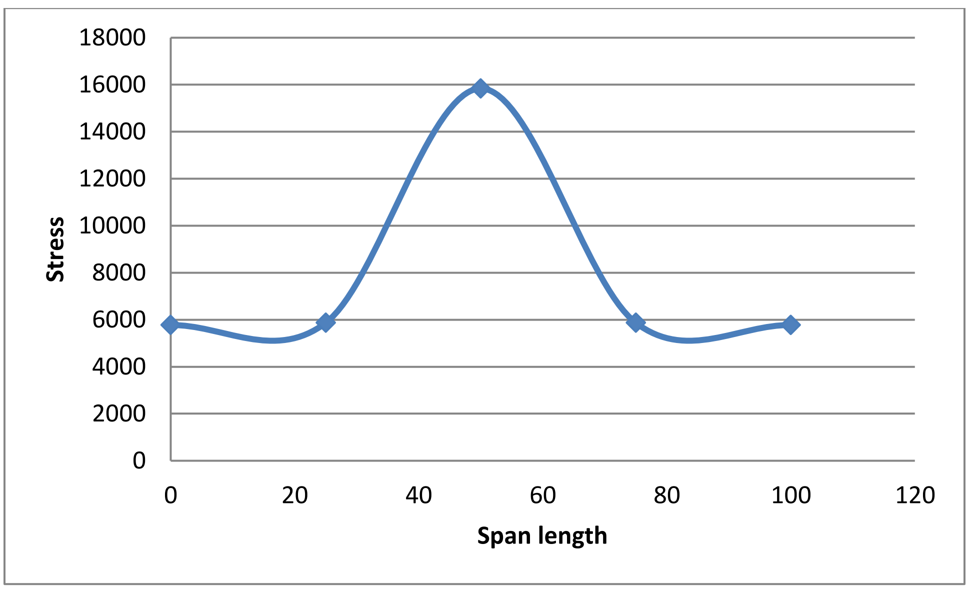

Figure 5.9 g. Variation in Span Length and Stress

TABLE 5.9 h. Variation of Stress with Span Length

Grade 35	
Span Length (45m)	Stress
0	6193.75
22.5	6158.2
45	15345
67.5	6159
90	6193.8

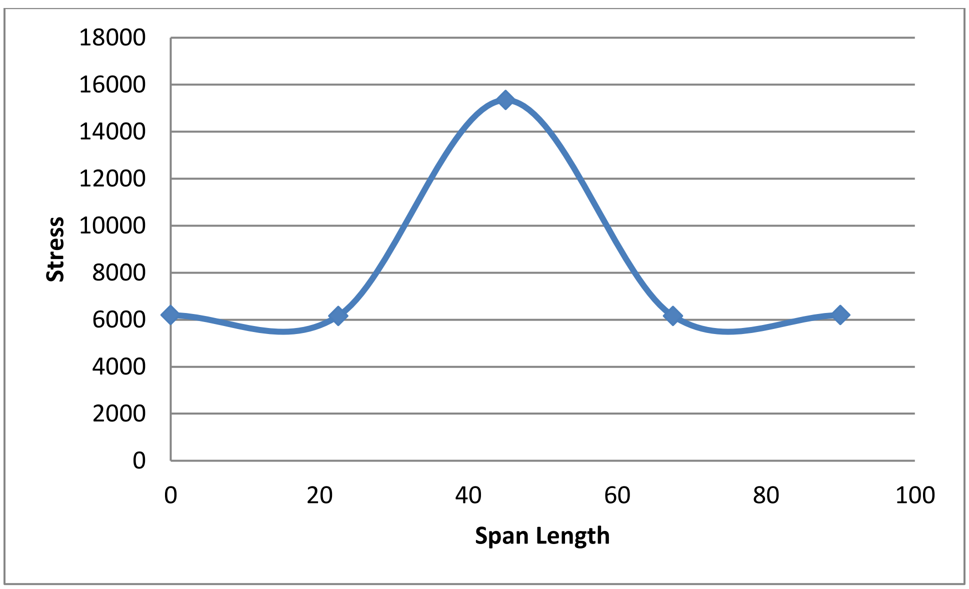

Figure 5.9 h. Variation in Span Length and Stress

TABLE 5.9 i.Variation of Stress with Span Length

Grade 35	
Span Length (40m)	Stress
0	6712.1
20	5832.9
40	14462.46
60	5832.4
80	6717.2

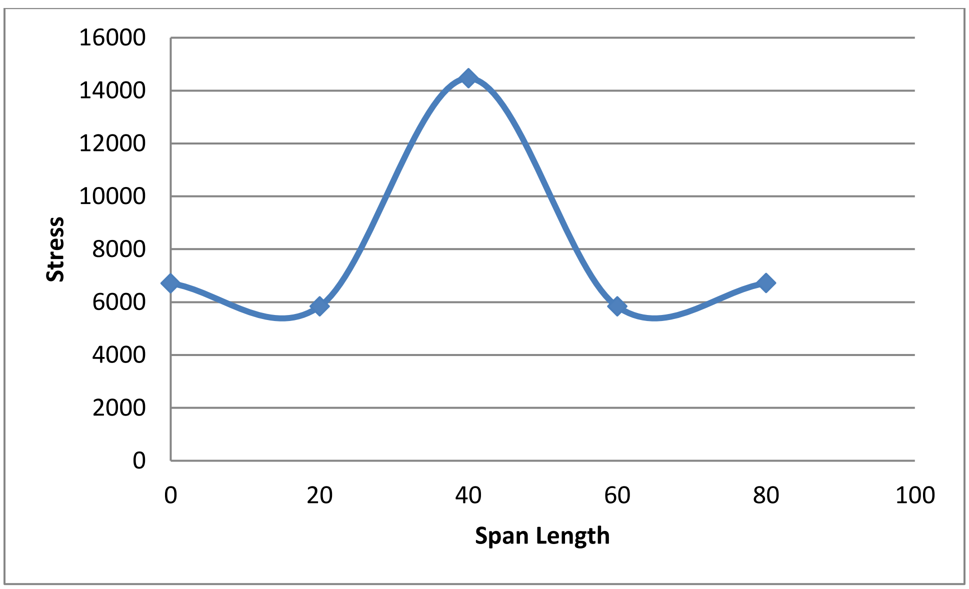

Figure 5.9 i.Variation in Span Length and Stress

TABLE 5.9 j.Variation of Stress with Span Length

Grade 35	
Span Length (35m)	Stress
0	6793.58
17.5	5289.99
35	14038.2
52.5	5290.1
70	6792.9

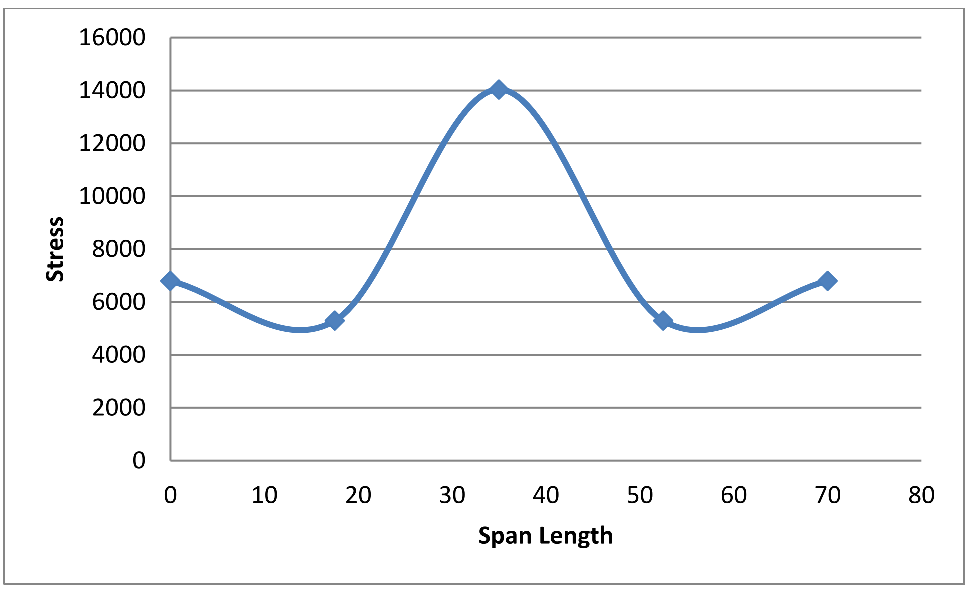

Figure 5.9 j.Variation in Span Length and Stress

TABLE 5.9.k. Variation of Stress with Span Length

Grade 35	
Span length (30m)	Stress
0	6766.1
15	4842.3
30	12311.1
45	4842.6
60	6766.3

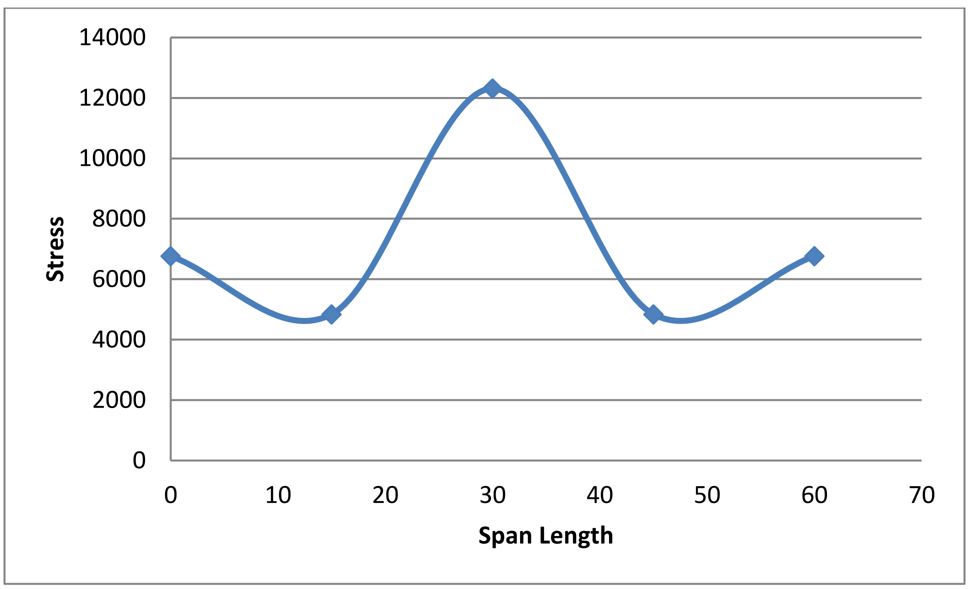

Figure 5.9 k. Variation in Span Length and Stress

TABLE 5.9 l Variation of Stress with Span Length

Grade 35	
Span Length (25 m)	Stress
0	7034.898
12.5	4567.05
25	10821.96
37.5	4568.2
50	7034.2

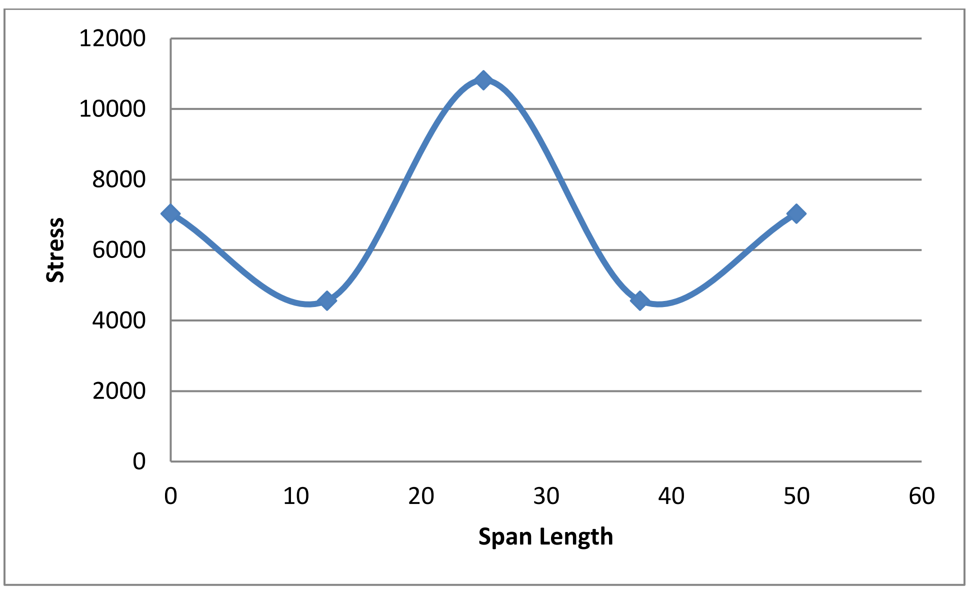

Figure 5.9 l Variation in Span Length and Stress

TABLE 5.9 m Variation of Stress with Span Length

Grade 30	
Span Length(50 m)	Stress
0	5785.77
25	7201.73
50	16225.25
75	7202.1
100	5785.86

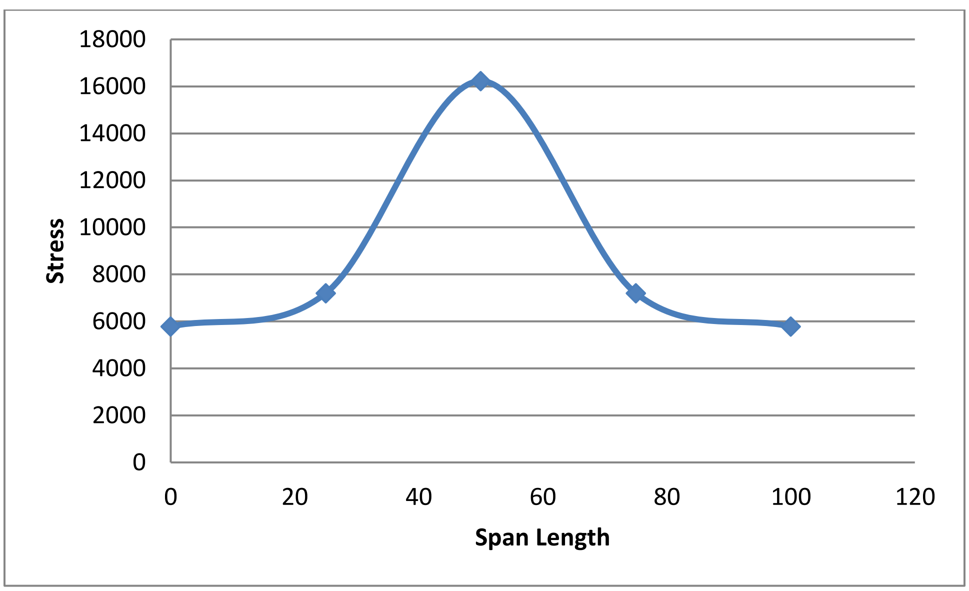

Figure 5.9 m Variation in Span Length and Stress

TABLE 5.9 n Variation of Stress with Span Length

Grade 30	
Span Length (45 m)	Stress
0	6211.81
22.5	6400.38
45	15687.38
67.5	6401.1
90	6211.9

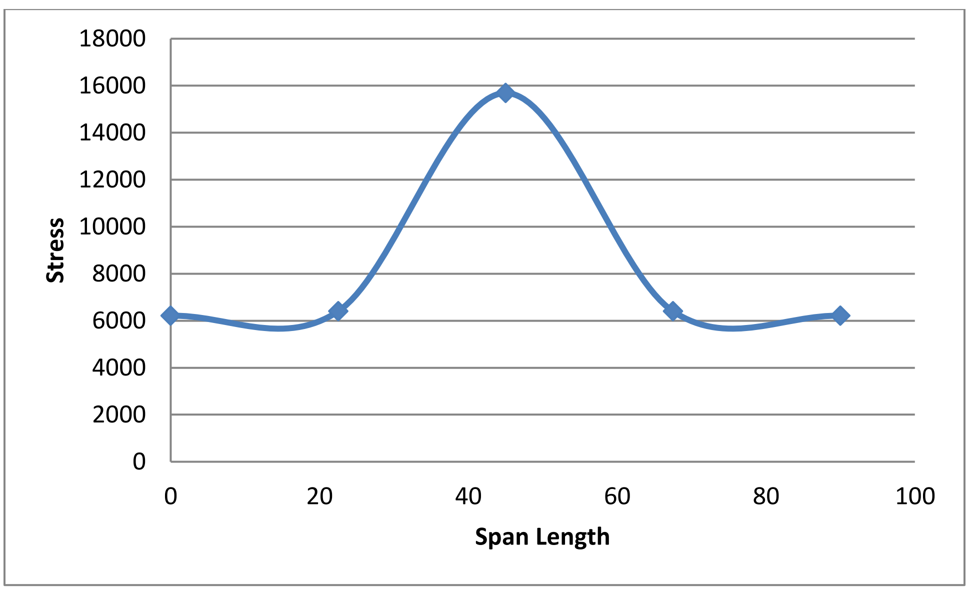

Figure 5.9 n Variation in Span Length and Stress

TABLE 5.9 o Variation of Stress with Span Length

Grade 30	
Span Length (40 m)	Stress
0	6824.6
20	5962.3
40	16642.5
60	5963.1
80	6830.6

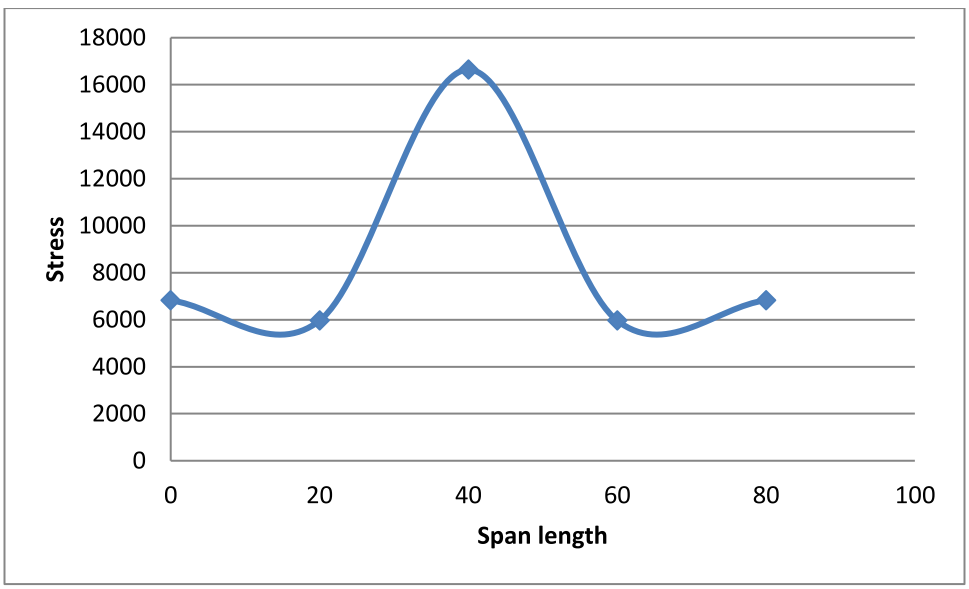

Figure 5.9 o Variation in Span Length and Stress

TABLE 5.9 p Variation of Stress with Span Length

Grade 30	
Span length (35 m)	Stress
0	6525.7
17.5	5530.02
35	144143.2
52.5	5531.1
70	6525.9

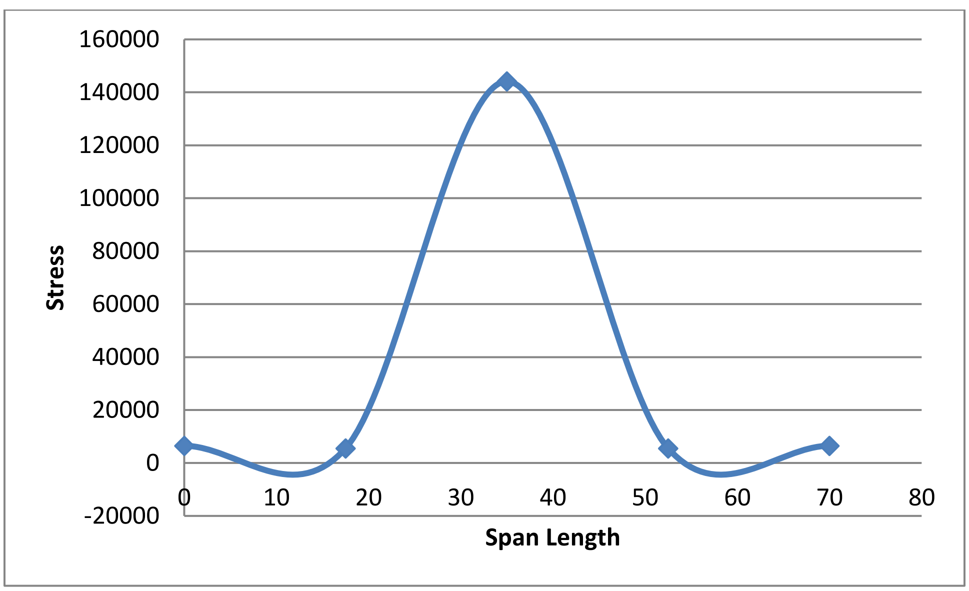

Figure 5.9 p Variation in Span Length and Stress

TABLE 5.9 q Variation of Stress with Span Length

Grade 30	
Span Length (30 m)	Stress
0	6778.8
15	5076.12
30	12582.7
45	5076.21
60	6778.73

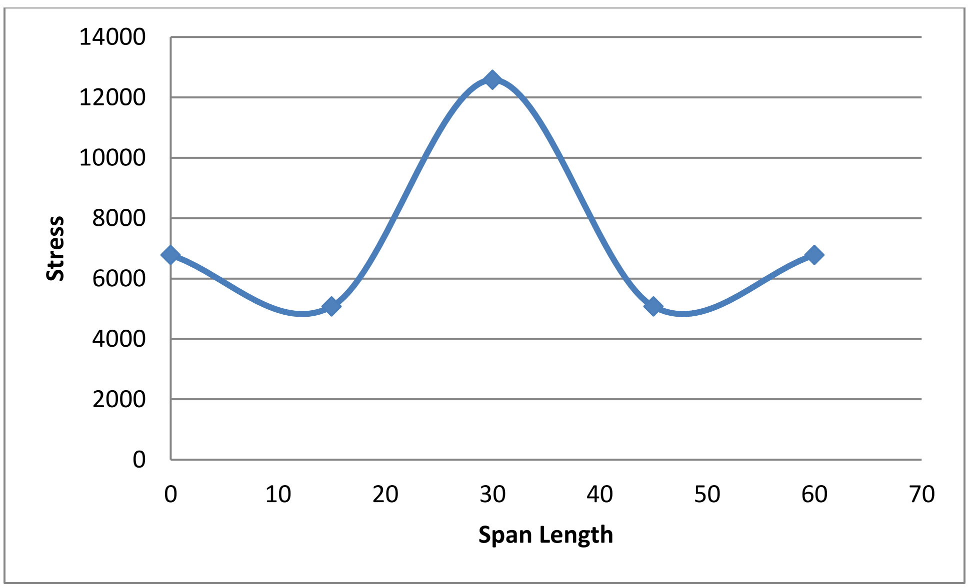

Figure 5.9 q Variation in Span Length and Stress

TABLE 5.9 r Variation of Stress with Span Length

Grade 30	
Span Length (25 m)	Stress
0	7048.5
12.5	5524.32
25	11568.69
37.5	5525.1
50	7049.1

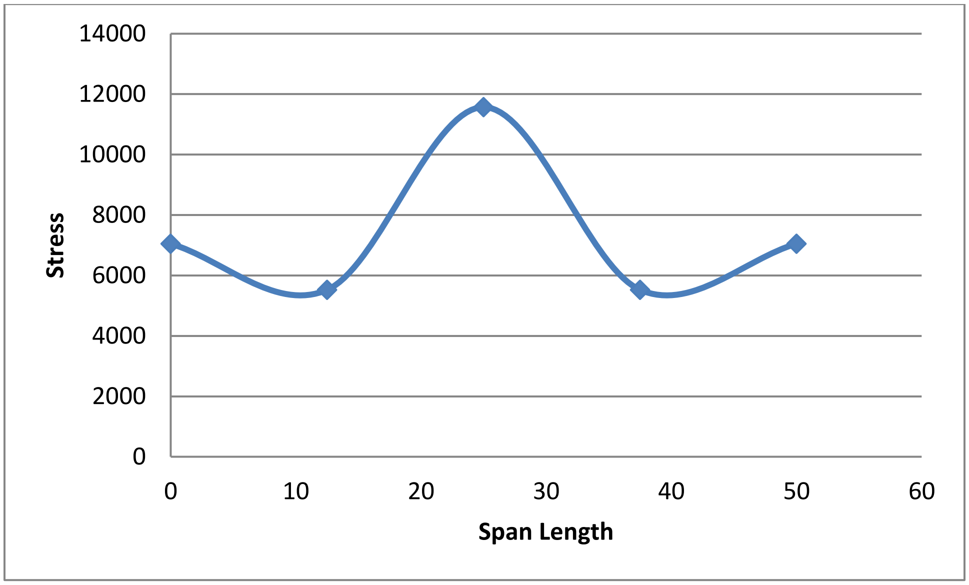

Figure 5.9 r Variation in Span Length and Stress

5.6 TORSION: - It is the stress produced by twisting. The parts of steel are more resistant to torsion. Torsion in the bridge decks can be produced by the motion of vehicles and wind motions.

$$\frac{T}{J} = \frac{\tau}{R} = \frac{C\theta}{L}$$

We have considered different spans 25 m, 30 m, 35 m, 40 m, 45 m, 50 m and have checked torsion with different grades of concrete using IRC code. As with the increase in length, torsion decreases. The variation is shown in the **Figure 5.10, Figure 5.11, Figure 5.12** and it can be seen that due to warping effect torsion occurs.

TABLE 5.10 Variation of Torsion with Different Span Lengths

Grade M 30	
Span Length	Torsion
25	227.47
30	94.312
35	12.42
40	-38.28
45	-28.918
50	-28.19

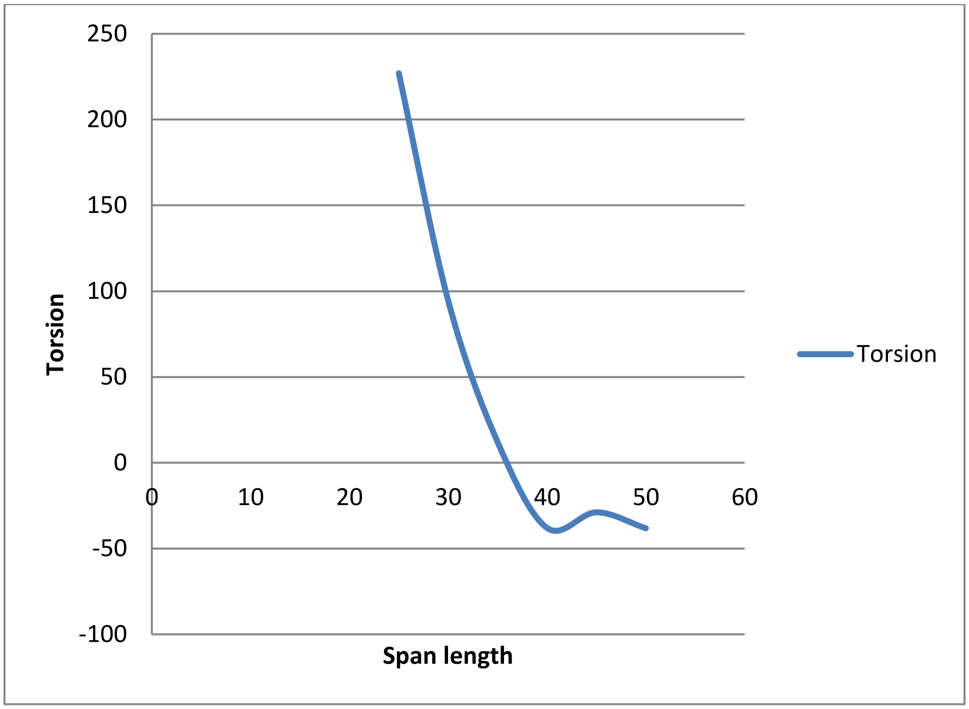

Figure 5.10 Variation of Torsion with Different Span Length

TABLE 5.11 Variation of Torsion With Different Span Lengths

Grade M35	
Span Length	Torsion
25	138.15
30	89.310
35	36.310
40	26.38
45	-10.25
50	-27.9

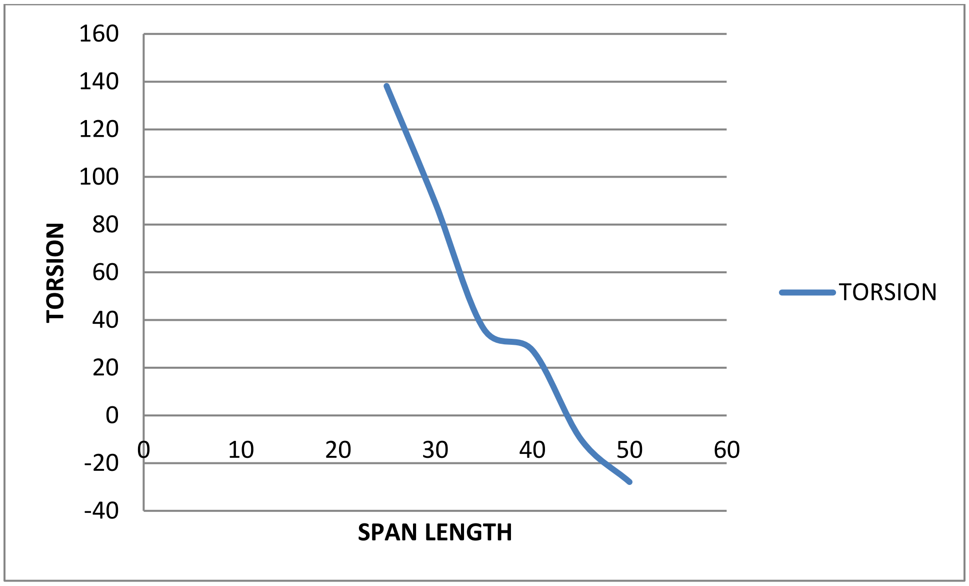

Figure 5.11 Variation of Torsion with Different Span Length

TABLE 5.12 Variation of Torsion with Different Span Lengths

Grade 40	
Span Length	Torsion
25	136.27
30	86.067
35	8.8719
40	-26.126
45	-27.631
50	-34.631

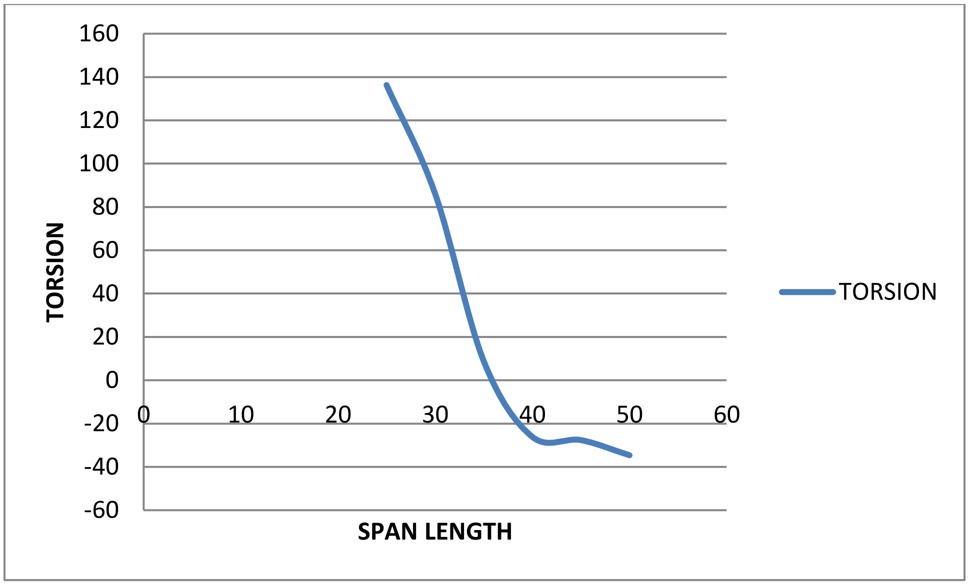

Figure 5.12 Variation of Torsion with Different Span Length

5.7 Axial Force and Shear Force at Different Girders

The principal motive is to compare the shear force and bending moment using the AASHTO and IRC codes. We have considered two span Steel I- Girder Bridge having span of 20 m each. In AASHTO HL-93K and HL -93M and in IRC code class A loading is used. After analyzing as shown in the **Figure 5.13,** that axial force for IRC code is more than that of AASHTO code. In **Figure 5.14,** variation in shear force is explained in the graph.

TABLE 5.13 Comparison of IRC and AASHTO codes

Forces	Left Ext. Girder		Int. Girder 1		Int. Girder 2		Int. Girder 3		Right Ext. Girder	
	IRC	AASTHO	IRC	AASTHO	IRC	AASTHO	IRC	AASTHO	IRC	AASTHO
Axial Force	61.14	6.19	68.54	34.26	65.884	49.96	96.084	34.26	77.5	6.91
Shear Force	126.60	78.486	179.47	98.85	232.401	125.63	218.429	125.634	168.324	78.48

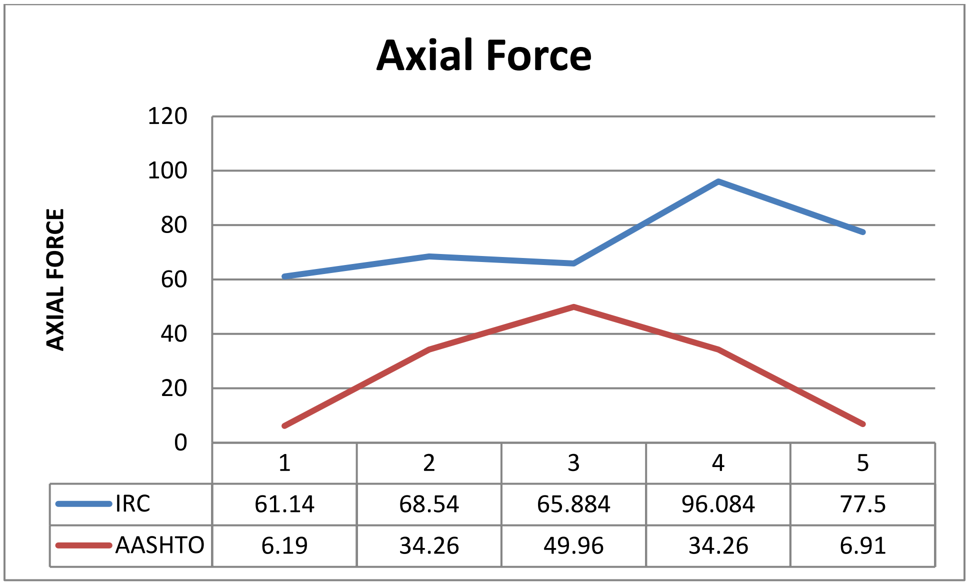

Figure 5.13 Comparison of Axial force For IRC and AASHTO codes

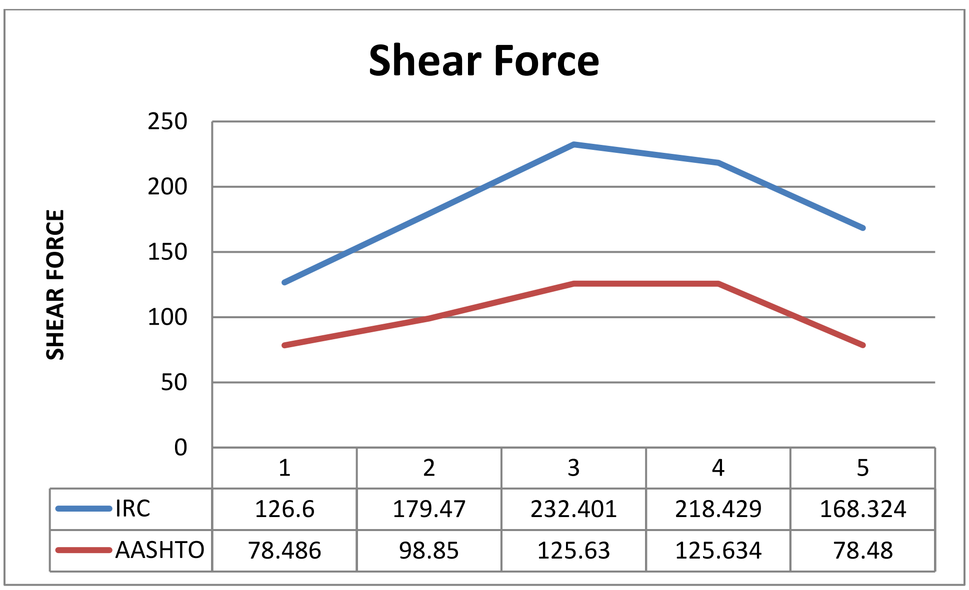

Figure 5.14 Comparison of Shear Force for IRC and AASHTO codes

CHAPTER 6

CONCLUSION

In the present thesis the two span bridges was modeled using CSI-Bridge and compared with the manual calculations using different frame sections and material properties. The girder section designed for IRC class AA loading and IRC class A loading . The bending moment and shear force was compared as analyzed by CSI- Bridge. Therefore, the different trial sections were taken in order to calculate the bending moments and deflections. However, some conclusions were drawn as follow. The bending moment decreases with increase in the grade of concrete in Steel I-Girder Bridges as span length increased. The excel sheets was developed for the design of medium to long Steel I-Girder Bridges (from 25 m span to 50 m span. However, the analysis and design of Steel I-Girder Bridges for any span can be obtained from mathematical models without doing lengthy calculations. The effect of grade of the concrete on the torsion was also explained for the different span length of in Steel I-Girder Bridges. The values of axial force and shear force for IRC and AASTHO was also compared.

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