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Analysis of Prestressed Concrete Girder for Bridges

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ABSTRACT

Today bridge building has gained worldwide importance. Bridges are the key elements in every road network and the use of pre stressed girder bridges is becoming more and more popular in bridge construction due to their better stability, service friendliness, economy and durability, aesthetic and structural appearance. Typically reinforced concrete construction, steel construction or steel composite construction is used. In the case of high spans, reinforced concrete construction is uneconomical due to the larger span. , the cross-section is used more efficiently than the reinforced concrete cross-section. Pre stressed concrete is used for long-span bridges with a span of more than 10 m. Conventionally, when calculating bridges, the superstructure and substructure are analyzed separately. The superstructure is usually a grid made up of main girders, transverse membranes and a deck slab. a grid of linear elements The columns of the main girders are anchored. The superstructure is examined according to IRC: 62014 and according to IRC: 182000 for unconsidered gravitational loads and moving vehicle loads. Reduction of the stress level and also of the deflection compared to the straight tendon profile.

KEYWORDS: *Post Tensioning, Moving Load Analysis, Tendons, Tendon Profile, Prestressed Concrete Girder MIDAS*

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1. INTRODUCTION

In short-span bridges of round 10 to 40 meters (30 to130ft.), Prestressing is commonly employed in the form of precastpre-tensioned girders or planks. Medium-length structures of around 40to200meters (150to650ft.), typically use precast- segmental, in-situ balanced-cantilever and incrementally-launched designs. For the longest bridges, prestressed concrete deck structures of ten form an integral part of cable-stayed designs.

MIDAS CIVIL

Midas civil is the nation of artwork engineering software program that set a kind new prefer for the layout of bridges and civil structures. It capabilities a distinctively person pleasant interface and premiere layout answer capabilities which can account for production levels and time established properties. It's a noticeably evolved modelling and evaluation characteristic permit engineers to triumph over not unusual place demanding situations and inefficiencies of finite detail evaluation. With Midas civil, you may be capable of create excessive best designs with unparalleled stages of performance and accuracy.

The post-processor can routinely create load mixtures according with designated layout standards. Changing the sort of show can produce numerous kinds of image output. Basically all of the outcomes may be animated, namely, mode shapes, time records outcomes of displacements and member forces, dynamic evaluation outcomes and static evaluation outcomes. Midas Civil additionally affords outcomes which can be well matched with MS Excel, which permits the person to check all evaluation and layout outcomes systematically. Midas Civil affords numerous layout test and cargo score functions including: Euro code & AASHTO LRFD Bending, shear & torsional strengths Composite plate girder layout Member forces & stresses for every creation level and max & min strain summations Automatic era of load mixtures according with numerous layout codes MS Excel layout calculation report.

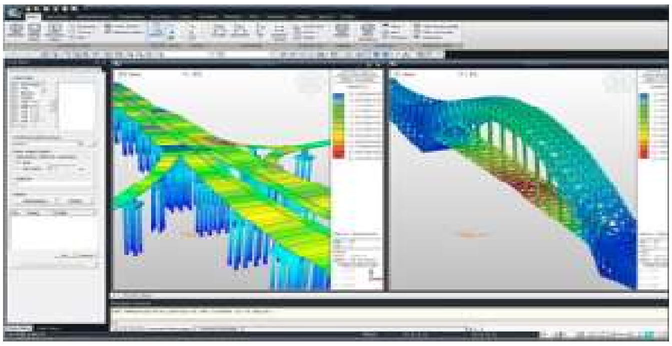


Figure 1.1 Analysis in MIDAS

2. OBJECTIVE

1. Analysis of prestressed concrete girder using MIDAS CIVIL software.
2. Comparative study between straight and parabolic cable profile.
3. To investigate the effect of eccentricity, pre-stressing force and Cable profile and to establish the structural static properties such as deflections and stress distributions.

CODES ANDSTANDARDS

LOADS

The loads are based on IRC:6-2014 standards pecifications and code of practice for road bridges (section:II) loads and stresses.

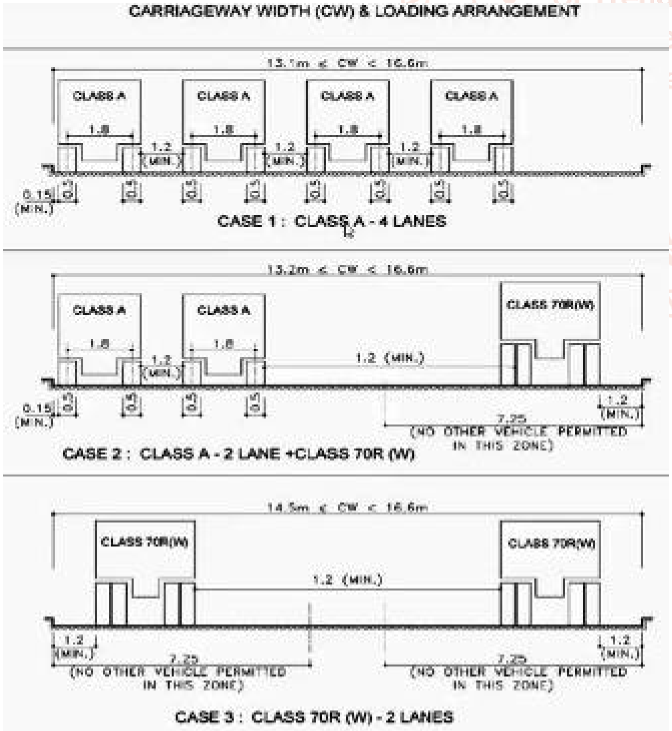


Figure 2.1Moving Load And Moving Load Tracer

Design procedure for Box girders as per IRC: 18-2000 2.2.1

Web thickness

The thickness of the web shall not be less than d36 plus twice the clear cover to there in for cement plus diameter of the duct hole where 'd' is the overall depth of the box girder measured from the top of the deck slab to the bottom of the soffit or 200mmplus the diameter of duct holes , whichever is greater .Where cables cross within the web, suitable increase in the thickness over the above shall be made. In case of cast in situ cantilever construction, if the pre stressing cables are anchored in the web, the web shall be locally thickened to not less than350 mmn or less than that recommended by the pre stressing system manufacturer, subject to design requirements.

Bottom flange thickness

The thickness of the bottom flange of box girder shall be not less than1/20 th of the clear web spacing at the junction with bottom flange or 200 mm whichever is more.

Top flange thickness

The minimum thickness of the deck slab including that at cantilever tips shall be 200mm. For top and bottom flange having pre stressing cables, the thickness of such flange shall not be less than-150 mm plus diameter of duct hole.

Spacing

In box girders, effective and adequate bond and shear resistance shall be provided at the junction of the web and the slabs. The slabs may be considered as an integral part of the girder and the entire width may be assumed to be effective in compression. For very short spans or where web spacing is excessive or where overhangs are excessive, analytical investigation shall be made to determine the effective flange width.

Thermal effects

For cantilever construction , preference shall be given to box type cross section with diaphragms provided at supports . Sudden change in depth of superstructure should not be permitted . For reducing the thermal effect suitable ventilation should be provided in box sections.

Ultimate strength

A pre stressed concrete structure and its constituent members shall be checked for failure conditions at an ultimate load of 1.25G+2SG+2.5Q under moderate condition and 1.5G+2SG+2.5Q under severe exposure conditions where G,SG and Q end permanent load, superimposed dead load and live load including impact respectively .The superimposed dead load shall included load of precast foot path ,hand rails, wearing course , utility services , Krebs etc. For sections, where the dead load causes effects opposite those of live load, the sections shall also be checked for adequacy or a load of G+SG+2.5Q.

Calculation of ultimate strength
Under ultimate load conditions, the failure may either occur by yielding of the steel (under-reinforced section) or by direct crushing of the concrete (over-reinforced section). Non-prestressed reinforcement may be considered as contributing to the available tension for calculation of the ultimate moment of resistance in an amount equal to its area times its yield stress, provided such reinforcement is welded or has sufficient bond under conditions of ultimate load. Ultimate moment of resistance of sections, under these two alternative conditions of failure shall be calculated by the following formulae and the smaller of the two values shall be taken as the ultimate moment of resistance for design:

Failure by yield of steel (under- reinforced section)
Mult= 0.9dbAsfp

As = the area of high tensile steel

fp= the ultimate tensile strength for steel without definite yield point

db= the depth of the beam from the maximum compression edge to the centre of gravity of the steel tendons

Failure by crushing of concrete
For rectangular section,

Mult=0.176bdb^{2}fck

For Tee sections,

Mult = (0.176 bwd^2 fck + 0.67 × 0.8 (bw) (d-0.5Df) Dffck)

B= the width of rectangular rsectionorwebofaTee0.8beam.

Bf=the width of flange of Tee beam.

t =thickness of flange of Tee beam.

Shear Sections uncracked in flexure
The ultimate shear resistance of a section uncracked in flexure, V, corresponds to the occurrence of a maximum principal tensile stress, at the centroidal axis of the section, of ft=0.24fck.

Vco= 0.67bd√(ft^2+0.8fcpft)

b= Width in the case of rectangular member and width of the rib in the case of T,I and L beams.

d= Overall depth of the member.

ft= Maximum principal tensile stress given by 0.24.

fcp= Compressive stress at centroidal axis due to pre stress taken as positive.

Sections cracked in flexure:
The ultimate shear resistance of a section cracked in flexure ,Ver may be calculated using the equation given below. Vcr=0.037bdb√fck+(Mt/M)V

Where, d = is the distance from the extreme compression fiber to the centroid of the tendons at the section considered;

Mt=(0.37√fck+0.8fpt)I/y in which f, is the stress due to prestress only at the tensile fiber distance y from the centroid of the concrete section which has a second moment of area I;

V and M= are the shear force and corresponding bending moment Vcr =should be taken as not less than 0.1bd√fc. The value of V, calculated at a particular section may be assumed to be constant for a distance equal to d,/2,measured in the direction of increasing moment from that particular section

3. PROBLEM STATEMENT
A box girder for 2 lane national highway bridge, with the data below:-

Type of support:- =Simply supported

Length: - = 27 m

Carriage way width: =7.5m Foot path width: 1.25m

Segmental width:- = 10m

Load type: - IRC class A loading and IRC class 70R loading

Concrete grade: =M60

4. MATERIAL PROPERTIES AND ALLOWABLE STRESSES TENDONPROPERTIES
Pre-stressing Strand: ϕ = 15.2 mm (0.6"strand)

Yield Strength: fpy =1.56906X106kN/m^2

Ultimate Strength: fpu = 1.86326X106kN/m^2

Cross Sectional area of each tendon =0.0037449m^2

Elastic modulus :Eps =2X108kN/m^2

Jacking Stress: fpj = 0.7f pu = 1330N/mm^2

Curvature friction factor: μ =0.3 /rad

Wobble friction factor: k =0.0066 /m

SECTIONPROPERTIES
Top slab thickness = 300mm

Bottom Slab thickness = 300 mm

External wall thickness =300 mm

Internal Wall thickness = 300 mm

Span =100

Total width = 23 m

Road Width of Carriageway = 7.5m

Wearing coat = 80mm

Cross-sectional Area = 7.58 m^2

I_{XX}=11.92427m^4

I_{YY}= 4.286286m^4

I_{ZZ}=53.79855m^4

Center y = 5 m

Centre z = 1.06 m

WEB THICKNESS (As per IRC:18-2000)

The thickness of the web shall not be less than d/36 plus twice the clear cover to the reinforcement plus diameter of the duct hole where ‘d’ is the overall depth of the box girder measured from the top of the deck slab to the bottom of the soffit or 200 mm plus the diameter of duct holes, whichever is greater. Where cables cross within the web, suitable increase thickness over the above hall be made .Incase of cast in situ cantilever construction, if the pre stressing cables are anchored in the web, the web shall be locally thick end to not less than350mm.

Web thickness = 300 mm > permissible

E of practice for road bridges (section: II)

loads and stresses. Generally the rear many types of loading classes in IRC:6-2014.The loads applied are IRC CLASS‘A’ loading and IRCCLASS‘70R’ loadings as per IRC6-2014 clause 204.1.value (safe)

5. LOADING ON BOXGIRDER

The loads are applied as per IRC:6-2014 standard specifications and code Using Freyssinet system with anchorage type 27K-15 (27 strands of 15.2mm diameter) In 110 mm diameter ducts. Force in each cable=(27×0.8×265)=5724kN

Using Freyssinet system with anchorage type 27K-15(27 strands of 15.2mm diameter) in 110mm diameter ducts.

Force in each cable = (27×0.8×265) = 5724 kN

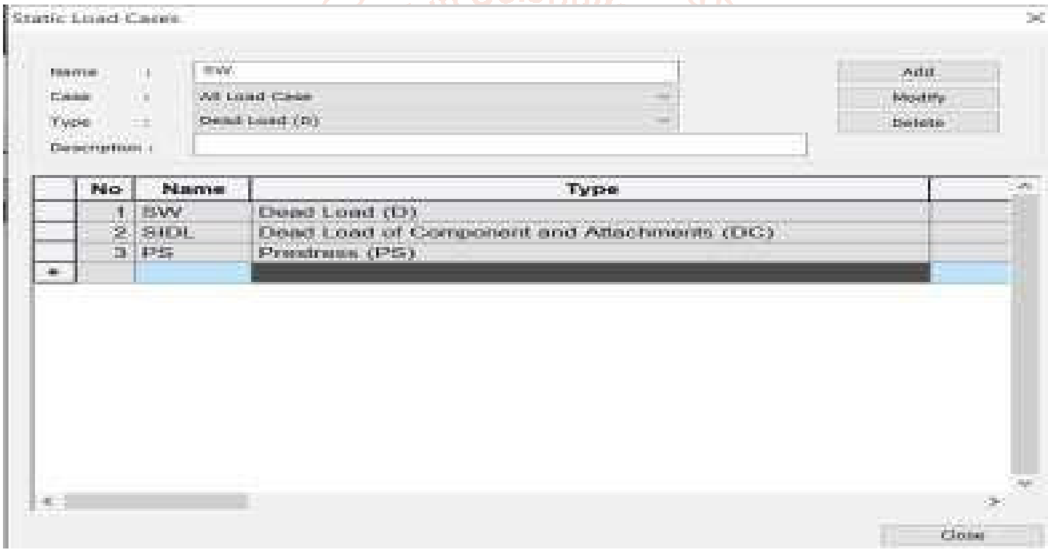


Figure 3.4 Load cases for analysis

Figure 3.5 Vehicle standards for moving loads

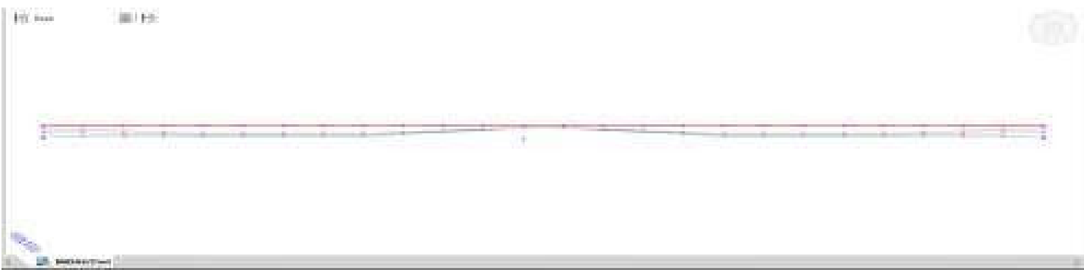


Figure 3.7 Parabolic cable profile

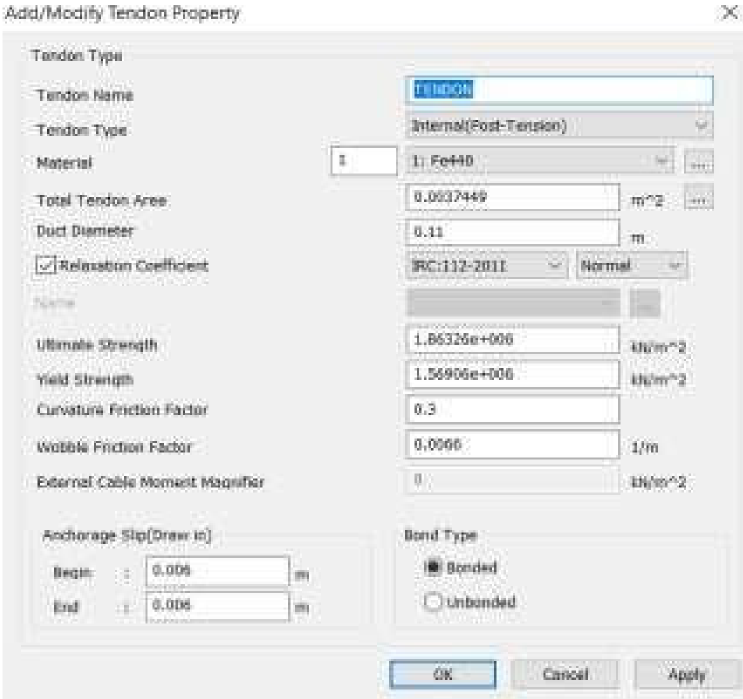


Figure 3.8 Tendon property for straight and parabolic profile

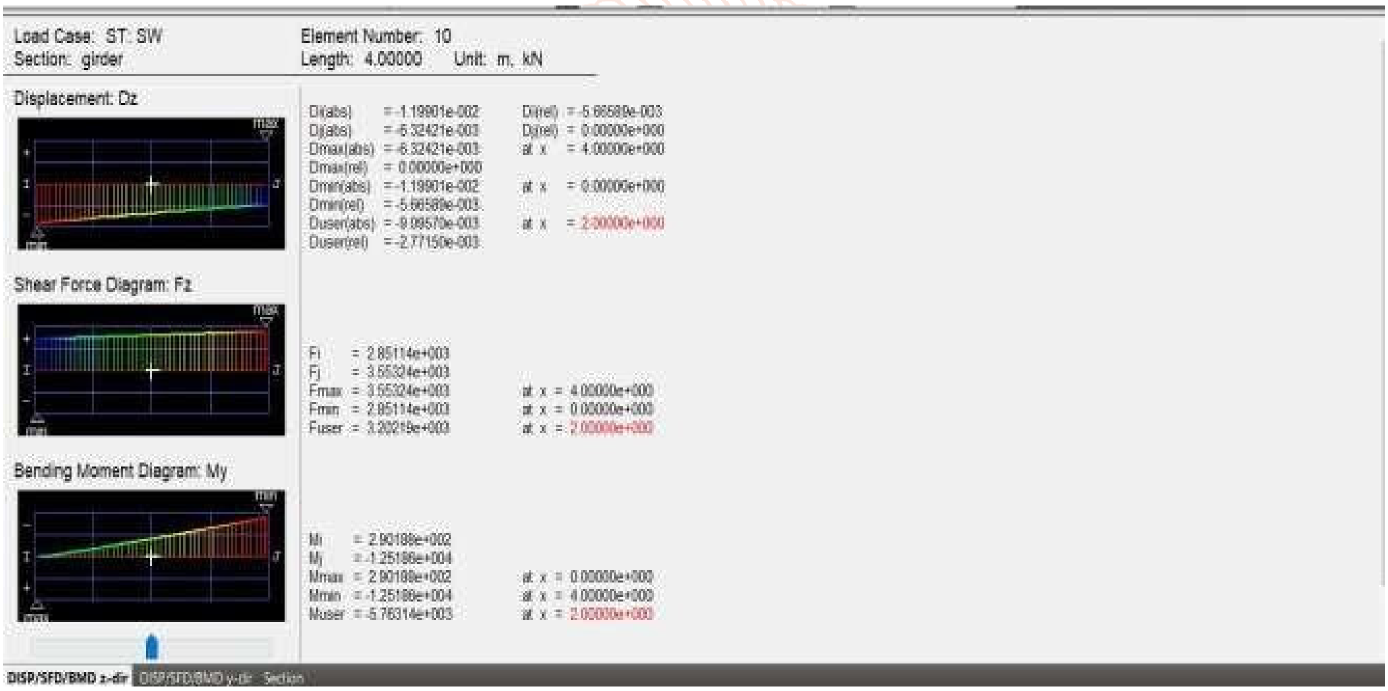


Figure 3.9 Bending moment of continuous beam

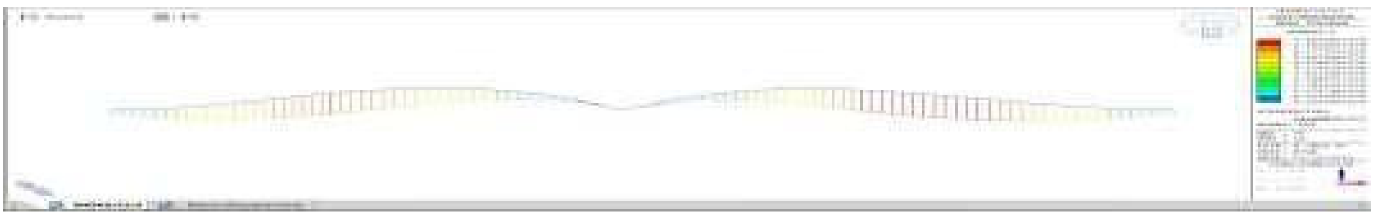


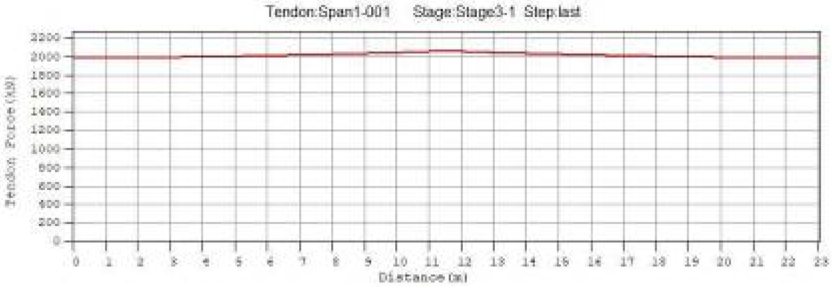
Figure 3.10 Bending moment of cable

Table 3: PSC Force along X –Direction (IS-Code

Elem	Part	Positive/ Negative	LCom Name	Design Situations	Type	CHK	M_Ed (kN*m)	M_Rd (kN*m)	M_Ed/ M_Rd	Aps (m^2)
277	I[118]	Negative	cLCB5	Basic & Seismic	FX-MIN	OK	0	5048.7215	0	0.005
277	I[118]	Positive	cLCB1	Basic & Seismic	FX-MAX	OK	9220.667	11991.13	0.769	0.005
277	J[129]	Negative	cLCB5	Basic & Seismic	FX-MIN	OK	0	5001.7543	0	0.005
277	J[129]	Positive	cLCB1	Basic & Seismic	FX-MAX	OK	9495.142	12086.872	0.7856	0.005

Elem	Part	Girder/ Slab	Comp. /Tens.	Stage	CHK	FT (kN/ m^2)	FB (kN/ m^2)	FTL (kN/ m^2)	FBL (kN/ m^2)	FTR (kN/ m^2)	FBR (kN/ m^2)	FMAX (kN/ m^2)	ALW (kN/ m^2)
307	I [382]	Girder(Composite)	-	-	-	-	-	-	-	-	-	-	-
307	I [382]	Girder(Composite)	Compression	Stage 2	OK	1809.8359	12432.11	1806.4104	12429.03	1813.2614	12435.196	12435.196	20684.28
307	J [393]	Girder(Composite)	-	-	-	-	-	-	-	-	-	-	-
307	J [393]	Girder(Composite)	Compression	Stage 2	OK	2135.5358	12043.73	2131.0413	12039.685	2140.0303	12047.775	12047.775	20684.28

Table 9 :Check for Stress At Cross-Section(AASTHO)



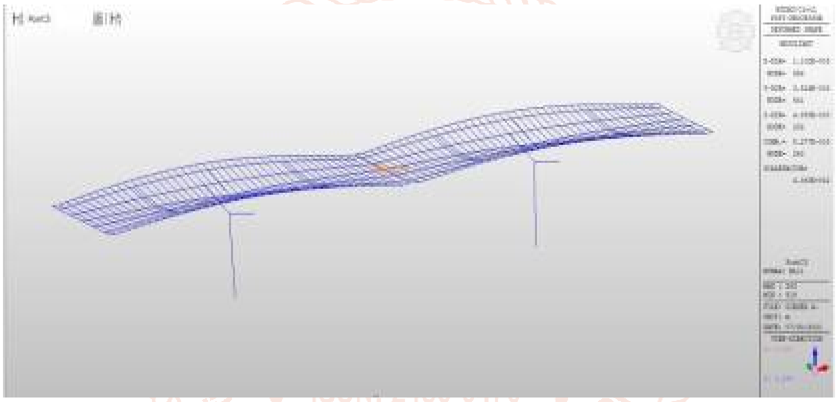


Figure 13: Deformed Shape of Girder Bridge In Global X-Y-Z Section

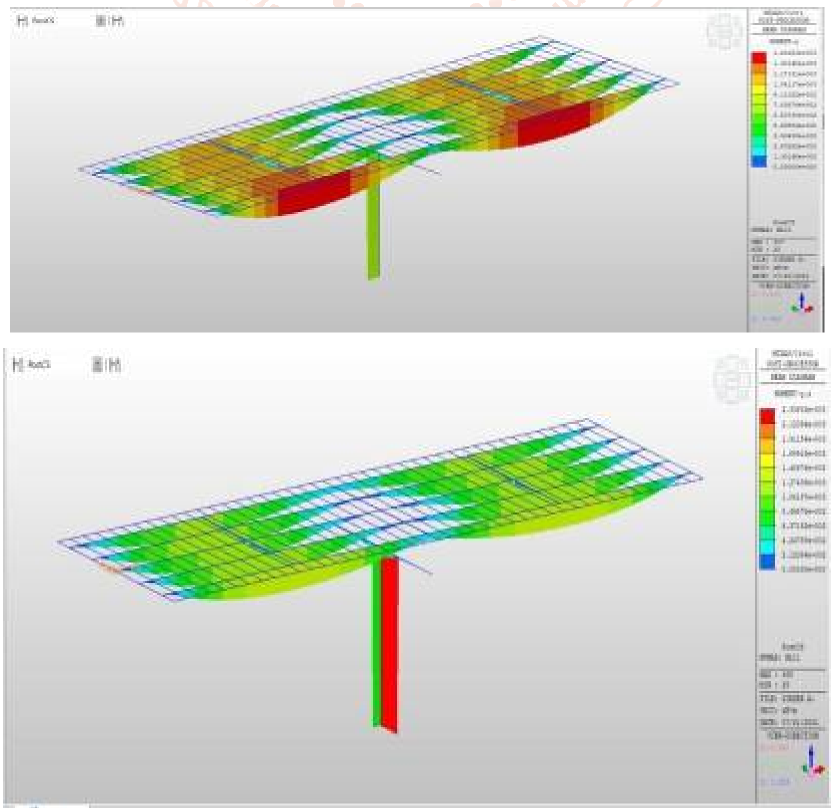


Figure 14: Reaction of Moment in Y- Direction

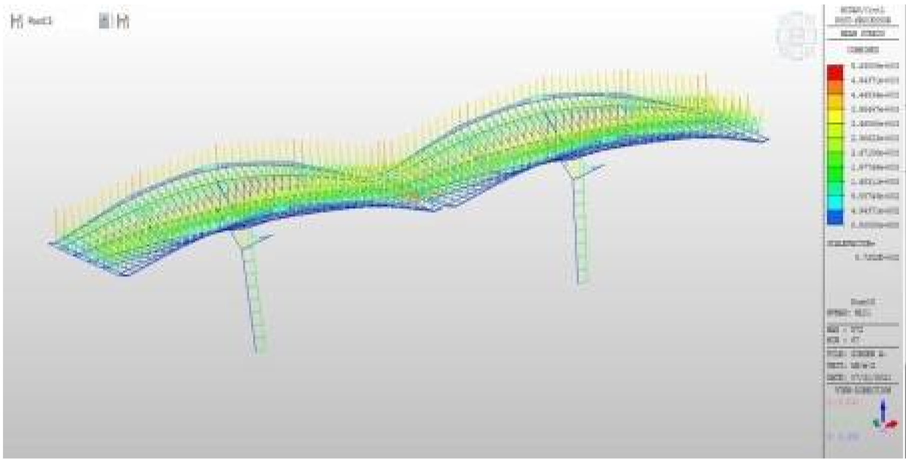
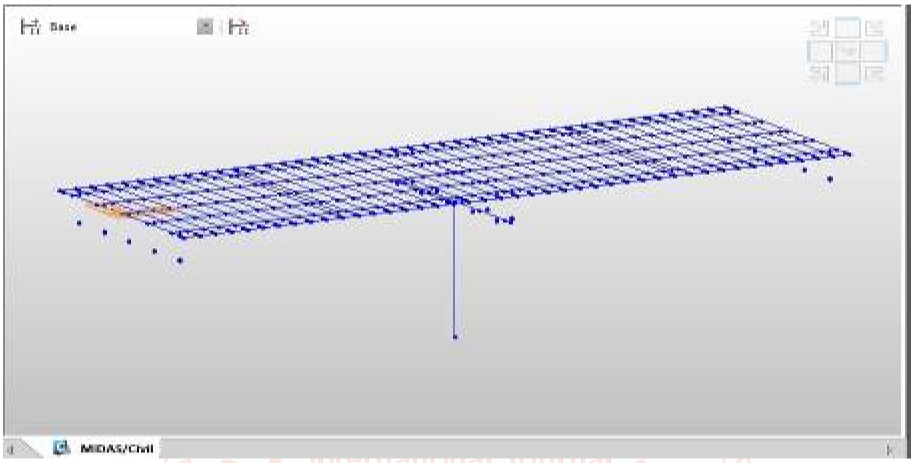
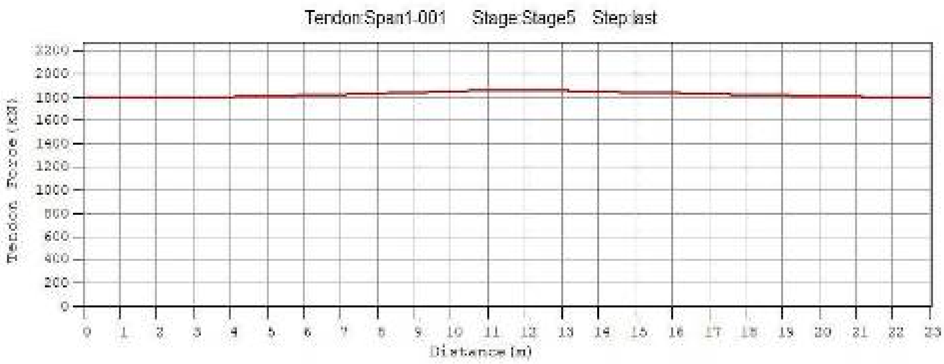


Figure 15: Reaction of Moment in Y-Z Direction





6. DISCUSSIONS

From results the straight tendon profile produces more stress at top and the shear force is also greater than parabolic tendon profile. Based on load balancing concept for uniformly distributed loads the parabolic tendon profile reduces the stresses than straight tendon profile.

7. CONCLUSION

- The straight and parabolic tendon profile was created for the four cell prestressed girder and study on the effect of eccentricity, Prestressing force and Cable profile.
- The structural static properties such as deflections and stress distributions was studied for the above girder.
- The deflection due to the application of live load at critical section is 7.5 mm for straight tendon profile and 7.06mm for parabolic tendon profile.
- Stress due to loads at critical section for parabolic profile is 1.745 N/mm2 and for straight cable profile 9.217 N/mm2.

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