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"PARAMETRIC STUDY ON PRE-STRESSED BOX GIRDER BRIDGE UNDER IRC LOADING"

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Abstract: Bridges are the life-line of nation. Now a days any project not only serves the purpose of need, strength and serviceability but aesthetics is a factor that has occupied the major share in finalizing any project's demand. Thus curved, skewed, sleek, box girders are being constructed these days. Box girders not only look pleasant but also serve the purpose of strength. A parametric study is performed on concrete box girders having different skew angles. Further these box girders are analysed as post tensioned box girder having different post tensioning forces and comparison is made in responses obtained using CSI Bridge 2021 software. For this purpose, four different skewed alignments are considered 0º, 5º, 10º, 15º. Again, two post tensioned forces 400Kips, 600 Kips are applied. The various responses like torsion, shear force, deflection, bending moment about vertical axis, bending moment about horizontal axis, modal frequencies, longitudinal stresses at soffit at entire girder are studied. Then a tension check is performed to check the stresses coming on soffit of girder before and after post tensioning.

Keywords: Box Girder, Multi Cell, Nonlinear Analysis and CSI Bridge.

I. INTRODUCTION

1.1 GENERAL

Concrete is used in the manufacture of most homes and bridges in India and can be said to be the backbone for improving the country's infrastructure. Prestressed concrete is ideal aimed at the building of standard and elongated connections. Meanwhile Freycinet improved pre-stressed binder at initial days, the company was been used to manufacture long bridges that require constantly changing metals that are expensive to repair due to the corrosion damage inherent in competitive environmental conditions.
Precast girders with on-site concrete slabs are one of the most often utilized superstructure variations for concrete bridges. Typically, this kind of superstructure is employed for spans between 20 and 40 meters. The most prevalent example of this kind is the T or I girder bridge, which is well known for its straightforward design, inexpensive production cost, neat assembly or casting, and low inanimate load. In this paper, we will consider the road loads in India that are considered in bridge design, as well as the factors that can be crucial in figuring out the initial size of concrete tank girders. For overpasses made of prestressed concrete, take into account IRC: 18-2000. Concrete box-girder road bridges with various spans and strengths are analysed to measure proportional measure proportional durability, cast - in - place road bridges with multiple spans and strengths are analysed.

1.2 ADVANTAGES AND DISADVANTAGES OF BOX GIRDER BRIDGE

ADVANTAGES
i) In case of long span bridges, large width of deck is available to accommodate pre stressing cables at bottom flange level.
ii) In recent years, single or multi-cell reinforced concrete box girder bridge have been proposed and widely used as economic aesthetic solution for the over crossings, under crossings, grade separation structures and viaducts found in modern higher system.
iii) Interiors of box girder bridges can be used to accommodate service such as gas pipes, water mains etc.

DISADVANTAGES
I) One of the main disadvantages of box decks is that they are difficult to cast in-situ due to the inaccessibility of the bottom slab and the need to extract the internal shutter. Either the box has to be designed so that the entire cross section may be cast in one continuous pour, or the cross section has to be cast in stages

1.3 EFFECT OF SKEWS

In particular, it is often not possible to place the bridge so that it extends perpendicular to the features it traverses. The important thing is to maintain a relatively straight alignment of the road above or below the bridge. Therefore, you need a "diagonal" bridge. This increases the span, but usually, the end and middle supports are at an angle to the bridge's vertical axis rather than perpendicular to the bridge. Tilted bridge stanchions and the horizontal curvature of the bridge transmit torsional forces that can cause unexpected stresses, displacements, and rotations during construction. The higher the angle of inclination and curvature, the more difficult it is to build a bridge. The skewness of the bridge girder changes the behaviour of the girder.

1.4 ABOUT CSI BRIDGE

INTRODUCTION TO CSI BRIDGE:
Modelling, analysis, and style of bridge structures are integrated into CSi Bridge to form the final word in computerised tools tailored to satisfy the wants of the engineering skilled. the convenience with that all of those tasks is accomplished makes CSi Bridge the foremost versatile and productive package program within the trade. Mistreatment CSi Bridge, engineers will simply outline advanced bridge geometries, boundary conditions and cargo cases. The bridge models are outlined parametrically, mistreatment terms that are acquainted to bridge engineers, like layout lines, spans, bearings, abutments, bents, hinges, and post tensioning. The package creates spine, shell, or solid object models that update mechanically because the bridge definition parameters are modified. CSi Bridge style permits for fast and simple style and retrofitting of steel and concrete bridges. CSi Bridge implements a constant quantity object-based modelling approach once developing analytical bridge systems. this permits designers to assign bridge composition as Associate in Nursing assembly of objects (roadway construction, substructure, abutments, piers, foundation system, etc.
After modelling, CSi Bridge provides choices for the assignment of load cases and combos. Vehicle, seismic, and wind loading are generated consistent with codification (AASHTO LRFD, Canadian, etc.) and assigned consistent with model pure mathematics. A series of templates for assignment and close load conditions create CSi Bridge intuitive and sensible. once the first object-based model has been translated into a finite-element model and subjected to load cases and combos, the analysis method follows directly.

II. OBJECTIVES

Based on Literature review, the following are the gaps were identified
1. To study the performance of conventional and skew type box girder bridge subjected to static and moving load
2. To evaluate the performance of conventional and skew type box girder bridge under the action of post tensioning

III. METHODOLOGY

3.1 Modelling Box Girder Bridges for Parameter Studies

All models of 12 are modelled in CSI Bridge 2021 for parametric studies. A 220 ft long multi-cellular box girder is first modelled as non- post tensioned and straight viaduct. Three models are provided with different skewness. The girder is rectangular in cross section. These geometrically similar models are then modelled with post tensioned load having different prestressed loads. Then the different responses like shear force, bending moment about horizontal axis, bending moment about vertical axis, torsion, deflection, longitudinal stresses and fundamental frequencies are studied.

3.2 Loading Combinations

Despite the fact that a normal bridge would have a variety of loads, the current parametric analysis of skew bridges only considers dead loads, prestress loads, and vehicle active loads.
1. Dead Load (DL): The weight of the girder or member, any fixed loads that the member supports, and a fraction of the weight of the superstructure together make up the dead load. During design, the dead load can be roughly approximated, and it can be managed during construction and service.
2.Live Load (LL): Transient loads brought on by moving vehicles are referred to as live loads. Once the bridge is exposed to traffic, the designer has very little control over these loads, which are impossible to estimate correctly. To use virtual loads as a design criterion, you must develop and specify loads that are at least somewhat realistic. There are four different types of standards loads that highway bridges are intended to support. Load, IRC Class 70R.
3.post-tensioning is carried out at 400 and 600 Kips

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IV. PROBLEM FORMULATION

220 ft long concrete box girder 2 span. Deck is 36 ft wide, with depth varies as parabola. The bridge will support 2 lanes of traffic each of width 14 ft. The bridge is prestressed in concrete deck section.
Deck section properties: Concrete box girder with vertical sides and 3 cells. It has a nominal depth of 5 ft. Vertical diaphragms are placed at each end of bridge deck. The parametric variation is given to the deck from zero variation at the exterior ends of the span to max of 5 ft to the interior of span that is mid of the bridge.
Bearings: Placed under the girder head of the abutment at the bridge end. Up to the transition, it is vertical and perpendicular to the laying line and can move freely in all other directions.
Foundation springs: They are fixed in all 6 degrees of freedom.
Abutment properties: The abutments are of concrete rectangular sections of 8ft deep and 4 ft wide. The bearings support over the abutment of length 30 ft and which further rests over the foundation springs. The abutments are skewed according to the considered case.
Bent properties: One bent is provided in the middle of bridge. The skewness is provided according to the case considered.
Column- A circular concrete section with diameter of 5 ft. the length depends over the depth of substructure.3 no's of columns are used. The moment released at top and bottom of columns are fixed.
Bent cap- It is a rectangular concrete cap with 30 ft length, 10 ft depth and 5 ft width. It should be integral with the column.
Tendon properties: The tendons are of area 10 in^2 with parabolic variation and modelled as a load. The tendons are provided in all girders.

V. ANALYSIS

The calculation of prestressed concrete girder bridges considers the following load cases:
1. DEAD LOAD CASE is the load of the structure.
2. MOVING LOAD CASE is applied to all lanes with a factor of one and with the Vehicle class created.
3. PRESTRESS LOAD CASE is the stress coming onto the structure due to the post tensioning of tendons.

5.1 MODELS OF BRIDGE:

Bridge Model With or without prestress, finite element modelling of one straight bridge and three ramps is performed on the CSI bridge 2021. Examine four different helix angles 0º, 5º, 10º, and 15º.The bridge has two spans. The various models are shown below.

1. Non post tensioned straight girder. Labelled as (m1).
2. Non post tensioned girder horizontally skewed to 5º(m2).
3. Non post tensioned girder horizontally skewed to 10º(m3).
4. Non post tensioned girder horizontally skewed to 15º(m4).
5. Post tensioned girder with 400kips load and straight in plan (m5).
6. Post tensioned girder with 400kips load and skewed to 5º(m6).
7. Post tensioned girder with 400kipsload and skewed to 10º(m7).
8. Post tensioned girder with 400kipsload and skewed to 15º(m8).
9. Post tensioned girder with 600kips load and straight in plan (m9).
10. Post tensioned girder with 600kips load and skewed to 5º(m10).
11. Post tensioned girder with 600kipsload and skewed to 10º(m11).
12. Post tensioned girder with 600kipsload and skewed to 15º(m12).

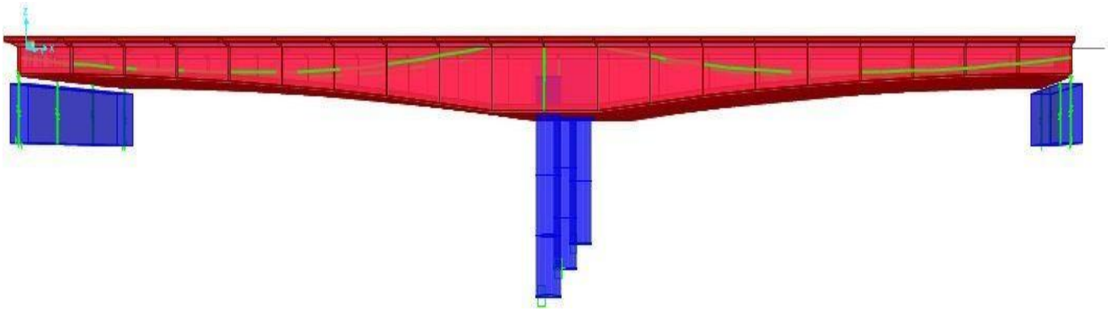

Figure 5.1 elevational view of Inclined hollow box girder bridge

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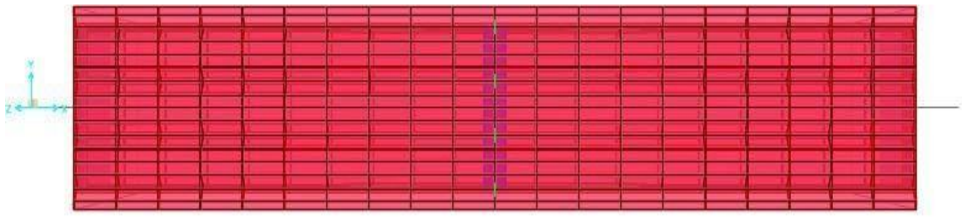

Figure 5.2 plan of straight box girder bridge

VI. RESULTS OF BRIDGE MODELS

Analysis of the inclined and straight box girder bridge models with non-post tensioning and post tensioning with 400kips load and 600kips load for DL and ML are conducted. The retorts such as twisting, Bending -moments, Horizontal stresses, deflections, shear forces are checked in each study.

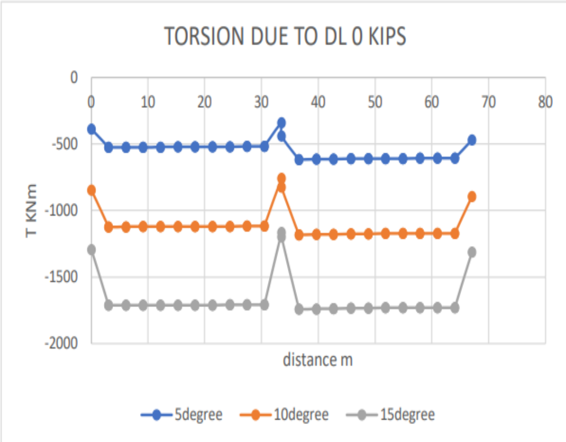

Fig 6.1 torsion due to DL in non-post tensioned girders

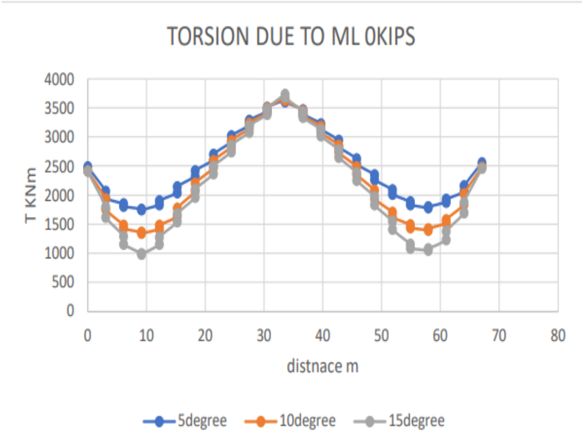

Fig 6.2 torsion due to ML in non-post tensioned girders

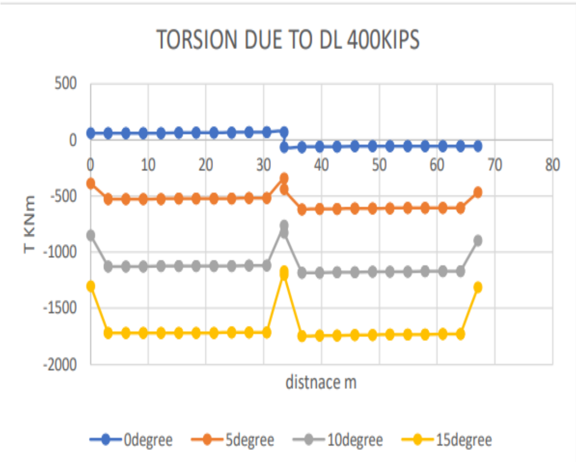

Fig 6.3 torsion due to DL in 400kips load post tensioned girder

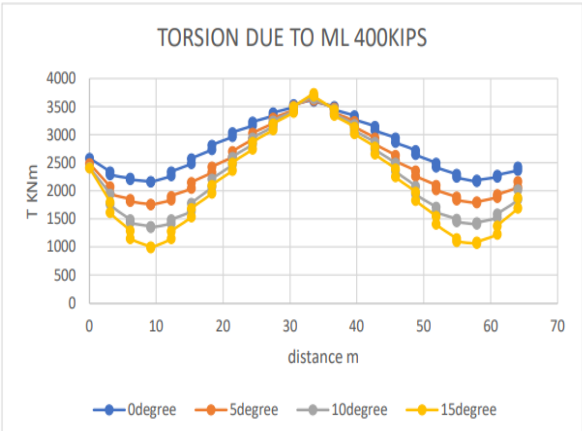

Fig 6.4 torsion due to ML in 400kips PTG

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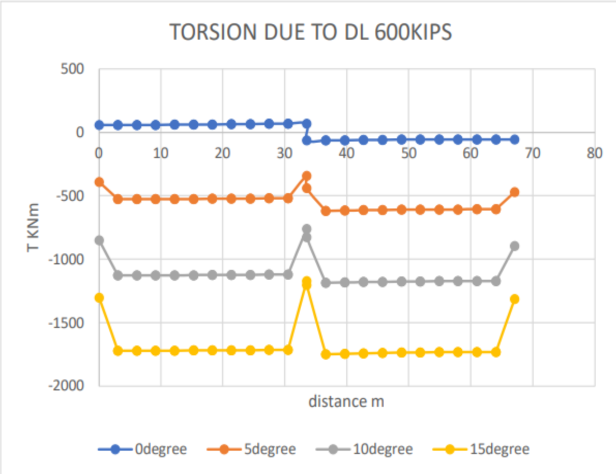


Fig 6.5 Torsion due to DL in 600kips PTG

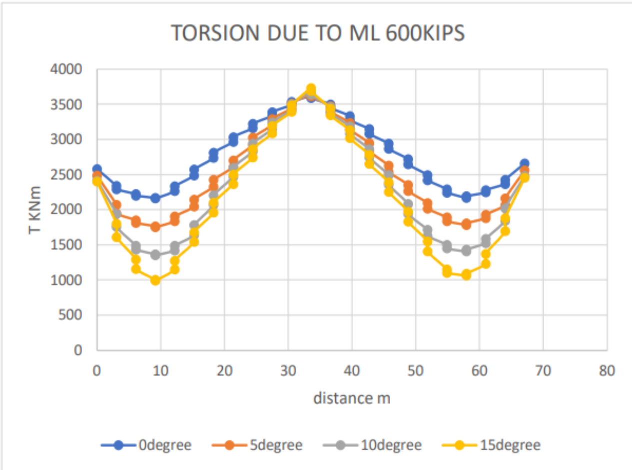


Fig 6.6 Torsion due to ML in 600kips PTG

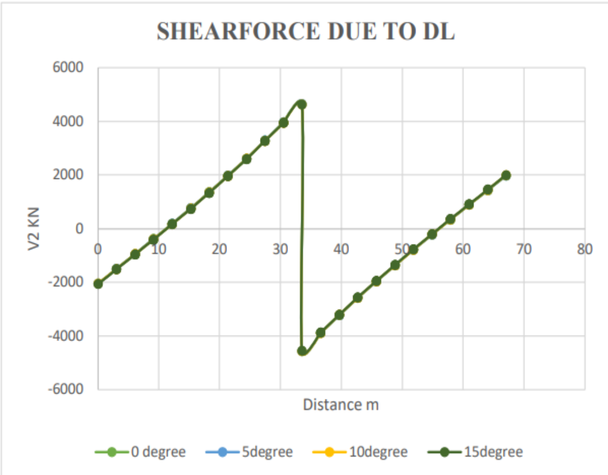


Fig 6.7 Shear force due to DL on post tensioned girders

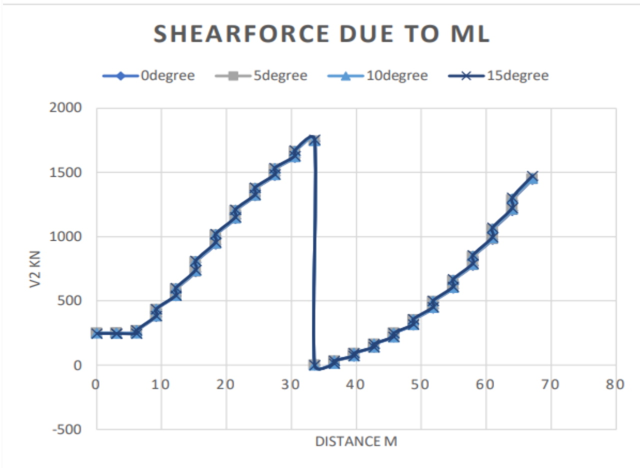


Fig 6.8 Shear force due to ML on post tensioned girders

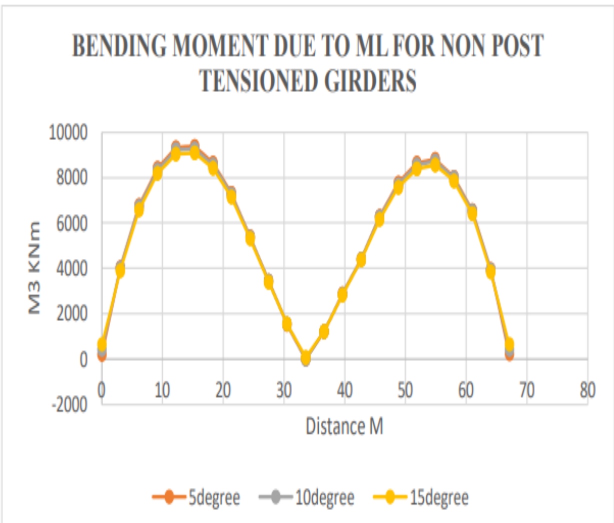


Fig 6.9 Moment due to ML in non-post tensioned girders

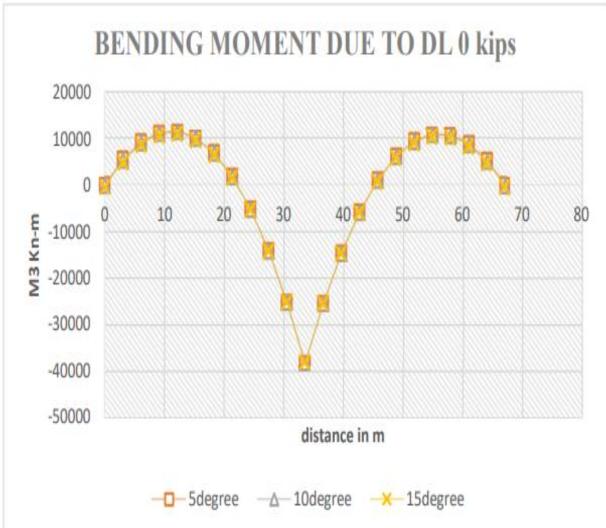
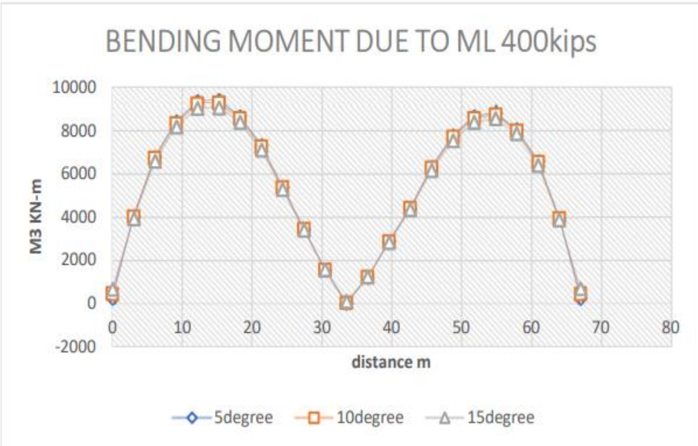


Fig 6.10 Moment due to DL in non-post tensioned girders



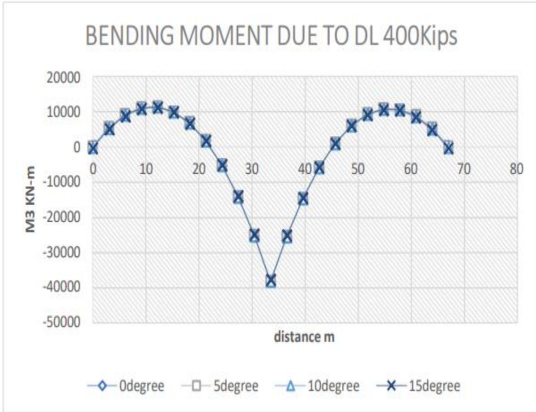
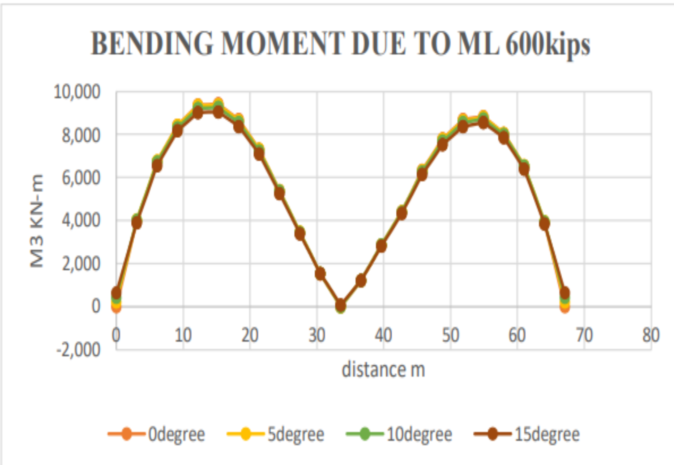


Fig 6.11 Moment due to ML in 400 kips post tensioned girders

Fig 6.12 Moment due to DL in 400kips post tension



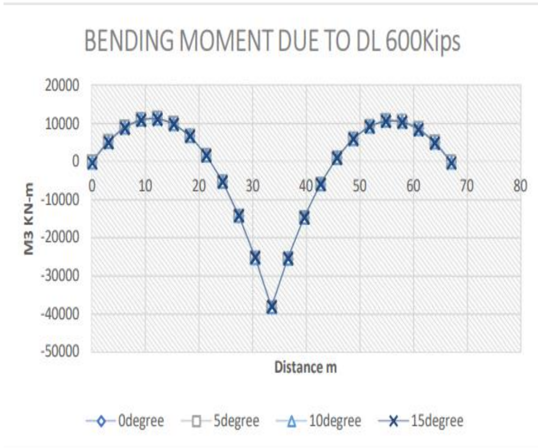
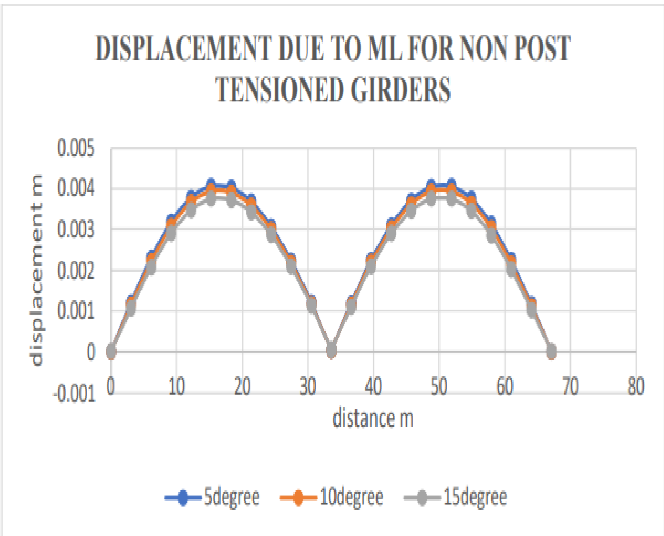


Fig 6.13 Moment due to ML in 600kips post tensioned girders

Fig 6.14 Moment due to DL in 600kips post tension



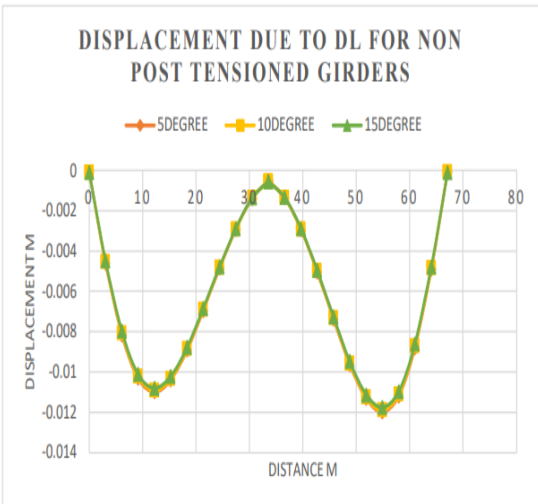


Fig 6.15 Displacement due to ML in non-post tensioned girders

Fig 6.16 Displacement due to DL in non-post tension

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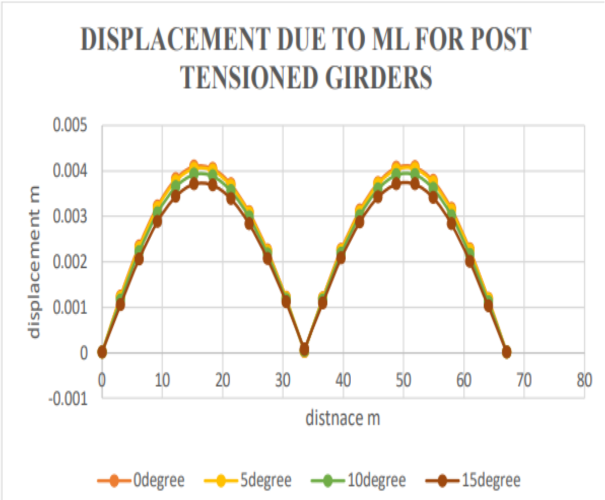

Fig 6.17 Displacement due to ML in post tensioned girders

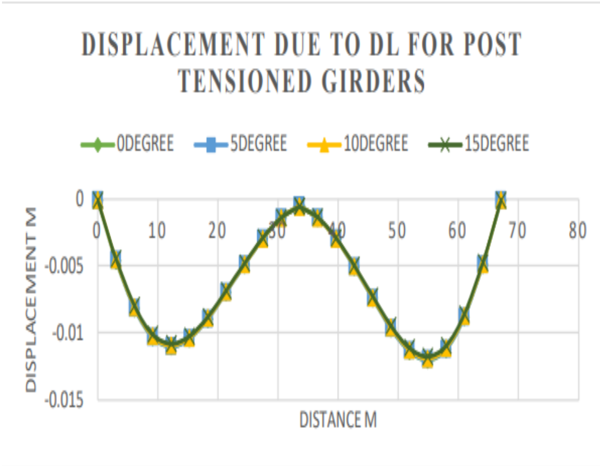

Fig 6.18 Displacement due to DL in post tension

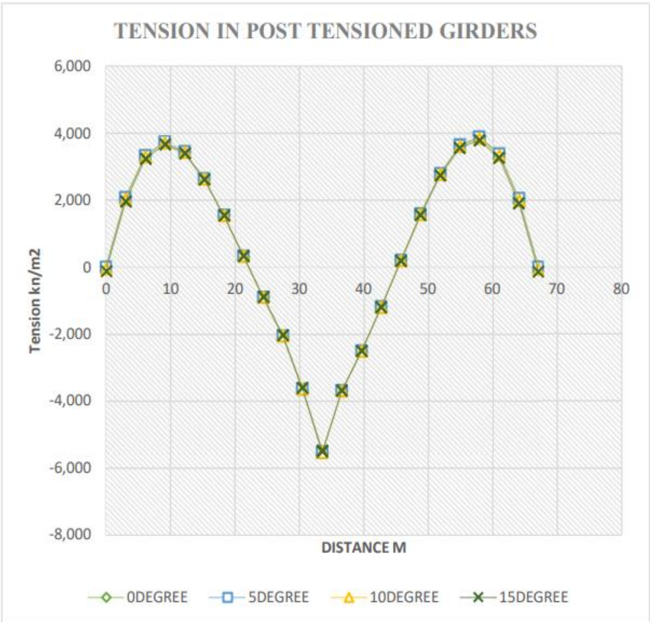

Fig 6.19 Tension in post tensioned girders

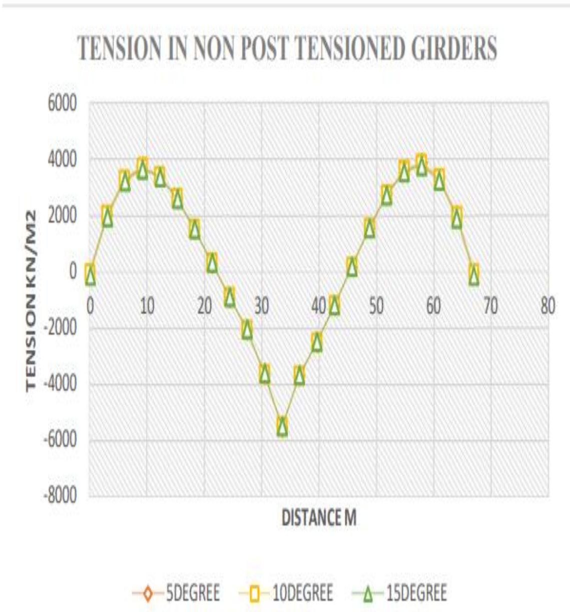

Fig 6.20 Tension in non-post tensioned girders

VII.CONCLUSIONS

1. On increasing the skewness in non-post tensioned girder bridge torsion increases due to dead load. On first 5^0 increase in skewness from straight to 5^0 change in torsion is about 123%, However, rate of change of torsion with increase in skewness up to 15^0 is decreasing.
2. In case of moving load, torsional forces were decreasing with increase in skewness. The torsional variations are comparable. During first 5 -degree skewness the torsion decreases about 2.5%. Here also the rate of decrease of torsion decreases with increase of skewness these results are valid up to 15 degrees.
3. Due to change in post tensioned forces at a particular skewness there is no marginal change in torsion.
4. In case of shear force due to dead load at different skewness very less variations are observed.
5. Again, shear force due to moving load at different skewness is not varying a lot. The behaviour and values are coming almost similar.
6. When at a particular skewness shear force is studied due to non-post tensioning, at 400kips post tensioning force and at 600kips post tensioning force, the changes are very less.
7. The skewed girders are more longitudinally stressed at bottom as compared to straight ones.

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8. We can observe that, bending moment (M3) due to moving load is decreasing due to increase in skewness of box girder. At mid span increase of about 225% is observed from 10-degree skewness to 15-degree skewness. At the starting end M3 increases about 47% from 10-degree skewed girder to 15-degree skewed girder.
9. Bending moment about vertical axis due to dead load are looking almost similar with small variations, the bending moments are varying from 0.15% to 1.7%.
10. Bending moment due to moving load is less than the dead load by increasing the post tensioned load on girders.
11. Displacement in vertical direction due to dead load in non-post tensioned case does not varying marginally with respect to the skewness of bridge. However, in case of moving load it decreases with increase in skew angle.
12. Displacement in vertical direction due to dead load in post tensioned case varying a bit with decrease in displacement as skew angle increases.

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