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INFLUENCE OF PRESTRESSING FORCE ON BOX GIRDER BRIDGE SUBJECTED TO SEISMIC LOAD

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ABSTRACT:

Bridges are often considered to be engineering marvels. Whether we need to cross rivers or valleys, connect islands to mainland, carry cars people etc are obstacles that are achieved only by bridges.

Pre stressed concrete is ideally suited for the construction of medium to long span bridges. The composition of pre stressed concrete is nothing but high strength concrete and high tensile steel which is aesthetically appealing and economical. The present study deals with the analysis of reinforced concrete and prestressed concrete bridges. Reinforced concrete and Post-tensioned bridges of spans 15m, 30m and 45m are considered. Analysis of these bridges is performed with SAP2000 software for various Earthquake zones. The bending moments due to load combinations, viz.,(Dead load+ live load), (Dead load+ Earthquake load in X-direction), (Dead load+ Earthquake load in Y-direction), (Dead load+ live load+ Earthquake load in X-direction) and (Dead load+ live load+ Earthquake load in Y-direction) by considering with and without application of prestressing are obtained and compared. Maximum deflections under these load combinations are obtained by considering with and without application of prestressing and compared.

INDEX TERMS: Box girder bridge, SAP 2000

INTRODUCTION:

The reduction of commuting time not only saves on precious man hours but also saves on fuel consumption and depreciation on vehicles, apart from giving added convenience. Majority of existing buildings in India and abroad can be grouped as follows. One group includes structurally deficient bridges that have deteriorated to such a condition that they cannot carry the load for they were designed. The second group includes functionally obsolete bridges that are in good conditions, but whose current loading requirement may have exceeded the original design load. Therefore, it is necessary to find easy, simple and cost-effective methods to meet current and future loading and traffic requirements. Three possible solutions this problem are bridge replacements, posting load restrictions or to strengthen these existing bridges. As the existing bridges are vital assets and preservation of these bridges is necessary form the aspect of historic and cultural heritage, strengthening of these buildings are appropriate solutions. Also, proper maintenance of these bridges and timely rehabilitation work may well save substantial capital expenditure of any country .Pre stressing with high strength steel tendons is the one of the best methods of strengthening of these bridges. The basic concept of pre-stressing is to introduce the internal stresses of such magnitude and distribution that the stresses resulting from given external loadings are counteracted to a desired level. It can be applied to a single member or group of remembers and can be in a single stage or multi stages.

METHODOLOGY

THE DATA ADOPTED FOR 15M SPAN BRIDGE:

- Effective span = 15m
- Width of road = 7.5m
- Kerbs = 600mm on each side
- Foot path = 1.5m wide on each side
- Thickness of wearing coat = 80mm
- Live load = IRC class AA tracked vehicle
- Material used for deck slab = M-20 grade concrete
- Material used concrete girders = M-50 grade concrete
- Prestressing Force in each cable = 571kN
- Total prestressing Force = 2855kN
- No of cables used = 5
- Seismic zones considered = Zone II, III, IV&V

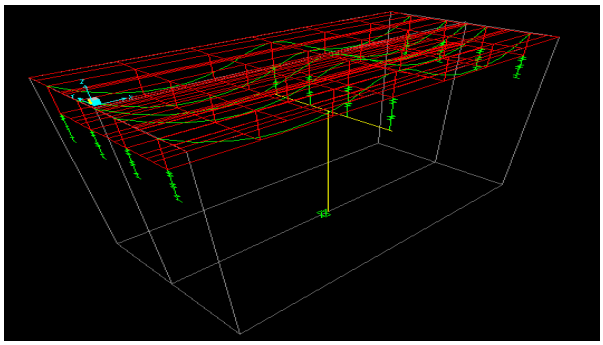


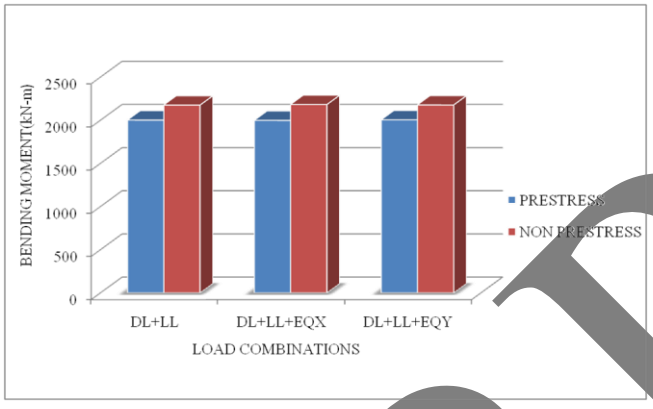
Figure.1 Wire frame Model of box Girder Bridge of span 15m from SAP200

i. BRIDGE OF SPAN 15 M

Bending moment and shear forces for Sesmic zoneII

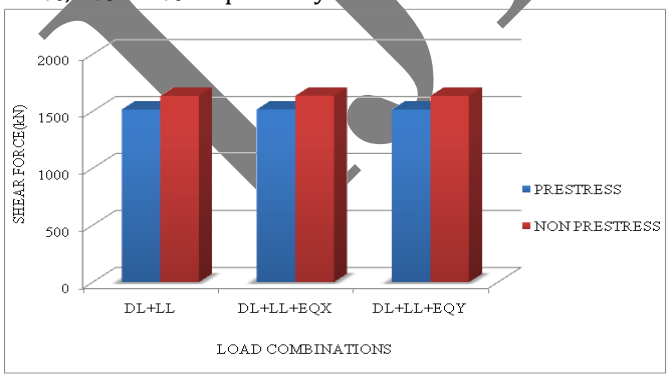
TABLE-1

LOAD COMBINATION	INTERIOR GIRDER		EXTERIOR GIRDER	
	Max. Bending Moment (kN-m)	Max. Shear force (kN)	Max. Bending moment (kN-m)	Max. shear force (kN)
DL+LL	2175.61	1634.515	2392.432	2024.588
DL+LL+PS	2001.798	1514.828	2268.622	1872.312
DL+LL+EQX	2181.853	1635.549	2396.720	2025.385
DL+LL+EQX +PS	1998.345	1515.862	2264.334	1873.109
DL+LL+EQY	2177.292	1634.714	2396.016	2027.177



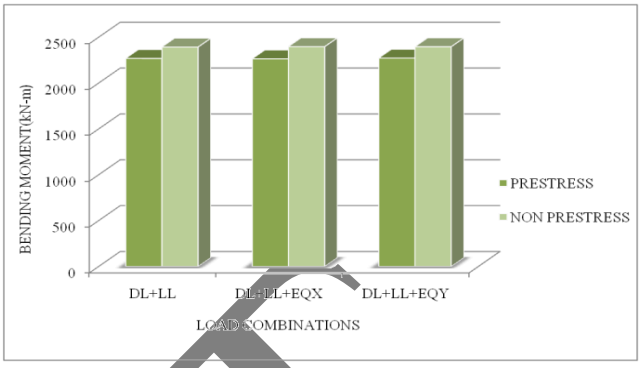
Graph.1 Bending moments of interior girder of a bridge of span 15m at seismic zone II

Above graph shows that the Bending moment of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing.The percentage decrease in Bending moment for the combinations DL+LL, DL+LL+EQ-Y & DL+LL+EQ-X are 8%, 9% & 8% respectively.



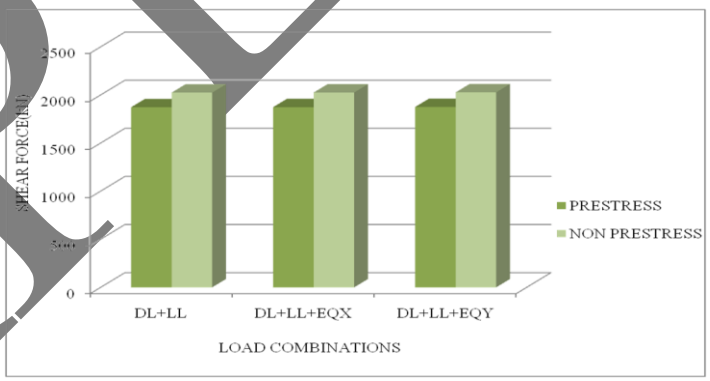
Graph.2 shear force of interior girder of a bridge of span 15m at seismic zone II

Above graph shows that the Shear force of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Shear force for the combinations: DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 7.5%,7.3% & 7.3% respectively.



Graph.3 Bending moments of Exterior girder of a bridge of span 15m at seismic zone II

Above graph shows that the Bending moment of the Exterior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Bending moment for the combinations: DL+LL, DL+LL +EQ-Y & DL+ LL+ EQ-X are 7.5%,7.6% & 7.6% respectively.



Graph.4 Shear force of exterior girder of a bridge of span 15m at seismic zone II

Above graph shows that the Shear force of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Shear force for the combinations DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 6%, 6% & 6% respectively.

BRIDGE OF SPAN 45 M:

BENDING MOMENT AND SHEAR FORCES FOR SESMIC ZONEII:

THE DATA ADOPTED FOR 45M SPAN BRIDGE:

- Effective span = 45m
- Width of road = 7.5m
- Kerbs = 600mm on each side
- Foot path = 1.5m wide on each side
- Thickness of wearing coat = 80mm
- Live load = IRC class AA tracked vehicle

- Material used for deck slab = M-20 grade concrete
- Material used concrete girders = M-50grade concrete
- Prestressing Force in each cable = 3963kN
- Total prestressing Force = 19815kN
- No of cables used = 5
- Seismic zones considered = Zone II, III, IV&V

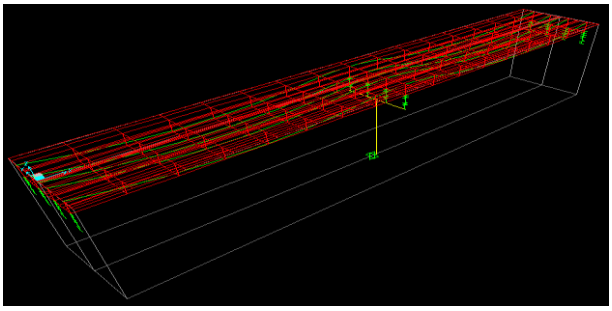
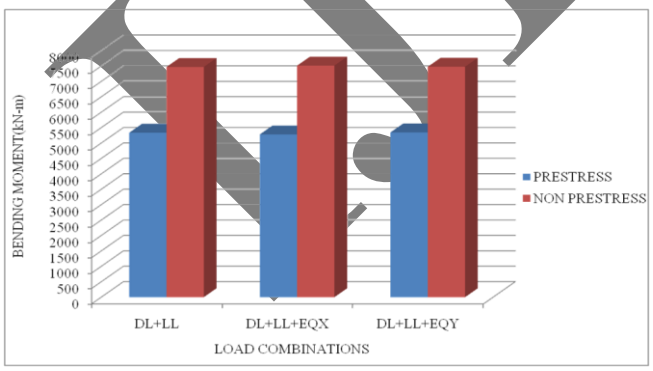


Figure.2 Wire frame Model of box girder bridge of span 45m from SAP2000

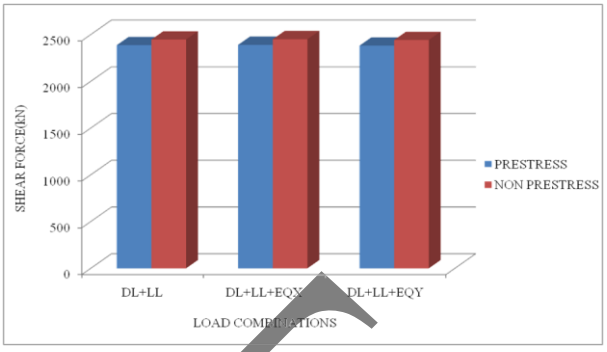
TABLE-2

LOAD COMBINATIONS	INTERIOR GIRDER		EXTERIOR GIRDER	
	Max. Bending Moment (kN-m)	Max.Shear force(kN)	Max.Bending moment(kN-m)	Max. shear force(kN)
DL+LL	7471.0116	2447.255	6106.5455	2696.9809
DL+LL+PS	5336.0497	2386.8489	4971.7546	2200.2031
DL+LL+EQX	7483.1411	2448.1905	6116.3588	2697.3691
DL+LL+EQX +PS	5320.9854	2387.844	4959.961	2201.1538
DL+LL+EQY	7472.6544	2445.8258	6107.3146	2709.8545
DL+LL+EQY +PS	5338.9285	2385.4197	4978.1336	2196.6195



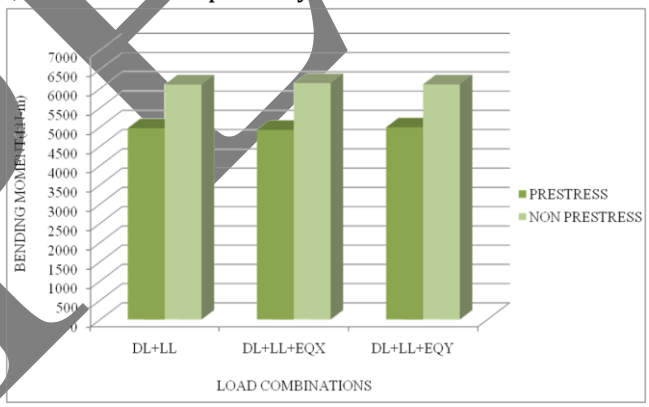
Graph.5 Bending moments of interior girder of a bridge of span 45m at seismic zone V

Above graph shows that the Bending moment of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Bending moment for the combinations: DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 28%, 30% & 29% respectively



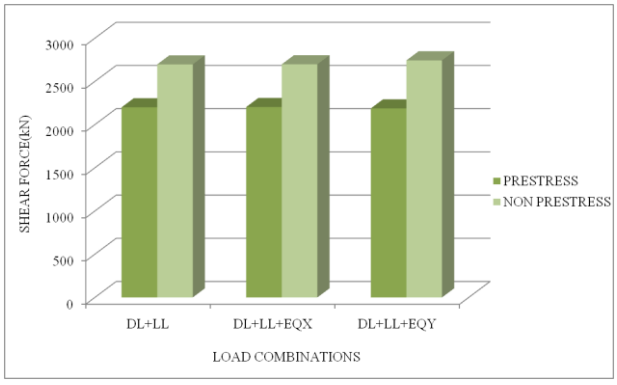
Graph.6 Shear force of interior girder of a bridge of span 45m at seismic zone V

Above graph shows that the Shear force of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Shear force for the combinations: DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 3%,2.5% & 2.5% respectively



Graph.7 Bending moments of Exterior girder of a bridge of span 45m at seismic zone V

Above graph shows that the Bending moment of the Exterior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Bending moment for the combinations: DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 18.5%,20% & 19% respectively.



Graph.8 Shear force of exterior girder of a bridge of span 45m at seismic zone V

Above graph shows that the Shear force of the interior girder of the box girder bridge with pre stressing is comparatively less than that of the girder of bridge without pre stressing. The percentage decrease in Shear force for the combinations: DL+LL,DL+LL+EQ-Y&DL+LL+EQ-X are 18.5%,18.5% & 21% respectively

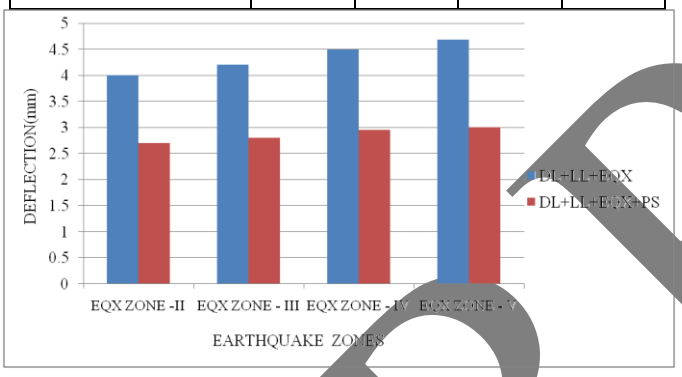
Deflection for various spans of Bridge

DEFLECTION OF 15M SPAN OF BRIDGE:

DEFLECTION OF 15M SPAN BRIDGE UNDER DIFFERENT LOAD COMBINATIONS AT VARIOUS SEISMIC ZONES

TABLE-3

LOAD COMBINATIONS	DEFLECTION (mm)			
	EQX ZONE - II	EQX ZONE - III	EQX ZONE - IV	EQX ZONE - V
DL+LL	3.8	3.8	3.8	3.8
DL+LL+PS	2	2	2	2
DL+LL+EQX	4	4.2	4.5	4.68
DL+LL+EQX+PS	2.7	2.8	2.95	3



Graph.9 Deflection of a bridge of span 15m at various seismic zones

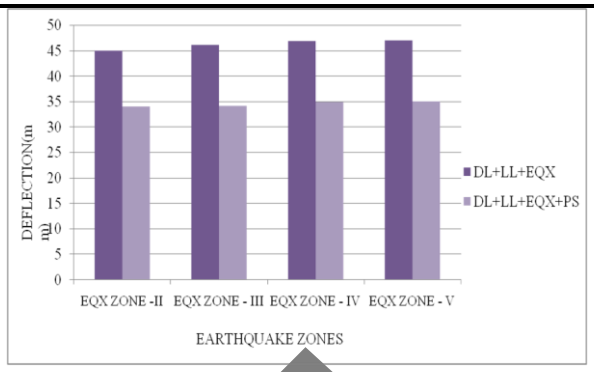
Above graph shows that the deflection of the box girder bridge with pre stressing is comparatively less than that of bridge without pre stressing. The percentage decrease in deflection of bridges in various earthquake zones are 32%,33%,34% & 35% respectively in the combination of DL+LL+EQX.

DEFLECTION OF 45M SPAN OF BRIDGE

DEFLECTION OF 45M SPAN BRIDGE UNDER DIFFERENT LOAD COMBINATIONS AT VARIOUS SEISMIC ZONES

TABLE-4

LOAD COMBINATIONS	DEFLECTION (mm)			
	EQX ZONE - II	EQX ZONE - III	EQX ZONE - IV	EQX ZONE - V
DL+LL	41	41	41	41
DL+LL+PS	32	32	32	32
DL+LL+EQX	45	46.1	46.8	47
DL+LL+EQX+PS	34	34.08	34.9	35



Graph.10 Deflection of a bridge of span 45m at various seismic zones

Above graph shows that the deflection of the box girder bridge with pre stressing is comparatively less than that of bridge without pre stressing. The percentage decrease in deflection of bridges in various earthquake zones are 24%,26%,25% & 25% respectively in the combination of DL+LL+EQX.

CONCLUSIONS:

The above results conclude that usage of pre stressing in bridges when compared to bridges without pre stressing take additional loads .This also proves that the bridge also resists additional bending moment applied by live loads, dead loads and also loads created by earthquakes.

FOR 15M:

1. For For 15m span bridge considered in Seismic zone-II, bending moment reduces 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.
2. For 15m span bridge considered in Seismic zone-III, bending moment reduced by 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.
3. For 15m span bridge considered in Seismic zone-IV bending moment reduced by 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.

4. For 15m span bridge considered in Seismic zone-V bending moment reduced by 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.

FOR 45M:

1. For 45m span bridge considered in Seismic zone-II bending moment reduced by 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.
2. For 45m span bridge considered in Seismic zone-III, bending moment reduced by 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.
3. For 45m span bridge considered in Seismic zone-IV, bending moment reduces 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.
4. For 45m span bridge considered in Seismic zone-V, bending moment reduces 9% for interior girder, 7.3% for exterior girder for load combination of DL+LL+EQ-X hence, the bridge decreases with pre stressing force when compared to bridge without pre stressing . Further there is decrease in shear force of 7.6% for interior girder and 6% for exterior girder for load combination of DL+LL+EQ-X.

Vise versa for 30m, during the process another vital conclusion is that when the box girder bridges earth quake zone varies the bending moment of interior and exterior girder changes moderately.

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