International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 08 | Aug 2018 www.irjet.net p-ISSN: 2395-0072

# COMPARISON OF SPAN 18M, 21M AND 24M OF T-BEAM GIRDER BRIDGE USING GRILLAGE ANALOGY METHOD

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**Abstract -** *An attempt has been made to study the behavior of T-beam bridges of their efficiency of the structure, higher stability,economy with respect to Bending moment, Shear force under standard IRC loadings. The varying span chosen for study are 18m, 21m and 24m for two lane and three lane analysis. The modelling and analysis of T-beam Girder Bridge by using SAP2000 Software and the analysis also carried out by Grillage analogy method. After analysis the results found that, In two lane analysis, Bending moment and Shear force of 31.59%,29.34%,28.49% and 25.77% ,27.12%,26.12%,is more in outer girder as compared to inner girder. In three lane analysis, Bending moment and Shear force of 39.48%,27.22%,31.27% and 46.63%, 30.12% and 31.96% of 18m,21m and 24m respectively, is more in outer girder as compared to inner girder. In both two lane and three lane analysis, 17.22%,63.38% and 42.46%, 52.20% of Bending moment is more in pier cap than compared to pier. Similarly 17.22%, 63.38% and 42.46%,52.17% of shear force is more in pier cap than compared to pier.*

***Key Words*: *T-beam, Stability, Grillage, Varying spans, SAP 2000, IRC loads.***

## 1. INTRODUCTION

The development of country is mainly depends on agricultural and industrial activities, so, it is required to facilitate the proper transportation by providing the Flyovers and Bridges. For constructing the flyovers or the bridges we find many type of section among which T-beam bridges are very popular. T-beam girders plays very important role in motorways and system of bridges because of their efficiency of the structure, higher stability, construction, economy and aesthetical look. T-beam Bridge are considered for small and medium span bridges wheeled and tracked arrangements as shown in fig1.

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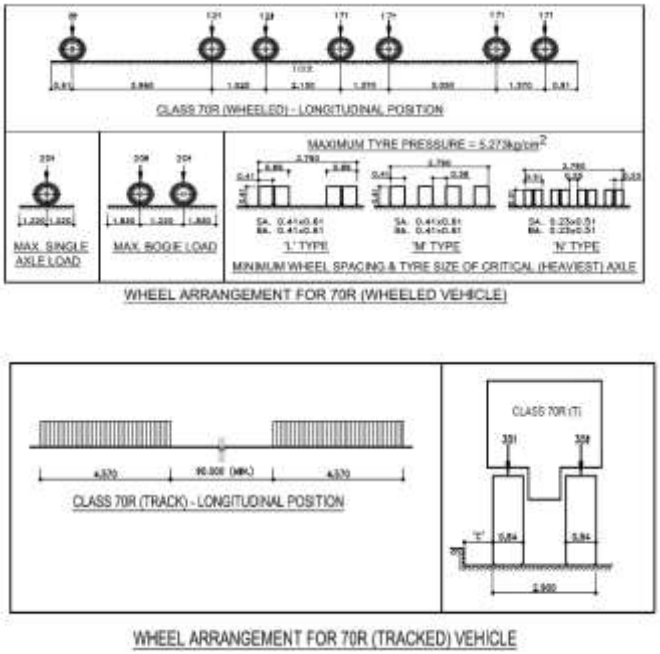


**Fig -1:** Wheeled and Tracked vehicle

## 2.IRC Classification

### 2.1 Loads on bridges

The following are the various loads are to be considered

- Dead load
- Live load
- Impact load
- Wind load
- Longitudinal force
- Centrifugal Forces
- Seismic load

## 3. METHODOLOGY

The methodology used in this project is described briefly in points mentioned below.

- Modeling of a T-beam girder bridge by varying span such as 18m, 21m & 24m and 12m wide across the traffic and depth of T-beam girder as 1.73, 2.03 and 2.33.
- The T-beam girder bridge is modeled with different lanes i.e. two lane and three lanes.
- The modeling of T-beam Girder Bridge is done by using SAP-2000 software.
- The modeling of T-beam Bridge is analyzed by grillage method.
- Then comparisons of two lanes and three lanes of T-beam Girder Bridge are done.
- Here comparison of the bending moments, shear forces and joint reaction for grillage method.
- The modeling of peir is done by using SAP-2000 software.
- Here comparison of the base reaction, bending moments, shears forces and joint reaction for grillage method.

## 4 .MODELLING AND ANALYSIS

Modelling and analysis of the models considered in the study using SAP 2000 software material properties are defined and assigned. Based on analysis parameters bending moments, shear forces and joint reaction for grillage method as shown in Fig 2.

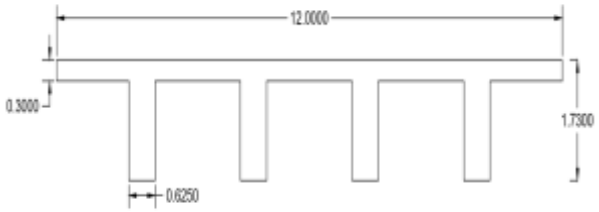


**Fig- 2**: Dimensions of the bridge (18m span)

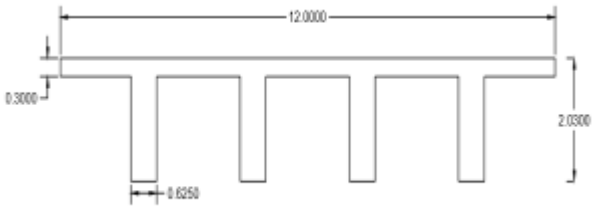


**Fig- 3**: Dimensions of the bridge (21m span)

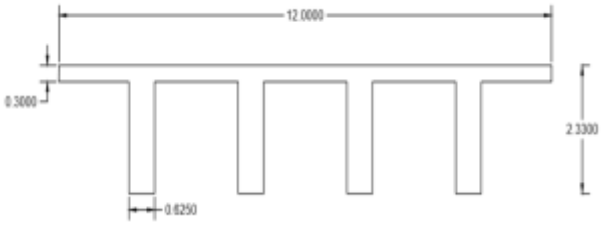


**Fig -4**: Dimensions of the bridge (24m span)

**Modelling for TWO and THREE lane**

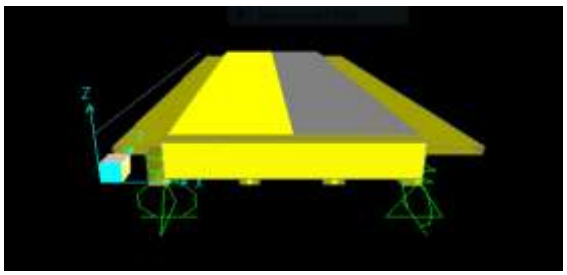

**Fig -5**: View in 3D Model with 18m span in two lane

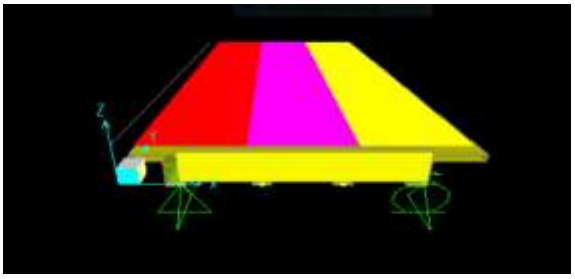

**Fig -6**: View in 3D Model with 18m span in three lane

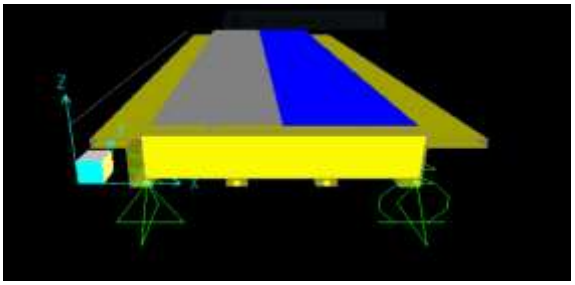

**Fig -7**: View in 3D Model with 21m span in two lane

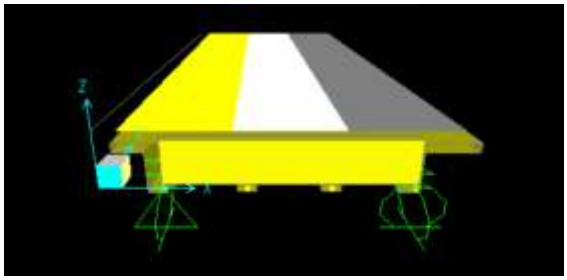

**Fig- 8**: View in 3D Model with 21m span in three lane

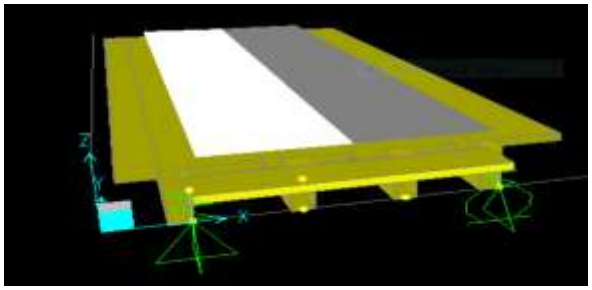

**Fig -9**: View in 3D Model with 24m span in two lane

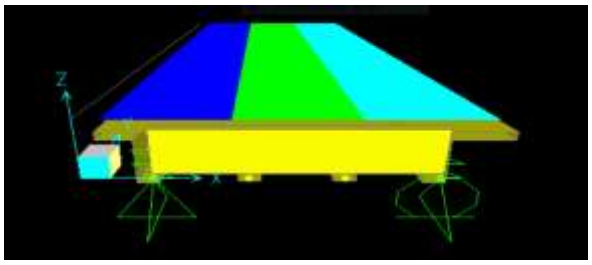

**Fig-10**:View in 3D Model with 21m span in three lane

### 4.1.Modelling

It includes modelling of sub structure in Two Lane & Three Lane

**Fig -11**: View in 3D Model with 18m span in two lane

**Fig -12:** View in 3D Model with 18m span in three lane

Similar methods have to be adopted for other two spans i.e. 21m and 24m

### 4.2.Analysis Results

The results of models are presented and discussed in detail. The results are included for all models. Totally eight models are considered in superstructures and substructures. i.e 3 in two lane and 3in three lane. All models and results are carried out by SAP2000 Software. The results of tables and graphs are shown below.

**Tabulations of Results for Superstructure:**

- **For Two Lane analysis**

**a) Bending moment**

**Table-1:** Comparison of Bending moment for Different Spans

| **BENDING MOMENT (kN-M)** | | | |
|---|---|---|---|
| **OUTER GIRDER** | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 5438.41 | 7218.03 | 18330.15 |
| Comb2 | 4535.24 | 8166.09 | 16757.54 |

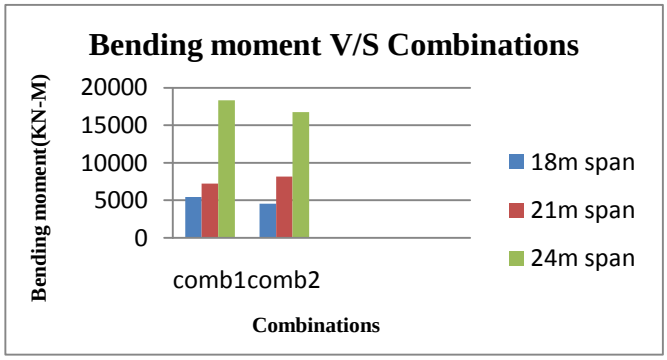


**Chart-1:** Comparison of combination and Bending moment for different span

From the graph it is observed that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases BM also increases.

**Table-2:** Comparison of Bending moment for Different Spans

| BENDING MOMENT (kN-M) | | | |
|---|---|---|---|
| **INNER GIRDER** | | | |
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 1078.14 | 1318.34 | 2949.63 |
| Comb2 | 865.69 | 1408.09 | 2693.46 |

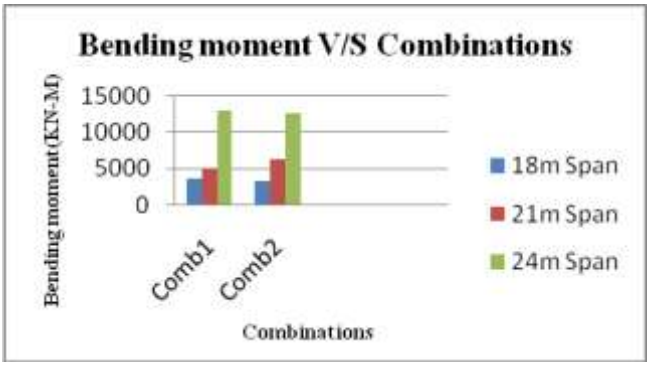


**Chart-2** Comparison of combination and Bending moment for different spans

From the graph it is observed that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases BM also increases.

**b) Shear force**

**Table-3 :**Comparison of Shear force for Different Spans

| SHEAR FORCE (KN) | | | |
|---|---|---|---|
| **OUTER GIRDER** | | | |
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 1078.14 | 1318.34 | 2949.63 |
| Comb2 | 865.69 | 1408.09 | 2693.46 |

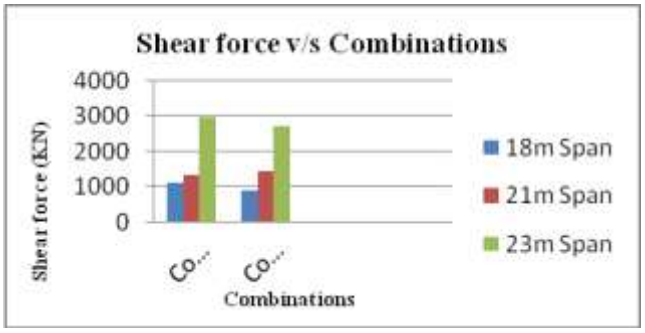


**Chart-3.** Comparison of combination and Shear force for different spans

From the graph it is observed that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases SF also increases.

. **Table-3:** Comparison of Shear force for Different Spans

| SHEAR FORCE(kN) | | | |
|---|---|---|---|
| **INNER GIRDER** | | | |
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 800.27 | 950.71 | 2179.30 |
| Comb2 | 725.57 | 1160.97 | 2085.03 |

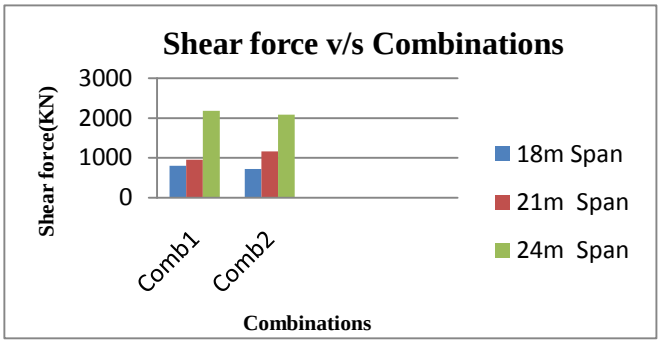


**Chart-4:** Comparison of combination and Shear force for different spans

From the graph it is observed that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R

loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases SF also increases.

**c) Joint reaction force**

**Table-5:** Comparison of Joint reaction force for Different Spans

| JOINT FORCE REACTION(kN) | | | |
|---|---|---|---|
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 3209.72 | 2018.20 | 4802.10 |
| Comb2 | 3013.61 | 2396.21 | 4671.88 |

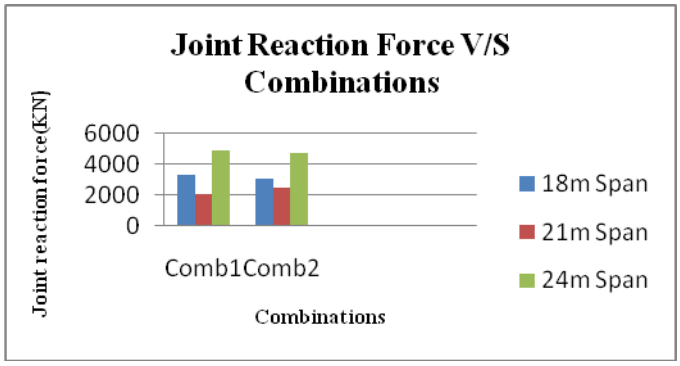


**Chart-**5: Comparison of combination and joint reaction force for different spans

It is observed from the graph that, Joint reaction at a support increases when the span increases. Joint reaction at the support is more for live load combination-1 as compared to the live load combination-2.

**For THREE Lane analysis**

**a) Bending moment**

**Table-6:**Comparison of Bending moment for Different Spans

| BENDING MOMENT(kN-M) | | | |
|---|---|---|---|
| OUTER GIRDER | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 3559.47 | 6930.32 | 9763.17 |
| Comb2 | 2932.24 | 6437.47 | 8793.89 |
| Comb3 | 4544.48 | 8461.51 | 11220.49 |

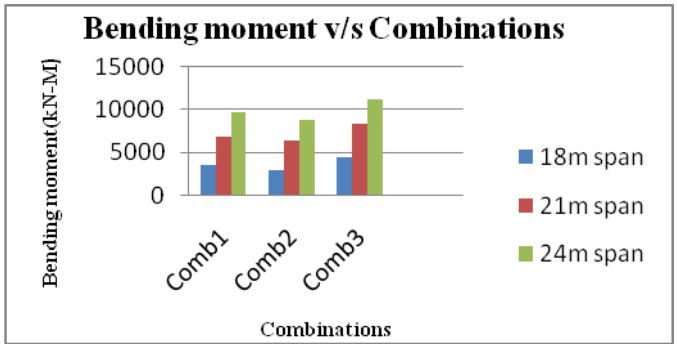


**Chart-6:** Comparison of combination and Bending moment for different spans

From the graph it is observed that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases BM also increases

**Table-7:**Comparison of Bending moment for Different Spans

| BENDING MOMENT(kN-M) | | | |
|---|---|---|---|
| INNER GIRDER | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 2154.30 | 5043.76 | 6709.89 |
| Comb2 | 2158.22 | 5366.04 | 6904.03 |
| Comb3 | 3761.69 | 7215.84 | 9069.60 |

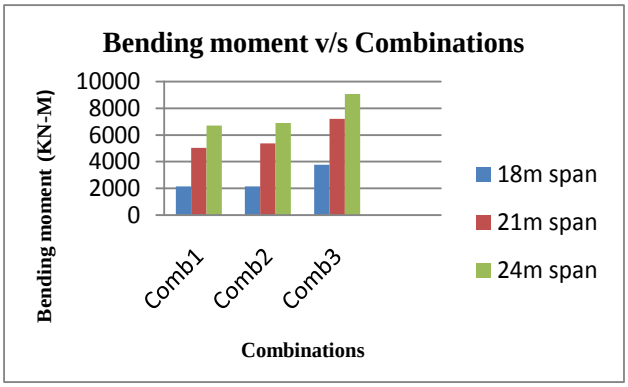


**Chart-7:** Comparison of combination and Bending moment for different spans

It is seen from the above graph that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading when the vehicle load increases BM also increases.

**b) Shear force**

**Table-8:** Comparison of Shear force for Different Spans

| SHEAR FORCE(kN) | | | |
|---|---|---|---|
| **OUTER GIRDER** | | | |
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 865.52 | 1357.93 | 1652.78 |
| Comb2 | 626.14 | 1173.77 | 1401.26 |
| Comb3 | 998.82 | 1563.03 | 1800.49 |

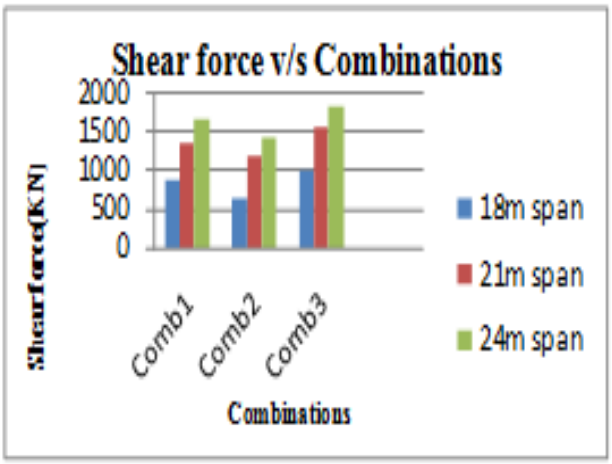


**Chart-8:** Comparison of combination and Shear force for different spans

It is seen from the above graph that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases SF also increases.

**Table-9:** Comparison of Shear force for Different Spans

| SHEAR FORCE(kN) | | | |
|---|---|---|---|
| **INNER GIRDER** | | | |
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 461.963 | 948.947 | 1124.523 |
| Comb2 | 462.482 | 975.957 | 1114.196 |
| Comb3 | 805.125 | 1350.402 | 1527.765 |

**Chart-9:** Comparison of combination and Shear force for different spans

It is seen from the above graph that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases SF also increases.

**c) Joint reaction force**

**Table-10 :**Comparison of Joint reaction force for Different Spans

| JOINT REACTION FORCE(kN) | | | |
|---|---|---|---|
| Combinations | 18m Span | 21m Span | 24m Span |
| Comb1 | 957.26 | 1977.98 | 2368.90 |
| Comb2 | 948.29 | 2044.28 | 2380.69 |
| Comb3 | 1378.22 | 2480.99 | 2821.89 |

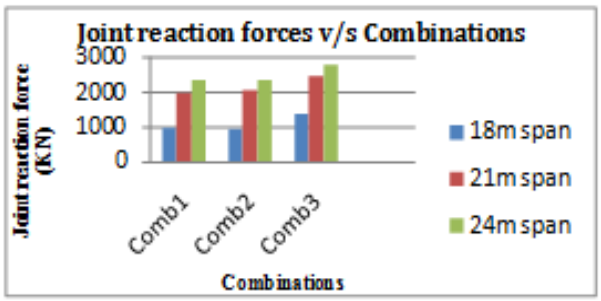


**Chart-10.** Comparison of combination and Joint reaction force for different spans

It is observed from the graph that, Joint reaction at a support increases when the span increases. Joint reaction at the support is more for live load combination-3 as compared to the live load combination-1 and combination-2. Because live load combination includes IRC 70R with Class-A loading.

**Tabulations of Results for Substructure**

**For Two Lane analysis**

**a) Base reaction**

**Table.11 Comparison of Base reaction for Different Spans**

| BASE REACTION(kN) | | | |
|---|---|---|---|
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 3756.83 | 4578.12 | 10257.87 |
| Comb2 | 3182.54 | 5138.14 | 9567.60 |

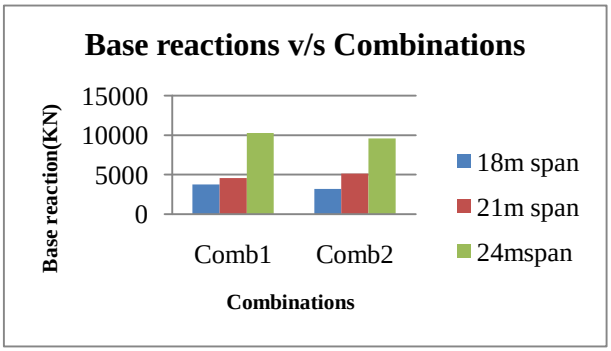


**Chart-11:** Comparison of combination and Base reaction for different spans

From the graph, it is observed that, when the span increases the Base reaction increases. Because when we increase length of the span changes, length of the span effects on this Base reaction. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Base reaction value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases Base reaction also increases.

**b) Bending moment**

**Table-12:** Comparison of Bending moment for Different Spans

| BENDING MOMENT(kN-M) | | | |
|---|---|---|---|
| PIER CAP | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 4320.00 | 5218.83 | 11796.54 |
| Comb2 | 3659.91 | 5908.85 | 10990.55 |

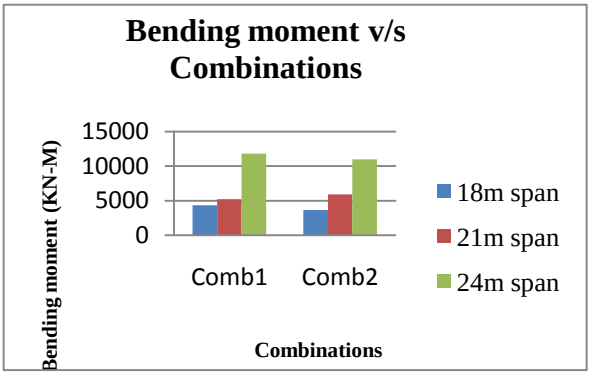


**Chart-12:** Comparison of combination and Bending moment for different spans

From the graph, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases BM also increases.

**Table-13:**Comparison of Bending moment for Different Spans

| BENDING MOMENT(kN-M) | | | |
|---|---|---|---|
| PIER | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 00000000367 | 000000002320 | 000000007611 |
| Comb2 | 000000001843 | 00000000002622 | 000000006769 |

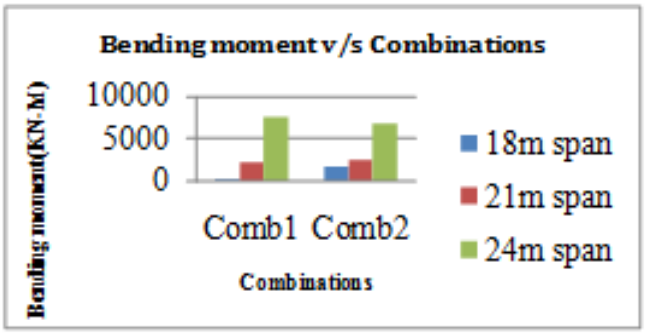


**Chart-13:**Comparison of combinations and Bending moment for different spans

From the graph, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases BM also increases.

**c) Shear force**

**Table-14:** Comparison of Shear force for Different Spans

| SHEAR FORCE(KN) | | | |
|---|---|---|---|
| **PEIR CAP** | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 1878.42 | 2269.05 | 5128.93 |
| Comb2 | 1591.269 | 2569.06 | 4778.50 |

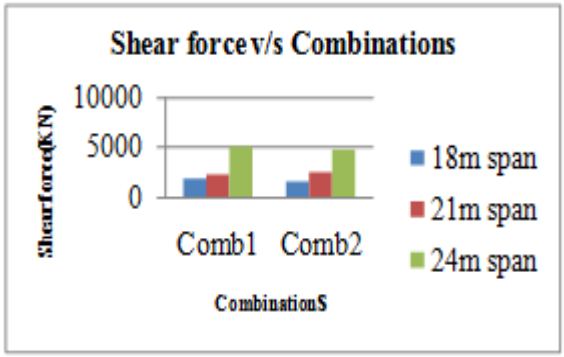


**Chart-14:**Comparison of combination and Shear force for different spans

From the graph it is observed that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases SF also increases.

**Table-15 :**Comparison of Shear force for Different Spans

| SHEAR FORCE(kN) | | | |
|---|---|---|---|
| **PIER** | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 3756.82 | 4578.12 | 10252.87 |
| Comb2 | 3182.54 | 5138.14 | 9567.60 |

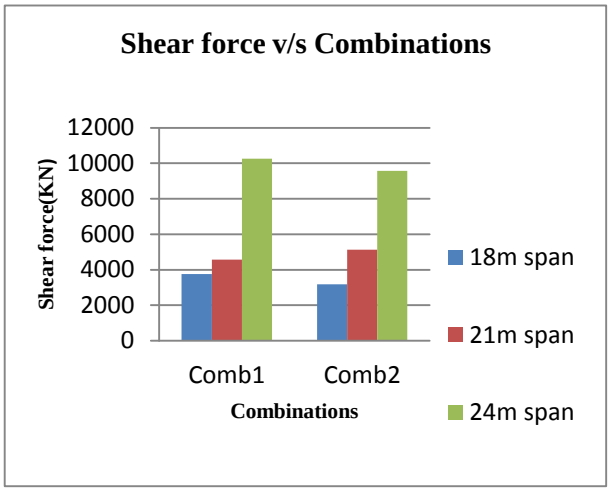


**Chart-15:** Comparison of combination and Shear force for different spans

From the graph it is observed that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination -1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. When the vehicle load increases SF also increases.

**For THREE Lane analysis**

**a) Base reaction**

**Table-16:** Comparison of Base reaction for Different Spans

| BASE REACTION (kN) | | | |
|---|---|---|---|
| Combinations | 18m span | 21m span | 24 m span |
| Comb1 | 2654.96 | 4613.76 | 5554.62 |
| Comb2 | 2177.26 | 4299.44 | 5030.92 |
| Comb3 | 3607.88 | 5826.84 | 6656.51 |

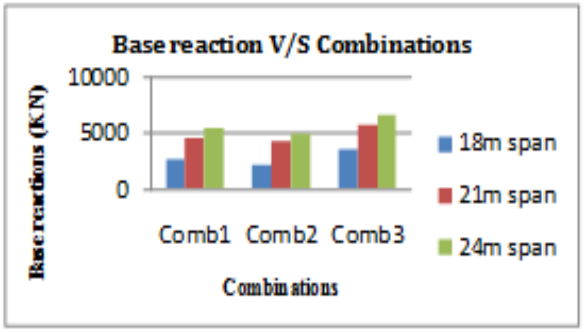


**Chart-16:**Comparison of Base reaction for different spans

From the graph it is observed that, when the span is more the Base reaction will be more. Because when we increase length of the span changes, length of the span effects on this Base reaction. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases Base reaction also increases.

**b) Bending moment**

**Table-17 :**Comparison of Bending moment for Different Spans

| BENDING MOMENT (kN-M) | | | |
|---|---|---|---|
| PIER CAP | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 3053.20 | 5305.82 | 6387.81 |
| Comb2 | 2503.24 | 4944.35 | 5785.55 |
| Comb3 | 4149.06 | 6700.86 | 7654.93 |

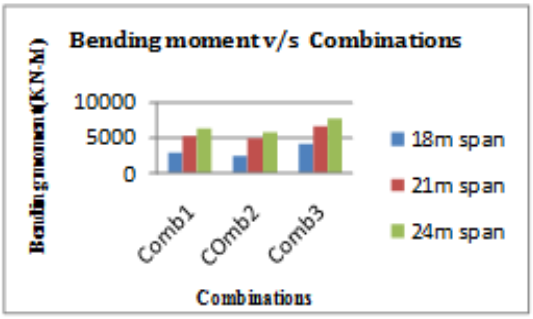


**Chart-17:** Comparison of combination and Bending moment for different spans

From the graph it is observed that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases BM also increases.

**Table-18:** Comparison of Bending moment for Different Spans

| BENDING MOMENT (kN-M) | | | |
|---|---|---|---|
| PIER | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 0000000000909 | 000000003935 | 000000005022 |
| Comb2 | 000000001364 | 000000003571 | 000000004587 |
| Comb3 | 000000001819 | 000000004682 | 0000000006103 |

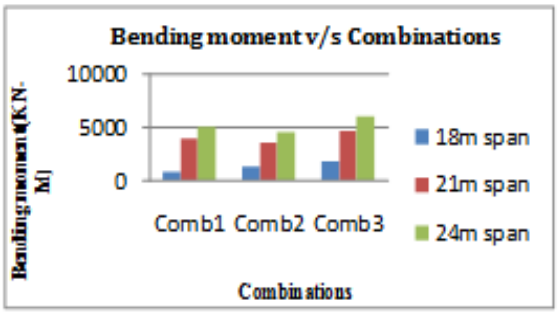


**Chart-18:**Comparison of combination and Bending moment for different spans

From the graph it is observed that, when the span is more the Bending moment will be more. Because when we increase length of the span changes, length of the span effects on this Bending moment. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R

loading. According to IRC-6, 70R loading is more compared to other loading. When the Bending moment value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases BM also increases.

**c) Shear force**

**Table-19:** Comparison of Shear force for Different Spans

| SHEAR FORCE (kN) | | | |
|---|---|---|---|
| PEIR CAP | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 1327.48 | 2306.88 | 2775.31 |
| Comb2 | 1088.62 | 2149.72 | 2515.46 |
| Comb3 | 1803.94 | 2913.42 | 3328.25 |

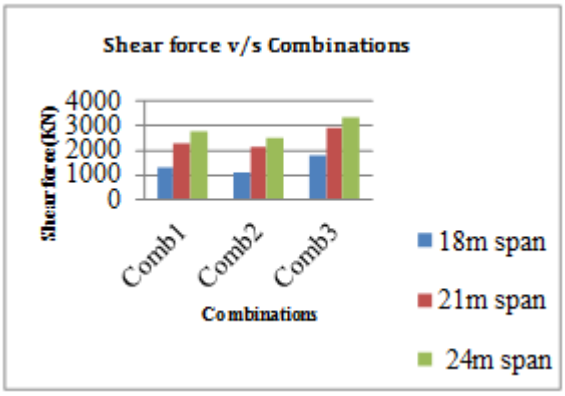


**Chart-19.:**Comparison of combination and Shear force for different spans

It is seen from the above graph that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases SF also increases.

**Table-20:** Comparison of Shear force for Different Spans

| SHEAR FORCE (kN) | | | |
|---|---|---|---|
| PIER | | | |
| Combinations | 18m span | 21m span | 24m span |
| Comb1 | 2654.96 | 4613.76 | 5554.62 |
| Comb2 | 2177.76 | 4299.44 | 5030.92 |
| Comb3 | 3607.88 | 5826.84 | 6656.51 |

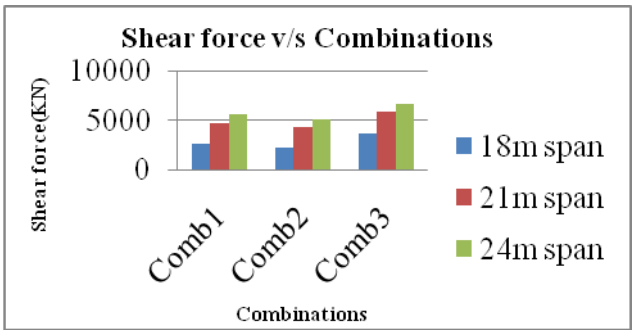


**Chart-20:** Comparison of combination and Shear force for different spans

It is seen from the above graph that, when the span is more the Shear force will be more. Because when we increase length of the span changes, length of the span effects on this Shear force. Combination-1 as per IRC-6. The combination of live load for this condition involves 70R loading. According to IRC-6, 70R loading is more compared to other loading. When the Shear force value decreases for the live load Combination-2, As per IRC-6, it includes Class- A loading. The class-A loading is less compared to the 70R loading. Combination-3 consisting both 70R and class-A loading. When the vehicle load increases SF also increases.

## 5. CONCLUSIONS

An attempt has been made to grillage analysis for 18m,span. Totally eight models have done in super structure and substructure. Grillage analysis are considered for IRC 70R and class-A loading.

- When the span increases, Bending moment and Shear force also increases.
- In two lane analysis, Bending moment and Shear force of 31.59%,29.34%,28.49% and 25.77%, 27.12%,26.12% is more in outer girder compared to inner girder.
- In three lane analysis, Bending moment and Shear force of 39.48% ,27.22% 31.27%and 46.63%, 30.12%, 31.96% is more in outer girder compared to inner girder.

Combination-3 consisting IRC 70R loading with class-A loading. When the vehicle load increases, Shear force and bending moment also increases.

- In both two lane and three lane analysis, 17.22%, 63.38% and 42.46%,52.20% of Bending moment is more in pier cap than pier.
- In both two lane and three lane analysis, 17.22%,63.38% and 42.46%,52.17% of shear force is more in pier cap than pier.

**ACKNOWLEDGEMENT**

The authors wish to thank the authorities of Visveswaraya Technological University, Belgaum for giving us an opportunity to conduct the analytical work in the CAD laboratory of University B.D.T College of Engineering. Davangere 577004.

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