Comparative Study on Construction Stage Analysis of Multi Span Conventional Bridge with Integral Bridge

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Abstract: Bridges are the important, useful and efficient civil engineering structure which decided the development of country. Bridges are of different types. They are designed based on the function of the bridge. Conventionally, bridges with bearing are most commonly used. The conventional bridges consist of simply supported spans separated by expansion joints and the bearings. During the service life of the bridge these expansion joints and the bearing, at the intermediate pier heads and abutments, are affected with rusting of steel reinforcement and deterioration of concrete due to the accumulation of debris and de-icing chemicals. This will lead high maintenance cost as well as the replacing cost. Hence engineers are recommended a new method for bridge construction i.e. integral bridge. Integral bridges are the bridges without joints which lead to the lower initial as well as the maintenance cost. This paper presents an analytical comparative study on the construction stages of both conventional bridge and integral bridge in terms of moment and deflection by using SAP bridge software. From the above study it can be concluded that the variation in the moments and deflection during the construction stage has to be studied for a long span integral and conventional bridge. It is recommended that the integral bridges show more effectiveness than conventional bridges to avoid the accidents at the construction stages.

Keywords: conventional bridge, deflection, integral bridge, moment

1. Introduction

Bridge is a structure built to span and provide passage over a river, road, or any other physical hurdle. The function required from the bridge and the area where it is constructed decides the design of the bridge. Bridges are classified on the basis that how the four forces namely shear, compression, tension, and moment are distributed in the bridge structure.

Most commonly used bridge consists of bearings and expansion joints at the abutment as well as in the intermediate pier heads, which allows expansion and contraction of the bridge. During the service life of bridge these expansion joints and the bearing, at the intermediate pier heads and abutments, are affected with rusting of steel reinforcement and deterioration of concrete due to the accumulation of debris and de-icing chemicals. This will lead high maintenance cost as well as the replacing cost. In integral bridges there are no joints on the superstructure.

In this paper conventional bridge (bridge with joints and bearings) and integral bridge (bridge with no joints and bearings) with same cross sectional details are modeled and analyzed in terms of construction stage analysis using SAP 2000 software.

2. Scope of Study

- To ensure the design calculation done by SAP 2000.
- To reduce the time involved in designing the structures.
- Results can be used for the future development and further construction of the bridges.
- Cost effective and effective material utilization of bridge

3. Objective of Study

- Compare and test the effectiveness of integral bridge with conventional bridge.
- To provide a new method of bridge construction technique for effective material utilization.
- Compare the deflection and construction stage moments of conventional and integral bridge.
• Construction stage analysis will provide future development of bridge analysis.

4. SAP 2000 Software

Sap 2000 software is integrated software for structural analysis and design purpose. Bridge Designers can use SAP2000 Bridge Templates for generating Bridge Models, Automated Bridge Live Load Analysis and Design, Bridge Base Isolation, Bridge Construction Sequence Analysis, Large Deformation Cable Supported Bridge Analysis and Pushover Analysis. Advanced analysis - Options for nonlinear base isolators, dampers, gaps, large deflection, and plastic hinges for pushover analysis. Modal, response spectrum, linear or nonlinear time history dynamic analysis. No limit on use of springs, dampers, and other elements in dynamic analysis. It can be used other types of general structures like stadiums, water retaining tanks, airport hangers, chimneys etc., It has predefined templates for the ease of modeling such complicated structures.

5. Specifications

a) Material
1) Steel
   • Young’s Modulus E=2.1 x 10^11 N/m²
   • Poisson’s ratio ν=0.3
2) Concrete
   • Young’s Modulus(super structures) E=4.5 x10^9 N/m²
   • Young’s Modulus(sub structures) E = 4.5 x10^9 N/m²
   • Poisson’s ratio ν=0.2
   • density of concrete = 2.4x10^4N/mm³

b) Bridges
3) Bearing
   • Neoprene pad bearings
   • Young’s Modulus E=6x 10^11 N/m²
   • Poisson’s ratio ν=0.5
   • density of 9.65x10^-7 N/mm³

4) Meshes
   • Mesh size= 20mm

Material specification of bridge shown in Table 2 and cross sectional details is shown in the fig.1 below.

| Table 2: Bridge specifications |
|--------------------------------|
| **Effective span** | **length** | 30000 |
| **Carriage way** | **width** | 7500 |
| **footpath** | **width** | 1500 |
| **Deck slab** | **thickness** | 240 |
| **Longitudinal girder** | **Top flange** | 850x150 |
| | **Bottom flange** | 600x200 |
| | **web** | 3000x1750 |
| **Bent cap beam** | **Cross section** | 3200x2300 |
| | **Width** | 10000 |
| **Bent column** | **diameter** | 2000 |
| **Pile cap beam** | **Cross section** | 1800x1800 |
| **Pile** | **diameter** | 1200 |
| **Tendon** | **Type** | 19T13 |

Figure 1: Cross section details of bridge

6. Modeling

For modeling of conventional bridge, five bridge spans each having 30m length and separated by means of expansion joints of 40mm are selected. Bearings are also provided between the superstructure and piers. Integral bridges are monolithic rigid structure, thereby eliminating the bearings and joints. The boundary conditions are set to restrain movement in vertical direction and accommodate movement in horizontal direction to maintain flexibility of the foundation. Other elements are modelled as same as that of conventional bridge.

| Table 1: Elastomeric bearing properties |
|----------------------------------------|
| **Properties** | **Size** |
| Elastomeric bearing length L(cm) | 35 |
| Elastomeric bearing width W(cm) | 45 |
| Elastomeric bearing height H(cm) | 8.5 |
| Total Elastomer thickness h(cm) | 6.1 |
| Thickness of one elastomer layer h₁(cm) | 0.8 |
| Thickness of one steel reinforcement layer h₂(cm) | 0.3 |
| Elastomer gross plan area A(cm²) | 1575 |
| Elastomer moment of inertia I(cm⁴) | 1600 |
| Shape factor S | 12.3 |
| Amount of bearing n(at end of girder) | 10 |
7. Construction stage analysis

Staged construction is a static modeling, analysis, and design application which enables the definition of a sequence of construction stages in which structural systems and load patterns are added or removed, and time-dependent behaviors are evaluated, including creep, shrinkage, aging (change in elastic modulus with age), and tendon relaxation. Material and geometric nonlinearity may be applied to staged construction. Further, staged construction may be part of a sequence of nonlinear static or direct-integration time-history analysis load cases. For linear load cases, the structural stiffness at a given construction stage may serve as the basis for analysis. A structure such as a pre-stressed bridge requires separate and yet inter-related analyses for the completed structure and interim structures during the construction. Each temporary structure at a particular stage of construction affects the subsequent stages. Also, it is not uncommon to install and dismantle temporary supports and cables during construction. The structure constantly changes or evolves as the construction progresses with varying material properties such as modulus of elasticity and compressive strength due to different maturities among contiguous members. The structural behaviors such as deflections and stress re-distribution continue to change during and after the construction due to varying time dependent properties such as concrete creep, shrinkage, modulus of elasticity (aging) and tendon relaxation. Since the structural configuration continuously changes with different loading and support conditions, and each construction stage affects the subsequent stages, the design of certain structural components may be governed during the construction. Accordingly, the time dependent effects for construction stage analysis is required to examine each stage of the construction.

8. Results

- Variation in the moments at different construction stages
  The following results were obtained from SAP2000 for the moments at different construction stage on the pier. The following graph shows the moment variation on the support pier element no 2.

- Deflection Variation at different construction stages
  The bridge deflection at the various construction stages are graphically shown in below.
9. Comparison of static analysis results

Maximum bending moments coming over the conventional bridges are 16733 kNm and the deflection is 21.89 mm. in the case of integral bridges 10124.856 kNm is the maximum bending moment and 10.57 mm are the deflections. Integral bridges shows lesser deflection and bending moments in the construction stages, it is because of the monolithic construction and the lesser number of joints and other accessories.

10. Conclusions

The above study shows the comparative study on construction stage analysis of integral and conventional bridge. From the above results it can be concluded that the variation in the moments and deflection during the construction stage has to be studied for a long span pre stress integral and conventional bridge. It is recommended that the integral bridges show more effectiveness than conventional bridges to avoid the accidents at the construction stages.

Reference

[1] Barbaros Atmaca and Sevket Ates, “Construction stage analysis of three-dimensional cable-stayed bridges Steel and Composite Structures”, Vol. 12, No. 5) 413-426, (2012)

[2] “Integral abutment bridge design guidelines”, VTrans, Integral Abutment Committee, 2nd Edition, 2008

[3] K M Pathan, Sayyad Wajed Ali, Hanzala T Khan, M S Mirza, Mohd Waseem, Shaikh Zubair, “Construction Stage Analysis of RCC Frames”, international journal of engineering & technology Research, Volume-2,Issue-3,pp54-57 (may-june,2014)

[4] Lakshmy Kakkanatt., Rajesh. A. K, “Comparative Study on the Seismic Performance of Integral and Conventional Bridges”, International Journal of Engineering Trends and Technology (IJETT) – Volume 28 Number 7 (October 2015)

[5] M.F. Granataa, P. Margiotta, M. Aricia and A. Recupero, “Construction stages of cable-stayed bridges with composite deck” Bridge Structures 8, 93–106(2012)

[6] Parag Dattatraya Patil, “Construction Stage Analysis of Balanced Cantiliver Bridge”, International Journal of Advance Foundation and Research in Science & Engineering (IJAFRSE) Volume 2.

[7] Shahanas P 1, Dr. Sabeena M.V., “Comparative Study on the Seismic Performance of Integral and Conventional Bridges”, International Journal of Innovative Research in Science, Vol. 4, Issue 6 (June 2015)

[8] Tabassum G Shirhatti, Dr. S. B. Vanakudre “The Effects Of P-Delta And Construction Sequential Analysis Of Rec And Steel Building With Respect To Linear Static Analysis” International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 04 |(July-2015)

[9] Vimala Shekar,Srinivas Aluri, Dr. Hota V.S.,GangaRao, “Integral abutment bridges with FRP decks – case studies”, 2005 – FHWA Conference, 2005, p. 113.

[10] Yasser Khodair and Sophia Hassiotis, “Numerical and experimental analyses of an integral bridge” Khodair and Hassiotis International Journal of Advanced Structural Engineering, 5:14, (2014)