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Influence of Transient Static and Transient Dynamic Analysis on Deflection of Bridge Slab Using Finite Element Method in ANSYS

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ABSTRACT

The deflection behavior of bridge slabs is critical for ensuring structural safety and longevity. By using the Finite Element Method (FEM) in ANSYS, engineers can simulate and analyze the effects of both transient static and transient dynamic loads on bridge slabs. This paper explores how these two types of analyses affect the deflection behavior of a bridge slab. We present the mathematical formulations, practical applications, and a case study involving a bridge slab subjected to time-varying loads. The comparative results demonstrate the significant impact that the choice of analysis method has on predicting deflection and ultimately guiding structural design decisions.

Keywords- FEM, Deflection, Varying Loads.

I. INTRODUCTION

In civil engineering, bridges are essential components of infrastructure, designed to withstand a variety of loading conditions over their lifetime. The deflection of bridge slabs under different loading conditions is a crucial factor in assessing structural performance. Both transient static and transient dynamic analyses, implemented through FEM in ANSYS, allow engineers to simulate the behavior of these slabs under time-varying loads. This paper examines how these two analysis methods influence the deflection of bridge slabs.

1.1 Importance of Deflection Analysis

The deflection of a bridge slab under load can influence the overall safety, functionality, and durability of the structure. Excessive deflection can lead to cracking, serviceability issues, and potential collapse. It is therefore crucial to accurately predict the deflection behavior under different types of loading conditions.[1][2]

1.2 Transient Analysis in FEM

Transient analysis is a time-dependent approach in FEM, suitable for studying the response of a structure subjected to varying loads. In the context of bridge slabs, transient static and transient dynamic analyses help model the deflection response to moving vehicles, thermal expansion, and dynamic forces such as earthquakes or impacts.

II. METHODOLOGY

Transient Static Analysis of Bridge Slab Deflection

2.1 Overview of Transient Static Analysis

Transient static analysis considers time-varying loads while ignoring inertia effects. It assumes that the system's response is quasi-static, meaning the load application is slow enough that the dynamic effects of inertia and damping can be neglected.

2.2 Mathematical Formulation

The equilibrium equation for transient static analysis is:

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Ku(t)=F(t)\math bf{K}\math bf{u}(t) = \math bf{F}(t)Ku(t)=F(t)

Where: K\math bf{K}K is the global stiffness matrix, u(t)\math bf{u}(t) u(t) is the displacement (or deflection) vector at time t, F(t)\math bf{F}(t) F(t) is the time-varying load vector.

2.3 Applications to Bridge Slabs

In bridge engineering, transient static analysis is useful for modeling slow-moving loads, such as vehicles passing over the bridge or gradual thermal expansion due to temperature changes. These loading conditions change over time but are slow enough that inertia forces do not play a significant role in the slab's response.

2.4 Influence on Deflection

In transient static analysis, deflection is solely a function of the stiffness and the time-varying load. Since inertia and damping are neglected, the deflection at any given time depends on the instantaneous load. For example, as a heavy truck crosses a bridge slowly, the slab will deflect in response to the weight, but no oscillations or dynamic effects are considered.

III. PRIOR APPROACH

Transient Dynamic Analysis of Bridge Slab Deflection

3.1 Overview of Transient Dynamic Analysis

Transient dynamic analysis takes into account the time-varying loads as well as inertia and damping effects. This is essential for modeling scenarios where loads change rapidly or where the structure experiences dynamic events such as impacts, vibrations, or seismic forces.

3.2 Mathematical Formulation

The equation of motion governing transient dynamic analysis is:

Mu¨(t)+Cu˙(t)+Ku(t)=F(t)\math bf{M}\math bf {\d dot{u}} (t) + \math bf{C}\math bf{\dot{u}} (t) + \math bf{K}\math bf{u}(t) = \math bf{F}(t) Mu¨(t)+Cu˙(t)+Ku(t)=F(t)

Where:

M\math bf{M}M is the mass matrix,

C\math bf{C}C is the damping matrix,

u¨(t)\math bf {\d dot{u}} (t)u¨(t) is the acceleration vector,

u˙(t)\math bf{\dot{u}} (t)u˙(t) is the velocity vector,

K\math bf{K}K is the stiffness matrix,

u(t)\math bf{u}(t) u(t) is the displacement vector,

F(t)\math bf{F}(t) F(t) is the applied load.

3.3 Applications to Bridge Slabs

Transient dynamic analysis is essential for analyzing bridge slabs subjected to rapid loading conditions, such as dynamic effects of fast-moving vehicles.

Seismic activities.

Impacts from external sources (e.g., falling debris or vehicular accidents).

In these situations, the bridge slab's response will not only depend on the applied load but also on how quickly the load is applied, leading to oscillations and vibrations that affect deflection.

3.4 Influence on Deflection

Unlike transient static analysis, transient dynamic analysis predicts time-dependent deflection by considering the combined effects of stiffness, inertia, and damping. A rapid load or impact will cause the bridge slab to oscillate before stabilizing, leading to transient deflections that are larger or smaller than the static deflection, depending on the dynamics of the system.

IV. OUR APPROACH

Case Study: Bridge Slab Under Moving Load

To illustrate the influence of transient static and transient dynamic analyses on bridge slab deflection, a case study is performed using a simple bridge slab model in ANSYS subjected to a time-varying moving load (e.g., a vehicle crossing the bridge).

4.1 Model Setup

The bridge slab is modeled using a shell or solid element in ANSYS, with the following parameters:

Length: 20 m,

Width: 5 m,

Thickness: 0.3 m,

Material: Reinforced concrete.

A time-varying load representing a vehicle moving at different speeds is applied. The slab is fixed at the ends to simulate the support conditions of a typical bridge.

4.2 Transient Static Analysis Results

In the transient static analysis, the load is applied slowly to simulate a vehicle moving at low speed. The results show that the maximum deflection occurs at the midpoint of the slab as the vehicle crosses. Since inertia effects are neglected, the deflection increases gradually and returns to zero after the vehicle passes.

Maximum deflection: 12 mm (under slow-moving load).

Behavior: No oscillation, smooth deflection curve.

4.3 Transient Dynamic Analysis Results

For the transient dynamic analysis, the vehicle moves at a high speed, simulating a more dynamic load scenario. The results show oscillations in the deflection as the slab experiences inertia and damping effects. The deflection is larger than in the static case due to dynamic amplification, and vibrations persist for some time after the load is removed.

Maximum deflection: 18 mm (under fast-moving load).

Behavior: Oscillatory deflection, with damping reducing oscillations over time.[3][4][5]

Discussion and Comparison

The comparison between transient static and transient dynamic analyses highlights the importance of choosing the appropriate method based on loading conditions.

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Transient Static Analysis:

The transient static analysis is performed accounting speed parameters, bridge damping, span length and class of vehicle. The maximum displacement pattern with respect to time and location of moving the load is obtained for each bridge model. Figure (a) shows the nature of static vertical displacement of a bridge of 8 m span considering the just effect of static IRC -6 Class 70R and Class A loading. similar behavior of bridge was observed in case of IRC Class 70R and Class A loading. Vehicle load .it has been seen that maximum displacement and bending moment is obtained when the load is placed at the center of span much like a simply supported beam. The maximum values of deflection obtained are obtained as 33mm,31mm ,33.03for IRC 70R, Class A and Class AA loading, respectively. It has been found out of these three loading pattern IRC Class AA gives maximum deflection value. Suitable for slow-moving or gradually applied loads where inertia can be ignored. The deflection is purely a function of the stiffness and the time-varying load, and the results are more straightforward and less computationally expensive.

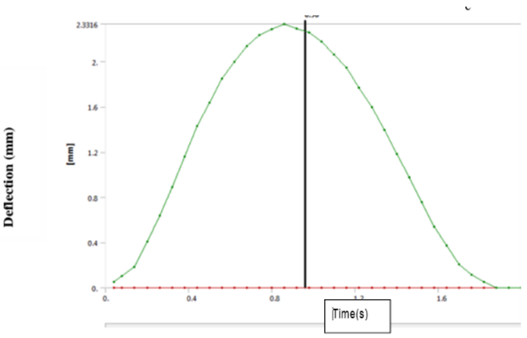
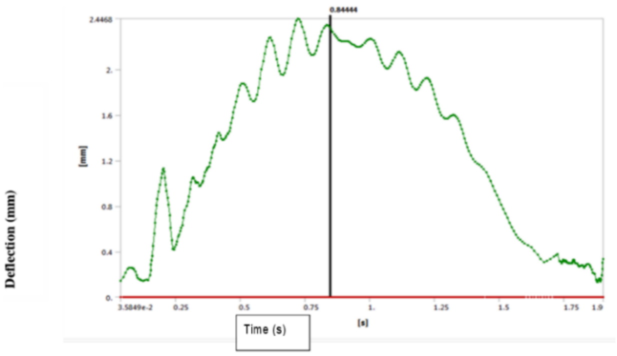


Figure (a)-Static deflection of bridge under Class AA loading

Transient Dynamic Analysis:

Transient dynamic analysis has been performed accounting speed parameters, bridge damping, span length and class of vehicle. The maximum displacement pattern with respect to time and location of moving load is obtained for each bridge model. Figure (a),(b) shows the nature of dynamic vertical displacement of bridge slab for 8 meter bridge and speed of 60 km/h.it is observed that in most of the cases maximum vertical deflection and bending moment is reported when load is at center or crossing the mid of span. The maximum dynamic deflection of 35 mm is reported for bridge length of 100 m with vehicle travelling speed of 200 km/necessary for fast-moving or dynamic loads where inertia and damping effects cannot be ignored. The deflection is more complex, involving oscillations and potentially larger peak values due to dynamic amplification. The results from the case study clearly show that transient dynamic analysis is crucial when dealing with high-speed loads or impact events. Transient static analysis, while simpler, may under predict deflection in such cases.



Figure(b)- Dynamic deflection of bridge slab

V. CONCLUSION

The influence of transient static and transient dynamic analyses on the deflection of bridge slabs is significant, particularly in the context of time-varying loads. While transient static analysis is effective for slowly applied loads, transient dynamic analysis is essential for capturing the true behavior under rapid or dynamic loading conditions. By using FEM tools like ANSYS, engineers can simulate these scenarios to ensure the safety and durability of bridge structures.

REFERENCES

[1] Cantieni, R," Dynamic load tests on highway bridges in Switzerland", Report No.211, EMPA Dubenprof, Switzerland,1983.

[2] Heywood, R., Roberts, W., and Boully, G." Dynamic response of bridges", Paper No 2731, Transportation Research. Record, 2001.

[3] Billing, J.R. and Green, R.," Designp provisisons for dynamic loading of highway bridges", Transport. Res. Record., No. 950,1984, pp 94-103

[4] Coussy, O., Said, M., and van Hoove, J. P. (1989). "The influence of random surface irregularities on the dynamic response of bridges under sus-pended moving loads." J. Sound Vib., 130(2), 313–320.

[5] Ilze Paeglite and Ainars Paeglitis (2013). "The Dynamic Amplification Factor of the Bridges in Latvia" Procedia Engineering 57 (2013) 851 – 858.