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Analysis of Bridge-Pile Foundation System in Multi-layered Non-Linear Soil Strata Using Energy-Based Method

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Abstract : The increasing demand for adopting pile foundations in bridgeshas pointed towardsthe need to constantly improve the existing analytical techniques for better understanding of the behavior of such foundation systems. This study presents a simplistic approach using the energy-based method to assess the displacement responses of piles subjected to general loading conditions: Axial Load, Lateral Load, and a Bending Moment. The governing differential equations and the boundary conditions for a bridge pile embedded in multi-layered soil strata subjected to the general loading conditions are obtained using the Hamilton's principle employing variational principles and minimization of energies. The soil non-linearity has been incorporated through simple constitutive relationships that account for degradation of soil moduli with increasing strain values.A simple power law based on published literature is used where the soil is assumed to be nonlinear-elastic and perfectly plastic. A Tresca yield surface is assumed to develop the soil stiffness variation with different strain levels that defines the non-linearity of the soil strata. This numerical technique has been applied to a pile foundation in a two - layered soil strata for a pier supporting the bridge and solved using the software MATLAB R2019a. The analysis yields the bridge pile displacements at any depth along the length of the pile. The results of the analysis are in good agreement with the published field data and the three-dimensional finite element analysis results performed using the software ANSYS 2019R3. The methodology can be extended to study the response of the multi-strata soil supporting group piles underneath the bridge piers.

Keywords : pile foundations, deep foundations, multilayer soil strata, energy based method
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