

Eigenvalue Solutions for Euler-Bernoulli Beams on Two-Parameter Foundations Using Stodola-Vianello Iteration Method and Polynomial Basis Functions

Charles Chinwuba Ike (PhD)

Professor, Department of Civil Engineering, Enugu State University of Science and Technology,
Agha 402004 Enugu State, Nigeria.

Corresponding Author: charles.ike@esut.edu.ng

ABSTRACT : The critical buckling load determination of axially compressed simply supported Euler-Bernoulli beams rested on two-parameter foundations (EBBo2PF) of Filomenko-Borodich, Pasternak or Vlasov is important for their analysis and design. This work uses the Stodola-Vianello iteration method to formulate the governing domain equation, and constructs a fourth degree polynomial shape function that satisfies the simply supported ends. By substitution of the derived polynomial basis function in the Stodola-Vianello iterations and use of boundary conditions, the four constants of integration in the algebraic formulation are calculated. The requirement for convergence of the iteration at the first iteration is used to establish the buckling equation, whose roots yield the eigenvalue from which the critical buckling load is derived. The critical buckling load expression is found to depend upon the two beam-foundation parameters $\beta_1 l^4$ and $\beta_2 l^2$; and presented in tabulated forms for given values of the foundation parameters. The critical buckling load solution obtained in this study showed insignificant difference of less than 0.075% from the previously reported solution by Arghel and Mares for all values of the foundation parameters. It is further found that when the second foundation parameter β_2 vanishes the buckling load becomes identical to the critical buckling load for Euler-Bernoulli beams on Winkler foundations, EBBoWF.

KEYWORDS Euler-Bernoulli beam on two-parameter foundation, eigenvalue, critical buckling load, characteristic buckling equation Stodola-Vianello iteration method.

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1. INTRODUCTION

Several problems in structural and foundation engineering can be analyzed as beam on elastic foundation problems. Such problems are formulated using the theories of beams and elastic foundations. They are complex soil structure interaction problems and certain other engineering problems have analogous equations and can be solved via the beam on elastic foundation approach (Dutta et al, 2021). In such problems, the structural footing beam and the soil are required to act together in supporting the loads (Dutta et al, 2021). The theories of beams have been derived by Euler and independently by Bernoulli, Timoshenko, Levinson (1981), Sayyad and Ghugal (2011), Dabake and Ghugal (2013) and several other researchers.

Similarly, elastic foundation theories have been developed by Winkler, Pasternak, Vlasov, Filomenko and Borodich and Hetenyi (1946). Euler and Bernoulli working independently used orthogonality hypothesis of cross-sectional planes normal to the longitudinal axis of the beam before deformation would retain plane and normal to the longitudinal axis after deformation to develop the classical beam theory now credited to them and called the Euler-Bernoulli beam theory (EBBT) (Emadi et al 2023). The normality assumption implies that transverse shear deformation is neglected, thus limiting the scope of application of the EBBT to thin plates for

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