1374. Instability and resonance analysis of a beam subjected to moving mass loading via incremental harmonic balance method

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Abstract. In this paper, the dynamic stability analysis of a simply supported beam excited by a sequence of moving masses is investigated. All components of the mass acceleration including the centripetal, the Coriolis and the vertical one are considered. The periodical traverse of masses across the beam results to a linear time-periodic problem. The Floquet theory and the Incremental Harmonic Balance (IHB) method are implemented to obtain the boundary between stable and unstable regions in the parameters plane. A new approach for identifying the conditions of resonance is investigated by presenting an intuitive definition of resonance for time-varying systems. This approach enables the IHB method to determine inherent curves of resonance conditions besides its ability to find the boundary curve separating the stable and unstable regions. Numerical simulations confirm the correctness of resulted curves.

Keywords: beam-moving mass interaction, incremental harmonic balance method, dynamic stability, resonance condition.

Nomenclature

ρ	Beam mass density
l	Beam length
A	Beam cross-sectional area
I	Beam moment of inertia
v	Transverse displacement of beam
E	Young's modulus
g	Gravitational acceleration
m	Mass of moving particle
V	Velocity of moving mass
α	Dimensionless particle's mass
Ω	Dimensionless particle's velocity

1. Introduction

A substantial variety of practical systems in engineering can be represented as a flexible beam carrying a moving mass. Many applications such as motion of vehicles or trains on bridges, cranes transporting loads along its span, robotic arms, fluid transfer pipe systems, space structures and high speed machining processes are some of these systems, to enumerate a few. Therefore, determining dynamic behavior of a beam subjected to moving mass has been an interesting subject of investigation for a long time. Historically, the first known attempts to solve a moving load problem arose in the study of the collapse of Chester Railway Bridge by Willis [1] and Stokes [2]. After that, there have been a lot of efforts in this field, including the investigations done by Ayre and Jacobson [3] and two well known monographs by Inglis [4] and Hillerborg [5]. Recently, two books have been published by Fryba [6] and Yang et al. [7]. The growing usage of heavy and rapid truck vehicles besides the employment of lighter and more flexible structures have drawn