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DYNAMICS OF PARTIAL SPACE ELEVATOR WITH PARALLEL TETHERS AND MULTIPLE CLIMBERS

Abstract

Partial space elevator is an attractive alternative to the classical space elevator due to its ability of long-range mass transfer between two satellites at low cost. Its main components are the main satellites, sub satellites, and one or multiple climber(s) moving along the multiple tethers for orbital transfer of payloads. The concept of multiple parallel tethers is proposed to increase the payloads transfer efficiency. However, the study of dynamics behavior of partial space elevator with multiple tether is seldom conducted. Here, in current paper, a high-fidelity model of partial space elevator with highly extensibility is developed by the nodal position finite element method in the arbitrary Lagrangian-Eulerian framework. In the newly proposed method, the material coordinate is introduced together with the nodal position coordinate as the general coordinate. The movement of climber along the tether is accomplished through the moving node and variable-length element. The moving nodes are assigned to the nodes where the climbers are locating, and the elements connecting with the moving nodes are defined as the variable-length element. The lengths of adjacent variable-length element change as the climber moves, where one element is increasing while the other element is decreasing. Moreover, the variation of material coordinate for the moving nodes follows the pre-defined trajectories of climbers. Initially, a numerical simulation is conducted to validate the proposed method. After that, four numerical cases are conducted to investigate the effect of multiple parallel tethers influencing on the dynamics behavior of partial space elevator. It show that the results of parallel tethers match very well with the results of single tether when the transfer motions of climbers of each tether are the same. On the contrary, the difference between the results of parallel tether and single tether is significant as the transfer motions of climbers of each tether are different, where the climbers are not moving simultaneously, and the climber is moving in opposite directions. The reason for this phenomenon is that the interaction effect (the direction of induced Coriolis force is opposite) between parallel tethers