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IMPACT OF ASCENDING AND DESCENDING CLIMBERS ON SPACE ELEVATOR CABLE DYNAMICS

Abstract

How cables (tethers) behave during the operation of space elevator is one of the critical issues for the safe and routine operation. Many types of external force act on the cables, among which Coriolis force due to climbers' ascent and descent as well as the earth's gravitational force and centrifugal force is a major driver for the cable movement with time. Here, we have carried out numerical calculation on how the cable movement would be impacted by the ascending and/or descending climbers. Our effort is mainly focused on identifying how simultaneous dual operation of both ascending and descending climbers improves the overall behavior of the cable movement compared to a single one-way operation of either ascent or descent. In the numerical model in this study, the cable is treated as a multi-body system, which is composed of many point masses, each of which has mass and elasticity, and they are connected to each other by spring. The cable is assumed to be equipped with some mechanism by which ascending and descending climbers can pass each other. The results indicate the following. For a single one-way ascending climber which weighs 670 kg and runs at 300 km/h, the cable behaves vibrating with time between the east and the west, and the climber goes up in a zig-zag way accordingly. The horizontal displacement of the cable reaches more than 1,500 km at a maximum in the western direction. As the mass and the speed of the climber increase, the maximum horizontal displacement also increases. For a single one-way descending climber, in contrary to the case with an ascending one, the cable shows larger displacement in the early phase, and then it gets smaller as the climber approaches the earth surface. For a simultaneous dual operation with ascending and descending climbers, the displacement of the cable is evidently suppressed compared to the single climber operation mainly because the ascending and descending climbers work together to compensate for each other's Coriolis forces, leading to the conclusion that such dual operation should be advantageous. This result suggests that appropriate climber traffic control could help adjust the cable movement as required.