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Effects of different lay angles on characteristic fatigue responses of steel wire ropes

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Abstract:
This paper establishes the effects of different lay angles of steel wire ropes on the resulting damage modes and fatigue fracture characteristics. For this purpose, seven-wire strand (1×7) wire ropes with left lay arrangement and lay angles, α of 11°, 18° and 24° were simulated using finite element (FE) method. Axial load cycles (Pmax = 0.144 minimum breaking load (MBL), R=0.1) along with the Coulomb friction μ of 0.5 between the contacted drawn steel wires are assumed. Results showed that the peak contact pressure, corresponding to the maximum applied load, varies from 1936 to 327 MPa when the lay angle is changed from 11° to 24°. The peak of the localized pressure, at any applied load level, is also higher for a smaller lay angle. The wire rope with the lay angle of 24° experiences the smallest load-displacement hysteresis loop with the relative displacement range of 22 μm. On the other hand, the wire ropes with the lay angle of 11° and 18° develop larger hysteresis loops with the displacement range of 75 and 48 μm, respectively. The dissipated energy due to the frictional contact is 469 N.mm, 314 N.mm, and 132 N.mm for the lay angle of 11°,18°, and 24°, respectively. In addition, the axial stiffness of the wire ropes decreases with the increase of the lay angle. It is anticipated that the wire rope with the large lay angle of 24° would experience fretting fatigue failure associated with the partial slip, while those with smaller lay angles (α=11°,18°) would fail by fretting wear mechanism under the gross slip condition.