The far-infrared absorption spectra have been recorded for hydrogen-bonded complexes of water with methanol and t-butanol embedded in cryogenic neon matrices at 2.8 K. The partial isotopic substitution of individual subunits enabled by a dual inlet deposition procedure provides for the first time unambiguous assignments of the intermolecular high-frequency out-of-plane and low-frequency in-plane donor OH librational modes for mixed alcohol–water complexes. The vibrational assignments confirm directly that water acts as the hydrogen bond donor in the most stable mixed complexes and the tertiary alcohol is a superior hydrogen bond acceptor. The class of large-amplitude donor OH librational motion is shown to account for up to 5.1 kJ mol⁻¹ of the destabilizing change of vibrational zero-point energy upon intermolecular OH...O hydrogen bond formation. The experimental findings are supported by complementary electronic structure calculations at the CCSD(T)-F12/aug-cc-pVTZ level of theory.