Carbon-Fiber Elevator Rope - Innovation Description

The KONE UltraRope™ is a new hoisting technology that could eliminate many of the disadvantages of conventional steel cable, or rope, as it is known in the trade, and opens up new possibilities in high-rise building design – an important consideration as urbanization brings increasing numbers of people to cities.

The primary problem with steel rope is that it is heavy. Comprised of a carbon-fiber core and a unique high-friction coating, KONE UltraRope is extremely light, which reduces energy consumption in high-rise buildings. The drop in rope weight means a dramatic reduction in elevator moving masses – the weight of everything that moves when an elevator travels up or down, including the hoisting ropes. Due to the significant impact of ropes on the overall weight of elevator moving masses, the benefits of KONE UltraRope increase as travel distance grows.

KONE UltraRope has an exceptionally long lifetime – twice that of conventional steel rope – and thanks to the special coating, no lubrication is required in maintaining it, enabling further cuts in environmental impact. This is achievable because the nature of the epoxy coating keeps the carbon fiber in a rectangular bar shape, transferring tension between carbon fibers. The fibers themselves have a high elastic modulus and good bending fatigue properties, and are inert in high temperatures – all serious considerations in tall buildings

Elevators are currently limited to a single-shaft height of approximately 500 meters, requiring transfers to reach the top of super tall buildings. Because steel rope's weight is dramatically affected by height, the amount of energy required to lift a car increases exponentially, even if all other factors remain the same. KONE UltraRope is only 19 percent of the weight of steel-cored rope of the same strength. At greater heights, steel ropes are subject to snapping under their own weight.

In a building of 500 meters in height, the steel rope weight needed to lift a 2,000 kg (4,400 lb) car would total 29,000 kg (64,000 lb), compared to 12,800 kg (28,000 lb) of UltraRope, a 55 percent reduction. This has enormous implications for the potential future height of buildings – a 1,000-meter single lift is now possible, effectively doubling the potential height of towers that now use multiple shafts and transfer lobbies to reach the top. That means a single-car ride to the top of a 1 kilometer building, or a two-car trip to the top of a 2 kilometer building, is now achievable.

UltraRope's mass has energy saving implications as well, as the steel rope configuration requires 1,180 megawatt-hour (MWh) of electricity to operate, and the KONE UltraRope requires only 1,050 MWh. In a 500-meter-tall building, this translates to a 60 percent reduction of overall moving mass, for an annual energy saving of 15 percent. Performance improves exponentially with height. In an 800-meter-tall building, the overall moving mass of a car would be reduced by 90 percent, for a 45 percent energy reduction.

Reduced moving masses also mean that, in a 500-meter tower using steel rope, the electrical current needed to counter gravity's acceleration can increase 3.5 times over the nominal current needed to move the car at ground level. With KONE UltraRope, acceleration currents are equal to those found in a 150-meter tower.

KONE UltraRope is extremely strong and highly resistant to wear and abrasion. Elevator downtime caused by building sway is also reduced, as carbon fiber resonates at a completely different frequency to steel and most other building materials. Steel rope solutions require additional compensating ropes and sometimes must be shut down completely if the building sways at the same or greater frequency than that of the ropes, KONE UltraRope is much lighter and sways at much higher frequencies than the building, thus shutdown under these conditions is not required.

KONE UltraRope has been developed and tested rigorously both in real elevators and simulation laboratories at KONE's research and development facilities in Finland. Since 2010, it has been tested in operation at the world's tallest elevator testing laboratory, KONE's Tytyri facility built 350 meters underground. It has been tested at speeds of up to 15 m/s, which is lower than the rope's practical limit. It was also tested while supporting a load of 1,600 kg at a speed of 6 m/s, on a machine that earlier could only lift 900 kg with steel rope under the same conditions. This has the potential to reduce elevator machine sizes in the future, which would "give back" even more floor space to occupiable areas of tall buildings. In October 2013 UltraRope was installed as a retrofit in a 195 m length passenger elevator from ground floor to floors 34-57 in Tower 3 of the Marina Bay Sands luxury resort in Singapore, one of the resort's 146 KONE elevators.

KONE UltraRope was recognized as one of two winners of the 2013 Innovation Award presented by the Council on Tall Buildings and Urban Habitat. ENR titled its January 27, 2014 article on KONE UltraRope "The Biggest Change in Elevators Since 1853."

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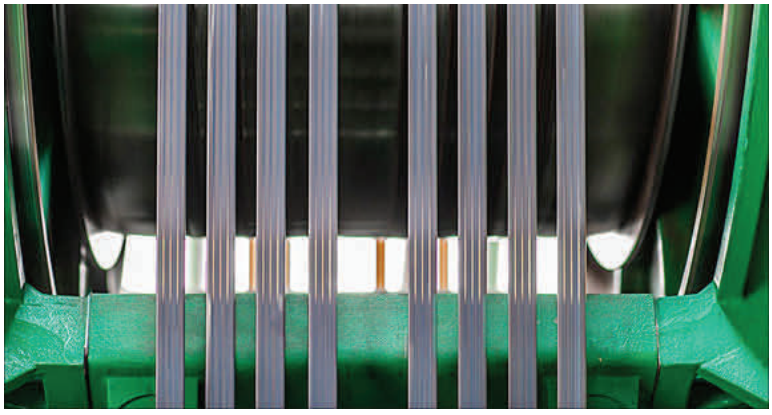
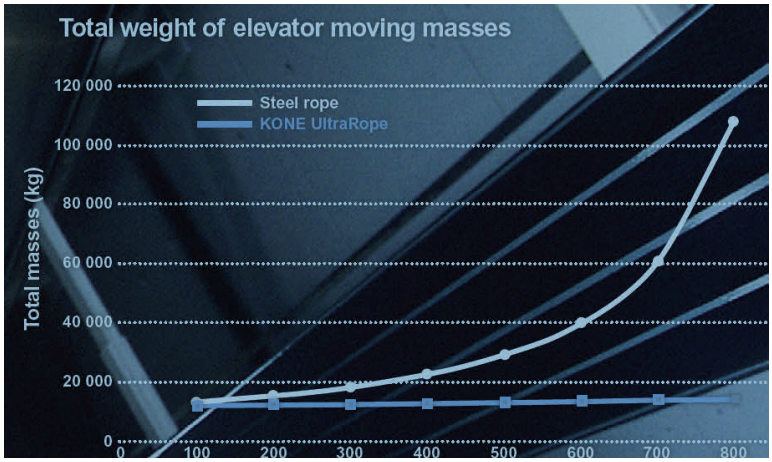
Elevator components

UltraRope is rectangular band vs round stranded steel rope



UltraRope in the elevator hoisting machine



Weight of elevator moving masses vs travel length of elevator for steel rope and UltraRope