

SPECIFICATION

TITLE OF THE INVENTION

ELEVATOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2013-179410, filed on August 30th, 2013, and the entire contents of which are incorporated herein by reference.

FIELD

Embodiments of the present invention relate to an elevator device for lifting or lowering, like a draw well, an elevator car and counterweight, which are provided in a hoistway so as to be able to go up or down, using a main rope of a novel configuration that is wound around a hoist.

BACKGROUND

In general, in an elevator device, as a main rope for lifting or lowering an elevator car and a counterweight, a wire rope that is made by braiding strands of steel wire is used. However, in the case of an elevator device for

high-rise buildings in which a lifting/lowering path is 500 to 600 meters in length, an increase in the weight of the rope leads to an increase in the slung load. Therefore, it is hoped that an increase in the weight of the rope will be curbed.

In recent years, as a main rope of the elevator device, a main rope that is made of material other than steel has been proposed. For example, such ropes include a rope having a load bearing portion made of a composite material that is made by impregnating non-metallic fiber such as carbon or glass fiber with polymer matrix (See Patent Document 1); and a rope that contains carbon and a filament covered with a matrix made of polymer material (See Patent Document 2).

Patent Document 1: Japanese PCT National Publication No. 2011-509899

Patent Document 2: Japanese Patent Laid-Open Publication No. 2013-504695

As described above, in the case of the elevator device that uses, as a main rope, a wire rope made of strands of steel, the problem is that the weight of the rope increases as the lifting/lowering path becomes longer, and the increase leads to an increase in the slung load.

Therefore, what is proposed is a main rope for elevators that uses material other than steel.

The object of the present invention is to provide an elevator device that uses a main rope of a novel configuration which is made of material other than steel and which is lightweight and high in mechanical strength.

An elevator device of an embodiment of the present invention that lifts or lowers, like a draw well, an elevator car and counterweight, which are provided in a hoistway so as to be able to go up or down, using a main rope wound around a hoist, wherein the main rope includes a load bearing member made of polymer material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating the overall configuration of an elevator device according to one embodiment of the present invention;

FIG. 2 is a cross-sectional view of one example of a main rope for the elevator device shown in FIG. 1;

FIG. 3 is a cross-sectional view of another example of a main rope for the elevator device shown in FIG. 1;

FIG. 4 is a cross-sectional view of still another example of a main rope for the elevator device shown in

FIG. 1; and

FIG. 5 is a cross-sectional view of another example of a main rope for the elevator device shown in FIG. 1.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

First, with reference to FIG. 1, the basic configuration of an elevator device of this embodiment will be outlined. In FIG. 1, an elevator device 11 includes an elevator car 13 and counterweight 14, which are provided in a hoistway 12 so as to be able to go up or down. The elevator car 13 and the counterweight 14 are connected together via a main rope 15, which is wound around a main sheave 21 of a hoist 20. The elevator car 13 and the counterweight 14 are driven in such a way as to go up or down like a draw well. That is, the elevator device is of a so-called draw-well type in which the elevator car 13 and counterweight 14 provided in the hoistway 12 are connected together via the main rope 15. A control panel 18 controls the driving of each part of the elevator device 11. As the elevator car 13 goes up

or down in the hoistway 12, a user can get to a loading zone 17 of any destination floor.

The hoistway 12 is provided in a vertical direction of a building across a plurality of floors. The above-described hoist 20, control panel 18, and the like are provided in an upper machine room 19 of the hoistway 12 or the like, for example. In the elevator device 11, the control panel 18 controls the hoist 20. As the main sheave 21 is rotated, the main rope 15 is driven in a length direction due to a friction force with the main sheave 21, thereby alternately lifting or lowering the elevator car 13 and the counterweight 14.

Instead of a conventional steel wire rope, the main rope used here has a load bearing member that is made of strands of polymer material. One example of the polymer material is an ultra-high-molecular-weight polyethylene whose molecular weight has been increased to one million to seven million. Examples of the configuration of the main rope 15 will be described with reference to FIGS. 2 to 4, which show a cross-section thereof.

A main rope 15 shown in FIG. 2 includes a load bearing member 251 that is a group of strands made up of a plurality of strands 25, which are made by molding

ultra-high-molecular-weight polyethylene into a fibrous, elongated shape. The load bearing member 251 is made by arranging a plurality of strands 25 along the length direction of the main rope 15 in the length direction thereof, and at equally-spaced intervals in the transverse direction thereof. The periphery of the load bearing member 251 is covered with a coating material 26, which is made of soft resin material such as urethane resin. Needless to say, the soft resin material that serves as the coating material 26 also fills the space between the strands 25. As a result, the strands 25 are kept at equally-spaced intervals. Moreover, the main rope 15 is formed into a belt-like shape that is greater in width than in thickness as shown in FIG. 2.

A main rope 15 shown in FIG. 3 includes a load bearing member that is made by twisting together a plurality of strands 25 (shown in FIG. 2), which are made by molding ultra-high-molecular-weight polyethylene into a fibrous, elongated shape, to make a relatively thin rope-like unit rope 252, and then arranging two or more unit ropes 252 (or eight ropes in the example of FIG. 3) parallel to each other and in a row. The peripheries of the unit ropes 252 that serve as the load bearing member are covered with a

coating material 26 made of soft resin material. The main rope 15 is formed into a belt-like shape that is greater in width than in thickness as shown in FIG. 3.

A main rope 15 shown in FIG. 4 includes a load bearing member 253 that is one thick rope made by twisting together a plurality of strands 25 (shown in FIG. 2), which are made by molding ultra-high-molecular-weight polyethylene into a fibrous, elongated shape. The periphery of the load bearing member 253 that is one thick rope is similarly covered as a coating material 26 made of soft resin material fills. In this case, the main rope 15 is circular in cross-section as shown in FIG. 4.

In that manner, if the load bearing members 251, 252, and 253 are made of ultra-high-molecular-weight polyethylene, the mass thereof is significantly lighter than that of a steel-material wire rope, or about one-seventh of the weight of the steel-material wire rope because ultra-high-molecular-weight polyethylene is smaller in specific gravity than water. The strength thereof turns out to be $3,500\text{N/mm}^2$, depending on the type. Therefore, the ropes made of ultra-high-molecular-weight polyethylene are strong enough to replace the steel wire rope. That is, the fiber of ultra-high-molecular-weight

polyethylene is lightweight and is excellent in flexibility, wear resistance, and flexural fatigue resistance. Therefore, an ultra-light, ultra-high strength rope can be obtained.

If the coating 26 of soft resin material is applied to the load bearing members 251, 252, and 253, it is possible to achieve a sufficient traction performance that is required for elevator devices because of a high friction coefficient of the coating material 26.

For example, the coating material 26 may be made of ethylene-propylene-diene rubber, chloroprene rubber, chlorosulphonyl-polyethylene rubber, ethylene vinyl acetate rubber, butyl rubber, acrylonitrile-butadiene rubber, natural rubber, styrene-butadiene rubber, acrylic rubber, fluorine-contained rubber, silicone rubber, polyolefin rubber, or a material made by combining any two or more of the above compounds.

The coating material 26 may be made of a thermosetting resin that is cured at 100 degrees Celsius or higher. For example, the thermosetting resin may be made of styrene-block copolymer, styrene-diene-block copolymer, a mixture of ethylene-propylene diene rubber and polypropylene, urethane-based thermoplastic

elastomer, copolyester-based thermoplastic elastomer, copolyamide-based thermoplastic elastomer, or a material made by combining any two or more of the above compounds.

The following describes the case where, as a polymer material for a load bearing member of a main rope 15, polyparaphenylenebenzobisoxazole (referred to as PBO, hereinafter) fiber is used. In this case, as shown in FIG. 5, the main rope 15 includes a load bearing member 35 that is made by molding a composite material that includes the PBO fiber and epoxy resin as polymer materials into a plate-like belt shape. The periphery of the load bearing member 35 is covered with a coating material 36 made of soft resin material.

The above-described PBO fiber has a high degree of elasticity, and can be made lighter than other fibers. If the PBO fiber is used for a main rope of an elevator device for high-rise buildings in which a lifting/lowering path is 500 to 600 meters in length, the PBO fiber is effective in curbing an increase in the weight of the rope. However, the PBO fiber is vulnerable to ultraviolet rays and visible light; in the case of a typical coating of elastomer, the rope can be quickly weakened in strength due to ultraviolet rays and the like.

If the load bearing member 35 contains the PBO fiber, or for example if a composite-material member made of the PBO fiber and epoxy resin is used as described above, the coating material 36 used is a resin coating material to which an ultraviolet absorber has been added as an additive agent. Then, the periphery of the load bearing member 35 is covered with the coating material 36. For example, the ultraviolet absorber is carbon black; a polyurethane resin to which carbon black has been added is used as the coating material 36.

In that manner, the composite material that includes the PBO fiber and epoxy resin, which is a tensile-strength material, is used as the load bearing member 35; the periphery thereof is covered with the coating material 36 that is the polyurethane resin to which carbon black has been added to absorb light such as ultraviolet rays. Therefore, it is possible to curb a decrease in the strength of the PBO fiber caused by ultraviolet rays and the like.

If the belt-like main rope 15, which includes the load bearing member 35 made of the composite material containing the PBO fiber and epoxy resin and which is covered with the coating material 36, is applied to an

elevator device, the diameter of the sheave (represented by reference numeral 21 in FIG. 1) that is used in combination with the main rope 15 is 50 or more times larger than the thickness t of the load bearing member 35, which is a composite material portion, with respect to a bending direction.

In this manner, the diameter of the sheave that is used in combination with the belt-structure main rope 15 is 50 or more times larger than the thickness t of the composite material portion. As a result, it is possible to prevent early deterioration of the epoxy resin portion which is made of the composite material, resulting in an improvement in the durability of the main rope 15.

Incidentally, the same is true for the main ropes 15 having the structures shown in FIGS. 2 to 4. That is, in the case of FIG. 2, the thickness of the group 251 (load bearing member) of strands that includes a plurality of strands 25 is the thickness t with respect to the bending direction. In the case of FIG. 3, the diameter of a plurality of unit ropes (load bearing member) 252 that are arranged parallel to each other and in a row is the thickness t with respect to the bending direction. In the case of FIG. 4, the diameter of one rope portion (load

bearing member) 253 is the thickness t with respect to the bending direction. When those ropes are used in combination with the sheave with a diameter 50 or more times larger than the thickness t , a decline in the strength caused by the bending of the main rope 15 can be curbed, resulting in an improvement in the durability.

According to this embodiment, the main rope made of the PBO fiber, which is the strongest among organic high-strength fibers and has a high degree of elasticity, is employed. Therefore, in a recently-planned building that is higher than 500 meters, the mass of the main rope can be reduced to about one-tenth of the conventional one. As a result, it is possible to greatly reduce the load applied to a building structure, as well as the amount of structural material used.

Incidentally, in each of the embodiments described above, when ultra-high-molecular-weight polyethylene is used in the load bearing member, the main rope 15 is formed as shown in FIGS. 2 to 4. If the PBO fiber is used, the main rope 15 is formed as shown in FIG. 5. However, the present invention is not limited to such combinations.

For example, a load bearing member 35 that is made by molding ultra-high-molecular-weight polyethylene into

a plate-like belt shape as shown in FIG. 5 may be used, and the periphery thereof may be covered with a coating material 36 made of soft resin material. A load bearing member 251 may be made by molding a composite material that includes the PBO fiber and epoxy resin into an elongated strand and forming a group of strands in which a plurality of the strands 25 are evenly arranged as shown in FIG. 2, and the load bearing member 251 may be covered with a coating material 26 and formed into a belt shape. Alternatively, as shown in FIG. 3, a load bearing member may be made by twisting together a plurality of strands to form a relatively thin rope-like unit rope 252 and by arranging two or more unit ropes 252 parallel to each other and in a row, and the periphery of a plurality of unit ropes 252 that constitute the load bearing member may be covered with a coating material 26 and formed into a belt shape. Furthermore, as shown in FIG. 4, a plurality of strands may be twisted together to make one thick rope that is used as a load bearing member 253, and the periphery of the load bearing member 253 may be covered with a coating material 26 and formed into a rope that is circular in cross-section. In this manner, any combination of shape structures is possible. Needless to say, if the PBO fiber is used, a

resin coating material to which an ultraviolet absorber has been added as an additive agent is used as a coating material 26.

Incidentally, as an example in which a rope other than the steel wire rope is used as the main rope of the elevator device, those proposed by the above Patent Documents 1 and 2 are illustrated. However, those ropes include a load bearing member made of a composite material that includes carbon fibers and the like in a matrix, and therefore are very different from the main ropes that include a load bearing member made of polymer material such as ultra-high-molecular-weight polyethylene or PBO fiber shown in the embodiments of the present invention.

Several embodiments of the present invention have been described. However, the embodiments are given for illustrative purposes, and not intended to limit the scope of the invention. These novel embodiments may be embodied in other various forms. Various omissions, replacements and changes may be made without departing from the subject-matter of the invention. The above embodiments and variants thereof are within the scope and subject-matter of the invention, and are similarly within the scope of the invention defined in the appended claims

and the range of equivalency thereof.

WHAT IS CLAIMED IS:

1. An elevator device for lifting or lowering, like a draw well, an elevator car and counterweight, which are provided in a hoistway so as to be able to go up or down, using a main rope that is wound around a hoist, wherein

the main rope includes a load bearing member made of polymer material.

2. The elevator device according to claim 1, wherein

as the polymer material, an ultra-high-molecular-weight polyethylene whose molecular weight is increased to one million to seven million is used.

3. The elevator device according to claim 1, wherein

as the polymer material, polyparaphenylenebenzobisoxazole (referred to as PBO, hereinafter) fiber is used.

4. The elevator device according to claim 3,

wherein

the load bearing member is a composite-material member that includes, as the polymer material, the PBO fiber and epoxy resin.

5. The elevator device according to any one of claims 1 to 4, wherein

the load bearing member is made by arranging a plurality of strands, which are made by molding the polymer material into an elongated shape, along and parallel to a length direction of the main rope in a length direction thereof, and at equally-spaced intervals in a transverse direction.

6. The elevator device according to any one of claims 1 to 4, wherein

the load bearing member is made by twisting together a plurality of the strands and is formed into a rope.

7. The elevator device according to claim 6, wherein

in the load bearing member, two or more unit ropes, which are formed into a rope, are arranged parallel to each

other.

8. The elevator device according to any one of claims 1 to 7, wherein

the load bearing member is formed into a plate-like belt shape.

9. The elevator device according to any one of claims 1 to 8, wherein

the load bearing member is covered with a coating material made of soft resin material.

10. The elevator device according to claim 9 or 10, wherein

as the coating material, a thermosetting resin that is cured at 100 degrees Celsius or higher is used.

11. The elevator device according to any one of claims 3 to 8, wherein

if the load bearing member contains the PBO fiber, the load bearing member is covered with a coating material to which an ultraviolet absorber is added as an additive agent.

12. The elevator device according to any one of claims 9 to 11, wherein

as the coating material, urethane resin is used.

13. The elevator device according to claim 11, wherein

polyurethane resin to which carbon black is added as the ultraviolet absorber is used for the coating material.

14. The elevator device according to any one of claims 1 to 13, wherein

the diameter of a sheave that is used in combination with the main rope is 50 or more times larger than a thickness of the load bearing member with respect to a bending direction.