Title: **Innovative Elevator Technologies To Future Proof Your Building**

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Subject: Vertical Transportation

Keywords:
Access Control
Destination Control
Energy Consumption
Technology
Vertical Transportation

Publication Date: 2014

Original Publication: CTBUH 2014 Shanghai Conference Proceedings

Paper Type:
1. Book chapter/Part chapter
2. Journal paper
3. **Conference proceeding**
4. Unpublished conference paper
5. Magazine article
6. Unpublished

Innovative Elevator Technologies To Future Proof Your Building

面向未来建筑的创新电梯技术

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Due to his exceptionally wide technical expertise he functions as one of the senior vertical transportation advisors globally. He has received several awards and mentions for his work.

He is a member of the advisory group of the CTBUH and a member on several technical workgroups of the European Elevator Code committee.

Johannes holds over 700 patents and has been involved in many of the world's tallest buildings.

Johannes de Jong (工程硕士) 是目前通力全球重点项目部的技术总监。

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Abstract

Urbanization is driving accelerated growth of cities. Buildings are becoming more complex and smarter. Integration of intelligent building systems and integration of multiple buildings is becoming more common. The latest elevator integration innovations, to future proof your building, are described in detail. Not only have cities grow fast, so has the height of buildings. Exponential rope weight increase is now limiting the commercial travel of elevators between 500 and 600 m. The latest innovation in rope technology "KONE UltraRope" will dramatically reduce rope weight, allowing us to clearly exceed the present travel limits. Energy consumption will also see a major improvement. Other rope related issues such as building sway; rope life etc. will improve considerably. These innovative new technologies will ensure a more sustainable vertical urban environment. These technologies can also be used to upgrade existing buildings to the latest standards of the 21st century.

Keywords: Vertical Transportation; People Flow Intelligence; Destination Control; Access Control; KONE UltraRope; Energy Consumption

摘要

城市化正推动着城市的快速发展。城市中的建筑正变得越来越复杂和高智能化。其中，对智能建筑控制系统和多栋建筑间的整合需求也变得越来越普遍。为了使您的建筑成功地面向未来-，本文详细描述了最新的电梯整合创新技术。 不仅城市快速发展，建筑的高度也同样不断提高。曳引绳重量呈指数的增加将目前电梯的最大行程限制在500至600米之间。 曳引绳技术的最新技术创新"通力UltraRope"将大大降低绳索的重量，使我们能够完全超越目前的电梯行程限制。同时，在能源消耗方面也会有可见的重大改进。 与曳引绳相关的其他问题，如建筑摇摆;绳索的寿命等，都将得到大大改善。 这些创新的技术将确保提供具有可持续性发展的城市垂直运输环境。这些技术也能将现有建筑物升级以达到21世纪的最新标准。

关键词: 垂直运输; 智能客流解决方案; 目的选层控制系统; 门禁系统; 通力UltraRope; 能源消耗。

Introduction

Urbanization is driving the growth of cities. The United Nations (1) estimates that between 2011 and 2030 the urban population will increase significantly by 1.36 billion. The trend is clear: cities will not only get bigger, but also denser.

As digitalization progresses buildings become more complex and smarter. Intelligent integration of technologies inside a building or even between buildings is becoming common. This paper describes the latest elevator systems for intelligent buildings and how these systems will future-proof these buildings.

Cities are growing and densification is clearly raising the number of high-rise buildings being built. According to statistical information by the CTBUH (2) there is a strong increase in the number of high-rise buildings being constructed, the height of these

导论

城市化推动着城市的增长。据联合国 (1) 估计，2011年至2030年间城市人口将显著增加近13.6亿。趋势很明显: 城市不仅会变得更大，也将更密集。

随着数字化的进程，城市中的建筑会变得更加复杂和智能化。建筑内部甚至建筑物之间的智能化集成技术已日趋普遍。本文详细介绍了最新的智能楼宇电梯系统以及这些系统将如何使这些建筑物成功地面向未来。

城市正在快速增长，密集化显而易见地增加了在建高层建筑的数量。据CTBUH的数据统计 (2) 兴建中的高层建筑的数量正强劲增长，这些建筑的高度也呈上升趋势。电梯使摩天大楼成为可能，但目前电梯的提升高度已达到极限。当电梯行程超过550米时，呈指数增长的钢丝绳重量会急剧增加，这也成为了摩天大楼设计中的最大障碍。

buildings is also on the rise. The elevator enabled the skyscraper, but the height limits of modern elevators have now been reached. Exponential elevator rope weight increase has become excessive for travels above 550 m. This has set limits on the way skyscrapers are designed.

This paper also explains how the latest innovations in rope technology will enable much higher travels. This revolutionary rope technology will completely change how skyscrapers and elevators will be designed in the future. This innovation also solves a lot of the other rope issues found in high-rise buildings.

These technologies discussed in this paper will ensure a more sustainable vertical urban environment, especially as they can also be used to upgrade existing buildings to meet the standards of the 21st century.

Intelligent People Flow solution

People Flow Movement Blocks

People Flow describes the movement of people through a building. Figure 1 shows a simple diagram, where each block shows one transition stage. The combination of the transition stages may differ depending on the design of the building. To move from one space to another one will have to use the different blocks shown in figure 1.

All movement blocks may restrict the flow of people and must be well planned to prevent them from becoming bottlenecks in the flow of people.

To find the correct path though a building guidance can be very important, especially for first time or sporadic users. Guidance outside a building is typically handled through navigation systems. Guidance inside the building is much more complex as this requires an extra vertical dimension. Positioning in buildings is being developed, but is not reliable enough for automatic guidance. Inside guidance is therefore often supported through fixed signature or digital solutions like information kiosks. There is a lot of research happening on in-building navigation, and breakthroughs are expected soon.

Intelligent Building Systems

Every building has multitudes of intelligent systems (see Figure 2). Each system may be intelligent on its own, and can perform very complex tasks to the benefit of the users. Users would however benefit even more if the different building systems could interact seamlessly. The result could be a magically tuned system, where every element works exactly at the right time, in the right way without human involvement. As systems may be manufactured by different suppliers, it is often difficult to find system integrators that can combine the different systems seamlessly. Manufacturers are often very protective of their knowhow.

Intelligent People Flow solution

As a first step to integrate intelligent systems in buildings, KONE has combined those systems related to People Flow into one single software platform. This platform is called KONE People Flow Intelligence or KONE PFI. Figure 3 shows a basic KONE PFI diagram.

KONE PFI will combine Access, Destination, Monitoring and Information systems for products such as Doors, Elevators and Escalators into one single platform.

Access and Destination systems have already been integrated into the KONE PFI while Monitoring and Information systems will be integrated

Figure 1. People Flow movement blocks. Source: KONE Corporation
图1客流的移动模块 来源: 通力电梯

Figure 2. Intelligent building systems. Source: KONE Corporation
图2智能楼宇系统 来源: 通力电梯

Figure 3. KONE PFI. Source: KONE Corporation.
图3. 通力PFI 来源: 通力电梯

本文还介绍了在绳索技术上最新的创新是如何使电梯的行程能达到更高。这一革命性的曳引绳技术将彻底改变未来摩天大楼和电梯的设计趋向。同时，这种技术创新也解决了在高层建筑中因钢丝绳引起的许多其他问题。

本文所提及的这些创新技术将确保更具可持续发展的垂直的城市环境，特别是这些技术也能将现有建筑物升级以达到21世纪的最新标准。

智能客流解决方案

客流的移动模块

客流描述了建筑物内人们的移动情况。图1是一个简单的示意图，其中每个模块显示了一个转移节点。转移节点的不同组合取决于建筑的设计。从一个地方移动到另一个地方将使用图1所示的不同的模块。

soon. All these systems work seamlessly together and can be controlled from one single platform. The KONE PFI Platform can then be linked to all other building systems. Access Control and Destination Control will be explained in more detail.

Access Control

Access control has existed practically as long as mankind. Earlier access control was typically a group of big strong man, sometimes heavily armed, guarding an entrance. Access control is in principle a controlled passage way where one needs a permit to pass.

Modern access control is usually linked to an RFID permission code and a computerized database checking the permission rights of a person for a certain barrier such as doors, gates, booms, tripods, turnstiles etc.

Elevators are nowadays often integrated into access control. Destination control, a system where the destination of the user is entered on an input device outside the elevators, often needs to know the access rights of the users, before assigning them. Access is therefore needed at a very early stage. To facilitate this KONE has now launched its own access control system. This system controls the People Flow rights, and can integrate all barriers from the front entrance, through turnstiles, elevators, doors etc., all the way to the final office door.

As access control must be tailored to the needs of the tenants, it is usually ordered at a late stage of construction. This can cause expensive rework once the needs of the tenants are known.

The KONE system is based on products provided by KABA and can be expanded by KABA when the organizational access needs of the customer are known at later stages. This is facilitated by the fact that both systems are fully based on each other.

KONE Access will allow the owner to have a basic access rights system before the building is occupied. When tenants arrive it can easily be upgraded through KABA to include all future organizational needs. This easy expansion of systems from People Flow to Organizational levels is unique.

Integration to a third party access control system is a second option. A simple IP based control protocol enables easy integration of elevators to the access system and to turnstile barriers. KONE Access is then replaced by the 3rd party access system. For KONE Access and integration see Figure 4.

Destination Control

In a conventional hall call systems, the user pushes up or down buttons in the lobby. If up traffic is heavy at a main lobby, a lot of people will enter the car. This also means that a lot of buttons on the car operating panel are pushed. A lot of calls will also mean a lot of stops. In a high speed elevator with a speed of 6 m/s (1200 fpm) each stop may require as much as 10 – 13 seconds.

Destination control is an elevator control system where the users destination is placed on a device called the Destination Operation Panel (DOP) outside the elevator. This device than indicates the assigned elevator. The elevator now knows both the source floor and the destination floor of the user before arriving. This extra information will allow the system to fill the car with people going to the same destination, drastically reducing the number of stops.

This also shortens elevator rides returning elevators sooner to handle the next badge of passengers. Destination control increases the up peak capacity noticeably. Inside the car there are only a few buttons;

Figure 4. KONE Access. Source KONE Corporation
图4 通力门禁 来源: 通力电梯

所有的移动模块可能会对人员流动有所限制，所以必须精心规划，以防止其成为人员流动的瓶颈。

通过楼宇指引找到正确的路径则显得非常重要，特别是对第一次或不常来的用户。建筑外部的指引通常由导航系统来完成。而建筑内部的引导则复杂得多，因为它有垂直方向上的额外维度。建筑内部的定位正在开发，但尚不可靠，还不能用于自动引导。内部的引导因此往往需要通过固定指示或信息亭类的数字化解决方案予以支持。目前有大量的研究针对大楼内部的导航系统，相信将会很快出现突破性进展。

楼宇内部的智能系统

每栋建筑都有众多的智能系统(见图2)。每个系统各自都可有其独立的智能，并且可以执行非常复杂的任务使用户受益。如果建筑中的不同系统可以相互无缝集成，则用户将受益更多。其结果可能成为一个非常神奇的和谐系统，其中的每一部分进行工作都能在正确的时间，通过正确的方式开展且无需人为干预。由于不同系统可能由不同的供应商制造，因此往往很难找到系统集成商将不同的系统进行无缝集成。并且，制造商往往非常注意保护他们的专业技术。

智能客流解决方案

作为集成大楼智能系统的第一步，通力可以在一个单独的软件平台上集合那些和客流相关的系统。该平台被称为通力智能客流解决方案或通力PFI。图3显示了一个基本的通力PFI图表。

通力PFI集合了门禁控制、目的选层、门/电梯/扶梯等设备的监控和显示系统，整合到一个单一的平台。

门禁控制和目的选层系统已经整合入通力PFI，并且电梯监控和信息显示系统也将很快被整合。所有这些系统被无缝集成在一起协同工作，并可以从一个单一的平台上进行控制。通力PFI平台可以连接至其他楼宇系统。门禁控制和目的选层将在下文中进行更详细的说明。

门禁控制

门禁控制实际上从人类存在起就已经存在。早期的访问控制是由一群强壮的男人组成，有时全副武装，守卫入口。门禁控制原则上是，人们需要一个许可才能允许进入受控的通道。

现代化的门禁控制通常是连接到RFID许可代码和通过计算机的数据库检查某个人是否有准许进入的权限，如门，大门，围栏，闸机等。

目前电梯与门禁控制通常被集成在一起。目的选层系统，是一种用户需要在电梯轿厢外的输入设备上输入目的楼层，故系统在进行电梯分配之前通常需要知道用户的访问权限。因此，在非常早期的阶段就需要访问控制。为了实现这一点，通力现已经推出了自己的门禁系统。该系统控制着客流进入权限，并可以整合所有的进入控制设施，从正门开始，十字转门，电梯，大门等，一直到最后的办公室大门。

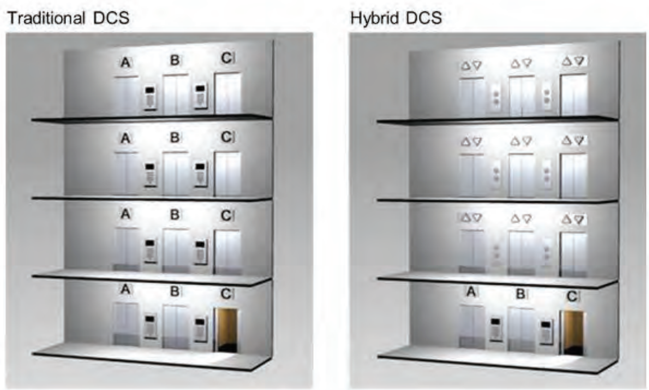

Figure 5. Conventional and Hybrid destination. Source KONE Corporation.
图5. 传统式和混合式目的选层操纵面板 来源: 通力电梯

Figure 6. Latest KONE Touch Screen. Source: KONE Corporation
图6. 最新的通力触摸屏 来源: 通力电梯

a door open, a door close (optional) and an alarm button, but no floor selection buttons.

Destination Control works well whenever a large flow of traffic is directed away from a floor. In such cases prediction is very exact, reducing stops efficiently.

Destination control allocates calls immediately. In sporadic traffic the optimum route may utterly change with every incoming call, and reallocation of calls would provide better service. To allow reallocation with light traffic, KONE introduced Hybrid destination. Floors with heavy traffic are equipped with DOP's, while floors with lighter traffic use normal up and down buttons. Inside the car there is a normal car operating panel. This panel is typically not active on floors with DOP's. Figure 5 shows the different destination control systems.

Destination control is often linked to turnstiles. Here the home floor of the user is used as the destination floor. As the user walks through the turnstile, the allocated elevator is shown on a display closer to the exit point. The user can directly walk to the assigned elevator for the ride to the home floor. If the actual destination is not the home floor, the user can re-enter this destination on a DOP after the turnstile. If this happens often, it is better to only grant the passenger access at the turnstile without elevator allocation.

由于门禁控制必须根据最终租户的需求定制，因此它通常是在施工的后期阶段才定货。一旦后期租户有特定需要，这可能会导致昂贵的返工费用。

通力的系统是基于KABA提供的产品，并且可以在后期了解了客户的组织内部的访问控制需求后由KABA进行扩展。这项工作非常简单，因为这两种系统是互相完美配合的。

通力门禁系统可以提供给业主在大楼被分租前有一个基本的进入权限系统。当租户入住后，它可以很容易地通过KABA升级，包括所有未来的组织性需要。这种简单易行的使系统从客流向组织化水平的扩展，是独一无二的。

集成到第三方的门禁控制系统是第二个选项。一个基于IP的简单控制协议，可轻松将电梯与门禁系统和旋转门的进入控制集成在一起。这样，通力门禁系统就被第三方门禁系统所取代。通力门禁和集成见图4。

目的选层控制

在传统的电梯厅站呼叫系统中，用户在大厅的呼叫面板上按向上或向下的按钮。如果在主大厅上行客流量十分繁忙阶段，会有很多人进入轿厢。这也意味着在轿厢操作面板上的许多按钮被点亮。很多的呼梯也意味着很多的停站。速度为6米/秒的高速电梯 (1200英尺/分钟)，每个停站可能需要花费10 - 13秒。

目的选层控制是一种用户可以在电梯外的目的操纵面板 (DOP) 上输入楼层的电梯控制系统。目的操纵面板 (DOP) 上将显示分配的电梯。电梯在抵达前，系统已知用户所在楼层及目的楼层。这个额外的信息使系统能将前往相同目的楼层的乘客安排在一起，大大减少停站次数。

这也缩短了电梯乘坐时间，使电梯能尽早返回运送下一批乘客。目的选层控制明显提高了上行高峰期的客流运载量。轿厢内只有几个按钮: 一个开门按钮，一个关门按钮 (可选) 和一个报警按钮，没有其他楼层的选择按钮。

目标选层控制的效果很好，尤其是较大客流量需要从某个楼层离开的时候。在这种情况下的预测是非常准确的，有效地减少了停站。

目的选层控制能立即分配呼叫。在客流较少时段，系统会根据每次呼梯调整出最佳路径，并重新分配以提供更好的服务。为了在客流较小时允许重新分配，通力推荐使用混合式目的选层解决方案。在客流繁忙的楼层配备DOP，而客流较少的楼层使用一般的向上和向下按钮。轿厢内有个一般的轿厢操作面板。此面板通常在有DOP的楼层不被激活使用。图5显示了不同的目的选层控制系统。

目的选层控制系统往往与闸机相连接。用户的归属楼层被视作目的楼层。当用户通过闸机后，被分配的电梯会在靠近出口的屏幕上显示。用户可以直接去被分配的电梯搭乘至其所要前往的楼层。如果实际到达的楼层不是用户所要前往的楼层，用户可以在通过闸机后重新在DOP上输入目的楼层。如果这种情况经常发生，则最好是只给乘客通过闸机的权限，而不进行电梯分配。

现代化的目的选层控制界面

› 现代化的触摸屏

作为目的选层控制的输入设备，触摸屏越来越受到欢迎。最新的通力触摸屏 (见图6) 的设计充分考虑了用户的需求。

300×300mm^2 的外形尺寸可以完美地嵌入一个10英寸的屏幕。这个屏幕尺寸非常适合于触屏手势。所有其它输入界面被放置在同一表面上。这使得视力不佳的用户也能更加容易地找到所有功能。玻璃表面易于清洁。供残障人士使用的语音信息扬声器被放

Modern interfaces for Destination Control

› Modern touch screens

Touch screens have become very popular as input devices for Destination Control. The latest KONE Touch Screen (see Figure 6) has been designed with the user needs in mind.

The 300 x 300 mm square size is perfect to incorporate a 10 inch screen. This size is perfect for swipe gestures. All other input interfaces are placed on the same surface. This makes finding of all functions a lot easier for the visual impaired user. The Glass surface is easy to clean. The voice message speaker for the impaired is placed in a shadow gap on the front surface. This directs sound to the user, while minimizing disturbance sideways.

The screen is black with white symbols. There is simply no better contrast than white on a black background, thus guaranteeing optimum readability under all light conditions. The curved shaped back creates a shadow gap with the wall. This hides possible imperfections of the wall.

The new KONE Touch Screen has four optional interfaces (see Figure 7):

- The List Interface can handle any amount of floors. One first selects from the ranges of floors, and then the desired floor in that range.
- The Keypad Interface also allows any amount of floors. The floor number is dialed in as on an ATM machine.
- The Slider Interface feels very modern and easy to use. One slides a circle on the screen in the up or down direction, if the desired floor is reached, the circle is released and the call is placed.
- This interface is less suitable for large amounts of floors, but when the served floors are limited through for example an access system, the sider is very easy and fast.
- The Direct Call Interface, where each floor has a specific button. Due to the space on the screen only about 24 floors can be shown. This is perfect for offices where zoning is typically limited to less than 20 floors. The direct call is a one touch system.

› KONE Remote Call

Another unique user interface is KONE Remote Call where the user places calls directly to the elevator system through mobile devices such as Pads or Cell phones via GSM or Wi-Fi.

As positioning inside a building is still in its infancy, the user needs to place the call closer to the elevator. Both the source floor and the destination floor need to be entered. The allocated elevator is then shown while the movement of the allocated elevator can be followed on the screen until doors open at the source floor (see Figure 8 for KONE Remote Call).

As the mobile device moves with the user, contact with the elevator system remains. This opens a lot of future opportunities to extend the functions of destination control.

› KONE Remote Call with fixed source floor

A special application is the remote call with a fixed source floor. If the mobile device is used in a fixed position as a DOP the source floor can be fixed. This means that the mobile device now operates as a wireless DOP. Only the destination floor needs to be entered. This is especially handy in receptions of offices and hotels. But this system

置在表面隐藏的间隙内。这种引导语音能直接指向用户，而使侧向干扰最小化。

屏幕由黑底白色符号组成。黑色背景上的白色显示提供了最佳的对比度，因此在所有的光线条件下都能保证最佳的可读性。流线型的外观能在墙上造成一个阴影区，可以很好地隐藏墙壁上由于接口界面等可能存在的问题。

全新的通力触摸屏有四种可选的用户操作界面(见图7):

- 翻动列表式界面可以选择所有楼层，首先选择楼层范围，然后在该范围内选择所需楼层。
- 触摸键盘式界面也可以选择所有楼层，输入楼层号码，就像在ATM机上操作一样。
- 滑动选层式界面感觉非常现代且易于使用。屏幕中的一个圆圈可在向上或向下方向滑动，如果达到所要前往的楼层，手离开圆圈，则该楼层的呼梯将被输入。 这个界面不太适用于楼层数较多的大楼，但当服务楼层有所限制时，例如门禁系统，滑动将非常易用和快速。
- 直接呼叫式界面，每个楼层都有一个特定的按钮。由于屏幕空间的限制，最多可以显示仅约24层，它对于办公大楼来说是最佳的选择，因为一般情况下办公大楼的分区被控制在20层以内。直接呼叫式是一一触式点击系统。

› 通力远程呼梯

另一个独特的用户界面是通力远程呼梯，用户可以通过移动设备，例如通过GSM或Wi-Fi网络连接的Pads或手机直接呼叫电梯。

Figure 7. Four optional user interfaces. Source: KONE Corporation
图7. 四种用户操作界面 来源: 通力电梯

Figure 8. KONE Remote Call. Source: KONE Corporation
图8. 通力远程呼梯 来源: 通力电梯

enables a large range of special uses. The wireless DOP can be used to temporarily increase the number of DOP's for special functions. The wireless DOP can be used as a temporary replacement in case of failure of a permanent DOP. In modernizations the capacity of none-destination elevators can be increased overnight by placing the wireless DOP's on the floors. This also gives the owner an opportunity to find the best positions for the DOP's before mounting the permanent DOP's.

KONE Ultrarope

Challenges with Steel Ropes

As buildings get higher, the weight of ropes increases rapidly. As stated by Adrian Smith (3), the architect of the highest tower in the world, when you get higher than 550m the weight of the cables gets too heavy. Ropes are needed to carry ropes.

Total rope weight for an elevator with a rated load of 2000 kg at a travel of 500 m can be about 27000 kg. This weight needs to be accelerated and decelerated, and starting currents and energy consumption grow fast with the increase in height. Ropes wear and need to be replaced. The bigger the rope weight, the more elaborate this becomes increasing downtime, while replacement costs increase exponentially with the travel. The strands in new steel ropes tighten up, causing permanent rope stretch. This requires shortening of ropes during early operation, also causing downtime. To minimize the increase in rope weight, safety factors are often minimized closer to the allowed safety factor. The effect is that rope life reduces even more and ropes need to be replaced more often, with all the above mentioned consequences.

As buildings get higher their natural periods get longer, and somewhere along the travel ropes will resonate with the building frequency. Rope sway can be excessive in heavy winds and precautions need to be taken to minimize these effects. Rope frequencies can be tuned with the weight of the rope compensator, but resonances cannot be omitted when buildings get higher. In strong wind conditions the speed of the elevator must be reduced and sometimes operation must even be suspended to prevent damage.

Rope limitation therefore influences the way buildings are designed and zoned. To overcome the problems mentioned, KONE studied the use of synthetic light weight ropes. After nine long years of extensive study and rigorous testing KONE UltraRope was approved by authorized bodies for both the European and the North American standards and was launched in June 2013 in London.

What is KONE UltraRope

KONE UltraRope consists of multiple carbon bars, where carbon fibers are held captured within an epoxy matrix. A high friction coat gives the rope a belt like shape (see Figure 9).

Carbon Fiber is used where high performance and ultra-light weight is needed. Carbon fiber is however sensitive to compressive stresses, but once one finds the minimum bending ratio for the shape used, it becomes hard to fatigue. This gives UltraRope superior rope life compared to steel. Wear of the high friction coat determines rope life, but rope life is clearly more than twice that of steel ropes. This reduces the lifecycle costs for rope replacement.

The weight of KONE UltraRope is only one fifth of that of a similar strength steel rope, while the E-modulus is higher. At higher travels the weight ratio grows as more steel is needed to carry steel. UltraRope is so light that this effect is hardly noticeable. At a travel of 500 m

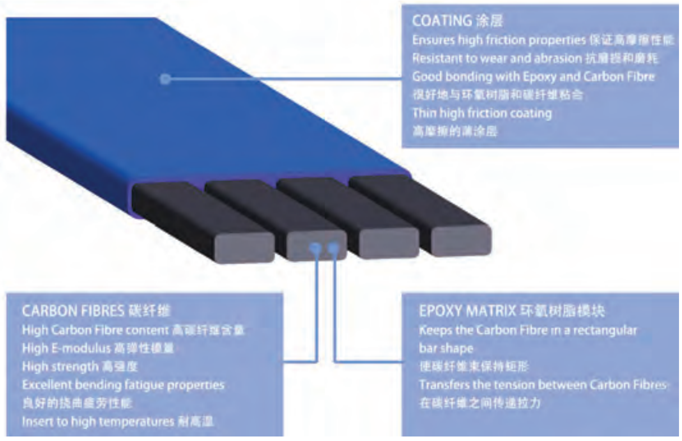

Figure 9. KONE UltraRope. Source: KONE Corporation
图9. 通力Ultrarope 来源: 通力电梯

作为建筑物内的定位仍处于起步阶段，用户需要靠近电梯进行召唤。用户当前所在楼层和目的地楼层都需输入。之后，被分配的电梯及其运动状态会一直在屏幕上显示，直到其到达用户所在楼层开门为止 (见图8 通力远程呼梯) 。

由于移动设备与用户一起移动，并与电梯系统仍然保持联系。这为未来进一步扩展目的选层控制的功能提供了更多的机会。

› 固定所在楼层的通力远程呼梯

通力远程呼梯中有一种特殊的应用是固定所在楼层的远程呼梯。如果移动设备被用在一个固定的位置类似于一个DOP，则所在楼层可以被固定。这就意味着移动设备现在作为一个无线的DOP，因此只需要输入目的楼层。这对办公楼和酒店的接待处来说特别方便。这个系统可提供更多的特殊用途。无线DOP可以用来暂时增加用于特殊功能的DOP的数量。一旦永久DOP出现故障，无线DOP可以临时代替使用。在更新改造中，可以通过设置无线DOP增加没有安装目的选层控制系统的电梯的运载能力。这也使业主能有机会在DOP被永久安装之前找到其最佳安装位置。

通力Ultrarope

对钢丝绳的挑战

当建筑更高时，钢丝绳的重量也迅速增加。正如世界最高建筑的建筑师Adrian Smith (3) 所述，当建筑高度超过550米，钢丝绳的重量已经过于沉重。结果是需要更多的钢丝绳来拖动其他钢丝绳。

对于载重2000公斤提升高度500米的电梯而言，钢丝绳的总重量近27000公斤。这个重量同样需要被加速和减速，起动电流和能量消耗也会随着高度的增加快速增加。钢丝绳会磨损而需要更换。钢丝绳的重量越重，这种情况越严重，停机时间也会越多，同时更换成本会随着提升高度呈指数增加。新钢丝绳被拧成股收紧，会造成钢丝绳永久性的伸展。这就需要在早期运行阶段缩短钢丝绳，也会造成停机。要尽可能地减少钢丝绳在重量上的增加，通常会最小化安全系数，使之更接近于所允许的安全系数。其结果是钢丝绳的使用寿命会更短且需要更经常更换，而还要加上综上所述的其他后果。

当建筑越高时，其本身的固有振动周期越长，并且钢丝绳在某处会与建筑的频率产生共振。在强风时钢丝绳会过度摆动，必须要采取许多防范措施来尽量减少这些影响。钢丝绳的频率可以通过钢丝绳补偿装置的重量来调节，但是当建筑越高时，共振便难以忽略。在强风条件下，电梯的速度必须降低，有时不得不暂停运行，以防止产生损坏。

钢丝绳的局限性因此影响了建筑的设计和分区方式。为了克服上

the weight of UltraRope is only 10% of the weight of steel ropes. This means that rope weight of a 2000 kg elevator travelling 500 m is only about 2500 kg with UltraRope, compared with 27000 kg with ultra-high strength steel ropes. The 90% reduction in rope mass also reduces the total moving masses by no less than 45%. Light weight ropes are also replaced much faster than steel ropes, reducing downtime considerably.

This large decrease in weight also reduces the energy needed in the acceleration and deceleration phases. Energy consumption of the above mentioned elevator is reduced by no less than 15%. As the reduction in energy consumption mainly takes place in the acceleration and deceleration phases, the reduction is bigger with longer accelerations. In other words, the higher the speed, the bigger the percentile energy reduction.

As UltraRope does not show permanent rope stretch, shortening of ropes is no longer needed.

UltraRope can manage higher temperature than steel ropes before they snap under load, and they are also halogen free.

Last but not least, due to the light weight of UltraRope, the natural frequencies are much higher than those of steel ropes. This also means that the ropes are hardly affected by rope sway. UltraRope is by far the best way of detuning rope sway.

A More Sustainable Environment

KONE PFI is an upgradable software platform that will ensure that the operation of these systems is easily updated to include the latest developments, ensuring Future-proof technology.

KONE UltraRope removed the height restriction of elevators. It is also a major improvement in the principle CO_2 component in the life cycle assessment of elevators, usage of the elevators.

B th innovative technologies can also be used for replacement of present technologies, allowing a more sustainable environment for the cities of the future.

述的问题，通力研究使用合成轻质绳索。经过长达9年的深入研究和严苛测试，通力UltraRope已获欧洲和北美标准认证机构的批准，并于2013年6月在伦敦发布。

什么是通力UltraRope
通力UltraRope由多个碳纤维条组成，其中碳纤维被包裹在环氧树脂模块中。带状绳索表面有高摩擦涂层（见图9）。

碳纤维通常用来满足高性能且超轻重量的需求。碳纤维对压应力较为敏感，但是，一旦保持了最小弯曲率，此时材料非常不易疲劳。这使得UltraRope相比钢丝绳有着更为出众的使用寿命。高摩擦涂层的磨损决定了绳索使用寿命，但碳纤维绳索的寿命至少是钢丝绳的两倍以上。这减少了绳索更换的生命周期成本。

通力UltraRope的重量仅为有着相似强度的钢丝绳重量的五分之一，而且弹性模数更高。电梯行程越高时钢丝绳重量所占比率递增，因为需要更多的钢丝绳来拖动钢丝绳。UltraRope很轻，因此这种情况带来的影响微乎其微。当电梯行程在500米时，UltraRope的重量只有钢丝绳重量的10%。这意味着， 2000公斤载重的电梯提升高度至500米，UltraRope的重量仅2500公斤，而超高强度钢丝绳重达27000公斤。绳索重量减少了90%，也将总的随行重量减少了至少45%。重量较轻的UltraRope比钢丝绳的更换更为快捷，大大缩短了停机时间。

重量的大大减轻也降低了电梯在加速和减速阶段所需的能量。上述电梯的能耗至少降低了15%。由于能耗的降低主要发生在加速和减速阶段，因此当加速越长则能耗降低的越多。换句话说，速度越高，能耗降低的百分数越大。

由于UltraRope不会有永久性绳索拉伸现象，因此也无需缩短绳索。

UltraRope在高负荷下比钢丝绳能承受更高的温度，且为无卤材质。

还有一点要提到的是，由于UltraRope质量较轻，其固有频率比钢丝绳要高得多。这也意味着，碳纤维曳引绳几乎不受建筑摇摆的影响。 UltraRope是迄今为止消除曳引绳共振的最佳途径。

更具可持续发展的环境

通力PFI是一个可升级拓展的软件平台，而且确保这些系统的操作更容易进行更新，并包括最新的研发成果，确保面向未来的技术。

通力UltraRope消除了对电梯的高度限制。它也是电梯使用中二氧化碳排放量在电梯生命周期中的评估上的一项重大改进。

这两项创新技术也可以用于替换当前的技术，为未来城市提供了更加可持续发展的环境。

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