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The Rejuvenation of a Tall Building
高层建筑的复兴

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Albert Williamson-Taylor, who founded AKT with Hanif Kara in 1995, combines the practice-wide role of overseeing design and technical matters with leading a design group, allowing him to infuse the many projects with which he is involved with cutting-edge technology. He enjoys providing project development input and ideas to clients and architects at the early stages of any project. Williamson-Taylor has been responsible for driving the technical direction of the practice and is also involved in determining the direction of Part (our computational research group) within AKT II.

Albert与Hanif在1995年成立了AKT，他不仅在全公司范围内负责设计与技术相关事项，并且领导设计团队参与了许多涵盖尖端技术的项目。 他热衷于在各种项目的早期阶段为客户与建筑师提供设计理念。 Albert一直致力于推动公司的技术走向并且参与了制定AKT II中P.art小组(公司的计算研究部门)的未来走向.

Abstract | 摘要

The incredibly rapid urbanization observed in many of the larger cities in the world is forcing society, and the construction industry in particular, to think of new ways to address this enormous demand. As cities grow, land becomes more valuable and thus scarcer; over time this land is also overdeveloped, as over the years different buildings are constructed in the same footprint. This paper discusses the merits of a different approach to the same question: how can more habitable space be created in the ever-decreasing available footprints? The South Bank Tower project in Central London seeks to pose a set of answers by pushing its existing structure to new limits through the addition of 11 floors on top of the existing 30-story tower.

Keywords: Cities, Densification, Elegance, Rejuvenation, Remodelling, Smartness

世界上很多大城市以令人难以置信的速度城市化，这迫使社会，尤其是建筑建造业，去考虑以一种新的方式来解决这个庞大的需求。随着城市的发展，土地会变得更有价值，因而导致土地资源的稀缺。由于在不同的时间段内各式各样的建筑会被建造在同一片土地上， 随着时间的推移土地也将会被过度开发。本文讨论了一个对于同一个问题的不同的解决方式:–如何才能在不断减少的土地上创造出更多的可居住空间。伦敦中心的南岸塔楼力求提出一套解决方案 – 在现有30层高的塔楼顶部添加11层，以将现有的结构推向新的极限。

关键词：城市、密集化、优雅、复兴、重新塑造、灵巧

The incredibly rapid urbanization observed in many of the larger cities in the world is forcing society, and the construction industry in particular, to think of new ways to address this enormous demand. As cities grow, land becomes more valuable and thus scarcer; over time this land is also overdeveloped, as over the years different buildings are constructed in the same footprint. This paper discusses the merits of a different approach to the same question: how can more habitable space be created in the ever-decreasing available footprints? The South Bank Tower project in Central London seeks to pose a set of answers by pushing its existing structure to new limits through the addition of 11 floors on top of the existing 30-story tower (Figures 1 and 2).

Designed by Richard Seifert, an eminent post-modernist of his time, the existing structure is a well-publicized building built in the early 1970s on the southern bank of the River Thames. The site is a congested island containing three buildings: the 30-story tower; a six-story, T-shaped office building; and a 10-story residential building which remained in use throughout the redevelopment process.

London Underground train lines run across the site, between the taller tower and the

Figure 1. Rendering of South Bank Tower expansion (Source: KPF)
图1. 项目效果图（来源：KPF）

Figure 2. Before and after photograph of South Bank Tower (Source: KPF/AKT II Limited)
图2. 项目照片，改造前与改造后（来源：KPF/AKT II有限公司）

T-shaped building, and directly below the tower foundations. The tower was founded on a piled raft with under-reamed piles. The raft bridges over the Waterloo and city line to creating a piling exclusion zone on either side of the London Underground tunnels.

The design of the development occurred during the era of Brutalist architecture and, as such, it contained exposed concrete elements. The floors of the tower structure typically consist of 380-millimeter-thick reinforced concrete waffle slabs and a central concrete core. The tower plan is split into four corner quadrants, with large concrete blade columns indicating the start of each quadrant. The northeast and southwest quadrants are curved while the northwest and southeast corners are closed with right angles, creating a symmetrical building on plan (Figure 3).

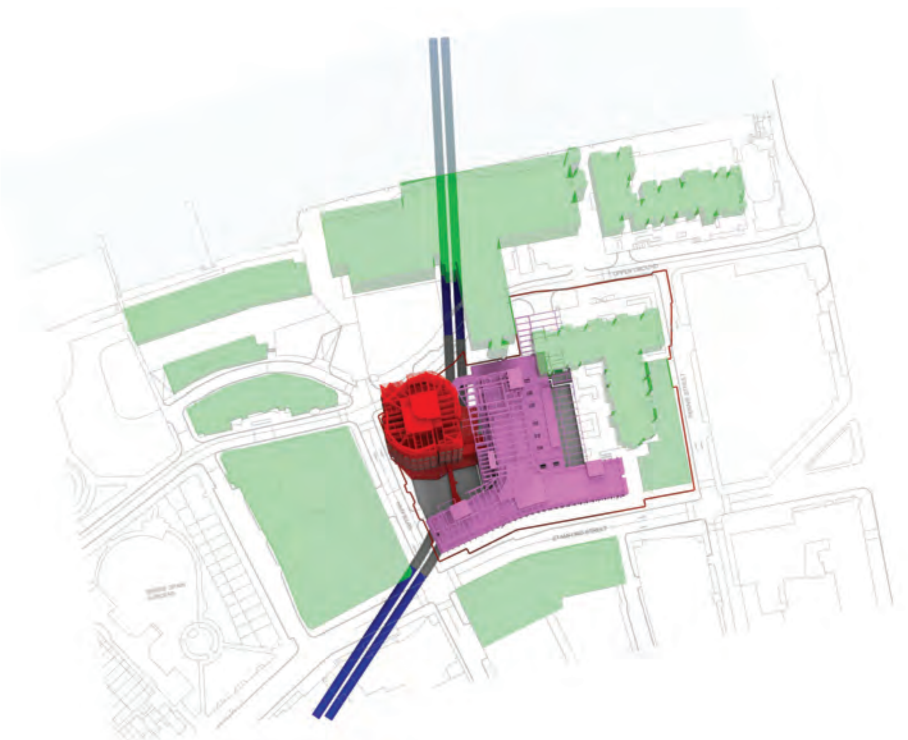

Figure 3. Site plan (Source: AKT II Limited)
图3. 场地平面图（来源：AKT II有限公司）

世界上很多大城市以令人难以置信的速度城市化，这迫使社会，尤其是建筑建造业，去思考以一种新的方式来解决这个庞大的需求。随着城市的发展，土地会变得更有价值，因而导致土地资源的稀缺。由于在不同的时间段内各式各样的建筑会被建造在同一片土地上， 随着时间的推移土地也将会被过度开发。本文讨论了一个对于同一个问题的不同的解决方式:–如何才能在不断减少的土地上创造出更多的可居住空间。伦敦中心的南岸塔楼力求提出一套解决方案 – 在现有30层高的塔楼顶部添加11层，以将现有的结构推向新的极限（图1、2）。

由后现代主义的杰出建筑师理查德.塞弗特（Richard Seifert）设计，坐落在泰晤士河南岸的广为人知的现有建筑群始建于20世纪70年代初。该建筑场地是一个拥挤的岛状场地，共拥有3栋建筑物：一座30层高的塔楼，一座6层高的T型办公楼和一座10层高的住宅楼。后者并不包含在此次重建中，而且在重建的过程中一直保持原有的使用。

伦敦地铁线在塔楼和T型楼之间穿过，并有一段直接穿过于塔楼地基的正下方。塔楼的地基为扩底桩的桩筏复合基础。 该桩筏地基跨过伦敦地铁的滑铁卢和城市线的打桩禁区。

现有建筑群是在当时粗野主义的时代所开发的，因此几乎所有的钢筋混泥土构建都是裸露的在外的。塔楼结构由380mm厚的钢筋混凝土双向肋形板及中心筒构成。 塔楼结构按平面而言，由四个大型的狭长型的混凝土立柱所划分为四个区域。东北和西南区域的楼板边缘为曲线状，而西北和东南区域的楼板边缘为直角，从而在平面上形成了对称的结构（图3）。

该塔楼的外沿结构立柱间隔为2.68米，突出于外墙面。这些单层预制立柱由吊车升起到指定楼层后固定在上层楼板和下层立柱之间。塔楼的外部轮廓在较宽立柱地辅助下向外如阶梯般延展，延展的位置并不固定但存在于2层与9层之间。 在延展发生的楼层，楼板由380mm厚的实心混凝土楼板构成， 楼板内嵌有的麦卡洛伊（Macalloy） 后应力钢筋索。在设计和施工的过程中，至关重要的是保证这些钢筋索不会应力过大，并且在施工过程中这些钢筋索得到有效的保护。

该场地的土层结构为：填土方，冲积岩土层，肯普敦帕克碎石层和伦敦粘土层。底层伦敦粘土层包含了较硬至极硬的深灰色粉砂质粘土，偶尔夹杂着淤泥与砂石，伦敦粘土层一直延伸至钻孔的底部（地面下40米）。由于场地邻近泰晤士河，地下水位由潮汐的原因在地下3至5米之间变化。

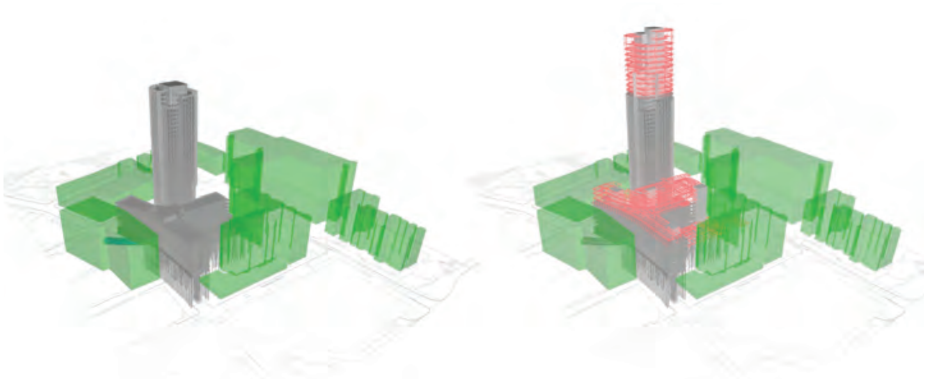

Figure 4. 3-D rendering of the project, before and after (Source: AKT II Limited)
图4. 项目的3D效果图，改造前与改造后（来源：AKT II有限公司）

The tower has expressed perimeter structural columns at 2.68-meter centers which pass through the façade. These were constructed in single-story lifts fixed to the slab above and pinned with dowel bars to the column below. The external profiles of the tower step outwards with the aid of wide columns; this step varies around the tower and occurs between the second and ninth floor of the tower building. The floors adjacent to the steps in profile are of 380-millimeter solid reinforced flat slab to accommodate post-tensioned Macalloy bars. During the design and construction, it was imperative that these Macalloy bars were not overstressed and remained protected during construction.

The site is underlain by a significant thickness of made ground, below which is alluvium, Kempton Park gravel, and London Clay. The underlying London Clay comprises of stiff to very stiff dark grey silty clay with occasional partings of silt and sand which extend to the full depth of the boreholes (40 meters below ground level). Due to the proximity to the River Thames, the water level was tidal and varied between three and five meters below ground level.

The Project

The presented scheme is the redevelopment and extension of both the 30-story tower and adjacent six-story podium; 11 stories were added to the tower and three stories to the podium building. To maximize the value of the site, new two-story basements were constructed around the existing buildings (Figure 4).

To explore the concept of extending the tower buildings, it was important that the client be convinced that the proposal was both feasible and viable. The discussions on viability were intertwined with the engineering aspirations. Detail information therefore had to be presented early in the process both to the client and the planning authorities. The value put on the sustainability and reuse benefits by the architects, as well as the benefits of the public realm spaces created, were key components of the planning approval.

The development transformed an office complex into a mixed-use site. The six-story podium was upgraded with the addition of three floors and the relocation of its cores; this provided the finished development with both sufficient commercial floor area, and a private residential roof garden. The tower remained an office below level 10, and is residential from level 10 up.

Stability

A fundamental understanding of the existing building was essential to exploring the extent of the tower's potential height increase. This included, but was not limited to, the existing stability system. Information from structural drawings and investigative surveys were reviewed and assessed. The building was re-analyzed to the original code, thereby allowing the team to understand the thought process when the original design was undertaken forty-five years ago. An assessment of the existing tower was undertaken using finite element analysis models to establish overall and local structural capacities.

It was established that, under high winds, the core of the existing building would experience some tension forces on the windward face of the core. This forensic analysis was confirmed by reviewing the existing structural detail drawing and confirming that cores had been detailed for this tension force. This initial analysis allowed us to conclude that whilst the existing design was adequate for a 1960/70s design approach, due to changes to the code, material testing and modern design techniques, the existing

项目概况

30层塔楼和毗邻的6层裙楼进行重建和改造：在塔楼上放增建11层，在裙楼上方增建3层。为了最大限度地提高场地的价值， 在现有的空地上再加建一座2层地下室结构（图4）。

为了拓展加建塔楼的概念，有一点至关重要，那就是客户必须被说服这个方案是有可能的并且是可以执行的。可行性的讨论与结构工程师的愿望是交织在一起的。因此， 结构设计的细节信息在项目的早期就必须提交给客户和负责城市规划的有关当局。 建筑上的可持续发展和再利用效益的增值，以及公共领域空间效益的创造，是得到规划审批许可的重要组成部分。

这次的重建将一个办公组楼改造成一个拥有商业，写字楼及住宅的综合小区。六层高的裙楼将原有的中心筒重新布局，并在顶部加建三层，这使得其既有足够的商用面积，并且还提供了住宅楼居民的私人屋顶花园。塔楼在10层以下保留了办公用地，在10层以上改造成了私人住宅。

稳定性

对现有结构的了解是对探讨增加塔楼高度的可行性的必不可少的要素。这包括，但不限于， 现有的稳定性系统。所有结构图纸和现场调查的信息都被进行了审查和评估。 现有建筑都根据原有的设计标准被重新分析，从而使团队了解到45年之前原始设计的思维过程。对现有塔楼的结构分析采用了有限元分析模型，从而确定了塔楼整体和局部的结构强度。

根据分析，在强风的影响下，现有塔楼的中心筒结构在迎风面会产生一些张力。这个分析结果根据对现有的结构细节详图的分析而得到验证，现有的中心筒结构的钢筋设计说明了这个张力的存在。这个最初的分析使我们得出以下结论，即使现有的设计符合1960–70年的设计方式，但由于设计标准，材料检验以及现代设计技术的改变，现有的结构系统会有一些富余的抗压能力，但是抗张能力却是有限的。于是，加入新楼层会使得中心筒受压，有助于减少或移除张力的出现。

但是，如果新的中心筒仅仅是简单的向上延伸，中心筒的墙体会受到过多的压力。如果改变墙体的厚度和配筋，墙体过载的问题将不会仅限于较低楼层，因此，加强墙体结构的设计方案并不可行（图5）。

永久稳定系统设计采用了四个6层楼高的混凝土墙体(翼墙)与现有的四个角落立柱所连接，作为新的外伸支架稳定系统的一部分。外伸支架稳定系统会产生较长的杠杆臂，相较于简单地延伸中心筒的高度，

system had some residual compression capacity, but only limited tensile capacity. As such, the addition of the new stories would pre-compress the cores, helping to reduce or remove the tension.

However, if the proposed core had simply been extended upward, the core walls would have been overstressed. Due to changing wall thickness and reinforcement, the overstress would not have been isolated to just the lower floors and therefore, strengthening the walls for this design approach would not have been viable (Figure 5).

The permanent stability design uses four six-story-high concrete walls (wing walls) to engage the four existing quadrant columns as part of an outrigger stability system. The outrigger system generated a longer lever arm and reduced the stress in the core compared to the simple extended system. The existing outrigger columns were formed of a mixture of pre-cast and in situ concrete. The pre-cast elements were constructed as single-story lifts fixed to the slab above and pinned to the level below. As such, the columns had limited tension capacity. The columns could not be strengthened as the concrete finish was exposed as part of the tower façade. Due to this limit, the full width of the floor plate could not be engaged as the lever arm; therefore, the lever arm was limited to the distance from the back face of the core wall to the outrigger columns. To ensure the outrigger columns do not take any tension force in the permanent condition, a vertical sliding joint was detailed between the wing walls and the columns (Figures 6 and 7).

Due to the configuration of the wing walls, large forces develop along the top and bottom of the walls depending on the wind force direction. To restrain the horizontal force, large bands of traditional reinforcement were introduced into the wing walls and continued into the new core. These forces were distributed across the core through a thickened floor plates within the core. The lower levels of the outrigger columns were strengthened with concrete jackets. This enabled them to support the additional vertical load from the tower extension and all the new lateral stability forces.

A CFD wind assessment was undertaken with the codified loads to clearly establish the difference between the original design's wind loads and present day wind loads, resulting on the building being classified as mildly dynamic. The CFD wind analysis reduced the wind forces by 40 percent in the one in 50-year wind intensity values when compared with the original forces for which the tower was designed. With both the outrigger column and the CFD analysis, deflection of the building due to wind loading was in the order of 1:1,250 (Figure 8).

A new site-specific ground investigation was carried out as part of the initial investigative works. By back calculating the pile capacity using the values obtained from the new investigation, the existing piles were found

此种方法中心筒墙体的压力会相对而言比较小。现有的外伸支架立柱是由现浇和预制混凝土所混合而成。这些单层预制混凝土立柱由吊车升起到指定楼层后固定在上层楼板和下层立柱之间。这些立柱由于作为塔楼立面的一部分暴露在外，结构上是无法被加强的。由于这些限制，楼板的宽度无法整个作为杠杆臂，只有从中心筒墙体的背面到外伸支架立柱这个距离才可以有效作为杠杆臂。为了确保在永久状态下外伸支架立柱不会承受任何的张力，在翼墙和立柱之间采用了垂直滑动接缝（图6、7）。

由于翼墙结构的重组，墙体的上部和下部所产生的力完全取决于风力的方向。为了抑制水平方向的力，大量的钢筋被加入了翼墙墙体之中并且延伸至新的中心筒里。这些力通过中心筒内部的加厚楼板分布于整个中心筒的墙体内。低楼层的现有外伸支架立柱用了新的混凝土外壳进行了补强。这使他们能够支撑住从塔楼延伸和新的横向稳定性结构所产生的额外的垂直荷载。

用设计标准所规定的力进行的计算流体力学(CFD)的风力评估清楚的确立了原有设计风荷载和现有风荷载的区别：该建筑被列入轻度震动范畴。与塔楼原有设计的风荷载比较，计算流体力学(CFD)的风荷载分析将50年重现期的风荷载降低了40%。加上外伸支架立柱的引用和计算流体力学（CFD）的风荷载分析，塔楼由于风荷载而导致的横向位移被控制在了1：1250（图8）。

作为最初调查工作的一部分，我们对现有的场地进行了新的土地勘测调查。从勘测

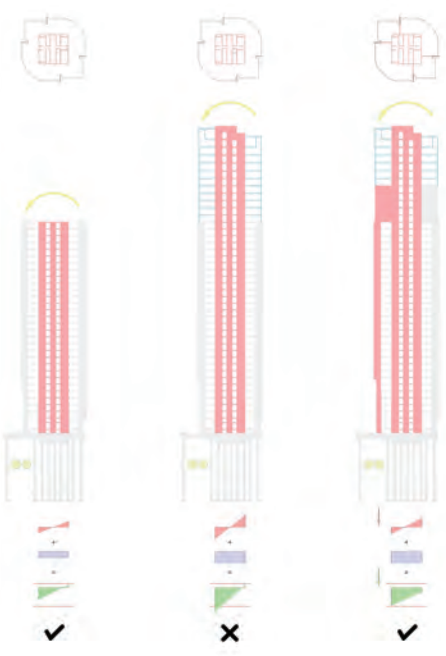
Figure 5. The structural stability approach (Source: AKT II Limited)
图5. 结构稳定性的设计方案（来源：AKT II有限公司）


Figure 6. Site photograph of completed core (Source: Central Photography)
图6. 中心筒建成后的工地照片（来源：Central Photography）


Figure 7. 3-D analytical model of tower (Source: AKT II Limited)
图7. 塔楼的3D 分析模型（来源：AKT II有限公司）

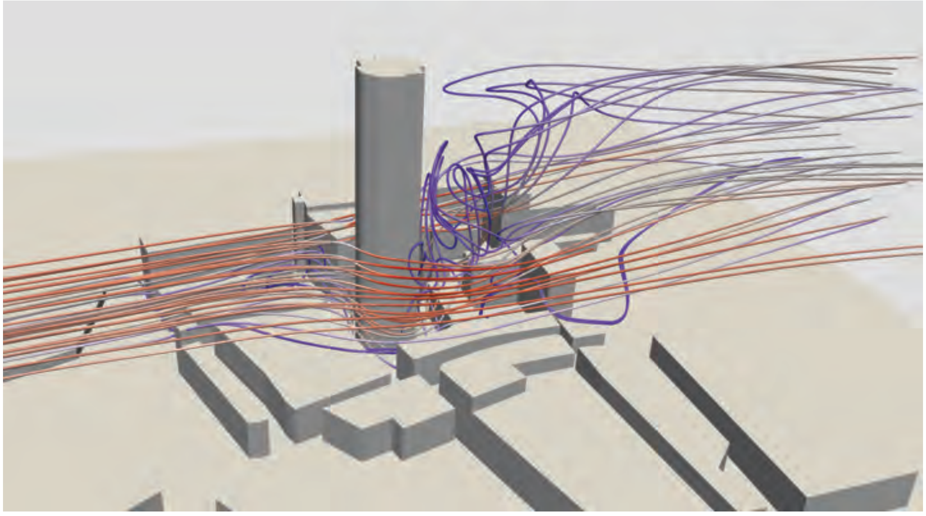

Figure 8. CFD wind analysis (Source: AKT II Limited)
图8. 计算流体力学(CFD)的风荷载分析（来源：AKT II有限公司）

to have sufficient capacity for the proposed project. One of the key constraints therefore became the capacity of the existing raft which spanned over the London Underground tunnels. By using a forensic approach to assessing the existing capacity of the raft – using finite element software, the enhanced strength of the concrete and by modeling the installed reinforcement – we were able to verify that the raft had sufficient capacity.

Core Modifications

Due to the tower's change in use, modern servicing and access requirements, substantial modifications to the existing core structure were required. Therefore both the global stability and the local strength of the core needed to be re-analyzed. The analysis had to factor in the program for the partial demolition and strengthening of the existing core, the tower extension, the removal and installation of new and existing cladding, and the loads from temporary cranes and hoists. The conclusion of this analysis enabled multiple work fronts to take place simultaneously on different levels within the tower. This enabled the eventual phased completion and hand over of the tower apartments.

The architectural and servicing requirements meant that new structural walls could be introduced to the core, so that despite the demolition required, the final stiffness of the core was reduced by only 17 percent. The increase in the vertical load on the core and change in the stability system ensured that the tension stress found within the existing system was eliminated. It was therefore only necessary to strengthen the walls above some door openings to account for localized points of stress. This was done with steel plates which allowed the redistribution of local forces and replaced the reinforcement cut when creating the new opening. The steel plates were designed to allow a 200-millimeter service zone between the plates and ceiling, and a limited number of 100-millimeter service penetrations through the plates (Figures 9 and 10).

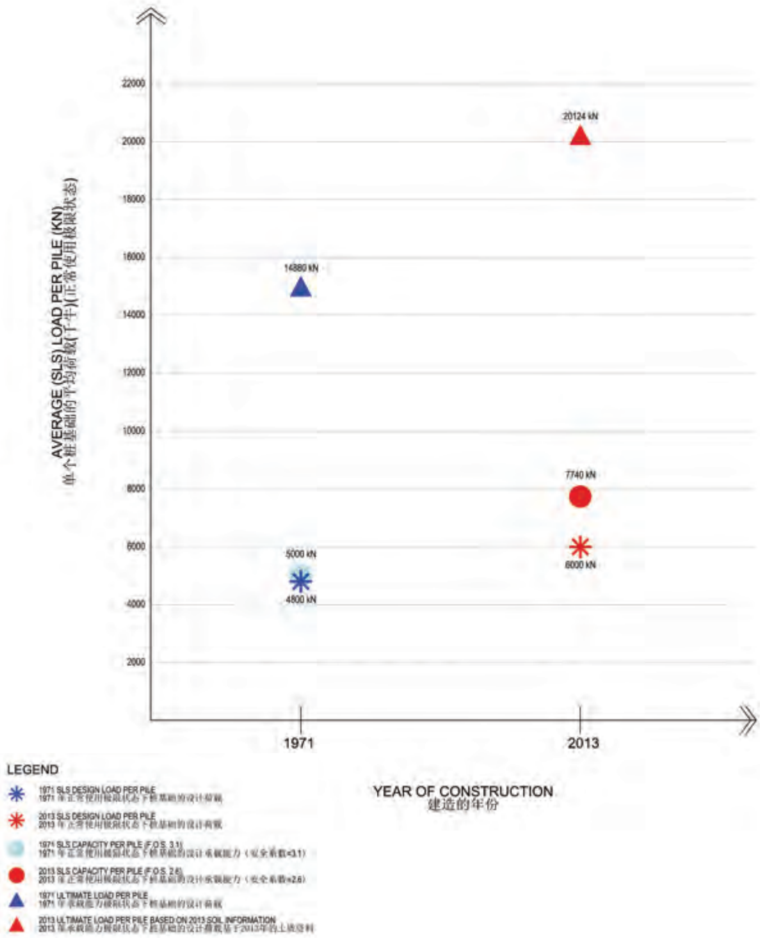

Figure 9. Pile capacity summary (Source: AKT II Limited)
图9. 桩基础承载力（来源：AKT II有限公司）

结果对现有的桩基础进行了承载力的回推计算，发现现有的桩基础对拟建结构有足够的承载力。因此，此次设计的主要制约因素便成为横跨伦敦地铁隧道的桩筏结构的承载能力，在利用有限元软件模拟现有强度增强后的混凝土和钢筋，通过分析和计算我们验证了现有的桩筏结构有足够的承载力。

由于塔楼使用目的的改变，以及对于现代化服务的要求，现有的中心筒结构需要进行实质性的整改。因此，无论是塔楼整体的稳定性和局部强度都需要被重新分析。这个分析必须考虑到以下几点：一部分的中心筒结构会被拆除，现有的中心筒会被补强，塔楼的高度会被增加，现有的幕墙会被拆除，新的幕墙会被安装，以及临时起重机和升降机的所产生的荷载。

这个分析的结论使得塔楼的很多重建工作在不同的楼层得以同时进行。这使得塔楼公寓能以分阶段完成和移交。

建筑和电气服务上的要求意味着新的结构承重墙可以增加到中心筒结构中，因此即使一部分中心筒结构需要拆除，中心筒的最终强度仅仅降低了17%。 由于中心筒垂直荷载的增加，以及稳定性系统的改造，这使得现有的中心筒墙体里的张力得以消除。因此只需要在一些新的门洞上方的墙体进行局部补强即可。在制造新的门

Figure 10. Core modification sequence (Source: AKT II Limited)
图10. 中心筒结构的变更（来源：AKT II有限公司）

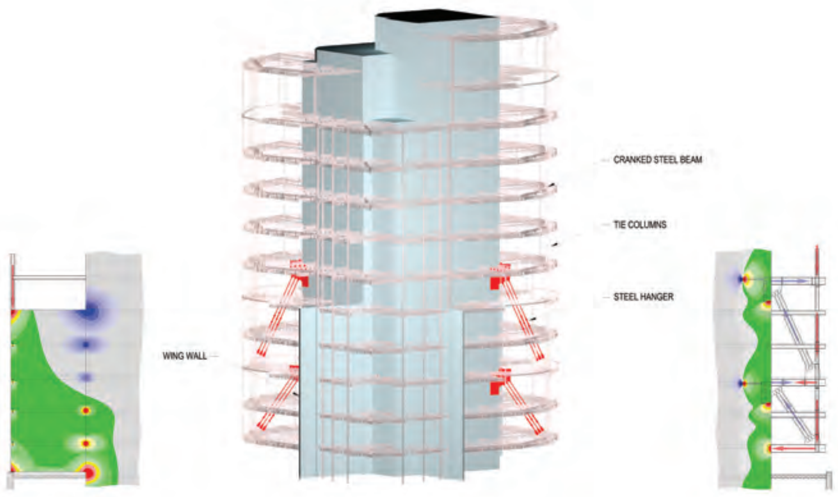

Figure 11. Tower extension (Source: AKT II Limited)
图11. 中心筒结构的变更（来源：AKT II有限公司）

New Superstructure

The tower was extended 11-storeies, utilizing a steel construction with composite deck and lightweight concrete. The existing columns' load capacity was limited by the post-tensioned cabling at the existing column step locations. To minimize the increase in load on the columns and to maximize the loading – and therefore the benefit of pre-compressing the existing core – the design principle was to support all new floors directly from either the core structure or outrigger columns. The southeast quadrant is the exception; here, the existing columns do not step outward and hence there are no post-tensioned cables.

Concrete wing walls and steel hangers were constructed from level 30, varying to levels 34, 35, and 36. The concrete walls were used where the vertical support was part of the stability system, as the stiffness of the wall was critical to the stability. To enable a rapid construction, steel hangers were used where stiffness was not critical to the stability. Early co-ordination with the design team was required to maximize the value of the apartments around these structural constraints.

The upper levels of the new structure are supported on columns sitting on either the new wing walls or steel hangers. Between these columns are fabricated sections which are cranked and pre-cambered to take out the dead load deflection. The steel hangers consisted of two sets of vertically stacked systems, each of three 100-millimeter-diameter diagonal rods with 85-millimeter solid gusset plates. The cables were pre-stressed to evenly balance the load between the six cables. The hangers were tied back into the cores with two sets of two 100-millimeter-diameter rods and bands of traditional reinforcement, which distributed the load around the core (Figure 11).

The steel frame system and its relationship with the stability system meant that it would move differently to the existing concrete frame, as no direct connection is made around most of the perimeter. This differential movement was mitigated by tying all the new floors together with columns, which lined up with the cladding mullions, and by increasing the tolerances in the finishes between levels 30 and 31 (between the new and existing floors).

Conclusion

The South Bank Tower now exists in its new form within the tall buildings cluster-zone south of the River Thames, rejuvenated with

洞时，墙体的补强是由钢板来代替被切割的原有钢筋从而使得局部的应力得以重新分配。这些钢板的设计允许在钢板底部到吊顶有200毫米高的电气供给区域，并且允许一些有限的100毫米直径的电气供给贯穿口通过（图9、10）。

新的上层结构

该塔楼运用了钢结构，复合楼板和轻质混凝土使其增高了11层。现有立柱的荷载能力被于立柱阶梯处后应力钢筋索的荷载能力所制约。为了尽量减少对现有立柱的负荷，并且最大限度的增加楼板的荷载– 并得益于现有中心筒的荷载能力–上层结构的设计理念为所有的新楼板的垂直荷载都将由中心筒和外伸支架立柱所支撑。但是东南区域为例外，这个区域没有阶梯式的立面外扩，因此没有后应力钢筋索的制约。

混凝土翼墙和钢悬挂结构是从第30层开始建造，于34,35和36层有些许变化。混凝土墙被用于稳定系统的垂直支撑的那部分，因为墙体的刚度是稳定性的关键。为了加快建造的速度，钢悬挂结构被用于稳定性的刚度不是太关键的那部分。为了在这些结构的制约条件下最大化公寓的价值致使与设计团队的早期协作是十分必要的。

新结构的上层楼板是由坐落在翼墙或者钢悬挂结构的立柱所支撑。在这些立柱之间是由弯曲的或者预拱的拼合钢结构来消除静荷载的位移。这些钢悬挂结构是由两组垂直堆叠系统形成，每组有三个100毫米直径的斜拉钢杆和85毫米厚的补强钢板。钢索都含有预应力，使得荷载与6个钢索所平衡。所有钢悬挂结构都由两组100毫米直径的钢杆拉回中心筒结构，传统的钢筋条带将荷载均匀地分布在中心筒的墙体内（图11）。

钢框架结构系统和其与稳定性系统的关系意味着它的位移将不会与现有的混凝土结构一致，由于在楼板边并没有直接相连。这种含差异的位移经由将所有与幕墙窗棂所对齐的新楼层的立柱绑在一起，并且增加第30层和第31层（旧楼板与新楼板之间）的饰面层的公差而得以缓解。

总结

坐落于泰晤士河南岸的高层建筑群中的南岸塔楼，因对未来的展望而焕然一新。此塔楼，依靠增强对地面的联系而对周围环境有所响应，与此同时解决了住宅密集化和办公娱乐娱乐一体化的问题，并且反映了国家城市对这部分伦敦的规划政策的意见。

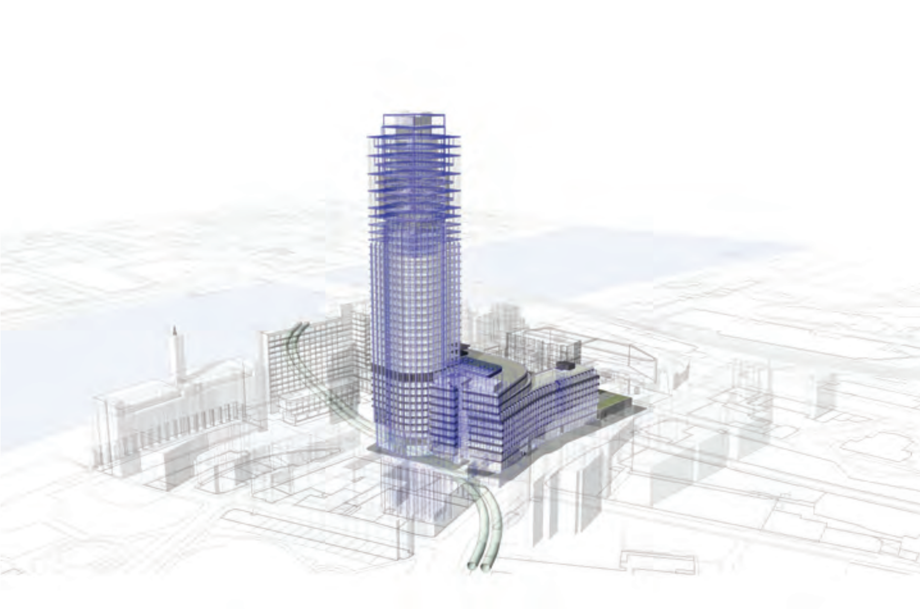

Figure 12. Rendering of the completed scheme (Source: KPF)
图12. 项目完成后的效果图（来源：KPF）

its sight on the future. It is now a true tower, responding to its environment with major improvement to its connection to the ground plane whilst addressing densification and mixed-use programs, and reflecting city-wide and national visions for planning policies for this part of London.

Historically, London was a low to medium-rise city with St. Paul's Cathedral dominating the skyline at a height of 111 meters; that is, until the 1960s when the BT tower exceeded that height. Since the "London Plan" was introduced in conjunction with local authorities' densification plans with the expected population growth – forecast to rise from 8.3 million to 10 million by 2020 – pressure on space is inevitable. Planning within established, under-resourced developments, including towers, could provide answers.

Working on buildings constructed between the 1960s and 1980s encourages designers and city planners to re-explore the configuration of their established ground plane while increasing height within the context of the urban fabric they reside. The robustness of these buildings, in a number of cases, far exceeds the forces imposed on them. A large area of inner city London boroughs have buildings which can benefit from this approach without impinging on London's views of St. Paul's.

Advances in computational tools, such as CFD wind analysis and finite element software, has allowed us as designers to utilize many different and complex systems at once, and analyze their cumulative effects. The maximization of existing buildings is also an inherently sustainable process, as it minimizes the energy and waste created by the demolition and construction of new ones. The South Bank Tower meets all modern standards; it is sustainable in its reinvention and it has increased its overall NIA by 50 percent across the project as a whole, all without losing its original architectural pedigree.

By forensically studying and understanding the design, buildings of this or any era, could, and perhaps should, become a key component in solving the problem presented by rapid urbanization within a finite city footprint. The South Bank Tower represents an example of this potential in London, and there is no doubt in our mind that this approach could be applied to any well constructed and well designed building around the world.

We hope this paper challenges developers and designers in their approach to project viability coexisting with rapid urbanization and meeting the requirement of the city context. London, New York, Paris, Hong Kong, and similar cities in Europe and the Americas are all responding to the rapid densification of cities, and so, this approach should be considered (Figure 12).

历史上伦敦因为圣保罗大教堂所规定的111米的限高而是一个低/中高层城市，一直到20世纪60年代英国电信塔的建立才打破了这个高度限制。自从”伦敦计划”与地方当局推出地住宅密集化的计划相结合从而应对伦敦人口的增长，预计将在2020年从830万人增长至1000万，这无可避免地对住宅空间产生了巨大的压力。因此，对现有的，但资金不足的包括塔楼的发展项目重新规划，可以对释放空间压力提供解决方案。

对20世纪60至80年代期间建造的建筑的改造，激发了设计师和城市规划者重新审视了地面与城市高度的格局。这些建筑的坚固性，在许多情况下，远远超过施加的荷载。伦敦市内很多地区的建筑可以因这个方法而获益，并与此同时不损害伦敦圣保罗大教堂的景观。

设计分析软件，譬如计算流体力学(CFD)和有限元软件的进步，使我们作为设计师能同时利用许多不同的，复杂的系统，分析他们所导致的累积效应。将现有建筑的潜力最大化也是一个可持续发展的过程，因为它最大限度减少了拆除现有建筑以及建造新建筑所产生的能量与浪费。南岸塔楼目前符合所有现代化的标准，由于其改造和作为一个整体增加了50%的净内部面积而达到可持续发展的目的，并且保留了其原有的建筑风格。

通过对标准的研究和对设计的理解，在这个时代或者任何一个时代所建造的建筑，他们可以，或者说他们应该，对解决在有限的城市里快速的城市化所带来的问题起到关键性的一步。虽然南岸塔楼仅代表伦敦所含有的潜力的一个例子，但是作者从不怀疑这种方法适用于世界各地任何构造良好的，精心设计的建筑。

我们希望本文能够向开发商和设计师，在快速城市化的情况下对项目的可行性，共存性，及满足城市环境需求等问题的解决途径，发出挑战。伦敦，纽约，巴黎，香港和欧美的其他同类城市都正在应对城市快速致密化所产生的问题。这个方法应该予以考虑（图12）。