

How Structure Adds to Architectural Beauty

结构如何提升建筑美感

gmp + sbp



Nikolaus Goetze

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Sven Plieninger

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引言

gmp – Nikolaus Goetze: 在介绍上海东方体育中心 (SOSC) 的设计方案的总体思路和概念之前, 首先要说明的是: 上海东方体育中心这一地标建筑设计的实现, 是各个专业团队共同努力的成果。建筑师、景观设计师、灯光设计师、可持续设计工程师等, 特别是结构工程师, 在设计团队中发挥了重要作用。

当今世界, 全球各地对优秀建筑的需求始终保持逐年攀升。考虑到各种影响, 城镇规划已要求需将建筑综合体融入现有的城镇结构。一个高品质的建筑设计必须保证持久的可识别性、高度的灵活性和最合理的利用程度。设计中融入的可持续理念应能减少未来的能耗, 同时提升建筑内用户的幸福感。而作为结构工程师应考虑以下几点: 1) 建筑和结构的统一; 2) 通过采用创新结构系统, 确保稳定性; 3) 建筑造价; 4) 通过设计高效的建筑系统, 优化建造时间。因此, 应尽早组建一个完整的团队开始设计过程。

设计团队应承担以下责任: 1) 紧锣密鼓地开展设计, 制定出比选方案; 2) 参与建设性批评; 3) 组织设计评估、讨论和各种研讨会, 并快速做出决策。在各方努力下, 我们最终完成了这一独特的设计。

sbp – Sven Plieninger: 不管是现代建筑, 还是体育设施, 其目标都是成为一个引人注目的地标性建筑。

在设计上海东方体育中心这一体育设施时, 我们面临了各种各样的复杂问题: 将现代建筑技术和赛事本身的巨大使用需求相结合, 同时最重要的是, 实现向全球直播这些赛事的需求。这尤其要求我们打造一个现代化的有特色的建筑, 以便形成出色的建筑外观。而对于大跨度结构的要求也至关重要, 这有助于满足建筑简约、轻盈、生态和经济性的要求。从这一方面讲, 我们在实践中的基本目标之一就是: 打造一个能够向来宾展示其“结构/工作原理”的建筑。

由于不同情况下边界或限制条件均各不相同, 我们针对这一问题可提供多种解决方案, 这为每个项目都提供了不同的机遇和挑战。基于gmp和sbp双方的长期合作关系, 我们认真分析了项目的任务, 找出项目的主导条件, 经建筑师和工程师共同研究后, 将其转化为建筑的设计理念。

企业历程

gmp – Nikolaus Goetze: gmp和sbp有众多共同之处, 两家事务所都起源于德国, gmp的总部设在汉堡, sbp的总部设在斯图加特。两家事务所都有着50多年的历史, 成立事务所的创始合伙人至今仍在所内任职: Meinhardt von Gerkan和Volkwin Marg于1965年创立了gmp; Jörg Schlaich和Rudolf Bergermann于1980年创立了sbp。此外, 双方还存在其他合作的共同基础: 双方的大部分项目都是从设计竞赛中脱颖而出的; 双方都重视概念研究; 双方的设计团队均执着于每个细节的完善; 双方的专业面均非常广, 能够胜任文化建筑、交通、办公、高层建筑、体育场、住宅等各种专业; 双方均勇于尝试。

如前所述, sbp成立于1980年, 但其根源可追溯到20世纪60年代Jörg Schlaich和Rudolf Bergermann为1972年慕尼黑奥运会打造的设计方案。该设计是德国首个轻型结构设计。自此之后, 采用钢

Introduction

gmp – Nikolaus Goetze: We would like to present the design of Shanghai Oriental Sport Centre, so called SOSC. Before introducing our general ideas and concept of SOSC to you we also would like to point out that the realization of a landmark building like SOSC is a result of teamwork of many disciplines. Architects, landscapers, lighting designers, engineers for sustainability and especially the structure engineers are part of a design orchestra which has the ambition to create an outstanding, complex, unique and sophisticated design for a building like SOSC, which you will see tomorrow in the original. The demands towards an outstanding building are rising year by year worldwide:

- The town planning asks you to integrate a building complex into a given town structure considering a huge amount of influences.
 - The quality of an architectural design must guarantee a long lasting identity, high flexibility and optimal use.
 - The input of sustainable philosophy has to decrease future energy consumption and increase the sense of well being inside a building.
- And last but not least the structure engineer has to consider:
- the unity of architecture and structure
 - the guarantee of stability by innovative structural systems
 - the building costs

Optimization of construction time by designing effective building systems. Therefore a holistic team has to be set up as early as possible to start the design process. The team undertakes: a fast track and intensive design process working out alternatives getting involved into constructive criticism evaluation & discussion & think tank moments and fast decision making Finally a unique result comes out and everybody hopes that the design convinces the judges of the competition.

sbp – Sven Plieninger: As explained, a contemporary building or sports facility aims to be an outstanding landmark.

In a sports facility like SOSC we are facing complex problems of integrating modern building technologies with huge demands concerning the usability for the event itself and foremost the ability to broadcast these events worldwide. This in particular requires a modern and unique architecture which gives an outstanding appearance.

Crucial requirements of long spanning structures are to fulfill the demands of simplicity, lightness and thus being ecological and economical. In this regard the idea of having a building which is able to tell the visitor: "what is the structural principle- how does the building work" - is one of the fundamental goals in the work of our practices.

The solutions which can be achieved are varying because the borderlines or given constraints in each case are different, creating different opportunities and challenges for each project.

Based on our long-term cooperation (gmp + sbp) we start to analyze the given tasks very carefully to find out the governing conditions and transform them via a mutual discussion between architect and engineers into an idea for the buildings.

History

gmp – Nikolaus Goetze: There are many similarities among our offices of gmp and sbp.

Both offices have their origin in Germany.

The headquarter of gmp is placed in Hamburg while the headquarter of sbp is placed in Stuttgart.

Both offices were founded almost 50 years ago by our still active senior partners:

Meinhardt von Gerkan and Volkwin Marg founded gmp in 1965 while Jörg Schlaich and Rudolph Bergermann founded sbp in 1980

Now 4 partners, who took over the responsibility to carry on the offices' philosophy and accountability, lead each of the offices.

There are other similarities which make the cooperation easy:

We profit from more than 50 years of experience.

Most of our projects are the result of competitions.



摄影: Heiner Leiska



摄影: Heiner Leiska

汉堡历史博物馆

索和张拉膜结构就成为了我们设计作品的核心理念。

由于双方对轻盈通透设计目标的共同追求，1989年，gmp和sbp首度携手，为汉堡博物馆这一庭院屋顶项目提供设计服务。这是一个近乎完美的结合，堪称建筑师和工程师最佳合作方式的典范。为博物馆提出的建筑概念是：通过一个近乎隐形、极度通透的薄膜，分隔建筑的室内外空间。但究竟如何实现该操作？此时，工程师们萌生出打造一个“玻璃外壳”的想法，完美地解决了该问题。此后，该方案被人们称为“网壳结构原理”。双方均认为，这正是彼此所需的互惠合作。

企业理念

gmp - Nikolaus Goetze: 随着全球化进程的不断推进，设计师之间的竞争愈演愈烈。欧洲的建筑师事务所跑到亚洲设计大楼，中国的建筑院同样也在加拿大等国实施各类项目。

随之而来的，则是令人回味的文化交流。考虑到建筑师能够在世界各地工作，业主们对于清晰的企业理念——我们称之为个性化的手迹，也提出了明确需求。有鉴于此，我们有必要通过抽象的理念来对建筑手法做出定义：1）设计概念必须清晰直观；2）力求避免流于表现和新潮，却无法与建筑用途、功能及结构匹配的设计元素；3）主要目标是精简设计，使建筑内容和外观达到恒久的品质；4）精简建筑形式和限制用材同样有助于实现简约的目标；4）在设计阶段，我们倡导的建筑设计指导思想是：与设计团队、业主和用户之间展开对话式交流。

sbp - Sven Plieninger: 相较于设计理念，我更愿意说：我们的一切行为背后都有明确的原则提供指导。我们力求在工作中遵循这些原则，这就是我们的设计理念。我们事务所流行着这么一句话，可以很好地表达我们的追求，大意是：建筑的艺术无法割裂成任何一个独立的学科或零星的片段，同样，简单堆积这些学科或片段也无法形成一个整体。正因为如此，我们并不把自己具体定位为结构或桥梁工程师。所以，无论是玻璃屋顶、高层建筑、体育设施或是桥梁，我们的所有项目都应达到同样的品质要求。具体为：1）轻盈，几乎不可见，以尽可能减少用材；2）按功能要求设计；3）容易理解的传力途径；4）拉压杆，避免弯曲。这些正是我们作为结构工程师所应完成的任务。我们力求突破极限，学习新的事物，从而不断提升我们的日常工作能力。

-We emphasize on the conceptual approach.

-Our design work takes care of every detail.

-We are not specialized and feel open for all kinds of disciplines like buildings of culture, traffic, offices, high-rises, stadiums and residential use.

-Both of us like to experiment.

sbp - Sven Plieninger: As already mentioned, schlaich bergemann and partner was founded in 1980 but the roots date back to the first collaboration of Jörg Schlaich and Rudolf Bergermann during the 1960s for the 1972 Munich Olympics which was the beginning of the structural lightweight design in Germany.

Since that moment the use of tensile structures with cables and membranes became the central idea of our work.

Together with the strong relationships to the Universities of Stuttgart and Berlin, this gave us the opportunity to research in this field and also brought about a bunch of international contacts which from the very beginning provided the chance to take part in projects in many different countries. Curiosity in terms of developing ourselves in technical regards as well as being interested in different cultures and human beings became a driving point.

The aim of achieving a light and transparent design brought both of our offices in contact with each other when gmp and sbp first met for the courtyard roof project of the "Hamburg Museum" in 1989. This was a nearly perfect coincidence since it was exemplary for what we believe is the most ideal form of cooperation between architect and engineer.

The architectural idea intended for the Museum: an almost invisible, ultra transparent, thin layer as a separation between interior and exterior - but how to achieve this?

The engineers - during this time thinking about a "glazed shell" - gave the perfect answer with the solution which is since then known as "grid shell principle".

Both practices recognized that this was the way they wanted to benefit from each other, thus many other co-operations followed.

Philosophy

gmp - Nikolaus Goetze: The competition among all designers has grown as a result of globalization. Architects from Europe are designing buildings in Asia. Chinese architects are realizing projects for example in Canada.

The global approach leads to an interesting cultural exchange. Since architects are able to work all around the world, clients do expect a clear philosophy - let's call it an individual handwriting. That is the reason why we like to define our architectural approaches by an abstract philosophy:

-The conceptual idea must be clearly visible.

-We try to avoid expressive and fashionable design elements, which do not fit to the use, function and structure of a building.

-Our main goal is to reduce our design to achieve a long lasting quality in respect to its content and appearance.

-Formal reduction and the limitation of materials also strengthen the aim of simplicity.

gmp – Nikolaus Goetze: 不过，我们的这一理念，究竟需要将建筑师和结构工程师紧密结合到什么程度呢？最重要的目标是，建筑和结构必须形成一个整体。因此，结构概念需进一步强化建筑的概念和理念。

sbp – Sven Plieninger: 反之亦然！

gmp – Nikolaus Goetze: 我们对于简约的需求同时影响结构构件的选择。因此，减少结构构件的使用，如限制钢用量或采用钢索结构，也可达到简约的目标。

影响设计的另一个方面是结构特征的可见度。事实上，我们通过两步展示结构特征，或许我们可以重新回到本文的标题：“结构如何提升建筑美感？”

第一步是使结构概念在功能上可见，让每个人都能理解结构构件的工作原理。结构系统作为建筑的组成部分，成为一个颇具美感的工程元素。

第二步是使结构概念服务于建筑的设计形式。结构构件可打造具有雕塑感的元素。

建筑师和结构工程师之间还应展开可激发创新的对话。创新源于特殊的功能需求，譬如体育场的活动屋顶或重量问题。出于减轻屋顶构件重量的需求，膜结构技术应运而生。同样的原因，人们开始使用索网幕墙代替传统幕墙元素。

sbp – Sven Plieninger: 在我看来，有个历史案例采用的方法需要我们牢记，这种思维方式也常见于gmp和sbp的作品中。

在万国博览会时期，以1889年的巴黎展为例，建筑已不再作为卓越结构性能的装饰，而结构的作用也不仅限于打造出色的建筑作品。

这些建筑传达了一个很明确的信息：只有建筑和结构工程达到平衡或合理分配两个专业间的工作任务，才能取得令人满意的效果。所以，我们始终致力于寻求双方对设计任务的共识，然后寻找形式和结构之间的最佳平衡。桥梁、体育场、大跨度展厅和火车站等对于工程技术的要求颇高，而博物馆或研发楼等则主要考虑建筑功能。建筑形式是双方讨论的结果。任何情况下，建筑师都不会只考虑功能性或美感，他同时还会促使工程师为该设计任务寻求合适的结构方案。而

-During design phase we provoke the dialogical design as a guideline of our architectural approach with our design team, client and user.

sbp – Sven Plieninger: Instead of Philosophy I would rather like to say that behind all what we do, there are clear principles which we try to follow in our work and we could call this our philosophy.

There is one (unfortunately German) key sentence in our office describing our intention: "Die Baukunst ist unteilbar"

This poem means that the "art of building" cannot be divided in disciplines/bits and pieces which are thought independent and brought together to form a unity.

So we do not divide ourselves in structural or civil engineers, thus our projects, regardless if it is a glass roof, high-rise, sports facility or a bridge, should reach the same qualities.

Words like:

-Lightweight, invisibility - minimization of material consumption

-Designing according the requirements

-Understandable flow of forces

-Tension and compression instead of bending

describe our tasks as structural engineers.

We try to go beyond limits in order to learn new things, in order to expand our capabilities for the day to day work.

Thus we are also engaged in developing designs for solar power plants which we think are one of the challenges of the future we should contribute to.

We see ourselves as a team of generalists in our field but after all we are specialized structural engineers for tasks which require special solutions.

gmp – Nikolaus Goetze: But in how far does our philosophical approach link architects and structural engineers together?

The most important aim must be that architecture and structure form a unity.

Therefore the structural concept has to strengthen the concept and idea of a building.

sbp – Sven Plieninger: Or vice-versa!

gmp – Nikolaus Goetze: Our demand of simplicity also influences the structural elements. Therefore the reduction of structural items like limitation of steel weight or the usage of cable constructions fulfills the aim of simplicity. Another aspect which affects our design is the way of visibility of the structural character. In fact there are 2 approaches of presenting structure or let's stick to the title:

How structure adds to architectural beauty.

The first approach makes the structural concept visible in its function. Everybody understands how the structural elements work together. The structural systems create an esthetical engineering element as a part of the architecture.

The second approach makes the structural concept serve the formal intention of the architecture. The structural elements contribute to the creation of sculptural elements.



摄影：Christian Gahl
浦东展览馆



摄影：Roman Mensing
步行桥“轻盈的弹簧”，奥伯豪森



摄影：Christian Gahl
大运会体育中心



摄影：Marcus Bredt

柏林中央火车站



1889年巴黎世博会，机械展厅——工程师：康泰明，建筑师：都特

工程师也会从他对项目的理解出发，针对建筑美感提出建议。这就要求一方学会倾听另一方的意见。双方的合作不仅是训练有素的，而且是从专业技能和其中一个专业的需求出发，并且要求语言互通。以我的经验来看，这种工作方式对于任何项目都大有裨益。

gmp & sbp 的项目经验

大连双子塔

gmp – Nikolaus Goetze: 大连双子楼是大连的地标性建筑综合体，定义了大连其中一条最重要的城市轴线。两栋塔楼及其相连的基底建筑，形成充满活力的中央城市广场。双子楼地上53层，总体高度240m。

双子楼的幕墙设计极为重要。我们的目标是使幕墙的结构和节奏随着建筑的升高而逐渐放缓。幕墙在每隔8层设置的空中大堂处分割，每隔8层形成一个宽阔大堂和入口空间。

sbp– Sven Plieninger: 结构工程师可能只将高层建筑看成是包括核心筒、楼板、柱和幕墙在内的简单的垂直悬臂梁，并无特别之处。但我们都知道：越靠近建筑底部，弯矩和剪力就越大。我们曾尝试在大连双子楼项目中，将这一原理体现在结构和建筑中。设计概念包括一个核心筒和外部框架。上部楼层采用8.4m的柱网，越靠近底层，柱网密度越大（2.1m）。从结构上来说，竖向构件和柱子随着正向力的加大而增多，因此越靠近底部，外部框架就越牢固。我们与合作伙伴—上海华东建筑设计院有限公司一起，实现了这一设计概念，幕墙设计采用了这一理念。

天津火车站



摄影：Hans Georg Esch

大连双子楼



摄影：Christian Gahl

天津火车站

The dialogue between architects and structural engineers also has to provoke innovation.

Innovation comes from the special requirements of functions, like the movable roof of a stadium, or weight problems.

The use of membrane technique is a result of decreasing the weight of roof elements.

The same preconditions are the reason for using cable string façades instead of conventional façade elements.

sbp – Sven Plieninger: For me there is an approach in historic examples which we should remember, and this kind of thinking can often be found in the work of gmp and sbp.

During the times of the famous World exhibitions like the one in Paris in 1889, architecture was no longer the decoration of exceptional structural performance or structure was not just making exceptional architecture work.

With these buildings it was made clear that only by an equality of architecture and structural engineering or by assigning the tasks adequately between the disciplines, a convincing result can be achieved.

So we always try to find a common understanding of design task and afterwards we find the right balance of form and structure.

I.e. a bridge, a stadium, a long-span exhibition hall or a railway station requires a key part in engineering, whereas museums or research buildings are driven by the architectural functions. In all cases architect and engineer will contribute with different intensity to the process.

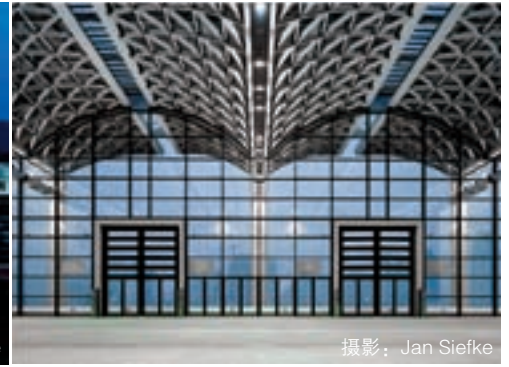
This may also explain why not each and every building formally looks the same. The building form is generated through the course of our discussions: By no means does the architect only care for functions or aesthetics; he will also motivate the engineer to find an adequate structural answer to the given task, whereas the engineer will give his aesthetical advice based on his understanding of the project.

This requires that one listens to the other, while the collaboration is at best trained and based on expertise and on the understanding of the language and needs of the other discipline.

From my experience I can say that this way of working is an enriching contribution to any type of project.



摄影：Jan Siefke



摄影：Jan Siefke

南宁国际展览和会议中心

gmp – Nikolaus Goetze: 中国对新一代火车站的需求，使我们有机会进一步打造出崭新宽敞的空间。350mx 90m的入口大厅，需设计成富有表现力而又舒适的空间来应对庞大的人流，并采用创新性的结构设计概念，引入更多的自然光。

sbp – Sven Plieninger: 天津火车站铁轨上方的站台上设置了一个具有桶形穹顶的主大厅，该桶形穹顶以交叉设置的拱形构件组成。这样，以结构形成建筑，或反之亦然。拱形构件在支座处刚接，因此结构高度相应较高，而其顶端旋转90°，形成平面，如同一个竹篮，实现了稳定可靠的结构体系。

南宁国际会展中心

gmp – Nikolaus Goetze: 在汉诺威共同完成了一系列的展厅项目后，南宁国际会展中心成为了我们在中国接手的首个展览类项目。它如同希腊雅典卫城一样，依山而建，是一栋朝向城市中央的地标性建筑。半透明的圆屋顶造型隐喻的开放花朵是南宁的标志，整个建筑也因而成为了新的城市符号。带有折叠式圆形屋顶的多功能大厅总体高度70m，直径48m，位于该建筑综合体的首端。

南宁国际会展中心是以低技术工艺实现的高科技建筑。直到今天，我仍无法理解：业主、建筑师和工程师团队是如何在当地建筑工人的协助下设法实现这一项目的。

sbp – Sven Plieninger: 展厅的最初设计理念是采用易于修建的预制混凝土壳体。后来我们发现，考虑到地震风险，这一理念并不理想，将质量设置得较高会对抗侧力体系带来负面的影响。我们与国内设计院共同决定，采用柱网-壳体和格构大梁组成的混合体系。这种体系可大大减轻结构重量。由于我们希望展现柱网-壳体结构，并定义出内部空间的特色，我们冒险决定将结构完全暴露在观众视线中。尽管面临着钢结构加工质量较差、细部设计未能令人满意等重重困难，我们还是取得了极其良好的效果。这主要归功于我们努力通过简单重复的设计手法精心完成的细部设计。

深圳会展中心 (SZCEC)

gmp – Nikolaus Goetze: 深圳会展中心为深圳中心商务区确定了一条鲜明的城市轴线。会展中心从外形而言，呈水平方向的长条造型，与两侧鳞次栉比的高楼的竖向结构形成了鲜明对比。整个展区位于同一层。展区平面呈长方形，宽约280m，长约540m，钢梁外露，赋予这一大型建筑物韵律感并体现其恢弘气势。管状造型的会议区宛如盘旋于展厅之上，且可独立运行。会议中心上方张扬的建筑姿态完全是因为项目场地空间有限所致。

Experience gmp & sbp

sbp – Sven Plieninger: We want to present a few examples of our work which show this mutual understanding and attempt to fill this collaboration with life.

We have to be honest that the real world is not ideal – it is not only the architect and engineer who define the project.

There are significant influences which neither Nikolaus nor me can deny and are often enough the driving forces of the project.

Dalian Twin Tower

gmp – Nikolaus Goetze: The Dalian Twin Towers define one of the most important town axes in Dalian as a landmark building ensemble. The composition of two towers with their neighboring base buildings creates a vital central city plaza. With 53 floors above ground the Twin Towers reach an overall height of 240 m.

The façade design of the twin towers has great importance. Our aim was that structure and rhythm of the façade loosen up along the building height.

The façade is subdivided in sky lobbies with the height of eight floors each to create a spacious lobby and entrance situations on every 8th floor.

sbp – Sven Plieninger: As structural engineer one might consider a high-rise as a simple vertical beam consisting of core, slabs, columns and facade. Nothing special, but we all know that bending moment and shear-forces are increasing towards the base. So one can decide to make this principle also visible in the structure and architecture, which we tried in the case of the Dalian Twin Towers. The concept consists of a core and an outer frame. The columns are positioned in a grid of 8.4m at the upper levels, getting denser (2.1m) towards the ground. Structurally the outer frame gets stronger towards the ground by adding more vertical members as well as the number of columns get more according the increasing normal forces. For us and our partner office ECADI from Shanghai a convincing concept. The facade follows this idea.

Tianjin Railway Station

gmp – Nikolaus Goetze: The new generation of railway stations in China gives us the chance to further develop new, generous spaces. The dimension of an entrance hall of 350 x 90m asks for a design forming an expressive yet comfortable space for a huge amount of people in combination with an innovative structural concept which furthermore allows daylight to enter.

sbp – Sven Plieninger: In the case of the Tianjin railway station, a barrel vaulted main hall is placed on the platform above the tracks. This barrel is formed by intersecting arches. In this way the structure forms the architecture or vice-versa. The arches are restraint at their supports so that the structural height is accordingly high whereas at the apex it turns 90° to flat. Like for a bamboo basket, a stable and reliable structure is achieved.

Nanning (NICEC)

gmp – Nikolaus Goetze: After completing a number of exhibition halls in Hannover together, our first project of this type in China was the NICEC.

We could give a lecture talking only about NICEC but summarizing this adventure I can only quote:

NICEC is a high tech building but was realized with low tech skills. Until today I still do not understand how the team of client, architect and engineers managed to realize it with the help of local workers.

sbp – Sven Plieninger: 建筑师和工程师必须解决的主要难题是，如何为长500m、宽250m的开阔的展览中心设计一个无柱空间，同时又使建筑保持人性化的尺度和城市尺度？因此，跨度达125m、横跨整个展区的主钢梁间距为30m，以一对箱型结构进行排列。为了减轻重量，采用了下弦张拉结构体系。从视觉比例考虑，钢梁的上弦杆高为2.5m，超出了结构受力的要求。受拉构件为两束三根直径为100mm的钢拉杆，极为纤细！由此一来，在结构上可用上部箱型梁的翼缘取代桁架所必需的斜腹杆。所有连接部位如钢梁底部的铰接处和拉杆及飞柱的连接处，在设计上均是为了将其结构原理视觉化。

太阳能塔

sbp – Sven Plieninger: 多年前（早在20世纪70年代石油危机期间），Jörg Schlaich就已经意识到未来能源供应的唯一希望将寄托于太阳光。自那时起，我们就不断地探讨可以利用太阳辐射的结构和原理。由于我们的结构设计工作所处理的就是大楼、缆索、薄膜和玻璃结构，利用相关知识制定解决方案是理所当然的。热气流上升的原理其实非常简单：它由玻璃温室包裹在外的通风管组成。阳光使透明外盖下面的空气温度升高，空气随之流向并贯穿于整个通风管内。在通风管的底部，安装由极高的风速驱动的高效风机。

gmp – Nikolaus Goetze: 正如我在讲座之始所提及的那样，建筑师和工程师必须具备革新精神。

新技术的发明将引领新建筑的到来，如我们刚才所展示的太阳能塔、太阳能发电站或潮汐发电站。尤其是，这些建筑是注定将建筑学和建筑结构结合起来的。

体育场—宝安体育场

gmp – Nikolaus Goetze: 国际性赛事日益成为人们关注的重点。体育场不仅是体育赛事的场地，同时它还是主办城市的名片。因此，体育场往往设计成为标志性建筑，我们希望能够在这类具有争议的需求之间找到平衡点。

sbp – Sven Plieninger: 宝安体育场所体现的正是令人折服的、简洁明快的建筑概念和最高效、最可靠的结构原理两者之间的绝佳结

NICEC is - like the Greek Acropolis - situated on a mountain site and is orientated as a landmark building towards the city center.

The shape of the translucent dome is a metaphor of an opening blossom, which has become the symbol of Nanning, and therefore defines a new symbol of the city.

The multi-functional large hall with its folded domical roof, an overall height of 70 m and a hall diameter of 48 m forms the head of the complex.

sbp – Sven Plieninger: The initial idea for the exhibition halls was a prefabricated concrete shell. Against our assumption that a concrete building must be easy to construct in China, we had to learn that in regard to the earthquake risk, it is not favorable. The mass placed on a high level would negatively affect the bracing system.

Together with our local design office we decided for a hybrid-system of grid-shell and lattice girder which considerably reduced the structural weight.

Since we wanted the grid-shell to be visible and to define the character of the interior, we took the risk and decided to fully expose the structure to the views of the visitors.

Against all odds that the quality of the steel manufacturer might be low and we would create an unacceptable detailing, we achieved a remarkably good result. This was mainly achieved by the careful detailing which we tried to keep simple and repetitive.

Shenzhen Convention and Exhibition Hall SZCEC

gmp – Nikolaus Goetze: SZCEC determines the powerful city axes of Shenzhen's CBD.

The design of SZCEC with its long, horizontal structure forms a contrast to the vertical structure of the numerous high-rise towers framing the exhibition center on both sides.

The whole exhibition area is located on one level with a rectangular plan of approximately 280 m by 540 m. The steel girders are exposed to the outside in order to give the huge building rhythm and scale.

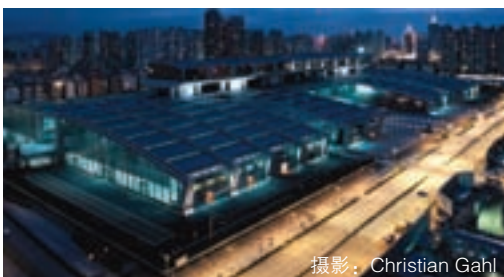
The tube-shaped congress building seems to hover above the exhibition halls and can be operated as a separate unit. The expressive position above the congress center is a result of the limited space on site.

Sven Plieninger - sbp: The main problem which the architect and engineer had to solve was how to achieve a huge column-free area for the 500m long and 250m wide exhibition center while maintaining a human scale as well as an urban scale of the building.

So the main girder which have to span the exhibition area across 125m are spaced 30m and are arranged as a pair of box type elements. In order to reduce the weight they are suspended by tension members.

For scale reasons the girders' upper chord are 2,5m high which is more than structurally required. The tension members are steel rods of 2*3*100mm and quite slender!

This creates the structural possibility that the necessary diagonals of a truss



摄影：Christian Gahl



摄影：Jan Siefke

深圳展览和会议中心



摄影：Christian Gahl

宝安体育场

合。带外压缩环的环形索屋面要求采用放射状的桁架和一个双重的内部受拉环，以便打造一个稳固的系统。线条简洁的钢拱支撑在径向索之上，并在顶部撑起薄如肌肤的薄膜。

上海东方体育中心的城市规划策略

gmp – Nikolaus Goetze: 在黄浦江两岸，人们可以深切地体会到上海令人匪夷所思的发展速度和循序渐进的再开发进程。旧码头和港口区的重构为多个重要项目创造了绝佳场地。数个毗邻黄浦江的重要项目已经随着上海世博一并竣工。所有这些项目均清晰地展示了上海作为“滨水城市”的特质。项目场地可饱览江景，同时紧邻市中心，是城市迅猛发展最为宝贵的先决条件，尤其是考虑到超大都市之间不断的互相竞争。

上海东方体育中心是黄浦江城市开发中一个重要的里程碑。北京奥运期间游泳赛事取得的巨大成功和受欢迎程度，使上海萌生了举办2011年世界游泳锦标赛的想法。最终，上海于2011年7月顺利获得第14届世界游泳锦标赛的主办权，比赛项目包括游泳、花样游泳、水球、跳水和公开水域游泳。此外，经过长期开发，SOSC的整个邻近区域都将发展成为一个具有可持续性的城市水岸体育和文化公园。公园将成为人们社交生活的好去处，为浦东居民提供一个休闲之所，同样，也是上海举办职业性和休闲体育活动的场所。

水岸体育和文化公园总体规划概念

gmp – Nikolaus Goetze: 根据总体规划，水岸体育和文化公园占地将达167.7公顷，其中包括占地为39.4公顷的核心场所——上海东方体育中心。

我们的景观设计将主要的体育场区融入水岸体育和文化公园的体系之中，且须对交通在城镇规划的方方面面加以考虑，如对令浦路、行人流线、人行道和重要的观景点进行划分景观设计，包括其独有的构成元素，如水、波涛、沙滩和桥梁，为体育综合体搭建起一个展示舞台。我们的主要概念是要将所有体育场所融入景观之中，并以视觉轴线将它们串联起来。

我们为景观设计提供的一个例子就是哈德良别墅，即在公元二世纪二十到三十年代期间由罗马皇帝哈德良在罗马附近建造的别

are replaced by the flanges of the upper box girder.

All connections such as the hinges at the girder foot points and at the connections of tension rods and posts were designed to visualize their structural principles.

The Solar Updraft Tower

sbp – Sven Plieninger: Many years ago (during the oil crises in the 1970ies) Jörg Schlaich recognized that the only hope for future energy supply will be the sunlight.

There are two reasons for this:

Firstly: The oil reserves are not endless - as we experience day to day through rising prices.

Secondly: Poverty in the world has to do with a lack of energy. And most of the people facing this problem live in areas of high solar radiation!

Since then we have been constantly working on structures and principles that make use of solar radiation. Because our structural practice is dealing with towers, cable, membrane and glass structures it was obvious to use this knowledge in order to provide solutions.

The updraft principle is quite simple: it consists of a chimney surrounded by a glassed greenhouse. The solar radiation heats the air underneath the transparent cover and the heated air will flow towards and through the chimney. At the base-point of the chimney efficient wind turbines are arranged which are driven by the extremely high wind speeds.

gmp – Nikolaus Goetze: As I mentioned at the beginning of our lecture, architects and engineers have to be innovative in the search for new building tasks. The invention of new technologies will lead to new building generations, like the just shown solar updraft towers, solar energy plants or tidal power plants. Especially these building types are predestined to bring together architecture and building structure.

Stadium - Baoan Stadium: Nikolaus Goetze - gmp: International sport events are more and more in the focus of the public. The sport event gives the hosting city or region a chance to present itself through spectacular stadia to hundreds of millions of spectators worldwide. The stadia do not only have to serve the pure purpose of being a sports venue. At the same time they have to be the name card of the city organizing the sport events. Therefore the stadia developed into iconic buildings. We try to find a balance between these controversial demands.

sbp – Sven Plieninger: The Baoan Stadium is a perfect example of the marriage of a convincing simple architectural idea and a most efficient and reliable structural principle.

Consisting of a ring-cable roof with one outer compression ring it requires radial girders and a double inner tension ring in order to create a stable system. Simple arches span between the radial cables and stretch the skin-like membrane on top of it.

Town Planning Strategy SOSC



哈德良别墅，罗马



上海东方体育中心



上海东方体育中心

墅。哈德良别墅是由超过30座建筑构成的综合体，占地面积至少达1平方公里。综合体包括宫殿、数个温泉区、剧院、神殿和图书馆。

建筑总体的主要设计概念是，所有的建筑均由顺应景观形态的轴线相连。轴线并非由几何设计而来，而是从景观特征、视野和流线衍生而来。我们从中国园林比方说苏州园林中学到的相类似的情况。除了相关景观轴线的建立之外，体育公园的景观主题为：1）蜿蜒起伏的林荫大道栽种各式树木，通向体育场综合体，沿途分布的是水岸体育和文化公园的各个活动区。它确保人们能够饱览令人震撼的城市天际线、黄浦江和体育馆；2）第二个主题则是一个面积为56 000m²的人工湖。在设计上，我们旨在将形态无拘无束的人工湖融入整个景观设计之中。这样一来，每座建筑都在湖畔占据了独一无二、美不胜收的位置，且可隔岸相望；3）与蜿蜒起伏的林荫大道形成对比的是：一条笔直的林荫步行道有如中轴线，将水岸体育和文化公园连起来，通向停车场和地铁站。

建筑外形

gmp - Nikolaus Goetze: 上海东方体育中心的整体设计概念就是要打造一个体育中心，它有别于拥挤稠密的上海，处处以水为主题。

体育场本身正如描绘中国园林的艺术品一般是作为人文元素融入水上公园的景观之中的。

环绕于体育场四周的抬升平台上设置了种类繁多、内容丰富的活动和餐厅，是整个滨水体育公园的中心。

夜幕下，体育场映入水中，为各种音乐会和演出营造节日氛围。波涛、桥梁以及潺潺流水，都成为建筑动态的一部分。

为使整个综合体具备明显的特征，找到能够给3座体育场馆带来韵律和结构感的建筑主题对于我们而言尤为重要，犹如建筑骨架的结构元素将整个体育场统一起来。带鲜明特征的统一结构重复出现，赋予室内体育馆、游泳馆和室外跳水馆不同的个性。自然而然地，就产生了以下的比喻：1）体育馆的整体外形就像一座桥梁，象征着上海东方体育中心的入口，迎接从周边公路进入上海市中心的八方来客。桥梁是将文明和水景连接起来的重要元素；2）游泳

gmp - Nikolaus Goetze: The fascinating growth and progressive redevelopment of Shanghai is impressively shown along the banks of the Huangpu River. The reorganization of old docks and harbor areas create fantastic sites for significant projects. Several important projects close to Huangpu River have already been realized together with EXPO 2010.

All these projects clearly point out the specific quality of Shanghai as the “City at the water”.

Having water view sites close to a city center is the most valuable precondition for a strong growth of a city, especially considering that all mega-cities are permanently competing with each other.

The SOSC is a further important mile stone of the urban development along the Huangpu.

The huge success and popularity of the swimming contest during the Beijing Olympics gave Shanghai the motivation to arrange 2011 FINA World Championships. Shanghai finally won the bid to host the 14th FINA World Championship in July 2011, for swimming, synchronized swimming, water polo, diving and open water disciplines.

Furthermore, based on a long term development, the entire neighborhood of SOSC will be developed as a sustainable urban Riverside Sports and Cultural Park.

The park will create a center of attraction for social life, leisure area of the residents of Pudong and a new center for professional and recreational sports activities in Shanghai.

Overall Master Plan Concept Riverside Sports and Cultural Park

gmp - Nikolaus Goetze: According to the overall master plan, the Riverside Sports and Cultural Park will cover 167.7 hectares including 39.4 hectares for the core venue of the Shanghai Oriental Sports Center.

Our landscape design integrates the main stadia area into the overall system of the Riverside Sport and Cultural Park and had to consider all town planning aspects of traffic, such as the subdividing Lingpu Road, pedestrian circulation, walkways as well as important viewpoints.

The landscape design with its characteristic elements of water, waves, beach and bridges builds up the stage for the sports complex.

Our main conceptual idea was to integrate all sport venues into one landscape topography and connect them through visual axes.

One example for our landscape design is the Villa Adriana, built by the Roman Emperor Hadrian close to Rome during the second and third decade of the 2nd century AD.

Hadrian's villa was a complex of over 30 buildings, covering an area of at least 1 square kilometer. The complex included palaces, several thermal bathes,

馆的特征是其一系列小弧形造型，让人们联想起拍岸的波涛。波涛象征了静默、韵律和永恒；3）室外体育场，作为从传统圆形竞技场衍生出来的新生事物，呈新月造型，人们可从中饱览黄浦江令人惊叹的美景。所有大跨度的弧形造型都覆盖了白色、略为弯曲的表层，使之具备海事建筑的形象。

结构外形

sbp – Sven Plieninger: 2008年夏秋两季举行了上海新体育场馆的设计竞赛，也就是在2011年8月世界游泳锦标赛举办的3年前。即便是以中国标准来看，该项目规划和建造期之短也让人难以置信，就紧凑的进度而言，更是超过了迄今为止所有项目。尽管如此，也绝对不能牺牲建筑的结构安全性。

时间不足常常造成施工质量不过关。同时，主体结构的杆件往往大于需要的截面，构造的细节被简化以致高效和经济环保的建造过程往往会被忽略。大型游泳馆和多功能体育馆的显著特征是其大量技术装置：需要对空调及通风系统、照明、声响和电视传输技术所带来的负荷给予充分考虑。

由于功能各异，根据其所需的建筑体积，每座建筑平面各有不同，要求不一，尽管如此，我们仍希望打造一个建筑族群，打造外形满足上述要求的建筑。依据此种理念，我们采用非常基本的方法表现主体结构的设计概念：游泳馆为拱形，室内体育馆为框架，室外为半框架，均非常精细，而技术细节则被融入到背景之中。

上海东方体育中心（SOSC）设计介绍

上海东方体育中心体育馆

gmp – Nikolaus Goetze: 2011年 7月16~31日开赛的国际泳联（FINA）世界游泳锦标赛对于上海这座城市而言的确是一场体育盛典。但我们的设计不只考虑了体育馆用于该赛事的功能，而且还考虑了体育馆在将来的使用。因此，我们将体育馆设计为一座适用于

theatre, temple and libraries.

The main concept of the building ensemble was that all buildings were linked together by axes respecting the typology of existing landscape. The axes were not designed geometrical. They resulted out of landscape character, views and circulation.

Similar phenomena we learnt from Chinese Gardens in - for example - Suzhou.

In addition to the input of relevant landscape axes, the main landscape motives of SOSC Park are:

-A hilly and curved boulevard planted with groves of trees connects the stadia complex with all activity zones of the Riverside Sports & Cultural Park. It guarantees impressive views to the skyline of the city, the Huangpu River and the stadiums.

-The second central theme is an artificial lake with a size of 56,000 sqm. The free formed lake is designed to be combined with the overall landscape design. This allows that each building occupies a special and striking position along the shoreline and can be viewed from across the water.

-In contrast to the hilly and curved boulevard, a straight tree promenade organizes the Riverside Sports & Cultural Park as a central axis and links it to the parking area and subway hub.

Architectural Appearance

gmp - Nikolaus Goetze: Our general idea of SOSC was to create a sport center that differs from the dense urban character of Shanghai and is dominated by water themes.

The architecture of the stadia stands - just like in the Chinese art of gardening - for artificial elements in the designed landscape of the Water-Park.

The elevated platforms surrounding the stadia offer a highly attractive variety of activities and restaurants to serve as the center for the whole Riverside Sport-park area.

At night the stadia are being reflected in the water, creating a festive atmosphere suitable for concerts and performances.

The gesture of these building quotes the elements of waves, bridges and the movement of water.

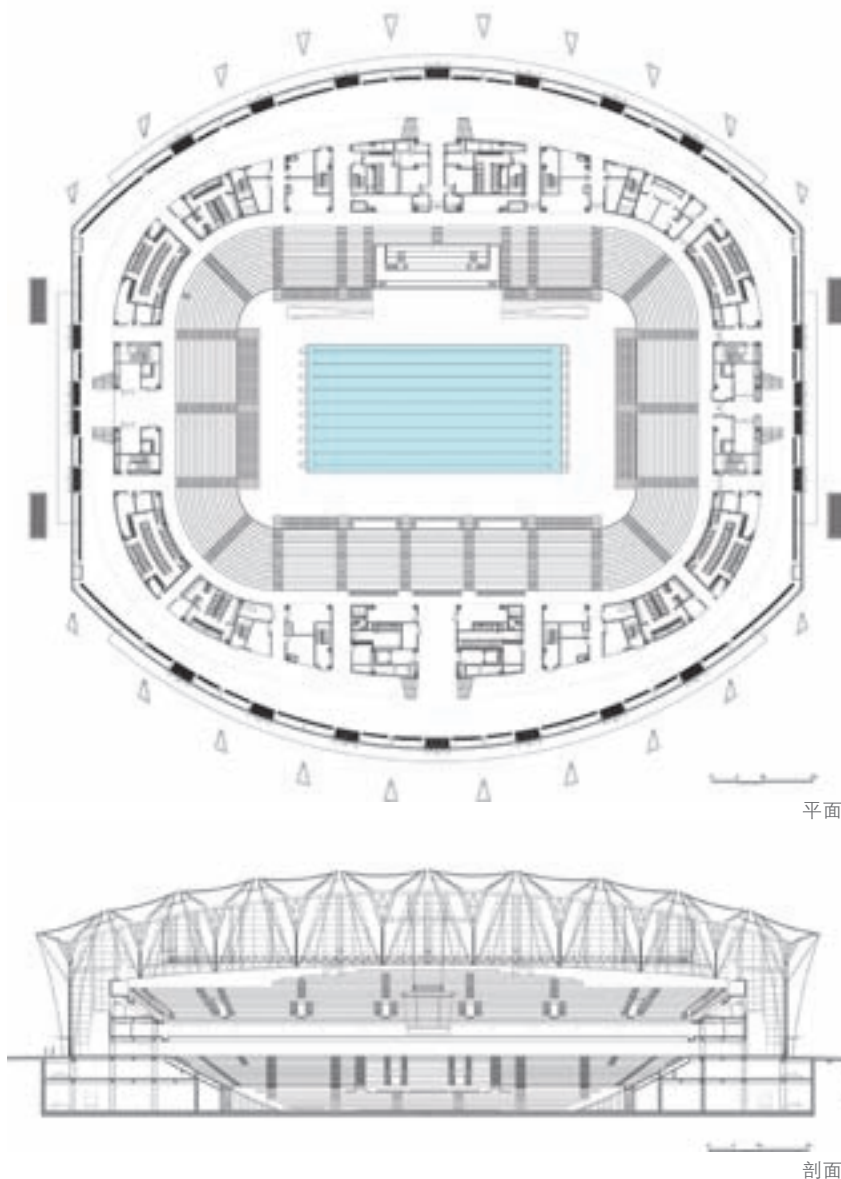
In order to create a strong identity for the whole complex, it was essential for us to find an overall architectural theme giving rhythm and structure to all the three sports facilities. A bonelike structural element now unifies the stadia. The overlapping of a unifying structure with the individual character gave the Indoor Stadium, Swimming Stadium und Outdoor Diving Pool its individual character.

As a result, the following metaphors were created:



摄影：Marcus Bredt

上海东方体育中心体育馆



各类体育、文化和休闲活动的多功能场地，且在今后数年乃至数十年内，仍将散发其独特的魅力。

体育馆是3座体育场馆中最大的场馆。其主体结构系统由10根平行的桁架组成，桁架的大小按其结构需要相应地连续设置，构成一座独特的建筑。屋面结构为跨度170m宽的钢结构，上覆白色铝面板。大跨度是该结构设计中的最大挑战。平行的钢桁架从中间分别向南、北两个方向形成35m高的桥拱，环绕在圆形开放式大厅的玻璃幕墙周围。观众通过架空广场（+11.00m）进入室内体育场。光线充足、空气流通的大堂区引导观众来到体育场的低看台或高看台。高看台和低看台之间设有一VIP层，内设了36个单人VIP包厢。这些专用包厢可通过几部电梯连接VIP下客点和地下室VIP停车位。观众、VIP、VVIP、运动员和货物流线彼此之间完全独立，以确保安全和快速通行，同时确保场馆运营的成本经济。

观众容量

gmp – Nikolaus Goetze: 固定坐席的常规容量为14 000人。但由于该多功能场馆的设计还须符合NBA标准，即：需设置18 000个观众席，因此需增设4 000个坐席的活动看台，从而使举行拳击赛、

-The overall shape of the Gymnasium stands for a bridge and symbolizes the entrance of SOSC welcoming guests entering Shanghai city center via the adjacent high ways. The bridge is the essential item bringing together civilization with water features.

-The Natatorium is characterized by a sequence of calm arched shapes, evoking the image of waves flushing up a shore. The waves stand for silence, rhythm and timelessness.

-The Outdoor Stadium as a new born generation of the traditional amphitheater allows with its crescent shape fantastic views to the Huangpu River.

All large spanning arches are clad in a white, gently bent surface and stand for a maritime image.

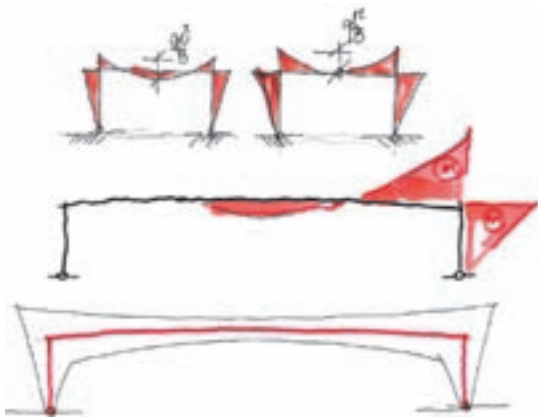
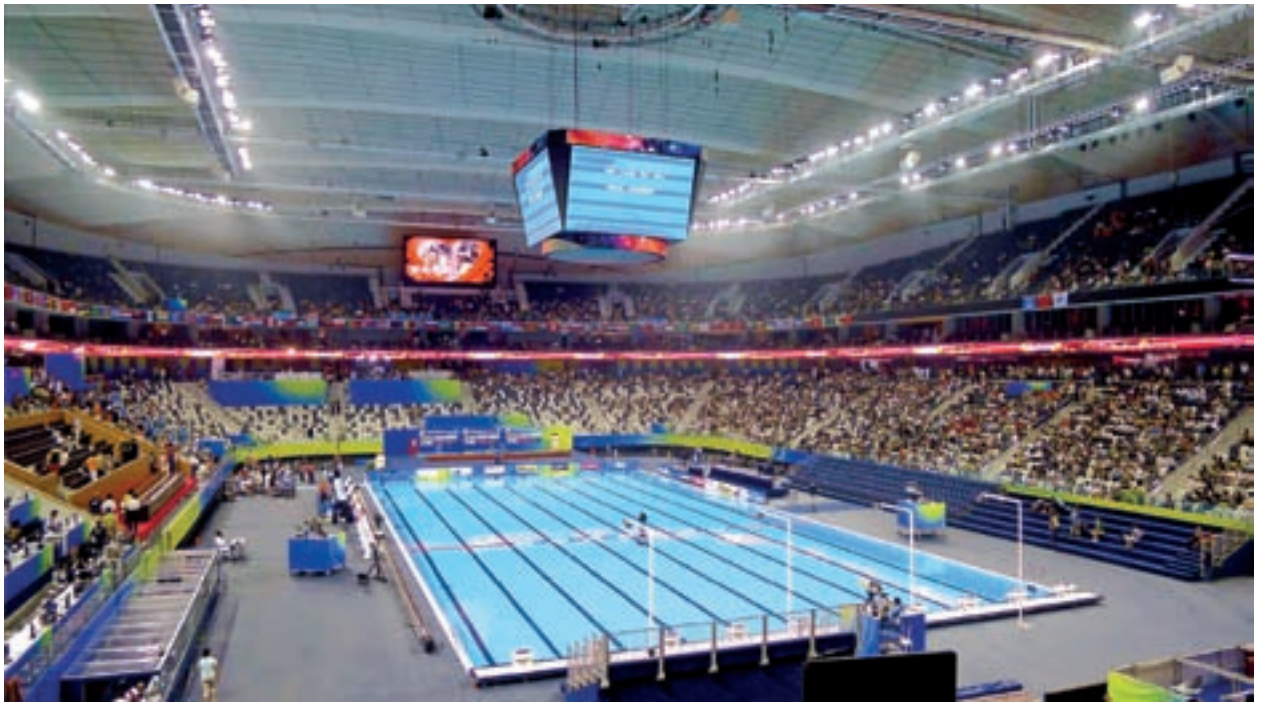
Structural Appearance

sbp – Sven Plieninger: For the new sports venue in Shanghai, a competition was held in the summer/autumn of 2008, almost exactly three years before the start of the actual World Championship in August 2011.

Even by Chinese standards, this resulted in an unbelievably short planning and construction period, outshining everything in terms of tight schedules that had hitherto been experienced.

Nevertheless, the structural safety of a building must not suffer even under such circumstances.

Shortage of time often leads to a loss of quality in terms of building execution. At the same time, the supporting structures are in danger of being over-dimensioned, and constructional details are simplified in such a way that the



摄影：Marcus Bredt

上海东方体育中心体育馆

篮球赛、羽毛球赛或音乐会等之类的活动能实现最大的观众容量。

sbp – Sven Plieninger: 室内体育馆的建筑基底造型为圆形。基座采用钢筋混凝土结构，屋面采用钢结构。室内与室外的气候环境分隔主要是通过安装在钢结构上的幕墙结构而实现的。屋面结构的外径约为170m，形成水平视角的围护结构。选择两铰框架结构体系，可同时展现大厅和休息厅。框架结构内的刚度分布设计力求使弯矩主要集中在框架的角部，从而确保结构“重量”也可在视觉上集中于这些角落。10个独立框架的跨距各不相同，从80m到150m不等。由于放置在环形结构上，每榀框架产生不同程度的扭曲。纵向穿越各框架的次结构体系将独立的构件连接起来，从而使其形成宽敞、稳固的框架结构。

上海东方体育中心游泳馆

游泳馆建筑设计

gmp – Nikolaus Goetze: 游泳馆是上海东方体育中心另一个重要的组成模块。游泳馆的矩形造型由13根平行的结构桁架打造而成。游泳馆建筑长边的立面构成主要为造型柔和、优雅的首层空间。这

idea of efficiency and hence of an economical and ecological building process tends to be dropped.

The wish to develop comprehensible and conceivable supporting structures is limited significantly unless these factors are taken into consideration already in the design process.

Large swimming halls and multi-purpose arenas are characterized by a high degree of technical installations: loads resulting from air conditioning and ventilation systems as well as from lighting, sound and television transmission technology need to be taken into consideration.

Due to their respective functions, the individual buildings have fairly different ground plan forms and requirements in terms of the necessary building volumes. Nevertheless, we wanted to create a family of buildings.

This in mind, we decided to develop buildings of a form that was supposed to be “robust” in respect of all aforementioned requirements. In this context, however, the supporting idea and its very special expressiveness also were to be communicated by very basic means.

So, the more or less pure structural principles - Natatorium = arch, Indoor Arena = frame, Outdoor = half of a frame - were elaborated and the technical detailing moved to the background.

Design SOSC – Gymnasium

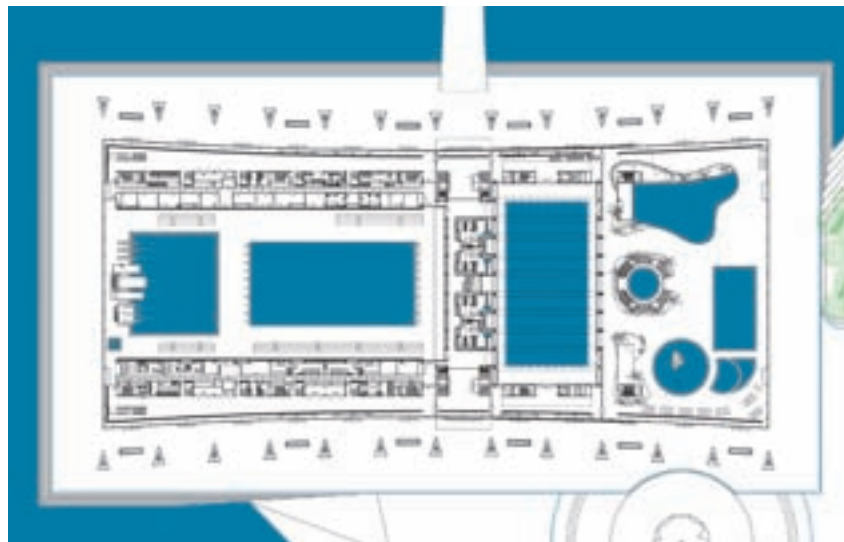
gmp – Nikolaus Goetze: The FINA Swimming World Championships from July 16th to 31st 2011 were in fact a spectacular event for Shanghai.



摄影：Marcus Bredt



摄影：Marcus Bredt



上海东方体育中心游泳馆

种动感通过水景沿线拱廊和平台忽宽忽窄的变换形成一种刺激的张力。借此，在连廊平台处形成较大的入口空间，作为大型活动的室内集合地点，塑造出大气的入口形象。不同于其它场馆的是：体育馆综合体的主入口设置在广场层，以确保通过建筑内部的天桥形成直接的公共交通流线。屋面结构跟随钢结构和三角形幕墙表面逐渐演变为95m的跨距。自然光通过两个结构桁架之间的天窗进入建筑物内。

游泳馆内设置了各类泳池，包括两个标准泳池、一个跳水池和一个自由式休闲泳池区。看台设计为斜坡状坐席布局。此外，VIP看台设置在中央区域，包括常规VIP看台、12个主席位及必要数量的裁判坐席。

观众容量

竞技泳池区内的固定坐席容量设定为3 500人。根据国际泳联的规定，须设置5 000个观众座位。因此，需增设1 500个活动座椅的临时看台。当撤除上述临时看台时，该空间可用作摆设植物的休闲区、休息区、儿童游乐区等。

But our design had not only to consider the functions for this event but had also to respect the future use. Therefore the Gymnasium was designed as a multi-functional venue for all kinds of sports, culture and leisure activities representing a unique attraction for years and decades.

The Gymnasium is the largest of the three stadia. Its main structural system is composed of ten parallel trusses that continuously adapt in scale according to the structural needs, generating a unique architecture.

The roof structure is a 170 m wide span steel construction, clad with white aluminum elements. The large span was the greatest challenge of the structure design. The parallel steel trusses are developing 35 m high bridge type arcades to north and south, surrounding the glass facades of the circulating open foyers.

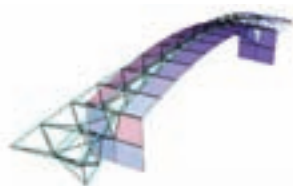
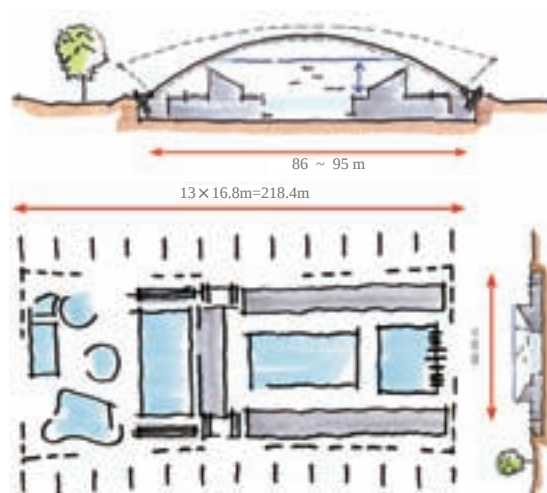
Spectators enter the indoor stadium from the raised plaza (+11.00 m). The circulating and light-flooded lobby areas lead the spectators to the lower stands of the arena or the upper seating.

In between the upper and lower stands, a VIP level is installed to provide 36 single VIP boxes. These private rooms are accessible via several elevators connecting VIP drop-off and the individual parking lots in the basement with the VIP area.

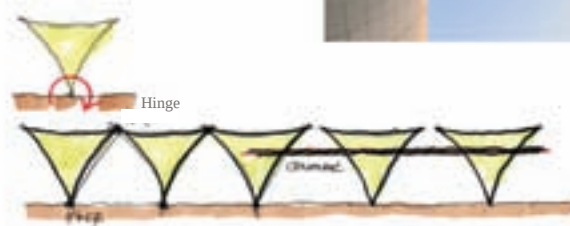
Spectators, VIP, VVIP, athletes and deliveries are completely separated in order to ensure a safe and quick access and at the same time a cost-effective operation of the venue.



摄影：Marcus Bredt



一个单元的计算模型示意图（整体模型，无屋面）



上海东方体育中心游泳馆

sbp – Sven Plieninger: 游泳馆内设置的几个泳池次第排列。观众沿泳池周边而坐。当赛事中无室内高台跳水比赛的安排时（如上海锦标赛），则游泳馆的高度不是一个控制因素；但应设置充足的高度，用以设置额外的临时坐席。游泳馆最终设计要求为约200m长、80~90m宽、无特定高度要求的设施。

游泳馆底部为钢筋混凝土构造的基座，顶部为钢结构的屋面结构。游泳厅屋面的基本结构造型为拱。

实际上，低矢高的纤细拱形足以承受均匀的荷载。然而，对于非对称荷载或单侧荷载，还需防止其失稳。为此，在拱管上设置两个略微倾斜的桁架层，最终形成一个空间的结构体。

13个此类基体呈90~100m不等的跨距，沿主轴方向按15m的间隔排列，彼此之间通过二级檩条结构连接起来，与它们之间的天窗顶一起，组成游泳馆的屋顶结构，且从视觉效果上围合了必要的游泳馆空间。玻璃幕墙围裹着的游泳馆主体就设置在这些整齐的造型内。

上海东方体育中心室外跳水池

gmp – Nikolaus Goetze: 室外跳水池朝向黄浦江，其结构由各种不同规格大小的、宏伟的悬臂组成。

为提供面向黄浦江的开敞视野，座椅和屋顶遮阳结构均集中在游泳和跳水池的东侧。室外跳水池的建筑以一种大气开放的姿态倚靠着黄浦江，展现出恢宏的城市天际线，使其成为跳台的背景。

建筑结构本身与其他场馆的外观相似。结构模块之间的采光膜起到了必要的防晒和防雨作用。

Capacity

gmp – Nikolaus Goetze: The regular capacity of the fixed stadium seating is laid out for 14,000 people. Since the design of this multifunction hall had to follow the NBA standard, 18,000 spectator seats were required. This will be reached by the addition of mobile stands with 4,000 seats, so events such as boxing, basketball, badminton or concerts can be held with the maximum capacity of spectators.

sbp – Sven Plieninger: The indoor stadium is defined by a circular footprint, with a pedestal structure made of reinforced concrete and a roof structure made of structural steel. The climatic separation between indoor and outdoor climate is mainly realized with a façade structure attached to the steel structure.

The roof structure is defined by an outer diameter of almost 170 m representing the envelope in plan view. A two-hinged frame system was selected that lets the hall and the foyer/lounge emerge at the same time.

The stiffness distribution within the frame structure was designed in such a way as to create a significant concentration of the bending moment at the frame corners and thus ensure that the “weight” can also be concentrated there in optical terms.

The span width of the ten individual frames is fairly different at 80 - 150 m. Placed on a circular structure, the frames are strongly warped in themselves. A secondary system vertically pushed through the frames connects the individual elements and thus stiffens them in spatial terms in a frame-like manner.

Design SOSC – Natatorium

gmp – Nikolaus Goetze: Architecture Natatorium

The Natatorium complex forms the second important module of the Shanghai Oriental Sport Center.

The rectangular shape of the Natatorium is defined by 13 parallel structural trusses that form the rectangular architecture.

The elevation of the long side of the Natatorium building is dominated by the soft and elegantly shaped ground floor.

作为一个供游泳人员使用的功能性体育运动场所，室外跳水池在体育运动区内位置显要，并与其他场馆一起，共同打造了一个具有国际标准的魅力休闲娱乐设施。

观众容量

gmp – Nikolaus Goetze: 场馆固定坐席的常规容量设置为 2 000 人，包括 VIP/VVIP 坐席。在游泳赛事以及比赛期间，可搭设临时坐席，将观众容量增加至 4 850 个坐席。

sbp – Sven Plieninger: 室外跳水池的结构类似体育馆，其基底也为环形。为突出室外跳水池的特殊区位，并形成壮观的视野，大看台或多或少地呈一侧布置。钢筋混凝土组成的大看台结构形成了古罗马圆形竞技场图案。屋顶结构也遵循这一特殊原则，也按环形布局设置在一侧。

L形的半框架呈新月形状设置在大看台的外边沿，是场馆的基础构件。其大小根据看台深度的变化而有所不同，框架的角部按有效荷载和受力的要求加高。各基础点相互连接起来，因此，悬臂末端为非常薄的设计。各单个主体相互连接起来，通过分别设

This movement creates an exciting tension by widening and narrowing the arcades and the platform along the water.

By this, a larger entrance space at the landing of the connecting bridge is created as a gathering place for big events under the roof, forming a generous entrance gesture.

Unlike in the other venues, the main entrance to the Natatorium complex is located on the plaza level in order to ensure direct public circulation through a bridge inside the building.

The roof structure grows as a 95 m wide span with a steel construction and triangular shaped façade surfaces.

Natural light shines into the building through skylights which is positioned between two structure trusses.

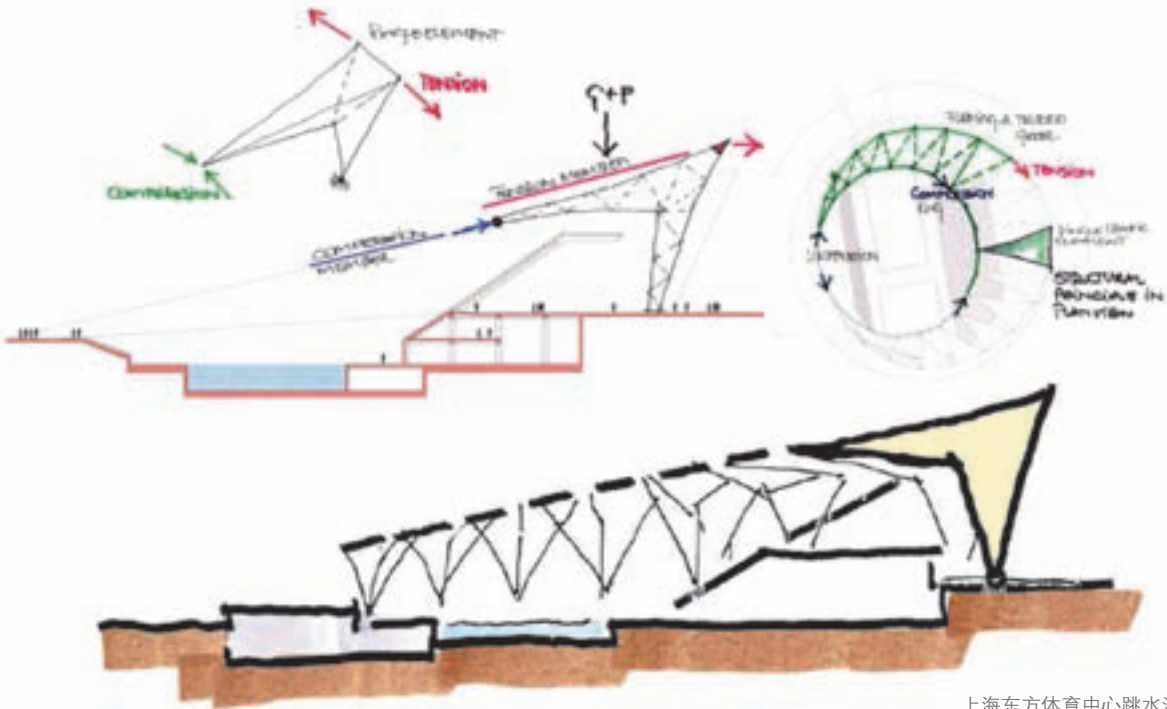
All swimming pools are arranged one after the other, consisting of

- two standard pools,
- a diving pool and
- a free-formed leisure pool area.

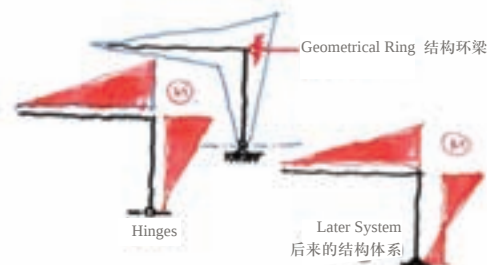
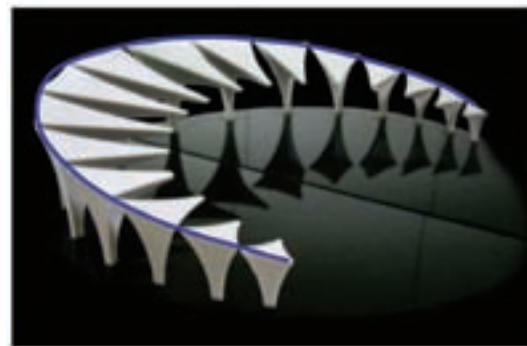
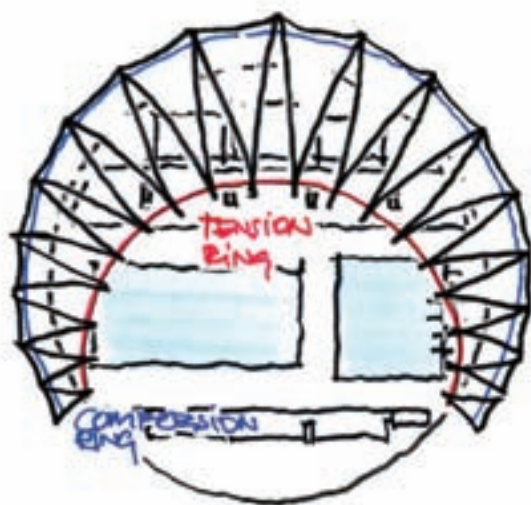
The stands are planned as a sloping seating arrangement. Additionally a VIP stand is arranged centrally with regular VIP and 12 chairman seats as well as the necessary number of seats for referees.

Capacity

The capacity of the fixed stadium seating in the competition pool area is



上海东方体育中心跳水池



摄影：Marcus Bredt



上海东方体育中心跳水池

于框架角部和屋面内边沿的两个压力环形成空间结构系统。

上海东方体育中心新闻中心

gmp – Nikolaus Goetze: 新闻中心这一中等高度的高层建筑（80m）设置在平台的北侧。建筑以白色的多孔铝板幕墙为特色。幕墙在建筑表面呈现水波效应，形成一种特殊的品质效果。

新闻中心的建筑结构采用规则的网格布局，可灵活地用于会议、医疗研究和办公设施。公共大堂与室外广场连接，室外广场由环湖周围和横跨湖体的人行道围合而成。建筑设有15层，内设健身区、会议室和体检中心，高区各层为VIP和办公层。

上海东方体育中心建筑的包覆层

gmp – Nikolaus Goetze: 各建筑的整体外观均采用了同一通用的结构原理，而各构件均呈负曲面造型，并采用统一的白色包覆层。我们采用了Grasshopper软件建立各设计阶段的3D参数模型。该软件不仅有助于精确地确定结构的几何形状，同时还能有效地调整几何造型系统。由于建筑表面为双曲面造型，因而必须遵循一些几何原理，以便实现经济的设计。因此，双曲面以球形几何造型为基础，使其可以重复地利用模具制造面板。

laid out for 3,500 persons. For FINA regulations, 5,000 spectator seats are required and will be reached by addition of 1,500 mobile stands. In case that the temporary upper stands are removed, the space can be used as a leisure area with plants, relaxing areas, playing areas for children, etc.

sbp – Sven Pliening: In the Natatorium, several pools are arranged one behind the other. The spectators sit alongside the pools. If there are, as for the championship in Shanghai, no indoor high-diving competitions to be held, the height of the hall is a rather unimportant factor, although sufficient height ought to be available for the installation of additional temporary seats. As a consequence, a facility of approx. 200 m in length, around 80 to 90 m in width and no particular height requirements had to be designed.

The natatorium is built up from a pedestal structure made of reinforced concrete and a roof structure made of structural steel.

The basic structure of the swimming hall roof is an arch.

Actually, a slender arch with a low arch rise is completely sufficient to carry an even load. For unsymmetrical or one-sided loads, however, it also needs to be protected against buckling. For this purpose, two slightly stilted lattice girder levels are placed onto the arch pipe, resulting in a spatial base body.

Thirteen of these base bodies with varying span widths (90 – 100 m) are lined up at a distance interval of 15 m along the principal axis and connected with each other by means of a secondary purlin structure. Together with the sky lights hung between them, they constitute the roof construction of the swimming hall and visibly encompass the necessary hall space. The hall body in its glass encasement is placed within the aligned forms.

Design SOSC - Outdoor Diving Pool

gmp – Nikolaus Goetze: The Outdoor Diving Pool is orientated to



上海东方体育中心新闻中心

在幕墙招标过程中，要求5家幕墙施工公司均制作实体模型，以考察其材料质量、几何造型和细部。

sbp – Sven Plieninger: 在本项目体育场馆建筑群的所有结构中，可明确看到基本的静态结构系统是如何通过构造和形式的影响而凸显出来的。

就这些大型建筑的造型外观而言，建筑上覆盖的面层绝对是至关重要的。该皮肤层由白色涂层表面的双曲率铝板组成。因此在这方面，大大减少面层的重量产生了积极的效果。主体结构造型放置在设计曲线上，其边缘为环线；从而形成了各边缘之间的双曲率面。这些造型的规划和制作只能通过参数化的描述和设计才能实现。为此，各表面主要通过具有唯一半径的球心角体的方式制作。内主体结构和外覆表面采用Rhinceros程序和Grasshopper附加工具作参数化设计；从而实现内支撑结构施工规定与表面几何造型之间的协调。通过上述推导方法，可对应地进行几何造型的变换和横断面的调整、并不断调整各单体构件的规格。

Huangpu River and its structure is composed with magnificent cantilevers in various scale changes

In order to provide an open view to the Huangpu River, the seats and a shading roof structure are concentrated on the east side of the swimming and diving pools.

In a generous open gesture the building leans towards the Huangpu River, presenting a wide city skyline as background for the diving towers.

The building structure itself is similar to the other venues' appearance. A light membrane between the structural modules provides the necessary sun and rain protection.

As a functional sports area for swimmers, this venue has an outstanding position within the sports area. In combination with the other stadiums it serves as an attractive recreation facility with all international standards.

Schnitt

Capacity

The regular capacity of the fixed stadium seating is laid out for 2,000 persons including VIP/VVIP-seats. For swimming events and during competition time temporary seats will raise the capacity to 4,850 spectator seats.

sbp – Sven Plieninger: Similar to the gymnasium, the outdoor swimming pool is defined by a circular footprint. To emphasize the very special location and to

上海东方体育中心的设计实践和挑战

sbp – Sven Plieninger: 上海东方体育中心的大部分建筑被核定为“超限”结构（即超过了适用的当地规划和施工规范中确定的标准），因而必须通过专家会议予以论证。通过专家研究讨论，我们不得不接受对原竞赛阶段的方案进行重大调整。由于批复程序简短，无法与专家进行充分研究讨论，因此导致了在整体刚度方面的调整，即：针对地震效应，进行了多道抗侧力体系的设计。对于体育馆和室外跳水池，对相关审查的顾虑导致对抗侧力体系进行了不同程度的加强。除纵向框架和横向框架之外，体育馆还设置了另一道支撑体系，该支撑体系后来也采用了拉压斜杆。

在室外跳水池的设计中设有整齐的半框架，这些半框架空间上整体相连，但是其空间承重能力未能完全被认可；而根据相关要求，每个半框架本身应具有稳定性和自承载能力。这一要求导致所有的柱脚均必须采用刚接和对应放大的柱脚。

从受力角度看，上述所有额外措施均必须在设计的过程中进行讨论和研究，并最终成为对建筑审批期限时间的压力。然而，最后还必须要声明的是：总而言之，最初的选型和结构造型已经证实其具有足够的包容性，足以承受所有增改的构件。

create spectacular views, the grandstands are arranged at more or less one side. The grandstand structure made of reinforced concrete creates the scheme of an ancient amphitheater. The roof structure follows that very special principal and is also arranged one-sided, based on the circular layout.

L-shaped half frames, placed at the outside edge of the grandstand along the crescent form, serve as the basic element. They vary in size according to the tier depth. The edge of the frame is stressed in compliance with the acting loads and forces; the base points are jointed and hence of a very thin design as are the cantilever arm ends.

The individual bodies are connected to form the spatial load-bearing system by means of two compression rings each at the edge of the frame and the inner edge of the roof.

Design SOSOC - Press Center

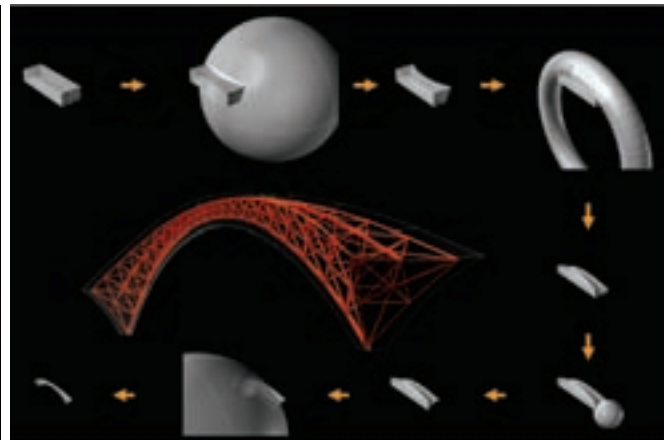
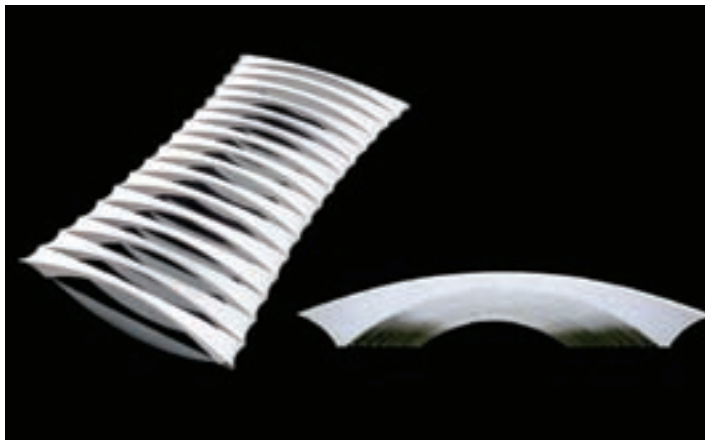
gmp - Nikolaus Goetze: Architecture Press Center

The moderate high-rise building (80m) is located on the north side of the platform.

The building is characterized by an outer façade layer of white perforated aluminum panels. The facade creates a special quality as it displays water wave effects on the building surface.

Due to the regular grid of the structure, the complex can be used in a highly flexible way for conferences, medical research and office facilities. The public lobby is linked to the outdoor plaza which is determined by the pedestrian ways around and across the lake.

The 15 levels include a fitness area, conference rooms and a medical checkup center. The upper levels are occupied by VIP and office levels.



相较于所有结构方面的挑战，最高层次的挑战在施工本身。施工单位必须在一个难以置信的短工期内完成这些设施的施工。不过，在施工现场经高度总动员的施工工人们已证明了自身的施工能力，按时完成了所有的施工作业。

gmp – Nikolaus Goetze: 总之，在德国，像上海东方体育中心这样规模的大型项目是无法在国内业主给定的时间框架内完成设计和施工的。在如此大型的项目中，将涉及许多决策者，且许多问题都会影响到设计过程。因此，我们欣赏项目业主以合格、坦诚的态度直面其责任的专业素养。体育办设立了一个经验丰富的专家团，使其能在正确的时刻作出正确的决定；同时，这一专家团还负责施工监管，从而导致项目最终以最佳的协调状态完工。项目的两家国内合作单位分别为上海建筑设计研究院和同济大学建筑设计研究院，凭借他们丰富的专业经验和通力合作，项目得以按时优质地完工。

回望这一快捷完工的项目历程，上海东方体育中心项目在我们心中留下了良好的体验。当然，我们曾面临许多挑战。有些问题可在与相关责任官员之间的讨论和会晤中解决；而另一些情况下，我们却无法说服相关的责任官员，不得不进行重新设计。以我们曾面临的一个特殊挑战为例，当我们已设计完成并已开始桩基施工之后，才发现要面对一处天然纪念物的保护问题——一株大树，大多数数人立即决定要将其保留。为此，需变更红线且需在最短的时间内对大部分设计进行调整。后来，这株估计约160年的古树成为了项目的一个真正亮点。

我们所面临的另一个挑战是上海东方体育中心这个“宝宝”长大后的未来问题。我们确实希望黄浦江畔体育和文化公园将来会吸引许多人去参观游览，并成为服务公众的体育公园。我们希望本项目的所有体育场馆将来按照设计发挥其应有的使用功能：1）游泳馆将用作公共游泳区；2）室外体育场将用作高台跳水运动员培训中心；3）体育馆用于各类活动。今年年初，已曾成功举办冰跑道比赛。

总而言之，我们的在本项目上的所有经历和体验也只是不同文化之间交流的一部分，并且会提高项目参与各方的学识；而这也正是我们乐于立足中国开展业务、乐做中德交流桥梁的原因。

Design SOSC – Cladding

gmp - Nikolaus Goetze: The overall appearance of all buildings is characterized by one general structural principle, and the shape of the negative curved surfaces of each element is covered by a uniform white cladding.

A parametric 3D-model was established for each design phase using the software of Grasshopper. This software helped to define the construction geometry precisely and was at the same time capable of adjusting the geometric system efficiently.

Since the surface is double curved, some principles of geometry have to be respected in order to achieve an economical design. Thus the double surface based on a ball geometry which enabled the use of repetitive molds for the manufacturing of the panels.

In the façade tendering progress, five façade construction companies were required to make a mock up in order to examine material quality, geometry and details.

sbp – Sven Plieninger: In all structures of this stadium family, it is recognizable how the basic static system is super-elevated through the exertion of constructional and formal influence.

For the appearance of these large forms, the covering skin is absolutely essential. This skin is composed of double-curved aluminum panels with a white-coated surface. In this context, significant reduction of the proper weight was a positive side effect.

The supporting forms are placed onto curved lines of the design, their edges consisting in circular lines. This leads to double-curved surfaces between the edges. Planning and production of these forms can only be realized through parametric description and construction.

For this purpose, the surfaces were produced primarily by means of spherical sectors with only one radius. The interior supporting structure and the exterior covering surface were described parametrically by means of the Rhinoceros program and the additional Grasshopper tool. In this context, the construction regulations of the interior supporting structure were reconciled with the surface geometry.

As a result of this derivation method, it was possible to respond to geometrical changes and cross section adjustments and to continuously adjust the specifications for individual construction elements.

Praxis of Design SOSC & Challenges

sbp – Sven Plieninger: Most of the buildings of SOSC were rated "over code" (i.e. exceeding the standards set in the applicable local planning and construction codes) and had to be proved in expert meetings.

As a result of these expert discussions we had to accept substantial changes to the original competition concept.

事件	座位	项目相关方
设计竞赛：2008年7~9月	体育馆：18 000座	业主：上海市体育局
规划开始：2008年10月	游泳馆：5 000座	设计：曼哈德·冯·格康和尼古劳斯·格茨以及玛德琳·唯斯 (gmp · 冯 · 格康, 玛格及合伙人建筑师事务所)
国际泳联世锦赛：2011年7月16~31日	室外跳水池：5 000座	结构设计：Sven Plieninger with WeiChen (Schlaich Bergermann und Partner)
占地面积：	标高	国内设计院：
体育馆：约16 200m ²	室内体育场：39m	多功能体育馆、游泳馆：上海建筑设计研究院有限公司
游泳馆：约17 600m ²	游泳馆：23m	室外跳水池：同济大学建筑设计研究院
室外跳水池：约3 800m ²	室外跳水池：29m	承建商：上海建工集团股份有限公司
建筑面积：	结构：	
体育馆：约75 145m ²	室内体育场：框架结构，最大150m跨度	
游泳馆：约43 228m ²	游泳馆：拱形结构，最大95m跨度	
室外跳水池：约10 438m ²	室外跳水池：悬臂结构，空间环效应，直径90~130m	

The short approval procedures did not permit sufficient discussions with the experts and led to adjustments in terms of the overall stiffening.

I.e. for the risk of an earthquake, the potential breakdown of individual supporting links is absorbed by additional existing ones.

In the case of the gymnasium and the out-door pool, the approval-related concerns led to a different assessment and more far-reaching requirements in respect of the stiffening systems.

In addition to the vertical and horizontal frames, the gymnasium thus received another line of support structures, which was afterwards also equipped with compression diagonals.

In the case of the out-door pool, the spatial load-bearing capacity of the aligned half frames with jointed base points was rejected completely. It was demanded that every half frame should be stable in itself and self-supporting. This led to the fully restrained support of all loads and a correspondingly enlarged base point.

From a static perspective, all these additional measures are up for discussion in the course of the regular planning process and ultimately attributable to the time pressure in building approval terms.

In the end, however, it also has to be stated that, all in all, the initially selected kind and form of construction has proved to be sufficiently robust to withstand all additions and amendments.

Compared to all structural challenges, the highest level of challenges was the construction itself. The executing company had to realize these facilities in an unbelievably short period. And they proved their capabilities and finished everything in time thanks to the highly motivated workers on site.

gmp - Nikolaus Goetze: In general, a huge project like SOSC could not have been designed and built in Germany within the timeframe given by our Chinese client. In such a big project many decision makers would have been involved and many doubts would have influenced the design process.

Therefore we appreciate the professionalism of our client who faced his responsibilities with a competent and straight-forward attitude. The Sport

Office had set up an experienced group of specialists who were able to make the right decisions at the right moments. They were also responsible for the construction supervision which led to optimal synergies.

Our two local partners SIADR and Tongji Institute supported us as a team member. Because of their great experience SOSC has been finished on time with its outstanding quality.

Looking back at the fast track project SOSC only good experiences come to our minds. Of course we were confronted with a lot of challenges. Some problems could be solved during colloquiums and meetings with the responsible officials; in other cases, we were not able to convince the responsible officials and unfortunately had to redesign.

One challenge we had to face was unique. After the design was finished and the piling drawings had already been started, we were confronted with a natural monument: During the construction works, a tall tree was discovered and the major spontaneously decided to save it! Within no time the red line was changed and most of the design had to be readjusted within shortest time. The tree - which later was estimated to be 160 years old - became a real tourist attraction.

Another challenge is the future of our grown up baby SOSC. We do hope that the Riverside Sports and Cultural Park will attract a lot of people in future and will serve as a sport park also for the public.

We hope that the future use of all stadia will function as designated:

- The Natatorium will serve as a public swimming area;
- The outdoor Stadium will be used as a training center for high diving athletes.
- The Gymnasium is already being used for all kinds of events. Beginning of this year ice track races were held with big success.

But all experiences we made are also a part of an exchange among different cultures and will improve the knowledge of all participating parties. That is the reason why we both like to work in China to link together China and Germany.^{AT}

