

Tall buildings

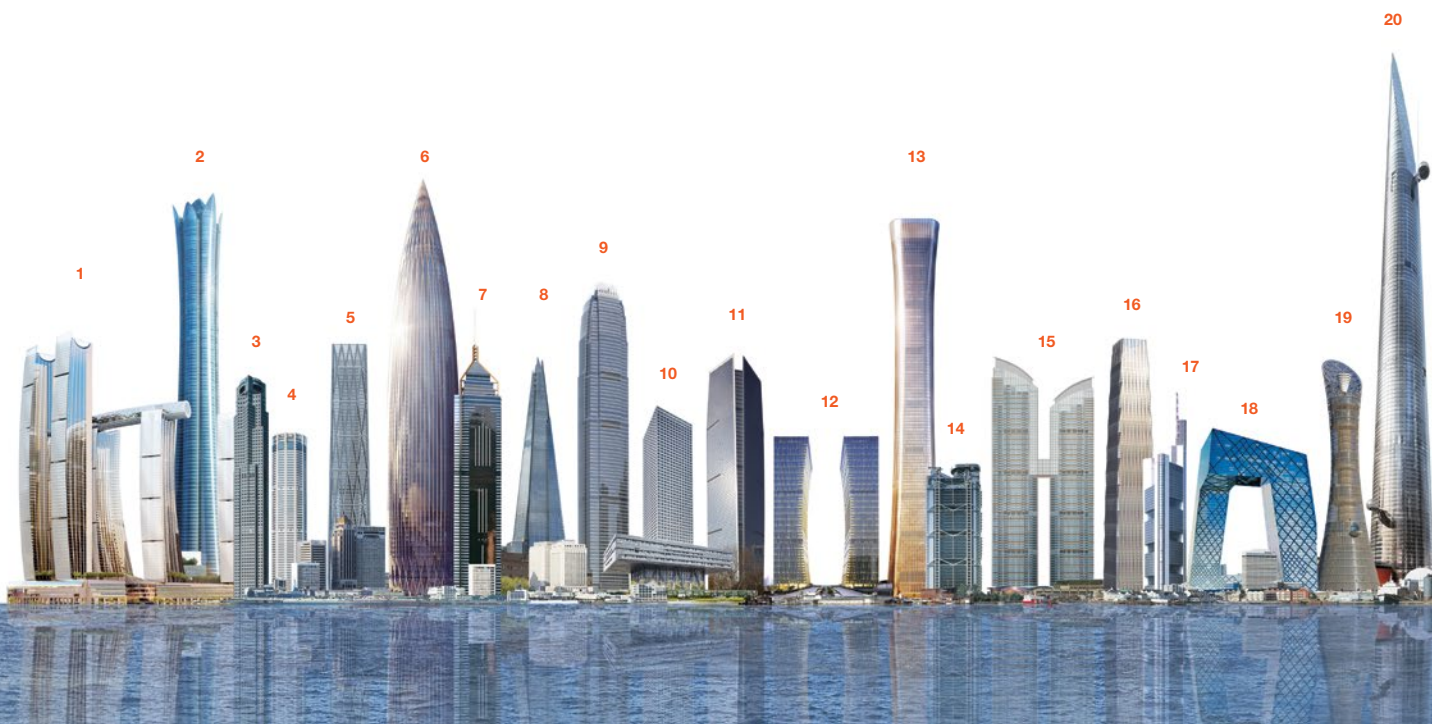
Safe, comfortable and sustainable solutions for skyscrapers



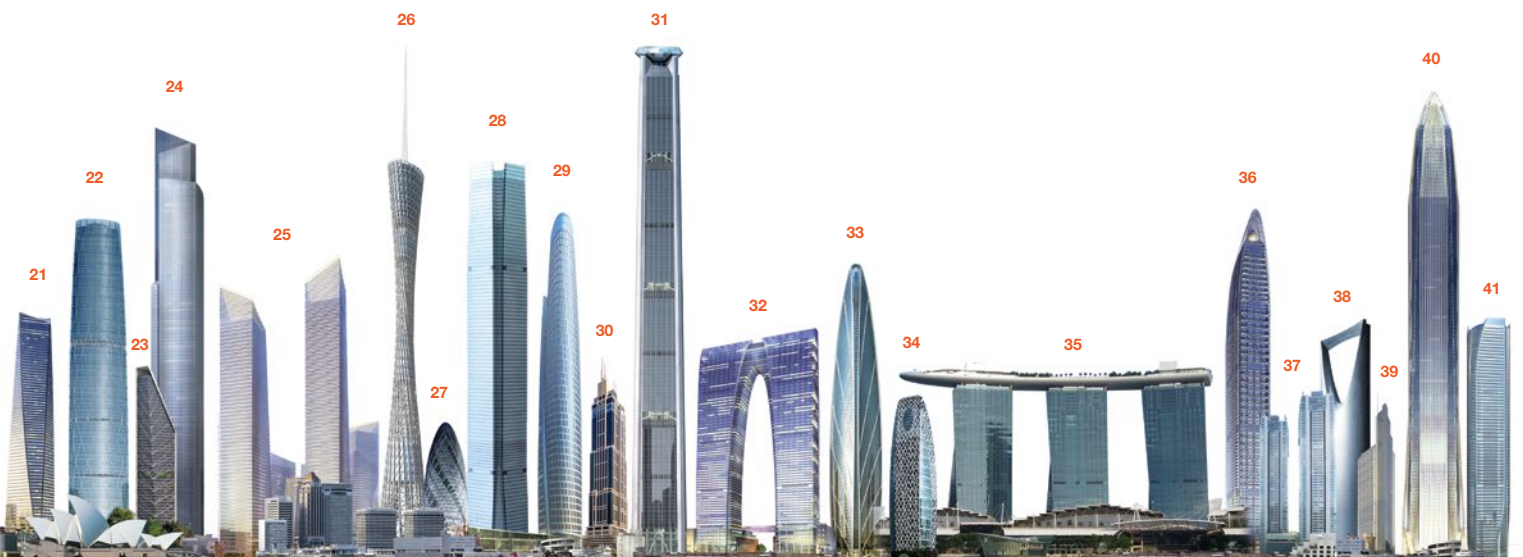
ARUP

Tall building projects worldwide

Drawing upon our diverse skillset, Arup has helped define the skylines of our cities and the quality of urban living and working environments.



No.	Project name	Location	Height (m)	
1	Raffles City	Chongqing	350	©Safdie Architect
2	Burj Al Alam	Dubai	510	©The Fortune Group/Nikken Sekkei
3	UOB Plaza	Singapore	274	
4	Kompleks Tan Abdul Razak	Penang	232	
5	Kerry Centre	Tianjin	333	©Skidmore Owings & Merrill
6	CRC Headquarters	Shenzhen	525	©China Resources Shenzhen Bay Development Co Ltd
7	Central Plaza	Hong Kong	374	
8	The Shard	London	310	
9	Two International Finance Centre	Hong Kong	420	
10	Shenzhen Stock Exchange	Shenzhen	246	©Marcel Lam Photography
11	Wheelock Square	Shanghai	270	©Kingkay Architectural Photography
12	Riviera TwinStar Square	Shanghai	216	©Kingkay Architectural Photography
13	China Zun (Z15)	Beijing	528	©Kohn Pedersen Fox Associates PC
14	HSBC Main Building	Hong Kong	180	©Vanwork Photography
15	East Pacific Centre	Shenzhen	300	©Shenzhen East Pacific Real Estate Development Co Ltd
16	China World Tower	Beijing	330	©Skidmore, Owings & Merrill
17	Commerzbank	Frankfurt	260	©Ian Lambot
18	CCTV Headquarters	Beijing	234	©OMA/Ole Scheeren & Rem Koolhaas
19	Aspire Tower	Doha	300	©Midmac-Six Construct
20	Landmark Tower	Yongsan	620	©Renzo Piano Building Workshop
21	Northeast Asia Trade Tower	New Songdo City	305	©Kohn Pedersen Fox Associates PC
22	Guangzhou International Finance Centre	Guangzhou	432	©Wilkinson Eyre
23	Torre Reforma	Mexico	244	©L Benjamin Romano Architects
24	Chow Tai Fook Centre	Guangzhou	530	©Kohn Pedersen Fox Associates PC
25	Forum 66	Shenyang	384	©Kohn Pedersen Fox Associates PC
26	Canton Tower	Guangzhou	600	©Information Based Architecture
27	30 St. Mary Axe	London	180	©Foster+Partners
28	International Commerce Centre	Hong Kong	484	©Sun Hung Kai Properties Ltd
29	International Trade and Commerce Centre	Chongqing	468	©Kohn Pedersen Fox Associates PC
30	Shanghai Hong Kong New World Tower	Shanghai	278	©Martin Saunders Photography
31	Goldin Finance 117	Tianjin	597	©P & T Architects & Engineers
32	Gate of the East	Suzhou	300	©RMJM
33	Z6, Beijing CBD Core Area	Beijing	405	©Foster+Partners
34	MODE GAKUEN Cocoon Tower	Tokyo	204	
35	Marina Bay Sands® Integrated Resort	Singapore	207	
36	Kingkey 100	Shenzhen	442	©TFP Farrells Ltd
37	St. Francis Shangri-la Place	Manila	217	©Mike Alquinto/AP Images
38	Kingdom Centre	Riyadh	300	©Ellerbe Becket Inc
39	Heron Tower	London	230	©Hutton+Crow
40	Ping An International Finance Centre	Shenzhen	660	©Kohn Pedersen Fox Associates PC
41	One Island East	Hong Kong	308	©Wong & Ouyang & Associates



Pushing the limits

The explosive urban population and limited land available in cities are continuously spurring the move towards building towers. Arup unites a global network of highly skilled building engineers and design specialists to deliver skyscrapers that work best for people.

We help architects realise their creative ideas while keeping occupants safe and comfortable with advanced approaches to structure, geotechnics, material use, fire, wind and elevator systems design.

Sustainability is at the core of our tall building design. We address energy and resource conservation as well as the social value and environmental consequences of the development, ensuring that our works leave a lasting legacy.

Our building designers engage with advanced analysis and research and continuously explore new tools and approaches, such as building information modelling, to fulfil highly original and ambitious visions.

Arup is a world leader in tall building design and has a proven track record worldwide. From International Commerce Centre in Hong Kong to Canton Tower in Guangzhou, Arup has successfully delivered many of the tallest buildings locally, helping our cities attain new heights.

China Central Television (CCTV) new headquarters, Beijing

The gravity-defying building is formed of two towers – 234m and 194m tall – linked by a 15 storey cantilevered 'overhand' with a 10-storey podium.

height

234m
&
194m



Goldin Finance 117, Tianjin

To ensure safety and stability of this superstructure on Tianjin's soft ground conditions, full instrumented trial piles tests were conducted to verify both the pile capacity and the constructability of the proposed long friction bored piles with 1m diameter and a construction length of 100m/120m.

height

597m



Wherever difficult ground conditions, sensitive environments or ambitious structures present geotechnical challenges, Arup provides robust and advanced solutions.

Geotechnics

Arup leads the field in the design of foundations and deep basements around the world. The effective use of substructure space lies unseen but has been developed by engineers and design leaders within Arup to meet the challenging requirements and the typically congested areas where tall buildings are constructed drives the design process.

Arup has the knowledge and expertise to provide innovative and practical solutions in a holistic approach to design foundations and deep basements with due consideration of the superstructure requirements in respect to difficult geological conditions, site constraints as well as enabling a fast-track construction programme.

Arup has developed and led the field in the implementation of shaft-grouting technique in friction barrettes, friction mini-piles, friction pre-bored H-piles as well as friction large diameters bored piles to enhance the pile capacity in Hong Kong and overseas. In close liaison with the government, Arup has also been working towards the adoption and acceptance of revised friction and end-bearing load capacities for foundations rested onto bedrock for structures encompassed by the local building regulations.

Marina Bay Sands, Singapore

This 15.5ha waterfront resort complex features the world's longest public cantilever at 200m above ground sitting atop three 55-storey hotel towers.

height

207m



Structural engineering

We are proficient in connecting a diverse range of disciplines to optimise structural efficiency and achieve commercial and environmental sustainability. Working closely with in-house specialists in the fields of wind engineering, mechanical and electrical engineering, seismic design, façade, sustainability and vertical transportation, Arup structural engineers produce holistic solutions for cost-effective buildings that attract premium tenants whilst keeping the architect's design intent.

We are at the cutting-edge of construction-led design. The use of Building Environment Modelling (BEM) is now commonplace and through 4D interfaces, enables virtual models of buildings to be constructed that facilitate evaluation of erection strategy, sequence and timings.

Sustainability is intrinsic to our approach to every tall building project. In close collaboration with architects and other engineering professionals, our structural engineers establish optimal building forms that result in better building performance.

The economics of tall buildings varies around the world and the international presence of Arup structural engineers enables us to understand the local market conditions and tailor tall building design to best suit the local context.

Arup structural engineers are at the forefront of realising ambitious high-rise buildings and have contributed to industry standards, guidance and codes of practice internationally.

Seismic engineering

The seismic design of tall buildings poses specific challenges related both to the complex response of tall buildings to ground movement and also the interaction between wind and seismic design requirements. Prescriptive building codes are based on rules for low- to medium-rise buildings that are not directly applicable to tall buildings. Arup has taken a performance-based design approach for decades and has completed projects in many places associated with earthquakes including mainland China, Japan, New Zealand, Taiwan, Indonesia, Turkey, California and Italy.

We continue to work on innovative solutions for tall buildings in seismic zones. These include the 217m St Francis Shangri-La Place in Manila which incorporates damped outriggers to control both wind and seismic response. We are now designing towers upwards of 500m in earthquake zones such as the Chow Tai Fook Centre, Guangzhou soaring over 500m.

We also take a leading role in the development of design guidance such as the seismic design recommendations by the 2008 Council on Tall Buildings and Urban Habitat (CTBUH).

Chow Tai Fook Centre, Guangzhou

The outrigger design was a first for China and a first in a seismic zone.

height

530m

Arup has unrivalled experience in designing tall buildings that are both earthquake-tolerant and economically feasible.



©Grim, Pedersen Fox Associates Pte



©Frank P Palmer

China World Tower, Beijing

We introduced a tube-in-tube system and a composite shear wall system which embeds steel plates into normal reinforced concrete core walls at lower levels, reducing wall thickness and improving seismic performance.

height

330m

Wind engineering

Wind can significantly influence the design and cost of high-rise buildings, particularly in typhoon prone areas. Wind studies should be fully integrated with all aspects of design to optimise the building, and this is where our team of wind engineers come in.

Arup's in-house team of expert wind engineers provide consultancy services to architects, planners, developers and industrial clients at all stages of a project. Our services include wind climate assessment, wind flow around buildings (for pedestrian comfort, mechanical and natural ventilation design), optimising structural design and wind-induced dynamic response and human tolerance of wind-induced motions.

We strive to deliver value in early stages of a project without resorting to expensive wind tunnel testing. Where wind tunnel tests are deemed necessary, we can help clients get the most value out of the tests through our experience of working with many wind tunnel labs around the world.

By combining 35 years of experience with state-of-the-art tools, our wind engineers work closely with design teams to deliver real value from the onset of a project.

The Pinnacle, London

Wind environment and structural loading for the 64-storey office tower with three levels of basement.

height

288m



Arup has actively developed and promoted the use of self-consolidating concrete (SCC) in tall buildings to improve constructability, cost-effectiveness and design flexibility.

Materials

SCC, first developed in Japan in the 1980s, is a flowable concrete that allows its own weight to consolidate and fill the voids and spaces without any mechanical vibration. It is particularly useful when it's difficult to place concrete with heavily congested reinforced concrete members and complicated formworks involved.

Arup has pioneered the use of this technology in tall building design. In Hong Kong, it was first put forward in 2002 for the construction of International Commerce Centre, now the tallest building in the city soaring at 484m. Throughout the project, Arup brought together our in-house materials specialists and concrete experts to develop high performance SCC and explore solutions for all related technical issues.

With the combined efforts and supports from the industry, we have set new standards for the use of SCC for tall buildings in the region.



International Commerce Centre, Hong Kong

The tallest building in Hong Kong uses high performance SCC for the first time in the city.

height

484m



©Camera Vision Studio

Central Plaza, Hong Kong

The 374m tower is the tallest reinforced concrete structure in the world, and it was the first time high-strength concrete (grade 60) had been used in Hong Kong.

height

374m

The Shard, London

Arup's innovative building services design was crucial in ensuring the building's functionality within its iconic form and complex geometry.

height

310m



Raffles City, Chengdu

Arup provided a holistic strategy on the mechanical systems and helped the complex to obtain LEED® certification.

height

116m to 123m

Arup has vast experience in addressing the particular electrical and mechanical challenges posed by high-rise buildings, creating environments that are comfortable for occupants, economical for owners and efficient with resources.

MEP

A performance-based approach to the design provides the flexibility and efficiency that is required by the owners and users of such commercial buildings. Arup's MEP experience covers the full range of building services including heating, ventilation and air-conditioning, fire services, plumbing, drainage, electrical, building management, public address, telecommunication, security as well as lifts and escalators.

Arup has broad experience in the design of electrical and mechanical services for the landmark tall buildings. A holistic approach will be adopted such that major concerns on MEP design for tall buildings will be addressed, including core size, floor efficiency and structural span, floor height, clear headroom and vertical zoning.

Super high-rise buildings are often considered as a small community in terms of the number of occupants that can be accommodated. As such, energy strategy is crucial to minimise energy consumption. The usage of gas, electricity, steam and renewable such as solar and wind should be carefully planned. Different outdoor conditions at different building height, as well as the thermal properties of façade should also be carefully examined.

**International Trade and
Commerce Centre,
Chongqing**

As part of the multidisciplinary commission, Arup designed an efficient vertical transport system for the tallest building in West China.

height

468m



©Kohn Pedersen Fox Associates PC

With extensive experience in vertical transportation design for tall buildings, we can provide strategic advice and ensure operational efficiency, ride comfort, effective plant use, and easy control and monitoring.

Vertical transportation

Vertical transportation system is not only to serve people and goods, but also to reflect the quality of the buildings. We tailor-make in every project the most suitable integrated solution of vertical transportation system to the client including sky lobby shuttle arrangements, double deck (or similar) shuttles and destination despatch systems with balance among benchmark design standards, occupied space, investment cost and tendering strategy.

We give clients the best range of options by drawing on our international experience, multidisciplinary knowledge and advanced analytical techniques with use of worldwide well-recognised software to simulate complicated and special traffic scenarios. We always offer integrated logistics solutions to improve operational efficiency and functionality, and also to achieve secure and intelligent building design. Working with Arup's fire engineers, we help developers and owners meet evolving challenges in evacuation, and also help shape guidance for the vertical transportation industry and regulators worldwide.

Façade engineering

Modern design commands façades to be innovative, sustainable, complex in geometry, and to carry corporate identities. New materials and construction techniques enable façades to be more transparent, energy efficient while pushing engineering boundaries to merge art with function.

At Arup we meet these challenges and provide integrated solutions to meet clients' and architects' visions within budget, on time and to the highest possible standards.

We specialise in all aspects of the external envelope systems from single-storey themed façades to curtain walling on super-highrise towers with the tallest being 600m. Our façade specialists have extensive knowledge on the local façade industry encompassing regulations, design, testing, supply and installations. We are also well versed with sustainability issues and our access specialists are experienced in providing consultancy service on façade cleaning and maintenance.

Arup's façade specialists incorporate cutting-edge materials and technologies to create building envelopes that reduce energy consumption and improve occupants' comfort.



The Imperial Towers, Mumbai

Arup designed the innovative façade system for the tallest residential buildings in India. The system includes very large sized punch windows, balcony windows and curtain wall of wide panel size, which will be subject to a harsh environment.

height

249m

Arup boasts broad experience in addressing the particular fire safety challenges posed by tall buildings, providing flexible and efficient solutions for both the owner and end users.

Fire engineering

Fire safety is always a major concern to occupants in tall buildings due to the huge accumulation of fire load, long escape distance, large stack effect, and difficulties in rescue and fire fighting activities. To tackle these challenges, an innovative approach is the key. Our innovative ideas include the use of lift evacuation in tall buildings and advanced structural fire analysis to prevent building progressive collapse in the event of a fire.

When developing the fire safety strategy for tall buildings, we are sensitive to the dynamic requirements of the owner and varied needs of the end users. We provide flexibility for multi-tenancies, maximise useable area, and minimise disruption to business. We also advise on the fire strategy and means to address extreme events where necessary.

Combining our tall building expertise with a performance-based approach results in safe and cost effective solutions to tall buildings.

Shanghai World Financial Centre

Arup's fire engineers developed performance-based fire engineering solutions and an overall fire safety manual for this super high-rise.

height

492m



**Parkview Green
FangCaoDi, Beijing**

Arup designed a micro climate for this LEED® CS registered mixed-use plaza, keeping its energy bills to a minimum for its lifetime.

height

87m

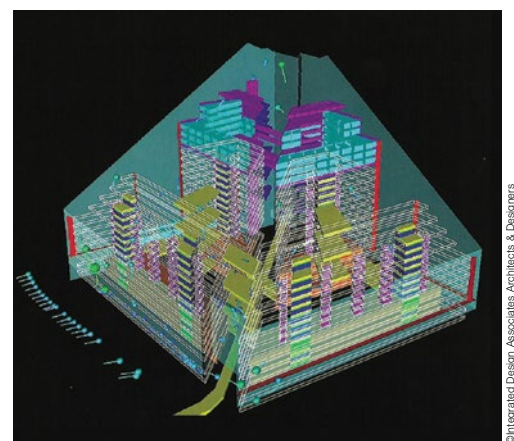


©Zhou Ruopu Architecture Photography

Building sustainability

The sustainable design of high-grade tall buildings presents unique challenges which necessitate a thorough understanding of multidisciplinary design work alongside the business models of the end product. Arup provides design input from concept planning stages through to post occupancy studies to ensure that diverse design and client teams are brought together to address sustainable design issues. Building performance is quantified and systems designed into the building to ensure that it is verifiable in operation.

Arup is very experienced in a wide range of environmental benchmarking tools to achieve various rating systems which enable portfolios to be matched to key tenant requirements. We work for a range of client to deliver innovative solutions for sustainable tall buildings. These include the 432m Guangzhou International Finance Centre with an impressive arrange of sustainable systems and Hysan Place which has achieved the highest level of BEAM Plus and LEED®.



©Integrated Design Associates Architects & Designers

Arup believes that it is only by considering the total building design that we can create buildings that are efficient with resources, affordable to build and operate, and appropriate to their context.



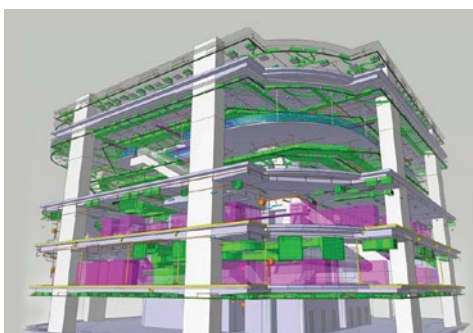
**One Island East,
Hong Kong**

The skyscraper pioneered the application of building information modelling to improve design coordination and work planning, reducing construction time and cost.

height

308m

©John Nye



©Garmon Construction

Arup is one of the leaders in modelling the built environment, driving a smarter, more streamlined approach to design and construction.

Building environment modelling

A key part of our multidisciplinary team's offerings, building environment modelling (BEM) is used at all levels of our projects. Taking advantage of digital information (using tools such as geographic information system and building information modelling), the modelling process helps us understand and coordinate the design more completely at a much earlier stage which often leads to better construction.

BEM allows information exchange with related analyses (such as traffic and pedestrian simulation, and environmental wind modelling), and facilitates data sharing with different stakeholders and specialists. This results in better communication and coordination between different parties, and hence better integrated designs.

We also use BEM to help our clients better manage cost, procurement and construction by measuring material volumes and visualising options and construction sequences.

BEM also permits real-time responses and automatic cascade of changes through the design. For Goldin Finance 117, Arup was able to respond quickly to changes in the design through careful development of parametric rules in our models. BEM also makes it possible to carry out optimisation studies in a logical and productive way.

Constructability and buildability

We are involved at all stages of projects from early feasibility design through to completion of works. As such our planners have good knowledge of site logistics issues, construction methodology and can propose ways to mitigate environmental impact of works on the local population.

As well as scheduling/programming works, we also look to actively manage construction risks and optimise opportunities. We present our work using latest graphical techniques including 4D construction animations (3D CAD geometry with fourth dimension of time) as well as in written reports and Gantt charts. These are updated as new ideas and actual progress evolves, often considering a number of options.

Arup has a dedicated team of construction planners who are ex-contractors and have significant experience of working on a wide range of sites.

B2 at Atlantic Yards, Brooklyn, New York

Arup's multidisciplinary approach and 4D modelling capabilities have supported innovative engineering of the tallest modular building in the world with 32 floors and 350 apartments.

height

~100m



Arup is at the forefront of the development of new concepts for the design of more economical, better performing and more resilient tall buildings.

Research and development

We have the ability to challenge conventional thinking and to propose radical alternatives, based upon a holistic understanding of multidisciplinary design interactions and the real performance of tall buildings in practice. Recent examples of our research and development initiatives include:

- Development of a family of damping systems, including the damped outrigger concept, that reduce wind and seismic forces of tall buildings and enable substantial structural and foundation savings to be made.
- Participation in the development of a new lightweight prefabricated floor system that significantly reduces the weight (and therefore vertical structure size) of tall buildings and enables accelerated construction schedules.
- Development of improved seismic design procedures and structural systems for tall buildings that reduce both structural cost and the potential for seismically induced damage.

St Francis Shangri-La Place, Manila

The highest residential building in the Philippines uses the Arup Damped Outrigger System which acts as energy absorbers dampening vibrations.

height

217m



1 Bligh Street, Sydney

MEP engineering, fire engineering, acoustics, façade engineering and lighting design

At 139m, 1 Bligh Street sets new benchmarks for premium office space and boasts the first double skin façade of this scale in Australia. Arup was instrumental in delivering many innovative design features, including the fire strategy to enable the full height atrium, specialist steelwork to support the spectacular atrium skylight and the highly efficient building services system. Our team translated the double skin façade concept into a solution which uses clear glass and automated louvers to maximise daylight and views whilst delivering high levels of solar control.

height

139m



©DEXUS/IMPFF & Cass Property



30 St Mary Axe, London

Structural engineering; fire engineering; resilience, security and risk; transport consulting; wind engineering and geotechnics

Known fondly as 'The Gherkin', the 180m tall, 40-storey office tower is one of the most dramatic landmarks in London. Arup helped architect Foster and Partners to achieve the ambitious curved form of the building by designing its distinctive diagonal steel structure — a diagrid. Its shape appears less bulky than a rectangular block, creating public space at street level. It also offers minimal resistance to wind, improving the environment for people on the ground and reducing the load on the building.

height

180m

©Grant Smith/VIEW

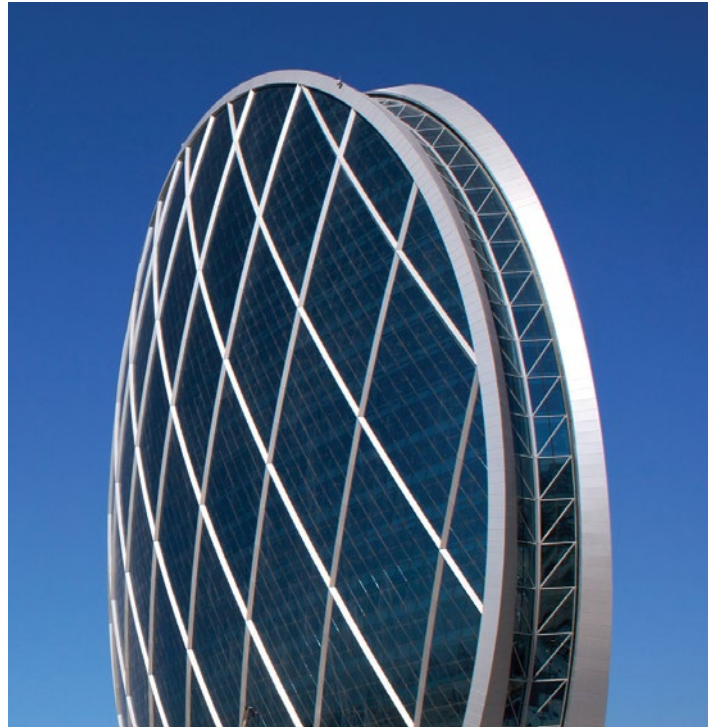
Aldar Headquarters, Abu Dhabi

Structural engineering, MEP engineering, façade engineering, vertical transportation and 3D modelling

The 121m tall, 23-storey commercial building is located on the exclusive Al Raha Beach development in Abu Dhabi. The groundbreaking building represents a fusion of tradition and modernity, with the striking circular shape symbolising unity and stability. The building's diagrid concept largely eliminates the need for internal columns, providing uninterrupted views and enhancing its aesthetic appeal. The steel diagrid is the first of its nature in the UAE and represents Arup's leading-edge approach to structural design in the region.

height

121m



Bade Urban Renewal Residence, Taipei

Architecture, structural engineering, MEP engineering, lighting design and sustainability consulting

This high-end project consists of four residential towers, a podium for commercial areas and amenities and a 3-level basement with public parking and a swimming pool. Each of the four towers feature panoramic views of the city and landscaped terraces, which take advantage of the centrally located site and the unusually high 90m height restriction. With natural ventilation, ample daylight and numerous sustainable amenities, this project aims to set the benchmark for sustainable design in Taiwan's residential market.

height

90m

height

600m

Canton Tower, Guangzhou

Structural engineering, MEP engineering, wind engineering, seismic design, architecture, masterplanning and urban design, lighting design, civil engineering, geotechnics and cost management

Soaring 600m in height, the tower boasts a feminine silhouette that twists and tapers into a slender waist about 22m at its narrowest, separating the building from its square, masculine counterparts. Using parametric associative software, we refined the tower's geometry so the final structure is both simple and complex — it is essentially a concrete core wrapped in a triangular lattice composed of structural steel, concrete-filled columns, rings and diagonal tubes.



Cheung Kong Center, Hong Kong

Structural engineering, geotechnics, wind engineering and façade engineering

Arup led the multidisciplinary design of this 62-storey, 283m office tower; and as structural engineer, was the driving force behind the choice of structural system and method of basement construction – a composite steel and high-strength concrete superstructure that also met the client's request for a fast-track construction process. The development sits above a 6-level basement, which required rigorous geotechnical monitoring during construction due to the close proximity of two historical buildings.

height

283m

height

528m

China Zun, Beijing

Structural engineering, geotechnics and fire engineering

At 528m tall with 108-storeys, China Zun will be the tallest building in Beijing upon completion. Inspired by the Chinese ritual vessel 'Zun', the tower's smooth vertical curve gives the building a contemporary and elegant expression that will assist in maximising the floor area at the top and provide structural stability at the base. Arup introduced a high efficient dual system for lateral force resistance composed of a fully braced mega frame and a concrete core. Composite steel-concrete material is also extensively utilised to minimise structural member size and increase usable floor area.



©Grim Pedersen Fox Associates PC

Chongqing Raffles City

Structural engineering

The super-scale development comprises eight towers connected with a 3-floor hanging garden offering office, hotel, serviced apartment and retail spaces. The two central 350m towers boast a slenderness ratio over 9.5, posing great challenges to our structural engineers. We adopted four mega corner columns connected to the central core wall, forming an effective structural system. To realise the high curvatures for the four residential towers, we used the curving perimeter columns, which are tied up with belt trusses and outriggers to provide the lateral stability.

height

350m



©Safdie Architect



©Zhou Ruogu Architecture Photography

Forum 66, Shenyang

Structural engineering, geotechnics and civil engineering

Forum 66 is an 8,000m² mixed-use development comprising a world-class shopping mall, a pair of office towers, a 6-star hotel and serviced apartments. The 4-storey shopping mall features a stunning façade and roof design with a full height cable-wall atrium. The twin towers, soaring over 350m, will become the tallest buildings in Northeast China upon completion. A steel outrigger mega column system was adopted to provide structural stability and robustness.

height

384m



©Four Seasons Hotel - Hong Kong

Four Seasons Hotel, Hong Kong

Structural engineering, civil engineering, geotechnics and façade engineering

The two hotel towers up to 205m in height complete the massive Hong Kong Station Development. One 40-storey, 400-room hotel and one 50-storey, 600-suite hotel sit above a 7-storey podium on top of a 2-level basement. The towers are constructed of reinforced concrete with lateral resistance provided by shear walls coupled with the lift cores. A 3m thick transfer plate is provided above the podium at the eighth floor to transfer the hotel wall/core structures into the podium/basement column structure.

height

205m

Gate of the Orient, Suzhou

Structural engineering and MEP engineering

As a focal point of Suzhou's new central business district, the twin-tower development will stand almost 300m high and sit directly above a major underground rail interchange. The two towers, which are of the same height but have a different number of storeys, will stand 60m apart at ground level and link together at the top eight floors. The mixed-use development will provide grade-A offices, a 6-star hotel and serviced apartments. Each tower comprises a reinforced concrete core and composite perimeter columns linked together by belt trusses and an outrigger system.

height

300m



© Jinji Lake Urban Development Co. Ltd



Guangzhou IFC

Structural engineering, wind engineering, MEP, façade engineering, fire engineering, vertical transportation and transport consulting

The 432m tall tower is the first in China to adopt a double curvature diagrid column system. This external double curvature diagrid column frame and central core wall provide both gravity and lateral resistance so hotel occupants in the top floors remain comfortably unawares during typhoons. Arup's engineers developed an effective geometry of the diagrid structure through extensive computational model analysis.

height

432m

© Zhou Ruogu Architecture Photography

Hangzhou Raffles City

Structural engineering, MEP engineering, fire engineering and sustainability consulting

The landmark development comprises two 250m tall towers, a retail podium and a connection with the metro system and has achieved LEED®-CS 2.0 certification. The design concept of the twisting towers and curved podium envelop are referenced from traditional western statues, and the arrangement of the building cores varies in accordance with the different floor functions along the towers. With Arup's integrated approach, well-coordinated solutions have been delivered against all these technical challenges.

height

250m



International Commerce Centre, Hong Kong

Structural engineering, geotechnics, civil engineering, fire engineering and materials

At 484m, the tallest building in Hong Kong boasts cutting-edge geotechnical and tall buildings design, with stunning 360° views of Victoria Harbour. The main stability structure consists of a 33m square reinforced concrete core with eight perimeter mega-columns and four levels of steel outriggers. High-stiffness concrete using volcanic aggregates was adopted to enhance the tower's overall rigidity. A series of detailed studies and comparison of various foundation types were carried out, and finally shaft grouted friction barrettes were chosen as the foundation system for its satisfactory load carrying capacity and settlement performance.

height

484m

Kingkey 100, Shenzhen

Structural engineering, MEP engineering, fire engineering, façade engineering, geotechnics and wind engineering

At 442m tall, Kingkey 100 is currently the tallest building in Shenzhen. The tower houses 100-storeys of commercial, retail and hotel facilities with one basement retail floor connected directly to a metro station. Multidisciplinary engineer up to the preliminary design stage, Arup provided integrated design solutions and performance-based design strategies for Kingkey 100. Given the slender nature of the building, up to a slenderness ratio of 9.5, we designed a structural solution that combines three different kinds of structural systems to ensure lateral stability.

height

442m



Landmark Tower, Yongsan, Seoul

Structural engineering, MEP engineering, acoustics, façade engineering, fire engineering, lighting design and vertical transport

At 620m tall, the Landmark Tower is slender and elegant, with its circular shape and tapering form minimising the effects of wind. A tubular core is coupled to helical bracing at the perimeter to provide a stiff, robust and efficient structural system. The building is the first in the world to adopt a Helix system which has the structural benefits of a braced perimeter tube without the dense structure historically associated with this type of construction.

height

620m

height

255m

Langham Place, Hong Kong

Structural engineering, geotechnics, façade engineering and wind engineering

Langham Place is a comprehensive redevelopment with retail and office space in a 255m tall tower, and a 42-storey hotel development. We designed the Grand Atrium which boasts a mega structure with 60m tall and 26m span portal frames on pinned bases forming the tallest single span glass wall in Hong Kong. It also holds the longest indoors escalator in the city – the Xpresscalator spans 42m of the shopping centre. We also designed the 'digital sky', an audio visual platform that spans the entire ceiling of the Grand Atrium.



MODE GAKUEN Cocoon Tower, Tokyo

Structural engineering

At 204m tall, this is the second tallest educational building in the world housing three vocational schools with capacity of 10,000 students. The tower serves as an incubation hub for the students, stimulating their professional development so that they eventually emerge like butterflies from a cocoon. Arup's structural design overcame the challenges of Tokyo's dense urban environment with a vertical campus with spacious interiors. The floor plan is simple — three rectangular classroom areas rotate 120° around the inner core which consists of elevators, staircases and service shafts. Student lounges are located between the classrooms and face three directions: east, southwest and northwest.

height

204m

©Loom Nye



Moscow City Plot 9

Structural engineering, MEP engineering, fire engineering and vertical transportation

The 335,000m² mixed-use development comprises two towers of 274m and 250m, providing office, retail and residential space with a 6-storey basement for car park. Working with international companies in the Russian market and bridging the needs and requirements of international codes into the Russian codes and context has become one of Arup's strongest skills.

height

274m
&
250m

New World Centre, Shanghai

Structural engineering, geotechnics and façade engineering

A 60-storey, 278m tower housing hotel, office and retail space including a 4-storey podium. The building is of composite construction using concrete services core is reinforced concrete with structural steel perimeter columns encased in Grade 60 concrete. Steel floor beams support reinforced concrete floor slabs. Two levels of steel outriggers are provided at the mechanical floors to achieve the required structural rigidity. The steel outriggers also serve as transfers to achieve the column setback features of the architecture.

height

278m



©Martin Saunders Photography



Northeast Asia Trade Tower, Songdo

Structural engineering; MEP engineering; ICT; resilience, security and risk; acoustics; audio visual and geotechnics

The tallest building in Korea and a landmark of Songdo International Business District, the 305m tall skyscraper comprises offices, a luxury hotel, serviced apartments and retail boutiques. The tapering tower is bound by a mixture of curved, sloping and vertical surfaces, and changes shape from a trapezoid at the base to a triangle at the top. Arup's creative design solutions enabled the project to be delivered in a safe, cost-effective manner.

height

305m

©Gale International

One One One Eagle Street, Brisbane

Structural engineering and fire engineering

Standing 195m tall, One One One Eagle Street is the latest skyscraper in Brisbane's skyline. The most striking feature of the building is the inclined perimeter column arrangement that was developed from an algorithm simulating the way in which plants grow towards light. This innovative approach produces an organic pattern to the façade columns that not only result in an impressive visual feature but also provides lateral stiffness to the tower. Working closely with the contractor, we devised an innovative top-down construction sequence that is allowing the existing facilities to continue to operate with minimal disruption.

height

195m



©Cox, Rayner Architects



©Marcel Lam Photography

Shenzhen Stock Exchange

Structural engineering, geotechnics, façade engineering, MEP engineering, fire engineering, building intelligence, vertical transportation and lighting design

The unconventional structural design of this 246m tall building encompasses a 3-storey cantilevered podium that houses the trading floor and clearing houses. The structural design is robust, passing stringent seismic tests and capable of withstanding typhoon wind loads. Upon completion, the building will be one of the first buildings in China to achieve a 3-star rating by the Green Building Code in China.

height

246m

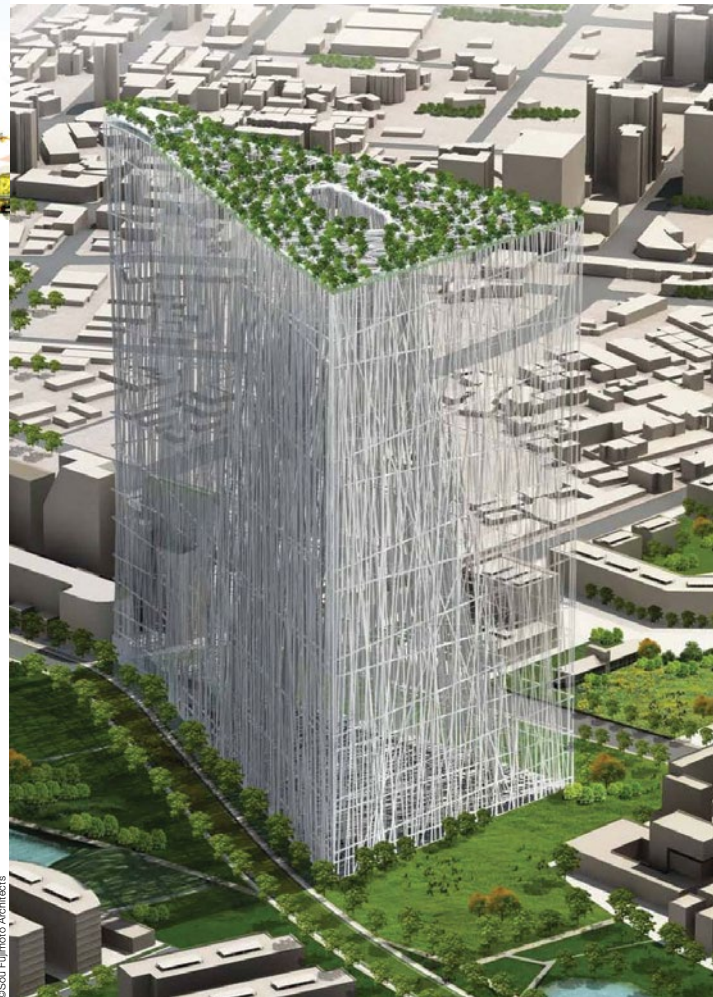
Taiwan Tower, Taichung

Structural engineering, MEP engineering and sustainability consulting

Soaring 300m in height, Taiwan Tower is an iconic skyscraper to be built at the southern tip of the Taichung Gateway Park on the former Taichung Airport site. Envisioned as a 21st Century Oasis, the tower will feature a grand structural frame that encases the site to create a shaded comfortable semi-outdoor space. A rooftop garden will provide an extraordinary oasis in the city with an opening shaped to resemble the island of Taiwan and flora selected to reflect the island's naturally rich and beautiful landscape.

height

300m



©Sou Fujimoto Architects

The Arch, Hong Kong

Structural engineering and geotechnics

The 230m development comprises two residential towers of 56 storeys above a 3-storey podium and a single-level basement car park. The tower structure is constructed of reinforced concrete with a coupled shear wall system to resist lateral wind loads. A central high block containing 23 storeys of residential floors, club house and swimming pools span 25m between the two towers at over 100m above the podium. This has created a large opening between the towers leading to the buildings name of 'The Arch'.



height

230m

Shenzhen East Pacific Centre

Structural engineering and geotechnics

East Pacific Centre serves as a concentrated hub for retail, commerce, entertainment and business. It comprises two grade-A office towers, two residential towers, one five-star hotel tower and a 3-storey high-quality retail podium. The two residential towers, the tallest of its kind in China at 300m and 265m tall, provide some of the most luxurious apartments in town. A sky-bridge, constructed of steel hollow sections and with a total weight of over 700 tonnes, links the twin residential towers at 170m above ground.

height

300m



© Wong & Cuyang HK Ltd

Tianjin Kerry Centre

Structural engineering, geotechnics and fire engineering

The mixed-use development consists of three residential towers, one 333m tall office tower, a 5-star hotel with a retail podium. All superstructure elements share the basement which is connected to metro system. Arup's structural engineers designed a structural solution which transfers half of the shear walls at Level 5. Composite sections including composite shear walls were used extensively at lower floors to realise this high level transfer and also a sideways transition in shear walls. The structural design enables the integration of different user spaces and a seamless life experience in the complex.

height

333m



©Skidmore, Owings & Merrill



©No Thanh Duy

height

164m

Times Square, Ho Chi Minh City

Project management, civil engineering, structural engineering, geotechnics, MEP engineering, architecture and façade engineering

The new 164m tall building houses a five-star hotel, top quality serviced apartments, office facilities and retail space. Arup designers and engineers enhanced its value and effectiveness by combining the two buildings originally proposed by the former architect into one L-shape building. This new design also helps to enhance the overall stiffness of the structure and reduces construction costs.



Torre Reforma, Mexico City

Structural engineering, MEP engineering, façade engineering, acoustics, fire engineering and sustainability consulting

With a height of 244m, Torre Reforma is designed as the tallest LEED® Platinum skyscraper in Latin America. The triangular design provides a large façade, which when completed will maximise the commanding views available from the site. The design incorporates sustainable measures including natural ventilation, high efficiency façades and water recycling. Arup used advanced analysis tools in the design process including performance-based fire protection and smoke evacuation analysis, and performance-based structural design. Energy modelling as a design tool was used to select systems and façade performance.

height

244m

© L. Benjamin Romero Arquitectos



Tower Palace Phase 1, Seoul

Structural engineering, geotechnics, façade engineering, MEP engineering, fire engineering, wind engineering, CFD modelling and acoustics

This commission involved value engineering and multidisciplinary review for four luxury residential towers up to 252m in height with 66 storeys. The towers typically comprise a central concrete core with a perimeter composite frame mobilised steel outriggers.

height

252m

© Yum Saung Hoon

Two International Finance Centre, Hong Kong

Structural engineering, geotechnics, wind engineering and façade engineering

This development is located in the Central Business District adjacent to Hong Kong Station at a height of 420m with 88 storeys. It is a landmark building which incorporates minimum structure to maximise panoramic views from the building. The tower was constructed in a 61m diameter conferrdam, which allowed a programme overlap with the construction of the surrounding top-down 5-level basement. To further accelerate construction, the design allowed for retro-fitting of the outriggers, enabling the slipformed core progress with minimum interruption at outrigger levels.

height

420m



UOB Plaza, Singapore

Structural engineering, geotechnics and façade engineering

This 274m tall landmark structure for the United Overseas Bank (UOB) was Singapore's tallest building at the time of its completion, housing many of the world's leading legal and financial organisations. The stability system comprises a steel braced central lift core encased in reinforced concrete acting with perimeter structural steel columns. A single set of steel outriggers near the mid-height of the building connects the core and columns. Floors are in-situ concrete slabs cast on profiled decking acting compositely with 15.5m span plate girders spanning between the core and perimeter columns.

height

274m



U-Silk City, Hanoi

Civil engineering, structural engineering and geotechnics

U-Silk City is the largest development in Hanoi and Arup has been engaged to work on nine residential blocks with towers ranging from 94m to 175m. Upon completion, U-Silk City will feature the tallest residential tower in Hanoi. Arup proposed a new structural solution to achieve the international standards desired by the client, and we also increased useable floor space which positively benefits the client's business, and the structural solution allowed for a better building façade treatment.

height

94 to 175m



©Franken Nguyen Consulting



Vattanac Capital, Phnom Penh

Construction management, ICT, resilience, security and risk, geotechnics, structural engineering, façade engineering and fire engineering

Located in the heart of Phnom Penh, Vattanac Capital is a grade-A office development that houses Vattanac Bank's headquarters and a stock exchange building. Shaped like the mythical dragon symbolising progress, health and prosperity, the 184m tall development is poised to become Cambodia's new finance centre and a landmark for the city.

height

184m

©TTP Partners

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry.

We offer a broad range of professional services that combine to make a real difference to our clients and the communities in which we work.

We are truly global. From 91 offices in 39 countries our 11,000 designers, engineers, planners and consultants deliver innovative projects across the world with creativity and passion.

Founded in 1946 with an enduring set of values, our unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working. This is reflected in everything we do, allowing us to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of our clients.

The people at Arup are driven to find a better way and to deliver better solutions for our clients.

