A COMPREHENSIVE CASE STUDY OF THE BUILDING SYSTEM INTEGRATION OF:

Jin Mao Tower
Huangpu, Shanghai, China
Skidmore, Owings, & Merrill LLP
Architect: Adrian D. Smith
Engineer: D. Stanton Korista

A Report Submitted as a Partial Fulfillment of the requirements of the course Arch 544: Reasoning For Design Integration

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The intent of the comprehensive case study is to evaluate, analyze, and understand good building design through a study of the construction documents and the project manual for the Jin Mao Tower designed by SOM in Shanghai, China. Investigations into the specific organization of subsystems and their function will demonstrate the architect/engineer’s methods of reasoning and decision making, and will also expose unexplored design possibilities that could have been used for better building system integration. The investigation will give factual descriptions of the building parts; express the plausible design reasoning behind the building’s systems, both teleological and functional; and propose alternative design possibilities.

This study will be based on information from construction documents, site visits, and consultations with the architects and engineers of the building.
# TABLE OF CONTENTS:

- CHAPTER 1: INTRODUCTION ................................................................. 4
- CHAPTER 2: BUILDING CONFIGURATION AND SPACIAL ORGANIZATION ... 7
- CHAPTER 3: SUPERSTRUCTURES ......................................................... 18
- CHAPTER 4: SUBSTRUCTURES ............................................................. 28
- CHAPTER 5: CURTAIN WALL DESIGN .................................................. 36
- CHAPTER 6: MECHANICAL SYSTEM OVERVIEW ............................... 43
- CHAPTER 7: SPACE CONDITIONING SYSTEMS .................................. 49
- CHAPTER 8: ELECTRICAL SYSTEMS ............................................... 55
- CHAPTER 9: SOURCES ................................................................. 60
CHAPTER 1: INTRODUCTION

SITE ORIENTATION
The most recognized building in China, inspired by the traditional tiered pagoda, is the Jin Mao Tower by Skidmore, Owings, and Merrill. A skyscraper at eighty-eight stories tall, the tower rises out of the Lujiazui area of the Pudong district of Shanghai in the People’s Republic of China at a total of 420.5 meters (fig.1.0, 1.6). Built on 290,000m² site in a major finance and trade center for China, the building is estimated to have cost $530 million dollars US. The building is located on a 24,000 square meter plot of land near the Lujiazui metro station.

Owned by the Jin Mao Group Co, LTD (formerly China Shanghai Foreign Trade Centre Co. Ltd), the building is a multipurpose structure with offices on the first 50 levels of the building and the Shanghai Grand Hyatt Hotel on the following 38 levels.

Just east of the Huang Pu River, the Jin Mao Tower shares the skyline of Pudong with the Oriental Pearl Tower, the Shanghai World Financial Center and the Shanghai Tower. Providing not only office space for financial and trade organizations, the Jin Mao Tower also has a shopping mall, food court, concert hall, and parking for cars and bicycles (fig.1.2,1.3).
Taking up an entire block, the Jin Mao complex consists of a podium which houses J-Life, the retail center for the complex, on the west side of the building site. The tower, which houses office space, several restaurants, a club, a hotel, and an observation deck, is located on the east side of the building site (fig. 1.4, 1.5).

Head architect Adrian D. Smith from Skidmore, Owings, and Merril, and head engineer Stanton Korista, also for Skidmore, Owings, and Merril, lead the design process from 1993 until completion in 1998. Over 30 architects and engineers worked on the project. Opening on August 28, 1998 with respect to the lucky number eight, which was a major player in the concept and design process, the building construction process was on an accelerated schedule.
CHAPTER 2: BUILDING CONFIGURATION & SPACE ORGANIZATION AND THE OVERALL SYSTEM

OCCUPANCY CONFIGURATION RISER DIAGRAM
Occupancy:

The Jin Mao Tower is a multiuse space with 123,000m square of office space, a shopping mall, a food court, several restaurants, conference and banquet facilities, nightclubs, parking for 600 cars and 7500 bikes, and a hotel. The building is serviced by 61 elevators and 19 escalators. With such a complex group of occupants, the circulation and transportation of the occupants becomes essential. Managed by the elevator riser system, occupants are directed through the building by a very selective program.
The following page (fig. 2.0) is a section diagram of the function of each level. There is a lobby, five different office zones, a double height mechanical level, and hotel. These all sit next to a six level podium building.

The building’s major tenant is the five-star, 555-room Shanghai Grand Hyatt hotel which occupies floors 53 to 87. The Hyatt’s barrel-vaulted atrium starts at the 56th floor and extends upwards to the 87th. Lined with 28 annular corridors and staircases arrayed in a spiral, it is 27 m in diameter with a clear height of approximately 115 m. It is one of the tallest atriums in the world.

The hotel floors also feature:
- 53/F: The Piano Bar, a jazz club.
- 54/F: The hotel lobby and Grand café, served by an express elevator from the tower's ground floor.
- 55/F: Canton, a high-end Cantonese restaurant that takes up the entire floor.
- 56/F: On Fifty-Six, a collection of restaurants including The Grill, the Italian Cucina, the Japanese Kobachi, and the Patio Lounge, which is located at the base of the atrium.
- 57/F: Club Oasis, a fitness club featuring the world's highest swimming pool.
- 85/F: Highest rooms; this is also a transfer level for the elevators going to the two floors above.
- 86/F: Club Jin Mao, a Shanghainese restaurant.
- 87/F: Cloud 9, with a split-level mezzanine called the Sky Lounge. It is chosen by some visitors as a comfortable alternative to the observation deck above, since the lowest-priced drinks are the same price as the admission to the deck.
The subsequent pages describe the elevator service for the office zones, the retail and hotel levels, service and emergency access, and the observation deck. The riser diagram for the tower is explained in two diagrams: one for the podium lever and a second one for the tower.
OFFICE ELEVATORS
- office: P1-P3 (level 1, level 3-6)
  - geared traction (1.75m/s)
  - 1350kg capacity
- office: P4-P9 (level 1, level 7-17)
- office: P10-P15 (level 1, levels 18-29)
- office: P16-P21 (level 1, levels 30-40)
- office: P22-P26 (level 1, levels 41-50)
  - gearless traction (3.5m/s to 6.3m/s)
  - 1600kg capacity
- floor to floor time: 8.9 seconds
RETAIL/HOTEL

HOTEL ELEVATORS
- hotel: P43-P48 (level 54-85)
- hotel: P27-P32 (level 1, 2, 54)
- gearless traction (5m/s to 6.3m/s)
- 1600kg capacity
- hotel: P52-P53 (level 53-56)
- hotel: P54-P55 (level 84-87)
- geared traction (1m/s to 1.75m/s)
- 1600kg capacity

RETAIL ELEVATORS
- retail: P56-P57 (level B1, level 1, level 2m-6)
- geared traction (1.75m/s)
- 1600kg capacity
- parking: P35-P37 (level B3-B1, levels 1-2)
- gearless traction (1.75m/s)
- 1350kg capacity
- floor to floor time: 8.0 seconds
SERVICES/EMERGENCY

SERVICE ELEVATORS
- hotel: S41, S42 (level B1, levels 1, 2, 2m, level 53)
- hotel: S49 (level 53-88)
- gearless traction (3.5m/s to 4m/s)
- 1600 to 2200kg capacity

- hotel (from podium): S60 (level B1, level 1-2)
- office (from podium): S62 (level B1, level 1)
- geared traction (0.5m/s to 1m/s)
- 2000 to 3000kg capacity

EMERGENCY ELEVATORS
- office: SF39, SF40 (level B3-B1, levels 1, level 3-51)
- hotel: SF50-51 (levels 51-88)
- gearless traction (3.5m/s to 4m/s)
- 1600 to 2200kg capacity

- retail: SF58-SF59 (level B1, level 1-6)
- geared traction (1.75m/s)
- 2000kg capacity
OBSERVATION DECK

OBSERVATION DECK ELEVATORS
- deck: P33-P34 (level B1 and 88)
- gearless traction (9.1m/s)
- 2500kg capacity
- total travel time: 35 seconds
The Jin Mao complex has a very complex elevator riser diagram. Office zones are serviced by 26 elevators in five zones. There is a hotel express shuttle elevator bay, an observation deck served by 2 elevators, 10 service elevators, 7 sets of escalators servicing the podium and 10 elevators for the hotel services.
CHAPTER 3: SUPERSTRUCTURE

CORE
MEGACOLUMN
SUPERCOLUMN
OUTRIGGER TRUSS
PIN CONNECTION
Adhering to the theme of eight, which signifies good luck in China, the structure of the tower contains an octagonal central reinforced concrete core, eight perimeter megacolumns made of concrete and steel, and eight steel built-up supercolumns, all resting on a 4m thick, reinforced-concrete, pile-supported mat.

“A structure should be designed, engineered and constructed to interact harmoniously with the most unpredictable of natural environments.”

-Mark Sarkisian
CORE (SHEAR WALL)

The southeast coastal region of China is impacted by typhoons and strong winds. Potential of a major earthquake in the region was predicted to occur within the next 50 years.

Advanced structural engineering system of wind and earthquake engineering which could withstand typhoon winds of up to 200 km/h (with the top swaying by a maximum of 75 cm) and earthquakes of up to 7 on the Richter scale.

Extensive wind and seismic engineering analyses performed (aspect ratio between the height and transverse width of 8:1).

Chinese wind design code did not address structures taller than 160 m 10 years ago when the Jin Mao Building was designed.

The Jin Mao was envisioned as a flexible and slender structure, thus, the building was constructed using both steel and concrete. As a composite building, materials could be located where they most efficiently resist loads, thus minimizing cost and materials. Reinforced concrete, with its mass, strength, stiffness, and damping characteristics, combined with the strength, speed of construction, long-span capabilities, and lightweight characteristics of structural steel were combined to control building behavior and maximize structural efficiency.
The concrete core provides excellent stiffness, while the structural steel floor framing allows us to use long, column-free spans with minimal weight. This, in turn, reduces the size of the vertical members and the foundation, creating a system that resists winds and earthquakes with the fewest possible structural elements. The composite approach also enabled the engineers to hollow out that portion of the central core where structural demands were less, and to create the tower’s centerpiece – a 650-foot-high atrium, tallest and highest in the world, extending up from the 56th floor.
The use of both steel and concrete created a dilemma as some deformations occur during construction due to self weight, while some occur over time, in some cases up to 10 years or more. Concrete and steel both deform elastically, but concrete also creeps and shrinks over time. For a building as tall as the Jin Mao, vertical displacement at the top could be as much as 12 inches. More significant is the relative movement between neighboring vertical elements, especially the core relative to the composite mega-columns that are interconnected with the stiff steel outrigger trusses.
When subjected to large relative displacements, these trusses would attract forces so great that they could be ripped apart. To counteract these forces, the engineers introduced pins into the trusses to allow rotation during construction. They did not bolt the connections until after the structure was completely built. After the bolts were installed, the structure was capable of resisting all future design loads. In addition, pins would also fuse and dissipate energy during earthquakes; after an event, friction in the joints is restored by high-strength bolts. During moderate earthquakes the joint remains fixed, but during a severe earthquake, the joints rotate. This allows the building to be flexible, dissipating energy and reducing potential damage. After the earthquake, the Pin-Fuse Joints return to their original positions.
Gravity loads are resisted by composite floor members that frame to structural steel supercolumns, the central core, and composite megacolumns. The steel shafts have shear joints that act as shock absorbers to cushion the lateral forces imposed by winds and quakes. The swimming pool on the 57th floor is said to act as a passive damper.
OUTRIGGER TRUSS

Provides resistance of lateral loads through a central reinforced concrete shear wall core interconnected with composite megacolumns. The concrete core is connected to the composite megacolumns on the perimeter using outrigger trusses. Three sets of 8 two-story high outrigger trusses connect the columns to the core at three levels (the 24nd–26nd, 51st–53th and 85th–87th floors).
everything is tied together

OUTRIGGER TRUSS

CROSS BRACE NO LONGER REQUIRED

PIN CONNECTION STEEL TO STEEL

LEVEL 85-87

LEVEL 51-53

LEVEL 24-26

OUTRIGGER TRUSS

CORE WALL TO OUTRIGGER TRUSS CONNECTION DETAIL

LONG SLOTTED HOLES - END CLIP
Pins in the trusses to allow rotation during construction. Workers did not bolt the connections until after the structure was completely built. After the bolts were installed, the structure was capable of resisting all future design loads.
CHAPTER 4: SUBSTRUCTURE

SLURRY WALL
MATT FOUNDATION
STEEL PILES
SLURRY WALL SYSTEM

A slurry wall is a technique used to build reinforced-concrete walls or a non-structural diaphragm in areas of soft earth close to open water or with a high groundwater table. Slurry wall construction involves excavating a narrow trench that is kept full of an engineered fluid or "slurry" at all times. The slurry exerts hydraulic pressure against the trench walls and acts as shoring to prevent collapse.

Bentonite slurry is the most common excavation fluid used in a slurry trench. In addition to stabilizing the excavation, bentonite reduces the slurry wall's final soil permeability.

Once sufficient excavation is complete, reinforcement is lowered in and the trench is filled with concrete. The concrete displaces the bentonite slurry, which is pumped out and recycled.
The slurry wall enables deep excavation around the site, blocks water from entering the foundation, and serves as an enclosure (parking, etc.) once the building is complete.

To prevent the concrete wall from collapsing into the newly open area, temporary supports such as tiebacks are installed.
MAT FOUNDATION

The mat (or raft) foundation can be considered a large footing extending over a great area, frequently an entire building. All vertical structural loadings from columns and piers are supported on the common foundation. Typically, the mat is utilized for conditions where a preliminary design indicates that individual columns or footings would be undesirably close together or try to overlap. The mat is frequently utilized as a method to reduce or distribute building loads in order to reduce differential settlement between adjacent areas. To function properly, the mat structure will be more rigid and thicker than individual spread footing. A mat foundation is typically used when there are poor and weak soil conditions.
The mat (or raft) foundation can be considered a large footing extending over a great area, frequently an entire building. All vertical structural loadings from columns and all are supported on the common foundation. Typically, the mat is utilized for conditions where a preliminary design indicates that individual columns or footings would be undesirably close together or try to overlap.
STEEL PILES

Pile foundations are the part of a structure used to carry and transfer the load of the structure to the bearing ground located at some depth below ground surface. The main components of the foundation are the pile cap and the piles. Piles are long and slender members which transfer the load to deeper soil or rock of high bearing capacity avoiding shallow soil of low bearing capacity.

The foundations rest on 1,062 high-capacity steel piles driven 83.5 m deep in the ground to compensate for poor upper-strata soil conditions. At the time those were the longest steel piles ever used in a land-based building. The piles are capped by a 4 m-thick concrete raft 19.6 m underground. The basement’s surrounding slurry wall is 1 m thick, 36 m high and 568 m long, and composed of 20,500 m³ of reinforced concrete.

Pipe piles are a type of steel driven pile foundation and are a good candidate for battered piles. Pipe piles can be driven either open end or closed end. When driven open end, soil is allowed to enter the bottom of the pipe or tube. If an empty pipe is required, a jet of water or an auger can be used to remove the soil inside following driving. Closed end pipe piles are constructed by covering the bottom of the pile with a steel plate or cast steel shoe.

The amount of corrosion for a steel pipe pile can be categorized; for a pile embedded in a non-aggressive and natural soil, 0.015 mm per side per year can be assumed from the British Steel Piling Handbook. Eurocode 3 now specifies various corrosion rates based on the nature or soil conditions and pipe pile exposure.

Steel pipe piles can either be new steel manufactured specifically for the piling industry or reclaimed steel tubular casing previously used for other purposes such as oil and gas exploration.
STEEL PILES - The foundations rest on 1,062 high-capacity steel piles driven 83.5 m deep in the ground to compensate for poor upper-strata soil conditions. At the time those were the longest steel piles ever used in a land-based building.
STEEL PILES carry ground located at some depth below ground surface. As with other types of foundations, the purpose of a pile foundations is: to transmit a foundation load to a solid 

**TYPICAL PODIUM LOW RISE**

- PILE CUTOFF
- SPICE DETAIL
- SHOE DETAIL
CHAPTER 5: CURTAIN WALL

UNITIZED SYSTEM
PANELS
TOWER BASE CONNECTIONS
FINS AND RODS
CHAPTER 5: CURTAIN WALL DESIGN CRITERIA

Considering water movement, thermal changes, construction tolerance, ease of installation, energy efficiency and aesthetic value.

Water:
The system in the Jin Mao tower is designed to be airtight and waterproof. Weeps are provided at each line of flashing to insure positive drainage. Exterior walls that enclose heated spaces are designed to meet the criteria for condensation control. Vapor barriers are placed on the warm side of the exterior wall. Positive drain holes are provided inside the aluminum window wall mullions and panels. All weep holes have a baffle.

Thermal Change:
The design temperature for the tower is 21 degrees Celsius. Thermal expansion/contraction and movement joints fulfill the exterior wall performance requirements resulting from a temperature change between -10 degrees to 40 degrees Celsius. Sponge Neoprene Glazing Gaskets and Silicone Glazing Gaskets allow for thermal expansion of the glazing.

Construction Tolerance:
The typical floor deflection is 20mm, while differential settlement is designed to be 8mm per 4 stories. In order to compensate for anticipated axial shortening of the structure as it is being erected the erection of the exterior wall commenced prior to the completion of the tower structure and prior to the application of superimposed dead loads on a particular floor. Copings, parapets, fins, and decorative elements were designed to withstand a 90kg concentrated load applied in any direction.

Ease of Installation:
All panels are prefabricated and assembled as a unit system.

Aesthetic Value:
An elegant skyscraper, the exterior enclosure system is covered with aluminum tubing lattice work and fins to provide a light pollution filter.
Thermal expansion/contraction and movement joints fulfill the exterior wall performance requirements resulting from a temperature change between -10 degrees to 40 degrees Celsius. The design temperature for the tower is 21 degrees Celsius.

Floor - summer $U = 3.12$, winter $U = 2.61$
Storefront - summer $U = 5.79$, winter $U = 5.68$
Skylights - summer $U = 3.12$, winter $U = 2.61$
All other wall portions - $U = 0.45$
Unitized curtain walls involve factory fabrication, assembly of panels, and glazing. Unlike a stick system, the unitized system is used mostly on large projects. Completed units are hung on the building structure to form the building enclosure. Mechanical handling is required to position, align and fix the units onto pre-positioned brackets attached to the structure or concrete floor. Some of the advantages of this system are: ability to assemble units in workshop with high precision, lower field installation costs as units can be carried out in parallel with building work to shorten construction period, and quality control within an interior climate controlled environment. Interlocking male and female profiles provide good resistance to typical floor deflections of 20mm and differential settlement of 8mm per 4 stories.
The skin is a state-of-the-art curtain wall comprised of high-performance glass and an expressed exterior mullion system composed of stainless steel, aluminum, and granite.

It uses new technology and building materials to create a fabric, texture, and detailing that relate to the historic and cultural values of the context.

When designing the curtain wall, the following requirements should be addressed:

(1) ease of installation
(2) construction tolerance
(3) water diversion
(4) energy efficiency
(5) thermal changes, and
(6) aesthetic value.
The system in the Jin Mao tower is designed to be airtight and waterproof. Weeps are provided at each line of flashing to insure positive drainage. Exterior walls that enclose heated spaces are designed to meet the criteria for condensation control. Vapor barriers are placed on the warm side of the exterior wall. Positive drain holes are provided inside the aluminum window wall mullions and panels. Pressure-equalization and proper drainage to achieve air and water tightness requirements. Sponge Neoprene Glazing Gaskets and Silicone Glazing Gaskets allow for thermal expansion of the glazing.
FINS & RODS

A complex latticework of cladding made of aluminum alloy pipes (i.e., a cage like system of decorative rails) is also used to remove light pollution.

Copings, parapets, fins, and decorative elements were designed to withstand a 90kg concentrated load applied in any direction.

The heavily articulated façade gives the tower a distinctly ornamented exterior that recalls the decorative carvings of a traditional Chinese structure. As the building rises, it steps back evoking the profile of a traditional Chinese pagoda.
CHAPTER 6: MECHANICAL SYSTEMS

CHILLER ROOM
DISTRIBUTION
HEAT EXCHANGERS
Jin Mao’s mechanical system services two distinct areas of the building: offices and hotels. This separation is necessary since the building itself is so large. The systems themselves are independent of each other and are not linked because the allocated sizes are sufficient for each area. In addition, linking the systems would require piping systems to become linked, which currently are not connected.
- The chiller room is located beneath the podium and houses refrigeration machines, pumps, and heat exchangers.

- Through the process of vapor-compression refrigeration, a circulating liquid refrigerant absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere.

- For each area, there are three 1,200 ton refrigeration machines and one 400 ton machine. The capacity of the machines were selected for the following reasons

  (1) smaller size saves space
  (2) maintenance is familiar with the systems
  (3) replacement parts are easier to procure, and
  (4) the machines are functionally flexible (one works while the other rests).
DISTRIBUTION: OFFICE

The office area is an All-Air Systems. All the space conditioning requirement is met by the supply of Conditioned Air to each space. The CHWS&R pipes transport water from the chiller to various cooling coils or supply fans and back to the chiller. Since this is a closed loop, an expansion tank is required. The expansion tank will then connect to domestic water supply. The CWS&R transports from the refrigeration room to the condenser and up to the cooling towers. In this case, the pipes rise throughout the tower for packaged air. This is also a closed loop which requires an expansion tank. For the refrigerant loop which is internal, a relief vent is required to release dangerous pressure build up.

The low pressure steam which is boiled in the boiler, exits and transports through the humidifier to various processes and heating application in each level.
DISTRIBUTION: HOTEL

This is the plumbing riser diagram for the hotel levels. They use air-water systems to control all of the hotel levels. Buildings that use the air-water systems are partially conditioned by air, typically 100% fresh air, but mostly by chilled water.

This system requires ventilation, which is fully provided by centrally supplied conditioned fresh air coupled with the required exhaust from wash rooms and kitchens. A fan coil unit supports each hotel room.

The 350 chilled water supply and return support all of the mechanical levels from 52-57 and roof level 1-4. 250 chilled water supply and return support all of the hotel floors.
HEAT EXCHANGERS

A heat exchanger is a device built for efficient heat transfer from one medium to another. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side.

The Jin Mao complex uses two different types of heat exchangers:
- The Plate and Frame HX are used with the Condenser Water Supply (CWS).
- The Shell and Tube HX are used with the Hot Water Supply (HWS) and are also pressurers.

<table>
<thead>
<tr>
<th>HX</th>
<th>LEVEL</th>
<th>TYPE</th>
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<td>LL3</td>
<td>P&amp;F</td>
<td>Water Side Economizer High Rise</td>
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<td>P&amp;F</td>
<td>Tenant CWS Low Rise</td>
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<td>Tenant CWS High Rise</td>
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<td>LL3</td>
<td>S&amp;T</td>
<td>HWS Podium</td>
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<td>S&amp;T</td>
<td>HWS Garage</td>
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<td>S&amp;T</td>
<td>HWS Tower L2-26</td>
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<td>13, 14</td>
<td>L51</td>
<td>S&amp;T</td>
<td>HWS Tower L27-50</td>
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<td>L PH 1</td>
<td>S&amp;T</td>
<td>HWS Tower L86-PH 1</td>
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<td>L51</td>
<td>S&amp;T</td>
<td>HWS Hotel Guest Rooms</td>
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</tbody>
</table>

*A signifies a standby unit
CHAPTER 7: SPACE CONDITIONING

RISERS
ALL AIR SYSTEM
AIR-WATER SYSTEM
AHU SPECS
SPACE CONDITIONING SYSTEMS

Jin Mao's space conditioning system is organized based on services, which are primarily office and hotel use. This ‘service zoning’ organization requires several different space conditioning systems (Air Handling Units, Packaged Air Conditioning Units, and Fan Coil Units) that provide the following:

1. Independent operation and control of the spaces for distinct characteristics (i.e., hotel and office).
2. Greater reliability and operational versatility (functionality).
3. Greater constructability and maintenance (economical).

Throughout the building, space conditioning systems have been strategically distributed and grouped into several mechanical spaces to provide optimum ambient air temperature, humidity, air movement, and supply of oxygen.
- Air is conditioned and delivered by supply fans (also known as air handling units) as well as packaged air conditioning units, which provide the following:

1. Heating and cooling of ambient air.
2. Controlled air movement (with controlled temperature provides high level of thermal comfort).
3. Ventilation for environmental comfort and health (circulation of fresh outside air).

<table>
<thead>
<tr>
<th>LEVEL 51/52</th>
<th>LEVEL 41-50</th>
<th>LEVEL 30-40</th>
<th>LEVEL 26</th>
<th>LEVEL 18-22</th>
<th>LEVEL 7-17</th>
<th>LEVEL 3-6</th>
<th>LEVEL 2/2M (PODIUM)</th>
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<td>OUTSIDE AIR</td>
<td>OUTSIDE AIR</td>
<td>OUTSIDE AIR</td>
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UNIT CEILING DIFFUSERS
SUPPLY FANS (AIR HANDLING UNITS)
CONDITIONED AIR
CONVECTION AIR
OUTSIDE AIR
SUPPLY
HOTEL DUCT RISER

- Cool or warm air is produced by running air over chilled/hot water through individually controlled fan coil units, which provide the following:

1. Heating and cooling of ambient air locally.
2. Control of temperature is easy, precise, and economical.
3. No need for reliable humidity control.
OFFICE: ALL AIR SYSTEM

- Space conditioning for the office area is an all air system, which supplies conditioned air exclusively to office space.

- Requires extensive ductwork (supply and return), which consumes space and is expensive (takes approximately 6" of floor height).

- Control is sometimes an issue and the system itself may be noisy (i.e., fan room).

HOTEL: AIR WATER SYSTEM

- Space conditioning for the hotel area is an air water system, which supplies air partially conditioned by fresh air and chilled water.

- All water systems require ventilation, which is fully provided by centrally supplied conditioned fresh air coupled with the required exhaust from bathrooms and kitchens.

- The system is relatively expensive to build as well as maintain (requires condensation drain, making the system tedious).
## AHU SPECIFICATIONS

### OFFICE TOWER AHU SCHEDULE

<table>
<thead>
<tr>
<th>UNIT</th>
<th>LOCATION</th>
<th>SERVICE</th>
<th>CAPACITY (LPS)</th>
<th>DESIGN BASICS</th>
<th>WHEEL TYPE</th>
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<tbody>
<tr>
<td>LS 1</td>
<td>L2 TOWER</td>
<td>LOBBY SUPPLY AIR</td>
<td>4100</td>
<td>DRAW-THRU UNIT SIZE 10</td>
<td>AXIAL</td>
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<td>L 30-40</td>
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<td>L 41-50</td>
<td>SUPPLY AIR L 41-50</td>
<td>7356</td>
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### HOTEL AHU SCHEDULE

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<thead>
<tr>
<th>UNIT</th>
<th>LOCATION</th>
<th>SERVICE</th>
<th>CAPACITY (LPS)</th>
<th>DESIGN BASICS</th>
<th>WHEEL TYPE</th>
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</thead>
<tbody>
<tr>
<td>OAS 7</td>
<td>L 52</td>
<td>OUTDOOR AIR SUPPLY GUEST RM L 58-72</td>
<td>13150</td>
<td>DRAW-THRU UNIT SIZE 30</td>
<td>AF</td>
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<td>OAS 8</td>
<td>L 52</td>
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<td>OAS 9</td>
<td>L 52</td>
<td>OUTDOOR AIR SUPPLY SUPPORT L 53-57</td>
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<tr>
<td>S 53</td>
<td>L 53</td>
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<td>S 54</td>
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<td>L 56</td>
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<td>L 57</td>
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<td>LL 1</td>
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<td>KS1-2</td>
<td>L 51/52</td>
<td>SUPPLY KITCHEN L 53,54,56</td>
<td>N/A</td>
<td>TRANE</td>
<td>CENTRIFUGAL</td>
</tr>
</tbody>
</table>
CHAPTER 7: ELECTRICAL SYSTEMS

POWER RISERS
PHASE 8: ELECTRICAL SYSTEMS

Four sets of 35 kV/6.3 kV transformers with a capacity of 48,000 KVA handle two separate incoming power lines from the city grid, which provide enough power for daily operation (two of the four are for emergency substitution). In addition, there are three efficient 1,600-KW diesel-fueled generators for emergency supply. Office section lighting (20VA/sq m) and power (30VA/sq m) provide illumination above 450-500 LUX and meet VDT international standard.

Bus duct system:
Bus duct is an enclosed metal unit containing copper or aluminum busbars for distribution of large amounts of power between components of the distribution system. Bus duct is used for the effective and efficient supply of electricity in mostly industrial locations. Copper or aluminum is used for the conductor of bus duct that can be insulated and enclosed completely for protection against mechanical damage and dust accumulation. A bus duct system is an effective method of distributing power to Jin Mao switchgear and various loads.
POWER RISER: LOWER LEVELS (LEVELS B3 TO 7)

LEVEL B3:
- Emergency lighting distribution panel on B2
- 3000 amp lighting receptacle plug in busway
- Switchgears

LEVEL B2:
- To transformer

LEVEL B1:
- MCC

LEVEL 1:
- Concert hall lighting

LEVEL B3:
- Emergency power

LEVEL B2:
- Elevator controls

LEVEL B3:
- Busway

LEVEL B2:
- Busway

LEVEL B3:
- MCC

LEVEL B2:
- Busway

LEVEL B3:
- MCC

LEVEL B2:
- Busway

LEVEL B1:
- McC

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway

LEVEL B1:
- Busway

LEVEL B2:
- Busway
POWER RISER: OFFICE (LEVELS 8 TO 51)

LEVEL 51
LEVEL 50
LEVEL 49
LEVEL 48
LEVEL 47
LEVEL 46
LEVEL 45
LEVEL 44
LEVEL 43
LEVEL 42
LEVEL 41
LEVEL 40
LEVEL 39
LEVEL 38
LEVEL 37
LEVEL 36
LEVEL 35
LEVEL 34
LEVEL 33
LEVEL 32
LEVEL 31
LEVEL 30
LEVEL 29
LEVEL 28
LEVEL 27
LEVEL 26
LEVEL 25
LEVEL 24
LEVEL 23
LEVEL 22
LEVEL 21
LEVEL 20
LEVEL 19
LEVEL 18
LEVEL 17
LEVEL 16
LEVEL 15
LEVEL 14
LEVEL 13
LEVEL 12
LEVEL 11
LEVEL 10
LEVEL 9
LEVEL 8
LEVEL 7
LEVEL 6
LEVEL 5
LEVEL 4
LEVEL 3
LEVEL 2
LEVEL 1
LEVEL 0

(continued to level 52)

(continued to level 7)
POWER RISER: HOTEL (LEVELS 51 TO ROOF)
SOURCES
STANDARDS

AAMA 501.1 “Standard Test Methods for Metal Curtain Walls or Water Pressure Using Dynamic Pressure.”

AAMA 501.2 “Field Check For Metal Curtain Walls For Water Leakage.”

AAMA 501.3 “Field of Water Penetration Through Installed Exterior Windows, Curtain Walls, and Door by Uniform Air Pressure Difference.”

ASTM E283 “Test Method of Air Leakage Through Exterior Windows, Curtain Walls and Doors.”


ASTM E783 “Field Measurement of Air Leakage Through Installed Exterior Windows and Doors.”

ASTM E90 “Method For Laboratory measurement of Airborne-Sound Transmission Loss of Building Partitions.”

SOURCES


Consultation w/ Dr. Michael Kim, University of Illinois at Urbana-Champaign, March 2010.


Consultation w/ Dr. Michael Kim & Mr. Jeff Kansler, University of Illinois at Urbana-Champaign, 2010.