MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF ARCHITECTURE / BUILDING SCIENCE PROGRAM

BS 536
STUDIES ON TALL BUILDINGS: DESIGN CONSIDERATIONS
Fall 2013-2014

Case Study: **Jin Mao Tower**
by
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METU BS536

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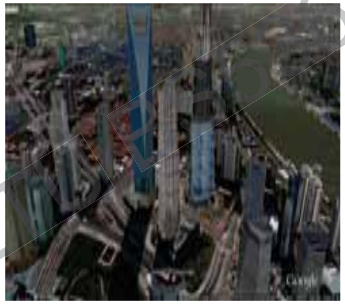
Submitted to: Günel, Tanyer – Fall 2013

JIN MAO TOWER

- Official Name : Jin Mao Building
- Former Name: Jin Mao Tower
- Location: Shanghai, China
- Building function: Hotel / Office
- Architectural height: 420.5 meter
- Architectural occupied: 348.4
- Floors above the ground: 88
- Status: Completed
- Completion: 1999
- Architect: Adrian D, Smith from Skidmore Owing, and Merril
- Structural engineer: Stanton Korista
- Structural system:
  1. Taranath: Mega frame with super columns
  2. Smith: outrigger braced system
  3. Oral Buyukozturk: Core and outrigger system



Project Awards

- 2001 • AIA • National Honor Award for Interior Architecture
- 2001 • AIA - Chicago Chapter • Interior Architecture Award: Honor Award
- 2001 • AIA - Chicago Chapter • Divine Detail Award: Special Recognition
- 2001 • World Architecture • World Architecture Award: Asia Category, Finalist
- 1999 • Institution of Structural Engineers • Structural Special Award
- 1998 • Structural Engineers Association of Illinois • Best Structure Award
- 1998 • ASHRAE - Illinois Chapter • Excellence in Engineering

https://www.som.com/project/jin-mao-tower

The Concept

Head architect Adrian D, Smith from Sikdmore, 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. Jin Mao tower evokes the architecture of the traditional Chinese pagoda by creating a rhythmic pattern growing in height. The proportion of the building revolves around the number 8. In Buddhism 8 is a lucky number, associated with prosperity, economy, gold and trade.

- ✓88 floors
- ✓Octagonal core
- ✓8 mega columns
- ✓8 super columns
- ✓8 sided exterior at the top

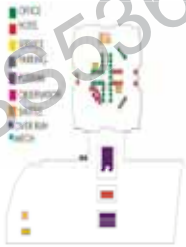
http://www.the-art-minute.com/just-a-second-pagoda

- 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

http:// commons.wikimedia.org/wiki/File:Shopping_by_the_Jin_Mao_Tower.JPG
http://www.smartshanghai.com/venue/458/The_Grand_Hyatt_Shanghai_shanghai

Vertical Transportation

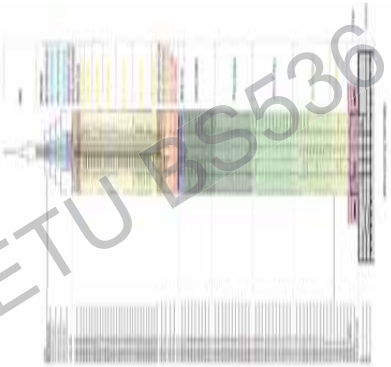
- There are 61 elevators in Jin Mao Tower.
- Office zones are serviced by 26 elevators in five zones.
- A hotel express shuttle elevator bay
- An observation deck served by 2 elevators, 10 service elevators,
- 7 sets of escalators for podium
- 10 elevators for the hotel



elevator riser diagram plan

- 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 53th floor and extends upwards to the 87th.
- The tower has an aspect ratio of 8:1 when considering the full building height (7:1 to the last fully occupied floor).
- The following page 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.

http://www-math.mit.edu/~rstan/photos/asia/2006/lobby.jpg



Structural system

- The composite structural system for the Jin Mao tower was designed to resist typhoon winds and earthquake forces and accommodate poor soil conditions while providing a very slender tower to be fully occupied for office and hotel uses.
- the structure of the tower includes an octagonal central reinforced concrete core, linked to the eight mega columns made of reinforced concrete by structural steel outrigger trusses, and eight steel built-up super columns, 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

- The core houses the primary building service functions, including elevators, mechanical fan rooms for HVAC services, and washrooms.
- It is nominally 27 m deep with flanges varying in thickness from 850 mm at the top of foundations to 450 mm at level 87 with concrete strength varying from c60 to c40. Four 450 mm thick interconnecting core web walls exist throughout the office levels with no web walls on the hotel levels, creating an atrium with a total height of 205 m which leads in to aspire.

- The central area of the core is open without webs from level 53 to level 87 or typically through the hotel floors creating an atrium which leads into the spire with total atrium height of approximately 206 meters
- The concrete strength for the core varies from c60 to c40.

THE JIN MAO TOWER: XU TENG, YUE WANG, FEI HUANG, JIAYU CHEN, MENGYUAN ZHANG
http://sk.wikipedia.org/wiki/%C5%A0ang-chaj_chuan-%C4%8Dchrou_%C5%A5in-%C5%BEung_%C4%8Dung-sin

OUTRIGGER TRUSS

- Provides resistance of lateral loads through a central reinforced concrete shear wall core interconnected with composite mega-columns. The concrete core is connected to the composite mega-columns on the perimeter using outrigger trusses.
- The outrigger trusses are located between levels 24 and 26, between level 51 and 53 and between level 85 and 87.

THE JIN MAO TOWER: XU TENG, YUE WANG, FEI HUANG, JIAYU CHEN, MENGYUAN ZHANG

- The outrigger trusses between levels 85 & 87 engage the 3 dimensional structural steel cap truss system.
- The cap truss system which frames the top of the building between level 87 and the spire is used to:

1. span over the open core
2. Support the gravity load of heavy mechanical spaces
3. Engage the structural steel spire
4. Resist lateral loads above the top of the central core wall / composite mega-column system.

Smith,2007

MEGA-COLUMN

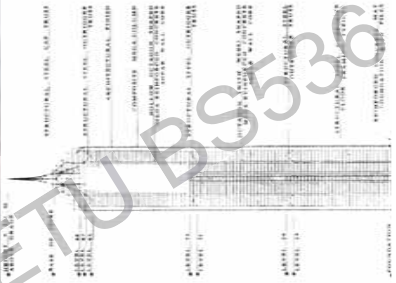
- The composite mega-columns vary from 1500mm x 5000mm at the foundation , to 1000mm x 3500mm at level 87
- The concrete strength for mega columns vary from c60 to c40

- Composite structural steel wide-flanged beams and build-up trusses are used to frame typical floors

Korista 1995

Concrete strengths and sizes of composite mega-columns and central core

Korista 1995



Tower structural system elevation

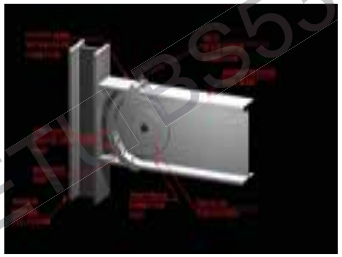
Korista 1995

Pinned joint

- The clue to control building behavior resided with the outrigger trusses using pinned joints.
- The trusses could be erected during the normal construction process allowing the members to act as mechanisms for specified period of time then allowing full bolting occur for permanent service. Allowing the trusses to act as mechanisms for extended period of time during construction greatly reduces the imposed loads on very stiff outrigger truss members due to relative movements.

- http://www.mtb.free.fr/mtb2006jin_mao.html

Pinned joint detail



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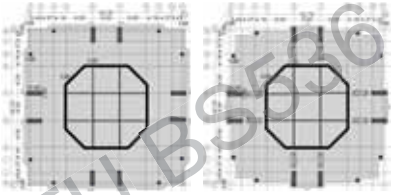
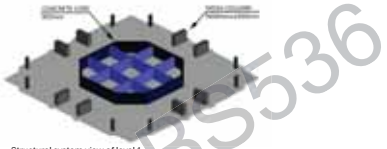


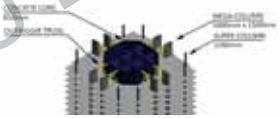
level 1 plan level 25 plan

Drawn by Ehsan Markazi

Korista 1995

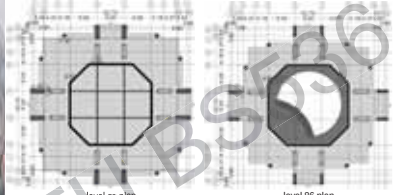


Structural system view of level 1



Structural system view of level 24-26

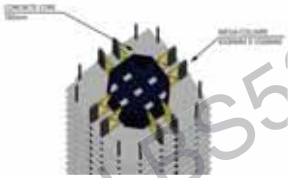
Drawn by Ehsan Markazi



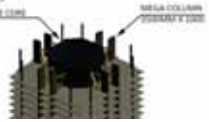
level 52 plan level 86 plan

Drawn by Ehsan Markazi

Korista 1995



Structural system view of levels 51-53

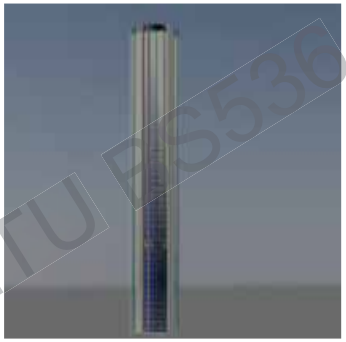


Drawn by Ehsan Markazi

Structural system view of levels 85-87

General view of the structural system

Drawn by Ehsan Markazi



Drawn by Ehsan Markazi

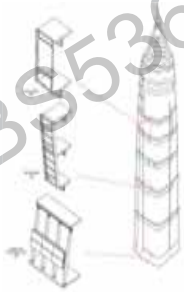
Curtain wall

- Thermal expansion/contraction and movement joints fulfill the exterior wall performance requirements from temperature change between -10 to +40 degrees. The design temperature for Jin Mao tower is 21 degrees Celsius.
- 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

http://www.galinsky.com/buildings/jinmao/jinmao2.jpg

- Some of the advantages of this system are:

1. Ability to assembling units in in workshop with high precision,
2. lower field installation costs as units can be carried out in parallel with building work to shorten construction period,
3. quality control within an interior climate controlled environment
4. . Interlocking male and female profiles provide good resistance to typical floor deflections of 20mm and differential settlement of 8mm per 4 stories.



THE JIN MAO TOWER: XU TENG, YUE WANG

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- www.mtb.free.fr/mtb2006jin_mao.html
- https://www.som.com/project/jin-mao-tower
- 上海金茂大厦各层平面图（1-50层）（reference for dimensions of plans)
- http://bbs.co188.com/home.php?mod=space&uid=10649450 上海金茂大厦各层平面图（1-50层)

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