Introduction

- Taipei 101 has a complex structural system
  - it is needed for the building to withstand its harsh environment and the potential dangers surrounding it.
- Through this case study we have tried to understand
  - the number of unique components of its structure
  - analyze its behavior to natural disaster
  - evaluate its continued ability to serve the occupants within
Tallest building in the world from 2004-2010.
Building Location

Taipei 101

Beijing
Shanghai
Hong Kong
Taipei

Taipei City Map

Sun Yat-sen Freeway
MRT Danshui Line
MRT Banqiao Line
MRT Zhonghe Line
MRT Xinzhu Line

Road
Grande Spot
Food
Hotel
Culture
Shopping
Bicycle Path
Mountain
Entertainment
Bank
Shopping District
Taipei Tourist Service Center

http://www.greenislandadventures.com/pics/Taiwan_Maps/Taipei-Tourist-Map.jpg

http://www.bing.com/images/search?view=detailV2&ccid=PFtAniks&id=F47968ABB69D56F55F5F61DF5384DF76FC57E35&lq=101&includeOp=18&Pf=O2 &Q=101&Q7=16Y8UL_M0707&I=EsD&Mediaurl=https%3a%2f%2fi.cbc.ca%2f1.3884005.14856550&Imagemap=1&image%3a14856550&derivatives%3a%2fderivates%2foriginal_620x620&lang=zh-trunc&x=635&y=239&sig=920q%3ataipei%3acon%3a14856550&selectedIndex=114&ajaxhist=0
Seismic Activities

Seismicity of Taiwan, 1990 - 2006

Taiwan Fault Lines
Overview

Taipei 101 (once known as Taipei World Financial Corporation)

- 1,667 feet (508 meters) from ground to the tip of the spire
- 101 floors above ground & 5 floors underground
- Plan Area - 50m x 50m
- Cost - $700 million
- Building Use - Office Complex + Mall
- Parking - 83,000 m², 1800 cars
- Retail - Taipei 101 Mall (77,033 m²)
- Offices - Taiwan Stock Exchange (198,347 m²)
- Construction took 5 years to complete
  - Finished in 2004
  - Cost $1.8 billion
- Tallest LEED certified building in the world (LEED Platinum)
- Designed to withstand typhoon winds and earthquakes tremors common in the area east of Taiwan
- Designed to withstand gale winds of 134 mph, and the strongest earthquakes in a 2,500-year cycle.
- Designed to be flexible as well as structurally resistant.
- Because of the height of Taipei 101, and the building being located 660 feet away from a major fault line, Taipei 101 used high-performance steel construction and concrete columns.
- Most famously, RWDI designed a 660-tonne steel pendulum that serves as a tuned mass damper.

https://archibillion.wordpegs.com/2012/10/10/taipei-101-by-c-y-lee-partners/#jp-carousel-2378
Background

Client - Taipei Financial Center Corporation.

Architect
- C.Y.Lee & Partners -
  Founded on the main principle of creating human-centered buildings that are rich in culture and emphasize innovative design.

Structural Engineer
- Shaw Shieh - Evergreen Consulting Engineering -
  One of the largest, engineering consulting companies in Taiwan
  Experienced in wind and seismic activity.

Structural Consultant
- Thornton - Tomasetti Engineers, New York City -
  Designed more than half of the top ten structures in Taiwan
  Recognized for their talents in overcoming special challenges through irregular shaped, high-rise structures

http://thornton.s3.amazonaws.com/content_images/167/tomasetti.jpg
Design Concept

- Pagoda Style
  - Traditional Architecture
  - Ties into Cultural Beliefs
- Bamboo - 8 Segments
  - Everlasting Strength
  - Youth and Longevity
- Icon of Taiwan and Finances
  - Part of Xinyin District
  - Seismically Resistant Area
Structural Features

Podium

- Retail mall that is home to restaurants, clubs, and hundreds of fashionable stores and attractions.
- The Atrium:
  - the connecting tower
  - twin vierendeel trusses that span the length of the podium.
  - As a lighter mass, it’s steel structure is not as heavy as the tower, the foundation (piles) are fewer in number and not as deep.
- 6 Stories

Tower

- 25 story truncated pyramid with an intervening floor taken up by the truss system, and eight stories of smaller segments of eight above.
- There are also exterior curtain panels slope 5 & 7 degrees, resembling a shoot of bamboo, and tying back to the mega-columns
- Facade is able to withstand an impact of up to 7 tonnes.
- Saw-toothed corners greatly reduced crosswind oscillation.
- 101 Stories + 5 Story Basement
Seismic Design

- Central core
- Trusses and Bracing
- Truncated Pyramid Base
- Flexible but Sturdy Materials
  - 10,000 psi concrete
  - 60 ksi steel
- Mass Damper
- Mini Dampers on Spire
Building Components & System

Central Braced Core
- Resists Moments and Gravity Loads

Large Perimeter Mega-Columns
- Concrete Filled Steel Boxes - Reinforced by Moment Frame

Outrigger Trusses
- 8 Segments of 8 Include a Story for Structure

Diagonals
- Through Occupied Space

Connections
- 5 Different Types
Building Components & System

Mass Tuned Damper

- 18' Diameter (Largest in World)
- 728 - ton tuned
- Suspended from the 92nd-87th floor
- Reduces overall building sway by 40%
- $4 million
- 41 steel plates in varying diameters each 125 mm thick welded together

Spire

- 2 - 7 ton dampers

Load Tracing

- Core adds Stiffness
  - Carries Gravity Loads
- Outrigger Trusses add Lateral Stability - Moment Frame Connections
- Super Columns along Perimeter for Strength
  - Carries Wind Loads
Foundation & Soil Type

- 660 feet away from a fault line
- 21m deep basement
  - Groundwater usually 2m below the surface
  - Soft rock usually 40-50m below colluvial soils and clay
- 2 Slurry Wall System
  - One around both the tower and the podium foundation
  - Second around just the tower foundation
- Drilled Piers
  - Continuous concrete mat transfers point loads
  - 380 piers driven 262ft into the ground
  - 5ft in diameter and can withstand 1100-1450 tons each
Multiframe Analysis: Perimeter Columns
Multiframe Analysis 2: Outrigger Truss
Taipei 101 honors the traditional Chinese Pagoda style with an innovative twist on handling the extreme lateral loads that come from being one of the tallest buildings in the world.
References


https://www.cylee.com/about


https://www.skyscrapercenter.com/building/taipei-101/117

Tectonic Relationships

There's just too much friction between us.

It's not my fault!

"Perhaps it's not a good idea to build skyscrapers that reach this far up."