Canton Tower

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Overview

Location : Guangdong, China

Height : 600 Meters

Project Area : 114,000 sqm

Project year : 2010

Architect : Mark Hemel and Barbara Kuit are the founding partners of Information Based Architecture.

Engineer : ARUP

Premise

- International competition held in 2004
- Program included : the tower, park at its base and the master-plan which includes Plaza, pagoda-park, retail facilities, offices, television centre and hotel
- Competition ran from April to August 2004 with 13 different proposals
- February 2005 finally choose Information Based Architecture’s Design

Design Concept

- Wanted to create a ‘female’ tower, being dynamic, transparent, curvy, gracious and sexy
- Free-form tower with a rich and human-like identity nicknaming it 'the supermodel’
- The non-symmetrical form portraying the building 'in movement' represents Guangzhou as a vibrant and exciting city

Design Concept

- Tightest waist as possible
- Twisted waist shape inspired by the east ward turning of Pearl River
- Eccentric core placement aligns the mast with the new central axis of the city
- Creates dynamic views of the north and south banks of the river

Building Layout

Five functional areas

- Section A : Two floors lobby, exhibition, public service, connections to underground
- Section B : 4d cinema
- Section C : leisure places observation hall snack shop

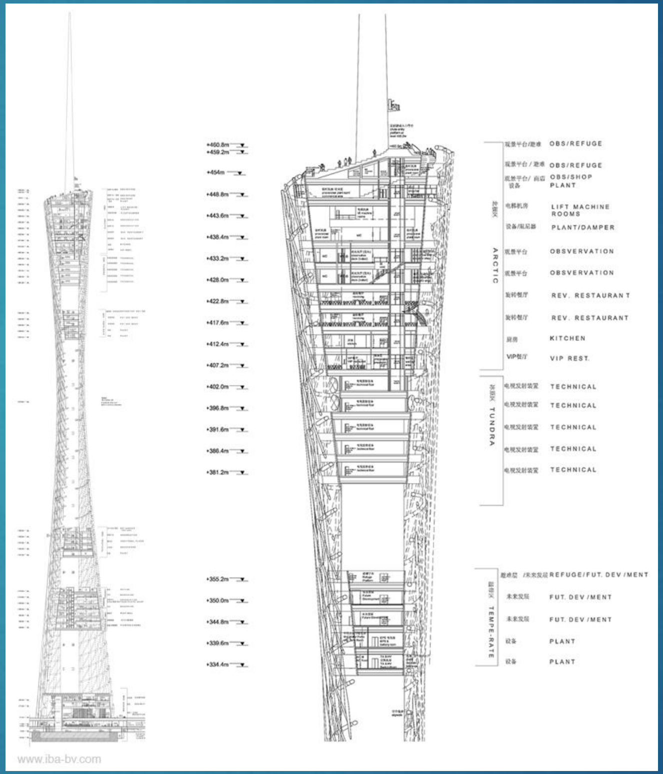
Hollow space with spiral staircase

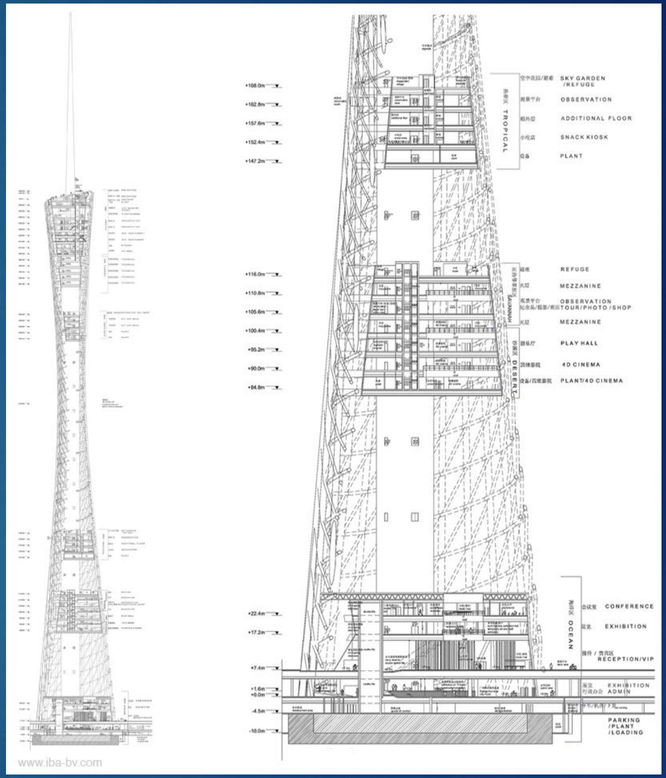
- Section D : tea rooms, resting places
- Section E : restaurants and damping floor open terrace observation square

Free fall ride on antenna

Four hollow vertical parts

37 occupied functional floors



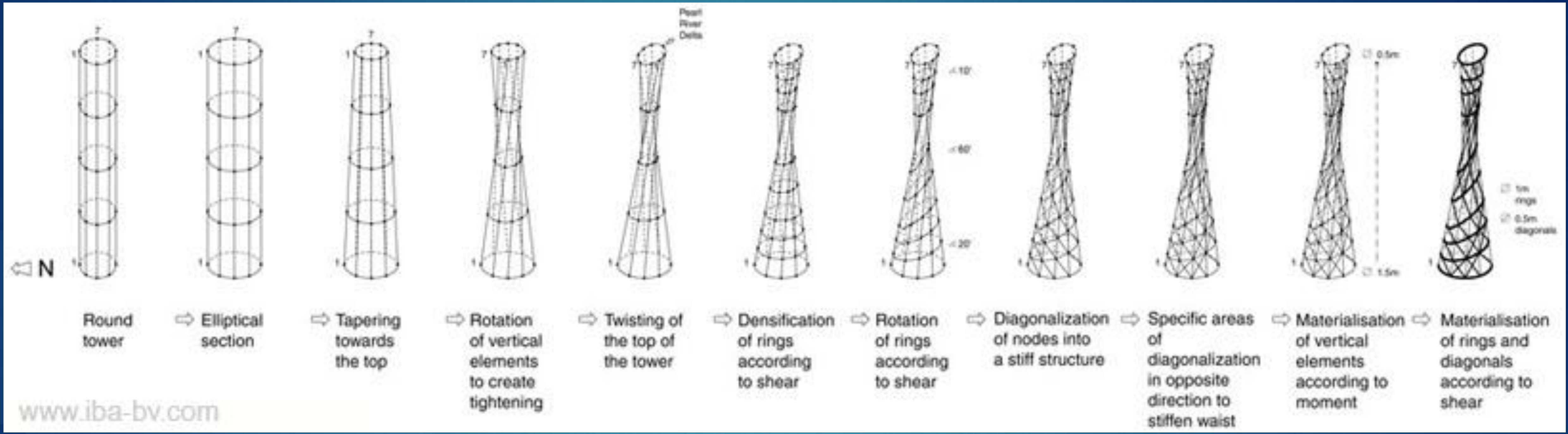


Innovative Features

- Triangular glazed panels
- Vertical transportation system
- Damping control system
- Structural health monitor system- five key cross sections monitored in real time
- Connection of inner and outer cores
- System of universal hinges to join differentiated nodes
- Connection between tower body and mast
- Gradual structural transfer

Building Structure

Building Structure

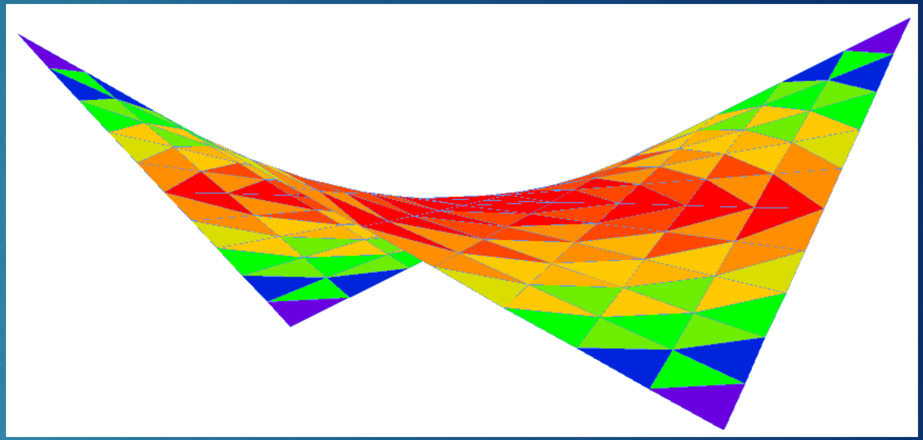


Hyperboloid Structure

- Invented by Russian engineer Vladimir Shukhlv
- First hyperboloid tower showcased in 1896 at the All Russia Expo
- Popular use in cooling towers

Hyperboloid Structure

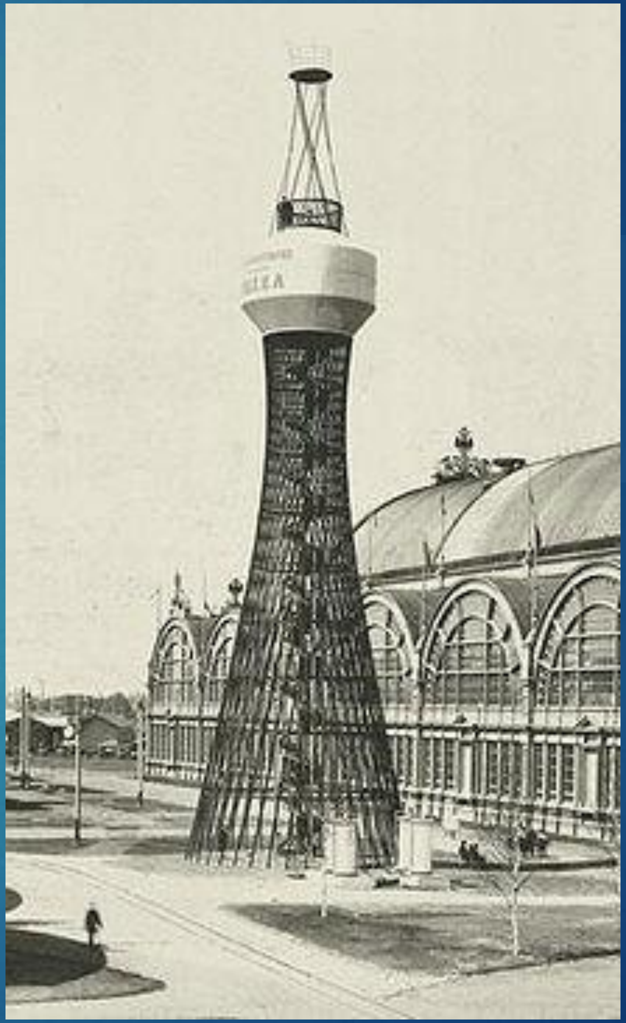
- Single curves surfaces such as cylinders have strengths and weaknesses
- standing on an empty coke can



- Double Curve surfaces avoid weak directions
- Components made from straight beams which are more resistant to buckling and economical

Hyperboloid Paradox

- Best buckling resistance because beams are straight
- Best overall buckling resistance because surfaces are double curved
- Shukovs tallest tower 50 m is taller then the Eiffel Tower but used ¼ of the steel



Building Components

Vertical Structure

foundation soil

Stand columns

Elevator core

Lateral Structure

Rings

Diagonal Bracing

Lateral Bracing

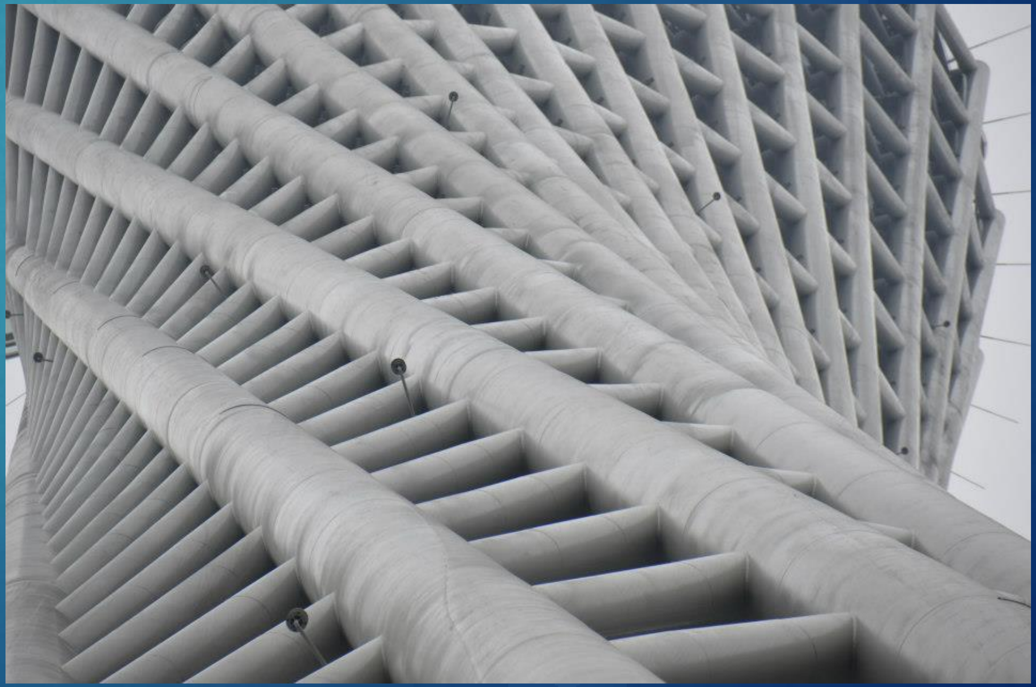
Hybrid Mass Damping system

Vertical Loading Foundation and Soil

- Foundation consists of 24 bored piles
- Each of the piles has a diameter of 4m (approximately 13ft)

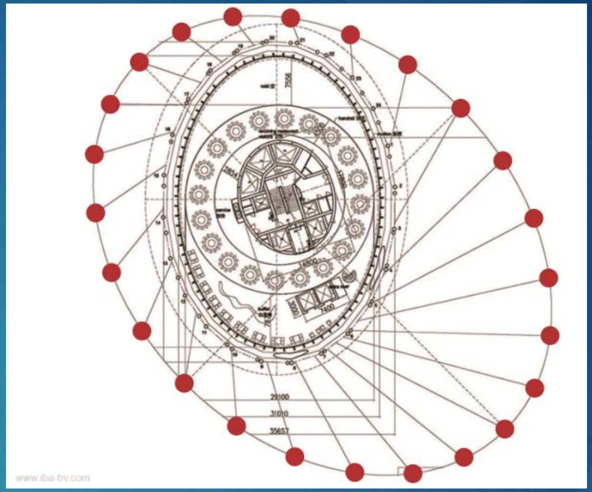
Vertical Loads: Stand Columns

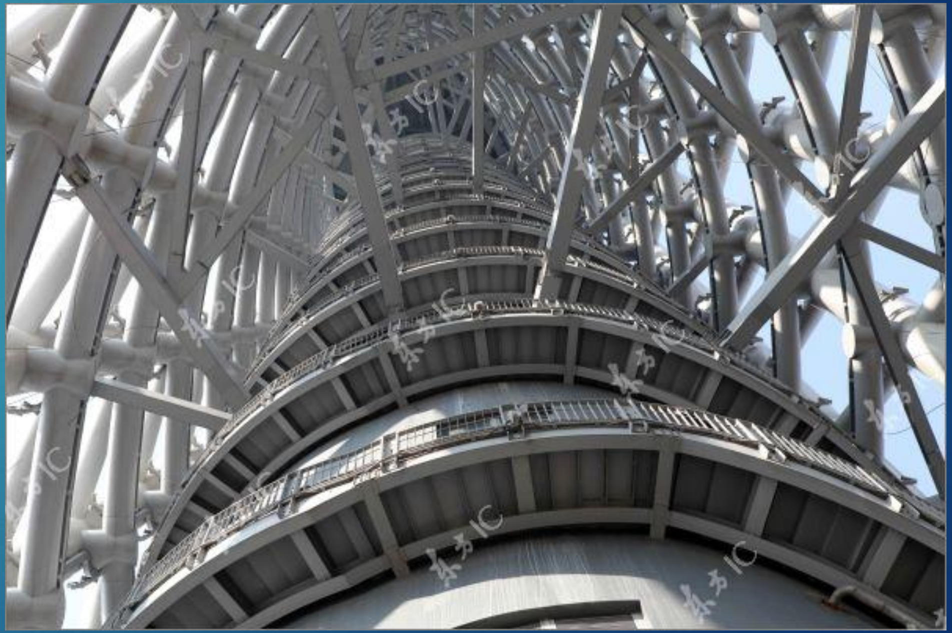
- Light grey
- 24 Conical steel tube columns, form a diagrid system
- Columns are straight but have slight slope
- Taper from 2 meters at the base to 1.2 meters at top
- Pre-fabricated members transported from Shanghai
- Materialization according to moment forces



Vertical Loads: Elevator Core

- Dark grey
- Ellipse measuring 14 x 17 meters (46 x 56 ft)
- Eccentrically placed relative to base ellipse
- Major design concern due to client desire for "thin waist"
- Code exceptions granted on performance based analysis allowed for smallest size
- Materialization based on moment forces





Lateral Loads: Rings

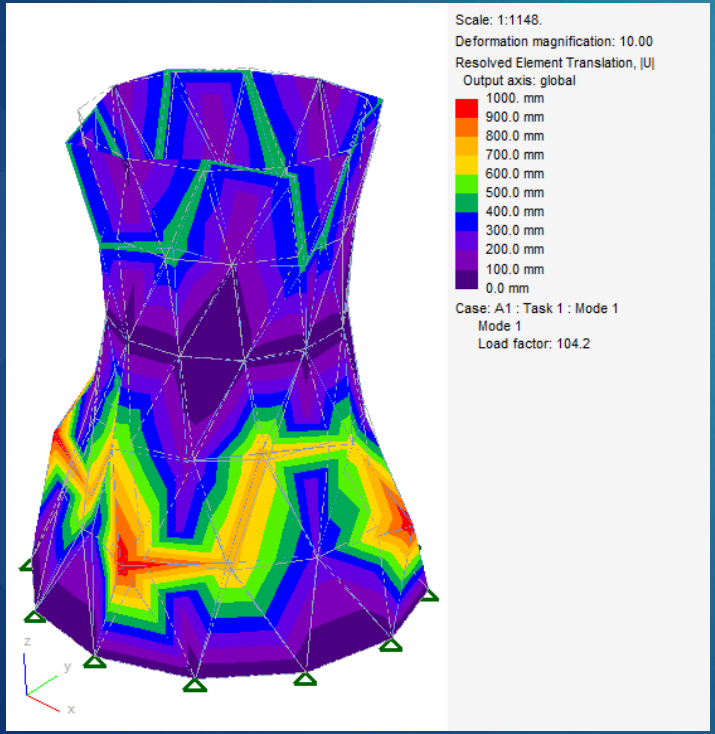
- 46 total from base to top of tower
- Rotated, inclined, and spaced according to shear
- Inclined to counteract slope of columns
- Ring diameter 800 mm (Approximately 30 inches)
- Materialization also based on shear

Lateral Loads: Diagonal Bracing

- Medium grey
- Densification to stiffen structure
- Specific areas of diagonalization in opposite direction to stiffen "waist"
- Materialization according to shear requirements

Lateral Loads: Bracing from Core

- Diagrid stabilized by bracing off the core
- Pin Connections used to allow for slight shifting of structure
- Reinforces weakest area of hyperboloid form



Lateral Loads:
HMD Damping system

- Hybrid Mass Damping System located near top of tower on the 85th floor
- Uses two symmetrical 600 ton Fire Water tanks for passive Tuned Mass Damping
- TMD rest on 3 bi-directional rail roller bearings

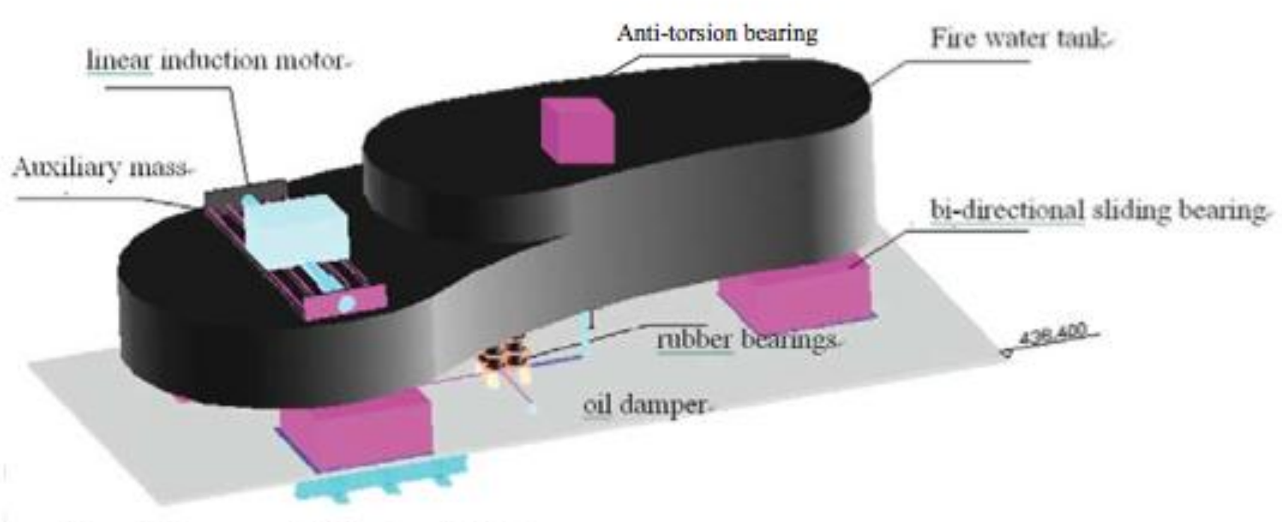


Figure 3. The proposed HMD system © EERTC

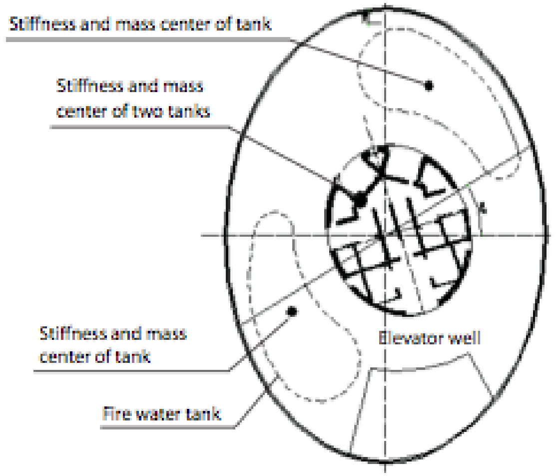


Figure 4. Stiffness and mass center of fire water tank © EERTC

Lateral Loads:
HMD Damping system

- Damping system is open to public and viewable by tour
- 50 ton induction motors atop the tanks provide Active Mass Damping to control the TMD behavior after it exceeds design constraints

Figure 5. Bi-directional rail roller bearing © EERTC

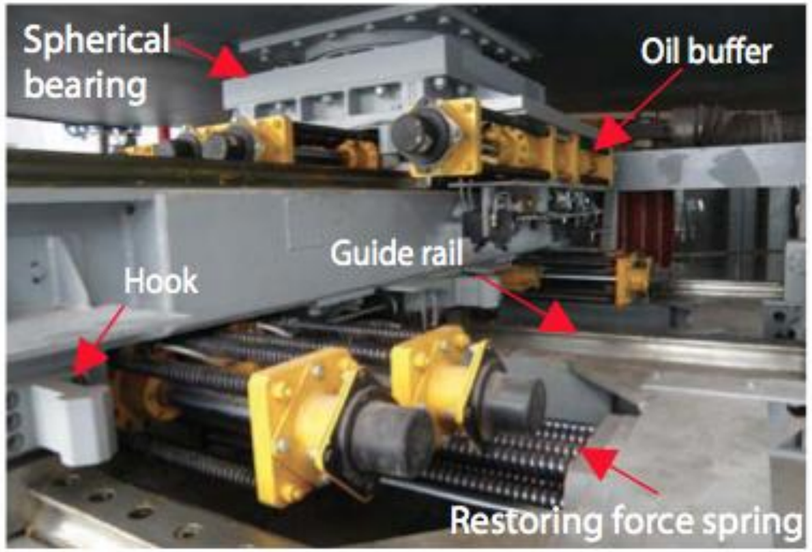


Figure 6. Soft collision device © EERTC

Connections

- Parametric design used for optimization of nodes and structural requirements
- 3300 individual pieces of all different sizes
- 1100 total nodes
- Varying sized members joined with system of universal joints
- Welded, moment connections used for entire diagrid (columns, rings, diagonals)

Connection Process

- Prefabricated tubes are connected by bolts
- Connections are welded
- After all the tubes have been welded together, bolted connections and brackets are torched off
- Then the columns are filled with concrete for stability and fire-proofing

Connections

- Floor plates are braced off the core (in addition to diagrid itself)
- Large pin connections used