China Central Television (CCTV) Headquarters Case Study

ARCH 631 Spring 2019

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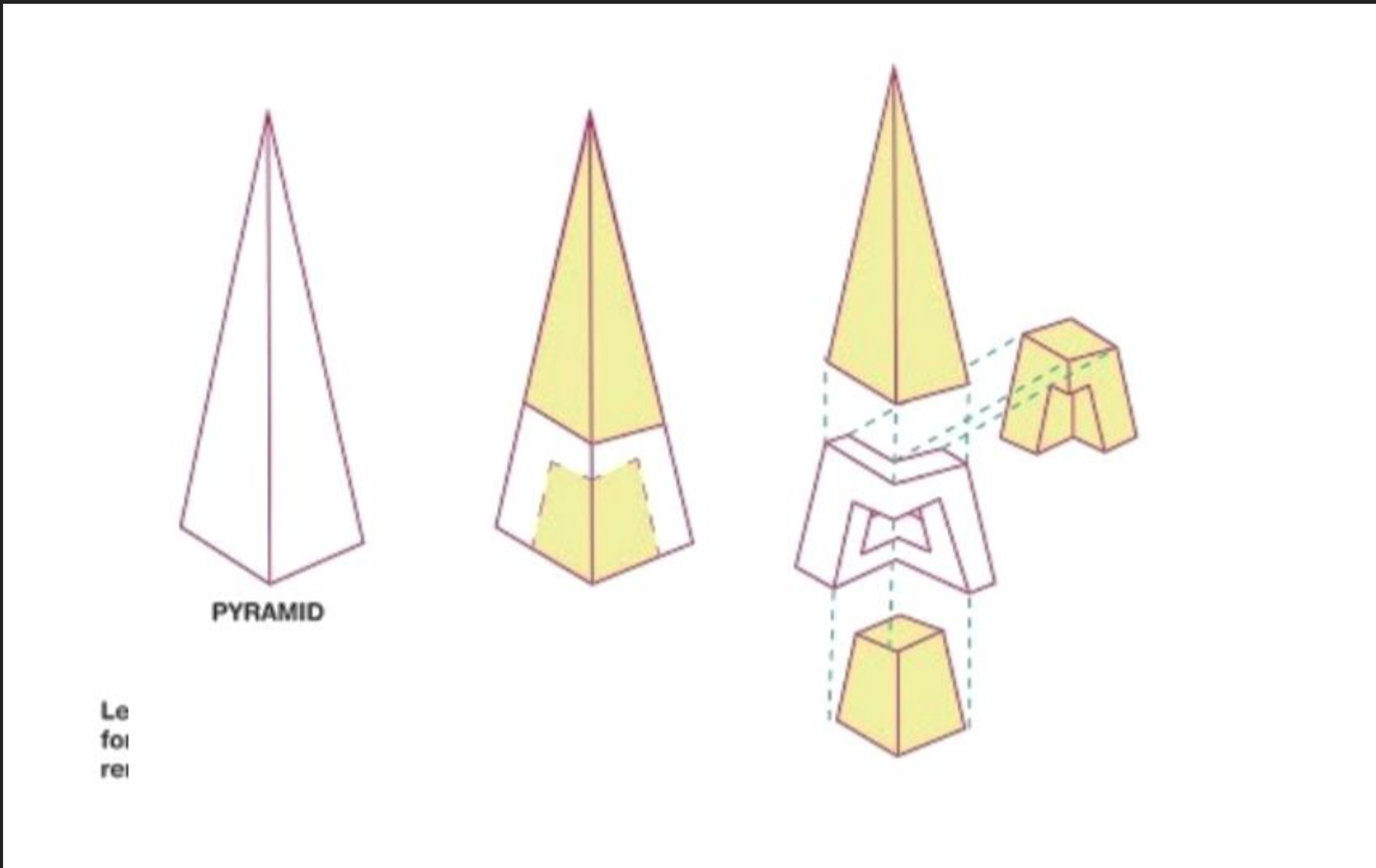
Introduction

- Developer: China Central Television (CCTV) Headquarters
  - international competition 2002
- Architect: Rem Koolhaas (OMA)
- Engineer: Arup
- Location: Beijing, China
- Floors: 51
- Height: 768
- Price: 600,000,000 euros
- Program: entire TV making process
- One singular building
  - “continuous loop”- closed circuit television
- Controversy
- 240 ft cantilever
- Diagrid structure
  - maps structural forces

"Rem Koolhaas." OMA. Accessed April 3, 2019. https://oma.eu/partners/rem-koolhaas.
Serialthrill. "Rem Koolhaas & OMA I CCTV Building, Beijing." SerialThriller. August 07, 2012. Accessed April 5, 2019. https://serialthriller.com/post/28924020894/rem-koolhaas-oma-cctv-building-beijing.

Geometry

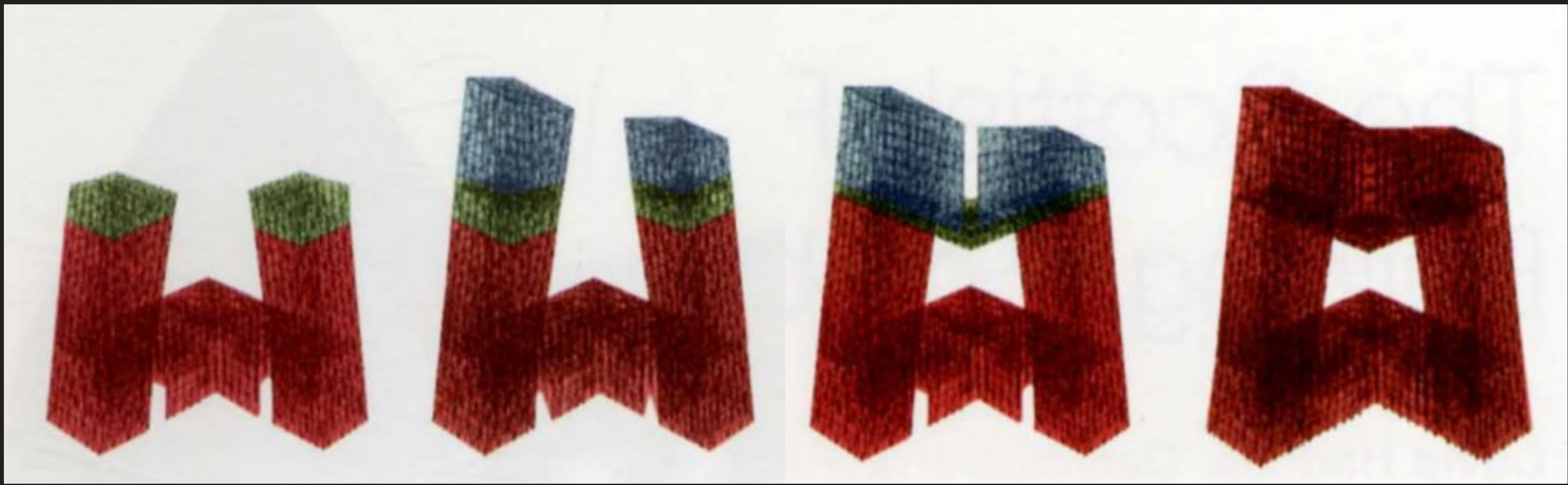


https://faculty.arch.tamu.edu/media/cms_page_media/4433/CCTVHeadquarters.pdf

Geometry

http://www.skyscrapercenter.com/building/cctv-headquarters/1068

Phases



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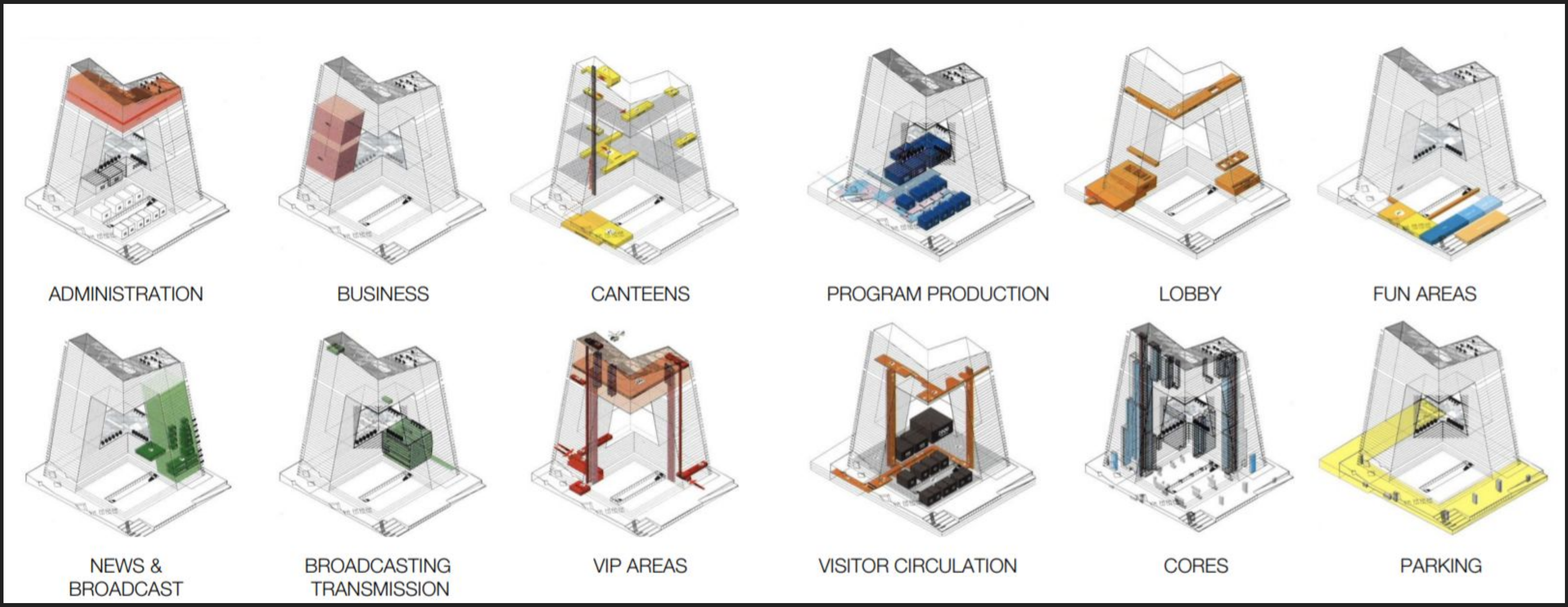
Program

- Administration
- Business
- Food
- Production
- Broadcasting
- Etc..



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Problems + Challenges

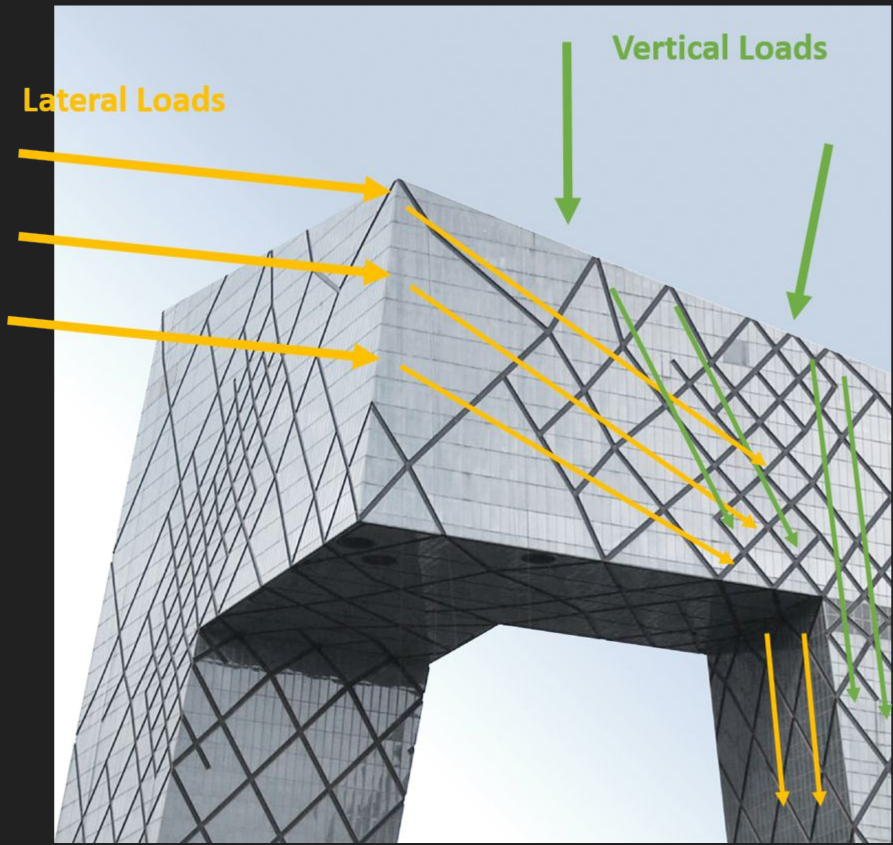
- Major issues faced when designing:
  - the structural system was to address the issues caused by tilting such a large structure
    - This was addressed with the cores
  - The cantilever to create a “closed loop” effect
    - This was addressed by anchoring to the cores
- Major issues faced during construction and site conditions
  - The temperature of the steel during construction
    - This was addressed by erecting the towers at dawn when the steel was all cooled to the same temperature
  - Earthquake zone
    - Addressed with the structural system and foundation system
  - Water underneath the soil
    - Addressed by the foundation system
  - Subsoil condition
    - The shallow subsoil was addressed by the foundation system

Building Code + Testing Practices

- Chinese Code
  - *Load Code for the Design of Building Structures*
  - Failed to comply
- Additional Testing needed to pass the building
  - Composite Column Test
  - Joint Test
  - Shaking Table Test
- Most complex and largest tested building that was working with a computer model

Forces Acting on the Structural Elements

- Regular Loads
  - Live Loads
    - People
    - Furniture
    - Technical Equipment
    - ETC….
  - Dead Loads
    - Fixed Furniture
    - Helipad
    - Structure
    - Floor/ Ceiling Systems
    - ETC…..
  - Gravity
  - Lateral
  - Seismic
- Supported By
  - Diagrid
  - Transfer Trusses
  - Perimeter Columns
  - 7 Cores



https://www.modumag.com/focus/beautified-china-an-architectural-photo-essay/

Structural System

1. External
2. Internal
3. Intermediate (Transfer Trusses)

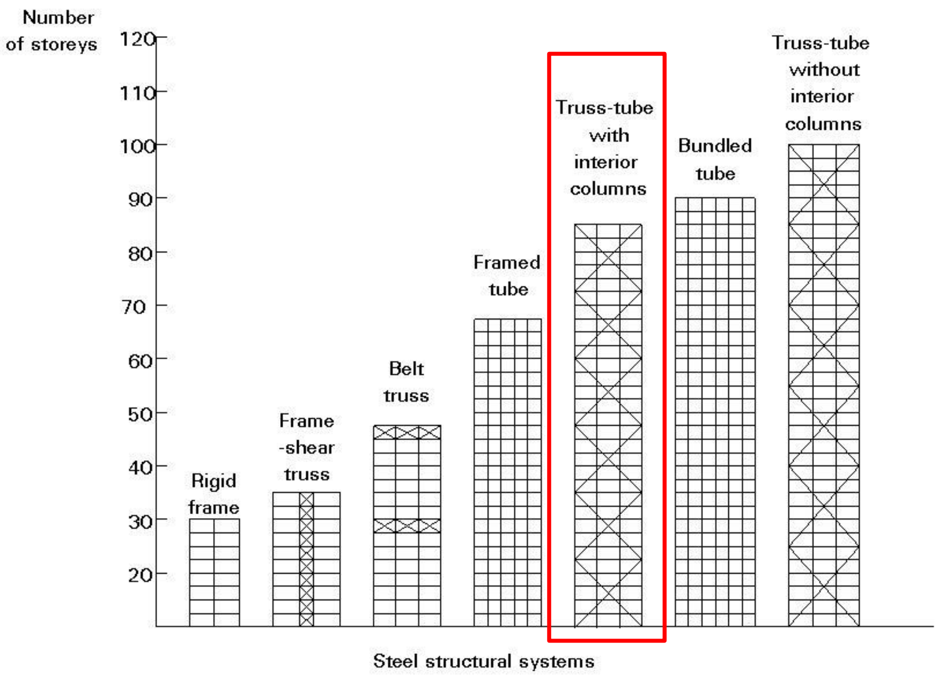


Figure 7 Steel structural systems and the number of storeys

- It is a ***Diagrid Truss-Tube structure with interior columns.***
- This structure is usually used for structures that go up to 90 stories
- Used here because of
    a. tilted towers
    b. seismic zone
    c. Wind loads
- It can also be classified as a ***trussed tube-in tube*** as it has 7 cores.

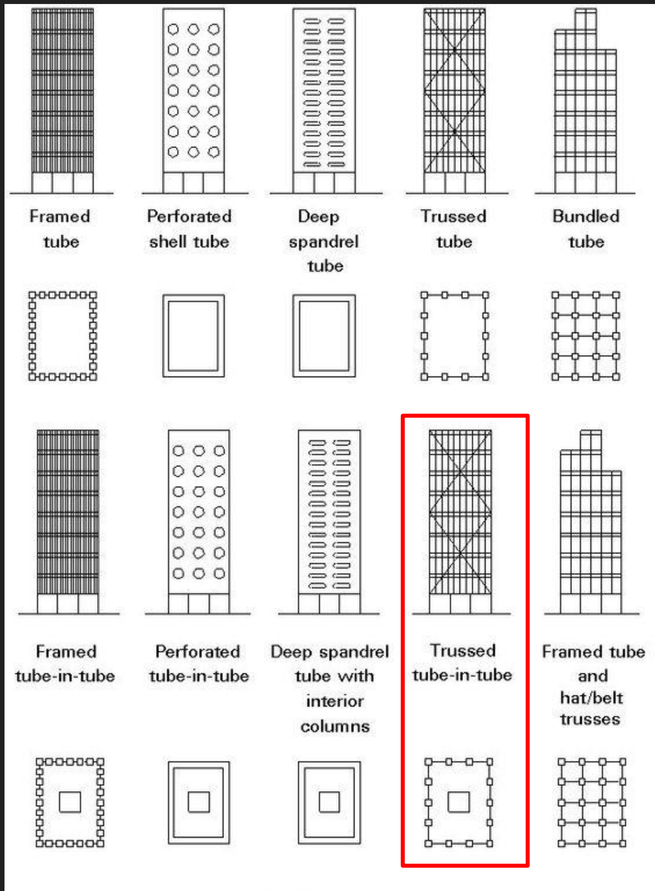
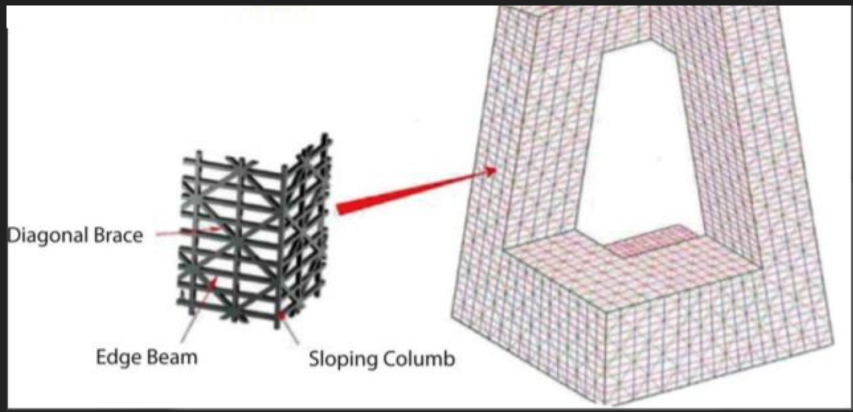


Figure 12 Tube systems

http://fgg-web.fgg.uni-lj.si/~/pmoze/esdep/master/wg01b/l0720.htm

External Structural System

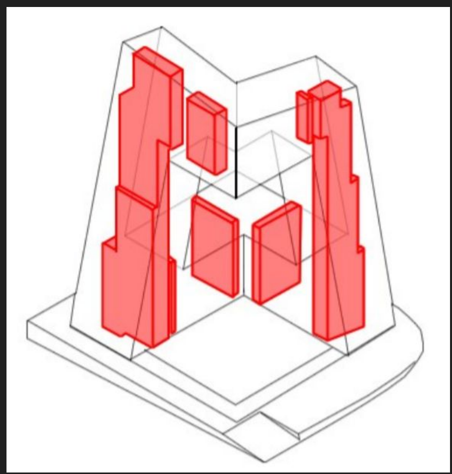
1. Diagrid
2. Sloped Columns
3. Beams or Rings

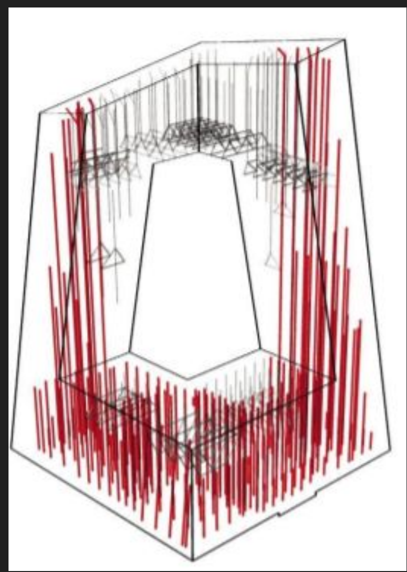


- The diagrid had to be non-uniform throughout the structure to facilitate varying stresses because of the angled shape and cantilever.

Internal Structural System

- Varying Columns height according to the levels.
- The seven major cores.





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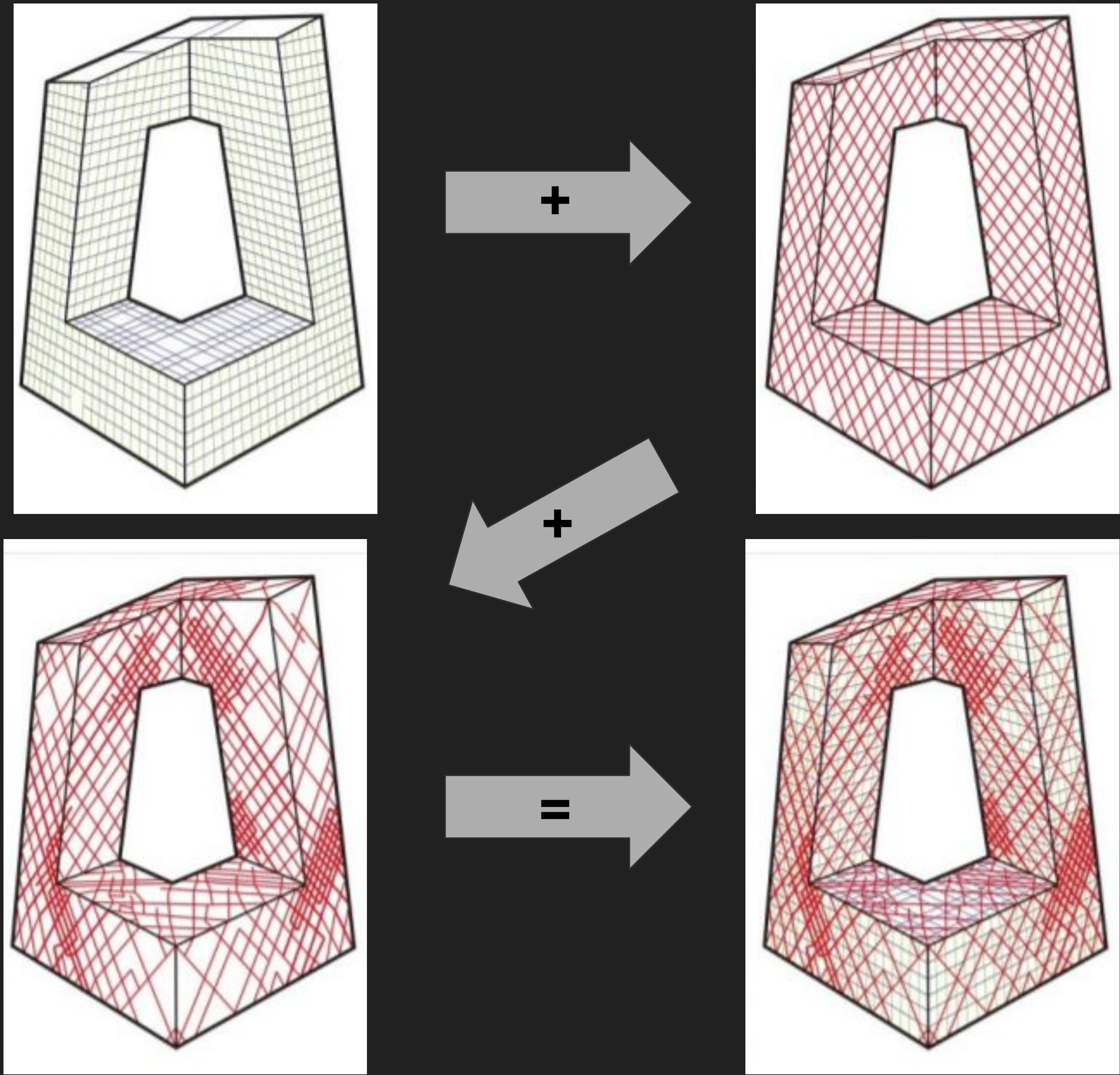
External Structural System



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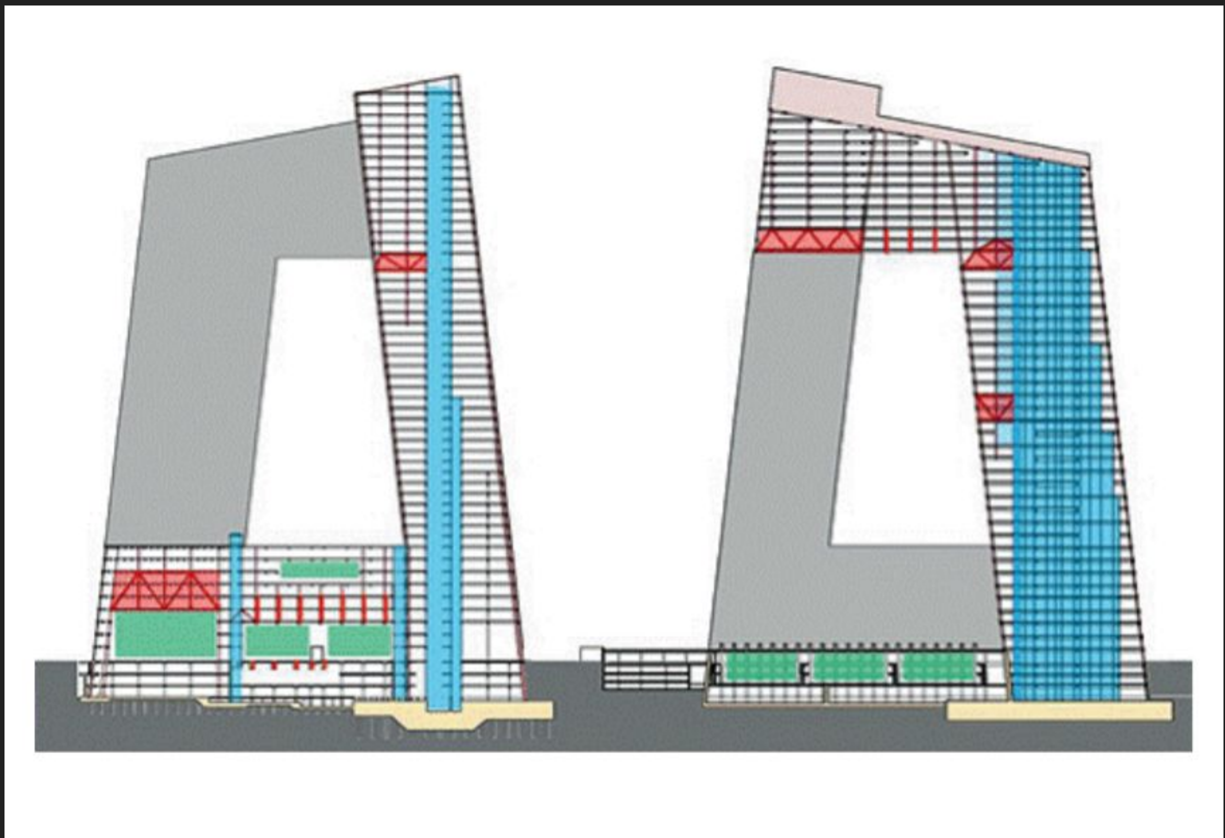
Transfer Trusses

- Span between internal cores and the external tube structure
- Only connects at ***singular pin joint locations*** *only*
- This allows the wind, live, and dead loads to be more evenly spread out across the structure so that one part of the system does not become over stressed



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Diagrid Force on Node

- Figure 1
  - Butterfly node under shear pressure
  - This figure shows how the node will behave when shear forces are applied caused by lateral loads such as wind
- Figure 2
  - Butterfly node under vertical load
  - This figure shows how the node goes into compression when under loads such as gravity, live loads, and dead loads

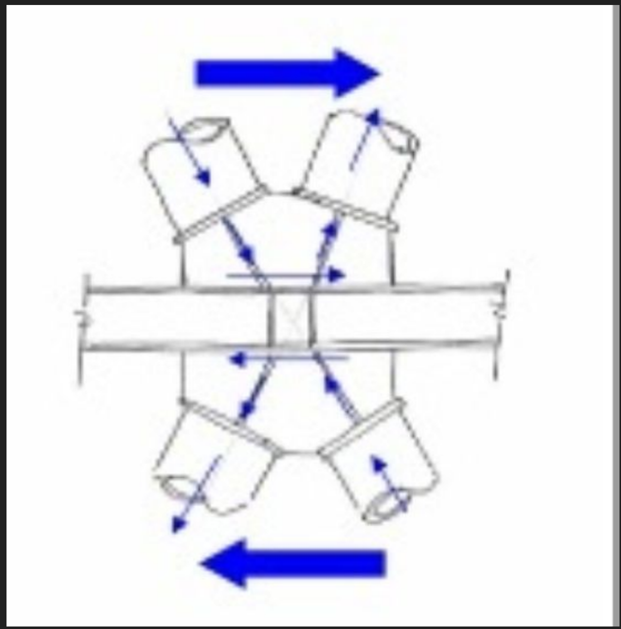


Figure 1

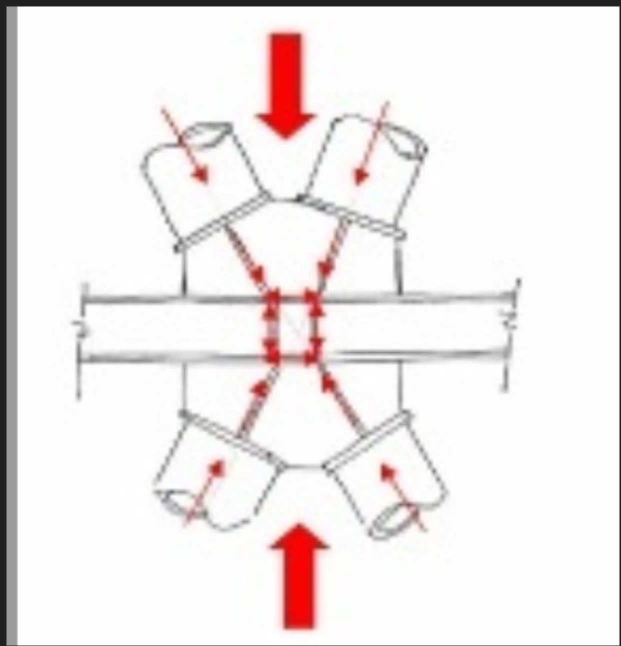


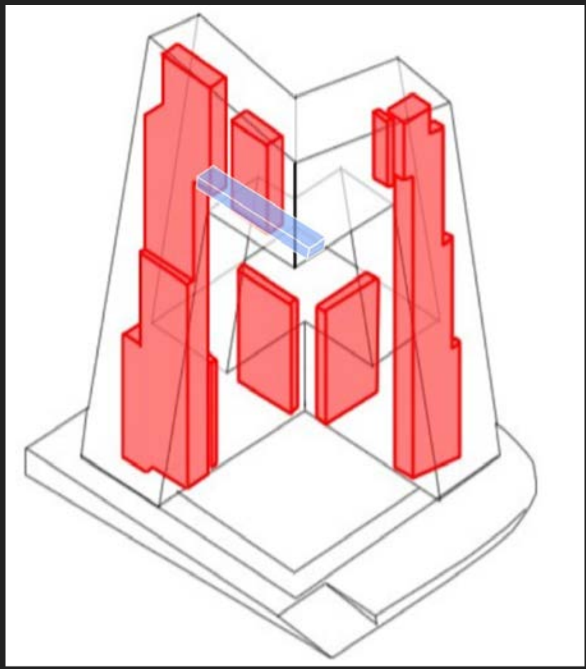
Figure 2

file:///C:/Users/britany%20bock/Downloads/The_Arup_Journal_Issue_2_2005.pdf
https://prezi.com/anmn7ckwvjtj/cctv-structural-analysis/

Cores + Cantilever

- Cores
  - There are 7 cores throughout the building
  - Helps to provide structure for different floor plate forms
  - 4 located in the towers
  - 3 located in the cantilever and bottom structure
  - The core of the cantilever is supported by a 2 story tall transfer deck that carries the load back to the tube structure

- Cantilever
  - 2 other options to construct
    - Building framework to temporarily hold up the cantilever as constructed
    - Constructing the base of the cantilever at ground level and then lifting it into place
  - Built option
    - To work inward from the tops of the tilting towers until the cantilever met in the middle



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https://faculty.arch.tamu.edu/media/cms_page_media/4433/CCTVHeadquarters.pdf

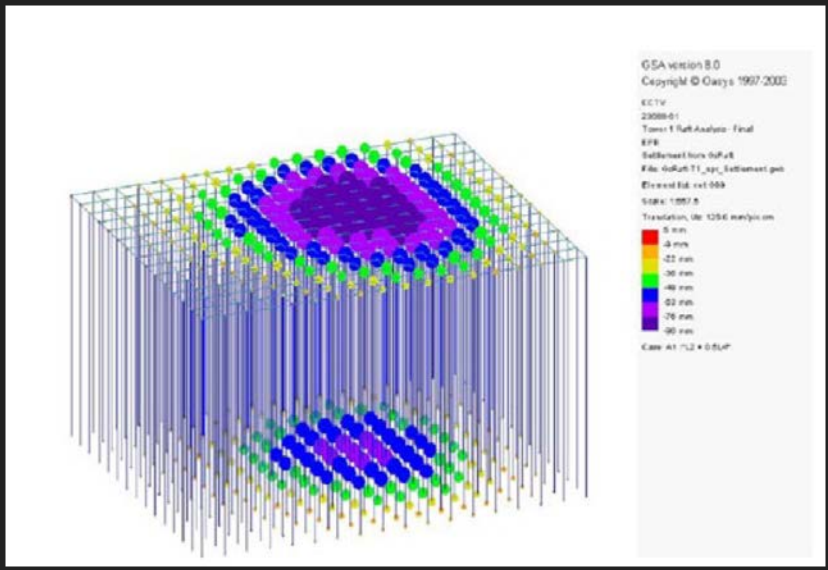
Site Exploration

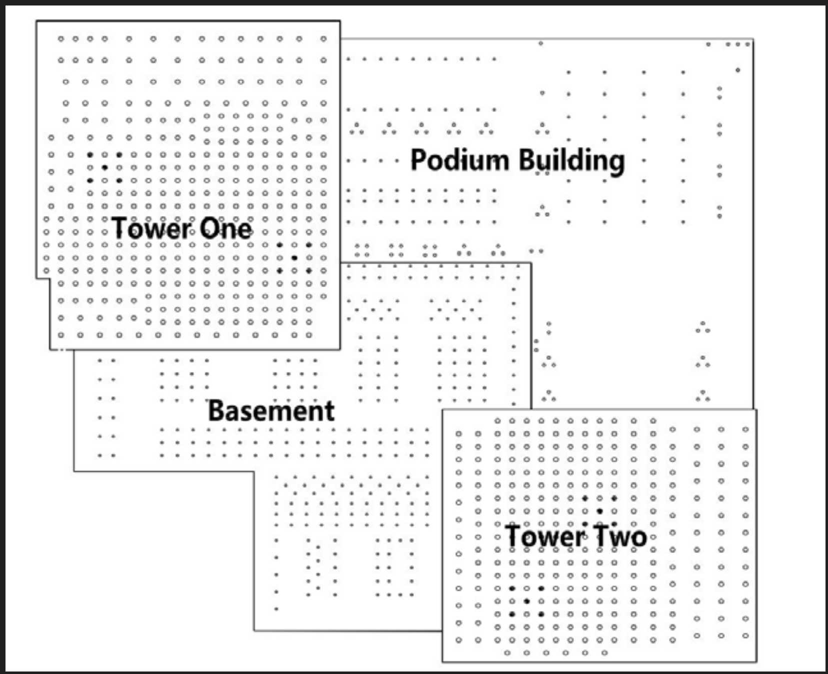
- Location
  - Proximity to Yongding River
- Soil
  - Multi layer of confined water and interactive layer of sand, gravel, soil and clay

http://global.ctbuh.org/resources/papers/download/13-case-study-cctv-building-headquarters-cultural-center.pdf

Foundation

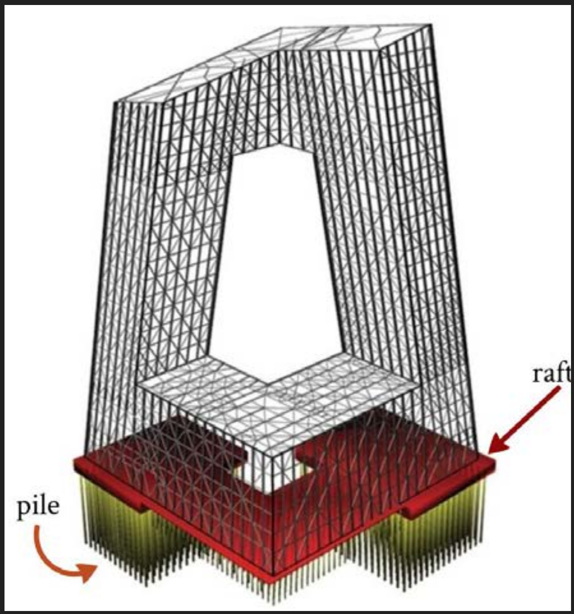
- Foundation requirements
    - Superstructure loads
    - Soil conditions
    - Water level
    - Seismic vibrations
    - Area resources
    - Time
    - Costs
- Design issues
    - Cantilever
    - Uneven loads
    - Soil has a low bearing capacity
    - Avoid bending and shearing
- Piled-Raft foundation system
- Foundation testing
    - Pile foundation test
    - Raft foundation test

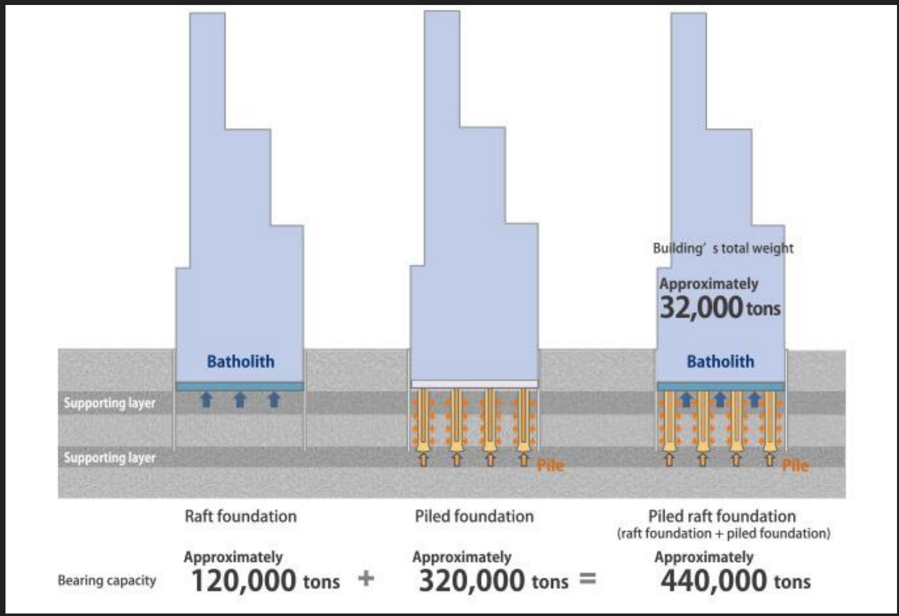




http://global.ctbuh.org/resources/papers/download/13-case-study-cctv-building-headquarters-cultural-center.pdf
https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=3035&context=icchge.

Piled-Raft Foundation System





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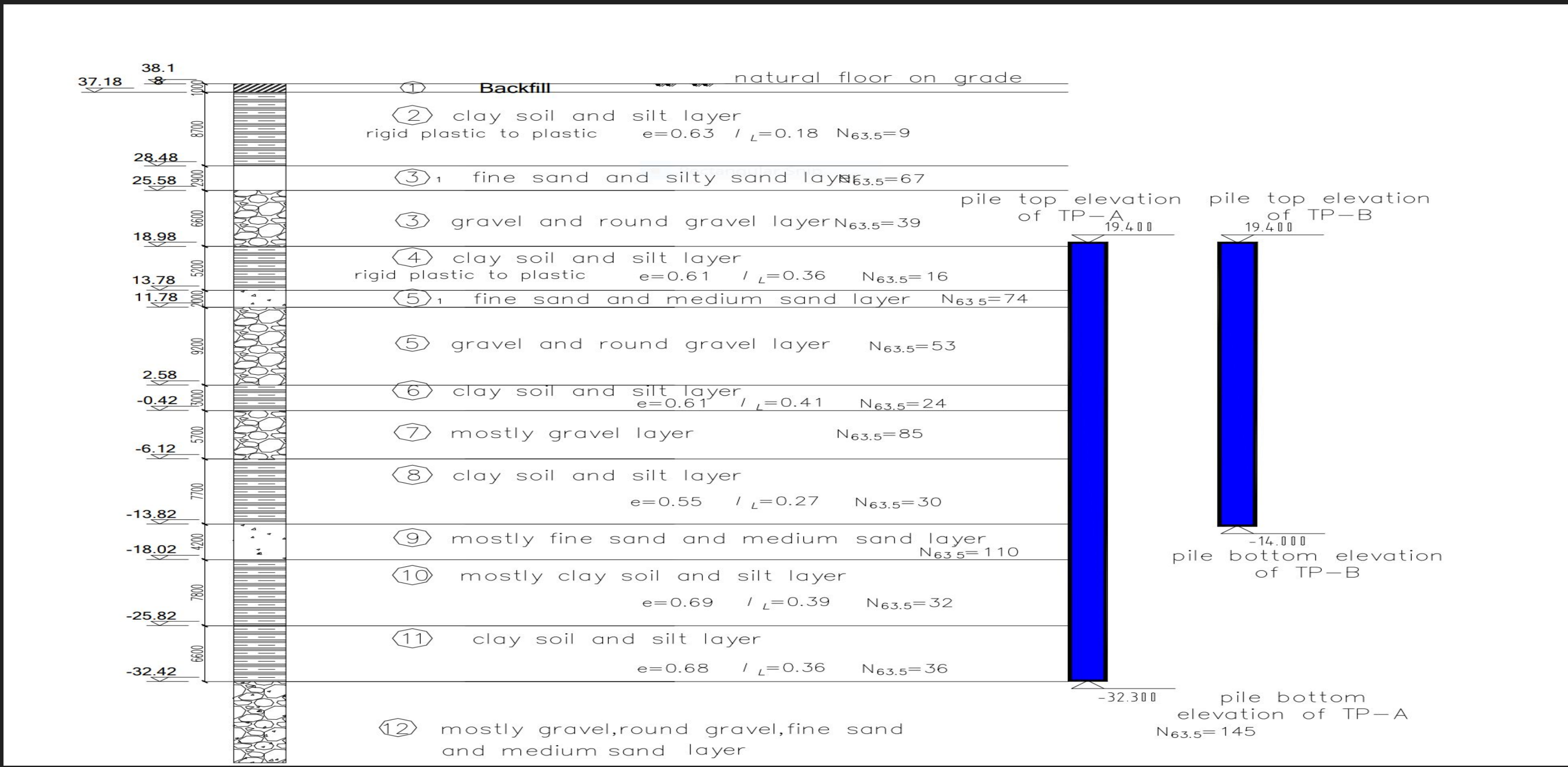
http://www.abeno.project-takenaka.com/abeno_e/saigai/sai-01.php.

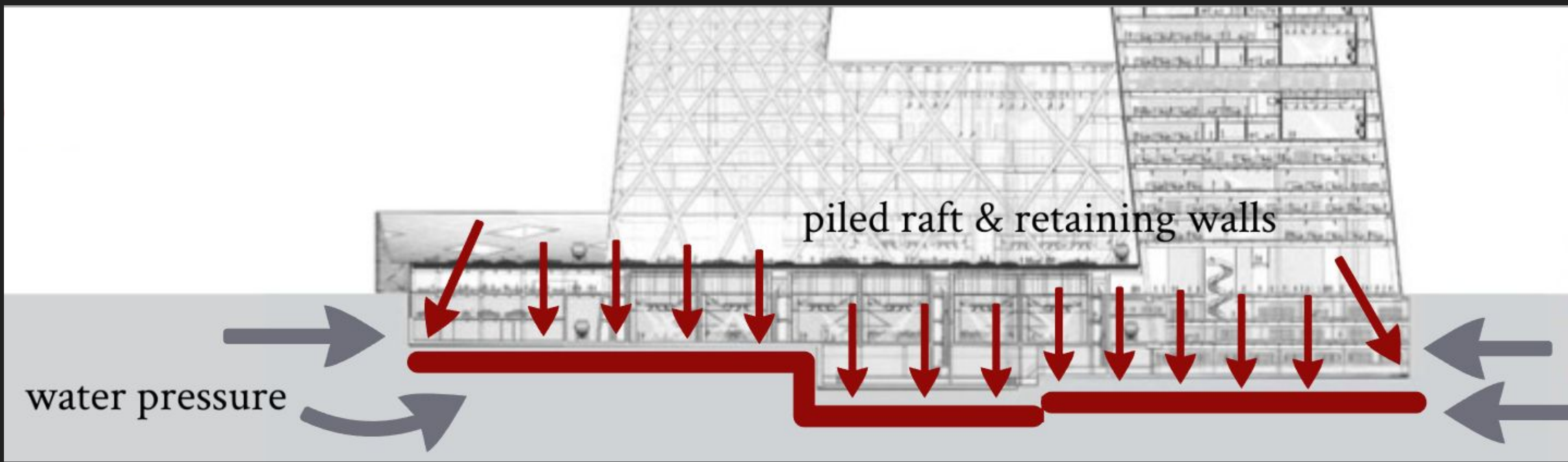
Sectional View



https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=3035&context=icchge.

Basement

- Resists upward force of water pressure around site
- 3 stories
- Retaining walls
- 50 per cent increase in floor area
- Zero footprint
- More parking



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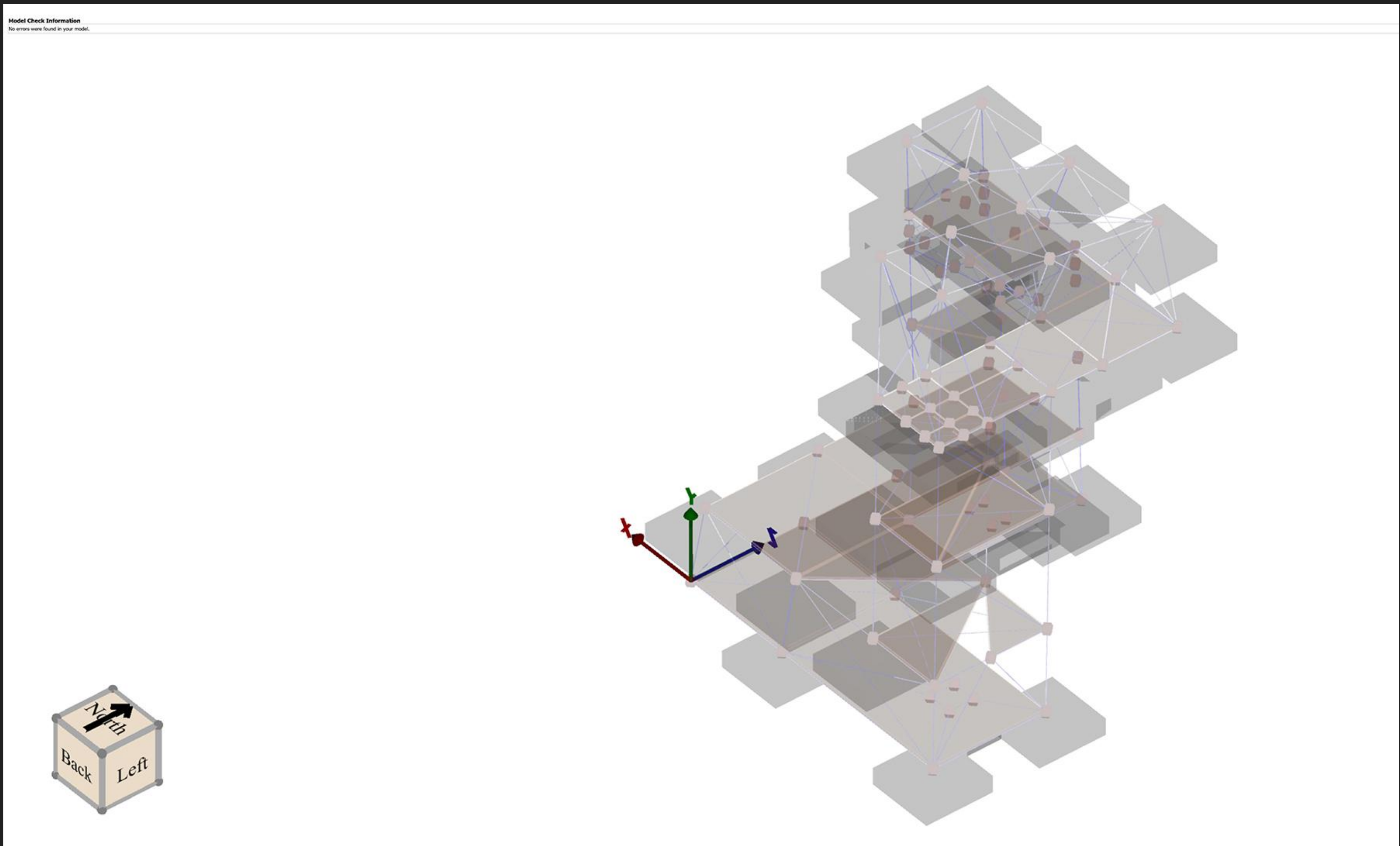
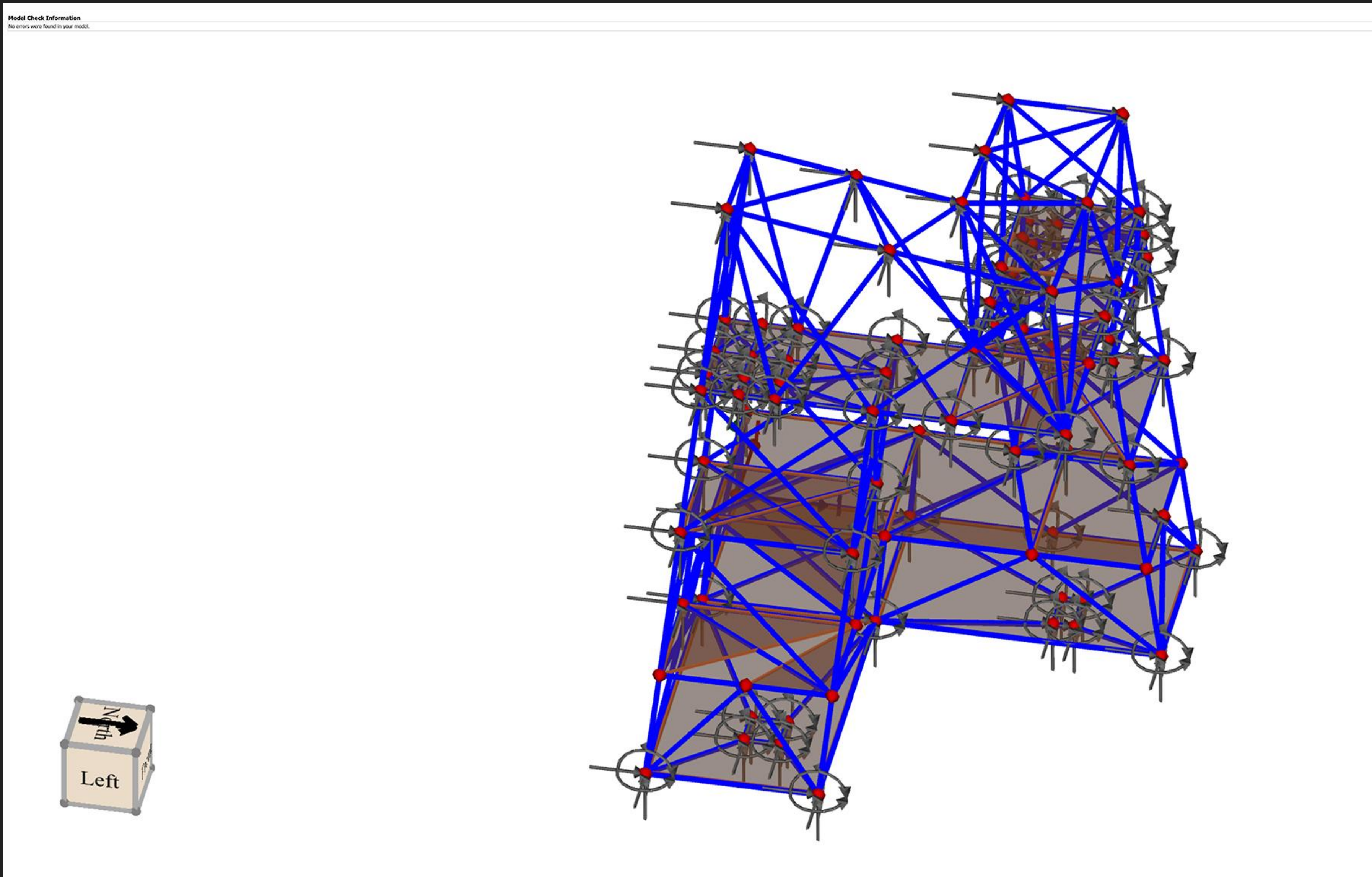
Visual Analysis



- *Fixed supports at the base of the building and pin supports at the major nodes*

Visual Analysis



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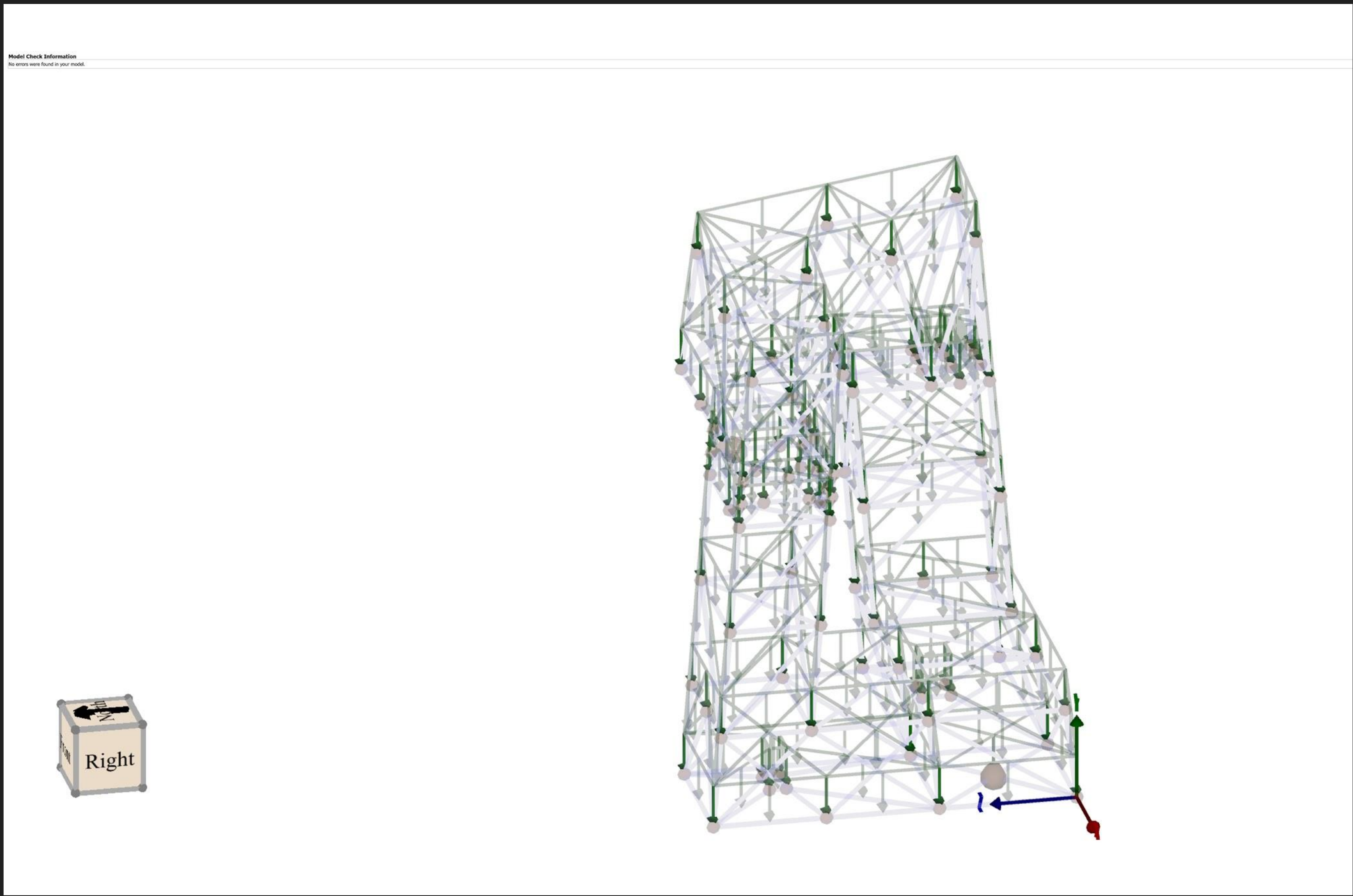
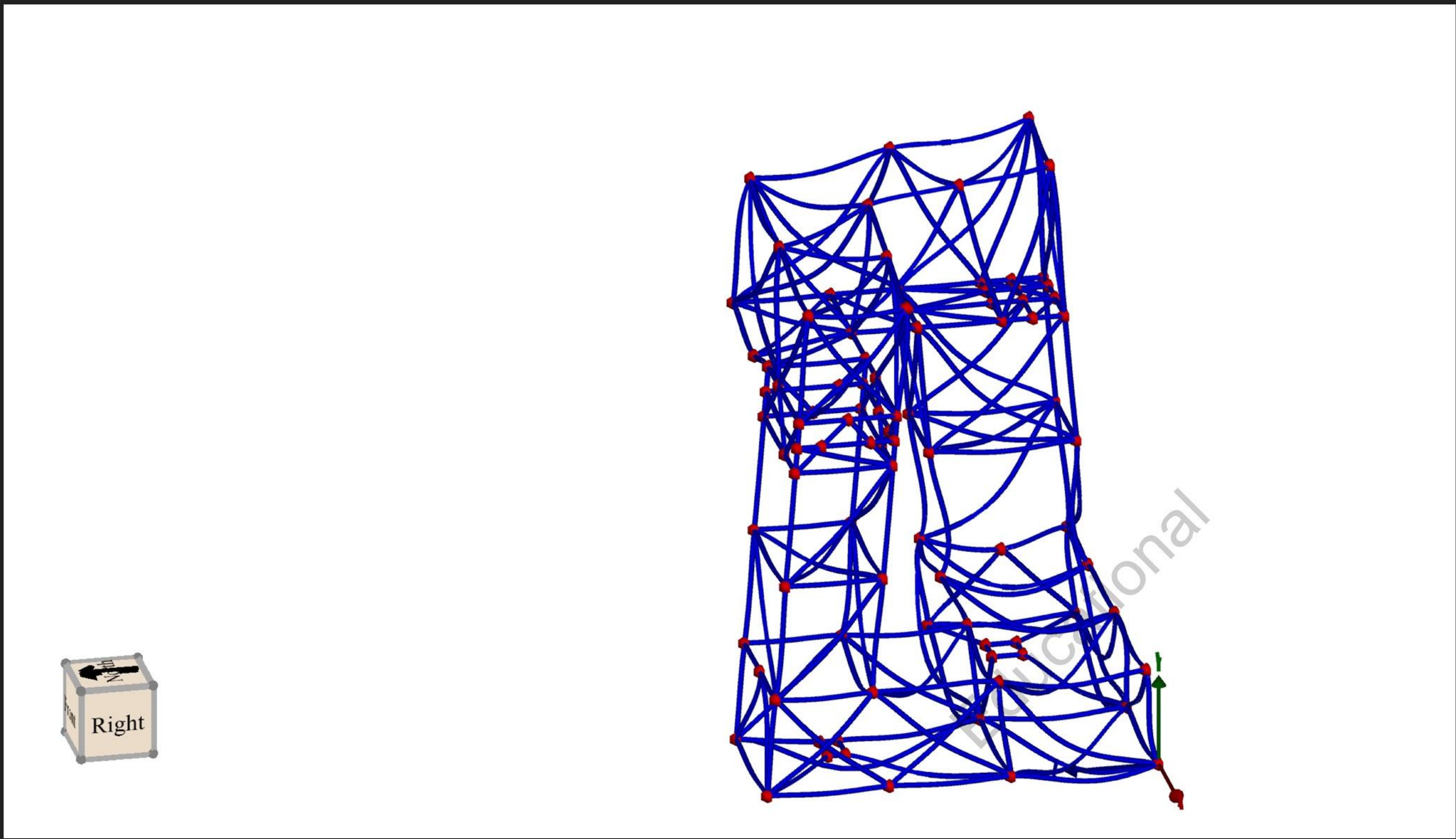


- *Dead loads applied at the nodes and the members using 3-Factored load combination using ASCE-17 LRFDF*

Visual Analysis



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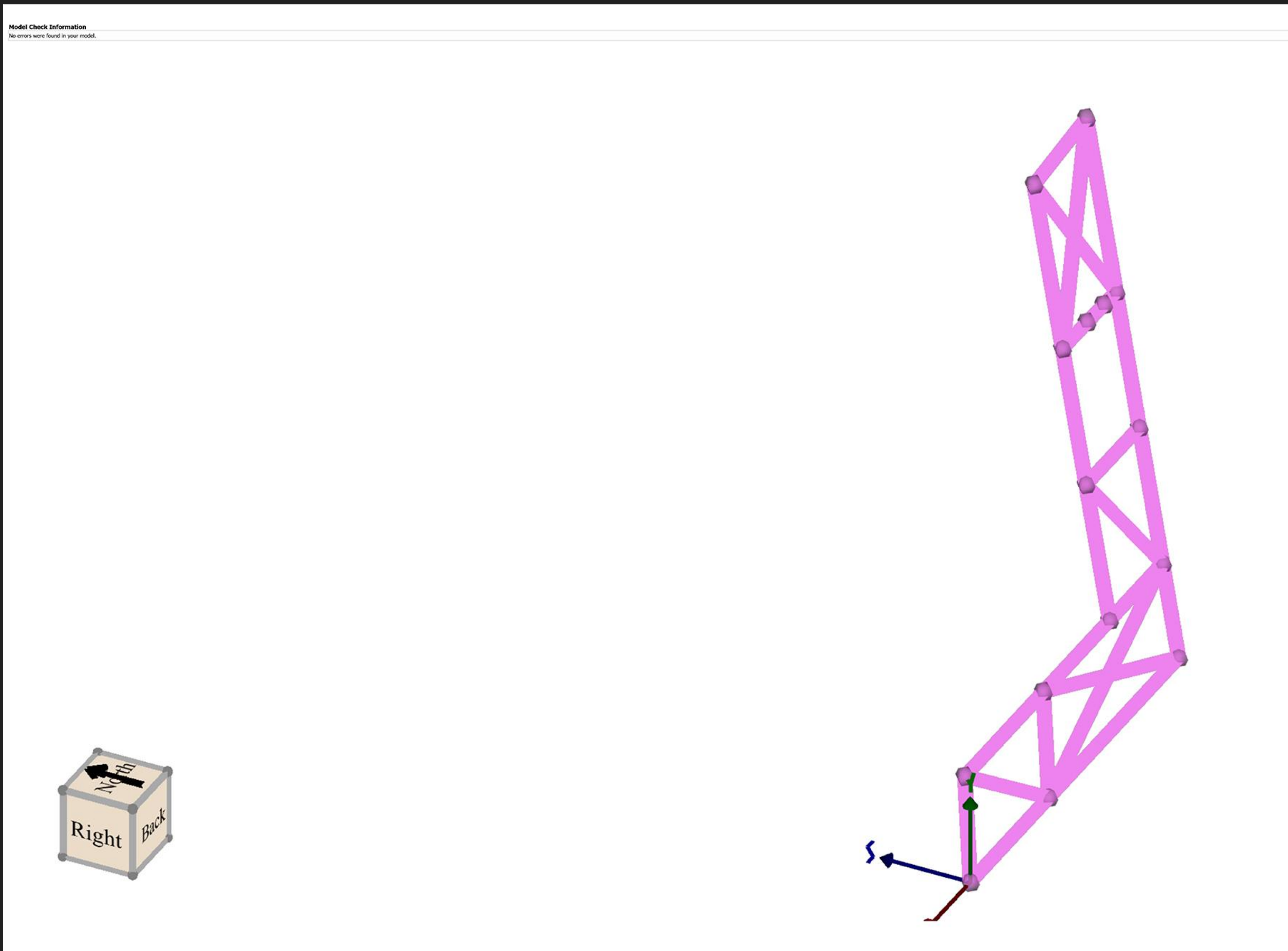
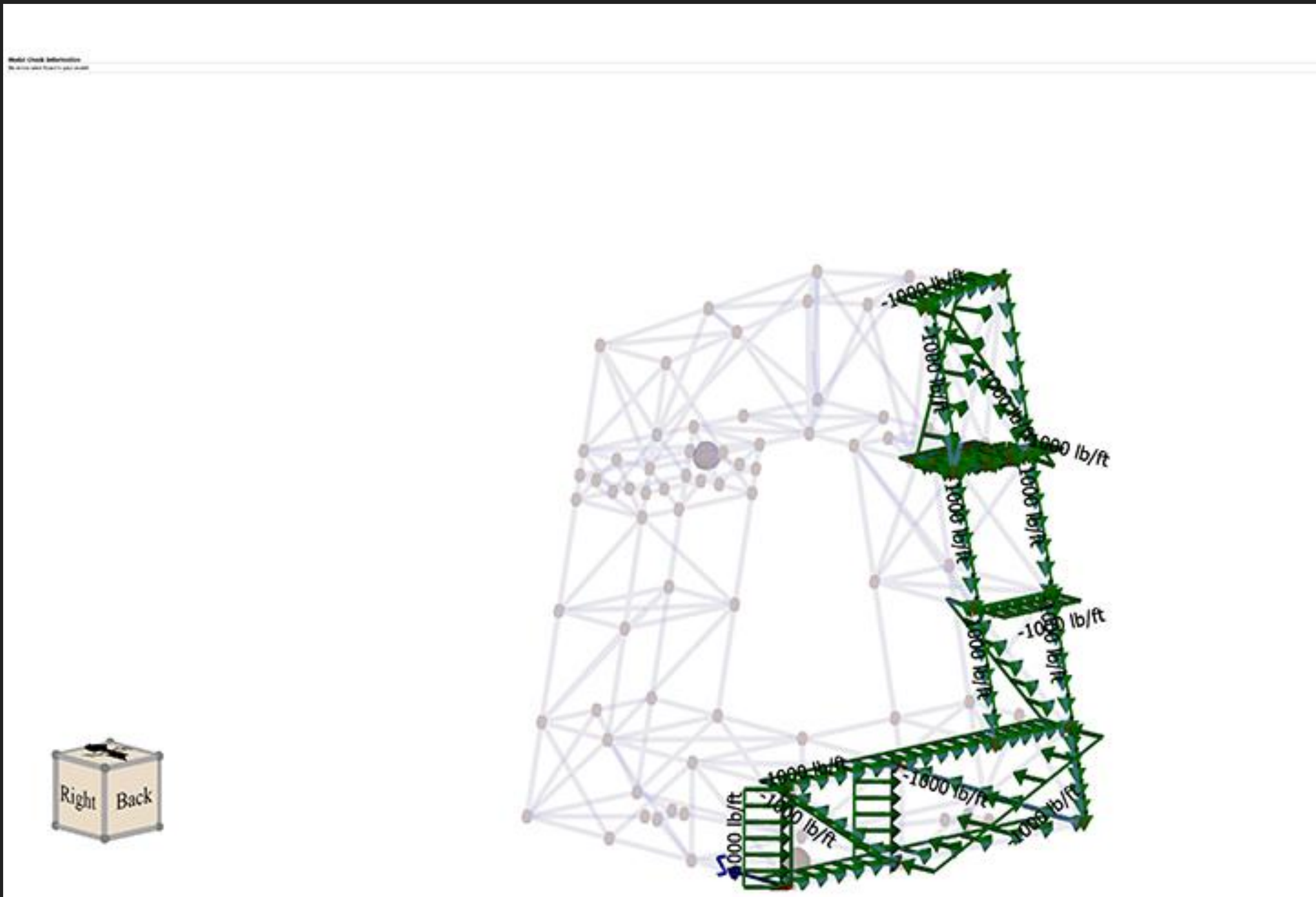
Visual Analysis



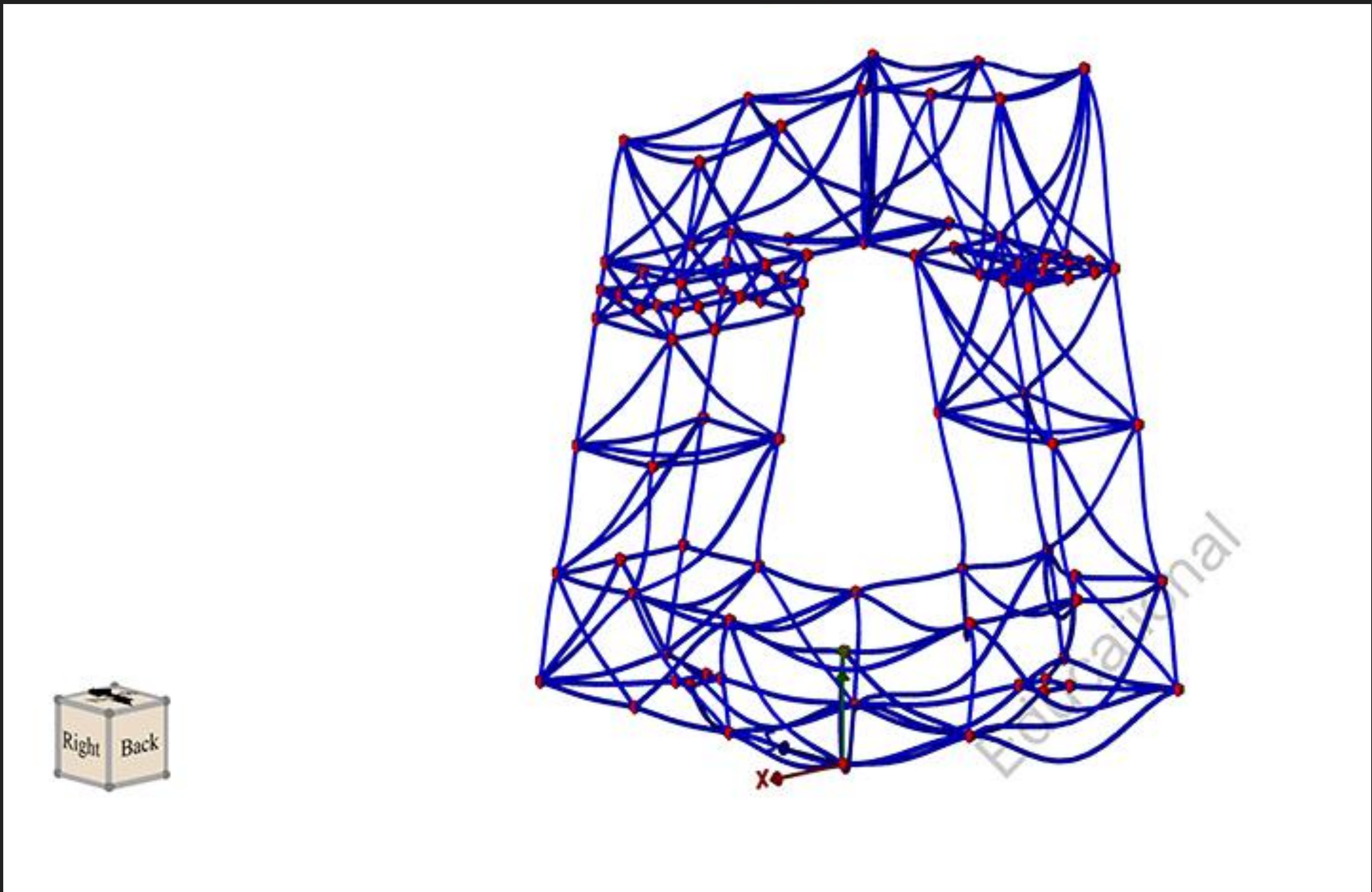
- *Wind loads applied to back facade of the building only, using 6-Factored load combination using ASCE-17 LRFD and ACI 350.*

Visual Analysis



- *Wind loading and consequent deformation*
- Total number of nodes: 116
- Total number of areas: 27

Visual Analysis



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Bibliography

ARCH 631, ‘09. *China Central Television (CCTV) Headquarters.* Report. Architecture, Texas A&M University. Accessed March 26, 2019. https://faculty.arch.tamu.edu/media/cms_page_media/4433/CCTV.pdf.

ARCH 631, ‘15. *CCTV Headquarters Case Study.* Report. Architecture, Texas A&M University. Accessed March 26, 2019. https://faculty.arch.tamu.edu/media/cms_page_media/4433/CCTVHeadquarters.pdf.

ARCH 631, Spring ‘18. *CCTV Headquarters.* Report. Architecture, Texas A&M University. Accessed March 26, 2019. https://faculty.arch.tamu.edu/media/cms_page_media/4433/CCTV HeadquartersPres.pdf.

Arup. "CCTV Boasts a Highly Unusual '3D Cranked Loop' Shape." Arup. Accessed April 12, 2019. https://www.arup.com/projects/china-central-television-headquarters.

Arup. "CCTV." CCTV（大裤衩）结构设计全程记录（pic Text）. December 10, 2010. Accessed April 1, 2019. http://www.360doc.com/content/10/1210/02/16546_76642178.shtml.

Bach, Peter M. *CCTV Headquarters, Beijing A Structural Design Overview.*Report. Civil Engineering, Monash University. August 2008. Accessed March 29, 2019. https://www.slideshare.net/peterbach/cctv-building-a-structural-design-overview.

Carroll, Chris, Craig Gibbons, and Goman Ho. "Case Study: CCTV Building- Headquarters & Cultural Center" *Central for Tall Buildings and Urban Habitat*, 2013, 14-24. Accessed April 1, 2019. http://global.ctbuh.org/resources/papers/download/13-case-study-cctv-building-headquarters-cultural-center.pdf

Carroll, Chris, Craig Gibbons, and Goman Ho. "CCTV Headquarters, Beijing China: Building the Structure." *The Arup Journal*, February 2008, 40-51. Accessed April 10, 2019. http://www.fadu.edu.uy/tallerdanza/carp-2015/files/2015/08/CCTV-arup-journal.pdf.

Carroll, Chris, Paul Cross, and Xiaonian Duan. "CCTV Headquarters, Beijing, China: Structural Engineering Design and Approvals." *The Arup Journal*, February 2005, 1-7. Accessed April 2, 2019. https://stavbaweb.dumabyt.cz/files/files/2012_05/CCTV_ARUP.pdf.

Carroll, Chris, Xiaonian Duan, and Craig Gibbons. "China Central Television Headquarters- Structural Design." *Steel Structures*, 2006, 387-91. Accessed April 1, 2019. http://www.kssc.or.kr/wonmun/KSSC_3_2006_6_5_387(C).pdf.

"CCTV Headquarters - Data, Photos & Plans." WikiArquitectura. Accessed April 9, 2019. https://en.wikiarquitectura.com/building/cctv-headquarters/.

Bibliography

"China Central Television (CCTV) Headquarters." Verdict Designbuild. Accessed April 7, 2019. https://www.designbuild-network.com/projects/cctv/.

CTBUH. "CCTV Headquarters." The Skyscraper Center. Accessed April 11, 2019. http://www.skyscrapercenter.com/building/cctv-headquarters/1068.

How, Kwee. "Week 4 : Reflection of " The Quest of Height"." KH Advance Module. May 5, 2014. Accessed April 21, 2019. http://kweehow.blogspot.com/2014/05/.

Leong, Ewing. *CCTV Structural Analysis.*Report. November 26, 2013. Accessed April 10, 2019. https://prezi.com/anmn7ckwvjtj/cctv-structural-analysis/.

Provoost, Kris. "Beautified China: An Architectural Photo Essay." Modu Magazine. December 6, 2018. Accessed April 3, 2019. https://www.modumag.com/focus/beautified-china-an-architectural-photo-essay/.

"Rem Koolhaas." OMA. Accessed April 3, 2019. https://oma.eu/partners/rem-koolhaas.

"Safety Technology to Prepare for Disasters." Prepare for Earthquakes/Safety Technology to Prepare for Disasters/Abeno Harukas/Takenaka Corporation. Accessed A pril 12, 2019. http://www.abeno.project-takenaka.com/abeno_e/saigai/sai-01.php.

Saieh, Nico. "CCTV Headquarters / OMA." ArchDaily. May 21, 2012. Accessed April 12, 2019. https://www.archdaily.com/236175/cctv-headquarters-oma.

Serialthrill. "Rem Koolhaas & OMA I CCTV Building, Beijing." SerialThriller. August 07, 2012. Accessed April 5, 2019. https://serialthriller.com/post/28924020894/rem-koolhaas-oma-cctv-building-beijing.

Wei-dong, Wang, Wu Jiang-bin, and Weng Qi-ping. *Foundation Design and Settlement Measurement of CCTV New Headquarter.*Report no. 1.04a. East China Architectural Design Research Institute Co. Ltd., Shanghai, China, Missouri University of Science and Technology. 2007. Accessed April 1, 2019. https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=3035&context=icchge.

Xu, You-Lin, and Department of Civil and Environmental Engineering. "Field Measurements of the New CCTV Tower in Beijing." *Central for Tall Buildings and Urban Habitat*, 2013, 171-78. Accessed April 1, 2019. http://global.ctbuh.org/resources/papers/download/2309-field-measurements-of-the-new-cctv-tower-in-beijing.pdf.