5th International Workshop
Design in Civil and Environmental Engineering
University of Rome La Sapienza. October 6-8, 2016

Structural Design Education

ideas, experiences

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Dept. Structures for Engineering and Architecture
University of Naples Federico II

DESIGN in Civil and Environmental Engineering

Wide theme

Several thought provoking workshop contributions

Great focus on interaction, integration and multisciplinarity

A big thanks to FB for arranging such an unusual and valuable opportunity for discussion

… only some notes concerning structural design

DESIGN

… basically, from thought to thing


approach
Case study
principles
open–ended problems
constraints
VISION
efficiency
Engineering
project
education
insight
right-questions
heroes
prediction
IDEA
quality
CULTURE
Responsibility
time
estimate
complexity
SHARE
cost
have fun
wisdom
solutions
DESIGN
robustness
sustainability
license to imagine
Cross-Fertilization
innovation
Back-of-the-Envelope
passion
tools
challenge
creativity
open-mind
mentality
material
rationale
awareness
big-picture
biomimicry
MAGIC
Judgment
method
PROCEDURE
Rule-of-Thumb
freedom
intuition
critical-thinking

Struct Design @

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

My experience 20+, 10 years

Design of r.c. buildings

Design of steel structures

Structures for high rise an long span buildings

Project-oriented

Open-ended problems

Design, not only modeling analysis checks

MIX education, research, practice (C. Gantes)

Code vs. concept, or "code is not the BIBLE"

Steel structures – major focus to buckling problems and connections

Define concept, remind mechanical formulation (equations are synthesis)

Tradition vs. Innovation

Preserving Cultural Legacy while embracing flexibility (reconfigure)

Tall Buildings @ Università degli Studi di Napoli Federico II

9 ECTS Course (Graduate Program, 2nd level Master)

Structures for High-Rise and Long-Span Bldgs

working with students

Project, Case Study, Research Topic, Thesis

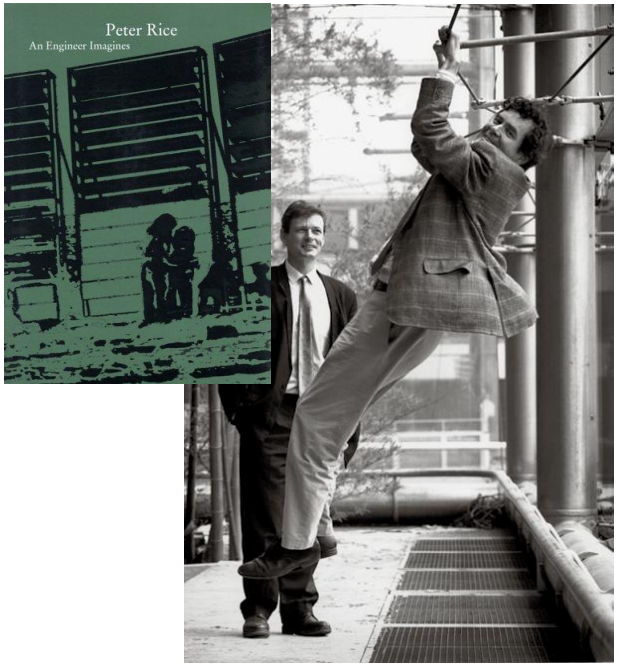
International Student Design Competition (CTBUH)

Outdoor internships

An Engineer Imagines. Peter Rice

combined an innate understanding of structure and engineering with an equally strong desire to explore IDEAS

He has given engineers the license to imagine

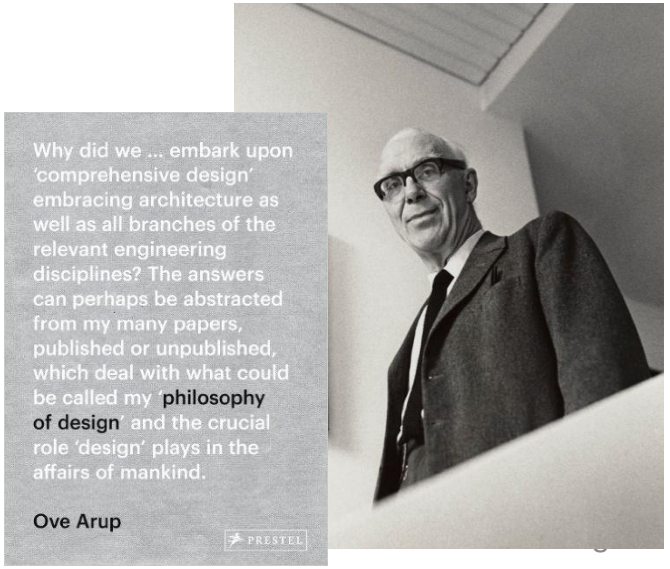


Philosophy of design. Ove Arup

… many solutions, good, bad, indifferent.

The art is, by a synthesis of ends and means, to arrive at the solution.

It's a creative activity, involving imagination, intuition and deliberate choice → can't get it from computer



Liquid Threshold. Neil Thomas

there are those people who look at the world as it is and ask why?
There are those people who look at the world as it might be and ask **WHY NOT ?**

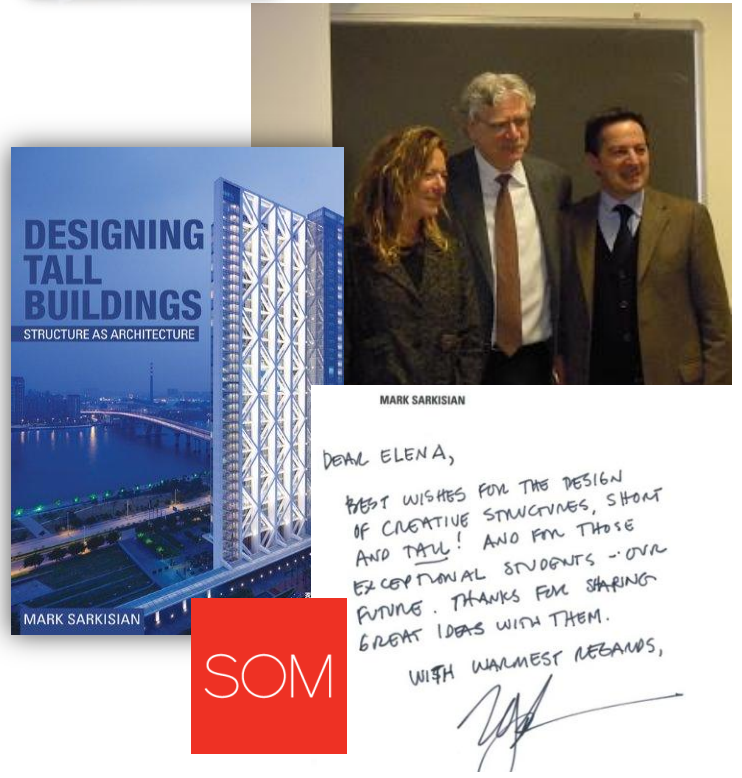
Design culture: to have fun while pushing the boundaries of engineering - and it's a 'yes' culture

Designing tall buildings. Mark Sarkisian

concepts and ideas for Tall Bldgs inspired by nature

Some suggestions: get where really forces are, think about buildings 3dimensionally, think about structures volumetrically, forget about beams and columns, can we do better ?, release the force, let the building move

→ fresh approaches, open minds



- design culture, sharp focus, **open-ended problems**
- learn how to apply design thinking, understand how to use intuition and judgment
- immerse (flow) in the problem, **pose the right questions …**

- have ideas
- use analysis, but understand the principle beyond calculations
- insight, not (only) numbers
- consider quality, time, cost, and adjust them independently, ideally improving all three, adding value
- balancing risks of new ways of doing with tried and tested methods
- *proud* of what they achieve, *passionate* about what they do

P.L. Nervi:
good design requires patience and **LOVE**

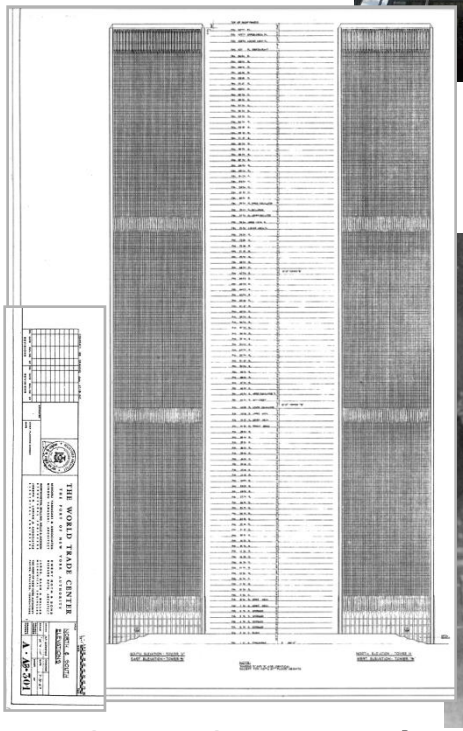
R. Morandi:
Final choice among possible design solutions is **SPIRITUAL**

Education for Future Designers: standing on the shoulders of giants

choose heroes and learn from them

Fazlur Khan (SOM Chicago)

a pragmatic visionary



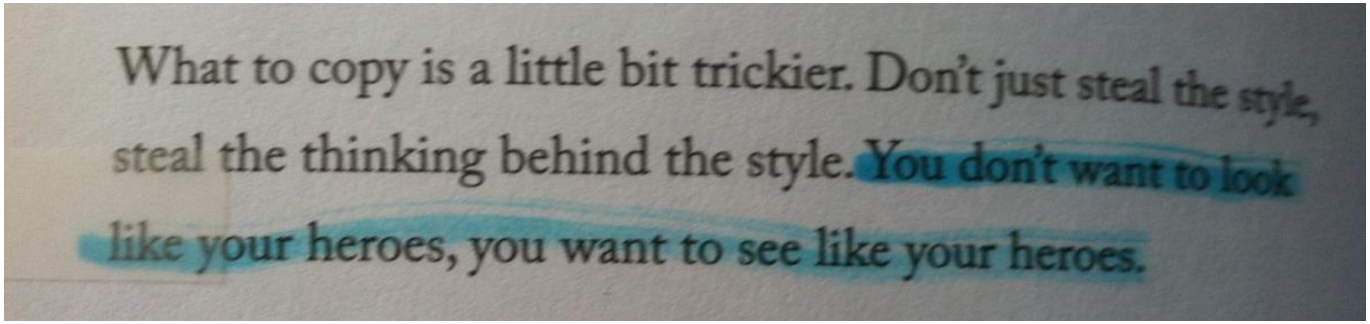
William F. Baker (SOM Chicago)

Engineering an idea

Leslie Robertson (LERA NYC)

WTC towers of innovation

Education for Future Designers: standing on the shoulders of giants



choose heroes and learn from them – case studies

- not simply “READING STRUCTURES”

- reverse engineering - informatics
- learning from precedents - architecture
- steal like an artist – art, poetry, creativity industry

Steps in Engineering Design

1. Identify the need
2. Define the problem
3. Search for information
4. Set Design Criteria and Constraints
5. Consider a number of solutions
6. Analyze the design
7. Make a decision
8. Develop specifications
9. Communicate the design solution

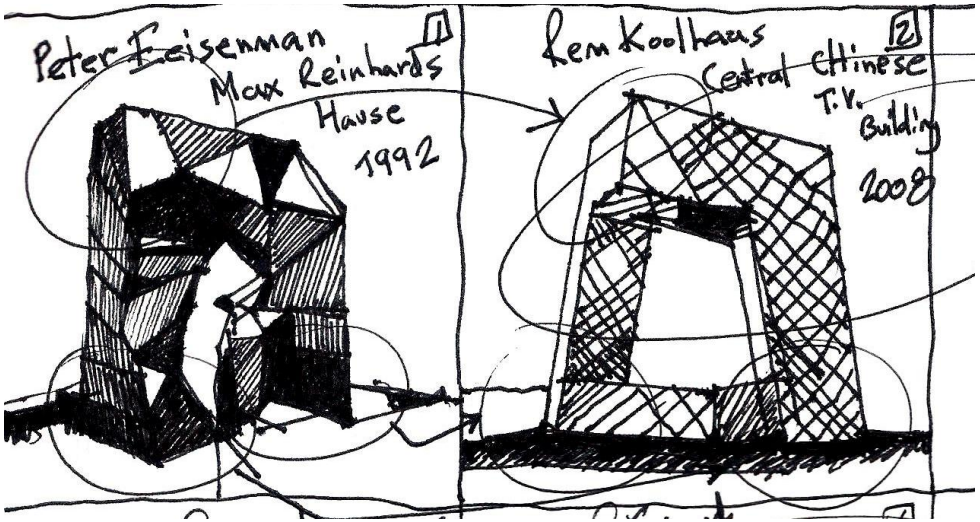
sometimes it helps to first

“reverse engineering” and then design

- Dissecting a product
- Understanding how it functions
- Learn basic principles

- Design/build a new product with the knowledge acquired from dissection

Influence
Inspiration
Replication
Copy
?

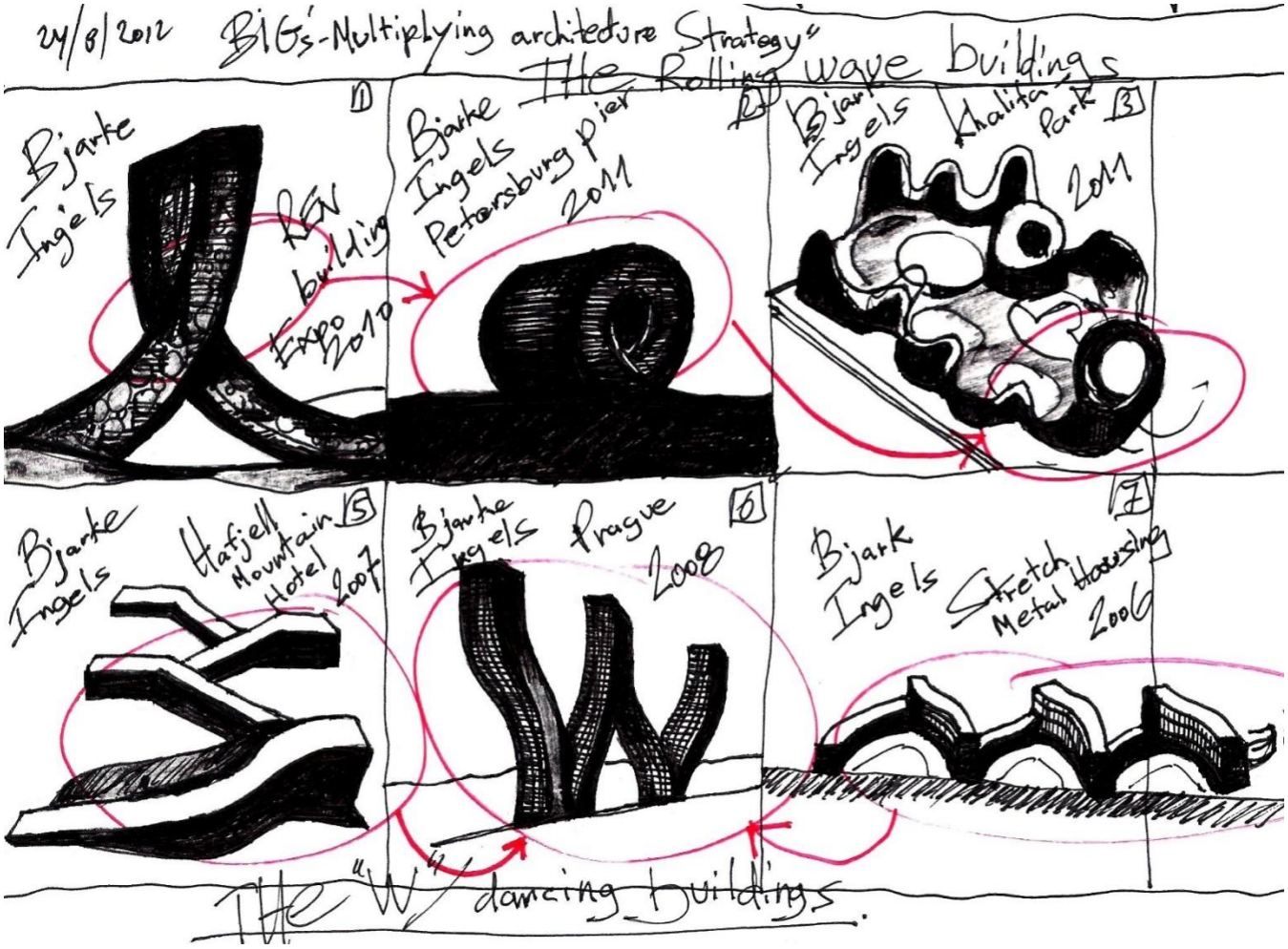


The Culture of the Copy

Neil Leach

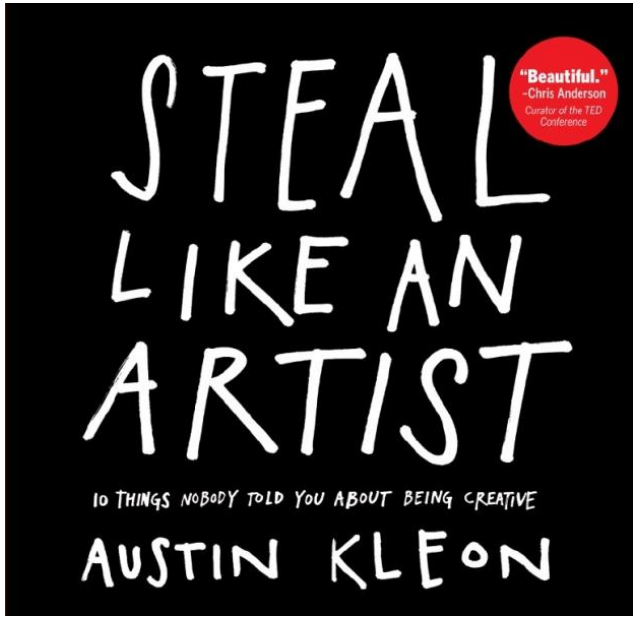
Is copying necessarily a bad thing? Theorists from Walter Benjamin to Richard Dawkins, and from Judith Butler to Homi Bhabha, have suggested not. Drawing on their work, **Neil Leach**, Professor of Digital Design at the European Graduate School and Visiting Professor at Harvard Graduate School of Design, challenges the notion of authenticity and argues that the entire history of human culture is built on a constant process of replication.

self-inspiration

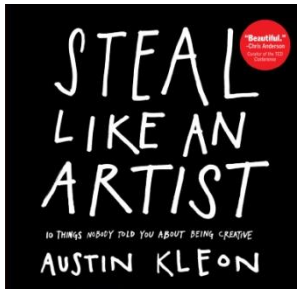


Poetry

Tradition and the Individual Talent - Thomas S. Eliot
relationship between the individual artist's creativity and the heritage of tradition, understood as an element paradoxically necessary to poetic originality

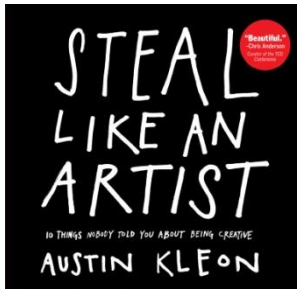

STEAL
LIKE AN
ARTIST
"Beautiful."
-Chris Anderson
Curator of the TED Conference
10 THINGS NOBODY TOLD YOU ABOUT BEING CREATIVE
AUSTIN KLEON

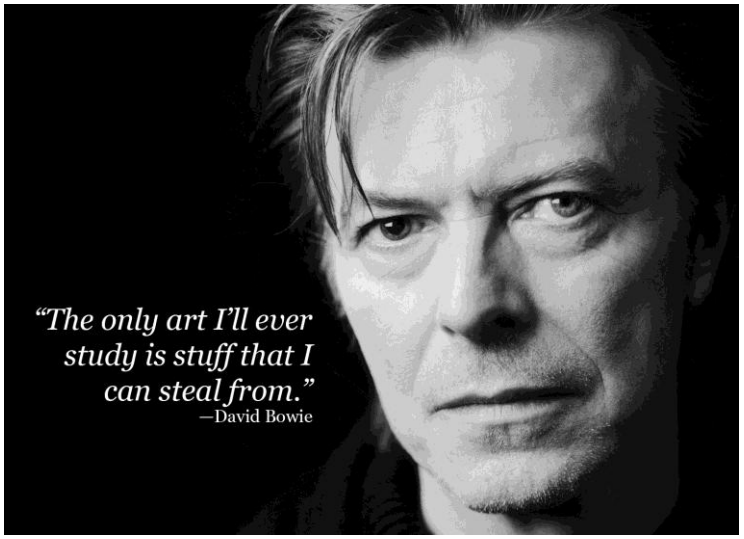

NOTHING
is
ORIGINAL.

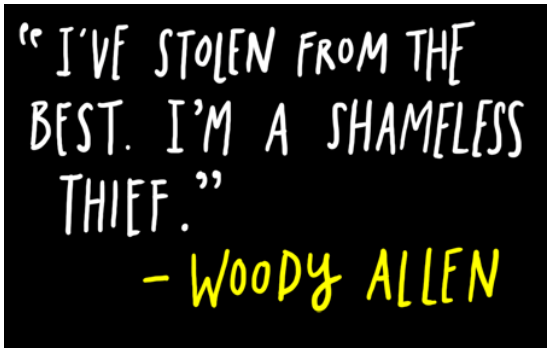

STEAL LIKE AN ARTIST
10 THINGS NOBODY TOLD YOU ABOUT BEING CREATIVE
AUSTIN KLEON


GOOD THEFT
VS.
BAD THEFT
HONOR
DEGRADE
STUDY
SKIM
STEAL FROM MANY
STEAL FROM ONE
CREDIT
PLAGIARIZE
TRANSFORM
IMITATE
REMIX
RIP OFF

steal like an artist – art, poetry, creativity industry







steal like an artist – STRUCTURE magazine

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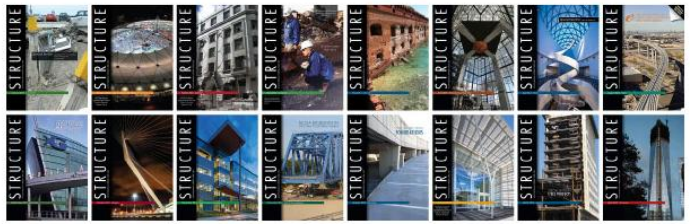

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C-InFocus-Arnold-July161...

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Pagina: 1 di 1 Larghezza pagina

InFocus | *Stealing like an Artist*

Theft, and Fraud – Do You Know the Difference?

By Barry Arnold, P.E., S.E., SECB

Stealing is bad. From a young age and throughout life, this principle is reinforced and emphasized. Regardless of whether it is petty theft or grand theft, and regardless of whether it involves burglary, embezzlement, larceny, looting, robbery, shoplifting, library theft, or fraud – stealing is bad.

As quickly as we learn this principle, we also learn that certain types of stealing are acceptable. For example, A young child working on their first finger-painting starts their composition with original ideas. However, after the child sees a classmate paint a big yellow sun with streaming rays of sunlight cascading onto a house with a gabled entry and smoke wafting from a chimney, he or she adds those elements to his or her painting. The painting may be accented with a tree or picket fence, so the finished work is an original – albeit, influenced by other children – but, nevertheless, an original.

Researcher Anders Ericsson assures us that we are all "pre-wired

Theft is defined as taking something from another person without the consent of that person. An engineer recently complained that after he had designed a 30-foot x 100-foot canopy, the architect he worked with used the engineer's plans for a variety of similar projects across a large geographic region. Although the original roof structure consisted of joists supporting 30psf snow loads and spanning 30 feet, the architect used the same joist designation for joists supporting 45psf snow loads and spanning 50 fe
also used the beam, column, and footing sizes show
plan without verifying the sizes were appropriate
conditions and gravity and lateral loads.

Fraud is defined as the intentional deception, d
over another to gain profit and an untruthful adv
A was bewildered when, after completing an AS
tigation and upgrade on a 50-year-old, single sto

Personalizza...

student works: case studies

Design of Tall Bldgs: why the analysis of a case study ?

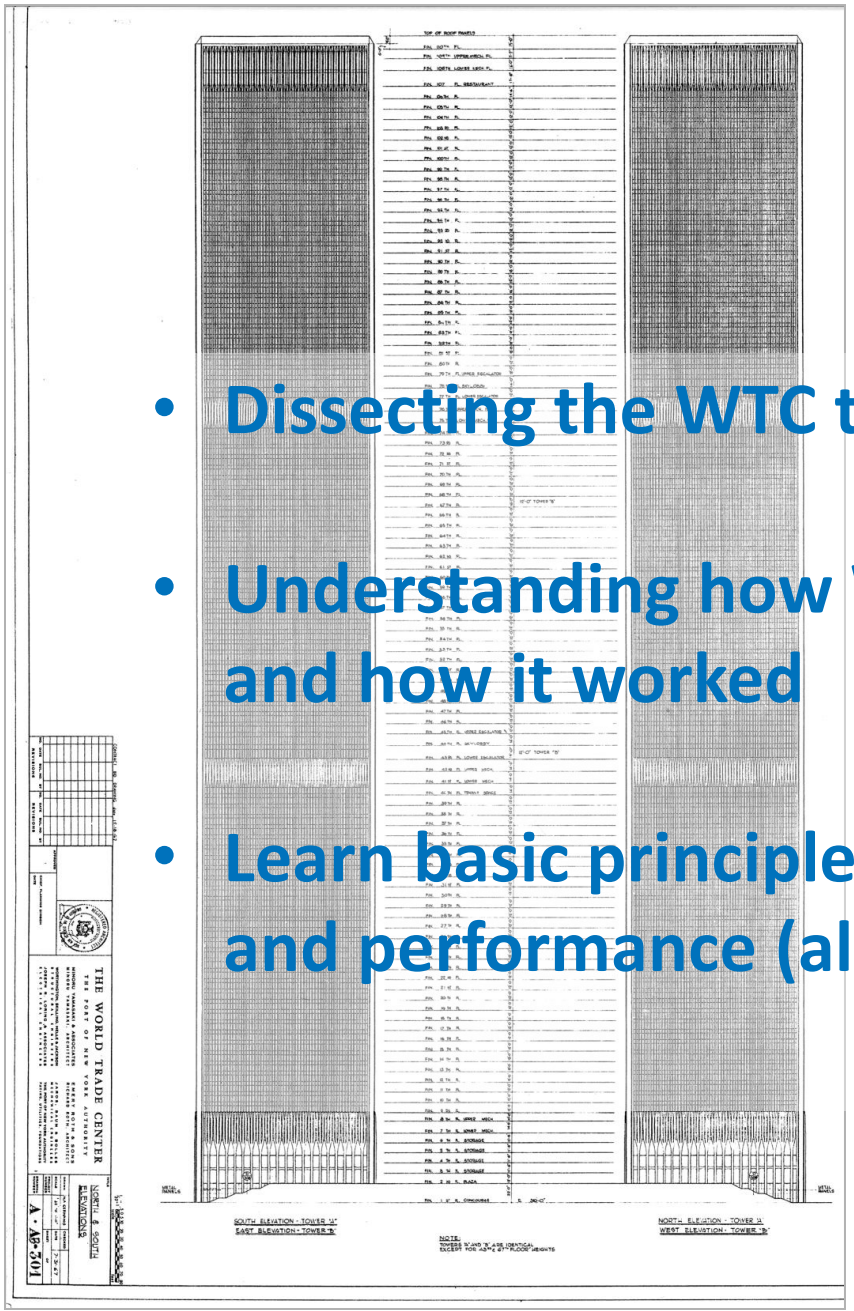
- Dissecting a product
- Understanding how it functions
- Learn basic principles

Analysis of a tall bldg case study

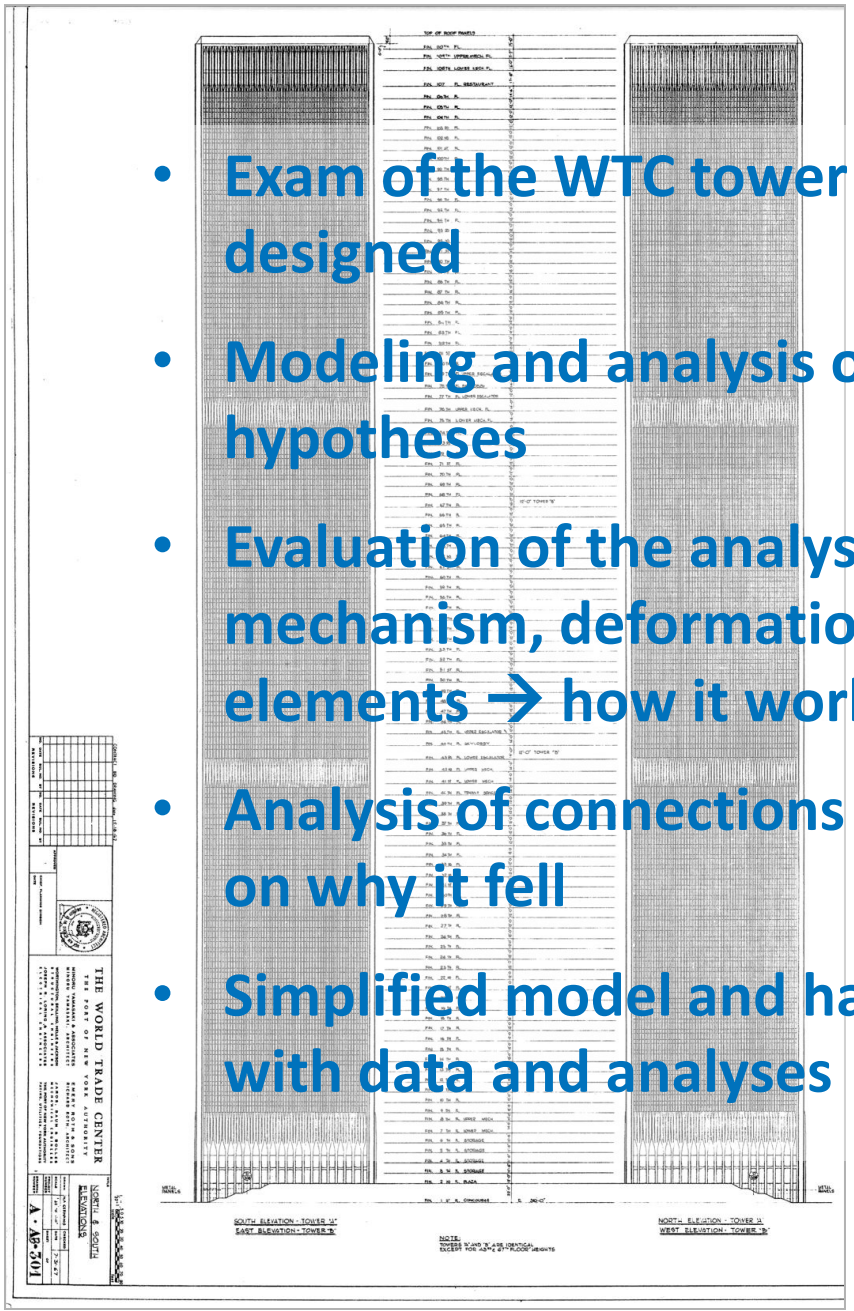
- Designing/building a new product with the knowledge from dissection

Project of a tall bldg

An example of reverse engineering: the WTC towers



- **Dissecting the WTC tower structure (tower 1)**
- **Understanding how WTC tower was designed and how it worked**
- **Learn basic principles from WTC tower design and performance (also under aircraft impact)**

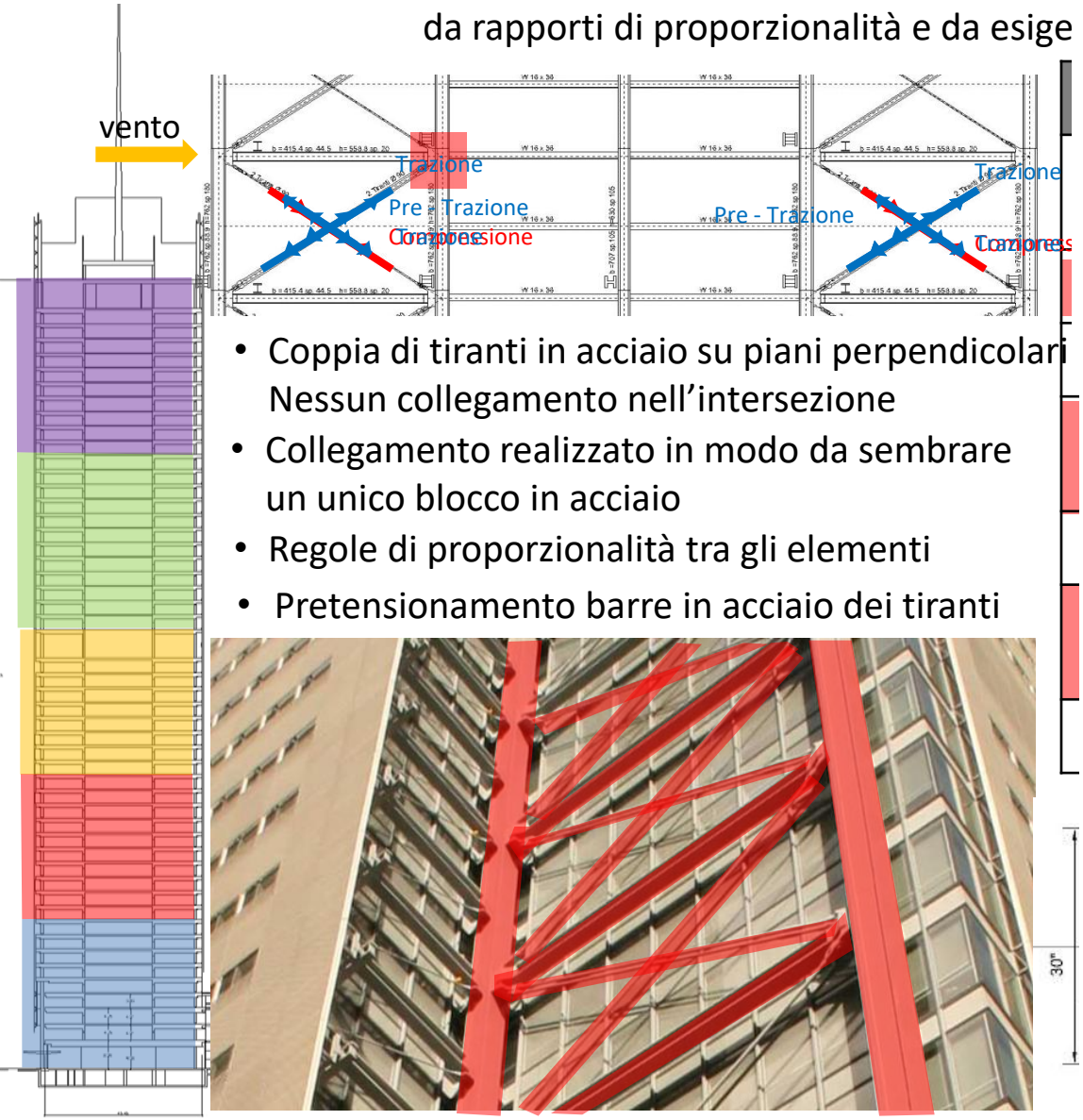


- Exam of the WTC tower structure (tower 1) → how it was designed
- Modeling and analysis of the bldg structure → some hypotheses
- Evaluation of the analysis results: load path, resisting mechanism, deformation mode, stress level in structural elements → how it worked under design loads
- Analysis of connections → some partial considerations on why it fell
- Simplified model and hand calculations → comparison with data and analyses

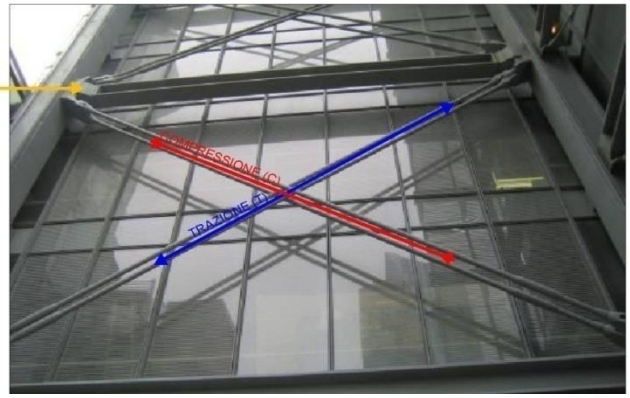
I telai con i controventi a X sono completam

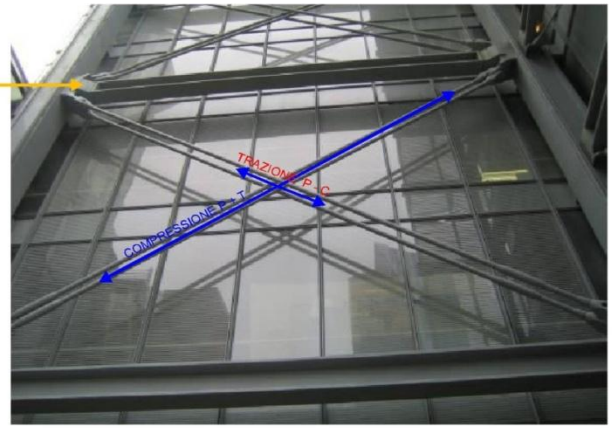
La loro progettazione viene influenzata oltre che da esigenz

da rapporti di proporzionalità e da esige



- Coppia di tiranti in acciaio su piani perpendicolari
  Nessun collegamento nell'intersezione
- Collegamento realizzato in modo da sembrare un unico blocco in acciaio
- Regole di proporzionalità tra gli elementi
- Pretensionamento barre in acciaio dei tiranti





o

n

i

Modello I – No outrigger ; No contr. A X

Max Deform. = 1.12 m = 1/200 H
NON ACCETTABILE
Max Δ_x= 0.68 % = 1/145
NON ACCETTABILE

Modello II – Outrigger ; No contr. A X

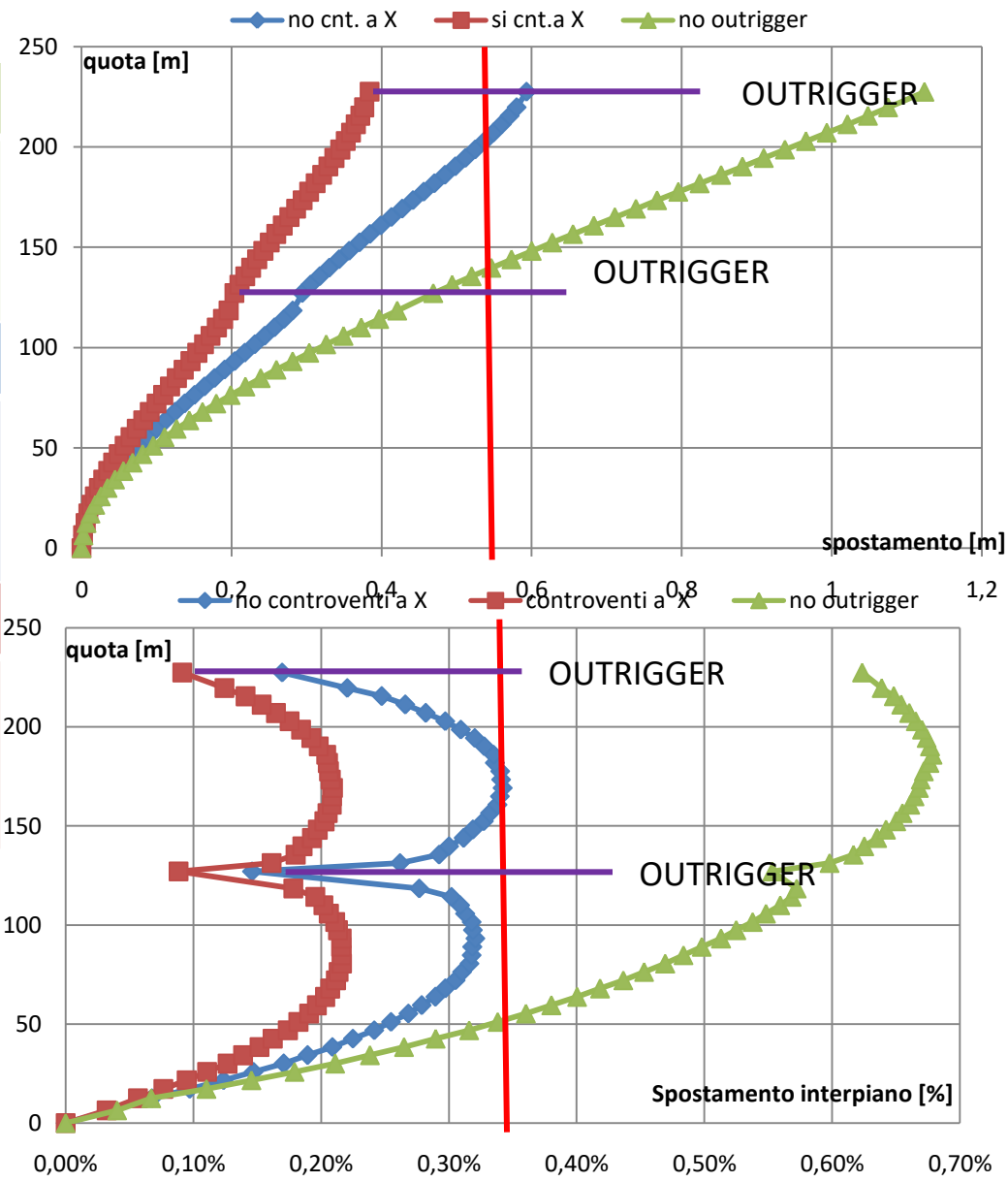
Max Deform. = 0.60 m = 1/370 H
NON ACCETTABILE
Max Δ_x= 0.34 % = 1/290
NON ACCETTABILE

Modello III – Outrigger ; contr. A X

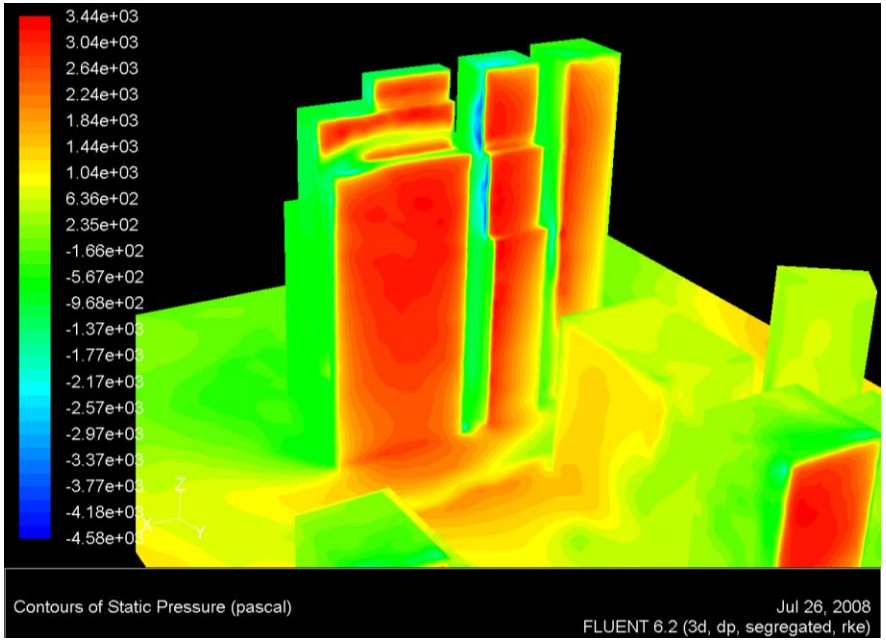
Max Deform. = 0.402 m = 1/450 H
ACCETTABILE
Max Δ_x= 0.22 % = 1/450
ACCETTABILE

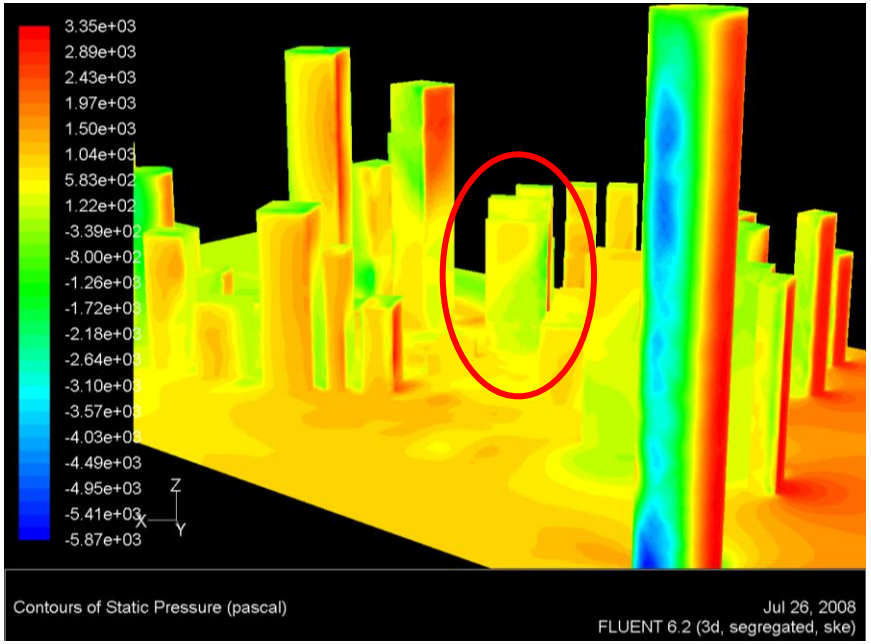
- Modello I, senza outrigger si deforma come una semplice mensola incastrata
- Gli Outrigger sono necessari per limitare la deformazione laterale, esercitando un ritegno alla rotazione del nucleo centrale
- Si conferma la necessità dei controventi a X esterni data l'eccessiva deformabilità.
- L'edificio soddisfa i limiti di normativa

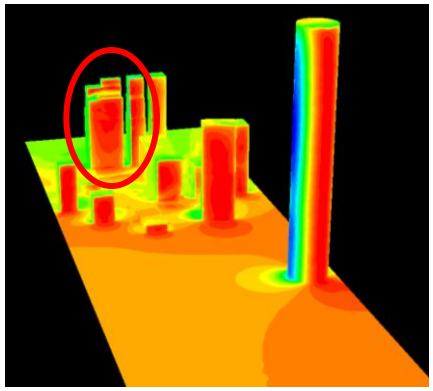
DIREZIONE X - tre modelli



Per verificare la validità delle approssimazioni sono stati analizzati vari modelli FEM dell'edificio impiegando il software Fluent del gruppo Ansys simulando un flusso d'aria a **50m/s**

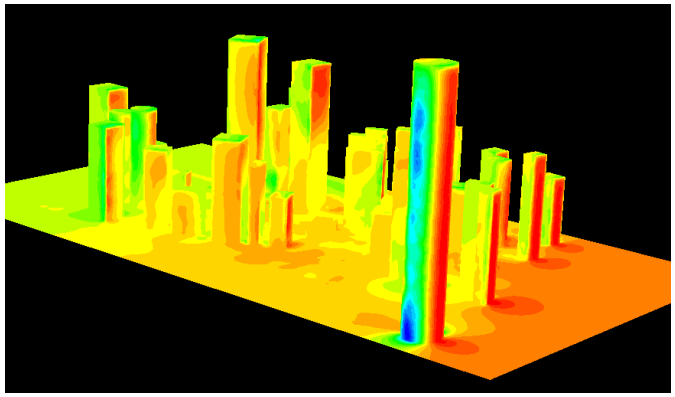


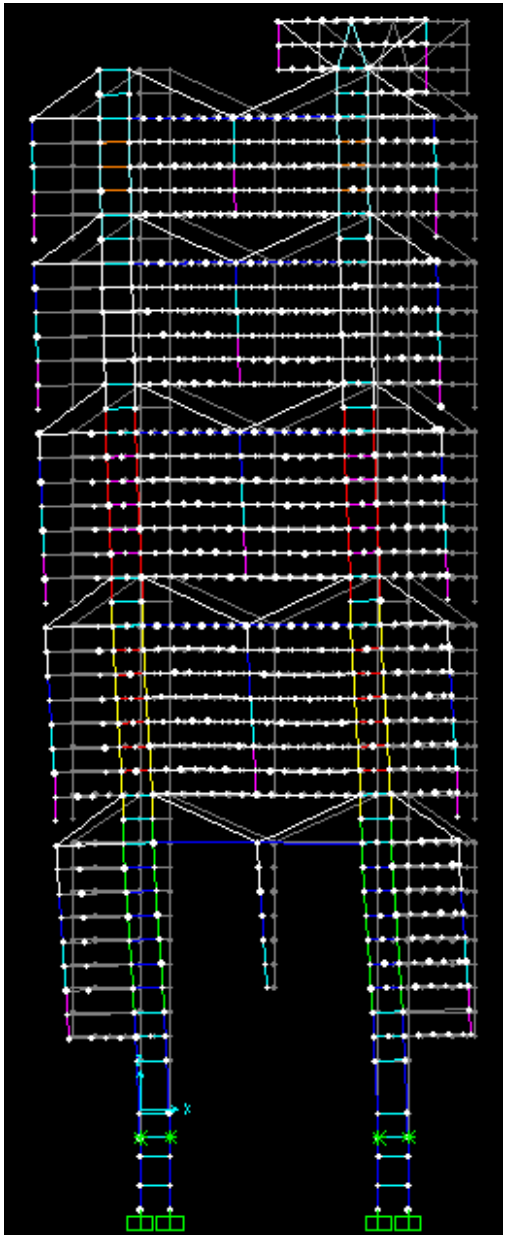




Flusso d'aria da N

Flusso d'aria da N-O





Lo spostamento max ottenuto dall'analisi FEM risulta:
$\delta_{max} = 26,68cm$

Dal calcolo manuale si ottiene:

- $\delta_{Ass} = 10,3cm$
- $\delta_{M,col} = 2,9cm$
- $\delta_{V,col}$ = *trascurabile*
- $\delta_{M,beam} = 11,6cm$
- $\delta_{V,beam} = 5,3cm$

Nonostante si tratti di un edificio alto prevale ancora la deformata tagliante!

$\delta tot = 30,2cm$

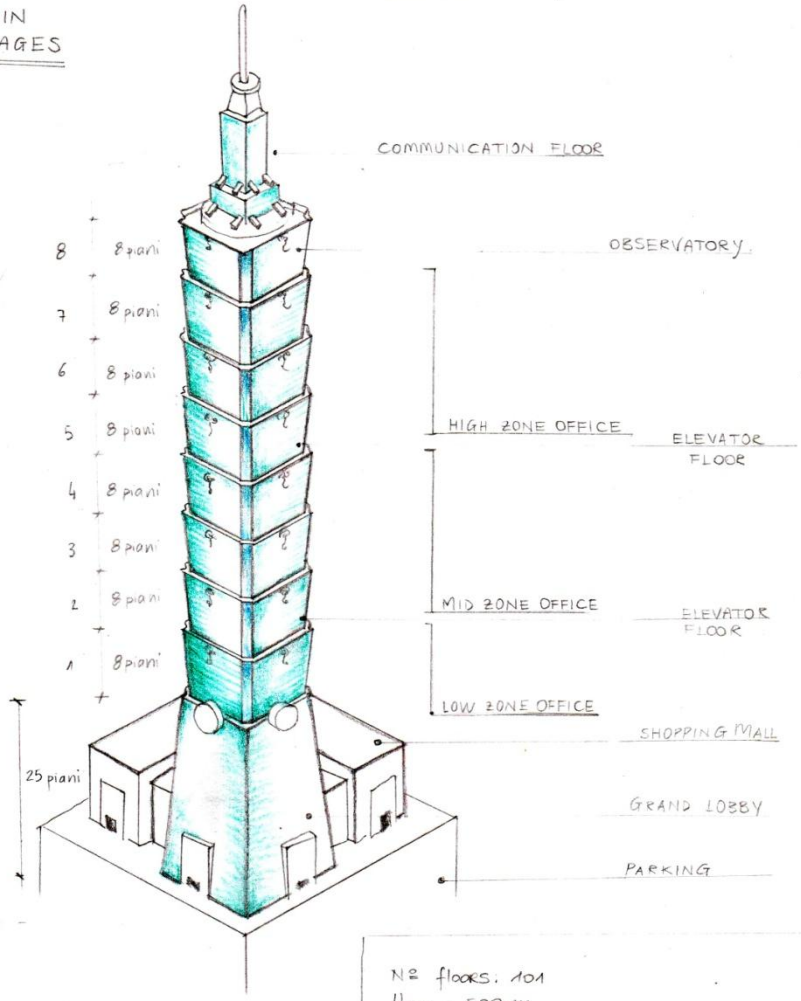
E'del 13% maggiore rispetto a quello ottenuto dall'analisi FEM ma è accettabile considerando che in genere il calcolo manuale sovrastima le deformazioni non considerando le dimensioni delle zone nodali

student case studies – Taipei 101: hand calculations and sketch

SARA CATTOLICO

TAIPEI 101, Hsinyi District, Taipei

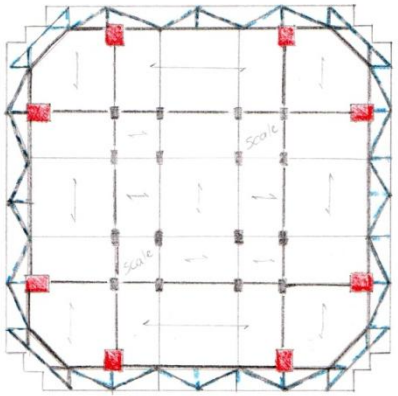
MAIN USAGES



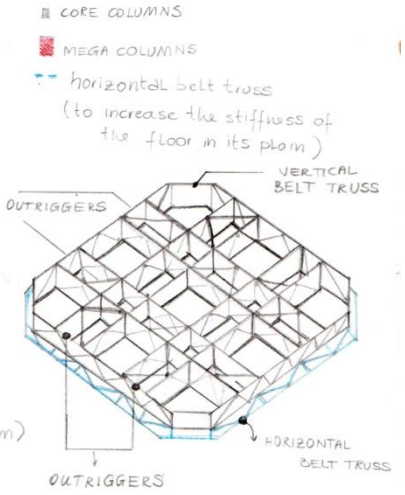
N° floors. 101
H_{TOT} = 508 m
Floor area ≅ 375 m^2 Plan area: 50x50 m

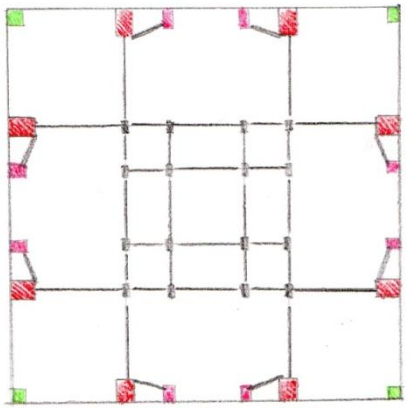
Architect: C.Y. Lee & Partners
Structural Engineers: Shaw Shieh
Year started: 1998/ completed 2004

FLOORS → COMPOSITE FLOOR : 3 different plants



1) MECHANICAL FLOOR (s 200 mm)
1 EVERY 8 STORIES.





CORE COLUMNS
MEGA COLUMNS
SUB-MEGA COLUMNS
CORNER COLUMNS.

2) LOWER STORY (s 135 mm)
up to 26° floor

On the basis of the following **guidelines**, you should carry out a critical assessment / discussion of the building structure; you have the tools and knowledge to do it

Important in the development of the case study exam are:
clarity, depth, extent of the assessment;

including meaningful details; comprehension of the global behavior.
Be precise in reporting sources, references, bibliography.

Both a report (file .doc) and a presentation (file .ppt) should be prepared.

…. 5. Critical assessment and discussion on the structural system

• define load paths and resisting mechanisms

under gravity load

under wind load → identify resisting elements and force type / distribution

under gravity + wind loads

• define major, predominant deformation mode under wind (* qualitatively, if possible quantitatively)

• evaluate and discuss structural efficiency (* qualitatively, if possible quantitatively):

bending efficiency: BRI

shear efficiency: SRI (relationship between SRI and shear lag)

unit structural quantity: put value on available diagrams and/or compare with similar buildings

• define simplified models for preliminary hand calculations / approximate analysis of structural behavior

…..

- some indexes useful to assess structural behavior:

compressive stress / force level due to gravity load

increase/decrease due to wind (accounting for shear lag effect)

Dtop/H; di/h; floor accelerations

- Approximate evaluation of lateral deflections (sway):

cantilever beam with equivalent inertia

consider that inertia usually varies along height; values at base and at top: average value, stepwise or linearly variation (variation of BRI)

accounting for SRI

wind force distribution: pressure / surface □ force (average value □ constant / variable)

- Considerations on robustness

CTBUH International Student Design Competition

De Gregorio, Franzese, Lamberti

CTBUH International Student Design Competition

D'Agostino, D'Amico, Iovane, Ricci

Raffaella De Falco (thesis)

Edificio alto con solette post-tese e diagrid in c.a. il caso della Torre Corporativa di Guadalajara

Education and Culture
Lifelong Learning Programme
ERASMUS

Luis Bozzo Estructuras y Proyectos, S.L.

Salvatore Varriale (thesis)

Nuove tendenze progettuali dei grattacieli residenziali a New York : forma e struttura

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

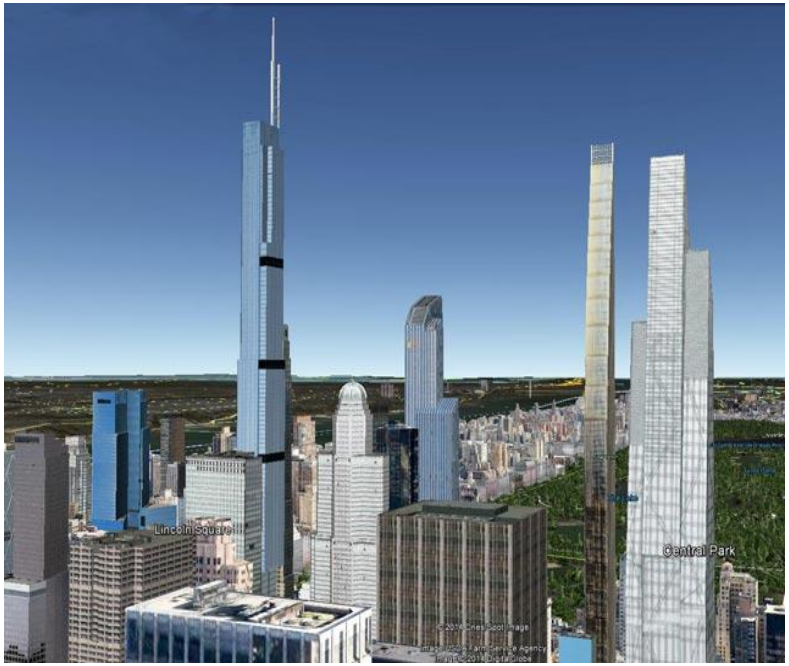
- Prof. Ing. Elena Mele

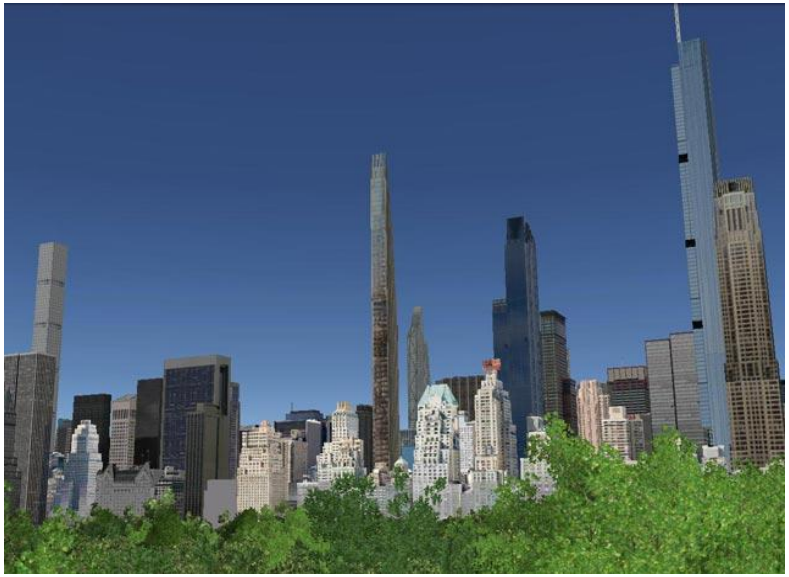
COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

- Prof. Ing. Rene B. Testa

WSP Cantor Seinuk Structural Engineers

- Ing. Stefano Braganti





Seismic performance improvement of highrise buildings with BRB outrigger system

A Dissertation Submitted in Partial Fulfilment of the Requirements for 2nd level Master Degree in

Emerging Technologies for Construction

By

Leopoldo Pisa

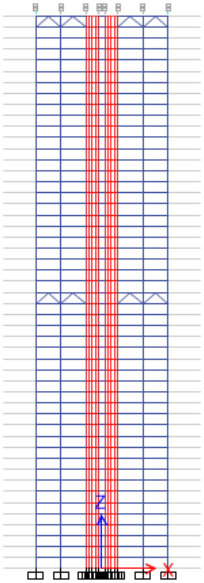
Supervisor: Prof. Elena Mele

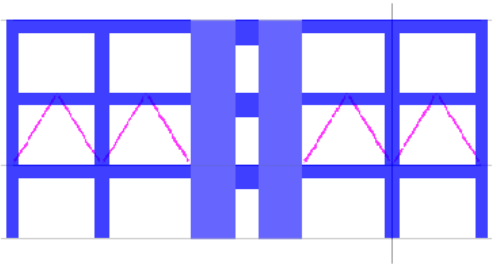
February, 2015

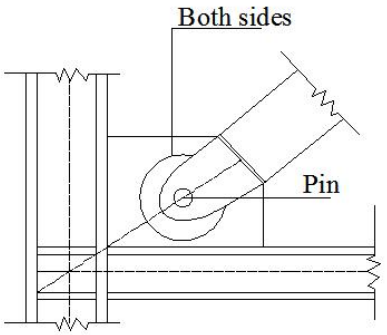
Department of Structures for Engineering and Architecture

Università degli Studi di Napoli "Federico II"

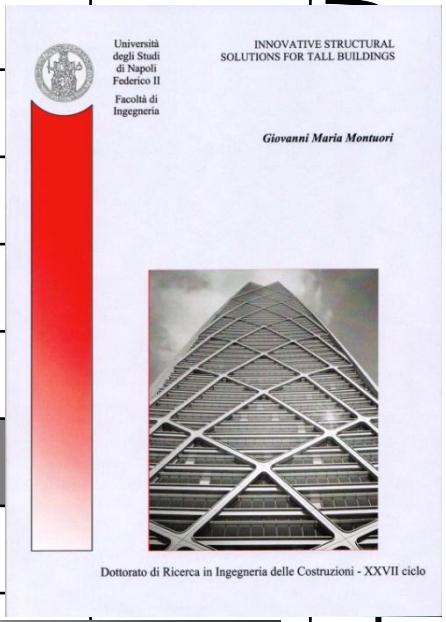
STAR SEISMIC

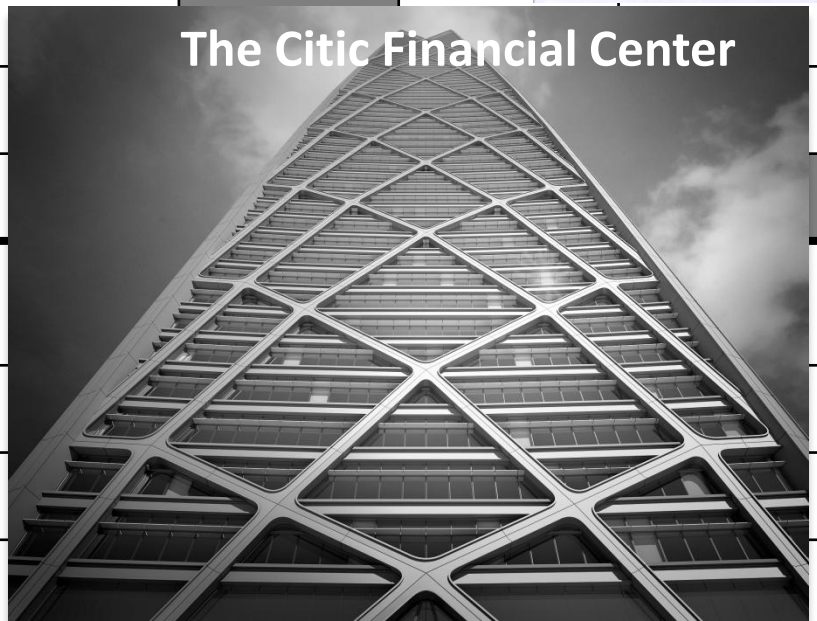






		2012	2013	2014	2015
DIAGRID SYSTEM	State of art				
	Design Procedures				
	Publication				
	Alternative geometries				
	Local problem studies				
	Publication				
ALTERNATIVE STRUCTURAL PATTERN	State of art				
	Structrual Design Study				
	FE models and analysis				
	Publication				
CITIC FINANCIAL CENTER	Structural behaviour study				
	FE models and analysis				
	Special studies				
	Final Design				





DIST

SOM

Martina Buttaro – internship June 2015 / June 2016

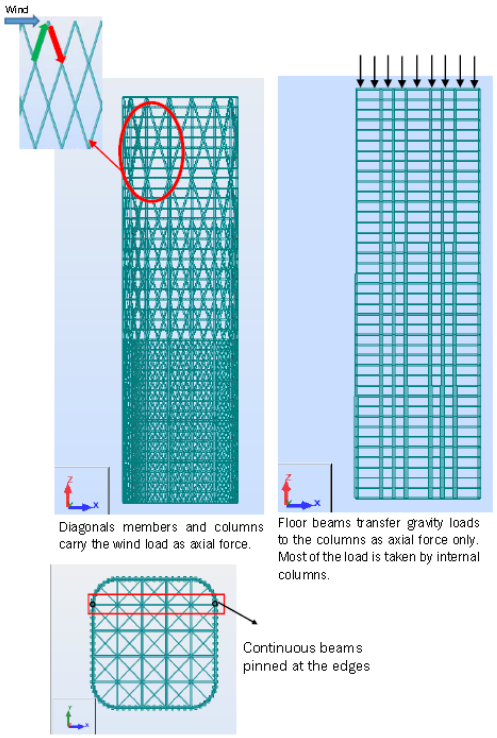
comparative analysis of different solutions for the design of a timber tall building

atelier one
STRUCTURAL ENGINEERS

atelier one

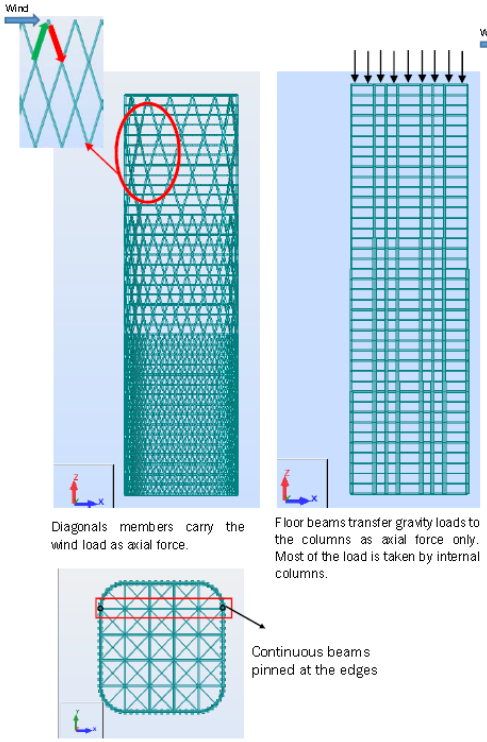
Option 3 – Diagrid System

The tower is braced through a diagonal grid regularly spanning on the façade which helps to resist to the lateral loads. Therefore the grid carries wind load mainly as axial force, avoiding the columns to be excessively loaded. Gravity loads are taken both by the external skin and internal columns. The floor system is a pinned frame, therefore there is no moment transferring between beams and columns.



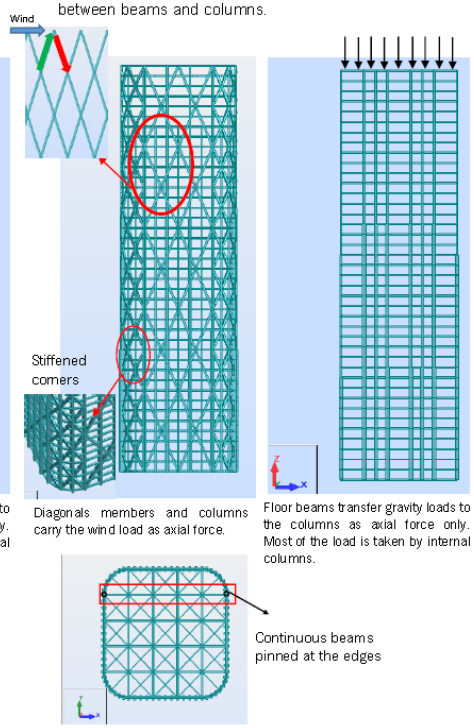
Option 4 – Diagrid System (No Column)

The façade is composed by diagrid only, which carries the lateral loads mainly as axial force. Therefore the external skin is free from columns. Gravity loads are taken both by the external skin and internal columns. The floor system is a pinned frame, therefore there is no moment transferring between beams and columns.



Option 5 – Braced Tube

The tower is braced through a diagonal grid regularly spanning on the façade which helps to resist to the lateral loads. Therefore the grid carries wind load mainly as axial force, avoiding the columns to be excessively loaded. The grid is tightened in the corners of the building where the effect of wind is greater. Gravity loads are taken both by the external skin and internal columns. The floor system is a pinned frame, therefore there is no moment transferring between beams and columns.

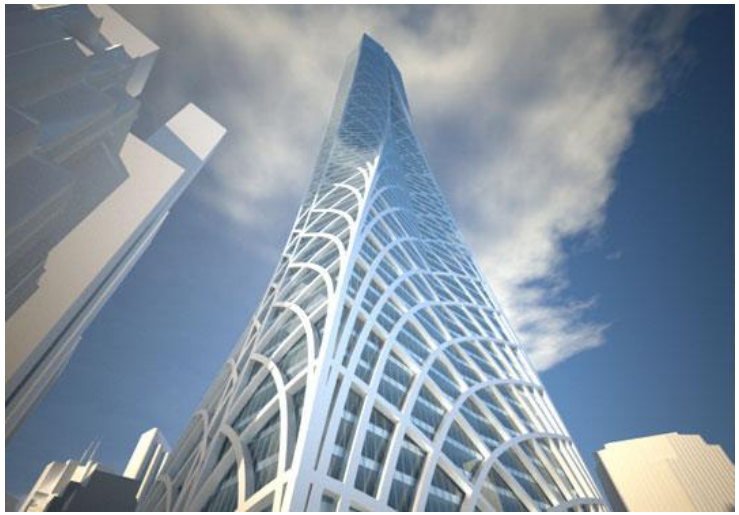


Laura Leone - 6 months internship (from Sept. 2016)

Form Finding, Form Improvement, Form Optimization

Stefano Di Paola - 6 months internship (from Sept. 2016)

Seismic behavior and improvements of wind-designed diagrid structures



SOM

San Francisco

Luis Bozzo, Barcelona

Columbia University, New York

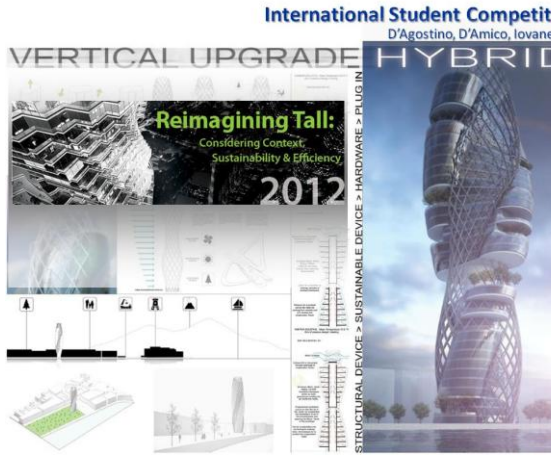
WSP, New York

StarSeismic Inc., Budapest

SOM, San Francisco

Atelier One, London

Tall Buildings @ Università degli Studi di Napoli Federico II



international student design competition

Structures for High-Rise and Long-Span Bldgs

(9 ECTS Course - Grad., Master)

student outdoor internship

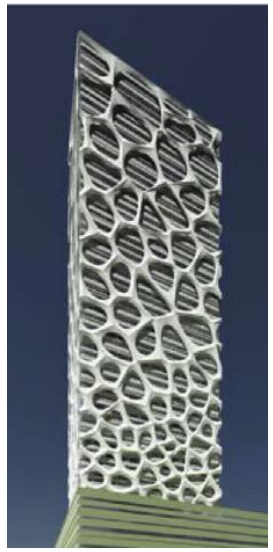
Luis Bozzo, Barcelona	Luis Bozzo Estructuras y Proyectos, S.L.
Columbia University, New York	Columbia University in the City of New York
WSP, New York	WSP Cantor Seinuk Structural Engineers
StarSeismic Inc., Budapest	STAR SEISMIC
SOM, San Francisco	SOM
Atelier One, London	atelier one Structural Engineers

Tall Buildings @ Università degli Studi di Napoli Federico II

- case studies
  learning from precedents
- stiffness vs. strength design
  posing the right questions
- secondary bracing systems
  a hidden design problem
- non-regular triangular patterns
  exploring non-conventional

Diagrid

- **Hexagrid** - patterns, modeling, design
- from Hexagrid to **Voronoi** patterns



MICRO-MEGA

Nature inspired structures for tall buildings: patterns, modeling, analysis