Skyscrapers

JT Wunderlich PhD

AGENDA

- Architecture Theory and Urban Design Throughout
- Engineering Innovations
Primary Sources


- Personal Architecture projects in Texas, California, and Pennsylvania
  - BS Architectural Engineering (U.Texas 84)
  - 1-1/2 years of Urban Design (UCSD 1986-87)
  - Education and experience for past 40 years applicable towards licensing as both a Professional Engineer and a Registered Architect
- Frequent international travel pictures of Architecture and Urban Design
A skyscraper is a Tower

During Feudal times (e.g. Europe or Japan), towers protected cities and castles, and demonstrated status of feudal Lords and Kings
Kasteel Beersel, Belgium
Belgium 2014

Selecting a castle to visit on 2014 Belgium/Italy/England trip

Kasteel Beersel, Belgium

From 10am to 12 noon and 2pm to 6pm, Tuesday to Sunday from 1 March to 15 November

OASBECK 10am to 8pm (last visit starts at 7pm), Tuesday to Sunday, April to October. €4. The big park surrounding the castle is open 8am to 8pm and admission is free. Daily, except a few Tuesdays and the first Saturday of the month. From 1st April to 30th September, from 10:00 am to 5:30 pm. Admission is 5 €.

The castle is open every day, except Mondays which are not public holidays, from 10:00 am to 6:00 pm (last admission 5:30 pm). Entry to the castle is 4.96 € for adults, 3.72 € for senior (over 60), youth (13 to 18)

Rivecourt Castle is only open on weekends and holidays from 2:00 pm to 6:00 pm, between 15 April to 31 October.

Entry cost 3.80 € for adults, 2.5 € for students and people between 13 and 18 and over 60 years old, 1.3 € for children between 6 and 13 years old and free under 6 and for disabled people. Guided tours take place every Sunday from April to October from 3:00 pm (6 €).

The castle is only open from 1st May to 30th September on Sundays and public holidays; from 10:00 am to 6:00 pm (also Saturdays in July and August), Entry is 7 € for adults, and 2 € for children between 6 and 10 years old.
DEFINING SPACE

“A obelisk or tower establishes a point on the ground and makes it visible in space

... a column generates a field about itself and interacts with the space” [2]
“At the center of its environment, a point is stable and at rest, organizing surrounding elements about itself and dominating its field” [2]
‘When moved off center, it's field becomes more aggressive and begins to compete for visual supremacy. Visual tension is created between the point and it's field” [2]
POINT off-center -- Visual Tension

“A vertical line can express a state of equilibrium with gravity, and symbolize the human condition” [2]
“vertical equilibrium ...the human condition” [2]
Prior to 1800’s, most buildings not very tall, and mostly made of wood, or unreinforced masonry or concrete.
Concrete is a “concretion” of a mix of AGGREGATE (rocks) and a cementations binding material (CEMENT).

- Romans used it extensively from 300BC to 475AD
Early 1800’s in the U.S.
First cast-iron frames and building fronts
(often painted to look like stone or other materials)

1865+ in the U.S.
Industrial revolution – mass production
Tall buildings a result of rising urban real estate values, and desire of businesses to remain in center of activity
William Le Baron Jenny

Home Insurance Building
Chicago 1883
Demolished 1931

First “Steel Skeleton”
– but also much cast iron, and the first floor had masonry load-bearing walls [1]

Also one of the first skyscrapers to use an elevator (hydraulic)
Hydraulic **elevators** for shorter buildings

High-speed **elevators** for skyscrapers -- use cables and electric motors
Elevator SAFETY-SYSTEMS allowed taller buildings

**Braking** system stops elevator from free-fall if cable snaps or melts
Also, **buffers** are at bottoms of shafts to dampen a falling elevator

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1. If the cables snap, the elevator's **safeties** would kick in. **Safeties** are braking systems on the elevator.

2. Some safeties clamp the **steel rails** running up and down the elevator shaft, while others drive a wedge into the notches in the **rails**.

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http://static.ddmcdn.com/gif/runaway-elevator-2.gif
Burnham and Root

Rand McNally Building

Chicago 1889

Demolished 1911

First to use Structural Steel for entire frame [1]
Cast IRON
“an alloy of iron, carbon, and silicon that is cast in a mold and is hard, brittle, nonmalleable”

Wrought IRON
“a form of iron that is tough, malleable, and relatively soft, contains usually less than 0.1 percent carbon, and carries 1 or 2 percent of slag mechanically mixed with it”

STEEL
“commercial iron that contains carbon as an essential alloying constituent, and is distinguished from cast iron by its malleability – less brittle (more "ductile")

## Comparison between Cast Iron, Wrought Iron & Steel

<table>
<thead>
<tr>
<th></th>
<th>Cast Iron</th>
<th>Wrought iron</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rusting</td>
<td>Does not rust easily</td>
<td>Rusts more than Cast Iron</td>
<td>Rusts easily</td>
</tr>
<tr>
<td>Malleability &amp; Ductility</td>
<td>Brittle &amp; cannot be welded or rolled into sheets</td>
<td>Tough, malleable, ductile &amp; moderately elastic</td>
<td>Tough, malleable &amp; Ductile</td>
</tr>
<tr>
<td>Reaction to sudden shock</td>
<td>Does not absorb shocks</td>
<td>Cannot stand heavy shocks</td>
<td>Absorbs shocks</td>
</tr>
<tr>
<td>Forging &amp; Welding</td>
<td>Brittle and cannot be welded or rolled into sheets</td>
<td>Easily forged or welded</td>
<td>Rapidly forged or welded</td>
</tr>
</tbody>
</table>
“Wide-Flange” steel beam or column (sometimes called an “I beam”) helped allow taller buildings

Great:

• Flexural Strength
• Compression Strength
• Shear Strength
• Tensile Strength
STEEL FRAME STRUCTURES

- Can melt, so fire safety coatings developed *(in Chicago after great fire of 1874)*
- Can handle large LATERAL LOADS
  - wind
  - seismic (earthquake) forces

• in one of two ways:

“BRACED-FRAME” Diagonal braces       OR       “MOMENT CONNECTION”

![Diagrams of bracings and moment connection]
**BRACED-FRAME**

- Cheaper

**MOMENT CONNECTION**

("MOMENT" = "TORQUE")

- Unobstructed views
- Simpler interiors

**STEEL**

**TYPE 1: MOMENT CONNECTIONS** - Beam flanges must be rigidly connected to column

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http://www.stlsi.com/images/DSC01209.JPG
https://d2t1xqejof9utc.cloudfront.net/screenshots/pics/a97e97f0e72c8856c002117a53f2bb1b/medium.jpg

http://programas.cype.es/imagen/nuevoMetal3D/union_1_soldada_49.gif
http://buildipedia.com/images/masterformat/Channels/On_Site/Technical_Lessons_Learned
BRACED-FRAME

http://jiano.typepad.com/photos/uncategorized/brb_02.jpg

MOMENT CONNECTION

http://www.featurepics.com/Thumb300/20070505/Highrise-construction-39655.jpg

STEEL
Louis Sullivan, The Father of Skyscrapers

Architect Louis Sullivan
1856-1924
Auditorium Building
Chicago, 1889, Adler and Sullivan

Architect Louis Sullivan
Frank Lloyd Wright
(a protégée of Louis Sullivan)
called this building:

"the very first human
expression of a tall steel
office-building as
Architecture"

Building has a base, a middle
section, and a top -- like a
classical column [1]
Union Trust Company Building,
St Louis, 1893, Adler and Sullivan

https://mohistory.org/collections/item/resource:140756

Architect Louis Sullivan
The Guaranty Building (now the Prudential Building)
Buffalo, New York, 1895, Adler and Sullivan

Architect Louis Sullivan
At age 21, Frank Lloyd Wright approached the most famous architect in Chicago, Louis Sullivan.

“I was accepted by Mr. Sullivan and went to work for Adler and Sullivan, then the only moderns in architecture, and with whom, for that reason, I wanted to work.”
• Frank Lloyd Wright quickly rose to chief draftsman in charge of 49 others
• Referred to Louis Sullivan as **Liebermeister** ("Dear Master")
• Given a five year contract, and asked Louis Sullivan for personal loan against contract to build a house

Frank Lloyd Wright and wife Catherine who he met at age 21 when she was 17

Architect Louis Sullivan
• Neither Architect liked Neoclassicism (Greek or Roman)
  – Both annoyed by “White City” built for 1893 Worlds Fair in Chicago
  – Frank Lloyd Wright quoted French poet Victor Hugo:
    “The setting Sun all mistook for Dawn”

• Both Architects in search of an entirely new American Architecture
Daniel H. Burnham & John Welborn Root

Monadnock Building
Chicago 1891

One of the last exterior load-bearing-masonry skyscrapers
  - Walls very thick, to carry load

Also an internal iron frame for lateral bracing of exterior walls [1]
External skin of terracotta and glass clipped onto internal steel skeleton [1]

Precursor to glass curtain walls of 1960’s and 70’s
Glass CURTAIN WALL common in modern commercial buildings
Structural Load carried by core and columns

Glass CURTAIN WALL doesn’t carry load

This allows a SHELL to be built, followed by TENANT IMPROVEMENTS in interior

Tenants given a fixed $ per square foot, and they use a different architect (a “SPACE PLANNER”)

http://www.expresstowers.in/images/floor_plan1_1.jpg
JT Wunderlich 1984,85 Project Manager / Designer
“West Lake Oaks” (13 buildings),
Doerring Development, Austin TX
• Architecture, Engineering, and management of 60 contracts and several employees
 JT Wunderlich 1984,85
 Austin TX

• 2018 Photo
66,000sf hi-tech office and light manufacturing
44,000sf office building

Recent CURTAIN WALL and Reinforced Concrete

JT Wunderlich 1985,86
Director of Projects / Designer
JDC Development, La Jolla, CA
JT Wunderlich 1985,86
La Jolla, CA

- Led Design Team, Modified forms, Selected materials & landscaping
- Project nominated for Award

Recent CURTAIN WALL and Reinforced Concrete
Balance of vertical and horizontal elements

Has “Chicago Windows” with large fixed panes between operable windows [1]

Daniel Burnham and Frederick Dinkelberg

*Flatiron Building*

*New York 1902*

One of the first very tall buildings
1903 REINFORCED CONCRETE

A COMPOSITE MATERIAL of:

1. Concrete
   (High Compression strength)

2. Steel Reinforcing-Bars ("Re-Bar")
   (High tensile strength)

First Reinforced Concrete Skyscraper

Elzner & Anderson
Ingalls Building
Cincinnati 1903

https://www.loopnet.com/listing/6-e-4th-st-cincinnati-oh/12158560/
Today’s REINFORCED CONCRETE

- Vertical bars
- Cement concrete
REINFORCED Concrete in more recent times

“SLIP FORMS” allows taller buildings
Wunderlich family project included reinforced concrete to strengthen the foundation.

Today’s REINFORCED CONCRETE
Cass Gilbert

Woolworth Building
New York 1913

Art Deco Architectural Style
William Van Alan
Chrysler Building
New York 1930

Art Deco Architectural Style

William F. Lamb, Gregory Johnson

Empire State Building
New York 1931

The World's tallest building for 40 years [1]

1933 Movie clip:
https://www.youtube.com/watch?v=CuRQH_hLcTw

Art Deco
Architectural Style
BAHAUS SCHOOL
Germany 1919 to 1933
Founder: Architect Walter Gropius

The Bauhaus combined art, architecture, graphic design, interior design, industrial design, and typography. This school had influence on the Modern Architecture movement to come – in Chicago

Modern Architectural Style

• Simplicity
• Minimalistic
• No ornament
• Harmony between function and Design

“Modern” Architecture

Closed due to pressure from Nazi’s claiming it was a center of communist intellectualism

https://en.wikipedia.org/wiki/Bauhaus
Le Corbusier

Unité d'Habitation
Marseille, France 1945

http://www.fondationlecorbusier.fr/CorbuCache/410x480_2049_791.jpg

Le Corbusier

Villa Savoye
Poissy, France 1931

http://www.fondationlecorbusier.fr/CorbuCache/410x480_2049_791.jpg

Modern Architectural Style
Le Corbusier - a planned city concept:

http://www.archdaily.com/411878/ad-classics-ville-radieuse-le-corbusier
Ludwig Mies van der Rohe
(a Bauhaus Architect from Germany)

**Seagram Building**
**New York 1958**

![Seagram Building](http://conservapedia.com/images/a/a6/Seagram_Building.jpg)

**S.R. Crown Hall**
**Chicago 1956**

![S.R. Crown Hall](http://www.curbed.com/maps/mies-van-der-rohe-important-works)

**Farnsworth House**
**Plano, IL 1951**

![Farnsworth House](http://conservapedia.com/images/a/a6/Seagram_Bilding.jpg)

Modern Architectural Style
The Word’s tallest building for 25 years after it surpassed the Empire State Building [1]

Phillip Johnson was first a **Modern** Architect

Phillip Johnson

*Glass House*
*Canaan, CT 1949*
POSTMODERN Architectural style - references elements prior to the Modernist movement -- in contrast to the simplicity of Modern movement [1]

At its top, a pediment. **Postmodern** reminiscent of a grandfather clock, or a tall 18th century chest-of-drawers
Phillip Johnson

AT&T Building, now Sony Tower
New York 1984

At its base, Postmodern reminiscent of Italian renaissance architecture

St. Peters Basilica in Rome 2011
Phillip Johnson

Sony Tower
New York 1984

Postmodern reminiscent of Italian renaissance architecture

Vatican Museum in Rome 2011

Postmodern Architectural Style
César Pelli

*Petronas Towers*

*Kuala Lumpur, Malaysia 1996*

**Postmodern Architectural Style**
C.Y. Lee & Partners

Taipei 101
Taipei, Taiwan 2004

Postmodern Architectural Style
Rem Koolhaas, Ole Scheeren

CCTV Headquarters
Beijing, China 2008

Deconstructive Architectural Style
Frank Gehry

Spruce St. Tower

New York 2011

Deconstructive Architectural Style
### “Deconstructive” Architectural Style

![Image](https://en.wikipedia.org/wiki/Deconstructivism)

<table>
<thead>
<tr>
<th>Gallery</th>
<th>[edit]</th>
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<tr>
<td>Jewish Museum, Berlin, Germany</td>
<td>Alpine Deconstructivism in Kitzbühel, Austria, by Christine &amp; Horst Lechner</td>
</tr>
<tr>
<td>City of Capitals in Moscow IBC, Russia</td>
<td>UFA-Palast in Dresden, Dresden, Germany, by Coop Himmelblau</td>
</tr>
<tr>
<td>The Gymnasium by Josef Kiszka and Barbara Potysz, in Orlóvá, Czech Republic</td>
<td>Hotel Porta Fira (left) in Barcelona, Spain, by Toyo Ito</td>
</tr>
</tbody>
</table>

Adrian Smith, Marshall Strabala, George J. Efstathiou, William F. Baker

Burj Khalifa
Dubai, United Arab Emirates 2014

World’s Tallest Building

Neo-Futuristic Architectural Style
Burj Khalifa

Neo-Futuristic Architectural Style

### Burj Khalifa

**Neo-Futuristic Architectural Style**

<table>
<thead>
<tr>
<th>Floors</th>
<th>Use</th>
</tr>
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<tbody>
<tr>
<td>160 and above</td>
<td>Mechanical</td>
</tr>
<tr>
<td>156–159</td>
<td>Communication and broadcast</td>
</tr>
<tr>
<td>155</td>
<td>Mechanical</td>
</tr>
<tr>
<td>139–154</td>
<td>Corporate suites</td>
</tr>
<tr>
<td>136–138</td>
<td>Mechanical</td>
</tr>
<tr>
<td>125–135</td>
<td>Corporate suites</td>
</tr>
<tr>
<td>124</td>
<td>At the Top observatory</td>
</tr>
<tr>
<td>123</td>
<td>Sky lobby</td>
</tr>
<tr>
<td>122</td>
<td>At.mosphere restaurant</td>
</tr>
<tr>
<td>111–121</td>
<td>Corporate suites</td>
</tr>
<tr>
<td>109–110</td>
<td>Mechanical</td>
</tr>
<tr>
<td>77–108</td>
<td>Residential</td>
</tr>
<tr>
<td>76</td>
<td>Sky lobby</td>
</tr>
<tr>
<td>73–75</td>
<td>Mechanical</td>
</tr>
<tr>
<td>44–72</td>
<td>Residential</td>
</tr>
<tr>
<td>43</td>
<td>Sky lobby</td>
</tr>
<tr>
<td>40–42</td>
<td>Mechanical</td>
</tr>
<tr>
<td>38–39</td>
<td>Armani Hotel suites</td>
</tr>
<tr>
<td>19–37</td>
<td>Residential</td>
</tr>
<tr>
<td>17–18</td>
<td>Mechanical</td>
</tr>
<tr>
<td>9–16</td>
<td>Armani Residences</td>
</tr>
<tr>
<td>1–8</td>
<td>Armani Hotel</td>
</tr>
<tr>
<td>Ground</td>
<td>Armani Hotel</td>
</tr>
<tr>
<td>Concourse</td>
<td>Armani Hotel</td>
</tr>
<tr>
<td>B1–B2</td>
<td>Parking, mechanical</td>
</tr>
</tbody>
</table>

*Dimetric projection with floors colour-coded by function*[^4]
Burj Khalifa

Video:

http://www.skymetweather.com/content/earth-and-nature/must-watch-natures-lightning-show-over-burj-khalifa/
INTERIOR STRUCTURES and corresponding building heights

[Bar chart showing different types of building structures and their corresponding number of stories.]

EXTERIOR STRUCTURES and corresponding building heights

Norman Foster

*The Gherkin*

London, 2004

Neo-Futuristic Architectural Style
Marshall Strabala, Jun Xia

**Shanghai Tower**

Shanghai, China 2015

**Artist’s rendition**

Sustainable Design

https://en.wikipedia.org/wiki/Shanghai_Tower
CONCEPTUAL DESIGN
CONCEPTUAL DESIGN
CONCEPTUAL DESIGN

- We reduce the exterior wall to make it very insulating, so the house uses less energy.

- The area of the central core is less than the exterior square, reducing energy consumption.

- The external skin is 14% less, lessening energy usage.

- The reduced area = less exterior.

- The reduction in energy = 20%.
Huge glass **curtain walls** hung from upper decks
Huge glass *curtain walls* hung from upper decks
Double outer walls allows for internal open spaces
1. Glass façade reduces wind loads by 24%. Therefore 25% less structural steel saves US$58 million.

2. Construction practices optimized.

3. Vertical-axis wind turbines at top generate 350,000 kWh of electricity per year.

4. Double-layered insulating glass façade reduces need for air conditioning.

5. Heating & cooling use geothermal energy.

6. Rain water collection.

Sustainable Integrated Solutions
Shanghai Tower

Has a concrete core, and structural steel.

Not tallest building, but doesn’t aspire to be – it’s something completely new

A VERTICAL GREEN CITY
However,

We hopefully won’t rely entirely on artificial interior worlds – no matter how well we can make them “Sustainable”
Frank Lloyd Wright

*Price Tower*

Bartlesville, Oklahoma 1952

Wright persuaded Harold Price to build headquarters on 19 floors instead of 3 by showing how power, climate control, plumbing, and communications are **simpler & more efficient** via a central stack [1].
Frank Lloyd Wright’s Earliest Influences

FROEBEL influenced by Taoism and Buddhism
- Japanese Shinto rooted in Chinese Taoism
  - Shinto Gods in everything, especially nature
  - FLW would later love Japanese Art, Design, and Culture

Mother’s family were all UNITARIANS
- Inspiration from all religions, love nature, God in everything

Most of childhood in rural WISCONSIN
- Like Pennsylvania farmland

Frank Lloyd Wright 1867-1959

The origins of Sustainable Design

From 2018 Wunderlich Lecture Series on Frank Lloyd Wright

Others in history homeschooled:

FATHER
Preacher, Lawyer, School Superintendent, Teacher, Musician
B.A., M.A. Colgate University
“Artist, photographer, and designer of furniture, graphics, books, and buildings, his patronage of Chinese and Japanese art, his obsession with every aspect of his surroundings, his dedicated collecting of beautiful things, owed much to his father” [Huxtable 2004]

MOTHER
Homeschool Teacher using Froebel System

Maria Montessori 1913 in Italy

Friedrich Froebel 1782-1852 Germany

From 2018 Wunderlich Lecture Series on Frank Lloyd Wright

WISCONSIN
Future Designers
20 to 26 years old (1887-1893)

Frank Lloyd Wright begins developing his “ORGANIC ARCHITECTURE”

“Bowels, circulation, and nerves were new in buildings.”

“A desire for simplicity that would yield a broader deeper comfort as organic… Organic simplicity… Ruthless but harmonious order I was taught to call nature … on the farm… Beauty in growing things.”
Organic Architecture PHILOSOPHY

[Wright 1954, Wright 1957]

- “Grow Form in realm of human spirit”
- “Human Scale is true Building Scale”
- “Forms more naturally significant of idea and purpose”

Oppose:
- Neoclassicism
- “Senseless excess”
- “Senseless expedience”
- Victorian ornamentation and compartmentalization

- “True ornament had to mean something … Integral ornament”

Building “Plasticity… like skin surface defined by skeleton …

Esthetic and structure become one … FORM AND FUNCTION ARE ONE”

Similar but different from the phrase coined by his Mentor Louis Sullivan: “Form Follows Function” which is similar to the ideas of Sculptor Horatio Greenough (1805-1852) on “Functionalism”
His “Organic Architecture” was revolutionary in creating over 100 years ago what is considered Green Architecture today.

Although considered a Modern Architect, his ideas were very different from other Modernists.

Frank Lloyd Wright's Modern Architecture vs that of Mies van der Rohe and Le Corbusier
Sometimes people prefer being more grounded and close-to-the-earth.

Especially if the building site, and the context of the surrounding environment, seems more compatible with building horizontal.
In Kyoto, no buildings are allowed taller than 60 meters to protect the overall quality of this historic city.
Kyoto 2013

No buildings taller than 60 meters
Kyoto 2013

No buildings taller than 60 meters
Kyoto 2013
No buildings taller than 60 meters
No buildings are allowed taller than 60 meters
Kyoto 2013

No buildings taller than 60 meters
Kyoto 2013

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Kyoto 2013

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No buildings taller than 60 meters
Kyoto 2013
No buildings taller than 60 meters
No buildings are allowed taller than 60 meters
Kyoto 2013

No buildings taller than 60 meters
Frank Lloyd Wright

known more for Horizontal Architecture

... designing on a Human Scale ,

.... and with a great respect for Nature
2015 Etown Architecture Students & Faculty field trip

Professor Kozimor-King works at Falling Water
But scraping the sky can be part of quality Urban Design
where buildings compliment each other,
and their surroundings
And a vertical culture is established
Austin Texas in early 1980’s

- U Texas BS Architectural Engineering
  with many classes on the upper floors of high-rises
- Then worked for Developers
Recent Austin skyline
San Diego in mid-1980’s .... One office in hi-rise working for developers, then worked for Planning Commission while in 2nd degree program in Urban Design at UCSD
San Francisco in late 1980’s .... Frequent meetings in downtown San Francisco skyscraper, and lived in the city, while working for an A&E firm, and starting grad school in Physics (to lead to M.Eng and PhD in Hi-Tech, then IBM Research)
So can skyscrapers be a “Joyful” thing?

VIDEO: https://www.youtube.com/watch?v=A_u2WFTfbcg
Things up high can certainly be “Joyful”

VIDEO: [https://www.youtube.com/watch?v=A_u2WFTfbcg](https://www.youtube.com/watch?v=A_u2WFTfbcg)
So yes, tall things can be joyful, including skyscrapers.
## Architectural Studies Minor

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ART 105</td>
<td>Drawing I</td>
<td>4.00</td>
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<tr>
<td>ART 280</td>
<td>History of World Architecture</td>
<td>4.00</td>
</tr>
<tr>
<td>ART 210</td>
<td>Drawing II \textit{OR} Sculpture</td>
<td>4.00</td>
</tr>
<tr>
<td>EGR 343</td>
<td>Green Architectural Engineering</td>
<td>3.00</td>
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Select \textbf{one} of the following elective options - 4 credits

- EGR 396 Spring Seminar \textbf{AND} EGR 276 Sustainable Resource Engineering & Design \textbf{1.00}  \textbf{3.00}

\textbf{OR} \textbf{one of the following options with an emphasis in Architecture**}

- EGR 280 Engineering Research/Project \textbf{4.00}
- ART/EGR 471 Internship \textbf{4.00}
- ART/EGR 481 Independent Study \textbf{4.00}

- ART/EGR 499A Architecture Design Studio \textbf{2.00}
- ART/EGR 499B Architecture Design Studio \textbf{2.00}

\textbf{SLE}

Contact Advisors:  \textbf{Joseph Wunderlich PhD} or Patricia Ricci PhD