Northeastern University
School of Architecture

Structures 2: Tectonics
Spring 2010
Instructor: Jose J Vargas
j.vargas@neu.edu

Office Hours: Saturdays 2:00pm-4:30pm

COURSE DESCRIPTION
This course will focus on the art of building, or “tectonics.” It is rooted in both a fundamental knowledge of building techniques and a study of the “significance” of materials, structure, and construction to larger architectural ideas. This course will be an extension of your previous Structures 1: Statics course in that this course will focus on the application of the structural concepts in built form.

We will complete a braced frame steel structural analysis to review and bring closure to Structures 1. We will study the four primary construction types: wood, masonry, steel, and concrete. We will investigate the wide range of structural and constructional variations within these four groups, and we will also explore the qualitative issues generated by a particular “tectonic” system. We will produce a series of detailed models and drawings that demonstrate your understanding of the construction types.

This course shall explore how architecture unites material, form, and performance in construction to embody meaning in the design of selected buildings.

There will also be a prevalent subtext that will pervade this course: the ethical responsibility of an architect in relationship to the environment, economics, and the law as s/he is making construction choices.

GRADING
Class Participation: 10%
Quizzes: 25%
Homework: 25%
Projects: 40%

SCHEDULE
Given on a bi-weekly basis starting on Tuesday January 19th.

COURSE REQUIREMENTS
1. Readings: All reading shall be completed before the class it is assigned. Required readings are all from:
   - Suggested reading for your education and for your assignments are as follows:
     - Packard, Robert T., Architectural Graphic Standards, copyright 1989 by Wiley & Sons

2. Quizzes: There will be a quiz every week, starting on the second week, based on both the required reading for that week and all lecture material delivered in class up to the time of the quiz. The quizzes will be open-book so you may bring your textbook and notebook for reference, and calculators. You must be in attendance for each quiz or you will fail the quiz for that meeting time; there are no make-up quizzes.

3. Projects: Projects are due at the beginning of class on the due date. Late projects will be reduced one full letter grade each day they are late. There will be three projects for the term.
4. Attendance and Participation: three unexcused absences will automatically drop your grade by one letter-grade, i.e., from an A to a B (28 meetings; 3 absences is 11% of the course). You will also fail the quiz if scheduled for that meeting time; there are no make-up quizzes. All students are required to participate in class discussions; active dialogue is encouraged and required.

ACADEMIC HONESTY

Northeastern University is committed to the principles of intellectual honesty and integrity. Members of the Northeastern community are expected to maintain complete honesty in all academic work, presenting only that which is their own work in tests and assignments. If you have any questions regarding proper attribution of the work of others, contact your professor prior to submitting work for evaluation.

NAAB STUDENT PERFORMANCE CRITERIA

The work that students produce toward their degree granted by the School of Architecture is the property of the School of Architecture. The complete course work from three students shall be collected by the Department for each course taught for the National Architecture Accreditation Board (NAAB) documentation. Students are welcome to and encourage to document their work for their personal portfolio if it is requested by the School for NAAB, but the work must be submitted to the professor no later than one week after final exams week. This course meets the following NAAB Student Performance Criteria to the extent designated:

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<tr>
<th>12.18</th>
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The School of Architecture guidelines for grading in lecture courses is as follows:

A exemplary quality work. The student:
* demonstrates one of the best performances on exams/quizzes/papers/projects the instructor has seen at Northeastern or any other accredited school of Architecture
* demonstrates a superior understanding of course readings and lectures
* participates in class discussions cogently and willingly

A- high quality work. The student:
* demonstrates one of the best performances on exams/quizzes/papers/projects within the class
* demonstrates a high level of understanding of course readings and lectures
* participates in class discussions intelligently and willingly

B+ good quality work. The student:
* demonstrates strong performance on exams/quizzes/papers/projects
* demonstrates a good understanding of course readings and lectures
* participates in class discussions intelligently

B above average work. The student:
* demonstrates above average performance on exams/quizzes/papers/projects
* demonstrates an above average understanding of course readings and lectures
* participates in class discussions when asked to respond

B- average work. The student:
* demonstrates average performance on exams/quizzes/papers/projects
* demonstrates an average understanding of course readings and lectures
* meets attendance requirements

C+ below average work. The student:
* demonstrates below average performance on exams/quizzes/papers/projects
* demonstrates a below average understanding of course readings and lectures
*meets attendance requirements

C well below average work. The student:
* demonstrates well below average performance on exams/quizzes/papers/projects
* demonstrates a well below average understanding of course readings and lectures
* engages in excuse-making, tardiness, and absence

C minimal work. The student:
* demonstrates minimal performance on exams/quizzes/papers/projects
* demonstrates a minimal understanding of course readings and lectures
* engages in chronic excuse-making, tardiness, and absence

D+, D, D- marginally acceptable work. The student:
* demonstrates unacceptable performance on exams/quizzes/papers/projects
* demonstrates an unacceptable understanding of course readings and lectures
* engages in chronic excuse-making, tardiness, and absence
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Spring 2010
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j.vargas@neu.edu
TA: Juliet Chun

Quiz 1

From the reading material answer the following:
1. Name 4 ways in which wind forces may damage a building.

2. Cite one advantage and one disadvantage of using cross bracing to restrain lateral movements.

3. For building design applications, what factors affect the velocity pressures due to wind.

The following tributary areas have been resolved for you in relation to a specific member or joint.

A) Board on wheels support
(4 roller supports)

\[ TA_1 = \frac{1}{2} L \times \frac{1}{2} W \]

\[ TA_2 = \frac{1}{4} L \times W \]

(Tributary Area for joint #1)
For simple span rectangular configurations, Tributary Areas may be found by locating the centroid of the area and then drawing a line from the centroid to the midpoint between adjacent joints or line support endings.

In case C) a distance of zero is considered between the endings of the line supports, therefore the midpoint between them coincide with their endings.

Constructions pile up and have many layers both horizontally and vertically. To find a structural clarity, it is very important to understand how subsequent layers are loaded (at what points and by how much). Tracking through the effects of a tributary area is a useful approximation of how the actual loads will travel across a structure towards a ground support.

Find the following assuming loading in the sense of gravity.

4) What is the Tributary Area from Board A supported by joint #2B?
5) What is the Tributary Area from Board A supported by joint #2B?

6) What is the Tributary Area from Board A supported by joint #2B?

7) What is the sum of the Tributary Areas from Board A and Board B supported by line support #2?
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QUIZ 2

Modify the attached example 9.11 so that...

1) ...the midspan bracing is for the x-axis instead of the y-axis. What is the Allowable Stress value for the W8 x W35 trial column (use Table C-36 of the American Institute of Steel Construction)?

2) ...the end connections are both fixed-top and bottom instead of pinned. What is the Allowable Stress value for the column W8 x 35 trial column (use Table C-36 of the American Institute of Steel Construction)? Use the recommended design value for K from AISC Figure 9.16.

3) ...the end connection on the top is "rotation fixed and translation free", and at the bottom it is "rotation free and translation free". What is the Allowable Stress value for the W8 x 35 trial column (use Table C-36 of the American Institute of Steel Construction)? Use the recommended design value for K from AISC Figure 9.16.
4A) List from low to high, the 4 Allowable Stresses found (1 from the original textbook example, and 3 calculated above).

B) Would any of the 3 new models produce an overstressed column, which one, and by how much? (Use % stress)

5) Briefly describe what the Health, Energy, Fire, and Electrical and Mechanical codes regulate.

6) Name two legal restrictions, other than the Building Code and the codes listed above, that must be observed in the design and construction of buildings.

7) How does MasterFormat assist in the construction of a building?
9.11 Select the most economical W8 shape column, 16' long, with \( P = 180 \) k. Assume lateral bracing is provided at mid-height in the weak axis of buckling and the top and bottom are pin connected. \( F_y = 36 \) ksi.

Solution:

Again, we need to begin by guessing at a size, and then checking the adequacy of the selection.

Try W8 × 35. (\( A = 10.3 \text{ in.}^2; r_x = 3.51''; r_y = 2.03'' \))

Determine the critical slenderness ratio:

\[
K_l = \frac{(0.80)(18' \times 12 \text{ in.} / \text{ft.})}{3.09} = 55.9
\]

\[
K_l = \frac{(0.80)(18' \times 12 \text{ in.} / \text{ft.})}{5.44''} = 31.8
\]

Buckling about the strong axis is more critical in this example because of the lateral bracing provided for the weak axis.

Therefore, the \( F_a \) value is obtained from Table 9.1 based on \( K_l/r = 54.7 \).

\( F_a = 17.93 \text{ ksi} \)

\( P_{\text{allowable}} = F_a \times A = (17.93 \text{ ksi}) \times (10.3 \text{ in.}^2) = 184.7 \text{ k} \)

\( P_{\text{allowable}} = 184.7 \text{ k} > P_{\text{actual}} = 180 \text{ k} \)

\( \% \text{ Stress} = \frac{180 \text{ k}}{184.7 \text{ k}} \times 100\% = 97.5\% \) (very efficient selection)

Therefore, use W8 × 35.
Homework#2  
Homework for Friday January 29, 2010

Find an appropriate diameter for a circular steel bar that would hold the tributary load defined in class.

Recall that each member of the assembly holds 1/4 of the total load. Find the bar Area that would most closely approximate the Required Area needed to satisfy the Allowable Stress. The steel used is A36, the same as the other examples.

Use the structural steel Dimensions and Properties Charts that have been uploaded. After finding a cross sectional area that would satisfy the strength requirement, check for slenderness.

The r (radius of gyration) values for the bars are not tabulated in the code and these would need to be calculated by the following formula r=square root of I/A. Or r=\(\sqrt{\frac{I}{A}}\)

A stands for Area (tabulated in the charts)
I stands for Moment of Inertia (the higher the moment of inertia, the stiffer the profile, that is, it will bend less)

The moment of inertia of a circular section is \(\frac{3.14*D^4}{64}\), where 3.14 stands for pi and D for diameter.

Once the area of bar and its slenderness are obtained, compare the bar option against the other options resolved in class.

Choose one design direction (one option), and change your mindset: after having computed the required bar and selecting a profile, design the connection to a platform as a designer. (If there is missing information, fill it in) The second part of the homework should be given in drawings, as many as you need to make your connection comprehensible. Use the platform sketch in class as a guide to make detailed drawings of the connection you are coming up with. Keep the first homework assignment in mind as you develop your joint - tectonics.
Homework #3
Design an Intersection Using 8 Squares

Squares should have a thickness of at least 1/4"!
They may be cut into strips -to make linear elements for example, or rectangles.
Or they may be creased to fold along a line as drawn in class.
Think of this exercise as a material essay. Translate what you wrote for the first
homework into a physical model that clearly demonstrates tectonics, structure, and
construction.
The model should be easy to assemble and disassemble (like the Maison Tropicale
though the intent is not to design a house, just a tectonic ensemble) and be made of
thin sheet material as Museum Board, Bristol Board or Chip Board.
Write about what your aim is, and how your model demonstrates the 3 independent
characteristics of Tectonics, Structure, and Construction.

Due on Tuesday, February 16, 2010.
PROJECT 1

The project is to determine the structural steel sizes and profiles for the structure presented in Lecture Two, see Diagram A below. The structure should adequately support the curtain wall enclosure as described in class - together with the attached details 1 to 6. The curtain wall system is under wind pressure (only no dead or live loads) as obtained through the Code Procedure presented before. Wind pressures are to be calculated at 10", 15", and 30" above ground. The wind pressure then would be conservatively stepped so that from 0 to 10", the wind pressure at 10" is used for analysis. From 10" to 15", the wind pressure at 15" is used for analysis. And, between 15" and 30", the wind pressure at 30" is used for analysis. These stepping wind loads affect the windward and leeward faces of the enclosure with their corresponding code coefficients. (If the code procedure yields a negative pressure at the roof, ignore it for your calculations because this is a benefit you may not count on as wind occurs at irregular intervals). The site for the structure is an urban site. The structure is a hinged-braced frame that would allow the use of the method of joints and the method of sections if it is statically determinate (see Diagram B). The second floor and roof are rigid diaphragms that act as horizontal deep beams. The whole analysis and design should be performed for the wind load acting on face A and face D respectively. All team-members are responsible for the content in your projects, make sure you have specific responsibilities, as well as to be able to understand and speak of other member's work.

Write a report explaining your process (with an Introduction, a Conclusion and all calculations).
Draw plan, section, and elevation of the structure and enclosure assembled together.
Make a physical model that demonstrates how the structure behaves (Use rubber bands, or the like, as the cross-braces to demonstrate deformation and elasticity)
Document your models in movement.
Submit a paper copy and a digital copy in disk format.
Prepare for Presentation.

![Diagram A](image1)

![Diagram B](image2)
INTERMEDIATE VERTICAL MULLION SUPPORT SECTION DETAIL, TYP.

SCALE 3" = 1'-0"
SLAB EDGE

CURTAIN WALL SNAP CAP MECH FASTEN TO C.W. STRUCT.

ALUMINUM CURTAIN WALL SYSTEM

HEAT STRENGTHENED, INSULATED GLASS

ANCHORS BY CURTAIN WALL MFTR.

INTERMEDIATE VERTICAL MULLION SUPPORT PLAN DETAIL, TYP.

SCALE 3" = 1'-0"