Lesson Objectives

1. Identify the “preferred material specification” and strengths of common steel shapes, using AISC Tables 2-4 to 2-6.
2. Select efficient compression members by trial and error.
3. Criticize and improve the efficiency of a column design, altering the column selection, as well as the bracing and/or rigid-frame components.
4. Identify shapes with appropriate and efficient $r_x/r_y$ ratios for given $KL_x$ and $KL_y$, including the typical column W shapes that are used for compression members: W8, W10, W12, and W14’s that are “wide” (have an $r_x/r_y$ ratio less than around 2.5).

Reference – AISC Tables 2-4 to 2-6, 4-22
Reading: Study Segui Example 4.8.

Exam 2: Wednesday, in class. Q&A Session, 8PM Tuesday night. See website for past exams and solutions. Remaining homeworks returned ASAP.

Important (read this):
Most standard AISC wide-flange (W) shapes are not engineered to be used as typical columns; they are not proportioned for the most common design case in which $KL_x$ is the same as $KL_y$. For these common design cases, it is obviously efficient if the column has an $r_x/r_y$ ratio of 1 (i.e., $r_x = r_y$). In fact, no wide-flange shapes have this characteristic. However, certain W8, W10, W12, and W14 shapes are characterized by $r_x/r_y$ ratios that are less than about 2.5 and these are considered “standard column shapes.” For example, a W14x90 is a very common column shape for situations in which $KL_x = KL_y$ because it has an $r_x=6.14''$ and $r_y=3.70''$ (ratio=1.66). In contrast, a W16x26 is definitely not a “standard column shape”, as evidenced by $r_x = 6.26''$ and $r_y=1.12''$ (ratio=5.59); a W16x26 (along with all other W16’s) is considered a standard beam shape (it is designed for strong-axis bending). Not all W14’s are standard column shapes, however. Note the fact that a W14x22 has $r_x=5.54''$ and $r_y=1.04''$ (ratio = 5.33). As a general statement, the heavier W8, W10, W12, and W14 shapes are standard for $KL_x=KL_y$ column applications and a shape is usually considered a “standard column shape” if $r_x/r_y < 2.5$ or so.

In contrast, a shape such as a W16x26 could be an excellent column choice if $KL_x$ is much greater than $KL_y$. In fact, it would be very efficient for an application in which $KL_x/KL_y$ is equal to 5.59 (which happens to be the $r_x/r_y$ ratio for that shape), as it would result in both $KL/r$’s being equal, which is one indicator of efficiency, but its not the only one. Another important measure of efficiency is the magnitude of the controlling $KL/r$. Generally, $KL/r$ ratios that are lower are efficient and a ratio above about 100 is a sign of great inefficiency (a ratio greater than 200 is strongly discouraged by AISC).
### Table 1-1 (continued) W-Shapes Properties

<table>
<thead>
<tr>
<th>Section</th>
<th>Moment of Inertia</th>
<th>Section Area</th>
<th>Flange Width</th>
<th>Flange Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>W12x60</td>
<td>2.36 in.²</td>
<td>40.0 ft²</td>
<td>16.0 in.</td>
<td>0.30 in.</td>
</tr>
<tr>
<td>W16x60</td>
<td>3.25 in.²</td>
<td>45.5 ft²</td>
<td>19.0 in.</td>
<td>0.33 in.</td>
</tr>
<tr>
<td>W20x60</td>
<td>3.93 in.²</td>
<td>51.0 ft²</td>
<td>22.0 in.</td>
<td>0.36 in.</td>
</tr>
<tr>
<td>W24x60</td>
<td>4.47 in.²</td>
<td>56.0 ft²</td>
<td>24.0 in.</td>
<td>0.39 in.</td>
</tr>
<tr>
<td>W28x60</td>
<td>4.97 in.²</td>
<td>61.0 ft²</td>
<td>26.0 in.</td>
<td>0.42 in.</td>
</tr>
<tr>
<td>W32x60</td>
<td>5.44 in.²</td>
<td>66.0 ft²</td>
<td>28.0 in.</td>
<td>0.45 in.</td>
</tr>
<tr>
<td>W36x60</td>
<td>5.89 in.²</td>
<td>71.0 ft²</td>
<td>30.0 in.</td>
<td>0.48 in.</td>
</tr>
</tbody>
</table>

### Table 1-1 (continued) W-Shapes Dimensions

<table>
<thead>
<tr>
<th>Section</th>
<th>Depth</th>
<th>Flange Width</th>
<th>Flange Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>W12x60</td>
<td>51.0 in.</td>
<td>16.0 in.</td>
<td>0.30 in.</td>
</tr>
<tr>
<td>W16x60</td>
<td>63.0 in.</td>
<td>19.0 in.</td>
<td>0.33 in.</td>
</tr>
<tr>
<td>W20x60</td>
<td>75.0 in.</td>
<td>22.0 in.</td>
<td>0.36 in.</td>
</tr>
<tr>
<td>W24x60</td>
<td>87.0 in.</td>
<td>24.0 in.</td>
<td>0.39 in.</td>
</tr>
<tr>
<td>W28x60</td>
<td>99.0 in.</td>
<td>26.0 in.</td>
<td>0.42 in.</td>
</tr>
<tr>
<td>W32x60</td>
<td>111.0 in.</td>
<td>28.0 in.</td>
<td>0.45 in.</td>
</tr>
<tr>
<td>W36x60</td>
<td>123.0 in.</td>
<td>30.0 in.</td>
<td>0.48 in.</td>
</tr>
</tbody>
</table>

### Notes:
- Dimensions and properties are for reference only and may vary slightly.
-工程师 should verify all calculations and properties before using them in structural design.

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In-Class:
1. Which shape is preferred for the column application below? Two views of the same column are shown. Circle your answer.

![Column shapes](image)

Answer: (a) or (b)?

2. Which shape is preferred for the column application below? Two views of the same column are shown. Circle your answer.

![Column shapes](image)

Answer: (a) or (b)?

Homework (Due Friday. Standard Homework Assignment – Presentation Counts)
Note: from now on, unless stated otherwise, you are to assume the “preferred ASTM material specification” for all shapes (on homeworks, exams, etc). Refer to AISC Tables 2-4 and 2-5 for “preferred material specifications.”

0. (Answer on your own. Do not hand in). Based on what you have read, is a W18x35 considered a standard column shape (i.e., would it be an efficient shape if \( KL_x = KL_y \))? Is a W12x96 considered a standard column shape?

For the problems, you may use and submit your Column Strength spreadsheet (be sure to include the problem statement, sketch, etc), but you must use pencil and paper to:
- Show a smart initial guess (trial size), based on a reasonable guess of the buckling stress, leading to a trial selection. Clearly explain whether you are trying a “standard column shape” (W8, W10, W12, or W14) or a non-standard column shape (all other W shapes), based on the KL’s that you have.
- Show any work not included on the spreadsheet.

1. Select the lightest wide-flange (W shape) shape that is adequate per ASD for the column at Grid Location B2, between the ground and 2nd floor. “Efficient and safe” means that it should be safe, but fairly close to the lightest possible adequate section. HINT: read the paragraphs, above! (what are the appropriate W shapes for the given \( KL_x \) and \( KL_y \)?)

Given: The following Floor Plan (horizontal view of the floor framing) and Typical Building Elevation (vertical view of a cut along a column line). All connections are simple pins and the building is braced, as shown. The floor acts as a diaphragm, so all columns are considered braced.
Load Given:
Roof Loads: Dead=25psf (this includes the slab and an allowance for all beam weights), Roof Live=0psf, Snow=30psf
2nd & 3rd Floor Loads: Dead loads consist of: 5"-thick concrete slab, Fill Beams are W18x35, Girders are W21x55. For column self-weight, make an initial assumption (and compare at the end)
Live = 100 psf. Live load reduction factor is applicable.
Concrete unit weight = 150 lb/ft³ (pcf)

2. A). Select the lightest W12 column for the applied ASD load, shown.
   B). Select the lightest W18 column for the applied ASD load, shown.
   C). Briefly explain why it makes sense that the W12 is lighter than the W18, for this application.
   D). Briefly explain why the W18 would be the right choice if the column was continuously braced to prevent y-y buckling.

3. Same as previous, except the Y-axis is continuously braced so that KLY=0.
   A). Select the lightest W12 column for the applied ASD load, P=480 kips.
   B). Select the lightest W18 column for the applied ASD load, P=480 kips.