In this example, a parallel-chord steel roof truss girder is analyzed for typical roof dead and live loads. The photo below shows two types of trusses: a truss girder (painted gray) and bar joists (painted white). As seen in the photo above, the corrugated steel deck is supported by the white bar joists, which in turn are supported by the gray truss girder. The truss girder is supported on columns (not shown).

**Figure 1.** Truss girders (gray), bar joists (white) and roof deck (white and corrugated) for a gymnasium roof

The roof framing for this example problem is shown in Figure 2. To help you visualize the framing, an orthographic “exploded” view of a similar steel structure is shown in Figure 3. The joists and girders have the same spacings as in Figure 2, but the joists in Figure 3 are Z-shaped cold-rolled steel purlins (rather than bar joists), and the girders are I-beams (rather than truss girders). Load information is provided below.

**Dead Loads:**
- Roof & Ceiling*:
  - 20 ga metal deck
  - Waterproof membrane with gravel
  - 2” thick Perlite insulating roof boards
  - Heating & cooling ductwork
  - Steel suspended ceiling
  - Acoustic Fiber Board

  Weight of truss girders = 4.05 k
  Weight of bar joists = 9 plf

*See “Typical Dead Loads” (posted on the class web site) for the weights of building components.

**Live Loads:**
- Roof live load specified in the building code (see “IBC (International Building Code) Live Loads”)
  - $10^k$ air conditioning unit

**Load Combinations**
- LC 3: $1.2D + 1.6L$
  (see “Load Combinations” posted on class web site)
Figure 2. Structural drawings of steel framing

Figure 3. “Exploded” view of steel frame
Identify the joists and girders. The first task (trivial as it sounds, but important) is to identify on the plan view which lines represent girders and which lines represent joists.

First of all, the “H”-shaped symbols represent the columns.

In the Plan View at left, we see that some of the “vertical” members in the sketch are attached directly to columns,

but that some of the “vertical” members are attached at their ends to other beams.

The ends of the “horizontal” members, on the other hand, all attach to columns (except for the cantilever ends).

Therefore, the horizontal members in the sketch are girders, and the vertical members are joists. Joists supporting a roof are often called “purlins”.

Problem Statement. Check the strengths of the chords and diagonals for a typical truss girder for the structure shown in Figure 2. The axial forces due to factored dead and live loads ($P_d$) in each type of member will be compared to the strengths ($\phi P_n$) listed in Table 1.

Solution Procedure.

1. Determine if the truss girder is stable and determinate.

2. Identify the critical truss girder, and calculate the loads it.

   2.1. Calculate the concentrated loads due to dead loads at the exterior and interior panel points of the truss girder.
   
   $p^{D \text{ext}}_{\text{ext}}$  
   $p^{D \text{int}}_{\text{int}}$

   2.2. Calculate the concentrated loads due to roof live loads at the exterior and interior panel points of the truss girder.
   
   $p^{Lr \text{ext}}_{\text{ext}}$  
   $p^{Lr \text{int}}_{\text{int}}$

3. Check the strength of the chords of the truss girder.

   3.1. Calculate the magnitude and location (i.e. member “x”) of the maximum compressive bar force due to dead loads in the chords. (Assume compression controls, since failure by rupture (in tension) occurs at a similar magnitude force as crushing in compression, but compressive forces can also cause buckling.)

   $f^D_{x} \text{ }$

   3.1.1. Estimate the location(s) (i.e. the members) with maximum compressive force due to DL.

   3.1.2. Calculate the bar forces at likely location(s) (from Step 3.1.1) of maximum
compressive force. Determine the maximum chord force due to dead load, and the member with maximum compressive force (member “x”).

| 3.2. Calculate the maximum compressive bar force due to roof live load in the member with maximum bar force due to dead load (i.e. member “x”). | \( f_{lx}^{lr} \) |
| 3.2.1. Draw the shape of the influence diagram for the member and determine the loading to cause maximum compressive force in member “x”. | \( I_x \) |
| 3.2.2. Calculate the compressive force in member “x” due to live loads using statics with load placement dictated by the influence diagram |  |
| 3.3. Calculate the axial force in member “x” due to factored loads: \( P_u = 1.2 \cdot P_d + 1.6 \cdot P_{lr} \) and check the strength | \( P_u \) |
| 4. Repeat Step 3 for the diagonals of the truss girder. |  |