Structural Design of Industrial and Office Building

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Abstract

The goal of this project was to earn realistic design experience that focuses on professional practice within the industry of Civil Engineering. This includes working in multidisciplinary teams in order to manage and complete the project on time. The task at hand was to complete all of the load calculations and structural member design necessary to construct an Industrial Office Building in North Jackson, OH. The structural members within the building include a steel truss roofing system, concrete masonry walls, columns with base plates, and a reinforced concrete slab on grade. All of these members must be able to withstand the necessary snow, wind, dead, and live loads specified within the National Building Code, Ohio Building Code, and ASCE 7-10.

Load Calculations

- Dead Load(D) - Self-Weight of individual members
  - Includes load for HVAC units of 2~5 psf per joist
- Roof Live Load(L_r) - 20 psf (ASCE 7-10 Table 4-1)
- Snow Load(S) - 20 psf (ASCE 7-10 Fig. 7.1)
- Wind Load(W) - 120 mph (ASCE 7-10 Fig. 26.5-1B)
- Loads distribute through the structure from the roof to the steel truss roofing system to columns and into the foundation
- Concrete Masonry walls were to be considered Non Load-Bearing
  - Designed to withstand wind load only
- Loads factored using LRFD load combinations from ASCE 7-10 as shown below
  - 1.4D
  - 1.2D+1.6L+0.5(L_r or S)
  - 1.2D+1.6(L_r or S)+(L or 0.5W)
  - 1.2D+1W+L+0.5(L_r or S)
  - 0.9D+1W

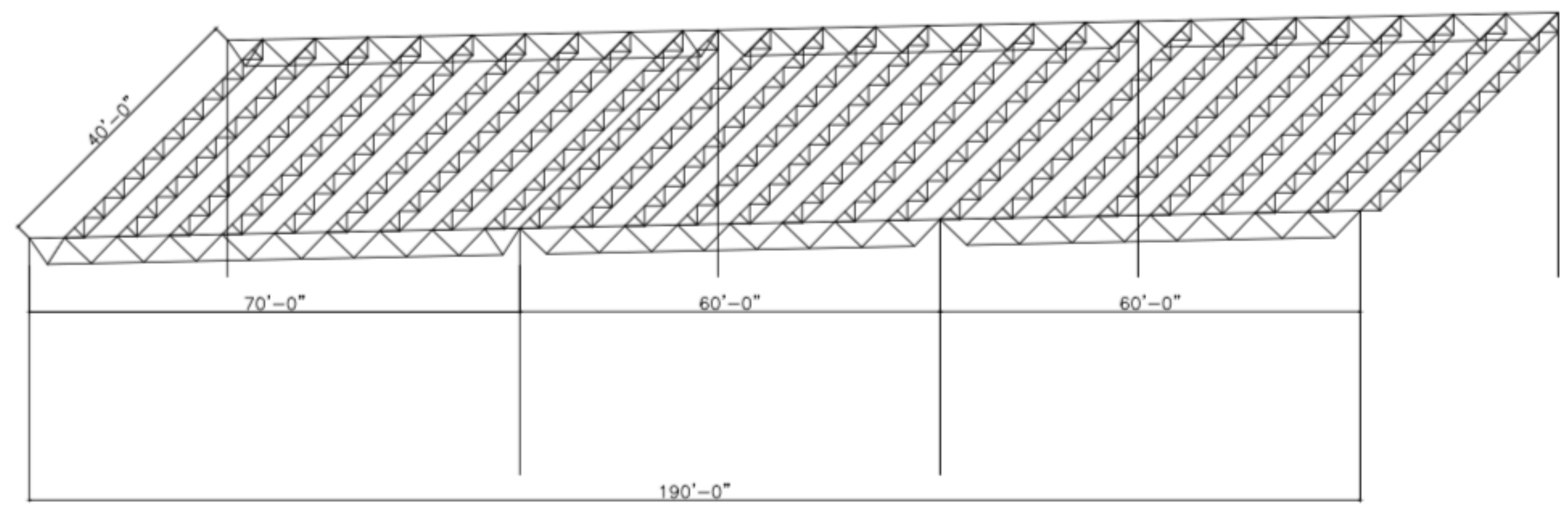
LRFD DESIGN METHOD

- Load and Resistance Factor Design
- Available strength is referenced as the design strength
- Design strength must equal or exceed the required strength of a given member

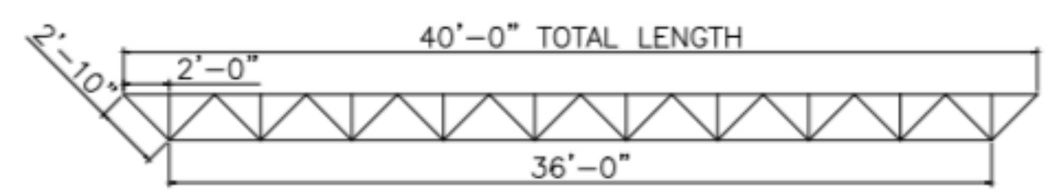
$$R_u \leq \phi R_n$$

- R_u = required strength using LRFD load combinations
- R_n = nominal strength
- ϕ = resistance factor
- ϕR_n = design strength

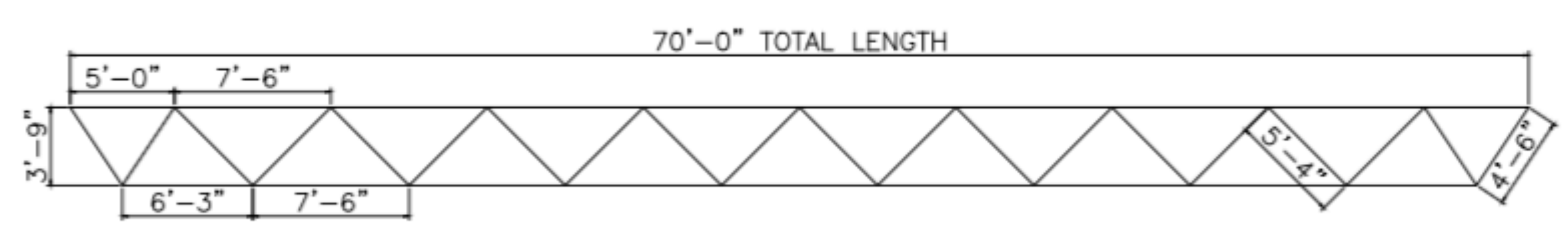
- Design based on limit states principles
  - Strength limit states
    - Load carrying capability and safety
  - Serviceability limit states
    - Performance under normal service conditions
- Structures designed to ensure that no strength or serviceability limit state is exceeded



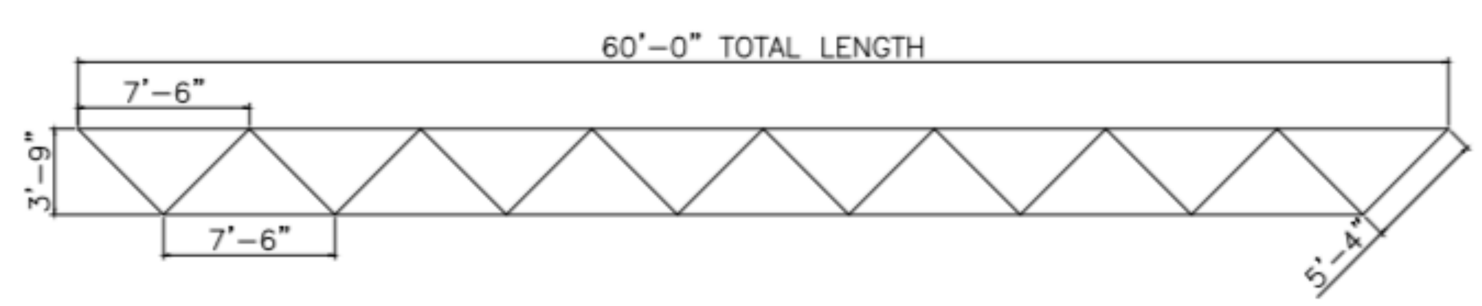
Building Section View



Joist



Girder Truss 1



Girder Truss 2

Proposed Site Location

Design Considerations

- Full scale industrial and office building
  - Must accommodate ~ 200 employees
  - Building use – storage of large construction equipment
- Safety
  - Most important aspect of any engineering application
- Simplified installation
  - Selected similar member sizes to alleviate construction errors
- Cost
- Steel members designed in accordance with AISC Fifteenth Edition
- All concrete members designed in accordance with ACI 318-14

Design Process

- Roofing Material
  - Selected from Vulcraft
  - Designed to withstand all applicable loads with spans of up to 7'6"
  - Maximum deflection = L/240
  - 18 GA B-Deck
- Joists
  - Spaced at 7'6" OC to accommodate roofing specifications
  - Maximum tension and compression members identified
  - Section - $L_{2x2x3/16}$
- Girder trusses
  - Spaced at 40' OC
  - Designed by the same method used for joists
  - Section - $L_{4x4x¾}$
- Columns
  - Designed as a compression member to withstand loads applied by the girder truss
  - Section – W14x61 with 18x18x¾" base plate
- CMU walls
  - Designed to withstand 120 mph wind load
  - 10" CMU with #5 bars at 27" OC
  - Reinforcement designed for the maximum required area based on:
    - Maximum moment on the wall
- Floor slab on grade
  - 6" thick reinforced concrete slab
  - #5 bars at 10½" OC in both directions
  - Reinforcement designed for the maximum required area based on:
    - Temperature and shrinkage
    - Subgrade drag

Structural Software Modeling

- 3-D Structural modeling software used to verify design
- All members modeled separately to verify the accuracy of hand calculations
- Used to optimize the design of large scale projects

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