FLUOR®

Industrial Steel Pipe Rack

Design Team S-6

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Introduction

Pipe racks are non-conventional structures that are typically utilized in refineries, chemical, power, and petrochemical plants. The proposed pipe rack for Fluor Corporation was designed to support power cables, pipes, cable trays, an air cooler exchanger, and a platform for air cooler maintenance. According to ASCE 7-16, pipe racks are non-building structures that are similar to buildings. As a result, typical design requirements found in building codes may not apply to this structure.

Structural Engineering Role in Industrial Facilities

In typical buildings, the structural engineer brings the architect's vision into fruition providing the desired safety and structural integrity to the structure. In industrial sites, however, a structural engineer's role is to design structures that best support the plot plans provided by the piping design group, as well as the materials and machinery specified by the chemical and mechanical engineers on-site.

Design Criteria

The governing building code for the industrial steel pipe rack, was the International Building Code (IBC) (ICC, 2019). The loads required were acquired from the ASCE 7 (ASCE, 2016). Load combinations were obtained from the Process Industry Practices (PIP) design criteria and checked with IBC Section 1605.

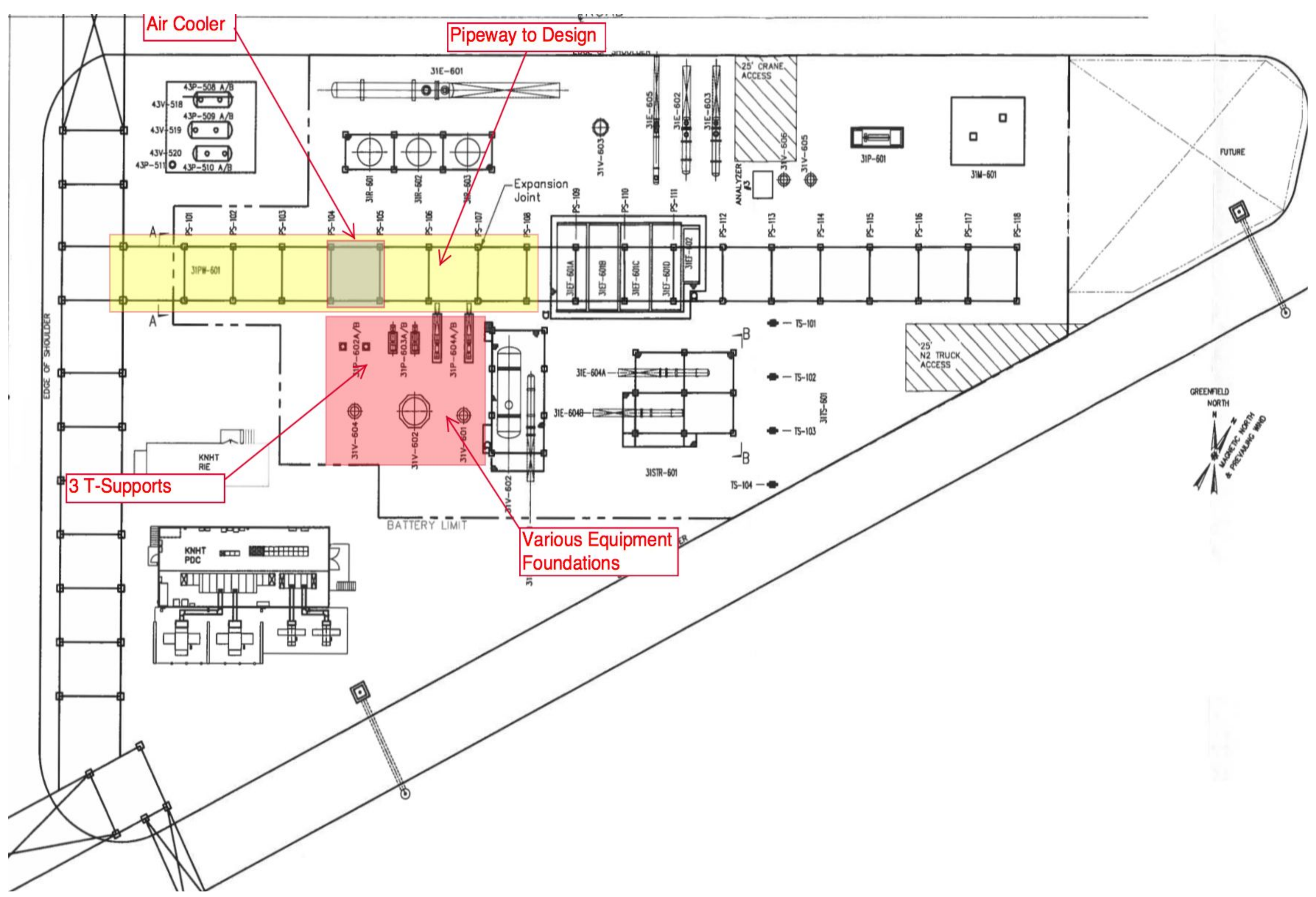

Figure 1. Plot plan of project site displaying the designed pipe rack highlighted in yellow.

Loading Demand

1. **Dead Loads (D):** Includes self-weight of galvanized A992 steel members and fire proofing, uniform operating load of pipes (40 psf), uniform operating load of cable trays (30 psf), and point loads from air cooler unit - max of 11 kips.
2. **Live Loads (L):** Accounts for live load on the platform underneath the air cooler unit including the uniform operating platform load (100 psf), uniform personnel access platform and walkways load (50 psf), uniform stairs and exitways load (100 psf), and point loads from the air cooler unit (0.6 kips).
3. **Thermal Loads (T):** Provisions were made for Self-straining forces arising from assumed differential settlements of foundations and from restrained dimensional changes due to temperature changes, moisture expansion, shrinkage, creep, and similar effects (4 psf).
4. **Earthquake Loads (E):** Lateral loads were obtained from the Equivalent Lateral Force Method Analysis with a response modification factor value of R = 3 and R = 3.5 for ordinary moment frames and braced frames, respectively.

   Site: (N33^{0}48'48.51", W118 ^{0} 14' 18.5")

   Site Class: D

   Occupancy Category: II
5. **Wind Loads (W):** Lateral loads were calculated for the structure to resist wind effects according to 2019 and ASCE-7-10. These loads were then compared to seismic

   Occupancy Category: III

   Velocity Pressure Coefficient: Kzt = 1.0

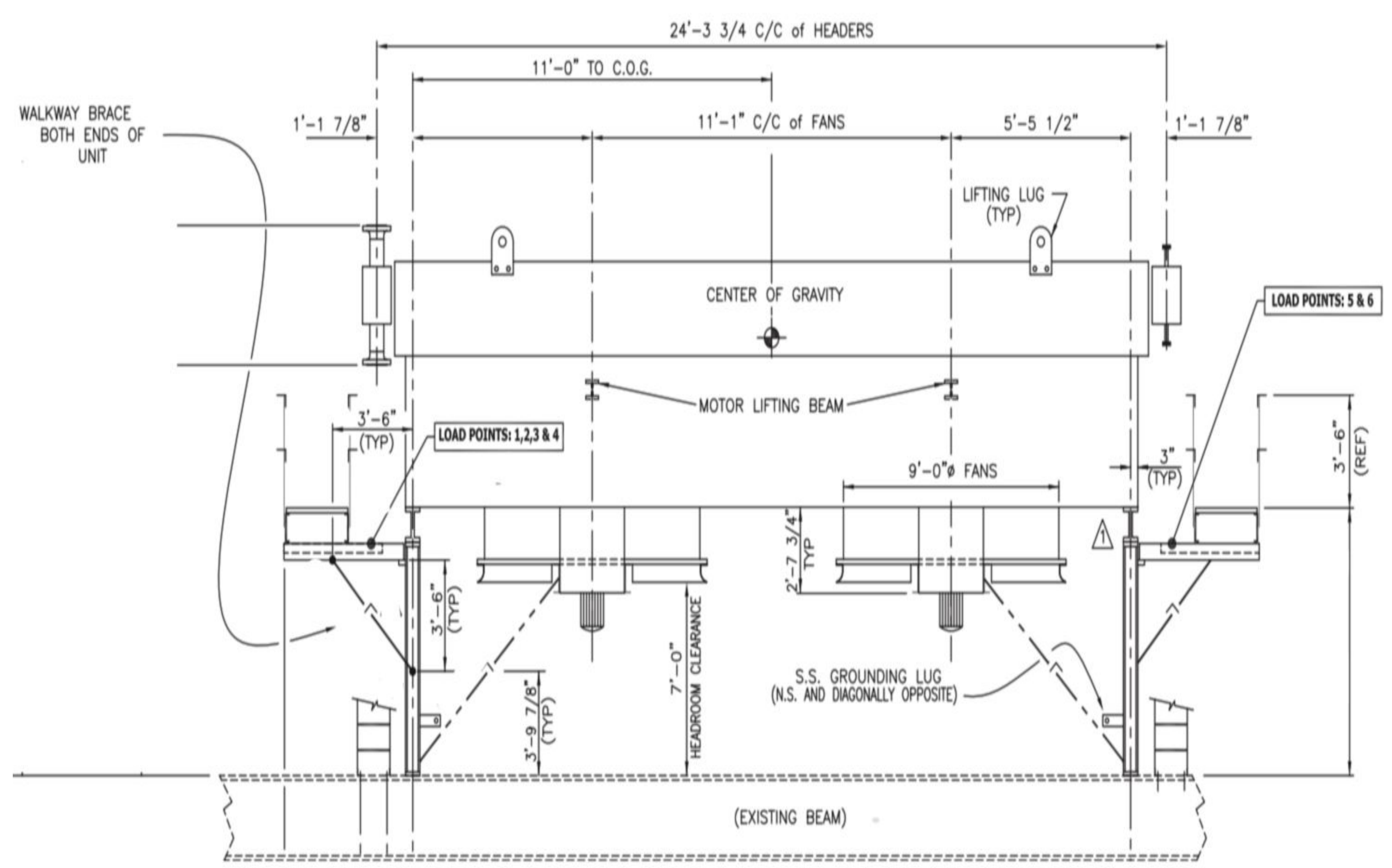

Figure 2. Elevation view of air cooler unit.

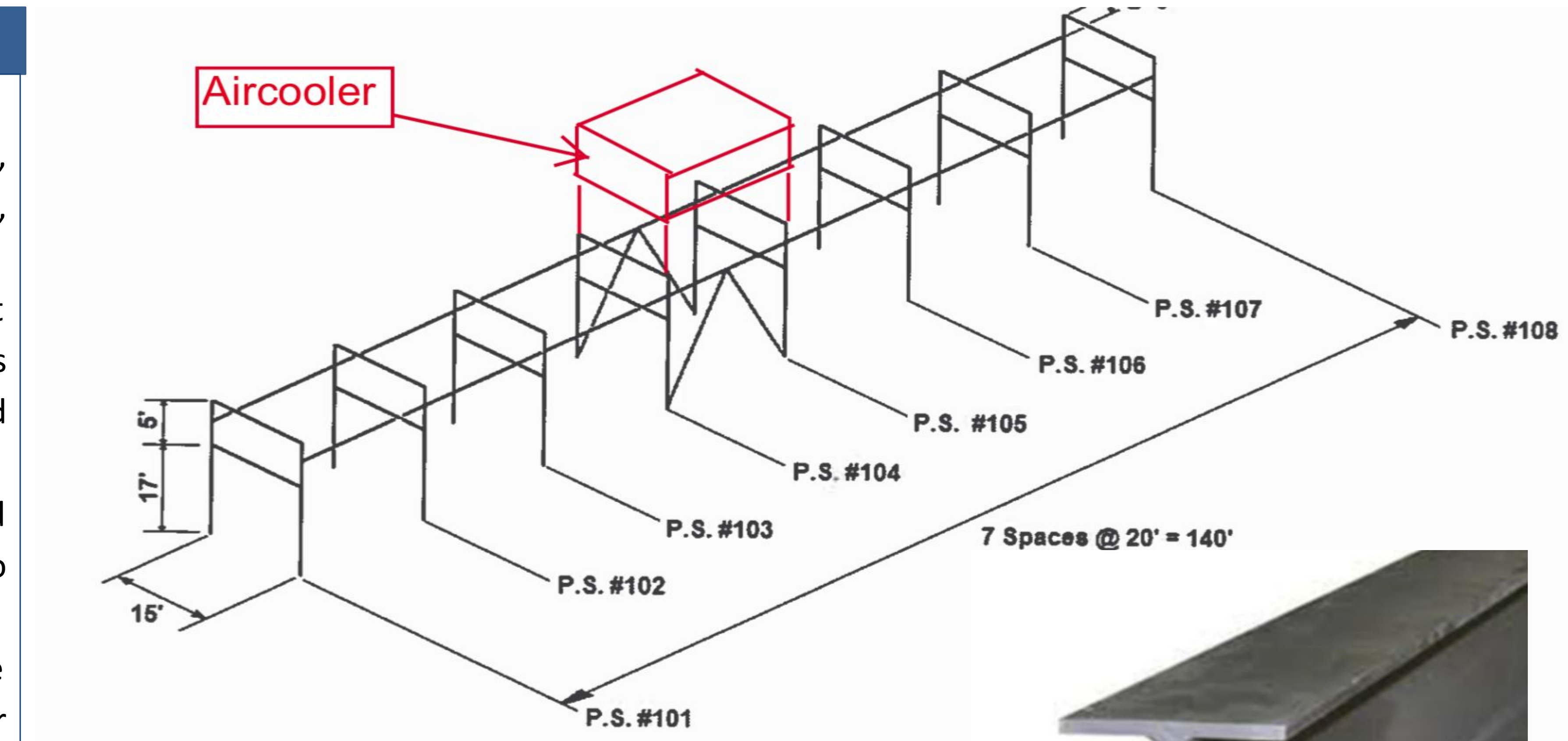

Figure 3. Pipe rack layout and typical cross section of steel members.

Connections

The following end conditions were established based on the frame type and chosen design approach:

- Fixed beam-to-column end conditions (shear tabs) in the moment frames.
- Pinned strut-to-column end conditions in the braced frames.
- Pinned column-to-foundation end conditions.

Design Procedure

Structural members were designed manually based on the loading and serviceability demand considering flexural,shear, and axial effects . A model of the design was created using SAP2000 to account for the required second order analysis of the structure and to generate a comprehensive report of the deflections and internal forces experienced by each member.

Conclusion and Future Steps

The load analysis, serviceability requirements and preliminary sizing of columns and beams were determined for the first half of the project. Throughout the project, costs, building department requirements, and existing building concepts were discussed. The next phase will encompass the following components:

- Design of connections
- Design of Bracing
- Design of foundations
- Design of T-Supports

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