STRUCTURAL ENGINEERING

To: Ryan Schultz

From: Luis

Subject: Basement structure

Date: June 9, 2019

Hi Ryan.

In the following paragraphs I've tried to describe how we plan to organize the drawings of the basement (precast structure and foundations) in order to align expectations and to receive your comments and feedback about it.

Concerning the modifications that you proposed in yesterday's message we are OK with that. We will need to update our calculations and, in a lesser extent the drawings cause they were already behind schedule. I think it will take about twelve days to put all that together. On the other hand, we will need to find a way to justify the structural strength of the precast structure. Normally we work with the data supplied by the precast manufacturer about the strength of his products. We will ask Grant about that tomorrow. I'll send him the details at the end of this document to receive his comments.

1 BIM model

In order to integrate the structure into the architectural BIM model as efficiently as possible we propose to define the geometry of the different parts (planks, beams and columns for the precast structure,...) without defining details that do not affect the fit of the structure in the building. In other words, define the 3D geometry of the structural elements to allow:

- Obtaining the element list of all the precast elements: hollow-core planks, inverted tee beams, steel beams and columns.
- Checking of the conflicts of the structure with the rest of the building components.
- Create the following drawings:
  - Plan view.
  - Precast concrete beams.
  - Column layout.
  - Foundation layout (basement wall foundation, ramp foundation, footings and concrete frost walls, elevator and stairs well foundation and patios foundations): using a similar approach to the one shown in figure 2.

The rest of the drawings (excavation, rebar detailing and details) will be done using traditional 2D CAD.

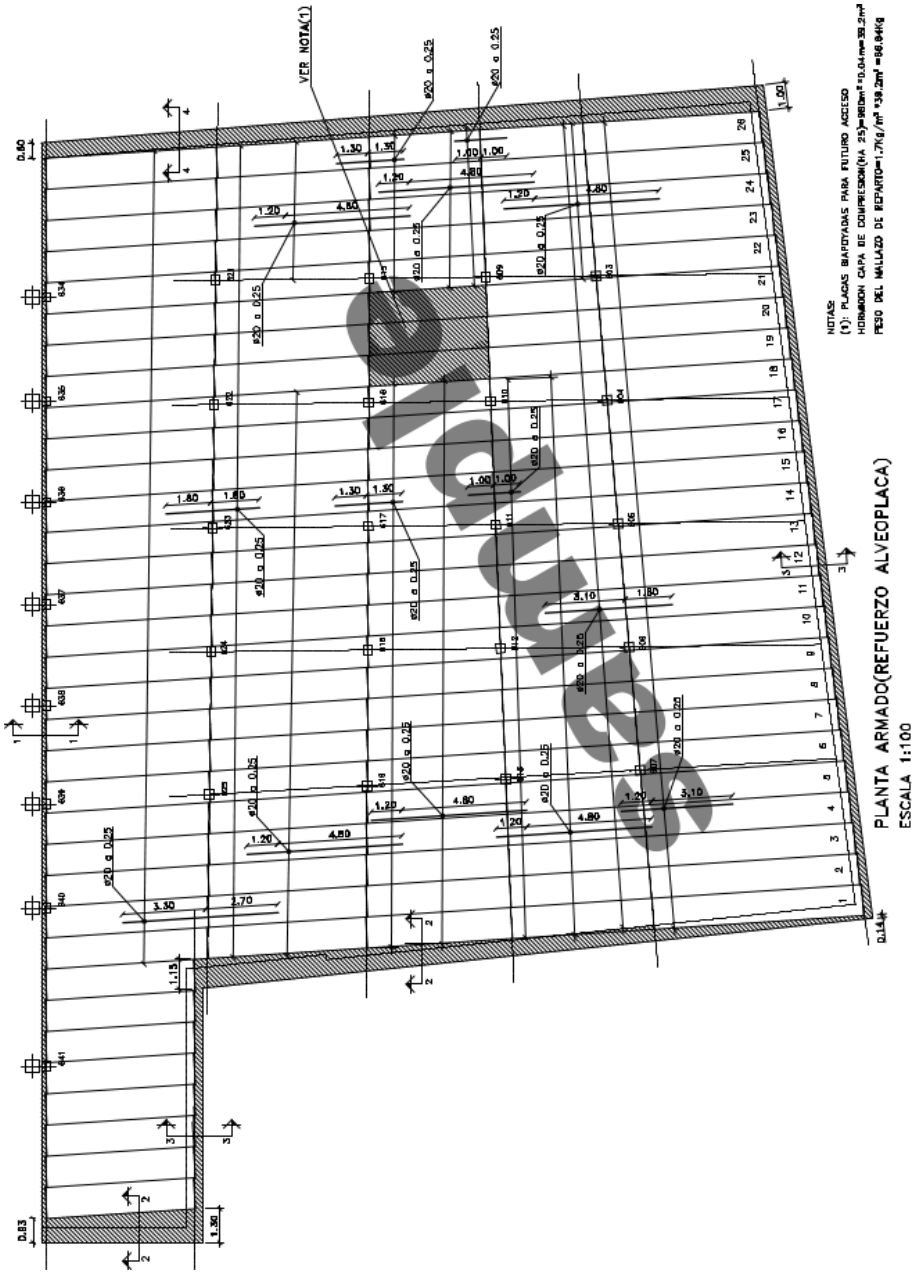

Figure 1: **Sample** drawing for the reinforcement of the hollow core slab.

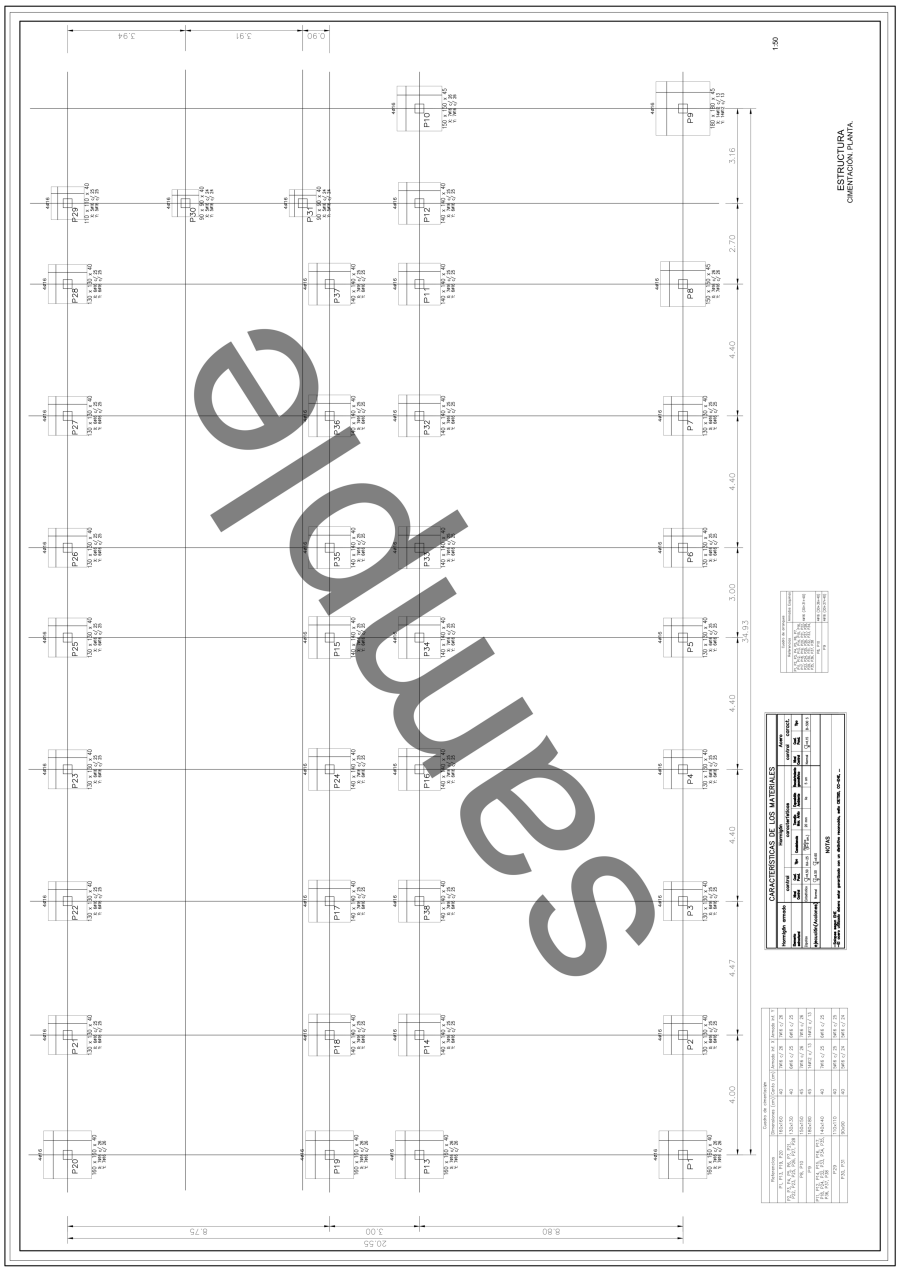

Figure 2: **Sample** drawing for the foundation layout.

2 Rebar detailing

2.1 Precast structure

The reinforcement will be defined in a rebar placing plan view (see, for example, figure 1).

2.2 Foundations

- The reinforcement of the footings will be defined with a 2D drawing similar to the one shown in the figure 3.
- The proposed approach for the definition of the wall reinforcement is shown in figure 4.
- The reinforcement for the ramp and the concrete slab will be defined using the same principle applied for the hollow core slab.

3 Details

3.1 Precast structure

We plan to draw the following details (see figures 5 to 15):

1. Precast structure. Slab to inverted tee beam.
2. Precast structure. Slab to ramp wall CMU.
3. Precast structure. Slab to ramp wall CMU parallel.
4. Precast structure. Slab to basement wall (RC beam over CMU).
5. Precast structure. Slab to basement wall CMU parallel.
6. Precast structure. Slab to basement wall RC parallel.
7. Precast structure. Slab to steel beam double.
8. Precast structure. Slab to steel beam single.
9. Precast structure. Embedded steel column.
10. Precast structure. Inverted tee beam to column.
11. Precast structure. Inverted tee beam to column (different levels). Adapt from the previous one.
12. Precast structure. Inverted tee beam to basement wall.
13. Precast structure. Stepped inverted tee beam.
14. Precast structure. Column to foundation.

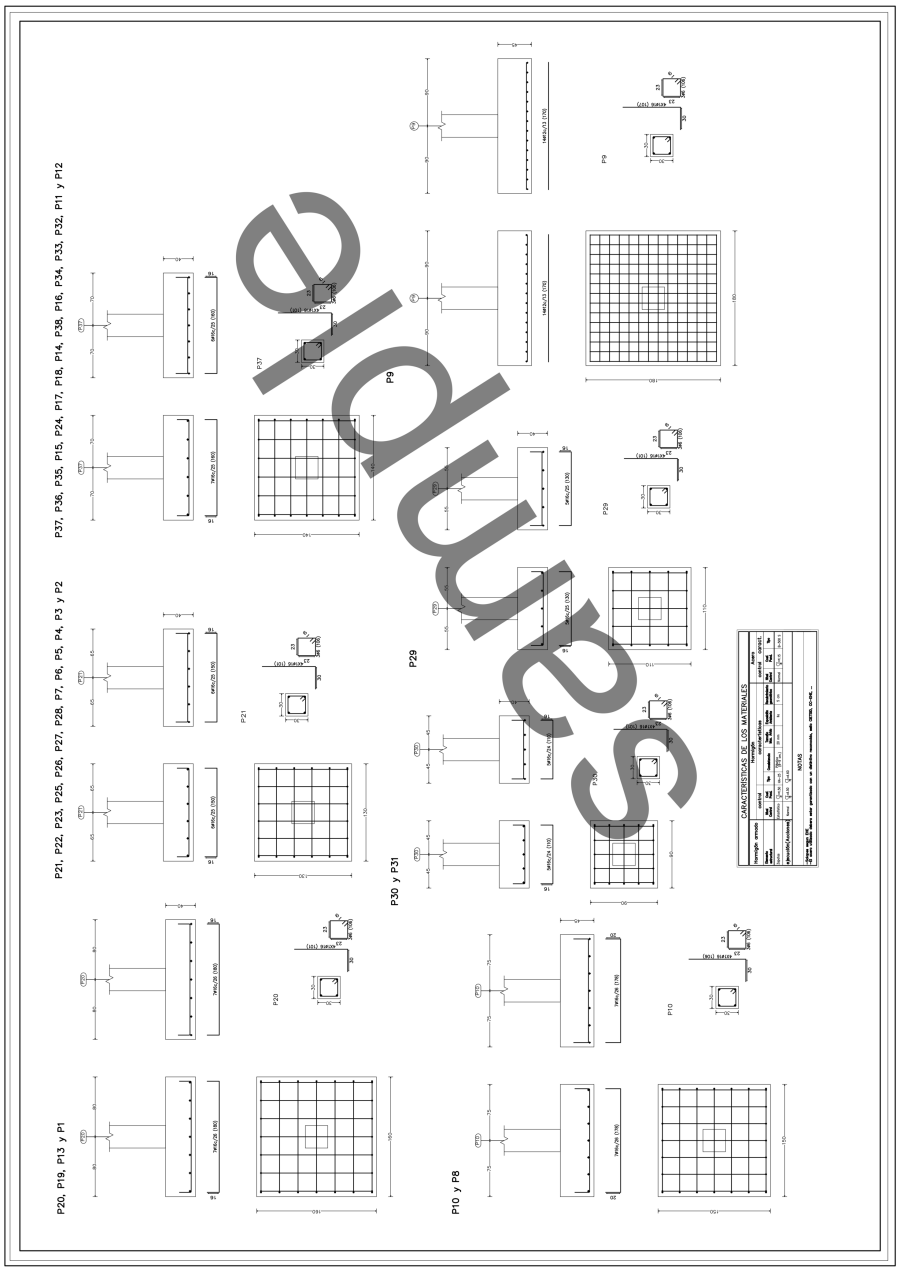

Figure 3: **Sample** drawing for the footings reinforcement.

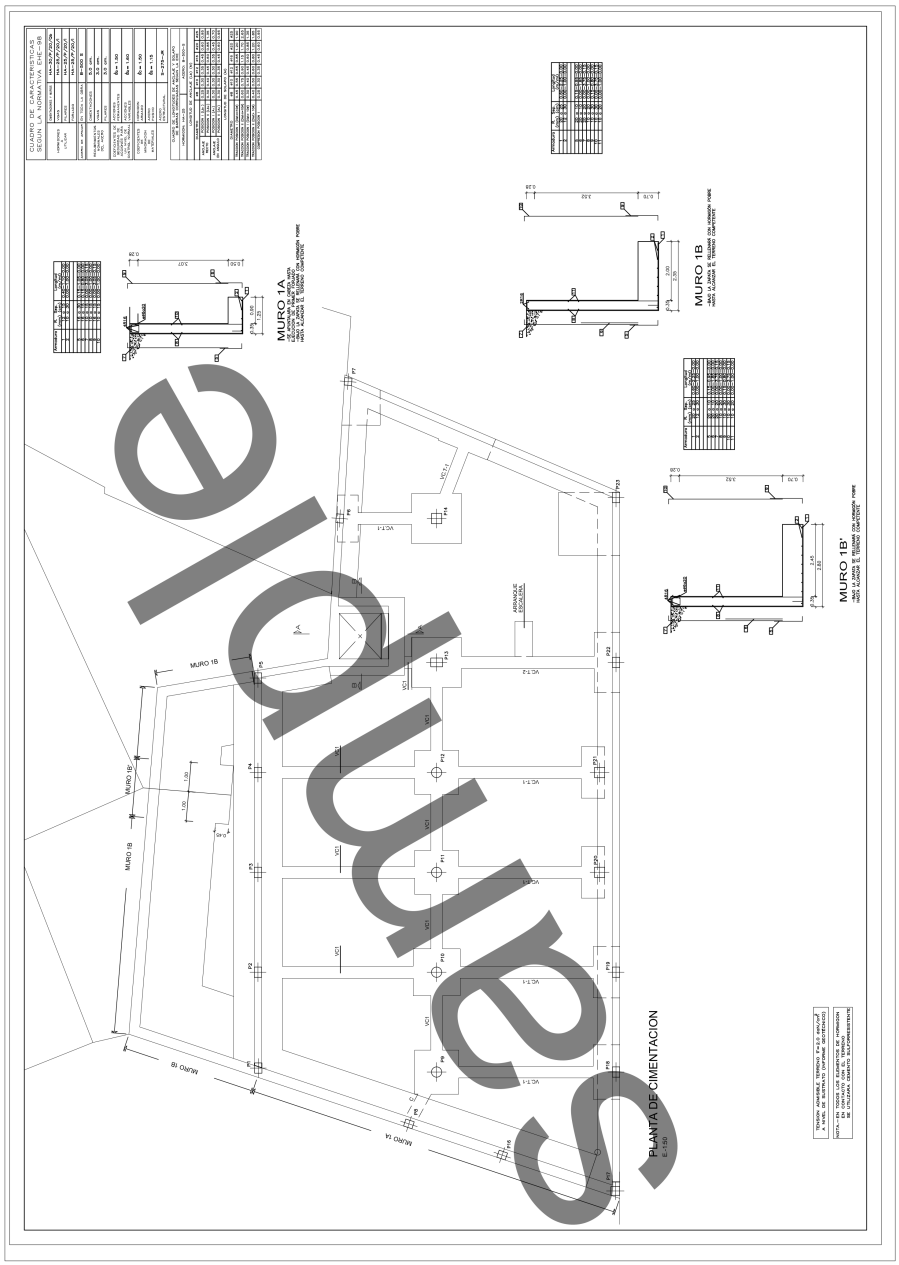

Figure 4: **Sample** drawing for the basement wall reinforcement.

Design Considerations:

- Can transfer internal diaphragm forces
- Can be designed as structural integrity tie
- Consider concrete cover on reinforcement over beam

Fabrication Considerations:

- Slab layout must have opposing joints lined up

Erection Considerations:

- Clean and simple

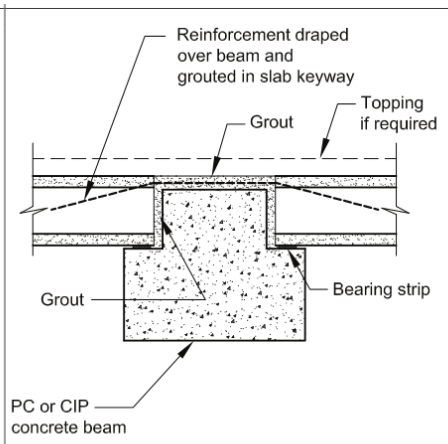

Figure 6.3.4

Figure 5: Slab to inverted tee beam

Design Considerations:

- Can transfer diaphragm shear
- With proper bar detailing, can provide lateral brace for wall
- Consideration should be given to forces developed as slab ends rotate

Fabrication Considerations:

- Clean and simple
- Small tolerance for placement of bars in walls

Erection Considerations:

- Simple for slab erection
- Mason can set bars independent of the slab joints
- Some block cutting may be required for bars from keyways

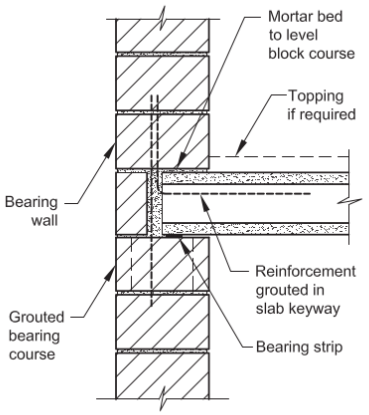

Figure 6.4.3

Figure 6.4.3

Figure 6: Slab to ramp wall CMU

Design Considerations:

- Can transfer diaphragm shear
- Can provide lateral brace for wall
- Consideration should be given to forces developed from deflection or camber growth
- Consider axial load path

Fabrication Considerations:

- If not done in field, slots and holes must be cut for steel
- In stack casting system, slots and holes might not be practically cut in plant

Erection Considerations:

- Allowance must be made for slab camber
- If not done in plant, holes and slots must be cut for steel
- Wall is not braced until steel is grouted

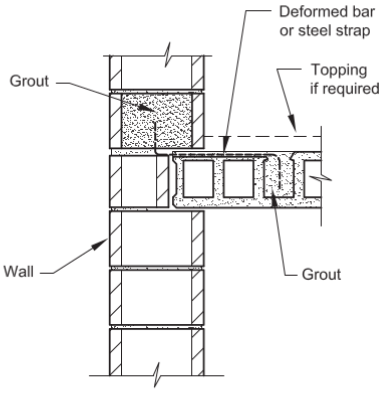

Figure 6.4.9

Figure 7: Slab to ramp wall CMU parallel

Design Considerations:

- Can transfer diaphragm shear
- Can be designed as structural integrity tie

Fabrication Considerations:

- Clean and simple for both beam and slabs

Erection Considerations:

- Reinforcement must be tied in place
- Concrete must be cast around reinforcement
- Edge form is required for cast-in-place concrete
- Dowels from beam may present safety hazard

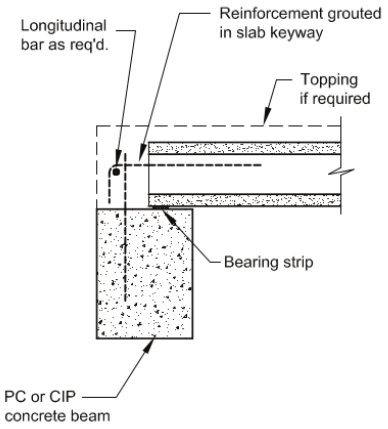

Figure 6.3.11

Figure 8: Slab to basement wall (RC beam over CMU)

Design Considerations:

- Can transfer diaphragm shear
- Can provide lateral brace for wall
- Consider effects of vertical restraint
- Connection capacity must be verified by test

Fabrication Considerations:

- Clean and simple

Erection Considerations:

- Minimum edge distances must be maintained
- Holes must be drilled through slabs into masonry

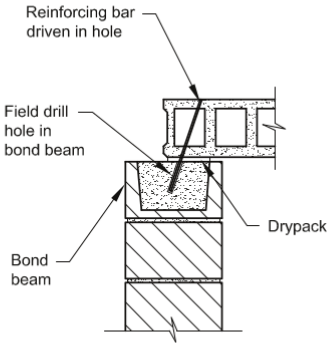

Figure 6.4.13

Figure 9: Slab to basement wall CMU parallel

Design Considerations:

- Wall thrust from earth pressure can be resisted
- Can transfer diaphragm shear only with special detailing of keyway and reinforcement
- For long spans consider effects of restraint of vertical movement

Fabrication Considerations:

- Clean and simple

Erection Considerations:

- Edge joint must be grouted which may not be standard practice

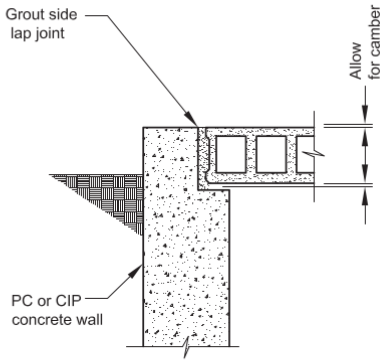

Figure 6.4.10

Figure 10: Slab to basement wall RC parallel

Design Considerations:

- Can transfer internal diaphragm forces
- Provides lateral brace for steel beam
- Will develop volume change restraint forces that must be considered in design of connection
- Select beam flange width to allow minimum bearing considering tolerances

Fabrication Considerations:

- Slab manufacturing system must allow for installation of bottom weld anchors

Erection Considerations:

- Welding of slabs to beam should be done as erection proceeds to laterally brace beams

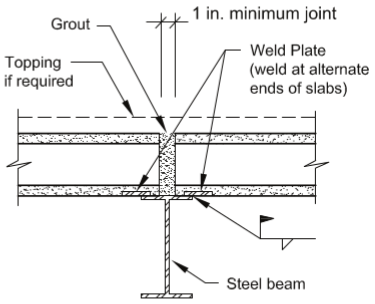

Figure 6.5.3

Figure 11: Slab to steel beam double

Design Considerations:

- Can transfer diaphragm shear
- Provides lateral brace for steel beam
- Potential torsion on steel beam should be considered
- Will develop volume change restraint forces that must be considered in design of connection

Fabrication Considerations:

- Slab manufacturing system must allow for installation of bottom weld anchors

Erection Considerations:

- Welding of slabs to beam should be done as erection proceeds to brace beam
- Spacer may be required to make weld

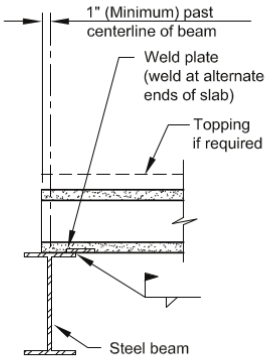

Figure 6.5.4

Figure 12: Slab to steel beam single

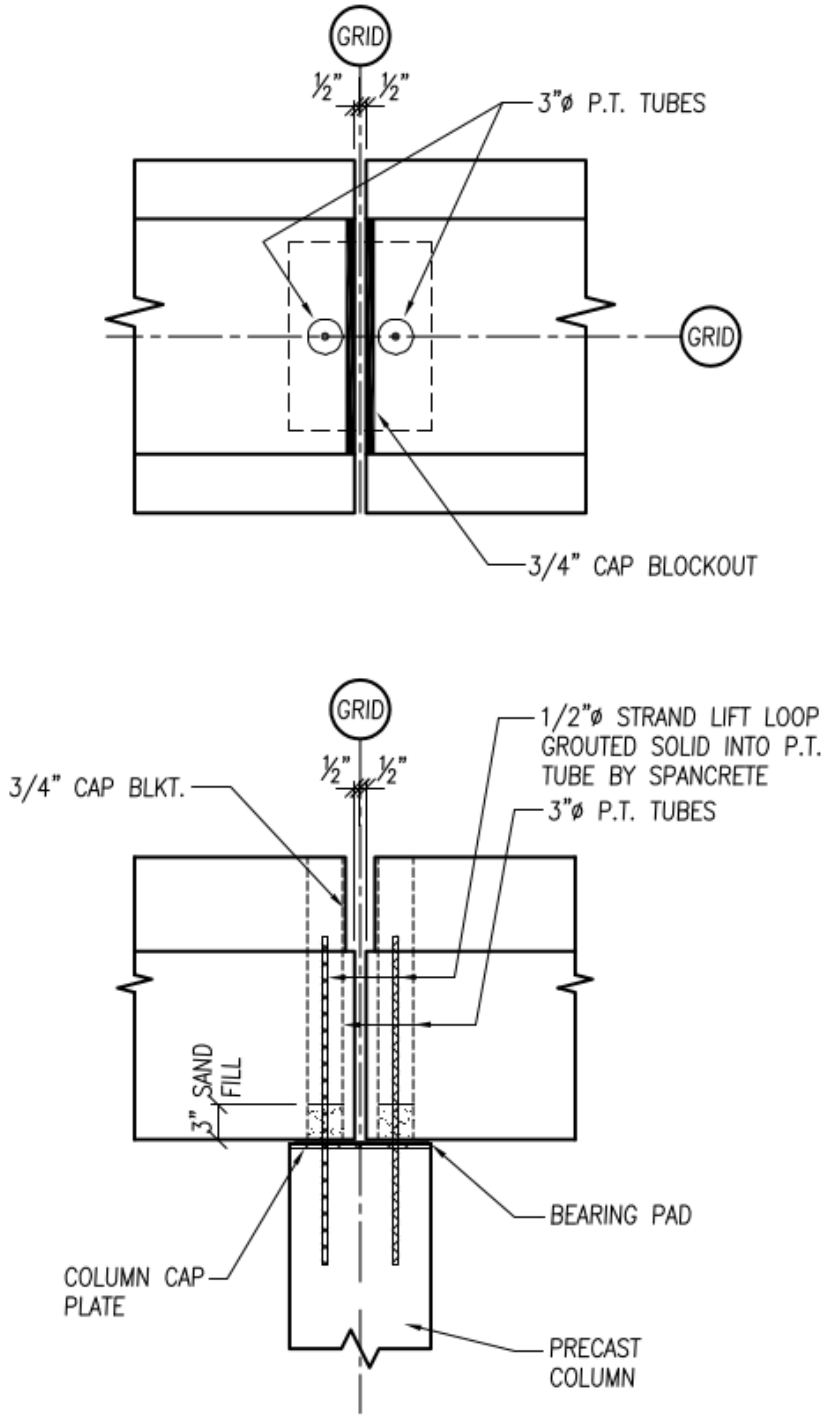

Figure 13: Inverted tee beam to column

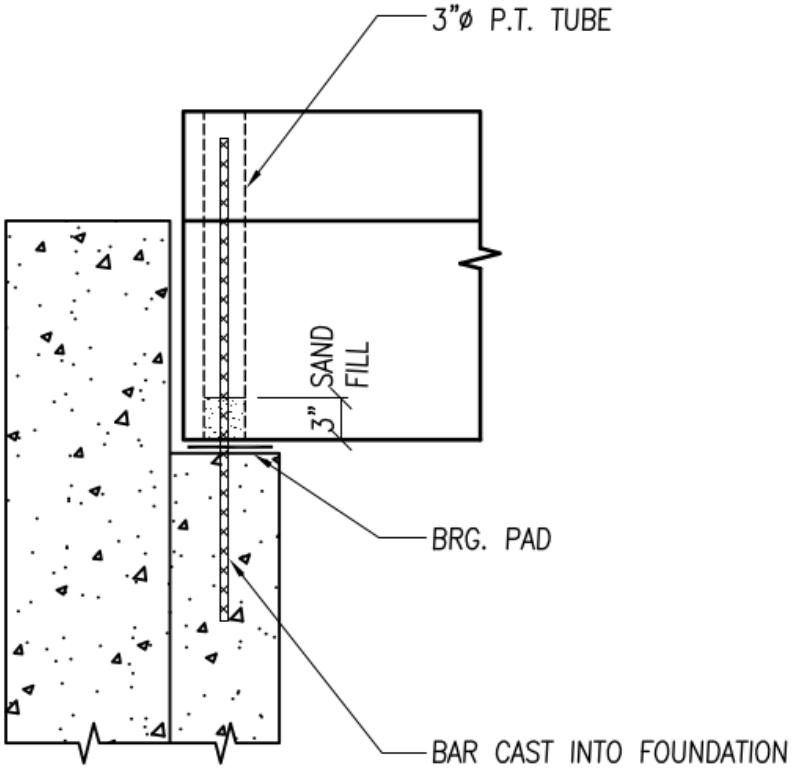

Figure 14: Inverted tee beam to basement wall

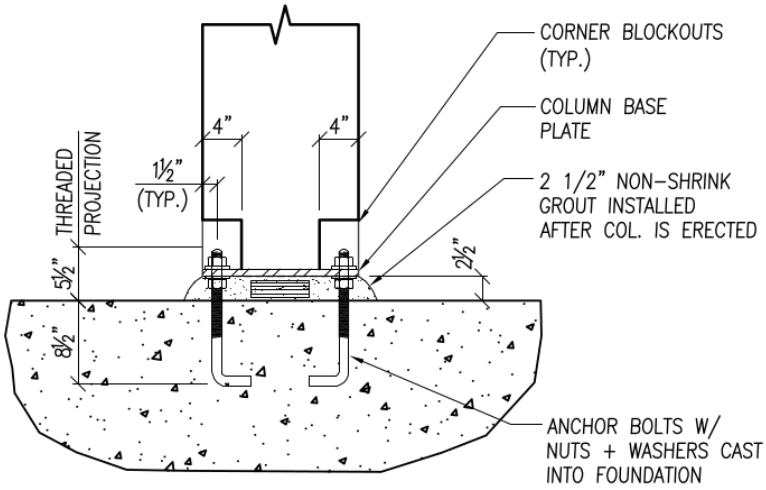

Figure 15: Column to foundation