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Pre-engineered buildings have been constructed and utilized in the market over many decades. During those decades pre-engineered buildings continue to advance in certain aspects to render a more sophisticated and flexible design system. Low-rise buildings are a majority of structures that account for pre-engineered buildings. An example of the typical use for pre-engineered buildings is industrial structures because the wide open spans provided in pre-engineered buildings allow large amounts of equipment required to manufacture, pack, and ship goods. The lack for unique architectural aesthetics based on the facility helps develop the popularity for pre-engineered buildings for such industrial uses. Each building is primarily constructed of cold formed I beams, which are simply created by three welded plates of the required size. Rolled form members are also utilized in certain scenarios. Overall pre-engineered buildings are laid out in a way that creates maximum space within the facility mainly by the large spans of the moment frames. In general, advantages of pre-engineered buildings include: fast construction time, lower costs, larger clear spans, quality control, low maintenance, energy efficient roofing, and erection (Zende etc al. May 2014). These advantages are created because more time is spent shop fabricating the pieces of the steel structure which lessens the time of field construction, ultimately saving money. However, as time passes and the desire to expand these facilities grows, pre-engineered buildings face renovation which can create several issues including structural capacity depending on the project scope.

As pre-engineered buildings require renovations, additions, or expansion issues may occur with the structural capacity. Certain alterations may be engineered in order to increase capacity of the facility. Each low-rise pre-engineered building is typically designed with larger spans and can create deflection problems. Most often the larger spans are not designed for high amounts of dead load, and live load. (Schmidt etc al., May 2014). One specific reason for smaller dead and lives loads is due to the fact that limited equipment is designed on the roof otherwise they are placed on the floor. Other loads such as snow and seismic loads depend on the geography. One disadvantage for pre-engineered buildings is foundations need to go through the design process again because of the increase in base force resulting from increased column loads. Not only are foundations an issue, but expansion can be limited due to the geometry of the building (Schmidt etc al., May 2014)

A suitable example can be seen within a project designed for a food processing plant that is currently being renovated. The project consisted of a pre-engineered building which required several areas of renovations that included upgrades with electrical work, HVAC, plumbing, and structural features. The owner was renovating the preexisting structure in order to produce beverages where several additional pieces of equipment were required for the process. Thus several large supporting platforms and mezzanines were to be designed to support the machinery. Throughout this essay several examples will be presented within this particular project explaining certain issues in the process of renovating pre-engineered buildings.

In the existing pre-engineered building, the design loads of the structure were low especially the dead load. Thus significant scope was necessary to improve the capacity of the
structure with the new equipment. Structurally the necessary renovations included new and improved foundations, reinforced roof joists and columns, along with construction of several mezzanines to support new equipment. For foundation purposes, new spread footings were poured for the new mezzanines which is pictured in Figure 1. Specific existing foundations needed upgrading due increased loads from equipment and mezzanines that framed into existing columns. The foundations were unable to be replaced with deeper foundations. However, each footing was reconstructed to create a larger base area and footing depth. Concrete was formed and cured around each necessary footing. Dowel rods grouted into the existing footing and bonded the new concrete with the pre-existing concrete to form the required spread footing design without exceeding the bearing capacity of the soil (Mueller, May 2014). New footings were constructed for masonry load bearing walls designed to support a new mezzanine within the structure. Problems appeared as the process progressed due to new plumbing being installed. The problem was solved by stair stepping the footings at the locations of interfering pipes which occurred in multiple locations. Figure 2 depicts the stair stepping construction of the footings.

Columns and joists within the building encountered increased stresses in the renovation design. HVAC units, piping and other structures contributed to the increase in loads resulting in overstressing. Figure 3 depicts the addition pipes being supported from the roof joists. In general, joists failures will occur in either the chord, webs or the joists due to point loads. Joists with overloaded chords are reinforced with steel bars and rods (Mueller, May 2014). Joists will be designed with point loads acting at locations where web members intersect. Thus if overstressing occurs at the point loads extra webbing will be added as support. On the other hand web members that fail require...
reinforcement of specific web members in order to increase the sectional area to bear the resulting forces. Both chords and web members were reinforced with angles and steel rods throughout the project to withstand the new larger loads. Joists chords were reinforced by angles added to the chord members while webs needed angles or steel rods welded around the member in order to create more area to withstand the force. Figure 4 depicts the detailed drawings for the joist reinforcing.

In addition to joists being reinforced, columns required reinforcement in order to prevent buckling under increased forces. Wide flange and tube shaped columns are constructed inside the

Figure 3: Depicts new piping being supported by existing roof joists.

Figure 4: Details and section views for joist reinforcement.
existing building thus different steel materials consisted of the reinforcement for both types of columns. Depending on the failing axis upon wide flange members, either the flanges or web was reinforced with plates. For wide flange columns the minor axis runs parallel to the webbing and the major axis parallel to the flanges. More often the web needed reinforcement if loaded in the minor axis then flanges when loaded in the major axis. In order to reinforce tube shaped columns, channel members at the flanges were welded to each tube that would be overstressed in compression. Cost effectiveness of reinforcing the existing columns outweighed the process of adding more columns and footings in order to help with support (Mueller, May 2014).

Lastly multiple mezzanines and platforms were designed within the structure in order to support the new equipment for the owner’s future production. These mezzanines were laid out in order to create a process line for the good being produced. Figure 5 depicts part of the multiple level mezzanine. As previously discussed, the mezzanines required new footings be constructed. Spread footings for columns and strip footings for the masonry walls were placed to support the mezzanine. Figure 6 and 7 both depict the construction of the same mezzanine but at different time frames.

Overall renovation of pre-engineered buildings requires a certain degree of redesign similar to this current production facility including foundation improvements, reinforcement for structural elements and even new support structures within the existing building. Ultimately due to the large space from long member spans per bay, room is available for renovations. However several developments may occur that require for situations to be solved by more construction resulting in addition costs over time.
Figure 6: An earlier stage of the construction of a mezzanine supported by a masonry wall.

Figure 7: Construction at a later point of the same mezzanine supported by a masonry wall.

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Renovations on pre-engineered buildings are becoming more frequent, and also pre-engineered are becoming more sophisticated and tailored for complex projects. Pre-engineered buildings still limit some aspects of the design phase for projects when renovation begins. Foundations also pose a problem when renovations occur due to the increase loads, and typically foundations will need to be redesigned to create stability for the base of the structure.
Sources:

